CONTACT REPORT

Person Contacted	Title	Phone Number
Mark Boriek	Fisheries Biologist	908-236-2118
Contacted By: Renee Nordeen		
Dates: August 21, 2015		
Site Name: Lower Hackensack River Sensitive Environments		
Technical Direction Document: 15-03-0008		
Subject: Fish habitat on the Lower Hackensack River		
Content: Mark indicated the Lower Hackensack River provides Spawning areas critical for the maintenance of fish as well as Migratory pathways or feeding areas critical for the maintenance of anadromous fish for striped bass as well as river herring. Information regarding the presence of Shortnose sturgeon and Atlantic sturgeon in the Lower Hackensack River was requested. Mr. Boriek did not have information regarding these species and suggested contacting the Marine Fisheries department for information. The contact number provided is 609-748-2020.		

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CONTACT REPORT

Meeting [ ] Telephone[X] Other [X] email

COMPANY	New Jersey Department of Environmental Protection
PERSON(S):	Mr. Mark Boriek, Fish Biologist
ADDRESS:	1255 County Rt. 629 P.O. Box 394 Lebanon, NJ 08833
PHONE: Tel:	(908) 236-2118
TO:	Gene Florentino
FROM:	Kathryn Des Jardin
DATE:	29 July 2015
CC:	Joseph Carlo

MARKET SECTOR:	
MARKET SUB-SECTOR:	
SUBJECT:	Hackensack River

SUMMARY: The Hackensack River

DETAILS: Following an Internet search of publicly available information regarding human food chain targets (species and number of fish caught in the river), Mr. Mark Boriek, a fisheries biologist, was contacted via telephone at approximately 1:30 pm EST by Ms. Kathryn Des Jardin (E&E).

Mr. Mark Boriek indicated that the New Jersey Department of Environmental Protection Fish & Wildlife does not keep records of fish caught in the Hackensack River. He also confirmed that the only type of fishing occurring on the river is recreational (sport). In a follow-up email, Mr. Mark Boriek sent Ms. Kathryn Des Jardin a link to the NJDEP's

Office of Science & Research for additional information. Trout stocking information for the spring of 2015 was also supplied. He advised that looking up the number of freshwater licenses sold in the area in an effort to estimate fish capture (via license limits) “would be quite a tedious task”.

ACTIONS: Ms. Kathryn Des Jardin will search the NJDEP Office of Science & Research website for additional fisheries information.

Code of Federal Regulations

Title 33 - Navigation and Navigable Waters

Volume: 1
Date: 2005-07-01
Original Date: 2005-07-01
Title: Section 117.723 - Hackensack River.
Context: Title 33 - Navigation and Navigable Waters. CHAPTER I - COAST GUARD, DEPARTMENT OF HOMELAND SECURITY. SUBCHAPTER J - BRIDGES. PART 117 - DRAWBRIDGE OPERATION REGULATIONS. Subpart B - Specific Requirements. - New Jersey.

§ 117.723 Hackensack River.

(a) The following requirements apply to all bridges across the Hackensack River:

(1) Public vessels of the United States, state or local vessels used for public safety, and vessels in distress shall be passed through the draw of each bridge as soon as possible without delay. The opening signal for these vessels is four or more short blasts of a whistle or horn, or a radio request.

(2) The owners of each bridge shall provide and keep in good legible condition clearance gauges for each draw, with figures not less than 18 inches high for bridges below the turning basin at mile 4.0, and 12 inches high for bridges above mile 4.0. The gauges shall be designed, installed and maintained according to the provisions of section 118.160 of this chapter.

(3) Train and locomotives shall be controlled so that any delay in opening the draw shall not exceed 10 minutes except as provided in paragraph (a)(1) of this section. However, if a train moving toward the bridge has crossed the home signal for the bridge before the signal requesting the opening of the bridge is given, the train may continue across the bridge and must clear the bridge interlocks before stopping or reversing.

(4) New Jersey Transit Rail Operations' (NJTRO) roving crews shall consist of two qualified operators on each shift, each having a vehicle which is equipped with marine and railroad radios, a cellular telephone, and emergency bridge repair and maintenance tools. This crew shall be split with one drawtender stationed at Upper Hack and the other drawtender at the HX drawbridge. Adequate security measures shall be provided to prevent vandalism to the bridge operating controls and mechanisms to ensure prompt openings of NJTRO bridges.

(5) Except as provided in paragraphs (b) through (h) of this section, the draws shall open on signal.

(b) Except as provided in paragraph (a)(1) of this section, the draw of the NJTRO Lower Hack Bridge, mile 3.4 at Jersey City shall open on signal if at least one hour advance notice is given to the drawtender at the Upper Hack bridge, mile 6.9 at Secaucus, New Jersey. In the event the HX drawtender is at the Newark/Harrison (Morristown Line) Bridge, mile 5.8 on the Passaic River, up to an additional half hour delay is permitted.

(c) Except as provided in paragraph (a)(1) of this section, the draw of AMTRAK's Portal bridge, mile 5.0 at Little Snake Hill, need not be opened Monday through Friday, except federal holidays, from 7:20 a.m. to 9:20 a.m. and from 4:30 p.m. to 6:50 p.m. At all other times, an opening may not be delayed for more than 10 minutes, unless the drawtender and the vessel operator communicating by radiotelephone, agree to a longer delay.

(d) Except as provided in paragraph (a)(1) of this section, the draw of the NJTRO Upper Hack Bridge, mile 6.9 at Secaucus, N.J. shall open on signal unless the drawtender is at the HX bridge, mile 7.7 at Secaucus, N.J. over the Hackensack River; then up to a half hour delay is permitted.

(e) Except as provided in paragraph (a)(1) of this section, the draw of the NJTRO HX bridge, mile 7.7 at Secaucus, shall open on signal if at least one half hour notice is given to the drawtender at the Upper Hack Bridge.

(f) Except as provided in paragraph (a)(1) of this section, the draw of the S46 Bridge, at mile 14.0, in

Little Ferry, shall open on signal if at least a twenty four hour advance notice is given by calling the number posted at the bridge.

(g) The draw of the Harold J. Dillard Memorial (Court Street) Bridge, mile 16.2, at Hackensack, shall open on signal if at least four hours notice is given.

(h) The draw of the New York Susquehanna and Western Railroad bridge, mile 16.3, and the Midtown bridge, mile 16.5, both at Hackensack, need not be opened for the passage of vessels, however, the draws shall be restored to operable condition within 12 months after notification by the District Commander to do so.

[CCGD01-91-029, 58 FR 39148, July 22, 1993, as amended by CGD01-98-091, 64 FR 38830, July 20, 1999; CGD01-99-076, 64 FR 62114, Nov. 16, 1999]

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Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
Tel: (206) 624-9537, Fax: (206) 621-9832

Project Name: Lower Hackensack River	
TDD Number: 15-03-0008	
Date: September 3, 2015	**Time:** 9:00 am
Contacted By: Linda Ader	
Person Contacted: Heather Corbett	
Title: Principal Biologist	
Agency/Affiliation: New Jersey Division of Fish and Wildlife	
Telephone Number: 609-748-2020	
Subject: Threatened or Endangered Sturgeon on the Lower Hackensack River	
Content: With regard to endangered sturgeon, the Division of Fish and Wildlife has not conducted any surveys of the lower Hackensack River to determine whether or not the endangered short-nose or Atlantic sturgeon are present. These species may occur in this area, but their presence has not been confirmed.	

Berry's Creek Study Area

Remedial Investigation and Feasibility Study

May 2009

Community Involvement Plan

Berry's Creek Study Area

Remedial Investigation and Feasibility Study

May 2009

Community Involvement Plan

PREPARED BY:
Malcolm Pirnie, Inc.
104 Corporate Park Drive
White Plains, NY 10602

FOR:
US Environmental Protection Agency
US Army Corps of Engineers

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Part 1
Project Summary and Community Profile

1.1 Overview

Purpose of the Community Involvement Plan

"Superfund" is a government program designed to clean up hazardous waste sites and to protect the environment and public health. Public participation is a key element in the Superfund process. The public needs to be informed of site activities, study findings, and cleanup alternatives and decisions. The United States Environmental Protection Agency (EPA) places a high value on partnering with the public by addressing the questions and concerns of all interested stakeholders. The need to maintain this avenue of communication and to encourage public participation is the foundation of the community involvement program that parallels and compliments the technical work performed at Superfund sites.

The EPA developed this Community Involvement Plan (CIP) to facilitate effective two-way communication between the EPA, the communities, and public within and around the Berry's Creek Study Area (BCSA). The plan serves as a guide for providing the public with opportunities to receive information on the BCSA investigations. Additionally, the plan will assist stakeholders from a broad spectrum to become involved in and informed about the project in a meaningful way. The CIP will be used to guide public outreach and involvement activities through the project's design phase; at which point, the plan will be updated for the cleanup phase of the project.

This CIP describes a variety of suggested community involvement tools and outreach activities designed to enhance public involvement at the site in compliance with EPA public outreach policy. However, not all of the tools and activities described in this plan will be implemented. The CIP should be used by the public to identify ideas and concepts for public involvement throughout the project and should be used as a reference point for outreach activities keyed to project milestones. EPA will regularly review the level of public involvement and the communication needs of the involved stakeholders, and it will select the tools and activities that are best suited to meet those needs while also considering project management and community issues.

This CIP is based on a series of community interviews conducted during summer and fall 2008. Interviewees came from a broad spectrum of the community, including stakeholder groups from the environmental, business, municipal, academic, and scientific arenas. Interviewees were asked about their level of awareness, knowledge, and concerns regarding the contamination of the BCSA; their perceived impacts to local development, business, and health; and their preferred methods for providing input and receiving information. (Refer to Appendix 3 for a complete list of interview questions.)

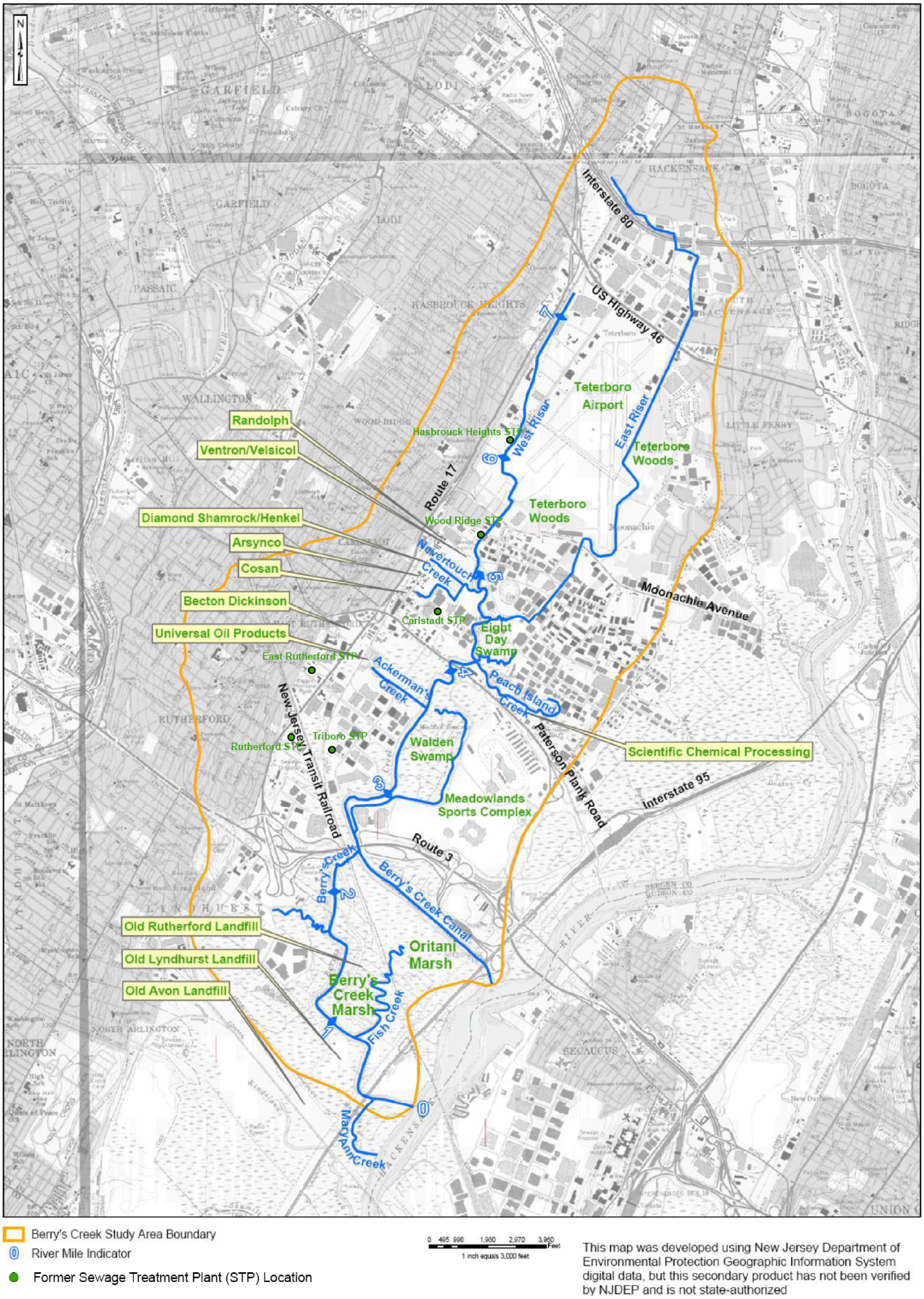
Legal Authorities

The Berry's Creek Study is being administered by the EPA with authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Recovery Act (SARA), commonly known as "Superfund." These regulations provide the EPA with the ability to investigate, rank, and conduct the cleanup of inactive hazardous waste sites on the National Priorities List (NPL). The NPL is a list of hazardous waste sites that meets the federal criteria for inclusion under Superfund. EPA also works closely with other federal and state agencies, such as the United States Army Corps of Engineers (USACE) and the New Jersey Department of Environmental Protection (NJDEP), to ensure that entities with shared jurisdictions are kept informed of EPA activities in the BCSA.

1.2 Background and Description of Study Area

Site Location

Located in Bergen County, New Jersey, Berry's Creek is a 6.5 mile long tributary of the Hackensack River that travels through the Boroughs of Carlstadt, East Rutherford, Lyndhurst, Moonachie, Rutherford, Teterboro, and Wood-Ridge. The majority of the creek is tidal, and tide gates located throughout Berry's Creek regulate the extent of tidal influence in the headwater tributaries. The creek has its origins in the West Riser Ditch near Teterboro Airport, meanders through the New Jersey Meadowlands, and then discharges into the Hackensack River, primarily via the Berry's Creek Canal and also the lower portion of Berry's Creek.



This map was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been verified by NJDEP and is not state-authorized

Figure 1. Berry's Creek Study Area Location Map Showing Some Representative Facilities Subject to Federal and State Cleanup Programs and Former Sewage Treatment Plants

Project Background

For many years, the area around Berry's Creek has been highly industrialized, and several municipal landfills are located in the lower portion of Berry's Creek. Over time, a considerable amount of industrial and municipal contamination has been discharged into Berry's Creek and has accumulated in the sediment beds and mudflats.

The BCSA has historically been associated with mercury contamination originating from the Ventron/Velsicol Superfund site. Mercury concentrations in Berry's Creek sediments are at levels greater than what is considered to be protective of wildlife and are among the highest levels known to exist in freshwater ecosystems in the United States. In addition to the historical mercury contamination, EPA will be investigating numerous other contaminants within the creek, which originated from other sources. For example, there are two other Superfund sites located in the BCSA, the Universal Oil Products site (located in the Borough of East Rutherford) and the Scientific Chemical Processing site (located in the Borough of Carlstadt). Several New Jersey State listed hazardous waste sites are also located in the BCSA, such as: Arsynco Incorporated; Becton, Dickinson & Company; Cosan Chemical Company; and Diamond Shamrock/Henkel. These listed hazardous waste sites are being addressed by the NJDEP while the Berry's Creek landfills are being addressed under the EnCap project (refer to page 11 of the CIP). In addition, other past and present sources of chemical and non-chemical stressors [*e.g.*, Publicly Owned Treatment Works (POTWs), urban runoff, combined sewer discharges, and sewage overflows] will be evaluated to ensure a comprehensive assessment of risks.

Contaminants are known to be elevated throughout the BCSA surface water and sediments at levels that warrant a detailed evaluation of the nature, extent, and potential risks to public health and the environment. Throughout the investigatory phase of this project, EPA will be examining the various contamination sources that may impact Berry's Creek to understand how these sources come together and interrelate within the Study Area. This process is highly complex and requires intense study and evaluation before a decision can be made on the best way to address the contamination; and therefore will take time before a remedy for the site is recommended.

Until such time when the contamination in Berry's Creek does not pose a threat to public health, it is important that the public heed the health advisories that are in place for their protection. New Jersey State has issued fish advisories on the waterways within the Newark Bay Complex, including Berry's Creek. Consequently, it is prohibited

Learn more about these nearby Superfund sites. Go to:

epa.gov/region2/superfund/npl/ventronvelsicol
or
epa.gov/region2/superfund/npl/universaloil
or
epa.gov/region2/superfund/npl/scientifichemical

To learn more about New Jersey's fish and shellfish advisories and to access NJDEP's "Fish Smart, Eat Smart New Jersey" website go to:

www.state.nj.us/dep/dsr/njmainfish/htm

to eat, sell, or harvest blue crab in these waters. Additional advisories are in place for striped bass, bluefish, American eel, American catfish, and white perch.

1.3 Project Activities to Date

Site Investigations and Activities

The Berry's Creek Study is a comprehensive and thorough assessment of multiple contaminants in the tidal waterways, including sampling of water, sediment, and biota in the creek as well as in the surrounding wetlands. Samples will be collected and analyzed, and the results will be used to evaluate potential risks to public health and wildlife. This portion of the investigation is known as a Remedial Investigation (RI). A study of potential cleanup alternatives, known as a Feasibility Study (FS), will be performed following completion of field investigations and risk assessments.

EPA is committed to investigating multiple contamination sources in the BCSA so that a comprehensive portrait of the Study Area is created and made available to the public.

In 2005, EPA developed a plan called the Framework Document, which describes the type of studies that EPA expected to be conducted for the Berry's Creek RI/FS. The Framework Document was provided to the parties that were being asked to conduct the RI/FS. To support the RI/FS, scoping activities were funded and performed by the Cooperating Potentially Responsible Parties (PRP) Group (under EPA supervision). These activities included geophysical surveys, research on historical development and land use changes in the BCSA, field reconnaissance and assessment of tidal gates, development of a preliminary hydrological model and conceptual site model, and testing of potential RI/FS field methods.

Settlement Agreement

In May 2008, EPA signed a settlement agreement (Administrative Order on Consent) with 98 parties to conduct an investigation of contamination in Berry's Creek and its surrounding waterways and wetlands. The investigation will be conducted under the Superfund program and consists of a RI/FS. One of the first tasks required by the settlement agreement is the submission of planning documents for the RI/FS. The RI/FS Work Plan and Quality Assurance Project Plan were submitted in March 2009 to EPA approval.

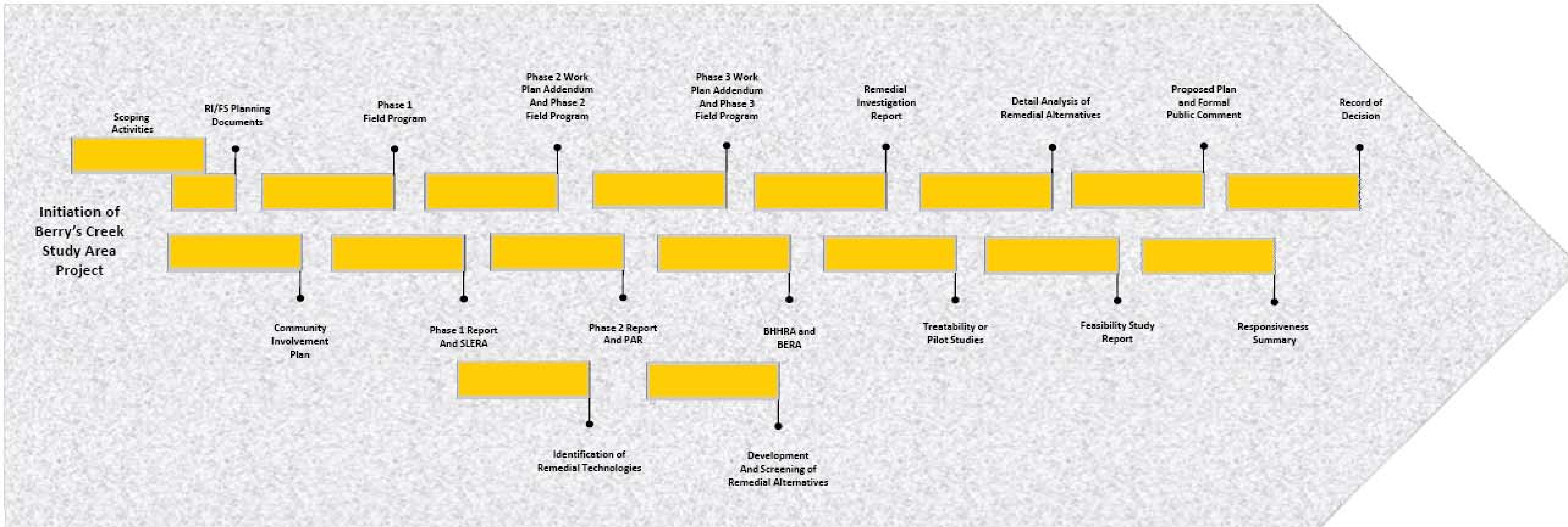
The 2008 Administrative Order on Consent and Statement of Work for the RI/FS can be accessed at:

www.epa.gov/region2/superfund/npl/ventronvelsicol/

EPA is closely overseeing the work of the Cooperating PRP Group, who has signed the settlement agreement on the BCSA. The parties have formed a Community Relations Outreach Program (CROP). The CROP will assist EPA in its community involvement efforts through input, coordination, and other forms of assistance as requested by EPA.

Activity	Requirements
Administrative Record	Establish an administrative record consisting of documents used by the agency to make its decision regarding the Site and make it available for public review.
Administrative Record Notification	Publish a public notice in a major local newspaper in the vicinity of the Site, announcing the availability of the administrative record to the public.
Community Interviews	Conduct interviews with a broad spectrum of the public affected by the Site, including local officials, public interest groups, and community members to solicit concerns and information needs; and to learn how people would like to be involved in the Superfund process.
Community Involvement Plan (CIP)	Before the beginning of field work for the RI, EPA must develop a CIP, based on community interviews and other relevant information. This document serves as a blueprint for community involvement activities during the Superfund process. This plan is generally updated during the cleanup phase.
Consent Decree	A legal, voluntary agreement between parties to a suit (*e.g.,* EPA and the Cooperating PRP Group) to provide for the implementation of the EPA's Record of Decision by the Cooperating PRP Group.
Information Repository	Establish at least one information repository containing site documents at or near the location of the Superfund site (such as a library), offering the public the opportunity to study, review, and copy the documents.
Meeting Transcript	EPA must have a court reporter present at the public meeting who will prepare a meeting transcript that will be made available to the public.
Notice and Availability of Explanation of Significant Differences	A document outlining a modification or modifications to a Record of Decision and the reasons for such modifications along with supporting information. A public notice briefly summarizing the Explanation of Significant Differences (ESD) must be published and the ESD made available in the administrative record and information repository.
Notice of Availability of the Record of Decision	A public notice published in a major local newspaper to notify the public that the Record of Decision has been published and is available for public review.
Proposed Plan	The Proposed Plan details EPA's findings in the RI/FS and provides the public with the proposed alternatives considered for remediation, as well as EPA's preferred alternative.
Technical Assistance Grant Notification (TAG)	EPA must inform the public of the availability of TAG and include information describing the TAG application process in the information repository. TAGs are used by stakeholder groups affected by a Superfund site for the purpose of hiring technical experts to assist in interpreting project documents.
Public Comment Period on RI/FS and Proposed Plan	EPA must provide the public with at least 30 days for the submission of written and oral comments on the Proposed Plan and supporting documents. The public comment period can be extended by a minimum of 30 days upon timely request.
Public Meeting	EPA must provide the public with an opportunity for a public meeting on the Proposed Plan. The meeting will be near the site during the public comment period at a location that is publicly accessible. Public comment will be taken at the public meeting and a court reporter will take down a record of the meeting.
Public Notice	EPA must publish a notice of the availability of the RI/FS and near the Superfund site. The notice must also include announcement of a public comment period so that the public is aware of when and to whom they should submit their comments.
Responsiveness Summary	A document that contains the public comments received and EPA's responses to those comments.
Record of Decision	EPA's official decision for the remediation of a Superfund site.
Record of Decision Amendment	When the basic features of the selected remedy are fundamentally altered, the Record of Decision must be formally amended. EPA must issue a notice of the proposed amendment in a major local newspaper; must follow the same procedures for notice and public comment as required on a Proposed Plan; and most publish a notice of the availability of the amended Record of Decision as well as make it available in the administrative record and information repository.

Figure 2. EPA's Minimum Public Involvement Requirements for Superfund



LEGEND
SLERA – Screening Level Ecological Risk Assessment
PAR – Pathways Analysis Report
BERA – Baseline Ecological Risk Assessment
BHHRA – Baseline Human Health Risk Assessment

Figure 3. Berry's Creek Study Area Sequence of Project Milestones and Documents

EPA Oversight and Decision Making

EPA will oversee the work being conducted by the parties that signed the settlement agreement to conduct the RI/FS. Oversight consists of many things, including field observation, split sample collection, and document review and approval. The NJDEP and other agencies, such as the National Oceanographic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS) will also review and comment on project documents.

Project Activities and Milestones

Data collections for the RI/FS are anticipated to start in spring 2009. An iterative process will be utilized so that future sampling programs will be determined based on the findings from the previous data collections. It is estimated that it will take approximately five years from commencement of field work to determine the nature and extent of contamination and develop potential cleanup options.

Following completion of sampling, data collection and analysis, and the evaluation of cleanup alternatives, EPA will develop a Proposed Plan for the BCSA. EPA will hold a public meeting to discuss the Proposed Plan and will take public comment on proposed cleanup plans. The selected cleanup plan for the site will be outlined in a Record of Decision. A Responsiveness Summary will be included in the Record of Decision which summarizes public comments on the proposed cleanup plan and other options evaluated and EPA's responses to those comments.

EPA will ensure that the public is kept informed of project activities, milestones, and results. This process will provide the public with ample opportunity to provide input and comment throughout the life of the project. Part 2 of this CIP describes how EPA will share information and solicit input.

Outreach Efforts

In April 2006, EPA released a fact sheet on the BCSA and also held a Drop-In Public Availability Session at the Rutherford Public Library. The session was advertised in a local newspaper, and a flyer was posted on the websites of local municipalities and organizations. Turnout for the session was light, but revealed concerns about development in the New Jersey Meadowlands; confusion over agency jurisdiction of hazardous waste sites in the area; publicity about mercury contamination in Berry's Creek; and local business versus residential development.

In accordance with Superfund regulations and to ensure that the public has access to site documents, an Information Repository was established at the Wood-Ridge Memorial Library in Wood-Ridge, New Jersey, and an additional Informational Repository will be established at the Meadowlands Environmental Research Institute (MERI) in Lyndhurst, New Jersey.

In August 2008, EPA released an updated fact sheet and conducted two days of community interviews with various stakeholders. The interviews were held at the parish house of Assumption Catholic Church in Wood-Ridge. In October 2008, a second series of interviews were conducted at the Rutherford Public Library with a group of individuals who were not available for the August session. The information gathered during these interviews has been used by EPA in the development of a program of public input and participation to last throughout the design phase and cleanup phase of the project.

BCSA Information Repositories:

Wood-Ridge Memorial Library
231 Hackensack Street
Wood-Ridge, NJ 07075
Phone: 201-438-2455

MERI
One DeKorte Park Plaza
Lyndhurst, NJ 07071
Phone: 201-460-1700

1.4 Community Profile

Physical Characteristics of the Berry's Creek Study Area

The Berry's Creek watershed encompasses about 12 square miles of wetlands inside the Hackensack River watershed with three tributaries draining Berry's Creek Marsh and Oritani Marsh. The New Jersey Turnpike (Interstate 95) and the New Jersey Transit Bergen County railroad line transect these marshes and Berry's Creek. Between 1902 and 1908, the Berry's Creek Canal was constructed near what is now the Route 3 Bridge. Berry's Creek passes through a culvert under the bridge. In addition, beyond the influences of the infrastructure in the BCSA, the physical characteristics of the BCSA are a reflection of past landfilling, sewage discharges, and upstream surface water diversions to outside the Hackensack River basin.

Walden Swamp is located on the eastern bank of Berry's Creek, adjacent to the Meadowlands Sports Complex. Ackerman's Creek is located opposite Walden Swamp near the former properties of Universal Oil Products and Becton, Dickinson & Company. Further upstream, Peach Island Creek merges with Berry's Creek near the former Scientific Chemical Processing property. This area also contains Eight Day Swamp (just north of the Paterson Plank Road), Never Touch Creek, and several ditches that drain the wetlands surrounding the former properties of Arsynco Incorporated, Cosan Chemical Company, Diamond Shamrock/Henkel, and Ventron/Velsicol. East Riser, a tributary located on the east side of Teterboro Airport, extends to Interstate 80 and flows into Berry's Creek.

Prior to installation of the Oradell Dam in 1923, the Hackensack River maintained a consistent freshwater flow that restricted salt water in Newark Bay from intruding more than a few miles upriver. The dam, as well as extensive ditching for mosquito control, changed this flow system and transformed the Meadowlands from a freshwater lowland tidal swamp into a brackish tidal estuary. This flow change resulted in replacement of freshwater species with brackish species (the entire community structure, *e.g.*, plants and animals) over large areas in the lower Hackensack River basin. Cattails, wild rice, and other freshwater wetlands plants were replaced by the common read *Phragmites australis* (phragmites) by the 1940s as a direct result of the Oradell Dam placement.

Past discharges of untreated sewage at up to five locations in the BCSA were major factors in the functioning of the BCSA through the late 1980s. Dissolved oxygen throughout the BCSA was frequently below detection levels. In addition, the current structure and functioning of the system is possibly still influenced by those harsh conditions. Even now, sewage effluents to the Hackensack River impact the BCSA with oxygen depression, nutrient addition, and pathogens.

Historical Development

Industrial and commercial properties are numerous within the BCSA, and the area has a history of industrial development reaching back to the late nineteenth century and early twentieth century.

For example, Becton, Dickinson & Company (which continues to operate in East Rutherford as a medical technology company) was established in 1907 as the first American company to manufacture hypodermic needles and syringes. During World War I and World War II, the company expanded its operations to manufacture disposable medical supplies. Another early industrial occupant of the area was Arsynco Incorporated, which first began operations in the early 1900s and continued until 1993. Arsynco manufactured pharmaceutical products and organic chemicals. Scientific Chemical Processing in Carlstadt was a chemical recycling and waste processing plant that opened during World War II and ceased operations in 1980.

Teterboro Airport is the oldest operating airport in New York and New Jersey and is located north of Moonachie Avenue and south of US Highway 46. A manufacturing plant operated on the property during World War I, and the United States military operated the airport during World War II. In 1949 the property was purchased by the Port Authority of New York and New Jersey, which assumed full responsibility for the airport in 2000.

The Meadowlands

A major component of the history of the area is the New Jersey Meadowlands (the Meadowlands) also known as the Hackensack Meadowlands. The Meadowlands is comprised of approximately 13 square miles of open undeveloped land in addition to the vast areas that have been developed but were once part of the wetlands. It is bordered on the north by Route 46, Routes 1 and 9 (Tonnelle Avenue) on the east, Port Authority of New York and New Jersey PATH train commuter lines and the Pulaski Skyway on the south, and Route 17 and the New Jersey Transit Pascack Valley rail line and the Kingsland rail line on the west. The Meadowlands is administered by the New Jersey Meadowlands Commission (NJMC), a state agency that oversees the management and development of the land within its jurisdiction.

The New Jersey Meadowlands Commission

The NJMC was created by the State of New Jersey in 1969 and was originally called the Hackensack Meadowlands Development Commission. In 2001 that name was changed to the New Jersey Meadowlands Commission. The NJMC is the planning agency for approximately 30 square miles of land along the Hackensack River that includes parts of fourteen municipalities in both Bergen and Hudson Counties in New Jersey. The municipalities involved are: Carlstadt, East Rutherford, Little Ferry, Lyndhurst, Moonachie, North Arlington, Ridgefield, Rutherford, South Hackensack, and Teterboro in Bergen County; and Jersey City, Kearny, North Bergen, and Secaucus in Hudson County. The NJMC is administered by a Board of Members appointed by the Governor of New Jersey with the advice and consent of the New Jersey State Senate. The Executive Director of the Board is appointed by the Board and is responsible for the day to day operations and implementation of Commission policies.

The NJMC campus is located at Richard W. DeKorte Park in Lyndhurst. DeKorte Park includes the Meadowlands Environmental Center (an educational facility operated by Ramapo College of New Jersey), approximately three and a half miles of trails, MERI, a newly opened center for Environmental and Scientific Education, and the William D. McDowell observatory.

Want to know more about the MERI? Go to:

meri.njmeadowlands.gov

The New Jersey Sports and Exposition Authority

The New Jersey Sports and Exposition Authority (NJSEA) is a state authorized entity that oversees the development and operation of numerous sports, convention, and entertainment venues. Some of these venues include Giants Stadium, the Meadowlands Sports Complex, and the Meadowlands racetrack, along with numerous redevelopment efforts in the Meadowlands, including the Xanadu Redevelopment Project (Xanadu). Xanadu is a proposed 4.96 million square-foot entertainment facility that includes outdoor and indoor amusement areas, a luxury hotel, and office and retail space; construction of this project is now nearly complete. The redevelopment plan also includes the Continental Airlines Arena, part of the Meadowlands Sports Complex. Although the Continental Airlines Arena is located outside the BCSA, the local transportation infrastructure that borders and is located inside the Study Area is slated for future improvements to accommodate the increased traffic expected when Xanadu opens. Improvements to public transportation are another key component to the redevelopment effort, and a railroad line and station at the Meadowlands Sports Complex are presently under construction. This proposed passenger station would be constructed in the BCSA between Giants Stadium and the Meadowlands Racetrack. The railroad line would travel across the Meadowlands Sports Complex along Paterson Plank Road, eventually connecting to the Pascack Valley Line near Route 17. The Paterson Plank Road Redevelopment Project that traverses the BCSA is also in the planning stages.

EnCap

The New Jersey Meadowlands/EnCap Mixed Use Redevelopment Project was initiated in 1999 by the NJMC to remediate abandoned municipal landfills in Rutherford and other boroughs in the Meadowlands. The project was intended to make use of New Jersey's redevelopment laws via a public/private partnership where the private entity funds the project for landfill remediation. The NJMC later withdrew its support for the project. Subsequently, on May 8, 2008, EnCap Golf Holdings, LLC filed for Chapter 11 bankruptcy protection (Brennan, 2008). The bankruptcy case was dismissed in February 2009 and more recently, the NJMC announced that American Home Assurance Company would make good on a performance bond obtained by EnCap in May 2004. The bond was intended to fund cleanup efforts at the site in the event of an EnCap default. Consequently, the NJMC is looking forward to restarting the cleanup.

Land Use and Industry

General Overview

The BCSA area is highly industrialized with a low population density. The dominant industry in the BCSA is manufacturing, with a total of over 14,000 businesses listed in the North American Industry Classification System (NJMC 2002). Major employers in the area include Howmedica Osteonics Corporation, the NJSEA, National Financial Services, and Lantis Eyewear Corporation. Zoning in the area is a mix of light industrial, residential, and recreational, along with a number of redevelopment zones and marshland preservation.

Prior to the 1970s, at least three municipal landfills were located on Berry's Creek Marsh: the Rutherford Landfill, the Lyndhurst Landfill, and the Avon Landfills. These landfills, as well as other landfills on the Meadowlands, have significantly affected the Meadowlands through the unregulated placement of solid wastes. Materials accepted by the landfills included domestic, industrial, and commercial debris, solid wastes, and other non-soil material. Currently, these landfills and other nearby landfills are to be redeveloped through the EnCap project.

Open Space: The Empire Tract Preservation

Located on the eastern boundary but outside of the BCSA is the Empire Tract, which consists of 587-acres of open space, bounded by Paterson Plank Road, Moonachie Avenue, and the Hackensack River. This open space is composed of mostly wetlands and upland areas that remain after the Borough of Carlstadt sold over 1,000 acres in 1949. As part of the Xanadu wetland mitigation plan, the Empire Tract will be preserved as open space, and the developers of Xanadu will donate an annual stipend of $100,000 over the next 75 years to manage and monitor the tract. The Meadowlands Conservation Trust accepted the title of the Empire Tract in 2005 as open-space preservation.

> Learn more about the Empire Tract and other open space issues go to:
>
> www.hackensackriverkeeper.org

Public Infrastructure

Transportation

Cities and towns throughout the BCSA are linked through a variety of major highways and roads, including the New Jersey Turnpike, Route 17, and Route 3. Public transportation in the form of the New Jersey Transit rail lines and bus service is regularly available, connecting the communities in this area with New York City and other parts of New Jersey.

Drinking Water, Sewers, and Power

Drinking water is supplied by United Water New Jersey and is derived from four reservoirs: Oradell, Woodcliff Lake, and Lake Tappan in Bergen County, New Jersey; and Lake DeForest in Rockland County, New York. On occasion, United Water New Jersey receives water from other suppliers including United Water Jersey City, United Water New York, the Park Ridge Water Department, Central Water New York, the Passaic Valley Water Commission, and the Ridgewood Water Department.

The sewer system is operated by the Bergen County Utilities Authority (BCUA), a public utility that provides both sewage disposal and solid waste services for the municipalities of Bergen County, New Jersey. Historically, Berry's Creek has received discharges from six sewage treatment plants (STPs), including the Rutherford STP, East Rutherford STP, Carlstadt STP, Wood-Ridge STP, Hasbrouck STP, and the Triboro STP. Currently, sewage is diverted to the STP in Little Ferry, New Jersey, which is operated by BCUA. Electricity is supplied by PSE&G.

Recreation

The Meadowlands Sports Complex is an important venue for sports, entertainment, and recreation for the States of New York and New Jersey. Numerous parks and cultural institutions are located in the area, including Riverside County Park in Lyndhurst and the William Carlos Williams Center for the Performing Arts in Rutherford.

Population and Demographics in the Berry's Creek Study Area

The BCSA is highly industrialized with low population density. The Meadowlands Sports Complex and other recreational areas dominate the middle section of the Study Area (south of Paterson Plank Road), while marshland preservations and redevelopment zones are typical near the Berry's Creek Canal. The municipalities that fall within the Study Area are: Carlstadt, East Rutherford, Lyndhurst, Moonachie, Rutherford, Teterboro, and Wood-Ridge.

Carlstadt

Carlstadt was originally formed as a village in Bergen County, New Jersey in 1860 and was declared a Borough in 1894. According to the 2000 United States Census, Carlstadt has a total of 4.2 square miles with a population of 5,917. The racial makeup of Carlstadt is 89% white; 2% African-American; 6% Asian; 2% other races; and 1% of mixed races (Hispanic or Latino of any race comprises 8% of the mixed race category).

Students in pre-kindergarten through eighth grade attend Carlstadt Public School, and grades 9 through 12 attend Henry P. Becton Regional High School in East Rutherford. Main transportation routes include Route 120, County Route 503, and the western spur of the New Jersey Turnpike (Interstate 95). Carlstadt is also served by a number of buses to the Port Authority Terminal in New York City.

East Rutherford

The Borough of East Rutherford was created in 1894. It is the home of the Meadowlands Sports Complex and numerous professional sports teams including the New York Jets and New York Giants football teams. The 2000 United States Census reported that East Rutherford consists of 4.2 square miles, with a population of 8,716. The racial makeup of East Rutherford is 80% white; 4% African-American; 11% Asian; 3% from other races; and 2% of mixed races (Hispanic or Latino of any race comprises 11% of the mixed race category).

Schools in the area that serve the community include Alfred S. Faust School and McKenzie School (pre-kindergarten through eighth grade), and Henry P. Becton Regional High School for grades 9 through 12. The borough is served by New Jersey Transit's Rutherford train station (on the Rutherford/East Rutherford border). The Pascack Valley rail line travels through East Rutherford but does not stop there. In addition, there are a number of buses from East Rutherford to the Port Authority Terminal in New York City. Major roads are Route 17, Route 120, Route 3, and the western spur of the New Jersey Turnpike (Interstate 95).

Lyndhurst

The Township of Lyndhurst was originally formed in 1852 and was incorporated in 1917. It encompasses 4.9 square miles and has a population of 19,383. According to the 2000 United States Census, the racial makeup of Lyndhurst is 90% white; 1% African-American; 5% Asian; 2% from other races; and 2% of mixed races (Hispanic or Latino of any race comprises 9% of the mixed race category).

Lyndhurst is served by six elementary schools (pre-kindergarten through eighth grade) and Lyndhurst High School for grades 9 through 12. There are two rail stations (Lyndhurst and Kingsland, both served by New Jersey Transit's Main Line) and numerous New Jersey Transit and DeCamp buses with connections to New York City. The major roadways that traverse Lyndhurst are Route 17, Route 507, and the northern spur of the New Jersey Turnpike (Interstate 95). In addition, Route 3 is near the northern border of Lyndhurst.

Moonachie

Moonachie was incorporated as a Borough in 1910 from portions of Lodi Township. In 1917, portions of Moonachie were taken to form Teterboro. (Portions of Teterboro Airport are located in Moonachie.) The Borough has a total of 1.7 square miles. According to the 2000 United States Census, the population of Moonachie is 2,754. Its racial makeup is: 86% white; 1% African-American; 6% Asian; 3% from other races; and 4% of mixed races (Hispanic or Latino of any race comprises 13% of the mixed race category).

Students attend the Robert L. Craig School (pre-kindergarten through eighth grade) and Wood-Ridge High School in Wood-Ridge, New Jersey. Several New Jersey Transit bus routes connect Moonachie to New York City. Major roadways include County Route 503.

Rutherford

The borough of Rutherford was formed in 1881 and has a total of 2.9 square miles. According to the 2000 United States Census, the population of Rutherford is 18,110. The racial makeup of the population is 82% white; 3% African-American; 11% Asian; 2% from other races; and 2% of mixed races (Hispanic or Latino of any race comprises 9% of the mixed race category).

Rutherford is served by four elementary schools and Rutherford High School, along with St. Mary's Roman Catholic Grammar School and High School. In addition, Felician College, an independent Roman Catholic institution, has made Rutherford its home since 1997. Rutherford has numerous recreational facilities including the Meadowlands Museum, Rutherford Memorial Park, several other smaller parks in the borough, and the Nereid Boat Club. New Jersey Transit offers several bus routes from Rutherford to New York City and also serves the borough with the Rutherford rail station as part of the Bergen Line. Route 17 and Route 3 are major roadways that go through Rutherford.

Teterboro

Teterboro was incorporated in 1917 from land taken from the boroughs of Moonachie and Little Ferry and from the Lodi Township. It is best known as the home of Teterboro Airport, operated by the Port Authority of New York and New Jersey. The airport takes up most of the borough. (Portions of Teterboro Airport are located in Moonachie.) Teterboro has a total area of 1.1 square miles. As of the 2000 United States Census, there were 18 people, 7 households, and 4 families residing in Teterboro, making it the smallest municipality by population in the State of New Jersey. The racial makeup of the borough was 83% white and 17% from two or more races. The 2000 United States Census failed to count any of the residents in the Vincent Avenue housing units, who had moved into the newly built homes in 1999.

Public school students in kindergarten through eighth grade attend Memorial School in South Hackensack. High school students have an option to attend Hackensack High School or Hasbrouck Heights High School. Additionally, Teterboro is home to the Teterboro campus of the Bergen County Technical Schools. Teterboro is served by New Jersey Transit on the Pascack Valley Line at the Williams Avenue train station, located near Route 17. Route 46 runs through Teterboro, and Route 17 runs parallel to the Hasbrouck Heights-Teterboro town line on the Hasbrouck Heights side.

Wood-Ridge

Wood-Ridge was incorporated as a Borough in 1894 and was ranked as one of the best places to live in New Jersey in 2008 by New Jersey Monthly Magazine. It has a total area of 1.1 square miles and a population of 7,664 people according to the 2000 United States Census. The racial makeup of Wood-Ridge is 91% white; 1% African-American; 5% Asian; 2% from other races; and 1% from mixed race (Hispanic or Latino of any race comprises 7% of the mixed race category).

There are two elementary schools in Wood-Ridge, and grades 9 through 12 are served by Wood-Ridge High School. New Jersey Transit's Pascack Valley rail line stops at the Wood-Ridge station. There are a number of buses that provide service between Wood-Ridge and New York City. Route 17 passes through Wood-Ridge.

Ethnic and Immigrant Populations

The communities in the BCSA are largely made up of American-born populations, who trace their ancestry to Western, Central, and Eastern Europe with large Italian-American and Polish-American populations. However, in recent years, there has been a considerable influx of immigrants from Korea, China, India, South and Central America, and Mexico.

Environmental Justice

According to the EPA, environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies. In February 1994, President Bill Clinton signed *Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* to focus federal attention on the environmental and public health conditions of minority and low-income populations with the goal of achieving environmental protection for all communities. Since that time, the EPA Office of Environmental Justice, which has an environmental justice coordinator in each EPA regional office, has worked to ensure that environmental justice issues are identified and addressed wherever

The EPA Region 2 Environmental Justice Coordinator is Terry Wesley. He may be contacted at:

Phone: 212-637-5027
Email: Wesley.terry@epa.gov

EPA is involved in protecting public health and the environment, including the BCSA.

According to demographic information from the 2000 United States Census and recent information gathered during community interviews, the communities adjacent to the BCSA do not have significant minority population numbers, nor do they have a significant population living at or below the United States poverty line. These communities do not appear to have a population that either fishes or hunts for sustenance in the BCSA. Consequently, environmental justice issues do not seem to be an issue at Berry's Creek. However, EPA will continue to be active within the community and will investigate and explore any information provided by the public that has environmental justice implications.

For more information about Environmental Justice visit:

www.epa.gov/compliance/environmentaljustice/index.html

Part 2

Action Plan: Community Involvement Tools and Activities

2.1 History of Public Involvement

Historic public interest in Berry's Creek is connected with the Ventron/Velsicol Superfund site, located in the Borough of Wood-Ridge, Bergen County, New Jersey. Ventron/Velsicol was listed on the NPL in 1984. The 40-acre site once contained a mercury chemical processing plant, and approximately 160 tons of process waste may have been buried on the property. Although access to the site is restricted, it is located in an area with nearly 12,000 people living within a 1 mile radius of the site. Discharges from this site are known to have migrated into Berry's Creek, and the mercury contamination in the Berry's Creek sediments is perceived by the public to be linked to the Ventron/Velsicol site.

Flooding is caused primarily by extensive development in the floodplain, storm tides, rapid runoff from developed upland areas during high tide conditions, and sea level rise over the long term, not solely because the area is tidal.

The public is aware of and concerned about other Superfund sites in the area, most notably the Scientific Chemical Processing site in Carlstadt and the Universal Oil Products site in East Rutherford, as well as hazardous waste sites under the jurisdiction of the NJDEP. The proximity of these sites within the BCSA has contributed to public confusion as to the significance of the sites as contributors to the overall contamination of Berry's Creek and as to which agency has jurisdiction over each site.

The various boroughs in the BCSA have shown interest in the creek mostly due to the flooding problems experienced by some of the nearby communities (Teterboro, Wood-Ridge, *etc.*). There are also concerns about public use of a contaminated site and the resulting public health risks. Some portions of Berry's Creek are used for fishing, crabbing, and a limited amount of trapping (*e.g.*, muskrats). There is historical evidence of some hunting of ducks and other waterfowl.

Primary chemicals of interest in Berry's Creek include volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), metals (*e.g.* arsenic, cadmium, copper, chromium, lead, mercury, nickel and zinc), polychlorinated biphenyls (PCB), and pesticides [*e.g.* chlordane and dichlorodiphenyltrichloroethane (DDT) isomers].

Environmental organizations such as the Hackensack Riverkeeper and the Passaic River Coalition are also interested in Berry's Creek and are concerned about the lack of cleanup over the years. Berry's Creek is also the subject of considerable scientific and academic interest and research, most notably performed by the MERI and Rutgers University.

2.2 Key Community Concerns

Overview of the Community Involvement Process

The community involvement process for the BCSA has its roots in contact and conversation with key constituencies within the project area. Representatives from the various municipalities in the BCSA, including research and academia, business and development, planning, environmental organizations, and the Cooperating PRP Group, were actively sought out and interviewed in one-on-one meetings with EPA technical and public outreach representatives.

In addition to asking a series of questions about the BCSA, in-depth conversations were held to clarify project information to the public, gather information and input from the public, and engage in an exchange of ideas and concepts for forming a plan of public outreach that is tailored to the communities of the BCSA and their concerns.

Key Community Concerns by Subject

Over the course of these interviews, a number of community concerns surfaced, many of which were common to a number of interviewees. Those concerns are enumerated in the section below.

Flooding

- Nearly all interviewees listed flooding, especially along Route 17, as a serious issue. Moderate or heavy rainfall will cause Route 17 to flood so badly that it becomes impassable.
- Serious flooding was also identified at Teterboro Airport, especially in the area of East Riser and West Riser.
- Flooding is connected to the failure of the tide gates on Berry's Creek. The poor function of the tide gates is a major issue among the municipalities in the BCSA.
- Flooding from Berry's Creek seriously impacts small businesses and industries in the BCSA.

Confusion Over Agency Jurisdiction

- Many members of the public are confused as to which agency is in charge of the BCSA and other sites in the area.

- There is also confusion on EPA's authority regarding the properties within the Meadowlands and belonging to the NJSEA.

Public Health and Quality of Life

- No serious concerns about public health impacts from the BCSA were voiced. The BCSA is viewed as a contaminated area that is not easily accessible by the general public; and the issues of contamination are so well known that the area is avoided by most.
- There have been some concerns voiced to the Lyndhurst Department of Health about the impacts of other hazardous waste sites in the area.

Hazardous Waste Sites in the Area

- There is considerable confusion about the contamination from other hazardous waste sites in the area, and what their contribution may be to the contamination in the BCSA.
- Concerns were raised about developing properties that may have been contaminated in the past.
- Concerns exist about the role of old landfills in the Meadowlands in the overall contamination of the BCSA.
- There is a tendency for the public to refer to all hazardous waste sites as "Superfund sites," regardless of agency jurisdiction.

Fishing, Crabbing, Hunting, and Trapping

- While there are no large populations using the BCSA for fishing or crabbing, there are some individuals who do. Consequently, there is a concern regarding the effectiveness of health advisory postings.

Economic Development and Wetland Preservation

- The continued development of the Meadowlands and other projects by the NJSEA has been raised as concerns, especially regarding the loss of wetlands.
- The addition of paved surface to new developments in the Meadowlands is perceived as another source of flooding in the BCSA.
- The continued flooding of the area is seen as an impediment to multi-use development, especially in the Borough of Teterboro.

- Concerns were raised about the dominance of non-native plants in the BCSA (*e.g.*, *Spartina* versus phragmites).

Public Perception

- Why study this creek again? The BCSA has been studied over the years by governmental agencies and academics.
- These studies seem to take very long before the public gets answers as to what was found and what will be done.
- The BCSA is perceived as a "lost area" that is basically a dump – what is the value of cleaning it up?
- So many entities in the "mix," such as EPA, NJDEP, NJMC, and NJSEA, confuse the issue as to what can be done to improve the area and who will do it.
- The public perceives that the BCSA is contaminated from the Ventron/Velsicol site.
- How can you develop on land that is contaminated anyway? It would never really be "safe."

Public Participation and Communication

- The municipalities in the BCSA are autonomous and need to be worked with individually.
- Local elected officials should be briefed before any public meetings, so there are "no surprises."
- The public encourages working with municipalities, local organizations, and environmental groups to post BSCA announcements and information on their web sites.
- NJMC should be used as a tool for public outreach.
- MERI should be the site of an EPA information repository on BCSA.
- Outreach should center on a targeted audience of academics, researchers, municipalities, business interests, and environmental organizations.
- EPA should hold informational briefings on BCSA two to three times a year.
- EPA should network with environmental organizations in the area (such as Hackensack Riverkeeper and Passaic River Coalition) to conduct environmental tours of the area.
- EPA should work with local reporters to get information about BCSA out to the public.

- EPA should seek to explain the "how" of the BCSA project, before the "why," so that the public understands the process.
- In order to manage public expectations related to the project studies, outreach activities should be targeted to those stakeholders who take a more active involvement in keeping pace with the studies and who are less likely to feel frustrated with the time taken to come to project conclusions.

Communication Tools

- Fact sheets or project updates.
- Targeted meetings with MERI.
- Public availability sessions.
- Individual briefings for municipalities and NJSEA.
- BCSA website.
- Participation in events with municipalities and local groups (*e.g.*, Hackensack Riverkeeper).
- Communication and coordination with CROP, the Cooperating PRP Group outreach organization.

2.3 Communication Goals

EPA is committed to meaningful and comprehensive public involvement throughout the life of the Berry's Creek Study using the following major goals to guide the outreach process.

Goal 1: Be Appropriate

Because "one size does not fit all," EPA will seek to use the most appropriate communication methods and tools geared to each segment of the public.

Goal 2: Be Understandable

EPA will use clear, consistent language when communicating with the public. Technical information and decision-making processes will be explained clearly in everyday language.

Goal 3: Be Responsive

EPA will respond to the community's questions and concerns by soliciting and considering public feedback from the various audiences reached throughout the life of the project. Every effort will be made to respond in a timely manner.

Goal 4: Be Accurate

EPA will provide the public with accurate information, and stakeholders will be made aware of new information when it becomes available through the outreach process.

To attain these goals, EPA will reach out and seek to involve the public and stakeholders under the broadest definition of these terms – those community members, interest groups, and other organizations located within the project area that are potentially affected by the project, or those who closely identify with cleanup and restoration efforts associated with the BCSA. The "public" in the BCSA area includes:

- Community Members.
- Elected Officials.
- Environmental Organizations.
- Academia and Scientific Foundations.
- Business and Economic Development Organizations.
- Potentially Responsible Parties.
- Local, State, and Federal Agencies.
- Civic and Community Groups.
- Local Media.
- Sports/Recreational Clubs and Organizations.

2.4 Public Involvement and Input

Based on information provided by the public during the community interview process and experience at other similar sites, EPA has identified a variety of public involvement and outreach tools that may be useful at the BCSA project. They are divided into "**Involvement and Input**" and "**Outreach**."

Involvement and Input refers to the methods by which EPA encourages participation by the public in the project and how public information is received. Outreach refers to the ways in which EPA will share information and encourage project awareness. Refer to Figure 2 for the Community Involvement Toolbox.

Involvement and Input

Public Comment Period

Public comment periods are formal opportunities for community members to review and comment on various agency documents or

Public comment at the BCSA will be taken on the RI/FS, Proposed Plans, Settlement Agreements, and Consent Decrees.

actions. Comment periods are legally required for several types of documents (*e.g.*, Proposed Plans) and allow the public to provide meaningful input and participate in the decision-making process. Generally, EPA will announce public comment periods in a manner that effectively reaches the community, such as through a public notice published in a newspaper, electronic mail (email) notifications, or direct mail.

Public Input

The public can provide feedback to EPA through written communication and/or informal discussion with agency staff. EPA firmly believes that an open line of communication is a crucial tool in gaining a good understanding of public concerns and needs. In addition, an open line of communication assists the agency in better serving the community in an efficient and effective manner. Public input can be offered at any time during the life of a project and through a number of different avenues including public availability sessions, open houses, community workshops, and community interviews.

Technical Assistance Grant

A Technical Assistance Grant (TAG) is a federally-funded grant that provides money to community groups to pay for technical advisors to help them interpret and understand the technical reports related to site investigations, findings, analyses, and cleanup proposals at Superfund sites. Up to $50,000 is available under this program for any Superfund site on EPA's NPL, any site proposed for listing on the NPL, or any site where a response action has already begun. There can be only one TAG for each site. The TAG program has proven highly successful in improving public understanding about the Superfund process and NPL site activities within the affected community. A TAG could be used at the BCSA for a variety of project activities, such as helping the public understand site analyses or in the evaluation of cleanup proposals.

For more information about the EPA TAG, go to:

www.epa.gov/superfund/community/tag/

Technical Assistance Support Contract

Description

The Technical Assistance Support Contract (TASC) is intended to provide independent and credible technical assistance to communities affected by hazardous waste contamination. Assistance is provided through review and interpretation of technical documents and other materials. It provides assistance to communities through a national contract that EPA regional offices tap into on specific tasks identified by community members. EPA headquarters reviews the requests and, if feasible, procures technical services through a national pool of pre-placed subject matter experts.

Goal

The goal of the TASC is to empower communities with an independent understanding of the underlying technical issues related to the removal project so that they may participate substantively in the decision-making process. Engagement in the TASC program also assists in addressing the community's continuing concerns about the contamination at the site. Community concerns and questions with topics such as sediment removal and processing, and natural resource/habitat restoration may be amenable to technical assistance through this contract. TASC could be used at the BCSA for assistance in understanding the technical issues and results of the RI/FS and how they may relate to the ecological issues of the estuary.

Method

Communities are encouraged to work with others in their community to coordinate requests with EPA. Requests are evaluated against a number of criteria to determine if technical assistance can be provided. More information on the TASC program is available at http://www.epa.gov/superfund/community/tasc. Specific requests should be sent to David Kluesner, EPA Community Involvement Coordinator, at 212-637-3653 or kluesner.dave@epa.gov.

Toll-free Hotline: 1-800-346-5009

Description

EPA has established a toll-free hotline available to the public.

Goal

The goal of the hotline is to provide the public with a free, direct method of communication between the community and EPA, particularly for those community members who do not use the Internet or have access to it.

Method

The public can phone the toll-free number (which will be included in outreach publications, signs, posters, *etc.*) to find out about upcoming meetings, where to get information about the project, and to speak with someone from EPA or leave a voicemail message.

Outreach

Fact Sheets

Fact sheets or project updates are a useful way to present technical project information to the public in everyday language and in a user-friendly format. Fact sheets generally serve several purposes: to address community concerns; to clarify the role of EPA, other governmental agencies, and the Cooperating PRP Group; and to provide important information about site history, contaminants of concern, health effects, and site activities. Fact sheets will be produced throughout the life of the Berry's Creek Study so that the public remains informed and educated on project progress and the decision-making process. Fact sheets are provided to the public through mailings, website postings, and public meetings/sessions and to stakeholder organizations for dissemination. EPA will use fact sheets to provide information to the public in the BCSA and will encourage the public to share the fact sheets with their neighbors and interested parties, ensuring a flow of accurate information to the public.

Field Notifications

Field notifications include posted advisories, signs, and restrictions which clearly illustrate to the public any project work areas and/or restrictions. These notifications are used to alert the public to any field work that may be underway or planned. Health and safety plans will also be used to inform and maintain a safe environment for the public and project field workers. If necessary, field notifications will be translated into languages other than English.

> Field notifications may be used at the BSCA for tide gate replacement or repair, or to alert the public to the presence of field workers.

Information Repositories

Information repositories are located in public buildings such as libraries, universities, or government offices where the public may review, read, and copy official site documents. The Information Repository for the BCSA is located at the Wood-Ridge Public Library and at the EPA Records Center (refer to Appendix 4). An Information Repository will be established at the MERI. The Information Repository functions as a one-stop shopping place for project information with available copying facilities and evening hours. The BCSA Information Repository is located at the Wood-Ridge Memorial Library, 231 Hackensack Street, Wood-Ridge, New Jersey 07075. The additional BCSA Information Repository at the MERI is located at the MERI, One DeKorte Park Plaza, Lyndhurst, New Jersey 07071.

Mailing List Updates and Maintenance

EPA maintains a list of organizations, elected officials, and stakeholders who may have an interest in the project. Throughout the project, additional names, and addresses will be added to this list to keep contact information current and to expand community access to project information.

Maps and Visual Aids

Maps and visual aids (such as charts, tables, photos, *etc.*) help the public to understand the geography of the BCSA and the locations of site activities in relation to where they work, live, or go to school. The use of maps is especially useful to the public in the BCSA due to the variety of hazardous waste sites within its boundaries along with the various areas in the Meadowlands that are slated for redevelopment.

Media Notification/Media Events

EPA will provide project updates and information to local media outlets such as newspapers, television, and radio. These activities allow EPA to share project information with a large audience and to reinforce important messages.

> Media notifications may be used at the BCSA to inform the public of site activities. They may also be used to remind the public of the importance of heeding fish and shellfish advisories.

Public Notices

Public notices are widely distributed and published announcements of public comment periods, meetings, and major project milestones. Public notices are used to announce important project news through newspaper display ads, website announcements, and press releases. These notices reach a wide public audience in an efficient manner and through a familiar medium. EPA will also reach out to stakeholder and community groups to request their assistance in getting the word out. In the BCSA, public notices of availability sessions have been used across many media to alert the public and encourage their participation.

Public Service Announcements

Radio and television public service announcements (PSAs) can be used to announce project news and provide basic information about upcoming site activities or meetings. This form of communication is a highly efficient method for distributing project information to a broad audience, including non-English speakers.

Project Site Visits/Tours

One way in which the public can be informed of how the work is being conducted is with photographs and video clips taken during the sampling activities. If appropriate and necessary to enhance what can be learned through the photographs and video clips, EPA may lead project site visits/tours. Small groups of stakeholders can be given guided tours to view the project site and/or project activities (such as sampling) when such tours are appropriate, feasible, and safe. These visits provide the public with a good understanding of actual project work and conditions "up close and personal." During the visit, project staff can explain field activities and why they are important to the project. It should be understood that, at times, activity or location-specific circumstances exist when public visits must be limited due to health and safety requirements. Project tours can be highly useful in the BCSA to illustrate to the public the complexities of the Study Area and its ecosystem, and to foster public understanding of the challenges posed by these issues.

Project Web Sites

A project website has been developed by EPA as another form of communication and information sharing. EPA will post project updates, notices, and technical documents in as timely a manner as practicable. Notice of public meetings, forums, and announcements related to the project will be posted immediately. The website will be updated and enhanced regularly. Public use of the project website is especially important in the BCSA to enhance public understanding of the work that is being performed at other sites within the area, and to place that work in the context of the BCSA.

BCSA Project Websites

www.epa.gov/region2/superfund/npl/ventronvelsicol/

and

www.epa.gov/region2/superfund/npl/berryscreekstudy/
(currently under development)

School/Educational Outreach

EPA will provide project information to local schools and academic institutions. In addition, EPA will work with existing educational programs to identify additional opportunities for presenting project information to school-affiliated groups such as Parent/Teacher Associations, school environmental and ecology clubs, and outdoor organizations. For example, information about sampling events and/or results may be disseminated to these groups, or an EPA representative may be featured as a guest speaker at the school.

Involvement and Input Integrated with Outreach

Community Advisory Group

A Community Advisory Group (CAG) is made up of stakeholder representatives from the various facets of the community, such as local elected officials, local utilities, business organizations, environmental groups, civic associations, educational facilities, *etc*. The CAG meets regularly with EPA project personnel to discuss community concerns, project activities, decisions, and impacts. Several factors affect whether a CAG is appropriate for a particular project. These factors include the level of public interest, the presence of many competing interests, how long the CAG would need to be in existence, and whether a broad-based group already exists that could function as a CAG. The formation of a CAG for the BCSA might be used to gather targeted stakeholders with interests across the lines of science, research, and development for in-depth discussion about technical issues and project findings.

Community Events

EPA will attend community events such as fairs, festivals, outdoor activities, and cultural festivals to distribute information about the project and answer questions at an information booth or table. This activity helps to build and maintain good relationships with area residents and reach an ever-wider audience than might generally be contacted through public meetings or other types of forums. For example, EPA might coordinate with local municipal, environmental, or civic groups to provide information at special events, such as Earth Day.

Coordination with Local Government and Other Agencies

EPA will ensure that local government and state agencies are informed of project activities. In addition, EPA will obtain feedback from these agencies regarding their concerns about issues such as green spaces, land use, restoration, and redevelopment. Communication and coordination through meetings and regular dialogue will continue throughout the life of the project.

> EPA will provide BCSA information on tide gate issues, local flooding, and zoning authorities with the appropriate state and local agencies.

Electronic Mail

Email can be used by the public to contact agency representatives for information or to ask questions and receive answers about the project. Email contact information for agency technical and public affairs staff will be included in all outreach materials. The public interested in the BCSA can use email to contact agency staff to ask their questions or alert EPA to local issues that might impact the BCSA (*i.e.*, flooding).

Public Availability Sessions (or Information Sessions)

Public availability sessions (or information sessions) are informal sessions open to the general public that make agency technical and outreach staff available to the members of the public outside of the setting generally found at formal public meetings. These sessions may feature posters, displays, presentations, videos, question and answer sessions, and informal interaction between agency staff and the public. There are no court reporters or meeting transcripts, although meeting summaries may be generated and made available to the public. These sessions create an atmosphere conducive to education and inquiry and promote dialogue in a comfortable, casual setting. These sessions will be conducted as needed and will be held at convenient times and at familiar, easy-to-reach locations in the project communities. EPA will make every effort to give the public at least a

> EPA will use public availability sessions to provide the public with information on project milestones, to give presentations on project findings, to exchange ideas, and to take formal public comment and public input.

2-week notice before the session is held. Notice of the meetings may be made via direct mailing, email notifications, or advertising in local print, radio, television, or Internet media. Public availability sessions will be used at the BCSA to inform the public of project milestones and to initiate dialogue between the stakeholders and EPA.

Public Meetings

Public meetings are structured, formal meetings often required by law that are open to the general public. They often feature a presentation and question and answer session between agency representatives and the audience. At times, these meetings may feature a court reporter to create a verbatim record of the proceedings from which a meeting transcript is produced. These meetings are often held at significant project milestones, such as when a Proposed Plan for cleanup is issued. At these milestones, EPA invites formal public comment and provides formal responses. Whenever possible, public notice will be given at least two weeks before scheduled public meetings.

Stakeholder Group Interaction

EPA will make every effort to coordinate with, and if requested, attend meetings of stakeholder groups to provide project information, address concerns, and receive input. Working with stakeholder groups helps to build bridges between EPA and the community, extending outreach capabilities across a broad public spectrum.

EPA will work with stakeholders to ensure awareness of issues such as flooding, tide gate repairs, and field activities in the BCSA.

Workshops/Seminars/Symposia

Workshops/seminars/symposia are classroom, lecture-hall, or round-table venues that are used to bring technical information to a wide audience from academia to the general public. Often focusing on project-specific topics such as public health and ecological risk or cleanup technologies, they provide scientific information in an educational atmosphere. EPA will participate, as appropriate, in symposia hosted by local academic institutions. In addition, EPA may conduct workshops on specific topics if sufficient public interest in that subject exists.

EPA will participate in the Meadowlands Symposium, sponsored by MERI. This forum takes place every other year (next event scheduled in 2009) and includes presentation and discussion of scientific work and research relevant to the ecology of the Meadowlands.

Tools	Community Concerns / Need Addressed
Community Advisory Group (CAG)	Addresses concerns about "keeping the project moving"; provides a forum for coordination with interest groups and municipalities on such issues as land restoration and redevelopment.
Community Events	Promotes interaction with individual community members and the environmental justice community.
Coordination with Local Government	Addresses concerns about coordination on all levels, clarity of health advisories, redevelopment, and green space issues.
Fact Sheets	Addresses public need for understandable information on project issues, ecological issues, and health advisories. May be available in other languages.
Field Notifications	Addresses need for information about project work areas; issues concerning public safety and health.
Information Repositories	Provides project documents for public study and use in a local facility that is easily accessed and user-friendly.
Maps and Visual Aids	Enhances public understanding and familiarity with project areas and the relationship of project areas to local communities.
Media Notification / Events	Increases / raises public awareness of project activities, health issues, fish advisories, and opportunities for involvement.
Newsletters	Raises overall public awareness and information level.
Project "Roadmap"	Addresses public concerns about communicating the project "at a glance" and in terms of installments.
Mailing List Updates and Maintenance	Provides timely notification and information regarding project activities, meetings, and events.
Project Websites	Addresses community concerns about access to project information, documents, and announcements; provides public with another communication tool.
Public Availability Sessions / Forums	Held in the local community; fosters an atmosphere of casual interaction and outreach.
Public Comment Period	Provides public involvement in the decision making process.
Public Meetings	Provides a more formal venue for public interaction and input on major project milestones and to take official public comment.
Public Notices	Ensures that the public receives timely information and announcement of project activities, actions, and comment periods.
Public Service Announcements (PSAs)	Provides important information / announcements and messages about health advisories and project actions via radio and television; addresses public concerns about reaching out and informing a broad spectrum of the community.
Public TV / Public Access TV	Brings important project information to a wide audience in their homes; raises public awareness about health advisories and environmental justice issues.
School / Educational Outreach	Engages the student / teacher / parent population; addresses public concern about project status, environmental stewardship / awareness of environmental justice / public and ecological health issues.
Project Site Visits / Tours	Offers an opportunity to provide project information and dispel public myths about Berry's Creek.
Speakers' Bureau	Addresses concerns about reaching business, civic, and municipal constituencies.
Stakeholder Group Interaction	Enhances communication between the various constituencies that make up the involved public.
Surveys and Focus Groups	Addresses public concerns with a "snapshot in time."
Technical Assistance Grant (TAG)	Fosters public understanding of technical issues.
Technical Assistance Support Contract (TASC)	Fosters public understanding of technical issues.
Toll-free Hotline (English/Spanish)	Provides the public with direct agency contacts, which is important for people who do not use the Internet.
Workshops, Seminars, Symposia	Addresses public concern regarding need to be kept informed of scientific and technical information and research related to the project.
Public Input	Provides public involvement in the decision making process.
Email	Enhances communication between the various constituencies that make up the involved public.

Figure 4. Community Involvement Toolbox

Appendix 1. List of Acronyms

BCSA	Berry's Creek Study Area
BCUA	Bergen County Utilities Authority
CAG	Community Advisory Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	Community Involvement Plan
CROP	Community Relations Outreach Program
DDT	Dichlorodiphenyltrichloroethane
email	Electronic Mail
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
FS	Feasibility Study
HSRC	Hazardous Substance Research Center
MERI	Meadowlands Environmental Research Institute
NJDEP	New Jersey Department of Environmental Protection
NJMC	New Jersey Meadowlands Commission
NJSEA	New Jersey Sports and Exposition Authority
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
PCB	Polychlorinated Biphenyl
POTW	Publicly Owned Treatment Work
PRP	Potentially Responsible Party
PSA	Public Service Announcement
RI	Remedial Investigation
SARA	Superfund Amendments and Recovery Act
STP	Sewage Treatment Plant
SVOC	Semi-volatile Organic Compound
TAG	Technical Assistance Grant

TASC	Technical Assistance Support Contract
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compound

Appendix 2. Glossary

Administrative Record: The body of documents that "forms the basis" for the selection of a particular response at a site. For example, the Administrative Record for remedy selection includes all documents that were "considered or relied upon" to select the remedy through the record of decision.

Cleanup: Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and/or the environment. The term "cleanup" is sometimes used interchangeably with the terms "remedial action," "remediation," "removal action," "response action," or "corrective action."

Community: An interacting populations of various types of individuals (or species) in a common location; a neighborhood or specific area where people live.

Community Advisory Group (CAG): A committee, task force, or board made up of residents affected by a Superfund or other hazardous waste site. A CAG provides a way for representatives of diverse community interests to present and discuss their needs and concerns related to the site and the site cleanup process. CAGs are a community initiative and responsibility and function independently of EPA.

Community Involvement and Outreach: The term used to identify its process for engaging in dialogue and collaboration with communities. Community involvement is founded on the belief that people have a right to know what the government is doing in their community and to have a say in it. Its purpose is to give people the opportunity to become involved in the government's activities and to help shape the decisions that are made.

Community Involvement Plan (CIP): A management and planning tool outlining the specific community activities to be undertaken during the course of a project. It is designed to provide for two-way communication between the affected community and federal and state agencies; and to ensure public input into the decision-making process.

Comprehensive Environmental Response, Cleanup, and Liability Act (CERCLA): Commonly known as "Superfund," CERCLA is intended to protect public health and the environment by investigating and cleaning up abandoned or uncontrolled hazardous waste sites. Under the program, EPA can either pay for site cleanup when the parties responsible for the contamination cannot be found or are unwilling or unable to do the work; or take legal action to force responsible parties to clean up the site or repay the federal government for the cost of cleanup.

Ecosystem: The complex of a community and its environmental functioning as an ecological unit in nature.

Environmental Justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, culture, education, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. It implies that no population of people should be forced to shoulder a disproportionate share of negative environmental impacts of pollution or environmental hazard due to a lack of political or economic strength.

Feasibility Study (FS): Evaluation of alternatives for cleanup and restoration, including overall protection of public health and the environment, implementability, and cost effectiveness, among others.

Floodplain: Low-lying lands located generally near rivers that flood when the river overflows its banks.

Habitat: A place where a plant or animal species naturally exists.

Information Repository: A file containing current information, technical reports, and reference documents regarding a site. The information repository is usually located in a public building convenient for local residents such as a public library, town hall, or local school.

Mitigation: Measures taken to reduce adverse impacts on the environment.

National Priorities List (NPL): EPA's list of serious uncontrolled or abandoned hazardous waste sites identified for possible long-term cleanup under Superfund. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year.

National Environmental Policy Act (NEPA): Requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.

Pollutant: Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Potentially Responsible Party (PRP): An individual, company, or other entity (*i.e.*, owners, operators, transporters, or generators of hazardous waste) potentially responsible for, or contributing to, the contamination problems at a Superfund site. When possible, EPA requires a PRP, through administrative and legal actions, to clean up hazardous waste sites.

Proposed Plan: A plan for a site cleanup that is available to the public for comment.

Public: The community or people in general or a part or section of the community grouped because of a common interest or activity.

Public Availability Session: Informal public sessions that often use poster displays and fact sheets and that include state and federal agency personnel and contractors who are available to discuss issues and answer questions. Public availability sessions offer the public the opportunity to learn about project-related issues and to interact with state and federal agency personnel on a one-to-one basis. Public availability sessions do not require the use of court reporters and transcripts, although meeting summaries may be issues through newsletters and progress reports.

Public Comment Period: A formal opportunity for community members to review and contribute written comments on various documents or actions.

Public Forum: Semi-formal, public sessions that are characterized by a presentation, question and answer session, and a less formal poster-display session. This format allows members of the public to participate via large or small group settings. Court reporters and meeting transcripts are required, although meeting summaries may be made available to the public.

Public Meeting: Formal public sessions that are characterized by a public presentation followed by a question and answer session and may involve the use of a court reporter and a meeting transcript. Public meetings are required for the Proposed Plan, Record of

Decision amendments, and National Environmental Policy Act Scoping.

Record of Decision (ROD): A document that formalizes the selected cleanup for a site.

Remedial Action: The actual construction or implementation phase that follows the remedial design; also referred to as site cleanup.

Remedial Design: The phase that follows the RI/FS and the Record of Decision and includes development of engineering drawings and specifications for site cleanup.

Remedial Investigation (RI): An in-depth study designed to gather data needed to determine the nature and extent of contamination at a Superfund site, identify public health and ecological risks, and establish preliminary cleanup criteria. The remedial investigation is generally concurrent with the FS; together they are referred to as the "RI/FS."

Remediation: Cleanup or other methods to remove or contain a toxic spill or hazardous materials from a Superfund site.

Restoration: Actions taken to return an injured resource (wetlands, rivers, shorelines, *etc*.) to its baseline condition, or the condition the resource would naturally be in if the pollution that injured it had not happened. Restoration consists of two kinds of activities: primary and compensatory. Primary restoration includes actions to speed up the recovery of the resource. Compensatory restoration compensates for the interim loss of the resources from the time the injury occurs until restoration is complete.

Risk Assessment: Provides a mechanism for evaluating the current and future public health and ecological risks from exposure to contaminants at a specific site. The assessments evaluate contaminants of concern, toxicity, and routes of exposure, along with risk characterization.

Stakeholder: People, interest groups, and other organizations or institutions that live in the project area or closely identify with issues associated with the project (such as wetlands preservation).

Superfund: Operated under the legislative authority of CERCLA, this program funds, oversees, and carries out EPA solid waste emergency and long-term cleanup activities. These activities include establishing the NPL, investigating sites for inclusion on the list, determining their priority for evaluation, and conducting and/or supervising a RI/FS, cleanup, and other remedial actions.

Technical Assistance Grant (TAG): A TAG provides funding for activities that help communities participate in the decision-making process at eligible Superfund sites, such as hiring a technical advisor to help interpret technical documents. The funding consists of an initial grant of $50,000. An additional $50,000 may be provided by EPA at complex sites.

Technical Assistance Support Contract (TASC): TASC is a national EPA contract vehicle that is potentially available to the public to better understand the hazardous contamination issues in or near their communities by providing free, independent, non-advocate, and technical assistance about contaminated sites. TASC services are provided through EPA's regional offices which tap into experts who provide site-specific support on tasks identified by the community.

Wetlands: Areas such as swamps, bogs, fens, marshes, and estuaries that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soils conditions.

Appendix 3. Community Interview Questions

GENERAL QUESTIONS – Background Information and History

1. Are you aware of the Berry's Creek area, and if so, what do you know or what have you heard?

2. How would you describe the community surrounding Berry's Creek (population, businesses, and residents)?

3. Do you have any knowledge of specific sites of concern located in the BSCA?

4. Is there a history of community concern or involvement in cleanup of Berry's Creek?

NON-TECHNICAL QUESTIONS - Stakeholder Involvement

5. What are your issues and concerns on Berry's Creek (*e.g.*, health risks, quality of life, economic impact, fish and wildlife, creek navigation, and cultural resources)?

6. What do you hope that the study will achieve?

7. What is your reaction to the contamination in Berry's Creek?

8. Is there a community concern on long-term health effects and exposure to the contamination on Berry's Creek?

9. Are you aware of any previous cleanup efforts on Berry's Creek? If yes, what do you think of those efforts?

10. What do you think of government involvement in Berry's Creek? Is the distinction between various federal and state agencies apparent to you?

11. Do you understand the role of EPA in the Berry's Creek study?

12. Do you feel well informed on the contamination on Berry's Creek?

13. Do you feel well informed about field sampling and schedule?

14. Do you have a concern on the future property value and ecological value of Berry's Creek?

15. What areas of Berry's Creek would benefit most from redevelopment, recreational use, green space preservation, or restoration of wetlands?

NON-TECHNICAL – Other questions

16. To the Cooperating PRP Group or community officials: Is a CIP available to assess the impact of the Berry's Creek (or the specific site) on the community?

17. Are there any environmental documents available, which may be helpful to the EPA to assess the impact of Berry's Creek (or the specific site) on the community?

18. Do you have any reports characterizing Berry's Creek, or data summarizing contaminant levels or biota surveys?

19. Were you involved in sampling on Berry's Creek? From that sampling experience, do you have any observation or data that you can share to assist in characterizing the site?

20. Are there any future economic development plans for the Berry's Creek area?

21. Are there any future plans for controlling the leachate that is potentially emanating from the old landfills in the lower Berry's Creek area?

TECHNICAL QUESTIONS

22. Have you observed any change in the biota (animals or plants) of Berry's Creek and the surrounding area?

23. What are the dominant wildlife and plants in Berry's Creek and the surrounding area?

24. Do you hunt or fish on Berry's Creek or its tributaries? Where are your favorite hunting/fishing grounds? Is hunting and fishing done as a recreational sport, or are the wildlife/fish consumed?

25. What sections of Berry's Creek and its tributaries are navigable?

26. Do you have any knowledge of the tidal gates located on Berry's Creek or its tributaries? Do the tidal gates operate correctly?

27. Do you have any knowledge of local drainage ditches that drain into Berry's Creek that are accessible for sampling?

28. Do Berry's Creek or its tributaries freeze solid in the winter (approximate month)?

29. When is the last time that Berry's Creek or its tributaries flooded?

30. Are there any historically significant places/buildings along Berry's Creek or its tributaries?

COMMUNICATION

31. What type of information would you want, and do you want to participate in commenting and providing input to EPA?

32. What is the most efficient way for EPA to disseminate information on Berry's Creek (local distribution sites, email list)?

33. What radio and television stations do most people in this area get their news from? What newspapers?

34. Do you think a website designed for the Berry's Creek Study would be helpful to the public?

35. What would be the best location to hold a meeting, or a special event with EPA to discuss the Berry's Creek project?

36. What would be the best location for an information repository?

37. Where would be the best location for a public observation deck?

38. Are there any existing local government councils or civic or property owners associations with which we can partner in holding community meetings and/or information sessions? If so, which do you recommend?

39. What type of meeting format do think is most productive – a "formal" public meeting or a more casual information session?

40. Do you think that field trips to the site would be helpful to explain sampling and analyses techniques?

41. Are you aware of any community within the Berry's Creek area that speaks a language other than English and for whom translation of materials may be needed?

Appendix 4. Information Repositories

BCSA Information Repositories

Wood-Ridge Memorial Library
231 Hackensack Street
Wood-Ridge, NJ 07075
Phone: 201-438-2455

MERI
One DeKorte Park Plaza
Lyndhurst, NJ 07071
Phone: 201-460-1700

EPA Records Center

290 Broadway, 18th Floor
New York, NY 10007
Phone: 212-637-3000

Appendix 5. Project Contacts

EPA Contacts

David Kluesner
Community Involvement Coordinator
Public Affairs
290 Broadway, 26th Floor
New York, NY 10007
Phone: 212-637-3653
Email: Kluesner.dave@epa.gov

Doug Tomchuk
Project Manager
Superfund Division
290 Broadway, 19th Floor
New York, NY 10007
Phone: 212-637-3956
Email: Tomchuk.doug@epa.gov

Terry Wesley
Environmental Justice Coordinator
Office of the Regional Administrator
290 Broadway, 26th Floor
New York, NY 10007
Phone: 212-637-5027
Email: Wesley.terry@epa.gov

Federal Elected Officials – United States Senate

Senator Frank R. Lautenberg
District Office
Senator Frank R. Lautenberg
One Gateway Center
23rd Floor
Newark, NJ 07102
Phone: 973-639-8700
Fax: 973-639-8723
Toll-free: 1-888-398-1642

Washington Office
Hart Senate Office Building
Suite 324
Washington, DC 20510
Phone: 202-224-3224
Fax: 202-228-4054
Email via Senator's website at: lautenberg.senate.gov

Senator Robert Menendez
District Office
Senator Robert Menendez
One Gateway Center
Suite 1100
Newark, NJ 07102
Phone: 973-645-3030
Fax: 973-645-0502

Washington Office
317 Senate Hart Office Bldg.
Washington, DC 20510
Phone: 202-224-4744
Fax: 202-228-2197
Email via Senator Menendez's website at: menendez.senate.gov

Federal Elected Officials - United States House of Representatives

Congressman Steve Rothman
District Office
25 Main Street
Hackensack, NJ 07601
Phone: 201-646-0808
Fax: 201-646-1944

Washington Office
2303 Rayburn HOB
Washington, DC 20515
Phone: 202-225-5061
Fax: 202-225-5851

New Jersey State Elected Officials

Office of the Governor

Hon. John S. Corzine
Governor of the State of New Jersey
Office of the Governor
P.O. Box 001
Trenton, NJ 08625
Phone: 609-292-6000

New Jersey State Senate

Senator Robert M. Gordon
14-25 Plaza Road
P.O. Box 398
Fair Lawn, NJ 07410
Phone: 201-703-9779

Senator Paul R. Sarlo
207 Hackensack Street, 2nd Floor
Wood-Ridge, NJ 07075
Phone: 201-804-8118

New Jersey State Assembly

Assemblyman Frederick Scalera
800 Bloomfield Avenue
Lower Level
Nutley, NJ 07110
Phone: 973-667-4431

Assemblyman Gary S. Schaer
1 Howe Avenue, Suite 302
Passaic, NJ 07055
Phone: 973-249-3665

Assemblywoman Joan M. Voss
520 Main Street
Fort Lee, NJ 07024
Phone: 201-346-6400

Assemblywoman Connie Wagner
205 Robin Road, Suite 216
Paramus, NJ 07652
Phone: 201-576-9199

New Jersey Department of Community Affairs

Joseph V. Doria, Commissioner
101 South Broad Street
P.O. Box 800
Trenton, NJ 08625-0800
Phone: 609-292-6420
Fax: 609-984-6696

New Jersey Turnpike Authority

Kris Kolluri, Chairman
Commissioner, NJDOT
P.O. Box 5042
Woodbridge, NJ 07095-5042
Phone: 732-750-5300

Bergen County Elected Offices

Bruce Bonaventuro, Director
Bergen County Department of Parks
One Bergen County Plaza, 4th Floor
Hackensack, NJ 07601
Phone: 201-336-7275
Fax: 201-336-7272

John DiRienzo, Chairman
Bergen County Environmental Council
c/o Bergen County Soil Conservation District
700 Kinderkamack Road
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Oradell, NJ 07649
Phone: 201-261-4407
Fax: 201-261-7573
Email: Info@bergenscd.org

Dennis McNerney, County Executive
One Bergen County Plaza
5th Floor, Room 580
Hackensack, NJ 07601
Phone: 201-336-7300

Municipalities Elected Offices

Borough of Carlstadt

Mayor William J. Roseman
500 Madison Street
Carlstadt, NJ 07072
Phone: 201-939-2850

East Rutherford

Mayor James L. Cassella
Grove Street and Uhland Street
East Rutherford, NJ 07073
Phone: 201-933-3444

Township of Lyndhurst

Mayor Richard J. DiLascio
253 Stuyvesant Avenue
Lyndhurst, NJ 07071
Phone: 201-804-2500

Moonachie

Mayor Frederick J. Dressel
70 Moonachie Road
Moonachie, NJ 07074
Phone: 201-641-1813

Rutherford

Mayor John F. Hipp
176 Park Avenue
Rutherford, NJ 07070
Phone: 201-460-3022

Borough of Teterboro

Mayor John P. Watt
510 Route 46 West
Teterboro, NJ 07608
Phone: 201-288-1200
Fax: 201-288-3203

Borough of Wood-Ridge

Mayor Paul A. Sarlo
85 Humbolt Street
Wood-Ridge, NJ 07075
Phone: 201-939-0202
Email: mayorsarlo@njwoodridge.org

Academia

New York Academy of Sciences

Consortium on Industrial Ecology
Marta Panero
NY Academy of Sciences
2 East 63rd Street
New York, NY 10021
Phone: 212-880-2916
Email: mpanero@nyas.org

Rensselaer Polytechnic Institute

Dr. Richard F. Bopp
110 Eighth Street
SC 1st Floor
Troy, NY 12180
Phone: 518-276-3075

Rutgers University

Environmental and Occupational Health Sciences Institute
170 Frelinghuysen Road
Piscataway, NJ 08854
Contact: Betty Davis
Phone: 732-445-0202
Email: davisbe@eohsi.rutgers.edu

Seton Hall University

Environmental Studies Program
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School of Public Health
Michael R. Greenberg, Ph.D.
c/o Rutgers University
Edward J. Bloustein School of Planning and Public Policy
Dept. of Epidemiology
New Brunswick Campus
Civic Square Bldg., Room 536
Phone: 732-0387
Fax: 732-932-0934
Email: mrg@rci.rutgers.edu

Development Community

Bergen County Department of Planning and Economic Development

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One Bergen County Plaza
4th Floor
Hackensack, NJ 07601
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Fax: 201-336-6449

Dredge Material Management Integration Work Group

James Tripp, Chair
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257 Park Avenue South
New York, NY 10010
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Xanadu

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John Samerjan, Public Affairs Office
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Email: jsamerjan@njsea.com

Non-Governmental Organizations

Association of New Jersey Environmental Commissions

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Mendham, NJ 07945
Phone: 973-539-7547
Fax: 973-539-7713
Email: sbatty@anjec.org

Association of New Jersey Environmental Educators

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Email: president@anjee.net

Bergen Save the Watershed Alliance (SWAN)

Lori Charkey
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Westwood, NJ 07675
Phone: 201-666-1877
Fax: 201-666-0220
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Clean Ocean Action

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Fax: 732-872-8041
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New York/New Jersey Baykeeper

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Keyport, NJ 07735
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Fax: 732-888-9873
Email: info@nynjbaykeeper.org

Nature Conservancy NJ Chapter

200 Pottersville Road
Chester, NJ 07930
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Sierra Club, New Jersey Chapter

Ken Johanson, Chair
145 West Hanover Street
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Fax: 609-656-7618
Email: kjohan@comcast.net

Local Schools with Potential Interest in Environment Issues & Education

Pierrepont School

70 East Pierrepont Avenue
Rutherford, NJ 07070
Phone: 201-438-7675

Sylvan School

109 Sylvan Street
Rutherford, NJ 07070
Phone: 201-438-7675

St. Mary Elementary School

72 Chestnut Street
Rutherford, NJ 07070
Phone: 201-933-8140

St. Mary High School

64 Chestnut Street
Rutherford, NJ 07070
Phone: 201-933-5220

Washington School

89 Wood Street
Rutherford, NJ 07070
Phone: 201-438-7675

Lincoln School

414 Montross Avenue
Rutherford, NJ 07070
Phone: 201-438-7675

Union School

359 Union Avenue
Rutherford, NJ 07070
Phone: 201-438-7675

Rutherford High School

56 Elliott Place
Rutherford, NJ 07070
Phone: 201-438-7675

Columbus School

640 Lake Avenue
Lyndhurst, NJ 07071
Phone: 201-896-2074

Franklin School
360 Stuyvesant Avenue
Lyndhurst, NJ 07071
Phone: 201-896-2077

Jefferson School
336 Lake Avenue
Lyndhurst, NJ 07071
Phone: 201-896-2065

Lincoln School
281 Ridge Road
Lyndhurst, NJ 07071
Phone: 201-438-5683

Roosevelt School
530 Stuyvesant Avenue
Lyndhurst, NJ 07071
Phone: 201-896-2068

Washington School
709 Ridge Road
Lyndhurst, NJ 07071
Phone: 201-896-2072

Sacred Heart School
620 Valley Brook Avenue
Lyndhurst, NJ 07071
Phone: 201-939-4277

St. Michael the Archangel School
624 Page Avenue
Lyndhurst, NJ 07071
Phone: 201-939-0350

Robert L. Craig School
20 West Park Street
Moonachie, NJ 07074
Phone: 201-641-5833

Wood-Ridge High School

258 Hackensack Street
Wood-Ridge, NJ 07075
Phone: 201-933-6777

Catherine E. Doyle School

12th Street and Wood-Ridge Avenue
Wood-Ridge, NJ 07075
Phone: 201-933-0440

Gretta Ostrovsky School

540 Windsor Road
Wood-Ridge, NJ 07075
Phone: 201-939-2103

Our Lady of the Assumption School

151 First Street
Wood-Ridge, NJ 07075
Phone: 201-933-0239

Carlstadt Public School

550 Washington Street
Carlstadt, NJ 07072
Phone: 201-672-3000

Henry P. Becton Regional High School

120 Paterson Avenue
East Rutherford, NJ 07073
Phone: 201-935-3007

Corpus Christi School

215 Kipp Avenue
Hasbrouck Heights, NJ 07604
Phone: 201-288-0614

Euclid School

1 Burton Avenue
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Media List

Newspapers

The Gazette (serves Lodi, Hasbrouck Heights, Moonachie, Teterboro, and Wood-Ridge)

1 Garret Mountain Plaza
West Paterson, NJ 07424
Phone: 201-847-0400

The Leader (serves Wood-Ridge, Carlstadt, East Rutherford, Rutherford, and Lyndhurst)

251 Ridge Road
Lyndhurst, NJ 07070
Phone: 201-438-8700
Fax: 201-438-9022
Email: Editor@leadernewspapers.net

The Record

150 River Street
Hackensack, NJ 07601
Phone: 201-646-4100
Fax: 201-646-4135

South Bergenite

33 Lincoln Avenue
Rutherford, NJ 07070
Phone: 201-933-1166
Fax: 201-933-5496

The Star Ledger

One Star Ledger Plaza
Newark, NJ 07102
Phone: 973-392-4040
Fax: 973-392-5845

Wood-Ridge Independent (serves Wood-Ridge and Moonachie)

P.O. Box 242
Wood-Ridge, NJ 07075-0242
Phone: 201-438-3574

Television Stations

ABC-TV

Eyewitness News Bureau NJ
201 North Avenue
Wood-Ridge, NJ 07075
Phone: 201-372-0545

NJN Network (Public)

50 Park Place
Newark, NJ 07102
Phone: 973-648-3630
Fax: 973-643-4004

WNET-TV (Public)

One Gateway Plaza
Newark, NJ 07102
Phone: 973-643-3315

WNJU (Spanish)

47 Industrial Avenue
Teterboro, NJ 07608
Phone: 201-288-5550
Fax: 201-288-0219

WWOR-TV

9 Broadcast Plaza
Secaucus, NJ 07096
Phone: 201-348-0009
Fax: 201-330-2488

Radio

Multicultural Radio Broadcasting

350 Paterson Plank Road
Carlstadt, NJ 07072
Phone: 201-635-1380

Univision Radio

277 Paterson Plank Road
Carlstadt, NJ 07072
Phone: 201-804-1739

WABC-AM (770.0)

2 Penn Plaza
New York, NY 10121
Phone: 212-268-5730

WADO-AM (1280.0) – Spanish

485 Madison Avenue
New York, NY 10022
Phone: 212-310-6000
Fax: 212-888-3694

WBBR-AM (Bloomberg)

1 Metro Road
Carlstadt, NJ 07072
Phone: 201-935-1133

WINS-AM (1010.0)

888 7th Avenue
New York, NY 10016
Phone: 212-397-1010
Fax: 212-247-7918

WPAT-AM (93.0)

449 Broadway
New York, NY 10013
Phone: 212-966-1059
Fax: 212-966-9580

WWRL-AM (1600)

333 7th Avenue
New York, NY 10001
Phone: 212-631-0800
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Appendix 6. Bibliography

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

MAR - 4 2015

Bill Sheehan
Hackensack Riverkeeper, Inc.
231 Main Street
Hackensack, NJ 07601

Subject: Preliminary Assessment Petition for the Hackensack River

Dear Mr. Sheehan:

This is to acknowledge the receipt of your letter dated February 10, 2015, requesting the Environmental Protection Agency (EPA) conduct a Preliminary Assessment of the Hackensack River under the Comprehensive Environmental Response, Compensation and Liability Act. According to the information provided in your letter, there is sufficient information to indicate that a release to the Hackensack River is possible and additional evaluation is necessary. The EPA accepts your request and will conduct a Preliminary Assessment evaluation of the Hackensack River, the completion of which will be within one year from February 10, 2015, the date of the petition.

If you have any questions or concerns, please let me know or you may contact Mel Hauptman, Chief of the Pre-Remedial Section, at 212-637-4338.

Sincerely,

Walter Mugdan, Director
Emergency Response and Remedial Division

cc: Mark Pedersen, NJDEP

EPA/ROD/R02-95/262
1995

EPA Superfund
Record of Decision:

PJP LANDFILL
EPA ID: NJD980505648
OU 01
JERSEY CITY, NJ
09/28/1995

RECORD OF DECISION

PJP Landfill Site

Jeresy City, Hudson County, New Jersey

New Jersey Department of Environmental Protection Site
Remediation Program Trenton, New Jersey

SEPTEMBER 28, 1995

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

PJP Landfill

Jersey City, Hudson County, New Jersey

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the PJP Landfill Site, which was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation and Liability Act, as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision document is based on the administrative record file for this Site.

The United States Environmental Protection Agency concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the PJP Landfill Site, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial threat to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy represents the first and only planned operable unit for the PJP Landfill Site. It addresses contaminated surface soils on the Site and groundwater contamination in the underlying shallow and deep aquifers.

The major components of the selected remedy include:

1. Removal of all known and suspected buried drum materials and associated visibly contaminated soil;

2. Capping of the remaining landfill area of the site with a multi-layer, modified solid waste cap in accordance with NJDEP Bureau of Landfill Engineering Guidance with gas venting;

3. Extension of the existing gravel lined ditch around the perimeter of the site to collect the surface water runoff;

4. A passive or active gas venting system installed in the new portion of the cap. (If an active system is deemed necessary, however, both areas will be included);

5. Site fencing and institutional controls (e.g., declaration of environmental restriction and public information program),

6. Quarterly inspections and maintenance, and a re-evaluation of the previously capped area,

7. Replacement of the Sip Ave ditch with an alternate form of drainage;

8. Quarterly ground water monitoring to evaluate the reduction of contaminant concentrations over time;

9. Modeling to demonstrate the effectiveness of the cap by predicting the impact of ground water leachate migrating to the Hackensack River from the landfill;

10. Because contamination levels in the ground water are above the Class IIA Ground Water

Quality Criteria (GWQC), a Classification Exemption Area (CEA)/Well Restriction Area (WRA) will bo established; and

11. Implementation of a wetlands assessment and restoration plan. (The wetlands assessment will be performed prior to implementation of any of the remedial actions).

DECLARATION OF STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. The remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable, and it satisfies the statutory preference for remedies that employ treatment which reduces toxicity, mobility, or volume as their principal element.

Because this remedy will result in hazardous substances remaining on the Site above health-baaed levels (soil will be capped over), a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. This review will include an evaluation of the data and information obtained in connection with remedial components 6, 8, and 9 above, as well as other appropriate components of the selected remedy.

Robert C. Shinn Jr. Date
Commissioner

RECORD OF DECISION SUMMARY

PJP Landfill Site

Jersey City, Hudson County, New Jersey

New Jersey Department of Environmental Protection Trenton, New Jersey

RECORD OF DECISION RESPONSIVENESS SUMMARY

PJP Landfill Site

Jersey City, Hudson County, New Jersey

SITE NAME, LOCATION, AND DESCRIPTION

The PJP Landfill Superfund Site is an inactive landfill located at 400 Sip Avenue, Jersey City (see figure 1). The Site occupies approximately 87 acres in Jersey City, Hudson County, New Jersey, and is identified on the Jersey City tax map (1977) as block 1639.1, lots 2A, 3, 4C, 5C, 7D, block 1639.2, lots 1C, 5C, 7 and 7E, block 1627.2 lot 1P, block 1627.1 lots 5A, 6A and parts of 2A, 3B and 4B. The Site is bordered on the north and west by the Hackensack River and on the southeast by Truck Routes 1 and 9. A recycling facility and a warehouse border the northeast side of the Site. The southwest side of the Site is boarded by several commercial trucking terminals. Multiple dwelling housing units are located northeast and southeast of the Site. The Pulaski Skyway, an elevated highway, passes over the Site. The Sip Avenue Ditch bisects the Site and conveys run-off from the PJP Landfill and Jersey City storm water/sewer into the Hackansack River (see figure 2).

SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Site was originally a salt meadow, a portion of which was condemned in 1932 for the construction of the Pulaski Skyway. The PJP Landfill Company operated a commercial landfill at the Site, accepting chemical and industrial waste from approximately 1970 to 1974.

From 1970 to 1985, subsurface fires (on the currently capped 45 acre area) which were attributed to spontaneous combustion of subsurface drums and decomposition of landfill materials, frequently burned at a 45-acre portion of the PJP Landfill and emitted large amounts of smoke. In 1977, the NJDEP issued an order to the PJP Landfill Company to properly cover and grade the landfill, and to remove wastes in contact with the Hackansack River and the Sip Avenue Ditch. The PJP Landfill Company did not comply with the order.

Throughout the early 1980s, NJDEP and the Hudson Regional Health Commission inspected the Site and conducted sampling and air monitoring. In December 1982, the Site was included on the EPA'a National Priorities List (NPL), which identifies hazardous waste Sites that pose a significant threat to public health or the environment.

During 1985 and 1986, NJDEP conducted an Interim Remedial Measure (IRM) to extinguish the fires and cap the 45 acre area. The IRM resulted in the extinguishing of fires; excavation and recompaction of approximately 1,033,000 cubic yards of material and the removal of grossly contaminated soils, cylinders and drums containing hazardous materials on approximately 45 of thee 87 acres. These hazardous materials were properly disposed of off Site at secure landfills or hazardous waste incinerators. A fire break trench was installed and the 45 acre area was regraded, capped and seeded. A gas venting system was also installed on the 45-acre portion of the landfill. All subsurface fires have been out since the completion of the IRM in May 1986.

The NJDEP contracted ICF Technology, Inc. (ICF) in 1988 to perform an RI/FS on the entire 87 acres of the landfill. The Remedial Investigation (RI) was completed by ICF in 1990. The RI identified areas and levels of contamination at the Site. The study included a geographical investigation and a shock- sensitive drum investigation to determine the density and condition of buried drums, extent of landfill material, the shock sensitivity of drums, and drum markings. An FS was also performed, which developed and evaluated various remedial alternatives for addressing Site contamination.

In the summer of 1993, NJDEP implemented a plan to assist in the evaluation of the current impact the Site was having on the adjacent Hackensack River and on the deeper aquifer of concern beneath the fill material. The sampling effort consisted of the sampling of three shallow and three deep monitoring wells, and six surface water and sediment locations. Water and sediment samples collected from the Hackensack River were obtained upstream and downstream from the Site. Water and sediment samples from the Sip Avenue Ditch were obtained from the Ditch adjacent to Routes 1 and 9 and at the confluence of the ditch with the Hackensack River. The samples were analyzed for organic and inorganic chemical parameters. In addition a series of bioassay (mysid shrimp chronic toxicity tests) were preformed using water collected from the Hackensack River, the Sip Avenue Ditch, and at the sediment sample locations and in the waters of the two wells with the highest levels of contamination was performed.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

The RI report, FS report, and the Proposed Plan for the Site were released to the public for comment on August 2, 1994. These documents were made available to the public in the administrative record file at the NJDEP file room in, 401 East State Street, Trenton, NJ and the information repositories at:

Jersey City Public Library   Jersey City Municipal Building 472
Jersey Avenue   Engineering Division Jersey City, NJ 07302
280 Grove Street (201)547-4516
Jersey City, NJ 07302 (201)547-6852

On August 18, 1994, NJDEP conducted a public meeting at the Jersey City Municipal Building to inform local officials and interested citizens about the Superfund process, to discuss the findings of the RI and FS and the proposed remedial activities at the Site, and to response to any questions from area residents and other attendees.

NJDEP responses to the comments received at the public meeting, and in writing during the public comment period, are included in the Responsiveness Summary section of this Record of Decision.

SCOPE AND ROLE OF RESPONSE ACTION

This ROD will address cleanup remedies for the Sip Avenue Ditch sediment, air and landfilled material which includes areas of buried drums and surrounding contaminated soil. A monitoring program will be established to determine whether additional actions may be necessary to mitigate the leaching of contaminants to ground water and surface water as well as to the Hackensack River. If a significant adverse impact is found, NJDEP and EPA will evaluate remedial alternatives and select an appropriate remedy in accordance with CERCLA and the NCP.

SUMMARY OF SITE CHARACTERISTICS

Site Geology and Hydrology The PJP Landfill Site lies in the Piedmont physiograph province of Northeastern New Jersey. The bedrock of the Piedmont Lowlands consists of igneous and sedimentary rocks. The bedrock underlying the site is the Brunswick Formation. This formation consists of fluvial and lacustrine reddish brown shales and some fine grained sandstone.

The Site is located on man-made fill deposits which are approximately 10 to 30 feet thick. The fill material is underlain by a discontinuous layer of peat. Under the peat layer is a layer of sand and silt. The bedrock at the landfill is approximately 60 to 90 feet below the surface.

The principal source of ground water in the area lies within the rocks of the Brunswick Formation. Ground water, which flows in a westwardly direction, is not used for potable water supply within the lower Hackensack Basin. However, due to industrial and commercial nature of the area it appears that the ground water is used for some commercial and industrial purposes. The area near the PJP Landfill is served by the Jersey City municipal water supply, which is the Boonton Reservoir.

Nature and extent of Contamination The RI identified contaminants above NJDEP current cleanup criteria in surface soils, subsurface soils (excluding test pits), test pits, sediments from the Sip Avenue Ditch, and air. The cleanup criteria, although not promulgated, are currently used in lieu of standards.

Soil Arsenic was detected in the surface soils samples in concentrations greater than the NJDEP Soil Cleanup Criteria of 29 parts per million (ppm). In the subsurface soils (excluding the test pits which are discussed later in this Record of Decision), the following contaminants were detected at levels exceeding the cleanup criteria: Benzene (maximum concentration detected 1.6 ppm), bis(2-ethylhexyl)phthalate (maximum concentration detected 180 ppm) and chlorobenzene (maximum concentration detected 2.92 ppm).

Chemicals were detected more frequently, and in higher concentrations, in the test pits than were detected in samples from other media Bis(2-ethylhexyl)phthalate (maximum concentration detected 33,100 ppm) and petroleum hydrocarbons were the predominant organic chemicals found in the subsurface soils of those that exceed the current RJDEP subsurface soil standards. Other predominant organic chemicals detected in the soils sampled from the test pits that exceed the RJDEP impact to ground water soil cleanup criteria are the following: benzene (maximum concentration detected 250 ppm), dieldrin (maximum concentration detected 200 ppm), tetrachloroethene (maximum concentration detected 41 ppm), and total xylenes (maximum concentrations detected 3900 ppm). Carcinogenic and non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) and inorganic chemicals (metals) were also detected frequently in the subsurface soils.

Sip Avenue Ditch

The Sip Avenue Ditch sediment samples were compared to the National Oceanographic and Atmospheric Administration (NOAA) sediment screening guidelines. This guidance sets criteria for contaminants which may have potentially harmful biological effects to aquatic life. Sediment contaminants found in the Sip Avenue Ditch exceeded these screening guidelines. The highest concentrations found were total PAH (14.8 ppm for carcinogenic PAH; 30.1 ppm for noncarcinogenic PAH), antimony (93.8 ppm), cadmium (6.3 ppm), chromium (771 ppm), copper (34,000 ppm), lead (406 ppm), mercury (5.1 ppm), nickel (1,260 ppm), and zinc (9,830 ppm).

Landfill Gas Vent Samples Landfill gas vent sample data obtained during the Remedial Investigation was used to approximate the total amount of contaminants discharged from the gas vent system in terms of pounds per hour. Eight of the forty-nine existing vents were sampled on three separate occasions, and used as representative vents for the entire system. The maximum flow rate from the forty-nine vents was used to calculate potential discharges (8.73 cubic feet per minute/cfm) and the maximum contaminant concentrations from the three sample rounds was used for each contaminant.

Discharge numbers were calculated for total emissions and toxic emissions. Using the average and maximum contaminant concentrations for the eight landfill gas vents, typical landfill emissions and the worst case scenario emissions were determined. The total emissions average of 43 lbs/hr, and maximum of 1.5 lbs/hr, respectively are within the acceptable/allowable limit of 1.5 lbs/hr. Toxic emissions average of .07 lbs/hr is also within the acceptable/allowable limit of .1 lbs/hr while the toxic emissions maximum of .27 lbs/hr is slightly above the acceptable/allowable limit of .1 lbs/hr.

The NJDEP 1993 Sampling Effort The monitor well analyses indicated that 11 compounds were detected in the three (3) ground water monitor wells at levels slightly above New Jersey's Ground Water Quality Criteria. Hackensack River water and sediment samples were collected upstream and downstream of the Site. Surface water samples obtained from the river indicated the presence of inorganics both upstream and downstream from the Site, such as iron, aluminum, copper and zinc. Sediment samples collected from the river indicated the presence of volatile organic compounds, semi-volatile organic compounds, pesticides, PCBs, and inorganics both upstream and downstream from the Site. Predominant chemicals detected in the sediments were polycyclic aromatic hydrocarbons (maximum concentration detected approximately 25 ppm), PCBs (maximum concentration detected approximately 360 ppb), lead (maximum concentration detected approximately 222 ppm), and mercury (maximum concentration detected approximately 2.7 ppm).

Contamination was also present in the Sip Ave ditch, both adjacent to Routes 1 & 9 and at the confluence of the ditch with the river. The ditch water and sediment samples adjacent to the highway were more contaminated that the sample obtained from the confluence of the ditch with the river. Chemicals detected in the water samples included volatile organics such as tetrachloroethene (detected at 44 ppb) and inorganics such as lead and zinc. Chemicals detected in the sediment samples included tetrachloroethene, (detected at approximately 10 ppb), toluene (detected at approximately ppb), numerous polycyclic aromatic hydrocarbons, and inorganics such as copper, lead and zinc.

All four (4) of the bioassay sampling locations in the river, the two monitor well sample locations, and the Sip Avenue Ditch location from the confluence of the ditch and the river showed significant mortality. The sampling location with the lowest percent mortality was from the Sip Avenue Ditch adjacent to Routes 1 and 9. This data indicates that potential adverse impacts on biota by these contaminated waters is likely occurring.

The Bedrock Aquifer Well sampling results indicate that all three well results are below New Jersey Ground Water Quality Standards. The sampling results indicate that none of the contaminants found in the wells exceed NJDEP's Ground Water Quality Criteria for Volatile Organics, Semi-Volatile Organics, and Pesticides.

SUMMARY OF SITE RISKS

Based upon the results of the RI, a baseline risk assessment was conducted to estimate the risks associated with current and future Site conditions. The baseline risk assessment estimates the human health and ecological risk which could result from the contamination at the Site if no remedial action were taken. The results from the 1993 NJDEP sampling effort were not incorporated into the baseline risk assessment for the Site, since the RI report predated the 1993 sampling event.

The following summarizes the finding of the Risk Assessment.

Human Health Risk Assessment

A four step process is utilized for assessing site-related human health risks for a reasonable maximum exposure scenario: Hazard Identification - identifies the contaminants of concern at the Site based on several factors such as toxicity, frequency of occurrence, and concentration; exposure Assessment - estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are potentially exposed (e.g., ingesting contaminated soil/water); Toxicity Assessment - determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response), and Risk Characterization - summarizes the combined output of the exposure and toxicity assessments to provide a quantitative (e.g., one-in-a-million excess cancer risk) assessment of site-related risks. Normally, a baseline risk assessment evaluates the risk posed by a site in the absence of remediation. In the case of PJP Landfill, an Interim Remedial Measure has already been implemented prior to evaluating site-wide risk.

EPA conducted a baseline risk assessment to evaluate the potential risk to human health and the environment associated with the PJP Landfill Site in its current state. The Risk Assessment focused on contaminants in the soil, ground water, surface water, sediment, and air which are likely to pose significant risks to human health and the environment A summary of the contaminants of concern in sampled materials is provided in Table 5-15 for human health and the environmental receptors, respectively. The exposure pathways and populations evaluated are in Table 5-17. A total of nine exposure pathways are assessed under possible on-site current and future land-use conditions. The plausible maximum and average case scenarios were evaluated.

Under current EPA guidelines, the likelihood of carcinogenic (cancer-causing) and noncarcinogenic effects due to exposure to Site chemicals are considered separately. It was assumed that the toxic effects of the site-related chemicals would be additive. Thus, carcinogenic and noncarcinogenic risks associated with exposures to individual compounds of concern were summed to indicate the potential risks associated with mixtures of potential carcinogens and noncarcinogens, respectively.

Noncarcinogenic risks were assessed using a Hazardous Index (HI) approach, based on a comparison of expected contaminant intakes and safe levels of intake (Reference Doses). Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects RfDs, which are expressed in units of milligrams/kilogram-day (mg/kg-day), are estimates of daily exposure levels for humans which are thought to be aefe over a lifetime (including sensitive individuals). Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) are compared to the RfD to derive the hazard quotient for the contaminant in the particular medium. The HI is obtained by adding the hazard quotients for all compounds across all media that impact a particular receptor population.

An HI greater than 1.0 indicates that the potential exists for noncarcinogenic health effects to occur as a result of site-related exposures. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. The reference doses for the compounds of concern at the Site are presented in Table 5-19. A summary of the noncarcinogenic risks associated with these chemicals across various exposure pathways is found in Tables 5-24, 5-25, 5- 26, 5-27, 5-29, 5-30, 5-31, 5-35, 5-36, 5-37 and 5-39. The results of the baseline risk assessment indicated that the greatest risk associated with the Site under current conditions is the incidental ingestion and dermal absorption of chemicals in sediment by trespassing children wading in the Sip Avenue Ditch. The carcinogenic risk for children was estimated to be 4x10.5, which is within acceptable EPA guidelines.

For incidental ingestion/dermal absorption of Sip Ave Ditch sediments, the HI was calculated to be four. This was based on the plausible maximum scenario Therefore noncarcinogenic effects may occur from this exposure route. Under an average case scenario, the HI is less than one. Potential carcinogenic risks were evaluated using the cancer slope factors developed by EPA for the contaminants of concern. Cancer slope factors (SFs), have been developed by EPA's Carcinogenic Risk Assessment Verification Endeavor for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs, chich are expressed in units of (mg/kg-day)-1, are multiplied by the estimated intake of potential carcinogen, in mg/kg-day, to generate an upper-bound estimate of the excess lifetime cancer risk associated with exposure to the compound at that intake level. The term "upper-bound" reflects the conservative estimate of the risks calculated from the SF. Use of this approach makes the underestimation of the risk highly unlikely. The SF for the compounds of concern are presented in Table 5-19.

A qualitative risk assessment was performed for future land-use conditions. Although not likely, it is possible that land use at the Site could change in the future, resulting in additional exposure pathways that do not exist under currant land-use conditions. The most plausible land-use change would be development of the landfill area as an industrial/commercial area. If the area were developed, on-site construction workers could be exposed via direct contact with contaminated sediments, subsurface soil, and materials in test pits. Generally, the concentrations of chemicals detected in test pits and subsurface soils are substantially higher than in sediments. Based on the substantially higher chemical concentrations in the subsurface soil and test pits, some of which are potentially carcinogenic, future workers exposed to these subsurface contaminants could be at significant risk. Inhalation exposures are estimated to be approximately equal to those estimated for trespassing children. For long-term exposures, this risk would probably be greater than the 10-4 to 10-6 range.

Environmental Risk Assessment

The environmental Assessment provides a qualitative evaluation of the actual or potential impacts associated with the Site on plants and animals (other than people or domesticated species). The primary objectives of this assessment were to identify the ecosystems, habitats, and populations likely to be found at the Site and to characterize the contaminants, exposure routes and potential impacts on the identified environmental components. The environmental assessment evaluated potential impacts associated with chemicals in the surface soil, surface water (including chemicals released to surface water from ground water) and sediment. Potential exposures evaluated were terrestrial plants, terrestrial wildlife, and aquatic life.

The Environmental Assessment identified several endangered species and sensitive habitats in the vicinity of the Site. The Hackensack River is considered critical habitat for the short-nosed sturgeion, which is a State and federal endangered species. The Site is also within the current or historical range of several other State endangered or threatened species that inhabit coastal areas and/or marshes, including the Atlantic sturgeon, Atlantic tomcod, pied-billed grebe, great blue heron, northern harrier, Henslow's sparrow, short-billed marsh wren, and osprey.

Estuarine intertidal wetlands occur along the Hackensack River and the Sip Avenue Ditch, which are tidally influenced in association/with the Hackensack River. A palustrine emergent scrub/shrub wetland occurs in the southeast corner of the Site adjacent to the entrance road and Routes 1 and 9. Due to some areas receiving less fill material than others, depressed areas have formed, leaving an appearance of wetland like features.

The environmental assessment is summarized as follows:

Plants-- Plants can be exposed to chemicals in surface soil. Chemical-related impacts in plants are not expected to be significant. If chemical-related impacts are occurring, they are most likely limited to localized source areas such as the drum disposal area, since surface soil contamination is not believed to be widespread at the Site. Impacts in these isolated areas would be expected to have minor impacts on the plant community and habitat quality of the entire PJP Site. Chemical-related impacts in plants are most likely insignificant compared to other current and past (non-chemical) stresses on the plant community at the PJP Site, such as past grading and filling at the Site.

Terrestrial wildlife -- Potential impacts were evaluated for wildlife exposed to chemicals of potential concern. Some species could use the Sip Avenue Ditch or Hackensack River for drinking water, however, exposure in these species is not expected to be significant given the availability of other water sources nearby and the relatively large foraging area of these species. None of the chemicals of potential concern detected in surface water are expected to be acutely or chronically toxic at the low levels of exposure potentially experienced by wildlife.

Aquatic life -- Potential impacts on aquatic life were evaluated for chemicals in surface water and sediment. Surface water concentrations were compared with ambient water quality criteria developed by EPA or lowest-observed effects levels. Sediment concentrations were compared with toxicity values derived from the available literature. There is a potential for food chain effects to occur via predation on aquatic species, since several of the contaminants of concern bioconcentrate (e.g., cadmium, mercury). Surface water and sediment concentrations for several chemicals in the Sip Avenue Ditch and in the Hackensack River exceeded their respective toxicity values, suggesting that aquatic life impacts may be occurring at the Site

In summary, the environmental assessment concluded that chemical contamination from the site is not expected to have significant impacts on plants or terrestrial wildlife, but may be impacting aquatic life.

Uncertainties

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to a wide variety of uncertainties. In general, the main sources of uncertainty include:

- environmental chemistry sampling and analysis
- environmental parameter measurement
- fate and transport modeling
- exposure parameter estimation
- toxicological data

Uncertainty in environmental sampling arises in part from the potentially uneven distribution of chemicals in the media sampled. Consequently, there is significant uncertainty as to the actual levels is present. Environmental chemistry-analysis error can stem from several sources including the errors inherent in the analytical methods and characteristics of the matrix being sampled.

There are also uncertainties in the risk assessment because the PJP Site is located in an industrial area. The Sip Avenue Ditch receives some runoff from Jersey City and during large storm events has received overflow sewage from the city. Regional pollution ha resulted in the state prohibiting swimming or other consumptive uses of the Hackensack River.

Uncertainties in the exposure assessment are related to estimates of how often an individual would actually come in contact with the chemical of concern, the period of time over which such exposure would occur, and in the models used to estimate the concentrations of the chemicals of concern at the point of exposure.

Uncertainties in toxicological data occur in extrapolating both animals to humans and from high to low doses of exposure, as well as from the difficulties in assessing the toxicity of a mixture of chemicals. These uncertainties are addressed by making conservative assumptions concerning risk and exposure parameters throughout the assessment. As a result, the Risk Assessment provides up-bound estimates of the risks to populations near the Site, and is highly unlikely to underestimate actual risks related to the Site.

More specific information concerning public health risk, including a quantitative evaluation of the degree of risk associated with various exposure pathways, is presented in the Risk Assessment Report.

Actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in the ROD, may present an imminent and substantial endangerment to the public health, welfare, or the environment.

REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives are specific goals to protect human health and the environment. These objectives are based on available information, applicable or relevant and appropriate requirements (ARARs), and risk-based levels established in the risk assessment. The following remedial action objectives were established for cleanup activities at the Site:

- Eliminate exposure to contaminated sediments in the Sip Avenue Ditch.
- Prevent additional contaminant influx into the ground water via infiltration of rain water.
- Removal of contaminant sources that may impact ground water.
- Evaluate if future actions are necessary to mitigate the leaching of Site contaminants into the Hackensack River through the monitoring and modeling to check the effectiveness of the remedy. If a significant adverse impact is found, NJDEP and EPA will evaluate remedial alternatives and select an appropriate remedy in accordance with CERCLA and the NCP

DESCRIPTION OF REMEDIAL ALTERNATIVES

The Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA), requires that each selected Site remedy be protective of human health and the environment, be cost effective, comply with other applicable or relevant and appropriate requirements, and utilize permanent solutions, alternative treatment technologies, and resource recovery alternatives to the maximum extent practicable. In addition, the statute includes a preference for the use of treatment as a principal element for the reduction of toxicity, mobility, or volume of the hazardous substances.

The FS evaluates in detail several remedial alternatives for addressing the contamination associated with the PJP Landfill Site. These alternatives are: Alternative LF-1: No Action Alternative LF-2: Minimal Action Alternative LF-3: Soil Cover Alternative LF-4: Modified NJDEP Solid Waste Cap (Extending Existing Cap) Alternative LF-5: NJDEP Hazardous Waste Cap Alternative LF-6: New RCRA Hazardous Waste Cap

The following two options are applicable to Alternatives LF-3 through LF-7:

Option 1: No Drum Removal Option 2: Drum Removal (All known Buried Drum Areas and associated soils)

As part of Alternatives LF-3 through LF-7: The Sip Avenue Ditch will be replaced with an alternative form of drainage, in order to maintain the integrity of the landfill cap and channel surface water runoff. Design details related to the Sip Avenue ditch will be resolved in the remedial design phase of the Project. Alternatives will address issues such as protectiveness to ecological receptors, the fate of stormwater runoff, and the effectiveness in preventing contaminant migration to the Hackensack River. Potential alternatives include, but are not limited to, excavation of sediments and placement under the cap, burial in place, or some other form of containment or disposal.

In order to comply with federal wetland ARARs, the remedial design will also include: (a) a wetlands assessment to determine what wetlands were impacted/disturbed by contamination or remedial activities, and (b) a wetlands restoration plan to mitigate those areas found to have been impacted. The assessment will be conducted and the restoration plan prepared prior to remedial activities.

Under Alternative LF-2, LF-3, and LF-4, the existing landfill gas venting system will be sampled during the design phase to determine compliance with current State and Federal air quality standards. If, at that time, air emissions are not in compliance with the accepted maximum limits for Total Volatile Organics, the appropriate measures will be incorporated into the design phase to bring the Site into compliance with air requirements.

For alternative LF-5, LF-6, and LF-7, the design phase will include a new landfill gas venting system that will be designed (active or passive) to comply (including treatment, if necessary) with State and Federal air quality standards.

In addition, because contamination levels in the ground water are above the Class IIA, Ground Water Quality Criteria (GWQC), each alternative includes a Classification Exemption Area (CEA)/Well Restriction Area (WRA).

This ROD presents alternative, which are described in greater detail below. Implementation times give include the time necessary to construct and implement the remedy but do not include the time required for design or award of a contract for the performance of the work.

ALTERNATIVE LF-1: NO ACTION

Estimated Capital Cost: None
Annual Operation and Maintenance: None
Estimated Present Worth: None
Estimated Implementation Time: None

The National Oil and Hazardous Substances Pollution contingency Plan (NCP) and CERCLA requires the evaluation of a No Action alternative to serve as a point of comparison with other remedial action alternative. Under this alternative, no action would be taken to contain, treat, or control the contamination at the Site. The subsurface soil contamination would decrease over a long period of time through natural processes such as flushing and attenuation. This alternative does not include any measures to restrict access to the Site. Essentially, the Site would remain the same as it is today. Regular monitoring and a five year review to re-evaluate this alternative would be performed.

ALTERNATIVE LF-2: MINIMAL ACTION Estimated Capital Cost: $209,000
Annual Operation and Maintenance: $105,000
Estimated Present Worth: $752,000
Estimated Implementation Time: None

Under this alternative, no remedial action would be performed at the Site to contain, treat, or control the contamination at the Site. However, institutional controls, such as deed restrictions to restrict future use of the Site and public information programs to increase public awareness of potential problems associated with the Site, would be implemented. In addition, although most of the Site is already fenced, the existing fence would be extended to restrict access and rduce the potential for direct exposure to sediment contamination. Long-term monitoring of soil, sediment and air quality would be performed for a minimum of five years to evaluate the migration of contaminants from the Site and to monitor the effects of natural attenuation.

A Site review would be instituted at the end of five years in order to reevaluate Site conditions. This includes an evaluation of what additional measures, if any, should be implemented based on the Site conditions.

ALTERNATIVE LF-3: SOIL COVER

Estimated Capital Cost: $16,368,000
Annual Operation and Maintenance: $291,000
Estimated Present Worth: $17,716,000
Estimated Implementation Time: 6 months

As described earlier, a 45-acre portion of the landfill was already excavated and capped with one foot of clay and one foot of soil during the completion of the IRM in 1986. Under this alternative, a two foot soil cover would be installed over the remaining, uncapped 42-acre area. The proposed soil cover design includes installation of a top soil layer over the uncapped area and vegetation to prevent soil erosion. Existing gas vents would be sampled and analyzed annually to monitor the gas releases to the atmosphere from the Site. If the gas poses a threat, treatment options would be developed and implemented. In addition, institutional controls and Site fencing would be implemented as described for Alternative LF-2 above.

The soil covered area would require quarterly inspections and maintenance, and a review and reevaluation of Site conditions after five years.

ALTERNATIVE LF-4: MODIFIED NJDEP SOLID WASTE CAP (Extending Existing Cap)
Estimated Capital Cost: $22,022,000
Annual Operation and Maintenance: $369,000
Estimated Present Worth: $13,707,000
Estimated Implementation Time: 1.5 years

As described earlier, a 45-acre portion of the landfill was already excavated and capped with one foot of clay and one foot of soil during the IRM. Under this alternative, the remaining 42-acre area, under the Pulaski Skyway on the north side of the Sip Ave Ditch, would be capped with a multi-layer, modified solid waste type cap. The cap may combine several layers of cover materials, such as waste type cap. The cap may combine several layers of cover materials, such as clean sand, soil and an impervious layer, such as a High Density Polyethylene (plastic) orclay liner but must maintain a minimum of 1x 10-7 impermeability to contain the contaminated solids. It may also include a top soil layer and vegetation to prevent soil erosion and to protect the clay/HDP from freeze-thaw effects. The existing gravel lined ditch along the southern border of the capped portion of the landfill would be incorporated into the design of surface water run-off controls.

The use of a passive or active gas venting system would be determined during the remedial design phase of the project. Periodic inspections of the cover installed during the IRM will be performed before and during the implementation of the remedial action and damaged or degraded areas will be repaired. A surface and ground water monitoring (quarterly) and modeling program will be implemented to evaluate the impacts ground water or leachate is having on the Hackensack River and to evaluate the reduction, if any, of contaminant concentrations and determine if natural attenuation is occurring at the Site. If a significant adverse impact is found, NJDEP and EPA will evaluate and implement hydraulic controls to mitigate those impacts. The Site would be reviewed at the end of five years in order to reevaluate Site conditions. The review would include an analysis of the ground and surface water monitoring data, evaluate the impact ground water or leachate is having on the Hackensack River. The review will also include an assessment of current residual health risks, and an evaluation of the effectiveness or site fencing to control acces.

ALTERNATIVE LF-5: NJDEP HAZARDOUS WASTE LANDFILL CAP

Estimated Capital Cost: $35,029,000
Annual Operation and Maintenance: $369,000
Estimated Present Worth: $36,714,000

Estimated Implementation Time: 3 years

As described earlier, a 45-acre portion of the landill was already excavated and capped with one foot of clay and one foot of soil during the completion of the IRM. Under this alternative, the existing 45-acre IRM cap would be left in place and a new multi-layer cap would be placed over the entire 87-acre area. The new cap would comply with the New Jersey Hazardous Waste Regulation (N.J.A.C. 7:26- 10.8(i)) regarding closure and post closure requirements for hazardous waste landfills. The proposed cap would consist of a vegetative top soil cover, a sand drainage layer, a bedding layer and a liner system constructed of two synthetic liners. The existing gravel-lined ditch would be incorporated in the design to facilitate the collection of surface water run-off.

In addition, institutional controls and Site fencing would be implemented as described for Alternative LF-2 above. Regular monitoring and a five year review would also be required as described for Alternative LF-4 above.

ALTERNATIVE LF-6: RCRA HAZARDOUS WASTE CAP - INCORPORATING IRM CAP

Estimated Capital Cost: $44,226,000
Annual Operation and Maintenance: $369,000
Estimated Present Worth: $45,911,000
Estimated Implementation Time: 3 years

As described earlier, a 45-acre portion of the landfill was already excavated and capped with one foot of clay and one foot of soil during the completion of the IRM. Under this alternative, the existing IRM cap would be upgraded and incorporated into a Resource Conservation and Recovery Act (RCRA) cap, hich would be installed over the remaining approximate 42-acre area. The RCRA cap is a multi-layer cap that combines several layers of cover materials such as soil, synthetic membranes, and clay to provide erosion and moisture control, in addition to containing the contaminated solids. The entire Site would be graded for proper drainage and seeded with grass for erosion control. The existing gravel-lined ditch would be incorporated in the design to aide in the collection of surface water run-off.

This alternative includes institutional controls and site fencing as described in Alternative LF-2. Regular monitoring and a five year review would also be required as described for Alternative LF-4.

Estimated Capital Cost: $47,879,00
Annual Operation and Maintenance: $369,000
Estimated Present Worth: $49,564,00
Estimated Implementation Time: 3 years

Under this Alternative, the existing IRM cap would be removed, graded, and used as the first layer of fill. A new RCRA cap would, bd placed over the entire 87 acre Site. As described in Alternative LF-6, the RCRA cap is a multi-layer cap that combines several layers of cover materials such as soil, synthetic membranes, and clay to provide erosion and moisture control, in addition to containing the contaminated solids. The entire Site would be graded for proper drainage and seeded with grass for erosion control. The existing gravel-lined ditch would be incorporated in the design to aide in the collection of surface water run-off.

This alternative includes institutional controls and Site fencing as described for Alternative LF-2. Regular monitoring and maintenance and a five year review would also be required as described for Alternative LF-4.

The following two options apply to alternative LF-3 to LF-7:

OPTION 1: NO DRUM REMOVAL

Estimated Capital Cost: NONE
Annual Operation and Maintenance: NONE
Estimated Present Worth: NONE
Estimated Implementation Time: NONE

Under this alternative, no excavation and removal of known buried drums and associated contaminants would be performed prior to capping

OPTION 2: DRUM REMOVAL (EXCAVATION AND REMOVAL OF ALL KNOWN AND SUSPECTED BURIED DRUMS AND ASSOCIATED SOILS)

Estimated Capital Cost: $514,000*
Annual Operation and Maintenance: NONE
Estimated Present Worth: $515,000
Estimated Implementation Time: 6 months

The figure is only a rough estimate: the actual coat will depend on the number of drums encountered. The excavation and removal of all known and suspected buried drums and associated contaminated soils prior to capping is an additional, separate option that could be used in conjunction with any or all of the containment Alternatives LF-3 through LF-7. Under this option, excavation would be initiated at two (2) test pit (TP) cluster locations (see figures 3 and 4), which includes TP-10 through TP-17 and TP-19 until ground water is encountered, the fill area depth limit is reached, or until no more drums are found. All excavated drums and visually contaminated soils would be sampled and tested. Contaminated materials would be shipped off-site for proper disposal. The Site would be regraded after drums were removed prior to installation of the selected cap.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In accordance with the NCP, a detailed analysis of each remedial alternative was conducted with respect to each of the nine criteria described below. This section discusses and compares the performance of the remedial alternatives considered against those criteria. All selected alternatives must at least attain the Threshold Criteria. The selected alternative should provide the best balance among the nine criteria. The Modifying Criteria were evaluated following the public comment period.

During the detailed evaluation of remedial alternatives, each alternative was assessed utilizing nine evaluation criteria as set forth in the NCP. These criteria were developed to address the requirements of Section 121 of CERCLA to ensure all important considerations are factored into remedy selection decisions.

Threshold Criteria

1 Overall Protection of Human Health and the environment addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2 Compliance with Applicable and Relevant and Appropriate Requirements (ARARs) address whether or not an alternative will meet all of the ARARs of the Federal and State environmental statutes or provide a basis for invoking a waiver.

Primary Balancing Criteria

3 Long-term Effectiveness and Permanence refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once remedial objectives a have been met.

4 Reduction of Toxicity, Mobility, or Volume addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as a principal element.

5 Short-term Effectiveness refers to the period of time that is needed to achieve protection, as well as the alternative's potential to create adverse impacts on human health and the environment that may result during the construction and implementation period.

6 Implementability is the technical and administrative feasibility of a remedy, including the availability of material and services needed to implement a particular alternative.

7 Cost Included estimated capital and operation and maintenance costs, and the present worth costs.

Modifying Criteria

8 Support Agency acceptance indicates whether, based on its review of the RI and FS reports and the ROD, the support agency opposes, and/or has identified any reservations with the preferred alternative.

9 Community acceptance refers to the public's general response to the alternatives described in the ROD and the RI/FS report. Responses to public comments are addressed in the Responsiveness Summary of this Record of Decision.

A comparative analysis of these alternatives, based upon the evaluation criteria noted above, is presented below.

Overall Protection of Human Health and the Environment

Except for the No Action and Minimal Action alternatives, all of the containment alternatives, LF-3 through LF-7, would minimize the potential human and ecological risk. These alternatives would also minimize precipitation infiltration to the waste, thereby reducing the potential for contamination migration. The Sip Avenue ditch sediments would be isolated from future exposure potential.

However, capping would result in the loss of alteration of terrestrial and aquatic wildlife habitats in the PJP Landfill area. Some estuarine emergent wetlands would be capped as part of the proposed actions. Shallow water aquatic habitat in the Sip Avenue ditch would be isolated as a result of the proposed filling. These actions generally could result in a loss of some wetland- associated species from the immediate Site area and in the loss of aquatic life from the ditch area. Terrestrial impacts adapted to grass/field environments are likely to inhabit the area once vegetation has been established on the cap. In order for the capping alternatives LF-3 through LF-7 to meet this criterion, wetlands mitigation activities (i.e. restoration, land banking) would have to be implemented at the Site.

Option 2: Removal of Drums, in conjunction with any of the capping alternatives, would provide protection of human health and the environment by reducing on-site contaminant concentrations and potential impacts to ground water quality.

Compliance with ARARs

Actions taken at any Superfund site must achieve ARARs of federal and state laws or provide grounds for waiving these requirements. The No Action, Minimal Action, and LF-3: Soil Cover alternatives do not comply with federal and state ARARs which regulate the closure and capping of either solid waste or hazardous waste landfills.

The No Action, Minimal Action, and capping alternatives do not address contamination in Sip Avenue Ditch sediments which are at levels in exceedance of the criteria set forth in NOAA sediment screening criteria. However, the capping alternatives all provide for replacement of the Sip Ave ditch with an alternative form of drainage, and would also provide protection from rainwater infiltration, thus reducing potential migration of subsurface contaminants into the ground water.

As part of the IRM in 1986 an estimated 10,000 drums (4,700 intact and 5,000 with contaminated soil) were disposed of off-site ARAR compliance would be aided by Option 2 in conjunction with any of the capping alternatives.

Because No Action and Minimal Action alternatives do not meet both threshold requirements of overall protection of human health and the environment or compliance with ARARs, they will not be discussed further in the evaluation of alternatives.

Long-Term Effectiveness and Permanence

The capping alternatives would promote surface water run-off; cap implementability will offset the need for ground water collection and treatment. Ground water data has shown a significant reduction in contaminant concentration on the IRM capped portion of the landfill. This fact suggest that by implementing one of the capping alternatives the natural attenuation of ground water would be enhanced, while at the same time isolating the Sip Avenue Ditch sediments from future exposure potential. However, the capping alternatives do vary in permeability. The least permeable cap will provide the least migration of landfill contaminants off-site. Alternative LF-7, New RCRA Hazardous Waste Cap, has the least permeability while LF-3, Soil Cover, has the greatest.

Option 2: Drum Removal in conjunction with a capping selection is the most effective in the long-term and the most permanent because the most concentrated areas of contamination would be permanently removed (in addition to the estimated 10,000 drums that were previously removed) from the Site and contaminated materials would then be shipped off-site for proper disposal.

Short-Term Effectiveness

In general, effective alternatives which can be implemented quickly with little risk to human health and the environment are favored under this criterion. The capping alternatives without the excavation option have high short-term effectiveness because they could be implemented relatively quickly (within three years) and would have relatively minor short-term risks to nearby workers, residents and commuters.

Construction of any of the capping alternatives would involve some excavation and handling of contaminated soils during the initial Site regrading, but exposure could be reduced through the use of suitable protective clothing and equipment. Exposure of the surrounding community through fugitive dust emissions could be easily controlled using good construction practices and air monitoring. Short- term risks to the community, workers, or the environment are expected to be minor.

However, Option 2 Drum Removal provides potentially increased hazardous conditions for the workers, community, commuters on the Pulaski Skyway, and the environment. However, this short term risk can be mitigated with proper health and safety, community awareness and air monitoring. Potential risks associated with the drum removal will be addressed during the design phase of the project via a site specific health and safety plan and an emergency response plan.

Reduction of Toxicity, Mobility or Volume

The capping alternatives without the excavation option would reduce mobility by preventing the migration of contaminants into the air and off-site run-off via erosion. The cap would also reduce leaching of contaminants into ground water However, these alternatives alone would not reduce toxicity or volume of the contaminants.

Option 2 Drum Removal, which consists of the excavation and removal of all known and suspected buried drums and associated soil would reduce the toxicity, mobility and volume of the contaminated material in the site itself. Option 2 would result in the reduction of the volume of contaminants in addition, the capping alternative would further reduce the mobility of any contaminants remaining on Site after excavation.

Implementation

All of the alternatives are fairly easily implementable from an engineering standpoint. The capping alternatives without the excavation option are easy to implement with the technology, equipment and resources being established and readily available. The RCRA Hazardous Waste Cap alternatives would take longer than the Solid Waste Cap alternative due to the multiple layer construction.

Option 2 Drum Removal is feasible, however, the implementation would present some difficulty due to the potential health and safety hazards. Again, these concerns can be mitigated. This option would also add to the length of time required to implement the remedy.

Cost

The capping alternatives are all the same order of magnitude, with the least expensive being the Solit Waste Cap and the cost expensive being the New RCRA and NJDEP Hazardous Waste Caps.

Option 2: Drum Removal increases the cost of each of the capping alternatives. Although subsurface contamination is not a current risk pathway, the excavation and removal option affords a degree of long-term effectiveness and permanence by excavation, removal and off-site treatment of buried drums and associated highly contaminated visibly stained soil. In addition, this option would minimize any future ground water contamination which may occur as the result of wastes contained in these known areas. Therefore, the cost of the value added from the reduction of subsurface contaminants may be warranted by reducing and possibly eliminating the need for long term ground water treatment.

Support Agency Acceptance

The United States Environmental Protection Agency supports the selected remedy presented in this Record of Decision.

Community Acceptance Community acceptance was evaluated after the close of the public comment period. Written comments received during the public comment period, as well as verbal comments during the public meeting on August 18, 1994, were evaluated.

The majority of comments received during the public comment period originated from the potentially responsible parties (PRPs). Their comments focused on the definition of landfill boundaries, the appropriateness of the preferred cap with respect to scope and effectiveness, as well as future use. Concerns were also raised during the public meeting regarding how reasonable risk is determined and the impact this remediation may have on currently operating facilities in the vicinity of the landfill. The PRPs we're concerned that a portion of the landfill area (as it was depicted in the FS drawings) was not a part of the PJP landfill site.

The responses to these and other comments are addressed in the Responsiveness Summary. Comments received during the public comment period indicated that the local residents were mostly satisfied with the preferred alternatives for the soil and ground water.

SELECTED REMEDY

RJDEP and EPA have determined after reviewing the alternatives and public comments, that Alternative LF-4 with Option 2 is the appropriate remedy for the Site, Because it best satisfies the requirements of CERCLA §121 42 U.S.C §9621, and the NCP's nine evaluation criteria for remedial alternatives, 40 CFR §300.430(e)(9).

Alternative LF-4: Modified RJDZP Solit Waste Cap (extending existing cap): $22,022,000, replacement of the Sip Ave ditch with an alternate form of drainage, and Option 2: Drum Removal (Excavation and Removal of All Known and Suspected Buried Drums and associated contaminated soil): $514,000, is the most appropriate remedy for the PJP Landfill Site.

The major components of the selected remedy include the following:

- Removal of all known and suspected buried drums and associated visibly contaminated soil;
- Capping the remaining landfill area of Site with a multi-layer, modified solid waste type cap; Extending the existing gravel lined ditch around the parameter of the Site to collect the surface water runoff;
- A passive gas or active venting system installed in the new portion of the cap. However, if an active system is deemed necessary, both areas will be included;
- Site fencing and institutional controls (e.g., deed restrictions and public information program);
- Periodic inspections of the cover installed during the IRM must be performed before and during the implementation of the remedial action. If the cover is damaged or degraded, then at least 1 additional foot of topsoil should be spread over the previously installed cover.
- Replacing the Sip Ave ditch with an alternate form of drainage;
- Quarterly ground water and surface water monitoring to evaluate the reduction of contaminant concentrations over times if a significant adverse impact is found, NJDEP and EPA will evaluate remedial alternatives and select an appropriate remedy in accordance with CERCLA and the NCP
- Because contamination levels in the ground water are above the Class IIA CWQC, a CEA/WRA will be established;
- Implementation of a wetlands assessment and restoration plan. The wetlands assessment will be performed before any of the remedial actions are begun.

The multi-layer cap would comply with RJDEP sanitary landfill closure requirements. Since removal of all known and suspected buried drum material and associated visibly contaminated soils would remove the significant hazardous waste known to be deposited in the landfill, closure utilizing a RCRA hazardous waste cap is not necessary. Based on the results of the baseline risk assessment the Site does not currently present an immediate risk to human health and the environment via the groundwater or surface water exposure pathways. Therefore, RJDEP and EPA determined it was appropriate to monitor and evaluate groundwater and surface water for a 5 year period and then assess what additional measures, if any, should be implemented. The use of a passive or active gas venting system would be determined during the remedial design phase of the project.

The capped area would require quarterly inspections and replacements, as necessary, of grass, seed and topsoil. Ground water and surface water monitoring will be performed quarterly to evaluate the reduction of contaminant concentrations and to determine if natural attenuation is occurring at the Site. The Site would be reviewed for five years in order to evaluate effectiveness of the remedy. The review will also include an assessment of current residual health risks, an evaluation of the effectiveness of the Site fencing to control access, and an evaluation of what additional remedial measures, if any, should be implemented based on the reviewed Site conditions.

The selected alternative provides the best balance among alternatives with respect to the evaluation criteria. RJDEP and EPA believe that the selected alternative would be protective of human health and the environment, would comply with the Remedial Action Objectives, would be cost effective, and would utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

The excavation and removal of drums and surrounding highly contaminate soil is protective of human health and the environment. The selected alternative has a favorable short-term effectiveness because it could be implemented relatively quickly. The selected alternatives also, provides for long-term effectiveness and permanence by removing and treating the highly contaminated materials from disposal areas. The long-term effectiveness and permanence of the alternative outweigh short-term risks associated with excavation.

Remedial Investigation and subsequent sampling results indicate that contaminants' concentrations in the shallow aquifer are reducing over time. Ground water contamination in the deep aquifer is at concentrations below any level of concern at the present time.

Implementation of the selected alternative (i.e., capping and drum removal) will reduce the leaching of contaminants into ground water. The five year ground water and surface water monitoring program and the model will enable NJDEP and EPA to reevaluate Site conditions and determine the effectiveness of the remedy selected. If a significant adverse impact is found, NJDEP and EPA will evaluate remedial alternatives and select an appropriate remedy in accordance with CERCLA and the NCP.

The preferred alternative provides protection to human health by preventing direct contact with the contaminated material, and by preventing the migration of contaminants by reducing infiltration and erosion. Moreover, the combination of this alternative and the excavation and removal of drums and surrounding contaminated soil option, would satisfy the statutory preference for remedies which utilize treatment as a principal element.

NJDEP realizes the inherent short-term risks associated with excavation and removal of contaminated drums and surrounding soil. For this reason, NJDEP would implement a comprehensive Site Health and Safety Plan to mitigate the short-term risks to nearby workers, residents, and commuters.

Maintaining the level of risk reduction afforded by the proposed remedy depends on preserving the long-term integrity of the cap and enforcement of institutional controls. Institutional controls would include use restrictions to restrict future use of the Site and public information programs to increase the public awareness of potential problems associated with the Site. The NJDEP Solid Waste Cap has proven to be a very effective and reliable remedial technology. Implementing the NJDEP Solid Waste Cap also presents few short-term risks. In addition, the NJDEP Solid Waste Cap with the incorporation of the existing IRM cap provides the maximum protection to human health and the environment at a reasonable cost.

STATUTORY DETERMINATIONS

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that when complete, the selected remedial action for the PJP Landfill Site must comply with applicable, or relevant and appropriate environmental standards established under federal and state environmental laws unless a statutory waiver is justified. The selected remedy also must be cost effective and utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes. The following actions discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy is protective of human health and the environment, as it effectively addresses the principal threats posed by the Site, namely: Chemical-specific ARARs:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs): (40 CFR Part 141)
- Clean water Act water Quality Criteria (WQC): (40 CFR Part 131)
- RCRA Maximum Concentration Limits (MCLs): (40 CFR 264)
- RCRA Land Disposal Restrictions: (40 CFR 268)
- New Jersey Safe Drinking Water Act MCLs: (NJAC: 7:10-16)
- New Jersey Water Pollution Control Act Standards for Groundwater: (NJAC: 7:9-6)
- New Jersey Water Pollution Discharge Elimination System: (NJAC: 7:14A)
- New Jersey Surface Water Quality Standards: (NJAC 7:9-4.1)

Location-specific ARARs:

< Clean Water Act, Section 404 (33 USC 466)

< Executive Orders on Floodplain Management and Protection of Wetlands: (E.O. 11988, 11990)

< EPA/COF Memorandum of Agreement on Wetlands Protection

< Fish and Wildlife Coordination Act: (16 USC 661)

< Endangered Species Act: (16 USC 1531)

< National Historic Preservation Act: (16 USC 470)

< New Jersey Flood Hazard Area Control Act: (NJSA 58:6A-50)

< New Jersey Freshwater Wetlands Protection Act: (NJAC 13:9B-1)

< New Jersey Freshwater Wetlands Transition Area Rules: (NJAC 7:7)

< New Jersey Freshwater Wetlands Protection Rules: (NJAC 7:7A)

< New Jersey Stream Encroachment Regulations: (NJAC 7: 13-1.1)

Action-specific ARARs:

< Clean Water Act Water Quality Criterial (WQC): (40 CFR Part 131)

< RCRA Land Disposal Restrictions: (40 CFR 268)

< Clean Air Act National Ambient Air Quality Standards: (40 CFR Part 50)

< OSHA General Industry Standards: (29 CFR 1910)

< OSHA Safety and Health Standards: (29 CFR 1926)

< OSHA Record Keeping, Reporting, and Related Regulations: (29 CFR 1904)

< RCRA Standards for Generators of Hazardous Waste: (40 CFR 262.1)

< RCRA Standards for Transporters of Hazardous Waste: (40 CFR 263.11, 263.20-21, and 263.30-31)

< RCRA Standards for Owners/Operators of Permitted Hazardous Waste Facilities: (40 CFR 264.10-264.18)

< RCRA - Preparedness and Prevention: (40 CFR 264.30-31)

< RCRA - Contingency Plan and Emergency Procedures: (40 CFR 264.50-264.56)

< RCRA - Groundwater Protection: (40 CFR 264.90-264.109)

< RCRA - Standards for Excavation and Fugitive Dust: (40 CFR 264.251-264.254)

< RCRA - Miscellaneous Units: (40 CFR 264.600-264.999)

< RCRA - Closure and Post-Closure (40 CFR 264.110-264.120)

< DOT Rules for Transportation of Hazardous Materials: (49 CFR 107, 171.0-172.558)

< New Jersey Hazardous Waste Manifest System Rules: (NJAC 7:26)

< New Jersey Hazardous Waste Treatment Storage and Disposal Facility Permitting Requirements: (NJAC 7:26)

< New Jersey Water Pollution Discharge Elimination System: (NJAC: 7:14A)

< New Jersey Surface Water Quality Standards: (NJAC 7:9-4.1)

< New Jersey Clean Air Act: (NJSA 26:2C)

< New Jersey Air Pollution Control Act: (NJAC 7:27-5, 13, 16, and 17)

Cost-Effectiveness

Of the alternatives which most effectively address the threats posed by Site contamination, the selected remedy provides for overall effectiveness in proportion to its cost. The estimated total project cost, including both the selected capping alternative and drum removal, is $22,536,000.

Utilization of Permanent Solution and Alternative Treatment Technologies to the Maximum Extent Practicable

Capping the Site would provide protection from rainwater infiltration, thus reducing potential migration of subsurface contaminations into ground water. This will significantly reduce the toxicity mobility and volume of the contaminants, and offer a permanent solution to the risks posed by surface soils.

Preference for Treatment as a Principal Element

In keeping with the statutory preference for treatment as a principal element of the remedy, the remedy provides for the excavation and removal of known buried drum and associated contaminants, which, would be shipped off-site for disposal, possibly by incineration.

The treatment of landfill material, however, is not practicable, because of the size of the landfill and because the identified on-site hot spots that represented the major sources of contamination were removed during the IRM.

DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the Site was released to the public on August 2, 1995. The Proposed Plan identified the preferred alternatives for groundwater and soil remediation. EPA reviewed all written and verbal comments received during the public comment period. Upon review of these comments, DEP determined that no significant changes to the selected remedy, as it was originally identified in the Proposed Plan, were necessary.

APPENDIX I

FIGURES

Figure #	Identification
1	General Location Map
2	PJP Site Map
3	Testpit (TP #10 - #17) Location
4	Testpit (TP #19) Location

<IMG SRC 0295262>
<IMG SRC 0295262A>
<IMG SRC 0295262B>
<IMG SRC 0295262C>
<IMG SRC 0295262D>
<IMG SRC 0295262E>

APPENDIX II

TABLES

Table #	Identification
5-15	Summary of Chemical Potential Concern At The PJP Landfill Site
5-17	Summary of Exposure Pathways To Be Evaluated For The PJP Landfill Site
5-24	Potential Exposures And Riskd Associated With Incidental Ingestion And Dermal Absorption Of Chemical In Surface Soils By Children Trespassing On The Landfill (Current Land Use)
5-25	Potential Exposures And Risks Associated With Incidental Ingestion And Dermal Absorption By Children Of Chemicals In Sediment From The Hackensack River Above The Sip Avenue Ditch (Current Land Use)
5-26	Potential Exposures And Risks Associated With Incidental Ingestion And Dermal Absorption By Children Of Chemicals In Sediment From The Hackensack River Above The Sip Avenue Ditch (Current Land Use)
5-27	Exposure And Risks Associated With Incidental Ingestion And Dermal Absorption By Children Of Chemicals In Sediment From The Hackensack River Downgradient Of The Ditch At The Western Corner Of The Capped Landfill (Current Land Use)
5-29	Potential Exposures And Risks Associated With Dermal Absorption By Children Of Chemicals In Surface Water In The Sip Avenue Ditch (Current Land Use)
5-30	Potential Exposures And Risks Associated With Incidental Ingestion and Dermal Absorption By Children Of Chemicals In Surface Water In the Hackensack River Above The Sip avenue Ditch (Current Land Use)
5-31	Potential Exposures And Risks Associated With Incidental Ingestion And Dermal Absorption By Children Of Chemicals In Surface Water In the Hackensack River Downgradient Of The Ditch At The Wester Corner Of The Capped Landfill (Current Land Use)
5-35	Potential Exposures and Risks Associated With Inhalation Of Volatile Chemicals By Trespassing Children (Current Land Use)
5-36	Potential Exposures And Risks Associated With Inhalation Of Volatile Chemicals By Nearby Residents (Current Land Use)
5-37	Potential Exposures And Risks Associated With Inhalation of Volatile Chemicals By Nearby Residents

(Current Land Use)

5-39 Potential Exposures And Risks Associated With Ingestion Of Chemicals In Groundwater (Hypothetical Future Land Use)

Table 5-15 SUMMARY OF CHEMICALS OF POTENTIAL CONCERN AT THE PJP LANDFILL SITE

Sediment

River Above West of Landfill Ditch

Chemical | Air | Surface Soil | Subsurface Soil | Test Pits | Grou

Organic:

Acetone

Aldrin X

alpha-BHC X X

Benzene X X X X X

Benzyl alcohol

Bis(2-chlorethy1)ether X X X

Bis(2-chloroisopropy1)ether X X

Bis(2-ethylhexyl)phthalate X X X X

2-Bustanone

Carbon tetrachloride X

Chlordane X X

Chlorobenzene

Chloroethane X

Chloreform X X X X

DDT X X

Di-n-butylphthalate

Di-n-octylphthalate X X X X

1.4-Dichlorobenzene X X

3.3' -Dichlorobenzidine X

1,1-Dichloroethane X

1,2-Dichloroethane X X

1,1-Dichloroethane X

trans-1,3-Dichloropropane X

Dieldrin X

2,4-Dimethylphenol X X

Dimethylphthalate X

Dioxin X

Endosulfan sulfate X X X
Endrin X
Ethylbenzene X
Heptachlor X
Heptachlor epoxide X
2-Hexanone X X
Methylene chloride X X X
3-Nitroaniline X
4-Nitroaniline X
n-Nitrosodipheny lamine X X
n-Nitroso-dipropylamine
PAH--cPAH X X X
PAH--ncPAH
PCBs X
Petroleum hydrocarbons X X X X X
Phenola (total) X
Tetrachlorethene X X
X
Toluene
X
1,1,1-Trichlorethane
X X
Trichlorethane X X
Vinyl acetate
Vinyl chloride X
X
Xylenes

Table 5-15 (Continued)

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN AT THE PJP LANDFILL SITE

Surface

River West of

Surface Subsurface Test

Above Landfil

Chemical Soil Soil Pits Grou

Ditch

Inorganic:										
Aluminum				X		X	X	X		X
Antimony	X		X		X		X			
Arsenic	X		X		X		X	X		
Barium				X			X	X	X	
Beryllium					X				X	
Cadmium										
Calcium	X					X				
Chloride						X	X	X		
Chromium					X		X	X	X	
Cobalt						X			X	
Copper						X		X		X
Iron			X		X		X	X	X	
Lead			X		X		X	X		
Magnesium			X		X			X	X	
Manganese						X	X	X		X
Mercury						X	X	X		X
Nickel		X		X			X	X		
Potassium						X	X	X		X
Selenium										
Sodium							X	X	X	
Sulfate						X	X	X		
Thallium						X				
Vanadium							X			
Zinc						X	X	X		X

Table 5-17

SUMMARY OF EXPOSURE PATHWAYS TO BE EVALUATED FOR THE PJP LANDFIL SITE

Potentially Exposed Population	Exposure Pathw
Current Land Use:	
Trespassing children playing on the landfill remediation staging area	Dermal absorption and incidenta soil
	Inhalation of chemicals release
Trespassing children wading in the Sip Avenue Ditch	Dermal absorption of chemicals sediment and surface water, and of chemicals in sediment
Trespassing children swimming in the Mackensack River near the site	Dermal absorption and incidenta chemicals in Hackensack River s sediment
Workers	Inhalation of chemicals is rele and dispersed offsite to adjace
Residents	Inhalation of chemicals release and disparsed offsite to nearby
Hypothetical Future Use:	
Residents	Ingestion of groundwater from aquifers (combined)
Workers	Dermal absorption and incidenta surface and subsurface soil and (Qualitative evaluation only.)
	Inhalation of chemicals release (Qualitative evaluation only.)

Table 5-24

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL
INGESTION AND DERMAL ABSORPTION
OF CHEMICALS IN SURFACE SOILS BY CHILDERN TRESPASSING O
THE LANDFILL
(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Quantity of Chemi
Quantity of Chronic
Soil Concentration (a) Ingested and Absorb
Dermally (c) Daily Intake (CDI) (d) Lifetime Upper Bound
(mg/kg) (mg/kg-day)
(mg/kg-day) Excess Cancer Risk (f)
Geometric Average Plausi
Average Plausible Potency Factor (e) Average Plausible
Chemical Mean Maximum Case Maximum Case
Maximum Case Case Maximum Case (mg/kg-day)-1 Case Maximu

Arsenic 1.00E+01 2.91E+01 3.64E-07 5.29F-
3.0E9-06 3.75E-07 8.39E-06 2.0E+00 7E-07 2E-
Bis(2-ethylhexyl)phthalate 1.70E+01 1.40E+02 9.27E-08 1.2
5.56E-09 1.49E-05 9.83E-08 2.76E-05 1.4E-02 1E-09
Chlordane 4.70E-02 5.65E-02 2.14E-10 5.14E-09
5.56E-11 4.01E-09 3.12E-10 9.14E-09 1.3E+00 4E-10
Chloroform 7.70E-03 7.10E-02 2.29E-10 1.29E-08
2.10E-10 6.29E-08 4.90E-10 7.58E-08 6.1E-03 3E-12
1,2-Dichloroethane 5.20E-03 1.90E-02 1.45E-10 3.45E-09
1.42E-10 1.68E-08 3.31E-10 2.03E-08 9.1E-02 3E-11
PAM--cPAH 1.00E+00 2.40E+00 5.18E-09 2.18E-07
4E-06
Tetrachloroethene 1.05E-02 1.50E-01 3.82E-10 2.73E-08
2.86E-10 1.33E-07 6.68E-10 1.60E-07 5.1E-02 3E-11
Trichloroethene 7.40E-03 6.70E-02 2.69E-10 1.22E-08
2.02E-10 5.94E-08 4.71E-10 7.16E-08 1.1E-02 5E-12

TOTAL --- --- --- --- ---

Quantity of Chemical Qu
Chemical Combined Chronic

Chemical	Soil Concentration (a) (mg/kg) Geometric Mean	Soil Concentration (a) (mg/kg) Maximum	Ingested and Absorb (mg/kg-day) Average Case	Ingested and Absorb (mg/kg-day) Plaus Maximum	Dermally (c) (mg/kg-day) Average	Dermally (c) (mg/kg-day) Plausible Maximum Case	Daily Intake (CDI) (d) Case	Daily Intake (CDI) (d) Maximum Case	Reference (RfD) (e) (mg/kg-day)	Ratio CDI: RfD (g) Average Case	Ratio CDI: RfD (g) Plausible Maxim
Antimony	2.07E+01	3.93E+01	8.78E-06	8.34E-05	4.88E-05	9.04E-06	1.32E-04		4.0E-04	2E-02	3E-01
Arsenic	1.00E+01	2.91E+01	4.24E-06	6.17E-05	1.27E-07	3.61E-05	4.37E-06	9.78E-05	1.0E-05	4E-03	
Bis(2-ethylhexyl)phthalate	1.70E+01	1.40E+02	1.08E-06	1.48E-0	6.49E-08	1.74E-04	1.15E-06	3.22E-04	2.0E-04	6E-05	
Cadmium	5.60E+00	2.81E+01	2.38E-06	5.96E-05	7.13E-08	3.49E-05	2.45E-06	9.45E-05	1.0E-05	2E-03	
Chlordane	4.77E-02	5.65E-02	3.04E-09	5.99E-0	5.07E-10	4.67E-06	3.64E-09	1.07E-07	6.0E-07	6E-05	
Chloroform	7.70E-03	7.10E-02	3.27E-09	1.51E-07	2.45E-09	7.34E-07	5.72E-09	8.85E-07	1.0E-07	6E-07	
Endrin	1.16E-01	7.50E-01	7.38E-09	7.95E-07	1.48E-09	6.20E-07	8.86E-09	1.42E-06	3.0E-06	3E+05	
Mercury	6.00E-01	1.70E+00	2.55E-07	3.61E-06	7.64E-09	2.11E-06	2.62E-07	5.72E-06	3.0E-06	9E-04	
Tetrachloroethene	1.05E-02	1.50E-01	4.45E-09	3.18E-0	3.34E-09	1.55E-06	7.79E-09	1.87E-06	1.0E-06	8E-07	
Trichloroethene	7.40E-03	6.70E-02	3.14E-09	1.42E-0	2.35E-09	6.93E-07	5.49E-09	8.35E-07	7.3E-07	7E-07	
HAZARD INDEX	---	---	---	---	---	---	---			<1 (3E-2)	<1 (6E-1)

(a) Conentrations as reported in Table 5-2.
(b) See text for methodology. Calculated using equation 1 and assumption Table 5-23.
(c) See text for methodology. Calculated using equation 2 and assumption Table 5-23.
(d) Sum of Ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by multiplying the CD1 by the potency factor.
(g) Calculated by dividing the CD1 by the Rfd.

Table 5-25

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL
INGESTION AND DERMAL ABSORPTION BY CHILDREN
OF CHEMICALS IN SEDIMENT FROM SIP AVENUE
(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Sediment Quantity of Chemi
Quantity of Chronic
Soil Concentration (a) Ingested and Absorb
Dermally (c) Daily Intake (CDI) (d) Lifetime Upper Bound
(mg/kg) (mg/kg-day)
(mg/kg-day) Excess Cancer Risk (f)
Geometric Average Plausi
Average Plausible Potency Factor (e) Average Plausible
Chemical Mean Maximum Case Maximum Case
Maximum Case Case Maximum Case (mg/kg-day)-1 Case Maximu

Arsenic 8.70E+00 2.01E+01 3.16E-06 3.05E-0
2.33E-06 3.27E-07 5.37E-06 2.0E+00 7E-07 1E-
Benzene 1.94E-01 5.82E-01 7.05E-09 8.82E-08 5
2E-08
Bis(2-ethylhexyl)phthalate 1.64E+01 5.90E+01 8.94E-08 4.47E-06
2E-07
Chloroform 3.81E-01 1.64E+00 1.39E-08 2.48E-07 1
1E-08
Methylene chloride 1.79E+01 2.30E+01 6.51E-07 3.48E-06 5
2E-07
n-Nitrosodipheny lamine 3.30E-01 3.30E-01 1.20E-08 5.00E-08
2E-09
PAM--cPAH 4.77E+00 1.48E+01 2.60E-08 1.12E-06
5.07E-06 1.14E-06 3.11E-08 2.26E-06 1.2E+01 4E-07 3E-0
Tetrachloroethene 2.79E-01 1.00E+00 1.01E-08 1.52E-07
6E-08

TOTAL --- --- --- --- ---

Sediment Quantity of Chemical
Chemical Combined Chronic
Concentration (a) Ingested and Absorb

(c) Daily Intake (CDI) (d)
(mg/kg) (mg/kg-day)
(mg/kg-day) Reference Ratio CDI: RfD (g)

Geometric Average Plaus
Average Plausible (RfD) (e) Average Plausible
Chemical Mean Maximum Case Maximum
Maximum Case Case Maximum Case (mg/kg-day) Case Max

Antimony	3.07E+01	9.38E+01	1.30E-05	1.66E-04	1.27E-04	1.34E-05	2.93E-04	4.0E-04	3E-02	7E-01
Arsenic	8.70E+00	2.01E+01	3.69E-06	3.55E-05	1.20E-07	2.72E-05	3.81E-06	6.27E-05 1.0E-03	4E-03	6E-02
Barium	2.06E+02	6.83E+02	8.74E-05	1.21E-03	2.84E-06	9.24E-04	9.02E-05	2.13E-03 5.0E-02	2E-03	4E-02
Beryllium	3.30E+00	2.58E+01	1.40E-06	4.56E-0	4.55E-08	3.49E-05	1.45E-06	8.05E-05 5.0E-03	3E-04	2E-02
Bis(2-ethylhexyl)phthalate	1.64E+01	5.90E+01	1.04E-06	5.21E-0	6.78E-08	7.98E-05	1.11E-06	1.32E-04 2.0E-02	6E-05	7E-03
Chloroform	3.81E-01	1.64E+00	1.62E-07	2.90E-06	1.31E-07	1.85E-05	2.93E-07	2.14E-05 1.0E-02	3E-05	2E-03
Copper	7.52E+02	3.40E+04	3.19E-04	6.01E-02	1.04E-05	4.60E-02	3.29E-04	1.06E-01 3.7E-02	9E-03	3E+00
Mercury	9.00E-01	5.10E+00	3.82E-07	9.01E-0						
Methylene chloride	1.79E+01	2.30E+01	7.59E-06	4.07E-05	6.17E-06	2.59E-04	1.38E-05	3.00E-04 6.0E-02	2E-04	5E-03
Nickel	5.63E+01	1.26E+03	2.39E-05	2.23E-03	7.78E-07	1.70E-03	2.47E-05	3.93E-03 2.0E-02	1E-03	2E-01
Tetrachloroethene	2.79E-01	1.00E+00	1.18E-07	1.77E-0	9.62E-08	1.13E-05	2.15E-07	1.30E-05 1.0E-02	2E-05	1E-03
Zinc	7.72E+02	9.83E+03	3.27E-04	1.74E-02	1.06E-05	1.33E-02	3.38E-04	3.07E-02 2.0E-01	2E-03	2E-01
HAZARD INDEX	---	---	---	---	---	---	---		<1 (5E-2)	<1 (4)

(a) Conentrations as reported in Table 5-11.
(b) See text for methodology. Calculated using equation 1 and assumption Table 5-23 and in the text.
(c) See text for methodology. Calculated using equation 2 and assumption Table 5-23 and in the text.
(d) Sum of Ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by multiplying the CD1 by the potency factor.
(g) Calculated by dividing the CD1 by the Rfd.

Table 5-26

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL
INGESTION AND DERMAL ABSORPTION BY CHILDREN
OF CHEMICALS IN SEDIMENT FROM THE HACKENSACK RIVER
ABOVE THE SIP AVENUE DITCH
(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Sediment Quantity of Chemi
Combined Chronic
Soil Concentration (a) Ingested and Absorb
Dermally (c) Daily Intake (CDI) (d) Lifetime Upper Bound
(mg/kg) (mg/kg-day)
(mg/kg-day) Excess Cancer Risk (f)
Geometric Average Plausi
Average Plausible Potency Factor (e) Average Plausible
Chemical Mean Maximum Case Maximum Case
Maximum Case Case Maximum Case (mg/kg-day)-1 Case Maximu

Arsenic 1.77E+01 6.34E+01 6.44E-07 9.61E-0
7.35E-06 6.65E-07 1.70E-05 2.0E+00 1E-06 3E-
Benzene 1.00E-03 1.00E-03 3.64E-11 1.52E-10 2
3E-11
Bis(2-ethylhexyl)phthalate 1.11E+00 4.70E+00 6.05E-09 3.56E-07
1E-08
Chloroform 6.00E-03 1.40E+02 2.18E-10 2.12E-09 1
1E-10
n-Nitroso-dipropylamine 4.13E-01 5.70E-01 1.50E-08 8.64E-08
4E-06
n-Nitrosodipheny lamine 1.60E-01 1.60E-01 5.82E-09 2.42E-08
9E-10
PAM--cPAH 4.91E+00 5.89E+01 2.68E-08 4.46E-06
5.22E-09 4.55E-06 3.20E-08 9.01E-06 1.2E+01 4E-07 1E-0

TOTAL --- --- --- --- ---

Sediment Quantity of Chemical
Chemical Combined Chronic
Concentration (a) Ingested and Absorb
(c) Daily Intake (CDI) (d)
(mg/kg) (mg/kg-day)
(mg/kg-day) Reference Ratio CDI: RfD (g)

Geometric Average Plaus
Average Plausible (RfD) (e) Average Plausible
Chemical Mean Maximum Case Maximum
Maximum Case Case Maximum Case (mg/kg-day) Case Max

Antimony 1.89E+01 2.20E+01 8.02E-06 3.89E-05
2.97E-05 8.28E-06 6.86E-05 4.0E-04 2E-02 2E-01
Arsenic 1.77E+01 6.34E+01 7.51E-06 1.12E-04
2.44E-07 8.57E-05 7.75E-06 1.98E-04 1.0E-03 8E-03 2E-01
Barium 1.72E+02 6.17E+02 7.30E-05 1.09E-03
2.37E-06 8.34E-04 7.53E-05 1.92E-03 5.0E-02 2E-03 4E-02
Bis(2-ethylhexyl)phthalate 1.11E+00 4.70E+00 7.06E-08 4.15E-0
4.59E-09 8.36E-06 7.52E-08 1.05E-05 2.0E-02 4E-06 5E-04
Cadmium 3.10E+00 5.00E+00 1.32E-06 8.84E-06
4.27E-08 8.76E-06 1.36E-06 1.56E-05 1.0E-03 1E-03 2E-02
Chloroform 6.00E-03 1.40E+02 2.55E-07 2.47E-08
2.07E-09 1.58E-07 4.61E-09 1.83E-07 1.0E-02 5E-07 2E-05
Mercury 1.60E-00 9.00E+00 6.79E-07 1.59E-0

HAZARD INDEX --- --- --- ---
--- --- --- <1 (3E-2) <1 (5E-1)

(a) Conentrations as reported in Table 5-12.
(b) See text for methodology. Calculated using equation 1 and assumption
Table 5-23 and in the text.
(c) See text for methodology. Calculated using equation 2 and assumption
Table 5-23 and in the text.
(d) Sum of Ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by multiplying the CD1 by the potency factor.
(g) Calculated by dividing the CD1 by the Rfd.

Table 5-27

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL
INGESTION AND DERMAL ABSORPTION BY CHILDREN OF CHEMICALS IN
SEDIMENT
FROM THE HACKENSACK RIVER DOWNGRADIENT OF THE DITCH
AT THE WESTERN CORNER OF THE CAPPED LANDFILL
(CURRENT LAND

POTENTIAL CARCIN

Quantity of Chemic
Combined Chronic
Sediment Ingested and Absor
Dermally (c) Daily Intake (CDI) (d) Lifetime Upper Boun
Concentration (a) (mg/kg-day)
(mg/kg-day) Excess Cancer Risk (f)
(mg/kg) Average Plausi
Average Plausible Potency Factor (e) Average Plausible
Chemical Case Maximum Case
Case Case Maximum Case (mg/kg-day)-1 Case Maximum Case

Benzene 8.00E-01 2.91E-08 1.21E-07
7.73E-07 5.27E-08 8.94E-07 2.9E-02 2E-09 3E-08
3E-11
Bis(2-ethylhexyl)phthalate 4.90E+01 2.67E-07 3.71E-
PAM--cPAH 1.08E+01 5.89E-08 8.18E-07
1.15E-08 8.34E-07 7.04E-08 1.65E-06 1.2E+01 8E-07 2E-

TOTAL --- --- ---

Quantity of Chemical Qu
Chemical Combined Chronic
Ingested and Absor
Daily Intake (CDI) (d)
Sediment (mg/kg-day)
(mg/kg-day) Reference Ratio CDI: RfD (g)
Concentration (a)
(mg/kg) Average Plaus
Average Plausible (RfD) (e) Average Plausible
Chemical Case Maximu
Case Case Maximum Case (mg/kg-day) Case Maximum Cas

Bis(2-ethylhexyl)phthalate 4.90E+01 3.12E-06 4.
2-Butanone 4.40E+01 1.87E-05 7.78E-05
4.96E-04 3.38E-05 5.74E-04 5.0E-02 7E-04 1E-02
Di-n-butylphthalate 9.80E-01 4.16E-07 1.73E-06
Ethylbenzene 5.50E+00 2.33E-06 9.72E-06
Mercury 2.00E+01 8.48E-08 3.
2.70E-07 8.76E-08 6.24E-07 3.0E-04 3E-04 2E-03
PAH--ncPAH 1.85E+01 1.18E-06 1.63E-05
Selenium 5.00E-01 2.12E-07 8.84E-07
1,1,1-Trichloroethane 1.30E+00 5.51E-07 2.30E-06

HAZARD INDEX --- --- --- ---
--- --- --- <1 (1E-3) <1 (2E-2)

(a) Conentrations as reported in Table 5-13.
(b) See text for methodology. Calculated using equation 1 and assumption
Table 5-23 and in the text.
(c) See text for methodology. Calculated using equation 2 and assumption
Table 5-23 and in the text.
(d) Sum of Ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by multiplying the CD1 by the potency factor.
(g) Calculated by dividing the CD1 by the Rfd.

Table 5-26

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION BY CHILDREN OF CHEMICALS IN SURFACE WATER IN THE SIP A DITCH

(CURRENT LAND USE)

POTENTIAL CARCINOGENS

	Surface Water Concentration (a) (mg/l)		Chronic Daily Intake (CDI) (b) (mg/kg-day)			Upper Bound Risk (d)	
Chemical	Geometric Mean	Maximum	Average Case	Plausibl Maximum Case		Average Case	Plausible Maximum Case
Arsenic	1.70E-03	4.50E-03	1.09E-09	1.96E-08	2.0E+00	2E-09	4E-08
Benzene	5.50E-03	1.60E-01	3.52E-09	6.98E-07	2.9E-02	1E-10	2E-08
Bis(2-chloroethyl)ether	1.24E-02	4.40E-02	7.94E-09	1.92E-07	1.1E+00	9E-09	2E-07
Bis(2-chloroisopropyl)ether	1.11E-02	2.10E-02	7.10E-09	9.16E	7.0E-02	5E-10	6E-09
Bis(2-ethylhexyl)phthalate	2.35E-02	1.70E-01	1.50E-08	7.42E	1.4E-02	2E-10	1E-08
Chlordane	4.00E-04	1.60E-03	2.56E-10	6.98E-09	1.3E+00	3E-10	9E-09
Chloroform	4.20E-03	1.00E-02	2.69E-09	4.36E-08	6.1E-03	2E-11	3E-10
n-Nitrosodiphenylamine	9.20E-03	1.30E-02	5.89E-03	5.67E-08	4.9E-03	3E-11	3E-10
TOTAL	---	---	---	---	---	1E-08	3E-07

NONCARCINOGENS

Surface Water Chronic Daily

Chemical	Concentration (a) (mg/l) Geometric Mean	Concentration (a) (mg/l) Maximum	Intake (CDI) (b) (mg/kg-day) Average Case	Intake (CDI) (b) (mg/kg-day) Plausible Maximum Case	RfD	Upper Bound Risk (d) Average Case	Upper Bound Risk (d) Plausible Maximum Case
Arsenic	1.70E-03	4.50E-03	1.27E-08	2.29E-07	1.0E-03	1E-05	2E-04
Barium	2.15E-01	1.56E+00	1.61E-08	7.94E-05	5.0E-02	3E-05	2E-03
Bis(2-chloroisopropyl)ether	1.11E-02	2.10E-02	8.29E-08	1.07E-06	4.0E-02	2E-06	3E-05
Bis(2-ethylhexyl 1)phthalate	2.35E-02	1.70E-01	1.75E-07	8.65E-06	2.0E-02	9E-06	4E-04
Chlordane	4.00E-04	1.60E-03	2.99E-09	8.14E-08	6.0E-05	5E-05	1E-03
Chloroform	4.20E-03	1.00E-02	3.14E-08	5.09E-07	1.0E-02	3E-06	5E-05
Chromium	1.85E-02	5.70E-02	1.38E-07	2.90E-06			
Ethylbenzene	1.05E-02	4.10E-01	7.84E-08	2.09E-05	1.0E-01	8E-07	2E-04
Manganese	2.11E-01	8.20E-01	1.58E-06	4.17E-05			
Mercury	2.00E-04	7.00E-04	1.49E-09	3.56E-08	3.0E-04	5E-06	1E-04
Nickel	1.99E-02	9.00E-02	1.49E-07	4.58E-06	2.0E-02	7E-06	2E-04
Vanadium	1.92E-02	3.10E-02	7.62E-08	1.58E-06	7.0E-03	1E-05	2E-04
Zinc	2.28E-01	2.31E-01	1.70E-06	1.18E-05	2.0E-01	9E-06	6E-05
HAZARD INDEX	---	---	---	---	---		

(a) Concentrations as reported in Table 5-8.
(b) See text for methodology. Calculated using equation 4 and assumption Table 5-28.
(c) Reported previously in Table 5-19.
(d) Calculated by multiplying the CDI by the potency factor.
(e) Calculated by dividing the CDI by the RfD.

Table 5-26

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENT INGESTION AND DERMAL ABSORPTION BY CHILDREN
OF CHEMICALS IN SURFACE WATER IN THE HACKENS RIVER ABOVE THE SIP AVENUE DITCH
(CURRENT LAND

POTENTIAL CARCI

Chemical	Surface Water Concentration (a) (mg/l) Geometric Mean	Surface Water Concentration (a) (mg/l) Maximum	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Average Case	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Plausible Maximum Case	Quan Abso Aver Cas	Combined Chronic Intake (CDI) (d) Plausible Case	Combined Chronic Intake (CDI) (d) Maximum Case	Potency Factor (e) (mg/kg-day)-1	Lifetime Upper Bound Excess Cancer Risk (f) Average Case	Lifetime Upper Bound Excess Cancer Risk (f) Plausible Maximum Case
Benzene	3.40E-03	9.00E-03	3.09E-08	3.41E-07	1.03	4.12E-08	4.54E-07	2.9E-02	1E-09	1E-08

NONC

Chemical	Surface Water Concentration (a) (mg/l) Geometric Mean	Surface Water Concentration (a) (mg/l) Maximum	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Average Case	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Plausible Maximum Case	Quan Abso Aver Cas	Combined Chronic Intake (CDI) (d) Plausible Case	Combined Chronic Intake (CDI) (d) Maximum Case		Reference (RfD) (e) (mg/kg-day)-1	Ratio DCI: RfD (g) Average Case	Ratio DCI: RfD (g) Plausible Maximum Case
Acetone	6.80E-02	6.80E-02	7.21E-06	3.00E-05	2	1.00E-05	9.61E-06	4.00E-05	1.0E-01	1E-04	4E-0
Barium	7.01E-02	2.64E-01	7.43E-06	1.17E-04	2	3.88E-05	9.91E-06	1.55E-04	5.0E-02	2E-04	3E-0
Beryllium	8.00E-04	1.00E-03	8.48E-08	4.42E-07							

```
1.47E-07    1.13E-07       5.89E-07            5.0E-03      2E-05           1E-0
      Chromium        1.55E-02        3.30E-02     1.64E-06     1.46E-05       5
      Copper          1.77E-02        8.80E-02     1.88E-06     3.89E-05       6
1.29E-05    2.50E-06       5.18E-05            3.7E-02      7E-05           1E-0
      Manganese            1.55E-02        3.78E-01     1.64E-05     1.67E-04
      Mercury         3.00E-04        6.00E-04     3.18E-08     2.65E-07       1
8-82E-08    4.24E-08       3.53E-07            3.0E-04      1E-04           1E-0
      Zinc            2.04E-01        2.13E-01     2.16E-05     9.41E-05       7
3.13E-05    2.88E-05       1.25E-04            2.0E-01      1E-04           6E-0

      HAZARD INDEX        ---        ---        ---           ---            ---
```

(a) Concentrations as reported in Table 5-9.
(b) See text for methodology. Calculated using equation 3 assumptions pr
5-28.
(c) See text for methodology. Calculated using equation 4 assumptions pr
5-28.
(d) Sum of ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by multiplying the CDI by the potency factor.
(g) Calculated by dividing the CDI by the RfD.

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INCIDENT INGESTION AND DERMAL ABSORPTION BY CHILDREN OF CHEMICALS IN SURFACE WATER

IN THE HACKENSACK RIVER DOWNGRADIENT DITCH AT THE WESTERN CORNER OF THE CAPPED LANDFILL

Chemical	Surface Water Concentratoin (a) (mg/kg)	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Average Case	Quantity of Chemical Ingested and Absorbed (b) (mg/kg-day) Plausible Maximum Case	Quan Abs Aver Cas	Quan Abs Plausible Maximum Case	Chronic (CDI) (d) Average	Chronic (CDI) (d) Plausible	Reference (RfD) (e) (mg/kg-day)-1	Ratio DCI: RfD (g) Average Case	Ratio DCI: RfD (g) Plausible Maximum Case
Barium	2.80E-02	2.97E-06	1.24E-05	9.88E-07	4.12E-06	3.96E-06	1.65E-05	5.0E-02	8E-05	3E-0
Chrmium	1.20E-02	1.27E-06	5.30E-06	4.24E-07	1.76E-06	1.70E-06	7.07E-06	5.0E-03	3E-04	1E-0
Copper	5.00E-03	5.30E-07	2.21E-06	1.76E-07	7.35E-07	7.07E-07	2.94E-06	3.7E-02	2E-05	8E-0
Di-n-butyTphthalate	1.20E-02	1.27E-06	5.30E-06	4.24E-	1.76E-06	1.70E-06	7.07E-06	1.0E-01	2E-05	7E-0
Manganese	1.15E-01	1.22E-05	5.08E-05	4.06E-						
Mercury	1.00E-03	1.06E-07	4.42E-07	3.53E-03	1.47E-07	1.41E-07	5.89E-07	3.0E-04	5E-04	2E-0
Zinc	2.16E-01	2.29E-05	9.54E-05	7.62E-06	3.18E-05	3.05E-05	1.27E-04	2.0E-01	2E-04	6E-0
HAZARD INDEX	---	---	---	--	---				<1 (1E-3)	<1 (5E-3)

(a) Concentration as reported in Table 5-10.
(b) See text for methodology. Calculated using equation 3 and assumption Table 5-28.
(c) See text for methodology. Calculated using equation 3 and assumption Table 5-28.
(d) Sum of ingestion and dermal intakes.
(e) Reported previously in Table 5-19.
(f) Calculated by dividing the CDI by the RfD.

Table 5-35

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE CHEMICALS BY TRESPASSING CHILDREN

(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Plausible Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Maximum Case	Potency Factor (c) (m	Upper Bound Average Plausible Case	Upper Bound Maximum Case
Benzene	1.31E-05	6.74E-04	1.10E-08	5.02E-06	2.9E		
Chloroform	1.89E-07	2.02E-05	1.58E-10	1.51E-07	8.1E		
Methylane chloride	4.21E-07	7.66E-05	3.52E-10	5.71E-07			
Tetrachloroethene	9.68E-07	2.91E-04	8.10E-10	2.17E-06			
Trichloroethane	7.74E-07	2.91E-04	6.47E-10	2.17E-06			
Vinyl Chloride	1.50E-06	8.57E-04	1.25E-09	6.39E-06			
TOTAL	---	---	---	---	---	7E	2E-06

NONCARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Plausible Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Maximum Case	R Dose (RfD) (c) (	(a) Average Plausible Case	Maximum Case
Chlorobenzene	2.51E-06	7.96E-05	2.55E-08	6.92E-06	5.0E		
1,1-Dichloroethane	6.29E-07	2.51E-04	6.14E-09	2.18E-05			
Methylane chloride	4.21E-07	7.66E-05	4.11E-09	6.66E-06			
Toluene	7.74E-06	1.44E-03	7.55E-08	1.25E-04	5.7E		

1,1,1-Trichloroethane	2.08E-07	1.44E-04	2.03E-09	1.25E-05	
Xylenes	1.98E-05	4.81E-03	1.93E-07	4.18E-04	4.0E
HAZARD INDEX	---	---	---	---	---

(6E-6) <1 (3E-3)

(a) Concentration as reported in Table 5-18.
(b) See text for methodology. Calculated using equation 5 and assumption Table 5-32.
(c) Reported previously in Table 5-19.
(d) Calculated by multiplying the CD1 by the potency factor.
(e) Calculated by dividing the CD1 by the RfD.

Table 5-36

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE CHEMICALS BY NEARBY WORKERS

(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Plausible Maximum Case	Potency Factor (c) (m	Upper Bound Average Case	Upper Bound Plausible Maximum Case
Benzene	6.11E-05	4.15E-05	8.61E-08	4.34E-06	2.9E		
Chloroform	8.83E-08	5.99E-07	1.24E-09	6.27E-08	8.1E		
Methylane chloride	1.97E-07	1.34E-06	2.78E-09	1.40E-07			
Tetrachloroethene	4.53E-07	3.07E-06	6.38E-09	3.21E-07			
Trichloroethane	3.62E-07	2.46E-05	5.10E-09	2.57E-06			
Vinyl Chloride	7.02E-07	4.76E-06	9.89E-09	4.98E-07			
TOTAL	---	---	---	---	---	6E	3E-07

NONCARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Plausible Maximum Case	Dose (RfD) (c) (	R (a) Average Case	R (a) Plausible Maximum Case
Chlorobenzene	1.22E-06	8.30E-06	1.34E-07	2.03E-06	5.0E		
1,1-Dichloroethane	2.94E-07	2.00E-06	3.22E-08	4.88E-07			
Methylane chloride	1.97E-07	1.34E-06	2.16E-08	3.27E-07			
Toluene	3.62E-05	2.46E-05	9.97E-07	6.01E-06	5.7E		

1,1,1-Trichloroethane	9.73E-08	6.61E-07	1.07E-08	1.61E-07	
Xylenes	9.28E-06	6.30E-05	1.02E-06	1.54E-05	4.0E
HAZARD INDEX	---	---	---	---	---

(3E-5)   <1 (5E-4)

(a) Concentration as reported in Table 5-18.
(b) See text for methodology. Calculated using equation 5 and assumption Table 5-33.
(c) Reported previously in Table 5-19.
(d) Calculated by multiplying the CD1 by the potency factor.
(e) Calculated by dividing the CD1 by the RfD.

Table 5-37

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE CHEMICALS BY NEARBY RESIDENTS

(CURRENT LAND USE)

POTENTIAL CARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Plausible Maximum Case	Potency Factor (c) (m	Upper Bound Average Case	Upper Bound Plausible Maximum Case
Benzene	2.51E-07	3.50E-07	4.93E-09	4.56E-08	2.9E		
Chloroform	3.63E-09	5.06E-09	7.13E-11	6.60E-10	8.1E		
Methylane chloride	8.09E-09	1.13E-08	1.59E-10	1.47E-09			
Tetrachloroethene	1.86E-08	2.59E-08	3.66E-10	3.38E-09			
Trichloroethane	1.49E-08	2.08E-08	2.93E-10	2.71E-09			
Vinyl Chloride	2.88E-08	4.02E-08	5.66E-10	5.24E-09			
TOTAL	---	---	---	---	---	3E	3E-09

NONCARCINOGENS

Chemical	Esitmated Air Concentration (a) (mg/m3) Average	Esitmated Air Concentration (a) (mg/m3) Maximum	Chronic Daily Intake (CDI) (b) (mg/kg-day) Average Case	Chronic Daily Intake (CDI) (b) (mg/kg-day) Plausible Maximum Case	Dose (RfD) (c) (	R (a) Average Case	R (a) Plausible Maximum Case
Chlorobenzene	5.02E-08	7.00E-08	7.67E-09	2.13E-08	5.0E		
1,1-Dichloroethane	1.21E-08	1.69E-08	1.69E-08	5.14E-09			
Methylane chloride	8.09E-09	1.13E-08	1.24E-09	3.44E-09			
Toluene	1.49E-07	2.08E-07	2.28E-08	6.33E-08	5.7E		

1,1,1-Trichloroethane	4.00E-09	5.58E-09	6.12E-10	1.70E-09	
Xylenes	3.81E-07	5.32E-07	5.32E-06	1.62E-08	4.0E
HAZARD INDEX	---	---	---	---	---

(2E-6)   <1 (5E-6)

(a) Concentration as reported in Table 5-18.
(b) See text for methodology. Calculated using equation 5 and assumption Table 5-34.
(c) Reported previously in Table 5-19.
(d) Calculated by multiplying the CD1 by the potency factor.
(e) Calculated by dividing the CD1 by the RfD.

Table 5-39

POTENTIAL EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF
CHEMICALS IN GROUNDWATER
(HYPOTHETICAL FUTURE LAND USE)

POTENTIAL CARCINOGENS

Groundwater Chronic Dai
Concentration (a) Intake (CDI) (b)
Lifetime Upper Bound
(mg/l) (mg/kg-day
Risk (d)

Geometric Average Plausible Po
Factor (c) Average Plausible
Chemical Mean Maximum Case Max
(mg/kg-day)-1 Case Maximum Case

Arsenic 4.70E-03 4.81E-02 1.16E-05 5.89E-04
2E-05 1E-03
Benzene 6.10E-03 5.80E-01 1.50E-05 7.10E-03
Bis(2-chloroethyl)ether 9.20E-03 2.00E-01 2.27E-05 2.4
2E-05 3E-03
Bis(2-chloroisopropyl)ether 8.90E-03 1.02E-01 2.19E-05 1
2E-06 9E-05
Chloroform 2.80E-03 1.00E-02 6.90E-06 1.22E-04
Methylane chloride 2.79E-02 5.60E-02 6.88E-05 6.86

TOTAL --- --- --- ---
5E-05 4E-03

NONCARCINOGENS

Groundwater Chronic Dai
Concentration (a) Intake (CDI) (b)
Lifetime Upper Bound
(mg/l) (mg/kg-day
Risk (d)

Geometric Average Plausible Po
Factor (c) Average Plausible
Chemical Mean Maximum Case Max
(mg/kg-day)-1 Case Maximum Case

Antimony 5.18E-02 1.13E-01 9.93E-04 3.23E-0
2E+00 8E+00
Arsenic 4.70E-03 4.81E-02 9.01E-05 1.37E-0
9E-02 1E+00
Barium 5.99E-01 1.74E+00 1.15E-02 4.97E-0
2E-01 1E+00
Bis(2-chloroisopropyl)ether 8.90E-03 1.02E-01 1.71E-04
Cadmium 2.80E-03 2.30E-02 5.37E-05 6.57E-0
1E-01 1E+00
Chloroform 2.80E-03 1.00E-02 5.37E-05 2.86E-0
5E-03 3E-02
Chromium 2.77E-02 1.35E+00 5.31E-04 3.88E-02
5.0E-03 1E-01 8E+00
Copper 2.31E-02 8.56E-01 4.43E-04 2.45E-0
1E-02 7E-01
Manganese 5.82E-01 4.19E+00 1.12E-02 2.
Mercury 4.00E-04 2.27E-02 7.67E-06 6.49E-0
3E-02 2E+00
Methylene chloride 2.79E-02 5.60E-02 5.35E-04 1.60E-0
9E-03 3E-02
Nickel 2.61E-02 2.10E-01 5.01E-04 6.00E-0
Thallium 2.10E-03 1.32E-02 4.03E-05 3.77E-0
6E-03 5E-02
Zinc 2.11E-01 4.18E+00 4.05E-03 1.19E-0
2E-02 6E-01

HAZARD INDEX --- --- --- --- ---

(a) Concentrations as reported in Table 5-7.
(b) See text for methodology. Calculated using equation 6 and assumption
text.
(c) Reported previously in Table 5-19.
(d) Calculated by multiplying the CD1 by the potency factor.
(e) Calculated by dividing the CD1 by the RfD.

APPENDIX III

ADMINISTRATIVE RECORD INDEX

Items Sent To Repository For PJP Landfill:

1.	Report of Health Effects Advisory Committee	12/7/88
2.	Community Respiratory Statue Relative to Burning Landfill	12/7/88
3.	NJ Bill 2661	12/7/88
4.	Supplement to Directive and Notice to Insurers Directive	5/17/88
5.	Community Relations Plan/Transcript of 12/7/88 Public Meeting	10/20/8
6.	HASP, FSP-QAPP	12/15/8
7.	RI Report Appendices A-S	12/5/91
8.	Background Investigation Report	11/21/9
9.	Buried Drum Investigation Report (Appendix A)	11/21/9
10.	Phase I RI	11/21/9
11.	Phase I, II & III FS	
12.	PJP Landfill - Interim Remedial Measures Health & Safety Volume I & II	
13.	Site Characterization Study Siegal Property	10/84
14.	Work Plan for Handling Hazardous Waste Drums and Other containers	10/17/
15.	PJP Landfill Interim Remedial Measure - Final Design Report	5/85
16.	PJP Landfill - Interim Remedial Measure - Final Report	
17.	PJP Landfill PRP Steering Committee - Comments of the Phase I Remedial Investigation for the PJP Landfill Site	1/92
18.	Volume 1 - Case Narrative - Characterization of Landfill Gases at PJP	
19.	D'Annunzio Associates - Project Plan including Health Safety Plan and Drum Handling Plan	
20.	D'Annunzio Associates - Fire & Hazardous Situation Contract	

21. Final report - PJP Landfill Bedrock Monitoring Well information

22. Work Plan Health and Safety Plan - PJP Landfill 12/7/93

23. Chronic BIO Monitoring Report 11/4&5/93

24. Field Sampling Episode Report - PJP Landfill Water and Sedimentation

25. PJP - Summary of November 1993 Sampling of Surface Water and Sedimentation

26. Letter "Notifying Potential Liabilility" 8/10/94

27. Letter "Directive & Notice to Insurer Number Two" 8/22/89

28. Letter "PJP Landfill Supplement to directive and Notice to Insurer Number One and Demand For Payment and its amendment 3/17/89

29. Letter "Multi-Site Directive and Notice to Insure" 5/7/9

30. Record of Decision for PJP Landfill Superfund Site, NJDEP 9/28/95

31. Maps, Surveys and Slides of PJP Landfill Superfund Site, Various dates (only located in NJDEP's Repository)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY - REGION II

290 BROADWAY

NEW YORK, NEW YORK 10007-1866

SEP 27 1995

Honorable Robert C. Shinn, Jr.
Commissioner
State of New Jersey
Department of Environmental Protection
401 East State Street
Trenton, New Jersey 08625

Re: EPA Concurrence of Selected Remedy
for PJP Landfill Superfund Site

Dear Commissioner Shinn:

This is to notify you that the Environmental Protection Agency (EPA) has reviewed the Record of Decision prepared by the New Jersey Department of Environmental Protection (NJDEP) for the PJP Landfill site. Based on this review, EPA concurs with the selected remedy to address contaminated surface soils and ground water at the site.

The major components of the selected remedy include the following:

- Removal of all known and suspected buried drum materials and associated visibly contaminated soil;
- Capping of the exposed landfill area of the site with a multi-layer, modified solid waste cap in accordance with NJDEP guidance;
- Installation of an appropriate gas venting system;
- Extension of the existing gravel-lined ditch around the perimeter of the site to collect surface water runoff;
- Replacement of the Sip Avenue ditch with an alternate form of drainage;
- Site fencing and institutional controls (e.g., land use restrictions and classification exemption/well restriction area);
- Routine inspections, maintenance and a reevaluation of the previously capped area of the landfill;
- Ground water and surface water monitoring to evaluate the reduction of contaminant concentrations over time and otherwise ensure the effectiveness of the remedy;
- Modeling to demonstrate the effectiveness of the cap in reducing the migration of ground water leachate from the landfill to the Hackensack River; and
- Implementation of a wetlands assessment and restoration plan.

In addition to the remedial components identified above, the Comprehensive Environmental Response, compensation and Liability Act, as amended, requires that the site be reviewed every five years because contaminants will remain on the site above health-based levels. The purpose of these reviews is to ensure that the selected remedy continues to provide adequate protection of human health and the environment. Further, if monitoring indicates that the landfill cap alone is not effective in reducing the migration of contaminants to ground and surface waters, additional remedial actions may be necessary.

We look forward to a continued cooperative working relationship with the Department to address the environmental concerns at this and other Superfund sites in New Jersey. If you have any questions regarding this concurrence letter, please do not hesitate to contact me at (212) 637-5000, or have your staff contact John Frisco, Deputy Director for New Jersey Programs, at (212) 637-4400.

Sincerely,

Jeanne M. Fox
Regional Administrator

RECORD OF DECISION
RESPONSIVENESS SUMMARY

PJP Landfill Site

Jersey City, Hudson County, New Jersey

New Jersey Department of Environmental Protection
Site Remediation Program
Trenton, New Jersey

This responsiveness summary is divided into the following sections;

A. Overview

B. Background on Community Involvement and Concerns

C. Summary of Comments Received During the Public Comment Period and NJDEP/UPFDA Responses

- I. Landfill Definition and Characteristics and Liability Issues
- II. Drums Found at Landfill
- III. Side Affects on Sip Avenue Ditch/Hackensack River/Newark Bay
- IV. Reuse of Site and Affect of Remediation on Adjacent Properties
- V. Recent Illegal Dumping at Site
- VI. Costs
- VII. Site Risk Issues
- VIII. Wetlands Issues
- IX. Interim Remedial Measures/Landfill Fires
- X. NJDEP Proposed Cap/Landfill Gas System

A. Overview

This is a summary of the public's comments and questions regarding the Pro Plan for remediation of the PJP Landfill Superfund site and the New Jersey Department of Environmental Protection's (NJDEP) responses to those commen

A public comment period was held from August 2, 1994 through September 30, and was extended, at the reques of potential responsible parties, until Oc 14, 1994. The purpose of the public comment period was to provide interes parties with the opportunity to comment on a Proposed Plan for remediation PJP Landfill site. During the public comment period, NJDEP held a public on August 18, 1994 at 7 p.m. at the Jersey City Municipal Building to disc results of the Remedial Investigation and Feasibility Study (RI/FS) report to present the NJDEP's preferred alternative for remediation of the site.

The preferred remedial alternative addresses cleanup remedies for the site includes landfill material, landfill gas and areas of buried drums and ass contaminated soil. Future monitoring and review requirements also are inc for ground water and surface water. The Proposed Plan's preferred remedia alternative includes components of media-specific alternatives developed f remediation of the site in accordance with NJDEP Bureau of Landfill Engine guidance, New Jersey Solid Waste Regulations regarding closure and post cl requirements for solid waste landfills, the Comprehensive Environmental Re Compensation and Liability Act (CERCLA) of 1980, as amended, and Section 300.430 (f) of the National Oil and Hazardous Substances Pollution Conting Plan (NCP). Specifically, the includes: 1) construction of a modified so waste cap over approximately 42 acres of the landfill area not addressed a of a 1986 Interim Remedial Measure (IRM); 2) installation of a passive or gas venting system; 3) replacement of the Sip Avenue Ditch with an alterna form of drainage; and, 4) quarterly ground water monitoring.

B. Background on Community Involvement

NJDEP prepared a community relations plan in June 1985 for the site detail site history, community concerns and remedial action taken to date. Also, June 1985, a public meeting was held in Jersey City to discuss NJDEP's pla extinguish subsurface fires present at the site. A public meeting was hel December 1988 to discussed the initiation of the RI/FS. Briefings for Jer officials and their county, state and federal representatives and various surrounding municipalicies were held in January 1989. Numerous press rele were distributed to the state-wide media announcing these public meetings describing remedial work to be performed. An update mailing list was deve in August 1994 for the site and used to inform interested residents and neighborhood groups as well as various officials about site activities.

c. Summary of Comments Received During the Public Comment Period and NJDEP/USEPA Responses

The majority of comments received during the public comment period origina from the potentially responsible parties. Their comments focused on the definition of landfill parameters, the appropriateness of the preferred ca future use of the site and the methodology and conclusions of the site ris assessment. One attorney submitted comments on behalf of a PJP potential responsible party group that included an alternate remedy that was present equally protective and more cost effective than the NJDEP preferred remedy Concerns were also raised during the public meeting regarding how reasonab is determined and the impact this remediation may have on currently operat facilities in the vicinity of the site. All written comments as well as t transcript of the August 18, 1994 public meeting can be found in the appen to this Responsiveness Summary.

I. Landfill Definition and Characteristics and Liability Issues

1. Comment: How much of the site is contaminated in cubic yards?

Response: Various written and photographic records and results of remedial work performed at the PJP Landfill site indicates that the site was used for the disposal of thousands of dru and hundreds of thousands of gallons of chemical waste alon with municipal, commercial and industrial refuse. It would cost prohibitive to determine whether every cubic yard of t site believed to be used for municipal, commercial and industrial refuse disposal also was contaminated by chemica wastes. Therefore, the goal of the RI was to characterize different media (i.e., ground water, soils, air, sediment) a broader scale to determine an appropriate response to mitigate potential adverse impacts on human health and the environment.

A 45-acre capped portion of the site contained significant amounts of hazardous materials in the form of drums, cylind and contaminated soils that were transported off site for permanent disposal. The remainder of the landfill also contains drums and contaminated soils that will be remediat as part of NJDEP's selected remedy noted in the Record of Decision (ROD).

2. Comment: How did the Department arrive at geographic boundaries of w is attributable to PJP? Can you give us an example of some the kinds of documents or sources you used to determine tha the landfill is 87 acres? Also, how do we know the chronology of dumping?

Response: Refer to the response to comment 3.

3. Comment: NJDEP's proposed cap inappropriately coincides with and is defined by the current property bounderies. Proper and adequate delineation of the landfill should have been performed to decline what need to be capped.

Response: The site description paragraph located on page 2 of the Rec of Decision defines those areas NJDEP intends to address as part of its selected remedy for the PJP Landfill site. The site boundaries are based upon studies conducted during the RI, NJDEP's review of reports of inspections conducted duri the operation of the PJP Landfill, aerial photographs of th site and document filed by the PJP operations in 1970. Collectively, these records and the RI/FS confirm that wast disposal activities extended well beyond the blocks and lot originally set forth in the documents filed by the PJP Landfill company. The Hackensack River, the fenced truckin terminals and Truck Routes 1 and 9 provided geographic limi of the site on the northwest, west, south and east sides. remedy will extend to the northeast to those parts of lots and 4B in block 1627.1 that are determined during design to have been used for disposal of hazardous substances.

4. Comment: Are logs available of the RI borings?

Response: Yes. logs of the RI borings are contained in the Administrative Record and available for review. The soil borings are in Appendix H of the Phase I RI report, Volume

5. Comment: Did the Department perform any investigation to determine whether any of the neighboring sites were contributing to contamination on this site?

Response: The only neighboring site up-gradient from the PJP landfill site is a cemetery to the east, which is not considered to a likely source of contamination.

6. Comment: How many PRPs are there?

Response: In 1992, NJDEP commenced cost recovery litigation seeking p costs and future costs and damages for the remediation of t Superfund site from entities and individuals alleged to be responsible for hazardous substances disposed at this site. As of September 1995 over 90 direct and third party defende have been included in this law suit.

7. Comment: Do you have many photographs in the Administrative Record? any photographs identify responsible parties for this site?

Response: There are aerial photographs taken during the years the landfill operated in the Administrative Record File at NJDE offices in Trenton. These photographs have been used to he determine what areas of the site needed to be capped. Also there are numerous slides and photographs of the PJP Landfi site.

II. Drums Found at Landfill

8. Comment: Approximately how many drums are located at the site?

Response: During NJDEP's IRM project, there were 4,700 intact drums removed from the site for permanent disposal. Also, an indeterminate amount of broken and crushed drums were remov along with contaminated soil.

Two additional areas were found during the RI that containe drums. These areas are included in the ROD as requiring remediation through excavation and off-site disposal. Duri the IRM pockets of drums usually were found to extend out a significant distance in several directions. Therefore, the current number of drums located at the site is not known an will not be determined until the excavations are actually performed.

9. Comment: Did any of the drums have markings on them?

Response: During the IRM a separate log sheet maintained for each of the 4,770 drums noting any markings in addition to a description of the contents of the drum.

10. Comment: Drum removal was not evaluated in the feasibility study and the areas of concern are unclear and inconsistent with the remedial investigation as only two areas have known buried drums, not 12, as DEP has proposed to investigate. Also, there is no criteria for proposed soil removal.

Response: In order for NJDEP's proposed cap to be effective and as suggested by NJDEP's 1993 sampling effort, it is necessary remediate the two known buried drum areas. These two known buried drum areas actually encompass the approximately 12 t pit areas. Although the exact criteria for soil removal wa not included in the Proposed Plan, it does state "associate visibly contaminated soils." The specific criteria for soi removal will be developed during the design phase. Such criteria may include, but not be limited to, the following examples: soils adjacent to or below containers (i.e., dru barrels, ets.) that have ruptured, looked or corroded; sta or discolored soils; material that visually appears to have orginated (i.e., leaked or spilled) from a container.

III. Site Affects on Sip Avenue Ditch/Hackensack River/Newark Bay

II. Comment: Was any investigation done by the Department to determine whether the Hackensack River or the Sip Avenue Ditch was in any way affecting the site, either positively or negatively

Response: It is not known whether the Hackensack River is affecting t site. No tidal studies were conducted in the RI. As is stated on page 420 of the RI, "The influence of the tides o (ground water) flow patterns is not known." In the future, DEP and EPA decide that a ground water remediation is neede for the PJP Landfill site, it may be appropriate to conduct tidal study. Such a study would be conducted through monitoring the tidal influence upon the wells at the site b continuously monitoring the shallow, deep and bedrock wells

The Sip Avenue Ditch does not affect the site. The ditch i a discharge point for ground water from both the northern a southern parts of the site, so no contaminants are moving f the ditch to the landfill. Ground water flow direction was determined during the RI by measuring water levels in site monitor wells. As is stated on page 225 of the RI, "Generally, most of the ground water at the site flows into. the SIP Avenue Ditch."

Leachate from the site is flowing into the ditch adding to contaminants already there. During the RI a leachate seep sampled (Landfill Leachate Sample PJP-SW-011) on the landfi adjacent to the Pulaski Skyway and Sip Avenue Ditch. Resul showed total volatile organic compounds of 1,017 parts per billion (ppb). The sample exceeded the Federal Surface Wat Quality Criteria for the following compounds: benzene (160 ppb), n-nitrosodiphenylamine (13 ppb), arsenic (4.5 ppb), barium (1,560 ppb), iron (8,410 ppb), manganese (235 ppb), lead (25 ppb) and nickel (90 ppb).

12. Comment: DEP's proposed 15-foot diameter enclosed concrete culvert f the Sip Avenue Ditch is grossly oversized. The proposed culvert is unnecessary to prevent contact with contaminated sediments along the Ditch because the contamination does no exceed the acceptable risk range. Some or all of sediment contaminants within the ditch cannot be attributed to the s because it is a storm water channel for areas beyond the si

Response: The exact design parameters for the Sip Avenue Ditch culver will be determined in the design phase. The reference to a 15-foot culvert, which appears in the FS, was an option proposed by NJDEP's contractor to address the Sip Avenue Di as part of an overall capping alternative. In order to properly maintain the integrity of the landfill cap, adequately channel surface water runoff and adequately prot human health and the environment, some type of remedial act is necessary for the Ditch.

Also, please refer to the response to comment No. 26 and 40

13. Comment: There may be a combined sewer overflow emptying into the Si Avenue Ditch from a truck stop area that would have to be addressed in the remediation.

Response: The design phase of this project will include the replaceme of the Sip Avenue Ditch with an alternate form of drainage that takes sewer overflow into account.

14. Comment: Is the leaching of contaminants from the landfill into the Hackensack River directly or indirectly affecting the dredg that is going on in the Newark Bay?

Response: NJDEP does not believe contaminant levels measured during RI in surface water and sediment at the site will adversely impact adjacent surface waters including the Hackensack Riv Consequently, dredging operations in Newark Bay, about two miles downstream from the site, also would not be adverseal affected.

IV. Reuse of Site and Affect of Remediation on Adjacent Properties

15. Comment: What steps are being taken to create the best opportunity f potential development in the future of this prime developme site? It appears that every ttime a site gets cleaned up it gets cleaned up to the minimum level that is required. A program needs to exist to try to preserve as much property possible for future development. Also, why did NJDEP not explore on-site remediation for the site to clean up the la and restore it to the tax base?

Response: In selecting a remedial alternative NJDEP must balance a number of factors including cost effectiveness and the requirement that the chosen remedy adequately protects huma health and the environment. While a cleanup plan that call for excavation and off-site removal of all contaminated was would leave the site available for unrestricted development the economics of such an alternative are not feasible becau the costs would be prohibitive. Removal and off-site dispo of all landfall materials was examined in the Phase II FS, was screened out due to excessive cost--approximately $1 billion--in the Phase III FS.

NJDEP's selected remedy will provide adequate protection of human health and the environment. Any proposed development the PJP Landfill site subsequent to implementation of NJDEP selected remedy will have to take such work into consideration. This means that the site owners or potentia developers may proposed to NJDEP and implement, if approved some type of redevelopment of this site as long as it does compromise the remedial measures performed.

Also, please refer to the response to comment No. 60.

It should be noted that the M & T Delisa Landfill Superfund site in Ocean Township, New Jersey, currently occupied by t Seaview Square Mail, is the only Superfund site in the stat that has been reused. The site was deleted in 1991 from th National Priorities List.

16. Comment: It appears that some currently active properties have been included in the area to be capped. How do you propose to

initiate further actions here while these facilities are still operating?

Response: NJDEP does not intend to disrupt any current large facilities with permanent structures. One aspect of the modified soli waste cap is to prevent additional infiltration into the ground water. Therefore, NJDEP considers areas that have buildings in place and concrete floors already to be capped

However, the area now occupied by A.T. Autowreckers, which operates a junk yard, will need to be either temporarily or permanently relocated off the site since this area will be capped and investigated for buried drums during the remedia design/action phase.

17. Comment: NJDEP's preferred remedy constitutes a compensable taking under the Fifth Amendment of the U.S. Constitution as priva property is being taken for public use. Also, future acces requirements for monitoring and maintenance constitutes imposing an easement and requires compensation.

Response: NJDEP believes that the remedial actions it intends to implement at the PJP Landfill site do not constitute a compensable taking under the applicable laws and regulation

18. Comment: The best use of the site is for light industry or possibly office or research and development facility. Also, recreational facilities could be constructed to benefit the local communtiy on certain areas of the landfill if an appropriate cap is installed.

Response: Please refer to response to comment No. 15.

V. Recent Illegal Dumping at Site

19. Comments: Comments were made that during the past year and a half abo 40,000 to 60,000 yards of fill material very high in polycyclic aromatic hydrocarbons (PAHs), demolition refuse possibly chemical wastes have been brought to or dumped at properties adjacent to the PJP Landfill site.

Response: NJDEP's solid waste enforcement element has investigated th fill material complaint and ordered the specific property owner to comply with appropriate state laws and regulations that cover the handling of such material. In terms of ille dumping of chemical wastes, NJDEP has forwarded the comment regarding continued dumping at this site to the New Jersey Division of Criminal Justice. Those allegations were investigated by that agency.

Much of the site is enclosed with a 10-foot high cyclone fence. While this fence restricts access to much of the si access can be obtained through a number of business establishments that border the site. The chosen remedy wil include security measures that will restrict, to the extent possible, all access to the unoccupied portion of the site.

VI. Costs

20. Comment: How did you arrive at an estimated cost for the NJDEP preferred alternative?

Response: The estimated cost includes calculations for capital costs, annual operation and maintenance costs and a present worth cost. The present worth cost is calculated using both the capital costs and annual operation and maintenance costs. Specifically, the present worth cost is derived from an analysis of expenditures that would occur at different time by discounting all future costs to a common year, usually t current year. The present worth cost is based on a 30-year period and a discount rate of seven percent. This allows t costs of each remedial action alternative to be compared on the basis of a single figure representing the amount of mon that, if invested in the base year and dispersed as needed, would be sufficient to cover all costs associated with the remedial action.

21. Comment: What is the margin of error in the cost estimates?

Response: The remedial cost estimates provided in the Proposed Plan c range from 30 percent less than to 50 percent more than the actual remedial costs.

22. Comment: How did you determine the preferred remedy is the most cost effective?

Response: In accordance with USEPA guidance, a detailed analysis of e remedial alternative in the Proposed Plan was conducted wit respect to nine criteria, one of which involves costs. A complete analysis using the nine criteria also is included the ROD on pages 16 to 20. The criteria in the ROD are divided into three separate references: threshold criteria primary balancing criteria and modifying criteria.

Under the provisions of P.L. 1993, c.139, Section 35g relat to remedial costs, DEP cannot require a responsible party t implement a permanent remedy at a contaminated site if a no permanent remedy can be implemented for less than half the cost. All of the alternatives presented in the NJDEP Propo Plan were nonpermanent remedies. Consequently, NJDEP's selected remedy noted in the ROD complies with the specific cost provisions of this statute.

23. Comment: Who is paying for the remediation currently and who will pa for the future remediation?

Response: NJDEP paid all costs associated with the RI/FS. Also, the performed by NJDEP was funded almost entirely with state monies. The Roman Catholic Archdiocese of Newark, an owner a portion of the PJP Landfill site, paid $46,575 toward a study conducted in 1985. Also, $336,824 was paid by a grou of potentially responsible parties in 1989 in response to a directive issued to those parties for the funding of the RI/FS. NJDEP is involved in cost recovery litigation seeki past and future costs associated with remediating the site. If the potential responsible parties will not perform futur actions, public monies will be used for an engineering desi and construction project to implement the ROD and long-term operation and maintenance costs.

VIII. Site Risk Issues

24. Comment: What was the worst case scenario used for calculating risks children from swimming in the Sip Avenue Ditch and what kin of exposure are you talking about?

Response: The maximum plausible scenario is the worst case scenario f calculating risks to children swimming in the Sip Avenue Di and is noted in Section 5.0 of the Phase I RI. The maximum plausible scenario is intended to place an upper bound on t potential risks by combining maximum plausible exposure estimates with upper bound health effects criteria. Data u to calculated the plausible maximum case are provided in Ta 5-25 of the Phase I RI. They include, sediment concentrati quantity of chemical ingested and absorbed, quantity of chemical absorbed dermally, combined chronic daily intake, potency factor and reference dose.

The exposure pathways evaluated for the Sip Avenue Ditch al are discussed in detail in Section 5.0 of the Phase I RI. Specifically, the potentially exposed population is trespassing children wading in the Sip Avenue Ditch. The exposure pathways evaluated for this population are dermal absorption of chemicals in the Ditch sediment and surface water and incidental ingestion of chemicals in the Ditch sediment.

25. Comment: How did you determine what is a reasonable risk with regard human health?

Response: In order to determine what is a reasonable risk for human health, NJDEP followed USEPA guidelines. These guidelines included an acceptable exposure as having an excess carcinogenic risk in the range of one in ten thousand to on in one million (1x10-4 to 1x10-6). After the RI/FS and Ris Assessment were performed for the PJP site, NJDEP adopted a new allowable cancer risk: one in one million (1x10-6) bas on P.L. 1993, c.139, Section 35d.

To assess non-carcinogenic effects, NJDEp follows USEPA's hazard index guidelines. A hazard index with a value great than one is generally identified with potential adverse hea effects. Details on the public health evaluation are provi in Section 5.0 of the Phase I RI.

26. Comment: NJDEP did not consider background conditions when evaluatin potential risks presented by the site. Arsenic is used as example of a naturally occurring inorganic that should not have been included in the assessment. Also, the proposed remedial action for the Sip Avenue Ditch is based on potent

risks from non-site related contaminants.

Response: NJDEP believes that it is inappropriate to compare sediment concentrations from the Sip Avenue Ditch with the NJDEP Soi Cleanup Criteria to determine site-related contaminants of concern. The example of 20 parts per million for arsenic i soils considered to be "natural background" is not relevant sediments in the Sip Avenue Ditch.

In the absence of native soils on site, it was unlikely tha true background samples could be obtained at this urban, industrialized site. NJDEP decided to rely on a reference location at the upgradient-most portion of the Sip Avenue Ditch. It is not unreasonable to include contaminants of concern at background levels if they pose a risk. Also, it may be conservative to retain a chemical detected at low concentrations if it is a class A carcinogen, such as arsen

NJDEP acknowledges that the Sip Avenue Ditch does not originated on site and does provide a pathway for non-site related contaminants to enter the on-site portion of the Ditch. Nevertheless, NJDEP's ultimate decision to remediat the Sip Avenue Ditch was largely based on engineering principles associated with the modified solid waste cap included in the selected remedy rather than solely human health and ecological risk concerns.

Also, please refer to response to comment No. 12.

27. Comment: The risk assessment concludes that excess risks warranting remedial action are present based on soil concentrations th are actually below NJDEP cleanup guidance.

Response: As shown in the Phase III FS, Table 1-3, numerous compounds were detected at concentrations exceeding NJDEP subsurface soil cleanup criteria.

28. Comment: The use of National Oceanographic Atmospheric Administratio (NOAA) sediment screening quidelines to evaluate impacts to Sip Avenue Ditch is not appropriate, since no data were collected to assess benthic community presence/absence, structure or function, or to assess upgradient chemical conditions.

Response: The environmental assessment performed for the site (Phase RI, Section 5.7) is considered to meet the standard practic for that time period. It was not then, nor is it now, standard practive to conduct benthic macroinvertebrate surv as part of a baseline ecological risk assessment. Risk to ecological receptors from contaminated sediments is initial screened based upon comparison with NOAA sediment quality guidelines. Exceedances of these guidelines may suggest th potential for adverse ecological effects and thus may sugge the need for rigorous ecological investigations, such as benthic surveys.

29. Comment: The chemical sensitivity of resident benthic species is hig

variable and may differ significantly from the organisms us in laboratory settings; selection of a remedy based upon laboratory bioassay results is not appropriate.

Response: NJDEP interpreted this comment to imply that the NOAA guidelines are based on laboratory bioassays and therefore not appropriate for determining effects on in situ benthic species. In fact, the NOAA guidelines are based upon data from three basic approaches: the equilibrium-partitioning approach; the spiked-sediment bioassay approach; and, vario methods of evaluating synoptically collected biological and chemical data in field surveys. NJDEP has always considere NOAA sediment quality quidelines, as well as other sediment quality guidelines generally available, as screening level values and are not intended to determine the need for a remedial action.

Also, please refer to response to Comment No. 12.

30. Comment: Since the upgradient sources of contaminants severely impac the Sip Avenue Ditch and Hackensack River, the area is not pristine and the evaluation of impacts to such a system require information regarding baseline conditions for comparison.

Response: Please refer to the response to comment No. 26.

31. Comment: The application of NOAA sediment screening guidelines to Si Avenue Ditch sediments is inappropriate because the criteri originated partly from data based on equilibrium partintion coefficients, which do not address bioavailability of the compound or the organic carbon/acid volatile sulfide concentrations in sediment.

Response: The equilibrium partitioning approach to sediment quality evaluations does in fact address organic carbon content, si partitioning of a contaminant between sediments and intersititial water is dependent upon organic carbon conten The total organic carbon (TOC) is an integral part of the calculation for the sediment-specific criterion value and T content is directly related to bioavailability.

NJDEP and USEPA Region II do not endorse the routine use of acid volatile sulfide (AVS) to normalize sediment metals concentrations. NJDEP believes that much research is neede before this approach is widely applied. For example, additional data is needed to evaluate the use of AVS for oxidized sediments, where AVS concentrations can be low, invalidation the normalization of metals concentrations.

32. Comment: NOAA Effects Range-Low (ER-L) and Effects Range Median (ER- values are not to be construed as NOAA standards or criteri exceedance of these values do not infer effects at a particular site.

Response: NJDEP's use of NOAA guidelines has always been for screenin purposes. They have never been used or construed as remediation "standards."

Also, please refer to the response to comment 28.

33. Comment: Of the data presented, the mean sediment concentrations exceeded the NOAA ER-M for only four inorganics. It is inappropriate to use the NOAA "effects-based" values for comparison to site data, since "effects" do not necessarily equate with mortality.

Response: Examination of Tables 4-8 and 4-10 in the Phase I RI indica exceedances of the ER-L values for six inorganics and eight PAHs; the ER-M is exceeded for four inorganics. NJDEP and Region II routinely consider both the ER-L and ER-M values, well as any other appropriate State, Federal or literature values, in a "weight of evidence" approach when determining sediment quality. While it is true that "effects" do not equate with "mortality," we are certainly concerned with an sub-lethal effect (such as effects on reproduction, decreas growth, etc.) that could negatively impact the ecosystem.

34. Comment: Biological effects-based approaches--such as sediment bioansays, tissue residues--based methods, apparent effects thresholds approach, etc.--should have been used to derive thresholds concentration limits for contaminants in sedimen

Response: Based on exceedance of NOAA guideline, it is agreed that mo rigorous evaluation of sediment toxicity could have been appropriate for studies subsequent to the Phase I RI. However, the need for remediation of the Sip Avenue Ditch w largely based on engineering principles associated with the modified solid waste cap included in the NJDEP selected rem rather than solely human health and ecological risk concern

35. Comment: There are insufficient data to characterize Sip Avenue Ditc as an aquatic habitat, or that site-related constituents contribute to potential ecological risk. Past studies did characterize presence/absence of a viable aquatic community nor did they use a biological effects-based approach for deriving threshold concentration limits; ammonia, hydrogen sulfide and dissolved oxygen should have been measured.

Response: Please refer to the response to comments 26 and 28-34. Als ammonia, hydrogen sulfide and dissolved oxygen would normal be run as part of sediment bioassay testing, which was not done during this portion of the RI.

36. Comment: Based on the information in the Chronic BioMonitoring Repor a determination cannot be made about impacts to surface wat and piota attributable to the site contrary to what is stat in the Proposed Plan. Specifically, the data set from November 1993 is inadequate to assess the ecological integr of the current system nor are the data adequate to differentiate site-related contributors to degradation, if any.

Response: Please refer to the detailed response to comments 26 and 28

37. Comment: Physical/chemical data, such as grain size, hydrogen sulfid in sediment, total organic carbon, dissolved oxygen, ammoni and temperature, should have been collected and used to conduct appropriate evaluation of the sediment and surface water data and bioassay results.

Response: NJDEP agrees that it would have been appropriate to measure the referenced conventional parameters and recommends their inclusion should any further testing be conducted. However their omission has no impact on the remedial decision becau the need for remediation of the Sip Avenue Ditch was largel based on engineering principles associated with the modifie solid waste cap included in the NJDEP selected remedy rathe than solely human health and ecological risk concerns. It should be noted that temperature, dissolved oxygen, pH, salinity and conductivity were measured by the laboratory conducting the bioassay on those samples, prior to test initiation. Those results are contained in the appendix to the Chronic BioMonitoring Report.

38. Comment: Inconsistencies between the analytical and bioassay results require that more information regarding test conditions be made available, and presented with the data. It cannot be concluded that the cause of mortality was the test solution

Response: NJDEP recognizes that the results of the bioassay tests are inconclusive. Based upon the contaminant levels measured i the river water, high mortality would not ordinarilly be expected. Furthermore, the lowest mortality observed is associated with the highest chemical contamination, while t highest mortality observed is associated with the lowest contaminant levels. It is the experience of NJDEP's Site Remediation Program that these ostensible inconsistencies between bioassay and chemical data are not uncommon and, therefore, we have come to use a "weight of evidence" appro employing various environmental assessment methods when assessing ecological impacts from contaminated sites.

39. Comment: Relevant background references should have been identified order to allow a comparison of the bioassay results associa with the site.

Response: Please refer to the response to comment 26.

40. Comment: The significant on-site risk identified as unacceptable in Proposed Plan in not greater than the EPA acceptable risk range of 1 x 10-4 to 1 x 10-6. Based on the Human Health R Assessment, there is no need to conduct a remedial response action addressing the Sip Avenue Ditch because the identifi site risks are within the EPA's acceptable risk range.

Response: Normally, a baseline risk assessment evaluates the risk pos by the site in the absence of any remedial action. In the case of the PJP Landfill site, an IRM cap had already been in place prior to evaluating site-wide risk. NJDEP decided that a residential exposure scenario (a house placed on top of the landfill with occupants eating the leachate and drinking contaminated water) was not realistic. Therefore, exposure was limited to children trespassing that included time spent playing in the Sip Avenue Ditch.

NJDEP acknowledges that the carcinogenic risk falls within EPA's acceptable risk range. However, a Hazard Index of 4 calculated for current land use for the plausible maximum c of potential exposures and risk associated with incidental ingestion and dermal absorption by children of chemicals in sediment from Sip Avenue Ditch.

Also of relevance is EPA's Directive 9355 3-11FS for CERCLA Landfill Sites." Page three of this EPA Directive states, "Where established standards, for one or more contaminants a given medium are clearly exceeded, the basis for taking remedial action can be established. Detailed, quantitative assessments that consider all chemicals, their potential additive effects, or additivity of multiple exposure pathwa are not necessary to initiate remedial action." On page 38 section 5.9.3 of the Phase I RI, the comparison of site dat to ARARs is discussed. Measured concentrations in soil, ground water and surface water exceeded these values.

Also, please refer to the response to comment No. 12.

41. Comment: There is no need to conduct a remedial response action addressing vented landfill gas because the identified site risk are all within or less than EPA's acceptable risk rang of 10-4 to 10-6.

Response: NJDEP acknowledges that the risk estimate for inhalation of vented landfill gas is within the EPA's acceptable risk ran However, NJDEP's ultimate decision to install a gas venting system is not a risk-based decision.

Also, please refer to the response to comment 59.

42. Comment: Risk estimates for carcinogenic PAHs are misrepresented bas upon the summation for the class of chemicals versus evaluation of individual components.

Response: At the time the risk assessment was perforemed, it was the policy of both NJDEP and EPA Region II to treat all carcinogenic PAHs quantitatively with the same potency as Benzo(a)pyrene, while recognizing in the uncertainty sectio of the risk characterization that this approach may overestimate the true risk posed by the site.

43. Comment: The potential off-site risk is actually greater than risk estimates for the potential exposure to current on-site conditions.

Response: Comparing risk from anthropogenic background conditions off site to site-related risks are not relevent for determining remedial actions at NPL sites.

44. Comment: The risk assessment used the detection limit as the concentration present when a non-detect was indicated for inorganic chemicals in determining site-wide averages of th compounds.

Response: This was NJDEP policy at the time the risk assessment was done. Total risk from the Sip Avenue Ditch is 4x10-5, of which 3x10-5 is a result of carcinogenic PAHs.

45. Comment: The scope of the remedy as it pertains to the Sip Avenue Di is inconsistent with the potential risk determined by NJDEP and supported by site engineering data.

Response: Please refer to the response to comment 12.

46. Comment: The Human Health Risk Assessment used extrapolated emission concentrations at estimated maximum discharge rates when evaluating risks that are overly conservative. The non-methane organic compound should have been quantified on a weight/time basis with results reported in pounds per eight hours. NJDEP should have used EPA Method 25C to analyze landfill vent gases rather then EPA Method TO-14.

Response: Table 5-18 of the Phase I RI lists a summary of estimated ambient air concentrations for the site for both the geomet mean and maximum air concentrations. It would be inappropriate to use results reported on an eight-hour basi for nearby residents. Not using a time-weighted approach f the trespasser and worker would probably overestimate site-related risks. However, site risks are already less than 1x10-6 for all scenarios except the Plausible Maximum Case the child trespasser, which is 2x10-6, a level EPA deems discretionary for taking remedial action. Finally, EPA Met 25C was not developed until 1991, so it was not feasible to use this methodology for the site RI completed prior to 199

47. Comment: A reference was made to a statement in the Phase III FS prepared by NJDEP's contractor ICF Technology Company that "there were no contaminants found in the surface soil sampl data in exceedance of the current NJDEP non-residential surface soil cleanup criteria; and there were no contaminan found in the subsurface soil sampling data in exceedance of the current subsurface soil cleanup criteria."

Response: Further scrutiny of the FS report indicates that the ICF statements are erroneous. In order to correctly evaluate t data, it is necessary to review the RI and Proposed Plan. RI data tables depict that contaminants were detected in surface, subsurface and test pit soil samples at concentrations greater than NJDEP's surface and subsurface soil cleanup criteria in use at the time the RI/FS was performed. Please note that the current soil cleanup crite categories are different from those used during the RI/FS. Presently, DEP's soil cleanup criteria is listed under the categories of residential direct, non-residential direct contact and impact to ground water.

48. Comment: The cost of the NJDEP proposed solid waste cap is not justified based on risk assessments:

Response: Please refer to the response to comments No. 26 and 40.

VIII. Wetlands

49. Comment: It is a presumption in the Proposed Plan that wetland mitigation/land banking will be required as part of the remediation of the site. A functional wetland evaluation should have been conducted at the site prior to determining if, and what types of, compensatory measures are required.

Response: While NJDEP implies in Section XIII of the Proposed Plan t a mitigation plan to address areas impacted will be prepare it is also stated that the design phase will include a wetl assessment. In Section XIII of the Proposed Plan NJDEP sta that "a qualitative assessment of the habitat values, acrea tidal influences and other defining factors will characteri the wetlands and better provide requirements for the restoration of any wetlands found to be impacted." Thus, wetlands are appropriately considered in the remedial design/action phases. During further wetland characterizat and compensatory decisions, NJDEP will use "Considering Wetlands at CERCLA Sites" (EPA540/R-94/019, May 1994) as a guide.

50. Comment: NJDEP did not evaluate the existing wetlands or perform a species inventory.

Response: This statement appears erroneous because it does not take i account work performed during the RI. Specifically, work performed during the RI, as noted in Section 5.0 of the Pha I RI, includes identifying wetlands, conducting a vegetatio inventory, and listing expected terrestrial wildlife and aquatic species and observed wildlife.

IX. IRM/Fires

51. Comment: In the late 1980's underground fires occured in an area defined as Lincoln Park West. Additionally, there have bee other underground fires in that area as late as a couple of years ago. What studies have been done to see what effects the PJP Landfill has had on this area? Can DEP require that additional testing be done in that area?

Response: Historical information indicates that underground fires did occur in 1986 in the Lincoln Park West area, which is near PJP Landfill site. These fires were extinguised in 1986 by Boots and Coots, the same NJDEP contractor responsible for extinguishing the fires at the PJP Landfill site. The PJP Landfill site and the Lincoln Park West area are separated roads and other paved surfaces. There is no connection between the fires at the two sites. Local officials can request that NJDEP conduct a preliminary assessment and sit investigation of the Lincoln Park West area as a separate action.

52. Comment: What kind of cap was used during the IRM?

Response: A two-foot cap was installed by NJDEP during the IRM. A cr section of the IRM cap consists of the following sections: six inches of clean fill material (bottom layer); 12 inches clay (middle layer); and, six inches of topsoil that was hydroseeded (top layer).

53. Comment: How can you guarantee the fire will not flare up again?

Response: NJDEP took all possible steps during the IRM to prevent a f from reoccurring. These included: removing hazardous materials that fueled the fire; excavating and dousing the fill to the water table; and, compacting and capping the fi to prevent it from reigniting.

X. NJDEP Preferred Remedy

54. Comment: The NJDEP proposed Solid Waste Cap design for the PJP Landf is not in compliance with the most current NJDEP Bureau of Landfill Engineering guidance. The NJDEP has not followed own guidance.

Response: NJDEP's proposed cap for the site is a modified solid waste cap. It should be noted that at the present time NJDEP's "Technical Guidance for Final Covers at Sanitary Landfills" guidance, not a promulgated regulation.

55. Comment: The NJDEP proposed solid waste cap may prove to be an ineffective "barrier" to prevent precipitation infiltration

Response: NJDEP's proposed cap for the site incorporates USEPA guidan that called for a cap with a 10-7 impermeability to ensure adequate impermeability for the site.

56. Comment: The NJDEP proposed impervious modified Solid Waste Cap will inhibit expedient natural attenuation since it does not account for the hydrological setting of the landfill medium A more "pervious" cover would be more beneficial.

Response: Due to the nature of the waste in the uncapped portions of site, it is necessary to install an impervious cap.

57. Comment: The NJDEP proposed 3.5 foot thick Solid Waste Cap map

Response: Please refer to the responses to comment No. 16.

58. Comment: The NJDEP proposed modified solid waste cap with a high density polyethylene (plastic) and/or clay layer will inhibit development in the area.

Response: NJDEP will work with interested parties to allow for reuse the site.

Also, please refer to the response to comment No. 15.

59. Comment: The NJDEP Proposed Plan is inconsistent with respect to landfill gas management. An active gas collection system w eliminated from consideration while a gas treatment system retained in the Phase I and II feasibility study, which is contradictory because you need a collection system if you h a gas treatment unit. The Proposed Plan should reflect gas management by monitoring or appropriate actions should be determined during the design phase. Also, gas management would be better served by the use of a "previous" cover.

Response: As with all major landfill closures, a gas venting or treatment system needs to be included in the permanent remedial actions selected for the PJP site. A gas venting system is operating on the portion of the site capped durin the IRM. Furthermore, a collection trench and venting syst will be included for the remainder of the site to be capped with the possibility that this system will be upgraded to a active system during the design phase. If an active system determined to be necessary, the IRM cap venting system will incorporated into the new active treatment system.

Overall, the reasons for installing a gas venting system ar regulatory and engineering based, in accordance with NJDEP solid waste guidance. A system is needed to control the pressure and migration of landfill gases under the proposed cap. The specific type of venting system--passive or activ will be determined during the design phase.

60. Comment: The PJP PRP Grounp submitted an alternate cap design that i states is equally protective--meeting or exceeding the expected performance of NJDEP's proposed remedy--and much m cost efficient.

Response: The ROD permits a degree of flexibility in the design of th cap, so long as the alternate design meets the ROD's requirements, e.g. an impermeability of 10-7 and other stat engineering controls.

61. Comment: Why did NJDEP not evaluate in the feasibility study a cap similar to the one the agency used as an IRM cap in 1985 fo a 45-acre portion of the site since NJDEP has since determi that the IRM cap to be a sufficient permanent remedy for this portion of the site.

Response: The IRM cap was part of an interim action. Prior to the IR cap installation, NJDEP removed 4,770 intact drums, 4,600 cubic yards of contaminated soil (including 650 cubic yards soil contaminated with polychlorinated biphenyls), 136 pressurized gas cylinders and other contaminated debris. Also, during the interim action approximately 1,033,000 cub yards of refuse were excavated and compacted.

62. Comment: Is this project the direct responsibility of NJDEP?

Response: NJDEP is the lead agency for this Superfund site. USEPA provides oversight with respect to review of the RI/FS and ROD. NJDEP will sign the Declaration Statement for the ROD with concurrence from USEPA.

63. Comment: Where would you take the known contaminated areas that are removed?

Response: Areas of contamination removed during the remediatio will b analyzed and disposed of at an appropriately licensed dispo facility.

Index of Attachments

A. Proposed Plan
B. Public Meeting Notice
C. Public Meeting Transcript
D. Written Comments

SUPERFUND RECORD OF DECISION

VENTRON/VELSICOL SITE
WOOD-RIDGE AND CARLSTADT
BERGEN COUNTY
NEW JERSEY

Prepared by: N.J. Department of Environmental Protection
Site Remediation and Waste Management Program
Bureau of Case Management
October 2006

SITE NAME AND LOCATION

Operable Unit 1
Ventron/Velsicol Superfund Site
Wood-Ridge and Carlstadt, New Jersey
EPA No. NJD980529879

STATEMENT AND BASIS OF PURPOSE

This Record of Decision (ROD) documents the selection by the New Jersey Department of Environmental Protection (NJDEP) of the remedial action for the Ventron/Velsicol site (the Site) in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), 42 U.S.C. §9601 et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300. An administrative record for the Site, established pursuant to the NCP, 40 CFR §300.800, contains the documents that are the basis for NJDEP's selection of the remedial action (see Appendix I). The Administrative Record file is located in the following information repositories:

Wood-Ridge Memorial Library
231 Hackensack Street
Wood-Ridge, New Jersey

NJ Department of Environmental Protection
401 East State Street, 5th Floor
Trenton, New Jersey

The United States Environmental Protection Agency (EPA) has been consulted on the planned remedial action in accordance with CERCLA §121(f), 42 U.S.C. §9621(f), and it concurs with the selected remedy (see Appendix II).

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances from the Site into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy represents the comprehensive remedial action for Operable Unit 1 at the Site. It addresses ground water and soil contamination. The major components of the selected remedy include:

- A vertical hydraulic barrier system will be installed to serve as a physical barrier to ground water flow and to encapsulate the areas of highest mercury concentrations under the Wolf Warehouse. Soil generated from the installation of the hydraulic barrier (approximately 1,650 cubic yards) will be placed under the cap in the undeveloped area.

- Ground water use restrictions will be placed on the extent of the ground water contamination plume in the form of a Classification Exception Area and a Well Restriction Area to restrict use of contaminated ground water.

- Ground water monitoring will be conducted to determine if hydraulic controls within the barrier are required. If required, hydraulic controls will be implemented. Ground water monitoring will also be conducted to ensure the hydraulic barrier is effective.

- Excavation of all mercury-contaminated soil above 620 mg/kg (approximately 7,150 cubic yards of soil) and off-site disposal of that soil, subsequent to any necessary treatment.

- Excavation of site-related contaminants on the Lin-Mor property to the NJDEP Residential Direct Contact Soil Cleanup Criteria. If the property owners of Lin-Mor agree to the placement of a deed notice, then excavation to the NJDEP Residential Direct Contact Soil Cleanup Criteria will not be required; however, a deed notice will be required.

- Capping areas and/or maintenance of the existing caps (i.e., parking lots and building foundations) with contamination in soil above the NJDEP Non-Residential Direct Contact Soil Cleanup Criteria.

- Excavation of soil within the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and the West Ditch; that soil may be placed under the cap in the undeveloped area. Certified clean fill will be placed in the buffer areas and native vegetation and erosion controls will be installed.

- Contaminated soil will be excavated from West Ditch to promote proper drainage and prevent transport of contamination to downstream areas.

- The drain line within the undeveloped area will be located and removed (if it exists) before installation of the cap.

- Deed notices will be required on all properties with contaminated soil exceeding the NJDEP Residential Direct Contact Soil Cleanup Criteria. If a deed notice(s) cannot be negotiated with a property owner(s), then all soil contamination above NJDEP Residential Direct Contact Soil Cleanup Criteria must be removed on that particular property or properties.

- To ensure the remedy is protective of surface water, monitoring of contaminant flux from ground water to surface water and sediment will occur.

DECLARATION OF STATUTORY DETERMINATIONS

Part 1: Statutory Requirements The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action (unless justified by a waiver), is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

Part 2: Statutory Preference for Treatment This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

Part 3: Five-Year Review Requirements Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

Irene Kropp, Assistant Commissioner
Site Remediation and Waste Management Program
New Jersey Department of Environmental Protection

10/30/06
Date

SITE NAME, LOCATION, AND DESCRIPTION

The Ventron/Velsicol site is located in the boroughs of Wood-Ridge and Carlstadt, Bergen County, New Jersey. The site is irregularly shaped and consists of 38.3 acres; approximately 15.7 of the 38 acres are within the Borough of Wood-Ridge and the remaining 22.6 acres are within the Borough of Carlstadt. The location of the site is depicted in Figure 1. The site is bordered to the east by Berry's Creek, to the west by the Diamond Shamrock/Henkel and Randolph Products properties and Park Place East, to the south by Diamond Shamrock/Henkel Ditch (south) and Nevertouch Creek, and to the north by Ethel Boulevard and a railroad track.

The portion of the site that is identified as OU1 is divided into three areas. The area defined as the "developed" portion is approximately 7 acres in size and is the northernmost portion of the site. Two active warehouses, referred to as the Wolf Warehouse and the U.S. Life Warehouse, are located on this portion. The former mercury processing facility was located on the area of the site that is now occupied by these warehouses.

Approximately 19 acres of land that were filled but not developed lie generally south of the developed portion of the site. This portion of the site is bordered to the north by the railroad track, to the south by Diamond Shamrock/Henkel Ditch (north), and to the east by Berry's Creek. This area is referred to as the "undeveloped" portion of the site.

The area referred to as the "off-site" portion consists of the following properties: the Blum Property, the Prince Packing property, the EJB property, the Lin-Mor property, Ethel Boulevard, and the railroad property. The Borough of Wood-Ridge owns Ethel Boulevard and Norfolk Southern owns the railroad property.

The remaining 12 acres of the site, south of the undeveloped area, are generally marsh, except for a fringe of fill along the western border. This portion of the site is not a part of OU1. This portion will be handled with Operable Unit 2, which is also referred to as the Berry's Creek Study Area. The Berry's Creek Study Area consists of the marsh, Berry's Creek, and other wetland areas adjacent to Berry's Creek. A remedial investigation of the Berry's Creek Study Area will begin in 2007.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Site History

Prior to 1927, most of the site was marshland. From 1927 to 1974, various parties constructed and operated a mercury processing plant on the developed portion of the site. In 1929 F.W. Berk and Company, Inc. (Berk) began operating a processing plant and manufacturing mercury products near the current location of the Wolf Warehouse. Berk continued to operate the plant until 1960, when the corporation dissolved and the plant and property were sold to the Wood Ridge Chemical Corporation (WRCC), a wholly owned subsidiary of the Velsicol Chemical Corporation (Velsicol). The main operations of the mercury processing plant included the manufacture of red oxide of mercury, yellow oxide of mercury, phenyl mercuric acetate, and other organic and inorganic mercury compounds. The plant also reclaimed mercury from both in-house and customer waste products (amalgams, batteries, thermometers, impure mercury, etc.).

Velsicol continued to operate the plant until 1968, when the Ventron Corporation (Ventron), a predecessor to Morton, purchased WRCC and the approximately 7- acre parcel on which the plant was located from Velsicol. Velsicol retained ownership of the rest of the site property until transferring ownership to NWI Land Management, Inc., in 1986. Ventron operated the plant until it was closed in 1974. In 1974, the parcel of land where the plant was located was sold to Robert and Rita Wolf (Wolf). Wolf demolished the plant in 1974, and in 1975, subdivided the land and transferred title of the westernmost parcel to U.S. Life Insurance Company. Two warehouses were constructed, one on each parcel.

The warehouse on the western portion of the site (U.S. Life [Jerbil] Warehouse) was built first, after removal of the upper layer of contaminated soil to the eastern portion of the site. Construction of the Wolf Warehouse on the eastern portion of the site was apparently meant to contain mercury-contaminated soils under the foundation and/or the asphalt pavement surrounding the building. However, no post construction documentation of this containment structure is available.

The approximately 19-acre portion of the site between the developed area and Berry's Creek (i.e., the undeveloped area) was used as a dumping area for various materials including demolition material and domestic solid waste subsequent to 1960.

At present, three parties own property on the site. Jerbil Incorporated owns the U.S. Life Warehouse property (approximately 4.2 acres), Jonathan and Roni Blonde own the Wolf Warehouse property (approximately 2.3 acres), and the LePetomane III, Inc. Custodial Trust owns the undeveloped (approximately 19 acres) and marsh (approximately 12 acres) areas. The LePetomane III, Inc. Custodial Trust is the successor to NWI Land Management, Inc. following the discharge in bankruptcy of NWI's parent, Fruit of the Loom, Inc.

Enforcement History and Previous Investigations/Actions

NJDEP has overseen various investigations of soil, ground water, surface water, sediment and air quality beginning in the 1970's. EPA placed the site on the National Priorities List (NPL) in 1984. In that same year, the Superior Court of New Jersey issued the "Stipulation and Supplementary Order Approving Cooperative Agreement for Remedial Investigation and Feasibility Study and Amending Procedural Order Involving Remedy" in which Ventron and Velsicol agreed to investigate the site. In 1990, NJDEP performed a removal action for soil in residential areas of Wood-Ridge and Moonachie near the site. The removal actions were conducted at ten properties in Wood-Ridge and one property in Moonachie. The work included excavation of mercury-contaminated soil, placement of clean back-fill, revegetation, and general restoration of the properties to their original condition.

The Stipulation was amended in 1996 by the Resolution of the Berry's Creek /Wood-Ridge Site Action Committee. This resolution specified that Velsicol and Morton would conduct a Remedial Investigation and Feasibility Study pursuant to an NJDEP-approved Scope of Work.

Beginning in 1996, Morton International, Inc., in consultation with NJDEP and EPA, began further investigation of the site. The resulting documents were:

- Operable Unit 1 Remedial Investigation Report (Exponent, June 2004)
- Ecological Risk Assessment (Exponent, April 2001)
- Human Health Risk Assessment (Exponent, July 2005)
- Feasibility Study (CH2MHill, April 2006)

HIGHLIGHTS OF COMMUNITY PARTICIPATION

The documents referenced above have been placed in the repository. The Proposed Plan, along with notice of the availability of the RI/FS, was released to the public on August 3, 2006. The documents and the plan were made available to the public in both the Administrative Record (Appendix I) and at information repositories maintained at the Wood-Ridge Memorial Library and at NJDEP's Trenton office.

The notice of availability was published in the Bergen Record on August 3, 2006. A public comment period was held from August 3, 2006 through September 2, 2006. A public meeting was held in Wood-Ridge, New Jersey on August 9, 2006. At this meeting, representatives from NJDEP, CH2MHill, and Exponent presented results of the remedial investigation and feasibility study and the preferred alternative. The public was provided the opportunity to ask questions and make comments.

Based on the comment received at the August 9, 2006 meeting, the local community and public officials generally supported the agencies' preferred alternative presented in the Proposed Plan. A detailed response to the comment received is contained in the Responsiveness Summary. No written comments were provided.

SCOPE AND ROLE OF ACTION

The scope and role of this action addresses Operable Unit 1 of the site, which consists of the upland soil and ground water. This will be the final remedy for Operable Unit 1.

A remedial investigation of Operable Unit 2, which is also referred to as the Berry's Creek Study Area will begin in 2007. The Berry's Creek Study Area consists of Berry's Creek and wetland areas adjacent to Berry's Creek.

SUMMARY OF SITE CHARACTERISTICS

Site Hydrology

Surface water features in the vicinity of the site are illustrated on Figure 1. Surface water drainage at the site is generally to the southeast, where Berry's Creek borders the site. Berry's Creek flows generally south from the site in a 5.25-mile course through tidal marshes before joining the Hackensack River. Much of the stream course is curving. The stream flow in the last 1.25 miles of this creek has been diverted to a straight, man-made channel known as Berry's Creek Canal.

Three ditches drain the southern (marsh) part of the site (See Figure 1). The Diamond Shamrock/Henkel Ditch (north), which marks the boundary between the undeveloped portion of the site and the marsh portion, flows in a southeasterly direction into Berry's Creek. The Diamond Shamrock/Henkel Ditch (south) is coincident with the site's southwestern property boundary and converges with Nevertouch Creek, which then forms the southern site boundary to its confluence with Berry's Creek. A drainage ditch is roughly halfway between the two ditches. The Diamond Shamrock/Henkel Ditch (south) is an open drainage channel that feeds Nevertouch Creek and Berry's Creek.

The marsh portion of the site reportedly floods to a depth of up to 2 feet during high tide. As the flood tide drains this area, the bulk of the water flows through a channel along the eastern edge of the marsh to Nevertouch Creek, before converging with Berry's Creek. The flow of water is diverted back to the Berry's Creek channel during low tide. There are no well-defined drainage patterns for the undeveloped area. The developed area is paved, and drainage generally is directed toward the drainage ditch between the warehouses. Drainage from this area flows along the western property boundary (in the West Ditch) toward the Diamond Shamrock/Henkel Ditch (north).

Site Geology/Hydrogeology

The geology at the site consists of the following, listed by increasing depth:

- Surficial fill in the undeveloped area, consisting of gravel, sand, silt and clay, with shale fragments as well as glass, brick, cinders, porcelain, wire, leather, cloth, coal, wood, shingles, rubber, plastic, metal, and other debris. Surficial fill in the developed area consists of predominantly silt and clay, with limited sand and gravel. The fill ranges in thickness from approximately 5-8 feet in the developed area of the site to approximately 3-14 feet in the undeveloped area of the site. Fill is not known to be present in the marsh area.

- Meadow mat, consisting of fibrous organic peat and silt, which, where present, ranges from 0.5 to 4 feet thick. The meadow mat is thinnest beneath the undeveloped area where artificial filling has occurred, which may indicate the meadow mat in this area has been compressed by the overlying fill.

- A 5 to 10 foot thick layer of fine to medium-grained sand.

- A varved, gray to red-brown silt that is 62 to 146 feet thick.

- A red-brown silty sand unit that is at least 20 feet thick.

- Bedrock, consisting of reddish-brown shale, siltstone and sandstone that is approximately 9000 feet thick.

The layers of fine to medium-grained sand and red-brown silty sand likely exhibit similar physical or hydraulic properties and appear to be indistinguishable from a hydrogeologic perspective. Therefore, they are considered undifferentiated.

Major features of the site-wide ground water flow patterns include:

- A generally radial flow pattern (outward from the center) is apparent in the undeveloped area, with the highest ground water levels in monitoring wells MW-2 and MW-3. This is most likely caused by higher infiltration of water in the undeveloped area than in the areas to the north and west of the undeveloped area.

- Along with the radial flow patterns, there is likely to be a small downward vertical component of flow generally in the center of the undeveloped area, which then transitions to a small upward vertical flow component near the perimeter of the undeveloped area.

- As part of the overall flow patterns, ground water in the eastern and southern portions of the undeveloped area flows toward Berry's Creek and the Diamond Shamrock/Henkel Ditch (north). Ground water in the western portion of the site flows towards the West Ditch and Berry's Creek.

Ground Water Impacts

A total of fifteen monitoring wells were installed in the developed and undeveloped portion of the site. During the remedial investigation, wells were sampled in 1997, 1999, 2000 and 2002, and the following contaminants were detected in ground water at levels exceeding the New Jersey Ground Water Remediation Standards: arsenic (up to 41.5 ppb), iron (up to 31,700 ppb), manganese (up to 4,180 ppb), mercury (up to 22.9 ppb), and benzene (up to 14 ppb). Concentrations of one metal, selenium, exceeded New Jersey Surface Water Quality Standards, but not the Ground Water Remediation Standards.

It was determined that there are three site-related contaminants of concern in ground water, namely arsenic, mercury and benzene. While iron and manganese have been detected in all site monitoring wells at concentrations exceeding the New Jersey Ground Water Remediation Standards during every sampling event, the concentrations both in upgradient and downgradient wells have not varied significantly over time. Therefore, it is believed that iron and manganese concentrations site ground water reflect background geochemical conditions and are not site related.

Soil Impacts

Based on the investigations, it has been determined that soil at the site within the OU1 boundary, both in the developed area and the undeveloped area, has been impacted with various contaminants at concentrations exceeding the New Jersey Residential Direct Contact Soil Cleanup Criteria (RDCSCC) and the Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC). The fifteen contaminants exceeding the RDCSCC in soil (both surface and subsurface) within OU1 are: mercury (up to 34,700 mg/kg), arsenic (up to 120 mg/kg), copper (up to 2,190 mg/kg), beryllium (up to 2.1 mg/kg), benzo(a)anthracene (up to 62 mg/kg), benzo(a)pyrene (up to 52 mg/kg), benzo(b)fluoranthene (up to 64 mg/kg), benzo(k)fluoranthene (up to 4.7 mg/kg), bis(2-ethylhexyl)phthalate (up to 380 mg/kg), chrysene (up to 12 mg/kg), dibenz(a,h)anthracene (up to 1.3 mg/kg), indeno(1,2,3-cd)pyrene (up to 2.6 mg/kg), lead (up to 4,320 mg/kg), thallium (up to 21.9 mg/kg) and zinc (up to 43,200 mg/kg). By comparing concentrations of some contaminants found in on-site soils to levels found in fill material, it was determined that benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, beryllium, and zinc were related to fill and would not be considered contaminants of concern related to the site. However, remedies for this historic fill material were considered during the evaluation of soil alternatives.

Surface Water and Sediment Impacts

Surface water and sediment were sampled in the on-site basin and the West Ditch. Mercury exceeded the NJDEP Surface Water Quality Standards in the on-site basin and the West Ditch. Lead also exceeded the NJDEP Surface Water Quality Standards in the West Ditch. The mercury, cadmium, chromium, copper, lead, nickel, silver, and zinc concentrations in sediments exceeded the screening criteria in both the on-site basin and West Ditch. Arsenic concentrations in one location of the on-site basin exceeded screening criterion.

Air Sampling

Air sampling was conducted at the site to determine the concentration of gaseous and particulate mercury in ambient air at the site. Four locations were monitored in the developed area of the site (one inside the U.S. Life Warehouse, one inside the Wolf Warehouse, and two outside locations adjacent to the warehouses) and one location was monitored in the undeveloped area. The results of the sampling showed the highest level of mercury was in the Wolf Warehouse at 30.39 ng/m^3. The NJDEP indoor air criterion for mercury is 300 ng/m^3.

CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

Site uses: The area is zoned commercial/industrial and future use of the property is expected to remain consistent with the current zoning and land use. Warehouses exist on the developed portion of the property, and there are preliminary plans to construct another warehouse on the undeveloped portion.

Ground Water Uses: Ground water underlying the site is considered Class II-A, a source of potable water. A recent survey indicated there are numerous wells within a half mile of the site. However, only three are identified in NJDEP well records as being used for possible drinking water purposes. Since the ground water plume related to this site is contained within the site boundaries, this site has not impacted off-site wells.

SUMMARY OF SITE RISKS

A Baseline Human Health Risk Assessment (BHHRA) was conducted to provide a quantitative assessment of the health risks to human receptors under current and future land-use scenarios if no remedial action were taken at the site.

Human Health Risk Assessment

As part of the RI/FS, a BHHRA was completed to estimate the potential current and future effects of site contaminants on human health. The BHHRA estimates the human health risk which could result from the contamination at the site if no remedial action was taken and without any institutional controls in place.

A four-step process is utilized for assessing site-related human health risks for a reasonable maximum exposure scenario: *Hazard Identification* – identifies the contaminants of potential concern (COPCs) at the sites based on several factors such as toxicity, frequency of occurrence and concentration. *Exposure Assessment* – estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways (e.g., ingesting contaminated well-water by which humans are potentially exposed). *Toxicity Assessment* – determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response). *Risk Characterization* – summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks. The reasonable maximum exposure, which is the greatest exposure reasonably anticipated to occur, was evaluated.

The area where the site is located is currently zoned commercial/industrial and future use of the property is expected to remain consistent with this zoning and land use. Warehouses exist on the developed portion at the northern section of the property. The undeveloped portion is likely to be accessed only by trespassers under current site conditions, while future use scenarios for the southern portion of the site anticipate this area to be developed as commercial/industrial use. Ground water underlying the site is considered Class II-A, a source of potable water. No current exposures to contaminated ground water are known; the BHHRA evaluated the reasonable anticipated future use as a drinking water source.

Hazard Identification

A BHHRA was conducted to evaluate the potential risks and hazards to human health associated with OU1 of the Ventron/Velsicol Superfund site in its current state. Although the risk assessment evaluated all contaminants identified in the ground water and soils, the conclusions of the risk assessment indicate that the significant risks and hazards are associated with mercury at the site, while lead is of concern in some discrete areas. A summary of the concentrations of the contaminants of concern for the site is provided in Table 1.

Exposure Assessment

The BHHRA addressed the potential risks to human health by identifying several potential exposure pathways through which the public may be exposed to contaminant releases at the site under current and future land use and ground water use conditions. Although the onsite ground water is not currently used for drinking, it is designated by the State as a potable water supply, meaning it could be available for drinking in the future. The site is zoned for commercial/industrial use, and it is anticipated that future use will be consistent with current use. Since the site consists of areas with operating warehouses in the northern portion of the property as well as undeveloped areas to the south, the exposure assessment evaluated potential risks from exposure to both areas. In the BHHRA, contaminants in soil, sediment, ground water and air at the site were quantitatively evaluated for potential health threats to current and future onsite receptors.

The BHHRA focused on a variety of possible receptors, including current and future onsite workers and construction workers in the developed areas and current and future trespassers/visitors, future onsite workers, and future construction workers in the undeveloped areas. In addition, the identification of a hot spot of mercury in the developed area and a hot spot of mercury and lead in the undeveloped area required that the BHHRA evaluate exposure to these discrete locations by taking into account that the exposure would likely be significantly less than exposure to the rest of the site. A complete discussion can be found in the Baseline Human Health Risk Assessment Report. The ground water was evaluated as a potable water supply under future use scenario only.

Toxicity Assessment

Under current EPA guidelines, the likelihood of carcinogenic (cancer-causing) and noncarcinogenic (systemic) effects due to exposure to site chemicals are considered separately. Consistent with EPA guidance, it was assumed that the toxic effects of the site-related chemicals would be additive. Thus, carcinogenic and noncarcinogenic risks associated with exposures to individual contaminants of concern were summed to indicate the potential risks associated with mixtures.

Noncarcinogenic risks were assessed using a hazard index (HI) approach, based on a comparison of expected contaminant intake and safe levels of intake (reference doses and inhalation reference doses). Reference doses (RfDs) and inhalation reference doses (RfDis) have been developed by EPA for indicating the potential for adverse health effects. RfDs and RfDis, which are expressed in units of milligrams per kilogram per day (mg/kg-day), are estimates of daily exposure levels for humans thought to be safe over a lifetime (including sensitive individuals). Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical vapor inhaled) are compared with the RfD or RfDi to derive the hazard quotient for the contaminant in the particular medium. The HI is derived by adding the hazard quotients for all compounds within a particular medium that impact a particular receptor population.

An HI greater than 1 indicates that the potential exists for noncarcinogenic health effects to occur because of Site-related exposures. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. The toxicity values, including reference doses and inhalation reference doses for the contaminants of potential concern at the Site, are presented in Table2.

Potential carcinogenic risks were evaluated using the cancer slope factors developed by EPA for the contaminants of concern. Cancer slope factors (SFs) and inhalation cancer slope factors (SFis) have been developed for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs and SFis, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to generate an upper-bound estimate of the excess lifetime cancer risk associated with exposure to the compound at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the SF or SFi. Use of this approach makes the underestimation of the risk highly unlikely. The SF and SFi values used in this risk assessment are presented in Table 3.

Risk Characterization

The quantitative hazard and risk calculations were based on reasonable maximum exposure scenarios. These estimates were developed by taking into account various conservative assumptions about the likelihood of a person being exposed to contaminated media at the site. Risk characterization involves integrating the exposure and toxicity assessments into quantitative expressions of carcinogenic risks and noncarcinogenic health effects. Specifically, chronic daily intakes were compared with concentrations known or suspected to present carcinogenic risks or noncarcinogenic health hazards.

For known or suspected carcinogens, EPA considers excess upper-bound individual lifetime cancer risks of between 10^{-4} to 10^{-6} to be acceptable. This range indicates that an individual has no more than approximately a one in ten thousand to one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year period under specific exposure conditions at a site. The New Jersey Brownfield and Contaminated Site Remediation Act, N.J.S.A. 58:10B-1, et. seq., has set the acceptable cancer risk for human carcinogens at 1×10^{-6} (one-in-one-million). The noncarcinogenic HIs are presented in Table 4. Excess lifetime cancer risks estimated at the site are presented in Table 5.

Lead was not quantitatively evaluated for the potential receptors at the Ventron/Velsicol site due to lack of toxicity values for this compound. It is, nonetheless, a chemical of concern for the site due to its widespread presence in the surface soil in the developed portion of the site, with a mean concentration of 2,110 ppm, and in the surface soil in the undeveloped area, with a mean concentration of 2,096 ppm. Both of these values exceed EPA health-based screening levels of 400 ppm for children and 800 ppm for adults. Therefore, exposure to site soils by these receptors may result in adverse health effects.

At the Ventron/Velsicol site, the quantitative excess lifetime cancer risk and noncarcinogenic HIs are as follows:

Developed Area

Future Long-term Workers: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of contaminants from surface soil; and inhalation of VOCs in indoor air from vapor intrusion from subsurface contamination. The calculated HI is 5.2, with exposure to mercury in the surface soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

Future Construction Workers: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of particulates released from subsurface soil. The calculated HI is 7.8, with exposure to mercury in the soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

Undeveloped Area

Current/Future Adult Trespassers/Visitors: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of particulates released from surface soil and sediments. The calculated HI is 3.8, with exposure to mercury in the soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

When the mercury hot spot in the undeveloped area is included in the assessment, the calculated HI is 17, and exposure to the mercury hot spot drives the risk.

Current/Future Adolescent/Pre-Adolescent Trespassers/Visitors: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of particulates released from surface soil. The calculated HI is 5.3, with exposure to mercury in the soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

When the mercury hot spot in the undeveloped area is included in the assessment, the calculated HI is 25, and exposure to the mercury hot spot drives the risk.

Future Long-term Workers: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of contaminants from surface soil; and inhalation of VOCs in indoor air from vapor intrusion from subsurface contamination. The calculated HI is 9.6, with exposure to naphthalene in indoor air from the subsurface soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

When the mercury hot spot in the undeveloped area is included in the assessment, the calculated HI is 23, and exposure to the mercury hot spot, along with the naphthalene in the subsurface soil, drives the risk.

Future Construction Workers: Risks and hazards were evaluated for incidental ingestion of, dermal contact with, and inhalation of particulates released from subsurface soil. The calculated HI is 2.8, with exposure to mercury in the soil contributing most significantly to the hazard. The incremental lifetime cancer risk is within the acceptable risk range.

Ground water

Future Adult and Child Residents: Risks and hazards were evaluated for ingestion of ground water, dermal contact with ground water, and inhalation of VOCs while showering with ground water. The estimated cancer risks are 4×10^{-4} (adult) and 2×10^{-4} (child); benzene and arsenic in the ground water are the most significant contributors to the cancer risk. The calculated HIs are 23 (adult) and 75(child), with mercury, benzene, and naphthalene as the most significant contributors to the hazard.

Summary

For these receptors, exposure to contaminants results in either an excess lifetime cancer risk that exceeds EPA's target risk range of 10^{-4} to 10^{-6} or an HI above the acceptable level of 1, or both, indicating that there is significant potential risk to populations from direct exposure to soil. Additionally, the average concentration of lead in soil exceeds the health-based screening value for both the adult and the child, indicating the potential for adverse health effects.

Discussion of Uncertainties in Risk Assessment

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to a variety of uncertainties. In general, the main sources of uncertainty include:

- environmental chemistry sampling and analysis
- environmental parameter measurement
- fate and transport modeling
- exposure parameter estimation
- toxicological data

Uncertainty in environmental sampling arises in part from the potentially uneven distribution of chemicals in the media sampled. Consequently, there is uncertainty as to the actual levels present. Environmental chemistry-analysis error can stem from several sources, including the errors inherent in the analytical methods and characteristics of the matrix being sampled.

Fate and transport modeling is also associated with a certain level of uncertainty. Factors such as the concentrations in the primary medium, rates of transport, ease of transport, and environmental fate all contribute to the inherent uncertainty in fate and transport modeling.

Uncertainties in the exposure assessment are related to estimates of how often an individual would actually come in contact with the chemicals of concern, the period of time over which such exposure would occur, and in the models used to estimate the concentrations of the chemicals of concern at the point of exposure.

Uncertainties in toxicological data occur in extrapolating both from animals to humans and from high to low doses of exposure, and from the difficulties in assessing the toxicity of a mixture of chemicals. These uncertainties are addressed by making conservative assumptions concerning risk and exposure parameters throughout the assessment. As a result, the risk assessment provides upper-bound estimates of the risks to populations near the site, and is highly unlikely to underestimate actual risks related to the site.

More specific information concerning public health and environmental risks, including a quantitative evaluation of the degree of risk associated with various exposure pathways, is presented in the risk assessment report.

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in the ROD, may present an imminent and substantial endangerment to the public health, welfare, or the environment.

Ecological Risk Assessment (ERA)

A four-step process is utilized for assessing site-related ecological risks for a reasonable maximum exposure scenario: *Problem Formulation* - a qualitative evaluation of contaminant release, migration, and fate; identification of contaminants of concern, receptors, exposure pathways, and known ecological effects of the contaminants; and selection of endpoints for further study. *Exposure Assessment* - a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure pathways and receptors; and measurement or estimation of exposure point concentrations. *Ecological Effects Assessment* - literature reviews, field studies, and toxicity tests, linking contaminant concentrations to effects on ecological receptors. *Risk Characterization* - measurement or estimation of both current and future adverse effects.

The comparison of contaminant concentrations in ground water, surface water, sediment and on-site surface soils against NJDEP-accepted screening values represents the preliminary screening level problem formulation. This comparison showed contaminants exist in ground water, surface water, sediment and on-site surface soils above the screening values.

The primary contaminant of concern is mercury; however, chromium, lead, and zinc are also contaminants of concern. Potential risks to benthic macroinvertebrates are likely. Moreover, aquatic dependent wildlife (e.g., piscivorous birds) may be affected through biomagnification of mercury.

The Screening Level Ecological Risk Assessment indicated that the various media at the site posed potential ecological risk. Rather than proceed to a Baseline Ecological Risk Assessment, it was decided that potential ecological risks would be addressed as part of the remedy. The response action selected in the ROD will minimize ecological risk by limiting the exposure of ecological receptors to site contaminants. The removal of soil within a 55' buffer of the waterbodies, and capping the non-developed and developed portions of the site will prevent exposures within the upland portion of the site. In addition, monitoring will be conducted to ensure that the remedy is protective and that contamination is not being transported via groundwater to surface water or sediment.

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), NJDEP's Ground Water Remediation Standards (GWRS), and the Federal Maximum Contaminant Levels (MCLs).

The following remedial action objectives for contaminated ground water and soil address the risks to human health and the environment at the Ventron/Velsicol site.

Remedial Action Objectives for Ground Water

The remedial action objectives for ground water are to:

- Prevent/minimize the potential downgradient and off-site migration of contaminated ground water to the marsh area and Berry's Creek;

- Reduce human and ecological receptor's potential exposure to contaminants in ground water to within acceptable risk levels.

There are currently no complete exposure pathways to contaminated ground water beneath the Ventron/Velsicol site because there are no known contaminated wells in use. All residents in the area of the Ventron/Velsicol site are currently on city-supplied water. If contaminated ground water were to be used as a drinking water source in the future, significant health risks would exist. All ground water alternatives, except for the no action alternative, include development of a Classification Exception Area and a Well Restriction Area.

NJDEP has identified remediation goals for the ground water at the Ventron/Velsicol site as the drinking water standards or the New Jersey Ground Water Remediation Standards. The most conservative of the two standards would be used as the remediation goal. Table 6 lists the contaminants of concern found in the ground water at the site, and their respective Cleanup Goals. The remediation goals listed in this table are chemical-specific ARARs for the Site.

Remedial Action Objectives for Soil

The remedial action objectives for soil are to:

- Prevent/minimize potential migration of contaminants in surface soil via windblown dust and surface runoff to the marsh area and Berry's Creek;

- Prevent/minimize potential migration of contaminants to ground water, which may discharge to surface water and sediment;

- Prevent/minimize potential migration of contaminants in on-site sediments via surface runoff to the marsh area and Berry's Creek;

- Reduce human and ecological receptor's potential exposure to contaminants in surface soil to within acceptable risk levels;

- Reduce exposure to contaminants in soil in the undeveloped area to allow for reasonable anticipated future land use.

The remediation goals for soil are the New Jersey Soil Cleanup Criteria. A summary of these criteria can be found in Table 7. The remediation goals listed on this table are chemical-specific ARARs for the Site.

DESCRIPTION OF REMEDIAL ALTERNATIVES

CERCLA §121(b)(1), 42 U.S.C. §9621 (b)(1) mandates that a remedial action must be protective of human health and the environment, cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions that employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity or mobility of the hazardous substances, pollutants and contaminants at a Site. CERCLA §121(d), 42 U.S.C. §9621(d), further specifies that a remedial action must attain a level or standard of control of the hazardous substances, pollutants and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA §121(d) (4), 42 U.S.C. §9621 (d)(4).

Based on the information contained in the RI and FS Reports, the Human Health Risk Assessment, and the Ecological Risk Assessment, the Proposed Plan evaluated, in detail, six remedial alternatives for ground water at the Site and seven remedial alternatives for soil at the Site.

Ground Water Remedial Alternatives

Common Elements

Except for Alternative G1, all the alternatives require water use restrictions, development of a Classification Exception Area (CEA) and a Well Restriction Area (WRA), and establishment of a long-term ground water monitoring program to ensure the protectiveness of the remedy.

Ground Water Alternative 1 (G1) No Further Action

Estimated Capital Costs: $ 0
Annual O&M Costs: $ 0
Total Present Worth Cost: $ 0
Estimated Construction Time Frame: 0 months

Regulations governing the Superfund program generally require that the "no action" alternative be evaluated to establish a baseline for comparison with other, active alternatives. Under this alternative, no further action would be taken at the site to prevent exposure to ground water contamination. The ground water contamination would not be treated or contained. Ground water contaminant concentrations would not meet the remediation goals within a reasonable time frame.

Ground Water Alternative 2 (G2) Monitored Natural Attenuation and Institutional Controls

Estimated Capital Costs:	$ 25,000
Annual O&M Costs	
Years 0-2:	$ 95,000
Years 2-50:	$ 24,000
Total Present Worth Cost:	$ 480,000
Estimated Construction Time Frame:	0 months

The objective of Alternative G2 is to rely on natural attenuation to reduce concentrations within the ground water plume to below the Ground Water Remediation Standards, while placing use restrictions on the area of ground water exceeding the Ground Water Remediation Standards. The use restrictions will consist of a Classification Exception Area (CEA) and a well restriction area (WRA) that will restrict the use of ground water within the designated area.

Ground water monitoring will also be required as a part of this alternative to verify that natural attenuation is occurring and that the concentrations of contaminants at perimeter wells continue to be below the Ground Water Remediation Standards.

Ground Water Alternative 3 (G3) Hydraulic Controls via Pumping

Total Capital Costs:	$1,020,000
Annual O&M Costs	
Years 0-2:	$ 251,200
Years 3-50:	$ 179,800
Total Present Worth Cost:	$3,630,000
Estimated Construction Time Frame:	6 months

In this alternative, ground water will be intercepted before entering Berry's Creek using a series of extraction wells and the extracted ground water will be discharged to the Publicly Owned Treatment Works (POTW). The system will pump at a relatively low flow rate, and will be used primarily as a protective measure for downgradient ground water quality rather than active contaminant removal. The ground water will not require significant treatment, if any, prior to discharge to the POTW, however if necessary, the levels of mercury, benzene, and arsenic in the ground water will be treated via filtration. The treatment will consist of two granulated activated carbon (GAC) units as well as a series of green sand filters to remove solids.

Ground Water Alternative 4 (G4) Ground Water Pump and Treat

Total Capital Costs:	$ 2,300,000
Annual O&M Costs:	$ 740;000
Total Present Worth Cost:	$10,910,000
Estimated Construction Time Frame:	8 months

The objective of this alternative is to aggressively remediate the ground water by active removal of the contaminated ground water for ex-situ treatment and ultimate discharge. This alternative consists of a series of wells, both within the developed and undeveloped areas, which will extract contaminated ground water. After the ground water is extracted, it will be treated via filtration and ion exchange before being discharged to the POTW.

Ground water will be monitored upgradient, within, and downgradient of the plume during operation of the treatment system to verify the effectiveness of the system.

Ground Water Alternative 5 (G5) Vertical Hydraulic Barrier

Total Capital Costs:	$1,360,000
Annual O&M Costs	
Years 0-2:	$ 95,000
Years 2-50:	$ 24,000
Total Present Worth Cost:	$1,820,000
Estimated Construction Time Frame:	1.5 months

The objective of this alternative is containment through the installation of a vertical hydraulic barrier around the mercury-contaminated soils located beneath the Wolf Warehouse. The vertical hydraulic barrier will serve as a physical barrier to ground water flow. The wall will be keyed 2 feet into the confining layer underlying the site at a depth of approximately 20 feet. The approximate length of the vertical hydraulic barrier is 1,300 feet, however the exact location and size will be determined during design. The asphalt parking area and the flooring of the Wolf Warehouse will limit the amount of infiltration into the area encompassed by the vertical hydraulic barrier, effectively serving as a cap of the area. It is anticipated that water levels within the vertical hydraulic barrier will stagnate, therefore it is expected that no hydraulic controls will be needed. However if it is determined that hydraulic controls are needed, those controls will be implemented. An example of a hydraulic control is pumping wells within the vertical hydraulic barrier.

Ground Water Alternative 6 (G6) Vertical Hydraulic Barrier Around Site Perimeter

Total Capital Cost:	$ 4,230,000
Annual O&M Cost	
Years 0-2:	$ 237,000
Years 3-50:	$ 166,000
Total Present Worth Cost:	$ 6,650,000
Estimated Construction Time Frame:	9 months

This alternative consists of surrounding the entire site (developed and undeveloped areas) with a low permeability hydraulic barrier to protect Berry's Creek and contain ground water contamination within the site limits. It is assumed that the barrier will be keyed 2 feet into the confining layer at a depth of approximately 20 feet and the approximate length of the barrier will be 5,400 feet.

Hydraulic controls will be necessary inside the barrier to remove infiltration and minimize mounding of ground water. The hydraulic controls will be implemented as described in Alternative G3, with the exact number of extraction wells to be determined during design. The ground water extracted will be discharged to the POTW but may have to be treated prior to discharge as described in Alternative G3. The volume of water will be less than that of Alternative G3 since the hydraulic barrier will limit horizontal migration of ground water into the footprint of the barrier.

Soil Remedial Alternatives

Soil Alternative 1 (S1) No Further Action

Under this alternative, there would be no additional remedial actions conducted at the site to control or remove the contaminants in the soil.

Total Capital Cost:	$ 0
Annual O&M Cost:	$ 0
Total Present Worth Cost:	$ 0
Estimated Construction Timeframe:	0 months

Soil Alternative 2 (S2) Capping and Institutional Controls and Limited Excavation to RDCSCC

Total Capital Cost:	$5,610,000
Annual O&M Cost:	$ 35,000
Total Present Worth Cost:	$6,090,000
Estimated Construction Timeframe:	6 months

This alternative consists of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation and capping of the West Ditch; excavation of site-related contaminants on the Lin-Mor Property to the Residential Direct Contact Soil Cleanup Criteria (RDCSCC); air monitoring for mercury in the Wolf Warehouse; capping all areas with soil contaminant levels that exceed the Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC) (either maintenance of existing caps or placement of new caps); and placement of deed notices on those properties with soil contaminant levels that exceed the RDCSCC.

Soil within a 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and the West Ditch will be excavated and certified clean fill will be placed in the excavation. This will address soil contamination in the area without installing a cap, which will allow for a transitional vegetated habitat between the upland cap and aquatic environment. The cap in the undeveloped fill area will cover a 5-foot portion of the buffer to reduce the potential for exposure of contaminants to animals that may burrow under the edge of the cap. The excavated material may be placed under the cap in the undeveloped area, unless mercury concentrations exceed 620 mg/kg, in which case the soil will be treated, if necessary, and disposed of off-site.

According to historical information, a buried drain line was located on the site, running from the developed area to Berry's Creek. During the investigation, the drain line could not be located, however further attempts will be made to locate the drain line, and if it is found, it will be removed.

Since the owners of the Lin-Mor property did not consent to placing a deed notice on their property, the areas of the Lin-Mor property that have been impacted with site-related contaminants will be excavated as necessary to meet the RDCSCC. The excavated material may be placed in the undeveloped fill area to be capped.

Institutional controls in the form of deed notices will be placed on all properties with contaminant levels in soil that exceed the RDCSCC, specifically the Blum, Prince Packing, Wolf Warehouse, U.S. Life Warehouse, EJB, Borough of Wood-Ridge (Ethel Boulevard), Norfolk Southern (railroad property), and the undeveloped fill area properties. The deed notices will include a summary of the contamination that remains on the property, a description of engineering controls (i.e., caps) on each property, the locations of the engineering controls, and the monitoring and maintenance requirements. Biennial certifications will be submitted while the engineering and institutional controls remain in place including inspections to verify the integrity of the engineering controls and to verify the engineering controls are still protective of human health and the environment.

Indoor air samples for mercury will be collected in the Wolf Warehouse during the summer and winter seasons for the first year, and then biennially thereafter. If NJDEP and/or EPA determine that additional monitoring or remedial actions are required to address indoor air issues, those actions will be implemented.

Capping is required on all areas that exceed the NRDCSCC. The existing caps in portions of the site will remain in place and will be upgraded, as necessary, to promote proper drainage. The existing caps include: building foundations of the U.S. Life Warehouse and the Wolf Warehouse; asphalt caps used for parking and/or streets adjacent to the buildings; the existing street of Ethel Boulevard; and the existing gravel sub-base of the Norfolk Southern railroad property. Upgrades to the asphalt caps will include resurfacing to repair any existing cracks or breaches in the surface.

A single layer cap will be placed over the undeveloped fill area, over the small property between Ethel Boulevard and the railroad (EJB property) and any other area that has soil with contaminant levels exceeding the NRDCSCC and currently is not capped.

Soil Alternative 3 (S3) Excavation of Soil with Mercury Levels over 620 mg/kg in Undeveloped Area, Capping and Institutional Controls, and Limited Excavation to RDCSCC

Total Capital Cost:	$7,930,000
Annual O&M Cost:	$ 35,000
Total Present Worth Cost:	$8,413,000
Estimated Construction Timeframe:	7 months

This alternative consists of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation and capping of the West Ditch; excavation of site-related contaminants on the Lin-Mor Property to the RDCSCC; air monitoring for mercury in the Wolf Warehouse; capping all areas with soil contaminant levels that exceed the NRDCSCC (either maintenance of existing caps or placement of new caps); and placement of deed notices on those properties with soil contaminant levels that exceed the RDCSCC. These components of the remedy are described in S2, above. In addition, prior to capping the undeveloped area, soil with concentrations of mercury over 620 mg/kg will be excavated. The areas exceeding 620 mg/kg for mercury were chosen as the target areas since these concentrations are an order of magnitude over 62 mg/kg, a level that EPA considers associated with a hazard index of 1. EPA considers a level 10 times higher (i.e., 620 mg/kg) as a basic guide to define a principal threat waste.

Soil generated during the excavation in the undeveloped fill area with mercury exceeding 620 mg/kg will be treated, if necessary, to meet the Resource Conservation and Recovery Act Land Disposal Requirements, prior to disposal at an offsite landfill. Off-site stabilization was the treatment alternative assumed for cost-estimation purposes, however the treatment will be determined during design.

Soil Alternative 4 (S4) Excavation of All Soil with Mercury Levels over 620 mg/kg; Capping and Institutional Controls, and Limited Excavation to RDCSCC

Total Capital Cost:	$13,550,000
Annual O&M Costs:	$ 37,000
Total Present Worth Cost:	$14,060,000
Estimated Construction Timeframe:	8 months

This alternative consists of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation and capping of the West Ditch; excavation of site-related contaminants on the Lin-Mor Property to the RDCSCC; air monitoring for mercury in the Wolf Warehouse; capping all areas with soil contaminant levels that exceed NRDCSCC (either maintenance of existing caps or placement of new caps); and placement of deed notices on those properties with soil contaminant levels that exceed the RDCSCC. These components of the remedy are described in S2, above. In addition, all soil with levels of mercury above 620 mg/kg will be excavated prior to capping, treated if necessary, and disposed of at an offsite landfill.

Soil Alternative 5 (S5) Excavation of All Soil with Mercury Levels over 620 mg/kg, Capping and Institutional Controls, Excavation of Other Properties to RDCSCC

Total Capital Cost:	$14,140,000
Annual O&M Costs:	$ 37,000
Total Present Worth Cost:	$14,650,000
Estimated Construction Timeframe:	9 months

This alternative consists of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation and capping of the West Ditch; excavation of site-related contaminants on the Lin-Mor Property to the RDCSCC; air monitoring for mercury in the Wolf Warehouse; excavation of all soil with mercury levels exceeding 620 mg/kg; capping all areas with soil contaminant levels that exceed the NRDCSCC (either maintenance of existing caps or placement of new caps); and placement of deed notices on those properties with soil with contaminant levels that exceed the RDCSCC. These components of the remedy are described in S2 and S4, above. In addition, the EJB, Blum, Prince Packing, and Borough of Wood-Ridge (Ethel Boulevard) properties will be excavated to meet RDCSCC. The soil excavated from the off-site properties may be placed on the undeveloped portion prior to capping. All other excavated soil will be treated, if necessary, and disposed in an off-site landfill.

The existing gravel sub-base of the Norfolk Southern will be maintained and a deed notice will be placed on that property.

Soil Alternative 6 (S6) Excavation of All Soils with Mercury Levels over 620 mg/kg, Capping and Institutional Controls, Excavation of Undeveloped Area and Other Properties to RDCSCC

Total Capital Cost:	$112,580,000
Annual O&M Costs:	$ 9,000
Total Present Worth Cost:	$112,700,000
Estimated Construction Timeframe:	28 months

This alternative consists of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation and capping of the West Ditch; excavation of the Lin-Mor, EJB, Blum, Prince Packing, Borough of Wood-Ridge and Undeveloped Properties to the RDCSCC; excavation of soil with mercury levels above 620 mg/kg in the Developed Area; air monitoring for mercury in the Wolf Warehouse; capping all areas with soil contaminant levels that exceed the NRDCSCC (either maintenance of existing caps or placement of new caps); and placement of deed notices on those properties with soil contaminant levels that exceed the RDCSCC. The existing gravel sub-base of the Norfolk

Southern will be maintained and a deed notice will be placed on that property. All excavated soil will be disposed of off-site, subsequent to any treatment, and the properties will be backfilled with clean, certified fill material.

Soil Alternative 7 (S7) Excavation of Undeveloped, Developed, and Other Properties to RDCSCC, Use Restrictions on the Railroad, Excavation of West Ditch

Total Capital Cost:	$135,300,000
Total O&M Costs:	$ 0
Total Periodic Costs:	$ 0
Total Present Worth Cost:	$135,300,000
Estimated Construction Timeframe:	36 months

This alternative consist of the following: excavation of the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch; excavation of the buried drain line in the undeveloped area (if it exists); excavation of the West Ditch; and excavation of the Developed Area, the Undeveloped Area, Lin-Mor, EJB, Blum, Prince Packing, and the Borough of Wood-Ridge properties to the RDCSCC. All excavated soil will be disposed off-site, and the properties will be backfilled with clean, certified fill material.

The existing gravel sub-base of the Norfolk Southern will be maintained and a deed notice will be placed on that property.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy, NJDEP considered the factors set out in CERCLA §121, U.S.C. §9621, by conducting a detailed analysis of the viable remedial alternatives pursuant to the NCP, 40 Code of Federal Regulations (CFR) §300.430(e) (9) and Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01. The detailed analysis consisted of an assessment of the individual alternatives against each of nine evaluation criteria and a comparative analysis focusing upon the relative performance of each alternative against those criteria.

The following "threshold" criteria must be satisfied by any alternative in order to be eligible for selection:

Threshold Criteria

1. **Overall protection of human health and the environment** addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. **Compliance with applicable or relevant and appropriate requirements (ARARs)** addresses whether or not a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes and requirements or provide grounds for invoking a waiver.

The following "primary balancing" criteria are used to make comparisons and to identify the major trade-offs between alternatives:

Primary Balancing Criteria

3. **Long-term effectiveness and permanence** refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

4. **Reduction of toxicity, mobility, or volume through treatment** refers to a remedial technology's expected ability to reduce the toxicity, mobility or volume of hazardous substances, pollutants or contaminants at the Site.

5. **Short-term effectiveness** addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. **Implementability** is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. **Cost** includes estimated capital and operation and maintenance costs, and net present worth costs.

The following "modifying" criteria are considered fully after the formal public comment period on the Proposed Plan is complete:

Modifying Criteria

8. **EPA acceptance** indicates whether, based on its review of the FS and Proposed Plan, the EPA supports, opposes, and/or has identified any reservations with the selected alternative.

9. **Community acceptance** is assessed based on a review of the public comments received on the technical reports and the Proposed Plan.

GROUND WATER ALTERNATIVES

Overall Protection of Human Health and the Environment

Alternative G1, no further action, is not considered protective of human health and the environment because it does not include ground water monitoring or required institutional controls to prevent use of the ground water. Future exposure to ground water would result in unacceptable risks.

Alternative G2 is considered protective of human health and the environment since institutional controls will restrict ground water use within the impacted area and any migration of contamination in ground water will be monitored. Alternative G3 is protective of human health and the environment since it involves the collection and ex-situ treatment of the downgradient portion of the ground water plume. Alternative G4 is protective of human health and the environment since it will treat ground water in the fastest time by aggressively removing the contaminant mass. Alternative G5 is protective of human health and the environment since it involves encapsulating contaminated ground water, institutional controls and monitoring. Although G5 does not encapsulate all contaminated ground water, it is anticipated that the ground water contamination outside the hydraulic barrier will decrease if this alternative is paired with a soil alternative that includes excavation of contaminated soil. Alternative G6 is protective of human health since it involves encapsulating ground water, hydraulic controls, and institutional controls and monitoring. However, this alternative includes encapsulating ground water that currently is below the Ground Water Remediation Standards. It is possible that the contaminants in ground water may migrate to ground water that is currently uncontaminated, but within the boundaries of the wall.

Compliance with ARARs

Alternative G1 does not include treatment, containment, or institutional controls therefore ARARs will not be met. Alternatives G2, G3, G4, G5 and G6 will meet all ARARs.

Long-Term Effectiveness and Permanence

All ground water alternatives (with the exception of G1) are effective in the long-term, since ground water use restrictions are placed on the impacted ground water until the concentrations of contaminants are below the Ground Water Remediation Standards. The long-term effectiveness of the ground water collection and treatment alternatives (G3 and G4) is ranked higher than the other three ground water alternatives because these involve reduction in mercury, arsenic and benzene concentrations in ground water. Alternative G4 ranks higher than Alternative G3 (the two pumping alternatives) in long-term effectiveness, since G4 removes a larger mass of mercury. The remaining three alternatives (G2, G5 and G6) are similar in their long-term effectiveness, since these alternatives rely on long-term containment of the impacted ground water. However, because of decreasing effectiveness of pump and treat systems over time, Alternatives G3 and G4 may leave residuals in ground water.

Reduction of Toxicity, Mobility, and Volume

Alternatives G3, G4 and G6 are the only alternatives that reduce toxicity, mobility and volume through treatment since they remove and treat mercury-impacted ground water through extraction and ex-situ treatment before disposal. Alternative G2 is not effective at reducing the potential for contaminants such as mercury and arsenic to migrate off-site. Alternatives G1, G2, and G5 do not reduce the toxicity, mobility and volume through treatment. Conversely, residuals remaining from GAC treatment (G3 and G6) and after ion exchange treatment in G4 will need to be disposed of after use.

Short-Term Effectiveness

Alternative G2 has minimal negative impacts with respect to the protection of workers during implementation, protection of community during remedial action, and environmental impacts of remedial action. The primary short-term risks are associated with proper worker protection during the collection of ground water samples to monitor compliance with the CEA. Alternatives G3 and G4, the two pumping alternatives, have slightly greater impacts to workers during construction than G2 since these alternatives involve the installation of extraction wells for pumping and treatment. Alternatives G5 and G6 have the largest short-term risks to workers, the community, and the environment, due to potential contact with impacted soil (wind blown dusts and/or impacts to surface water via storm water incidents) during installation of vertical hydraulic barrier and the additional safety considerations that must be followed for stabilization of the excavation. These risks are greater for Alternative G6 than G5 since the barrier in G6 is larger and hydraulic controls (i.e., pumping wells) also need to be installed.

The short-term effectiveness with respect to the time until the Ground Water Remediation Standards are achieved would be the shortest for G3 and G4 since these alternatives would reduce the concentrations of mercury, arsenic and benzene in ground water.

Implementability

All of the ground water alternatives can be implemented at the site. There are technical challenges with Alternatives G5 and G6 with the installation of the vertical hydraulic barrier adjacent to operating warehouses.

Cost

The total cost is a sum of the capital (construction) cost in addition to the present worth of the periodic costs and operation and maintenance of the alternative over time. Present worth is based on a discount rate of seven percent and a 30-year period. The present worth cost for the alternatives are as follows, from most expensive to least: Alternative G4, Ground Water Pump and Treat ($10,910,000); Alternative G6, Vertical Hydraulic Barrier Around Site Perimeter ($6,650,000); Alternative G3, Hydraulic Controls via Pumping ($3,630,000); Alternative G5, Vertical Hydraulic Barrier ($1,820,000); Alternative G2, Institutional Controls ($480,000); and Alternative G1, No Further Action (no cost).

SOIL ALTERNATIVES

Overall Protection of Human Health and the Environment

The no further action soil alternative (S1) is not protective of human health and/or the environment because it does not eliminate potential migration, either through infiltration control or airborne emission control, and does not eliminate potential direct contact exposure routes to impacted soil. Soil alternatives S2 through S7 are all considered protective of human health and the environment since they would eliminate potential direct contact to impacted soil, eliminate potential migration of impacted soil, and include locating and removing the drain line in the undeveloped area, thereby eliminating a potential migration pathway from the developed area to Berry's Creek. Furthermore, soils with concentrations that exceed ecological benchmarks do not remain available to ecological receptors after the remedial alternatives have been conducted because each alternative (except S1, No Action) includes capping or removal.

Soil alternative S2 relies primarily on a cap, which is protective since it will prevent migration and will eliminate exposure. Alternative S3 is more protective than S2 since some contaminated soil will be removed in the undeveloped area prior to capping. Alternative S4 is more protective than S2 and S3 since some contaminated soil will be removed in the developed and undeveloped areas. Alternative S5 includes excavation of all contaminated soil over 620 mg/kg in the developed and undeveloped areas and excavation of soil exceeding the RDCSCC on the off-site properties, so that is more protective than S2, S3 and S5. Alternative S6 is more protective of human health and the environment since all contaminated soil exceeding the RDCSCC will be removed in the undeveloped areas and on the off-site properties. Alternative S7 is the most protective since all soil exceeding the RDCSCC will be removed on the developed, undeveloped and off-site properties.

Compliance With ARARs

All soil alternatives other than no further action, S1, are expected to comply with ARARs. Soil alternatives that include restricted use through engineering and institutional controls (S2, S3, S4, S5 and S6) would comply with ARARs through restrictions on deeds and long-term monitoring of the integrity of any engineering controls.

Long-Term Effectiveness and Permanence

The active treatment or removal alternatives, such as alternatives S5, S6 and S7, are generally more effective in the long term over passive alternatives such as alternative S2, which will leave behind capped contaminated soil. Alternatives S3 and S4 would be slightly more effective than alternative S2, however residual risks would continue with both of these alternatives since a majority of the contaminant mass would remain under a cap. S7 is the most effective in the long term since all of the impacted soil is removed from the site. Alternatives S6, S5, S4, S3, and S2 follow in effectiveness, respectively, since soil is removed with alternatives S6, S5, S4, and S3, while alternative S2 does not include any soil removal.

Reduction of Toxicity, Mobility, and Volume

Alternatives S1 and S2 do not reduce the volume or toxicity of contaminants through treatment however, S2 will reduce mobility via capping. Alternative S3 removes and treats approximately 2,100 cubic yards of impacted soil in the undeveloped area. Alternative S4 removes and treats approximately 7,150 cubic yards of impacted soil in both the developed and undeveloped areas. Alternative S5 removes approximately 14,000 cubic yards of soil for off-site disposal. Alternative S6 removes approximately 130,000 cubic yards of soil. Alternative S7 removes approximately 157,500 cubic yards of soil. Alternative S7, with respect to reduction of toxicity, mobility, and volume through treatment, is rated the highest since 160,000 cubic yards of soil will be disposed of off-site.

Short-Term Effectiveness

Alternative S2 is most effective in the short term to workers and residents since there will be no fugitive dust emissions or increased truck traffic. Alternatives S3, S4, S5, S6, and S7 (stated in increasing order of potential impacts) have the potential for adverse impacts to both workers and the community during construction related to fugitive dust emissions and truck traffic hauling impacted soil. Alternatives S6 and S7 would require the closure of and/or restriction of traffic on Ethel Boulevard for a period of several months, including restrictions to the businesses located on Ethel Boulevard. Alternatives S2, S3, and S4 would take the shortest time to implement, ranging from 4 to 6 months, so short-term impacts would be minimal. Alternative S5 would take nearly 8 months to complete, S6 would take nearly 2.5 years to complete, and S7 would take over 3 years to complete, thereby increasing short-term impacts.

Implementability

Alternative S2 is the easiest to implement since all soil will remain in place and be capped. Alternative S3 is the next easiest to implement since the area of excavation is relatively small (approximately 2,800 cubic yards; 2,100 cubic yards from the undeveloped area and 700 cubic yards from Lin-Mor) and not within an area that is currently developed. Alternative S4 is somewhat more difficult to implement because the volume of soil to be excavated increases to approximately 7,150 cubic yards, and some of the excavation areas are in the developed area. Alternative S5 requires the additional excavation and transfer of impacted soil above the RDCSCC from the EJB, Blum, Prince Packing, and Borough of Wood-Ridge properties to the undeveloped fill area. The implementation of S6 is difficult because of the volume of soil that must be handled, staged, and trucked off-site for disposal which would take nearly two years due to weekly capacity limitations at the disposal facility. Alternative S7 is the most difficult to implement since it involves excavation at the U.S. Life and Wolf warehouses, both operating facilities. It would require demolition of those buildings and their foundations followed by removal of over 160,000 cubic yards of soil. It would take over 3 years to implement Alternative S7.

Cost

The total cost is a sum of the capital (construction) cost in addition to the present worth of the periodic costs and operation and maintenance of the alternative over time. Present worth is based on a discount rate of seven percent and a 30-year period. The present worth cost for the alternatives are as follows, from most expensive to least: Alternative S7, total excavation and off-site disposal ($135,300,000); Alternative S6, undeveloped area and off-site properties excavation to RDCSCC, limited excavation of developed area, cap, and institutional controls ($112,700,000); Alternative S5, excavation of all soil with levels above 620 mg/kg mercury, cap and institutional controls, and excavation of off-site properties to RDCSCC ($14,650,000); Alternative S4, excavation of all soil with levels above 620 mg/kg, cap and institutional controls ($14,060,000); Alternative S3, excavation of soil with levels of mercury above 620 mg/kg in the undeveloped area, cap and institutional controls ($8,413,000); Alternative S2, cap and institutional controls for all properties ($6,090,000) and Alternative S1, no further action (no cost).

USEPA Acceptance

The USEPA concurs with the selected remedy. USEPA's concurrence letter is attached (Appendix II).

Community Acceptance

Community acceptance of the preferred alternative presented by the Proposed Plan was assessed during the public comment period. Based on the comments received, the community accepts this approach. The attached Responsiveness Summary (Appendix III) addresses all verbal comments received at the public meeting. No written comments were received.

PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430(a)(1)(iii)(A)). The "principal threat" concept is applied to the characterization of "source materials" at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to ground water, surface water or air, or acts as a source for direct exposure. Contaminated ground water generally is not considered to be a source material; however, Non-Aqueous Phase Liquids (NAPLs) in ground water may be viewed as source material. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of the alternatives using the nine remedy selection criteria. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

Soil with mercury contamination exceeding 620 mg/kg is considered a principal threat waste at the Ventron/Velsicol Site because soil exceeding this level may be a continual source to ground water contamination. Alternative S4 addresses this principal threat through excavation and off-site disposal of soil exceeding 620 mg/kg mercury.

SELECTED REMEDY

Based upon consideration of the requirements of CERCLA, and the detailed analysis of alternatives, and public comments, the NJDEP and EPA have determined that alternative G5 is the appropriate remedy for ground water and S4 is the appropriate remedy for soil because they best satisfy the requirements of CERCLA §121, 42 U.S.C. §9621, and the NCP's nine evaluation criteria for remedial alternatives, 40 CFR §300.430 (e) (9).

This alternative consists of the following:

Ground Water Component:

A vertical hydraulic barrier system will be installed to serve as a physical barrier to ground water flow and to encapsulate the areas of highest mercury concentrations under the Wolf Warehouse. The hydraulic barrier will be keyed approximately 2 feet into the confining layer underlying the site at a depth of approximately 20 feet. Figure 2 identifies the location of the proposed hydraulic barrier.

Soil generated from the installation of the hydraulic barrier (approximately 1,650 cubic yards) will be placed under the cap in the undeveloped area.

Ground water use restrictions will be placed on the extent of the ground water contamination plume in the form of a Classification Exception Area and a Well Restriction Area to restrict the use of contaminated ground water.

Ground water monitoring will be conducted to determine if hydraulic controls within the barrier are required. If required, hydraulic controls will be implemented. Ground water monitoring will also be conducted to ensure the hydraulic barrier is effective. The monitoring requirements will be determined during design.

Soil Component

The soil component of the remedy includes excavation of all mercury-contaminated soil with levels above 620 mg/kg, excavation of site-related contaminants to the RDCSCC on the Lin-Mor property, capping and institutional controls. This alternative consists of the following:

- Excavation of all mercury-contaminated soil above 620 mg/kg (approximately 7,150 cubic yards of soil) and off-site disposal of that soil, subsequent to any necessary treatment.

- Excavation of site-related contaminants on the Lin-Mor property to the RDCSCC. If the property owners of Lin-Mor agree to the placement of a deed notice, then excavation to the RDCSCC will not be required; however, a deed notice will be required.

- Capping areas and/or maintenance of the existing caps (i.e., parking lots and building foundations) with contamination in soil above the NRDCSCC.

- Soil within the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and the West Ditch will be excavated and that soil may be placed under the cap in the undeveloped area. Certified clean fill will be placed in the buffer areas and native vegetation and erosion controls will be installed.

- Soil will be excavated from West Ditch to promote proper drainage and remove contaminated soil. Specific details of the excavation depth, liner design and installation (if necessary), depth of certified clean fill placed into the ditch, and soil management will be determined during the design phase of the project.

- The drain line within the undeveloped area will be located and removed (if it exists) before installation of the cap.

- Deed notices will be required on all properties with contaminated soil exceeding the NJDEP Residential Direct Contact Soil Cleanup Criteria. If a deed notice(s) cannot be negotiated with a property owner(s), then all soil contamination above NJDEP Residential Direct Contact Soil Cleanup Criteria must be removed on that particular property or properties.

- To ensure the remedy is protective of surface water, monitoring of contaminant flux from ground water to surface water and sediment will occur.

The excavation in the undeveloped area is estimated to be a depth of four feet, however additional delineation will be conducted prior to excavation or post-excavation samples will be taken to ensure the impacted soils have been removed. Based on the four-foot depth, it is estimated that 2,100 cubic yards will be excavated.

Treatment may be required under the Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions. The method of treatment will be determined during design and will occur prior to disposal at an off-site landfill.

STATUTORY DETERMINATIONS

As previously noted, CERCLA §121(b)(1), 42 U.S.C. §9621(b)(1), mandates that a remedial action must be protective of human health and the environment, cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Section 121 (b)(1) also establishes a preference for remedial actions that employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, or contaminants at a Site. CERCLA §121(d), 42 U.S.C. §9621 (d) further specifies that a remedial action must attain a degree of cleanup that satisfies ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA §121(d)(4), 42 U.S.C. §9621(d)(4). For the reasons discussed below, NJDEP has determined that the selected remedy at the Ventron/Velsicol Site meets the requirements of CERCLA §121, 42 U.S.C. §9621.

Protection of Human Health and the Environment

The selected remedy provides protection of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

The National Contingency Plan, Section 300.430(f)(ii)(B) requires that the selected remedy attain Federal and State ARARs. The remedy will comply with the following action-, chemical- and location-specific ARARs identified for the Site and will be demonstrated through monitoring, as appropriate.

Action-Specific ARARs:

- N.J.A.C. 7:26E - Technical Requirements for Site Remediation
- P.L. 1997 c. 39 - Brownfield and Contaminated Site Remediation Act
- 40 CFR 6301 (c) - National Historic Preservation Act

Chemical-Specific ARARs/TBCs

- 40 CFR Part 141 – Federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs)
- N.J.A.C. 7:26E-1.13(b) - Ground Water Remediation Standards
- NJDEP Soil Cleanup Criteria

Location-Specific ARARs:

- 40 CFR Part 6, Appendix A
- E.O. 11988, "Floodplain Management"
- E.O. 11990, "Protection of Wetlands"
- EPA's 1985 "Statement of Policy on Floodplains/Wetlands Assessments for CERCLA Actions"
- Coastal Zone Management Act
- N.J.A.C. 7:7A – New Jersey Freshwater Wetlands Protection Act

Cost Effectiveness

Each of the alternatives has undergone a detailed cost analysis. In that analysis, capital costs and annual costs have been estimated and used to develop the total cost. The cost effectiveness of an alternative is determined by weighing the cost against the alternative's ability to achieve ARARs and remedial action objectives. The selected remedy for the Site, Alternatives G5 and S4, will achieve the goals of the response actions and is cost-effective because it will provide the best overall effectiveness in proportion to its costs.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy meets the statutory requirement to utilize permanent solutions and treatment technologies to the maximum extent practicable.

Preference for Treatment as a Principal Element

The selected remedy satisfies the statutory preference for remedies that employ treatment as a principal element.

Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted at five-year intervals starting after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the Ventron/Velsicol site was released for public comment in August 2006. The Proposed Plan identified Alternative G5, Vertical Hydraulic Barrier and Alternative S4, Excavation of All Soil with Mercury Levels over 620 mg/kg; Capping and Institutional Controls, and Limited Excavation to Residential Direct Contact Soil Cleanup Criteria as the Preferred Alternative for the site. NJDEP reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

FIGURES

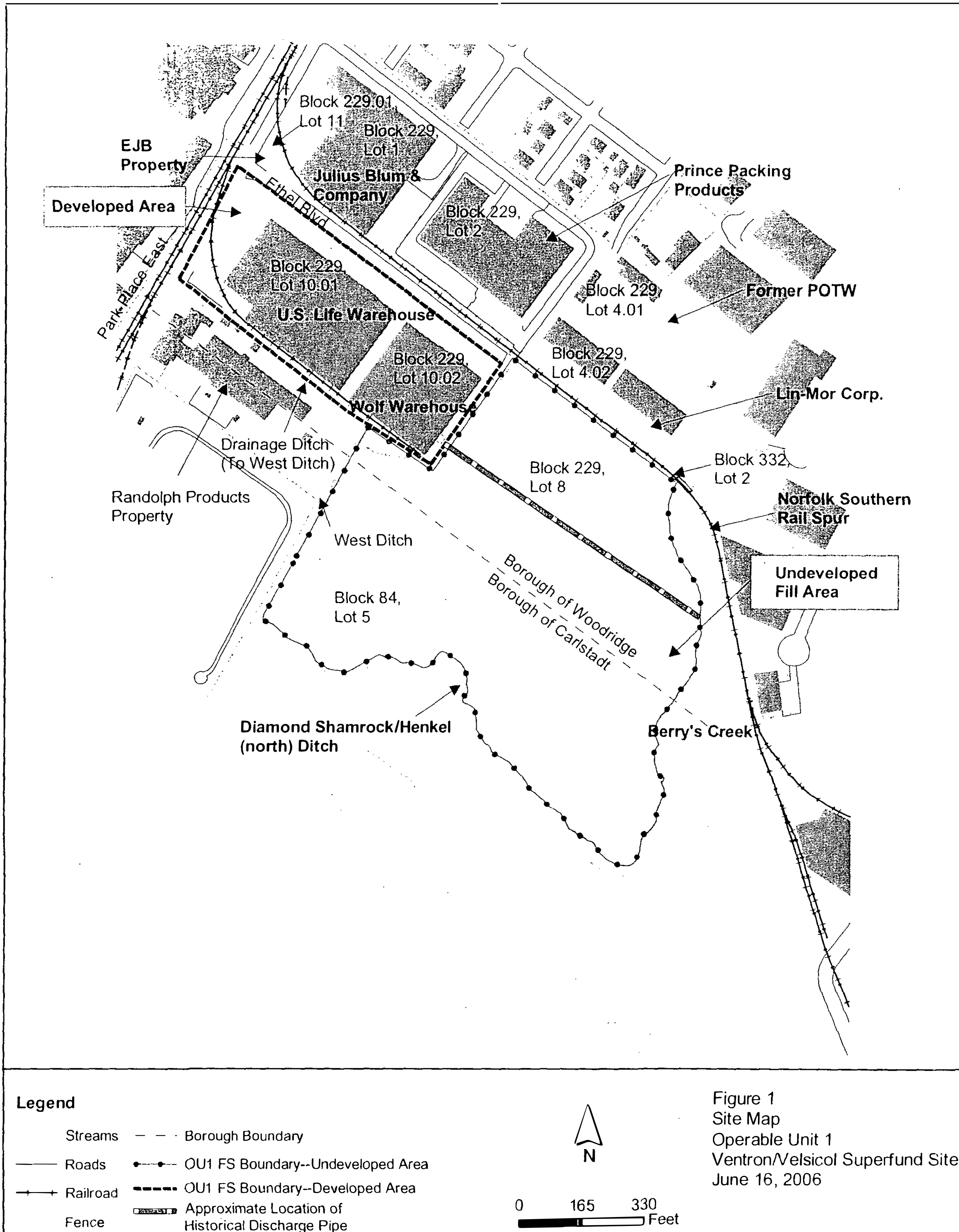
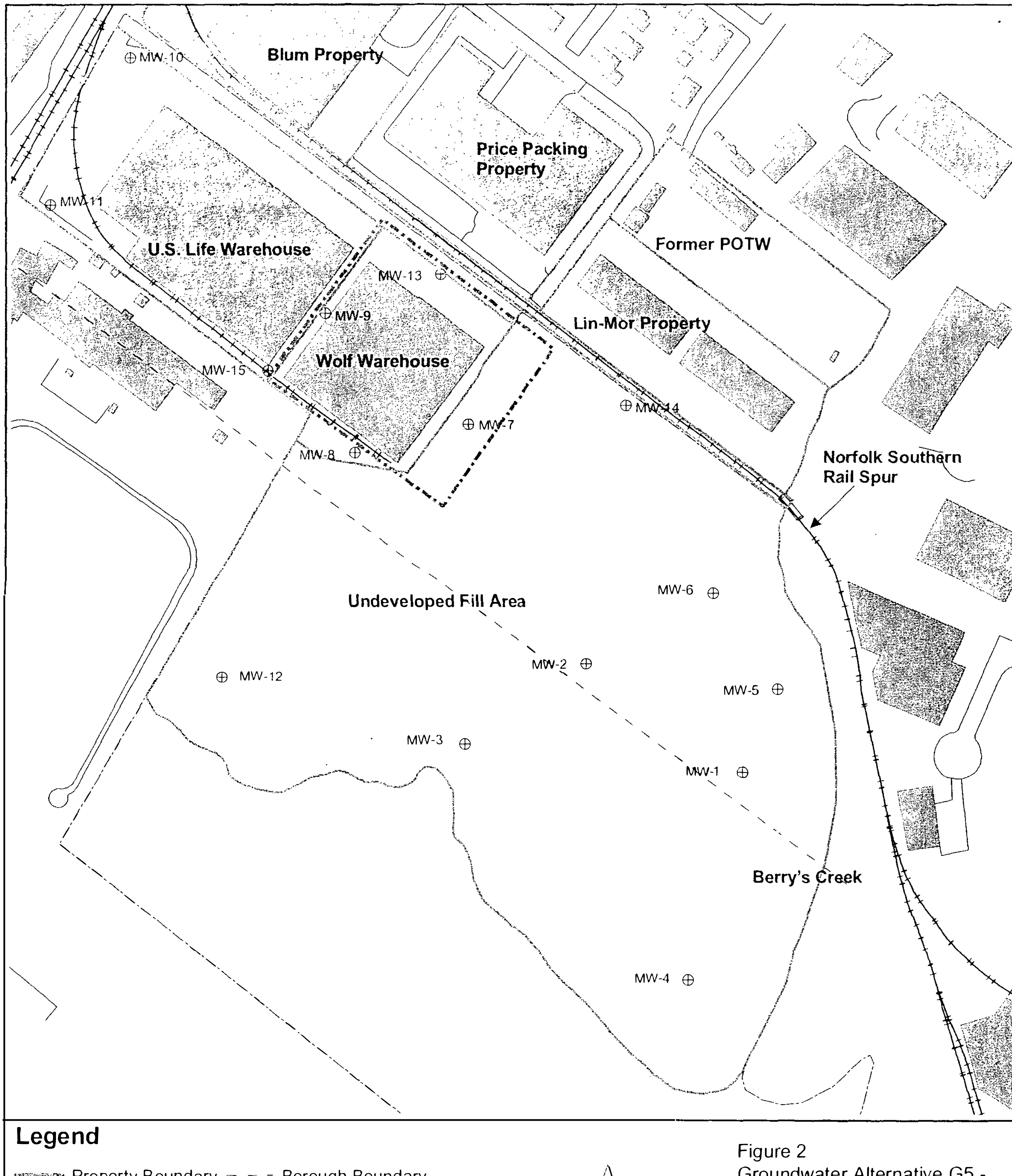


Figure 1
Site Map
Operable Unit 1
Ventron/Velsicol Superfund Site
June 16, 2006

CH2MHILL



Legend

Property Boundary
Borough Boundary
Streams
Monitoring Wells
Roads
Vertical Hydraulic Barrier Alignment
Railroad
Existing Buildings
Site Boundary

N

0 75 150 300 Feet

Figure 2
Groundwater Alternative G5 - Vertical Hydraulic Barrier
Ventron/Velsicol Superfund Site
OU 1 Feasibility Study
April 06, 2006

CH2MHILL

TABLES

TABLE 1

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Developed Area Surface Soil	Mercury	9.3	310	mg/kg	3/3	310	mg/kg	Max

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Developed Area Surface Soil	Mercury	9.3	2300	mg/kg	15/15	1300	mg/kg	UCL-P

The hot spot of mercury detected in the Developed Area Surface Soil is 13800 mg/kg. As discussed, risk and hazard associated with exposure to the hot spot was estimated separately and is presented in Table 4.

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Developed Area Subsurface Soil	Mercury	0.42	5150	mg/kg	35/35	2900	mg/kg	UCL-N

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Undeveloped Area Surface Soil	Mercury	0.331	5900	mg/kg	40/40	1800	mg/kg	UCL-P
	Naphthalene	0.062	120	mg/kg	7/27	49	mg/kg	UCL-N

The hot spot of mercury detected in the Undeveloped Area Surface Soil is 295000 mg/kg. As discussed, risk and hazard associated with exposure to the hot spot was estimated separately and is presented in Table 4.

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Undeveloped Area Subsurface Soil	Mercury	0.15	34700	mg/kg	103/104	730	mg/kg	ULC-P
	Naphthalene	0.009	22	mg//kg	14/42	6000	mg/kg	UCL-N

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Surface Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Undeveloped Area Surface Sediment	Mercury	18.95	1290	mg/kg	7/7	1290	mg/kg	Max

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration	EPC Units	Statistical Measure
		Min	Max					
Groundwater	Mercury	0.0108	54.243	ug/l	39/46	19	ug/l	UCL-N
	Naphthalene	9	100	ug/l	2/13	44	ug/l	UCL-N
	Benzene	1.2	140	ug/l	8/27	60	ug/l	UCL-N
	Arsenic	2.6	41.5	ug/l	8/43	9.4	ug/l	UCL-N

Key

mg/kg: milligram per kilogram; parts per million
ug/l: micrograms per liter; parts per billion
UCL-N: Normal Distribution, Upper Confidence Limit
UCL-P: Parametric Distribution, Upper Confidence Limit
Max: Maximum detected concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The tables present the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in the surface and subsurface soil, sediment, and groundwater (*i.e.*, the concentrations that will be used to estimate the exposure and risk from each COC in each medium). The tables include the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was calculated.

TABLE 2

Non-Cancer Toxicity Data Summary

Pathway: Ingestion/Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfD: Target Organ	Dates of RfD:
Mercury	Chronic	3e-04	mg/kg-day	2.1e-05	mg/kg-day	Immune	1000	IRIS	2/15/05
Naphthalene	Chronic	2e-02	mg/kg-day	2e-02	mg/kg-day	Body Weight	3000	IRIS	2/15/05
Benzene	Chronic	4.0e-03	mg/kg-day	4.0e-03	mg/kg-day	Blood	300	IRIS	2/15/05
Arsenic	Chronic	3e-04	mg/kg-day	3e-04	mg/kg-day	Skin	3	IRIS	2/15/05

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC Value	Inhalation RfC Units	Inhalation RfD	Inhalation RfD units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfC/RfD: Target Organ	Dates:
Mercury	Chronic	3e-04	mg/m^3	8.6e-05	mg/kg-day	CNS	30	IRIS	2/15/05
Naphthalene	Chronic	3e-03	mg/m^3	8.6e-04	mg/kg-day	Nasal	3000	IRIS	2/15/06
Benzene	Chronic	3e-02	mg/m^3	8.6e-03	mg/kg-day	Blood	300	IRIS	2/15/05
Arsenic	Chronic	NA		NA					

KEY
NA: No information available
IRIS: Integrated Risk Information System, U.S. EPA
mg/kg-day: milligrams per kilogram per day
mg/m^3: milligrams per cubic meter

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information which is relevant to the contaminants of concern. When available, the chronic toxicity data have been used to develop oral reference doses (RfDs).

TABLE 3

Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor	Units	Adjusted Cancer Slope Factor (for Dermal)	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Mercury	NA				D		
Naphthalene	NA				C		
Benzene	5.5e-02	1/(mg/kg-day)	5.5e-02	1/(mg/kg-day)	A	IRIS	2/15/05
Arsenic	1.5	1/(mg/kg-day)	1.5	1/(mg/kg-day)	A	IRIS	2/15/05

Pathway: Inhalation

Chemical of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Mercury	NA						
Naphthalene	NA						
Benzene	7.8e-06	$1/(ug/m^3)$	2.7e-02	1/(mg/kg-day)	A	IRIS	2/15/05
Arsenic			1.5e01	1/(mg/kg-day)	A	IRIS	2/15/05

Key:

NA: No information available
IRIS: Integrated Risk Information System, U.S. EPA
NCEA: National Center for Environmental Assessment, U.S. EPA

EPA Group:
A - Human carcinogen
B1 - Probable Human Carcinogen-Indicates that limited human data are available
B2 - Probable Human Carcinogen-Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Summary of Toxicity Assessment

This table provides carcinogenic risk information which is relevant to the contaminants of concern. Toxicity data are provided for both the oral and inhalation routes of exposure.

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Long-term Worker – Developed Area (see Table 10.2 RME of HHRA)
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface Soil	Developed Area Surface Soil	Mercury	Immune	2.1	NA	NA	2.1
Total Receptor Hazard Index for all media and exposure routes. =								5.2
Total Immune HI for Chemicals of Concern=								2.1

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Current/Future
Receptor Population: Construction Worker – Developed Area (Table 10.6 RME of HHRA)
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Subsurface Soil	Developed Area Subsurface Soil	Mercury	Immune	7.5	NA	NA	7.5
							Total Receptor Hazard Index =	7.8
							Total Immune HI =	7.5

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Current/Future
Receptor Population: Trespassers/Visitors – Undeveloped Area (see Table 10.8 RME of HHRA)
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil/Sediment	Surface Soil and Sediment	Undeveloped Area Surface Soil and Sediment	Mercury	Immune	2.5	NA	NA	2.5
							Total Receptor Hazard Index for all media and exposure routes =	3.8
							Total Immune HI for Chemicals of Concern=	2.5

HI values do not include exposure to the mercury/lead hot spot area. The total receptor HI with the hot spot is 17. All calculations can be found in the BHHRA.

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Current/Future
Receptor Population: Trespassers/Visitors – Undeveloped Area (see Table 10.9 RME of HHRA)
Receptor Age: **Adolescent/Pre-Adolescent**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil/Sediment	Surface Soil and Sediment	Undeveloped Area Surface Soil and Sediment	Mercury	Immune	3.65	NA	NA	3.65
							Total Receptor Hazard Index =	5.3
							Total Immune HI (the value of 3.2 is for mercury in sediment only. The total value of 4.2 includes all contaminants, media, and exposure routes) =	3.65

HI values do not include exposure to the mercury/lead hot spot area. The total receptor HI with the hot spot is 25. All calculations can be found in the BHHRA.

TABLE 4

Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Long-term Worker – Undeveloped Area (see Table 10.5 RME of HHRA)
Receptor Age: **Adult**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface soil	Air	Indoor Air (derived from subsurface soil	Naphthalene	Nasal	NA	4.8	NA	4.8
							Total Receptor Hazard Index =	9.6
							Total Nasal HI =	4.8

HI values do not include exposure to the mercury/lead hot spot area. The total receptor HI with the hot spot is 23. All calculations can be found in the BHHRA.

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Construction Worker -- Undeveloped Area (see Table 10.7 RME of HHRA)
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface soil	Subsurface Soil	Undeveloped Area Subsurface Soil	Mercury	Immune	1.9	NA	NA	1.9
							Total Receptor Hazard Index =	2.8
							Total Immune HI for Chemicals of Concern =	1.9

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Resident – Domestic Use of Groundwater (see Table 10.12 RME of HHRA)
Receptor Age: **Adult**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground-water	Ground-water	Groundwater	Mercury	Immune	1.7	NA	0.13	1.9
			Arsenic	Skin	0.86	NA	0.0045	0.86
Ground-water	Air	Indoor Air (showering/ bathing)	Napthalene	Nasal	NA	11	NA	11
			Benzene	Blood	NA	1.4	NA	1.4
							Total Receptor Hazard Index =	23
							Total Nasal HI for Chemicals of Concern =	11

TABLE 4
Risk Characterization Summary - Non-Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Resident – Domestic Use of Groundwater (see Table 10.13 RME of HHRA)
Receptor Age: **Child**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground-water	Ground-water	Groundwater	Mercury	Immune	6.1	NA	0.38	6.5
			Arsenic	Skin	3.0	NA	0.0013	3.0
Ground-water	Air	Indoor Air (showering/ bathing)	Napthalene	Nasal	NA	32	NA	32
			Benzene	Blood	NA	4.4	NA	4.4
							Total Receptor Hazard Index =	75
							Total Nasal HI for Chemicals of Concern =	32

Key
NA : Route of exposure is not applicable to this medium or was not quantitatively evaluated.
Summary of Risk Characterization - Non-Carcinogens
The table presents hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse non-cancer effects.

TABLE 5

Risk Characterization Summary – Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Resident – Domestic Use of Groundwater (see Tables 8.22 RME and 8.23 RME of HHRA)
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Arsenic**	2e-04	NA	9e-07	2e-04
Groundwater	Air	Indoor Air (showering/ bathing)	Benzene	NA	1e-04	NA	1E-04
						Total Risk =	4e-04

TABLE 5

Risk Characterization Summary – Carcinogens (RME)

Scenario Timeframe: Future
Receptor Population: Resident – Domestic Use of Groundwater (see Tables 8.24 RME and 8.25 RME of HHRA)
Receptor Age: Child **(This gets confusing because benzene was evaluated for AIR as the exposure medium and INDOOR AIR (SHOWERING/BATHING) as the exposure point. It was also evaluated for ingestion and dermal absorption for "groundwater sitewide" as the exposure point. Therefore, there are values where you have NA. The table should be restructured to be consistent with the HHRA.)**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Groundwater	Arsenic	1e-04	NA	5e-07	1e-04
Groundwater	Air	Indoor Air (showering/ bathing)	Benzene	NA	9e-05	NA	9E-05
						Total Risk =	2e-04

Key

NA : Route of exposure is not applicable to this medium or was not quantitatively evaluated.

Summary of Risk Characterization - Carcinogens

The table presents risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of the receptors exposure to soil and groundwater, as well as the toxicity of the COCs.

Table 6: Site-Related Ground Water Contaminants and Remediation Goals

Contaminant	NJ Ground Water Remediation Standard (µg/kg)
Arsenic	3
Benzene	1
Mercury	2

Table 7: Site-Related Soil Contaminants and Remediation Goals

Contaminant	RDCSCC (mg/kg)	NRDCSCC (mg/kg)
Arsenic	20	20
Bis(2-ethylhexyl)phthalate	49	210
Chrysene	9	40
Copper	600	600
Lead	400	600
Mercury	14	270
Thallium	2	2

RDCSCC = New Jersey Residential Direct Contact Soil Cleanup Criteria
NRDCSCC = New Jersey Non-Residential Direct Contact Soil Cleanup Criteria

APPENDIX I

Ventron/Velsicol Site Administrative Record

- *Superfund Record of Decision*, Venton/Velsicol Superfund Site (NJDEP, October 2006)
- Notice of Public Meeting, *The Bergen Record*, August 3, 2006, page A-12
- *Superfund Proposed Plan*, Ventron/Velsicol Superfund Site (NJDEP, August 2006)
- *Feasibility Study Report, Operable Unit 1* (CH2MHill, April 6, 2006)
- *Operable Unit 1 Human Health Risk Assessment Report* (Exponent, July 2005)
- *Operable Unit 1 Remedial Investigation Report* (Exponent, June 2004)
- *Operable Unit 1 Ecological Risk Assessment Report* (Exponent, April 2001)
- Resolution of the Berry's Creek/Wood-Ridge Site Action Committee (NJDEP, August 1996)
- Stipulation and Supplementary Order Approving Cooperative Agreement for Remedial Investigation and Feasibility Study and Amending Procedural Order Involving Remedy (October 1984)

APPENDIX II

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

IK 10/10

SEP 28 2006

Irene Kropp, Assistant Commissioner
Site Remediation Program
New Jersey Department of Environmental Protection
401 East State Street
P.O. Box 028
Trenton, New Jersey 08625

Re: Ventron/Velsicol Operable Unit 1 Record of Decision

Dear Ms. Kropp:

EPA has reviewed the draft Record of Decision (ROD) to address contamination at the upland portion of the Ventron/Velsicol Site (Operable Unit 1). The comments received on the Proposed Plan during the public comment period did not alter the preferred alternative. EPA concurs with the remedy selected. Components of the selected alternatives for ground water (Alternative G5) and soils (Alternative S4) are described below:

Ground Water – Vertical Hydraulic Barrier, Institutional Controls, Monitoring (Alternative G5)

- A vertical hydraulic barrier system (e.g., slurry wall or sheet pile wall) will be installed to serve as a physical barrier to ground water flow and to encapsulate the areas of highest mercury concentrations.

- Ground water use restrictions will be placed including a Classification Exception Area and a Well Restriction Area to prevent use of contaminated ground water.

- Ground water monitoring will be conducted to determine if hydraulic controls within the barrier are required. If required, hydraulic controls will be implemented. Ground water monitoring will also be conducted to ensure the hydraulic barrier is effective.

Soil – Containment of Mercury-Contaminated Soil Under the Wolf Warehouse; Excavation of Remaining Soils with Mercury Greater Than 620 milligrams per kilogram (620 mg/kg); Capping of Developed and Undeveloped Areas; Excavation of a 55-foot Buffer Area Adjacent to Wetlands and Waterways; Excavation or Capping for Neighboring Properties; and Institutional Controls (Alternative S4)

- Soils greater than 620 mg/kg mercury that are currently under the Wolf Warehouse foundation would remain on site, relying on the foundation as a containment structure. An estimated 7,150 cubic yards of mercury-contaminated soil above 620 mg/kg not under the Wolf Warehouse would be excavated and disposed of off site. Treatment will be conducted prior to disposal, as necessary, to meet RCRA Land Disposal Restrictions. Remnants of the former drain line within the undeveloped area would be located and removed, if they still exist.

- All areas with soil contamination exceeding the NJDEP Non-Residential Direct Contact Soil Cleanup Criteria (NRDCSCC) will be capped to prevent direct contact with residual soil contamination. Existing parking lots and building foundations will be maintained as part of the capped areas.

- In the undeveloped area, soil within the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and the West Ditch would be excavated. The excavated soil and debris may be placed under the cap in the undeveloped area. Certified clean fill would be placed in the excavated buffer areas and native vegetation established.

- Deed notices would be required on all properties with contaminated soil exceeding the NJDEP Residential Direct Contact Soil Cleanup Criteria (RDCSCC). If a deed notice(s) cannot be negotiated with a property owner(s), then all site-related soil contamination above RDCSCC must be removed on that particular property or properties (for example, the Lin-Mor property).

- Soil would be excavated from the West Ditch to promote proper drainage. Specific details of the excavation depth, liner design and installation (if necessary), depth of certified clean fill placed into the ditch, and soil management will be determined during the design phase of the project.

- To ensure the remedy is protective of surface water and adjacent wetlands, monitoring of contaminant flux from ground water to surface water and sediment will be performed.

Because the selected remedy will result in contamination remaining on site, five-year reviews of the remedy will be required to ensure that the remedy is working as expected.

EPA concurs with the selected remedy as described above. The selected remedy will address direct contact risks from contamination on the site and will allow for future non-residential land use.

If you have any questions please feel free to call me at 212-637-4390, or have your staff speak with Douglas Tomchuk, the EPA Remedial Project Manager for the site, at 212-637-3956.

Sincerely yours,

George Pavlou, Director
Emergency and Remedial Response Division

cc: Gwen Zervas, NJDEP

APPENDIX III

Responsiveness Summary

A. Overview

This is a summary of the comments and questions from the public regarding the Proposed Plan, dated August 2006, for the remediation of Operable Unit 1 of the Ventron/Velsicol Superfund Site, and the New Jersey Department of Environmental Protection's (NJDEP) responses to those comments and questions.

A public comment period was held from August 3, 2006 through September 2, 2006 to provide interested parties the opportunity to comment on the Proposed Plan for the Ventron/Velsicol Site. During the comment period, the NJDEP held a public meeting on August 9, 2006 at 7:00 PM at the Wood-Ridge Municipal Building to discuss the results of the Remedial Investigation/Feasibility Study (RI/FS) reports and to present the NJDEP/USEPA preferred alternative for remediation of the site.

The selected alternative includes the installation of a vertical hydraulic barrier to serve as a physical barrier to ground water flow as well as excavation of contaminated soil and capping. The Proposed Plan's suite of remedial alternatives were developed for remediation of the site in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

B. Summary of Comments Received during the Public Comment Period and NJDEP responses

Only one verbal comment was received at the Public Meeting on August 9, 2006. No written comments were received during the public comment period.

<u>Comment 1:</u>

During major storm events, for example, Hurricane Floyd in 1999, the streets around the Ventron/Velsicol Site become flooded. Is the flood water actually contaminated water coming from Berry's Creek?

<u>Response 1:</u>

Since the installation of the tide gate in Berry's Creek periodic flooding in the area of the Site has not been an issue. However, during unusual storm events flooding may occur. It is difficult to determine the exact origin of the flood water during these unusual events, however, the quantity of water is so great during these storms that any water that may come from the creek would be greatly diluted and therefore not of any human health concern.

APPENDIX IV

Appendix IV

Ventron/Velsicol OU1 Superfund Site

Statement of Findings: Wetlands and Floodplains

Need to Affect Wetlands and Floodplains

The Ventron/Velsicol OU1 Superfund Site contains wetlands and is partially situated in the 100-yr floodplain. The locations of the site, wetlands, and the 100-yr floodplain are shown in Figure 1. Site wetlands include Section 10 wetlands along and in the West Ditch, along the Diamond Shamrock/Henkel (north) Ditch, and along Berry's Creek. Section 404 wetlands occur on site along Berry's Creek north of the tide gate and in a depression called the onsite basin, located in the undeveloped fill area east of the Wolf Warehouse. A small section of Section 404 wetland identified between the U.S. Life Warehouse and the Wolf Warehouse in the wetland delineation report was later determined to be underlain by asphalt and hence not a jurisdictional wetland. Adjacent to the site, wetlands also occur in the Diamond Shamrock/Henkel (north) Ditch, the marsh area south of the site, and portions of Berry's Creek.

The remedial investigation and risk assessments concluded that contaminated soil and sediment at the site including that in wetlands and the floodplain pose risk to human health and ecological receptors. In addition, groundwater was considered to pose risk to humans and ecological receptors that might come in contact with it. The feasibility study considered six groundwater and seven soil remedial alternatives. The selected alternative for groundwater includes a hydraulic barrier in the vicinity of the Wolf Warehouse and is not expected to affect wetlands and floodplains. All soil alternatives except for no further action require 1) excavation of approximately 450 cubic yards of wetlands/floodplain soils in the West Ditch followed by regrading, capping, and filling that is compatible with wetland/floodplain restoration and 2) excavation of approximately 10,000 cubic yards of wetlands/floodplain soils in the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch, and West Ditch followed by backfill with clean fill to grade that is compatible with wetland/floodplain restoration. Approximately 5,000 square yards of wetland vegetation along the 55 foot buffer and consisting primarily of common reed (*Phragmites australis*) would be removed during these remedial activities. All soil alternatives except for no further action would also result in capping of the on-site basin in the undeveloped fill area. The selected remedial alternative is illustrated on Figure 1.

The New Jersey Department of Environmental Protection (NJDEP) and the U.S. Environmental Protection Agency (EPA) have determined that there is no practicable alternative that is sufficiently protective of human health and the environment that would not result in the excavation and capping of these soils and sediments. Consequently, since remedial action is necessary, any remedial action that might be taken would necessarily affect wetlands and floodplains associated with the site.

Facts Considered in Deciding to Affect Wetlands and Floodplains

The primary facts considered in the decision to affect wetlands and floodplains were 1) contaminated soil and sediment in wetlands and floodplain areas of the site pose unacceptable risks to human health and ecological receptors and 2) there is no practicable alternative that is sufficiently protective of human health and the environment that would not result in the excavation and capping of these soils and sediments. The no further action alternative does not involve excavation or capping of contaminated soils and sediments (i.e., no remedial actions would take place within delineated wetlands or floodplains). However, contaminated soils and sediments would remain in place and would continue to be a potential source of contamination to the site and to adjacent wetlands and floodplains. Consequently, the no further action alternative would not be protective of human health and the environment. The implementation of any of the action alternatives would be more protective of human health and the environment than the no further action alternative, and all action alternatives would involve substantial actions within wetlands and floodplains.

Compliance with State or Local Wetland, Floodplain, and Coastal Zone Protection Standards

The selected remedy will comply with state and local standards for protection of wetlands, floodplains, and coastal zones. Standards include New Jersey laws (N.J.S.A.) and regulations (N.J.A.C.) pertaining to work within wetlands (the Freshwater Wetlands Protection Act [N.J.S.A. 13:9B], the Wetlands Act of 1970 [N.J.S.A. 13:9A], the Freshwater Wetlands Protection Act Rules [N.J.A.C. 7:7A], and the New Jersey Meadowlands Commission Zoning [N.J.S.A. 13:17]), floodplains (the Flood Hazard Area Control Act [N.J.S.A. 58:16A] and the Flood Hazard Control Act Rules [N.J.A.C 7:13]), and coastal zones (the Waterfront Development Act [N.J.S.A. 12:5-3] and the Coastal Permit Program Rules [N.J.A.C. 7:7]).

Wetlands disturbances in the Hackensack Meadowlands Development Area (i.e., the portion of the site located in Carlstadt) are exempt from the NJDEP wetlands program but will require permits from the Army Corps of Engineers or the New Jersey Meadowlands Commission (formerly the Hackensack Meadowlands Development Commission). In addition, local zoning requirement such as those from the Borough of Wood-Ridge will be met.

The selected remedy will also comply with federal applicable or relevant and appropriate substantive requirements relating to wetlands and floodplains including Executive Order 11990: Protection of Wetlands, Executive Order 11988: Floodplain Management, 40 CFR Part 6 Appendix A, and EPA's 1985 Statement of Policy on Floodplains/Wetlands Assessments for CERCLA Actions.

Measures to Minimize Potential Harm to Wetlands and Floodplains

Implementation of the selected remedy will entail excavation of soil within the 55-foot buffer area adjacent to Berry's Creek, the Diamond Shamrock/Henkel (north) Ditch and the West Ditch and excavation and capping of the West Ditch (Figure 1). These actions will result in temporary physical disturbance of wetland and floodplain habitats in these areas. Wetland and floodplain assessments will be performed during the remedial design phase. Measures to minimize potential adverse impacts that cannot be avoided will be evaluated as part of and incorporated into the remedial design. Measures to be used during and after the remedy to prevent soils or sediments from being transported to other parts of adjacent wetlands or floodplains during remediation and/or flood events could include common practices, such as installation of silt fencing, hay bales, hay/straw mulch, jute matting, temporary berms, silt curtains, coffer dams, and operational controls. Areas of the 55-foot buffer zone from which soil is to be excavated will be remediated by placement of clean fill, re-vegetation with native species, and installation of appropriate erosion controls. Areas of the West Ditch subject to excavation and capping will also be remediated by placement of clean fill to restore a natural hydrological gradient.

The wetland assessment will determine the baseline conditions for the wetlands prior to remedial action. Further, this assessment will be used to design a wetlands restoration plan to reestablish wetland functions and values to the greatest extent possible during the restoration process. A post-remediation monitoring plan will be developed for remediated areas. The monitoring plan will evaluate the progress of wetland restoration toward the desired results including prevention of the establishment of unwanted invasive species. Mitigation options will be evaluated for any wetland losses that cannot be replaced via on-site restoration.

Effects of Proposed Action on the Natural and Beneficial Values of Wetlands and Floodplains

Excavation of soil within the 55-foot buffer area, excavation and capping in the West Ditch, and capping of the onsite basin will eliminate pathways to ecological receptors inhabiting those locations as well as human who may be exposed to these areas. Soil will be excavated from the West Ditch to promote proper drainage, which should help to restore normal hydrological function to the wetland. In addition, the remedial action objectives (RAOs) for OU1 include the prevention or minimization of potential downgradient and off-site migration of contaminated groundwater to the marsh area and Berry's Creek and the migration of contaminants in surface soil and sediments to the marsh area and Berry's Creek via surface runoff and windblown dust (for soil only). Since the selected remedy will be expected to achieve the RAOs, soils or sediments with contaminants will no longer function as a source of contamination to off-site areas or to ecological receptors in those areas. Accordingly, it is anticipated that no long-term adverse effects to wetland or floodplain resources will result due to implementation of the selected remedy since any short-term negative impacts to the natural or beneficial uses associated with soils or sediments that are already affected by existing contamination will be more than compensated for by the long-term benefit to the marsh area and Berry's Creek once those soils and sediments are removed or capped.

A previous evaluation of wetlands on the site concluded that vegetation communities were altered due to past human activities on the site and that the wetland is dominated by dense stands of common reed (*Phragmites australis*). Habitat restoration of the 55-foot buffer zone and wetland areas following remedial activities should restore a natural plant community that will provide higher value to wetland resources than the existing habitat.

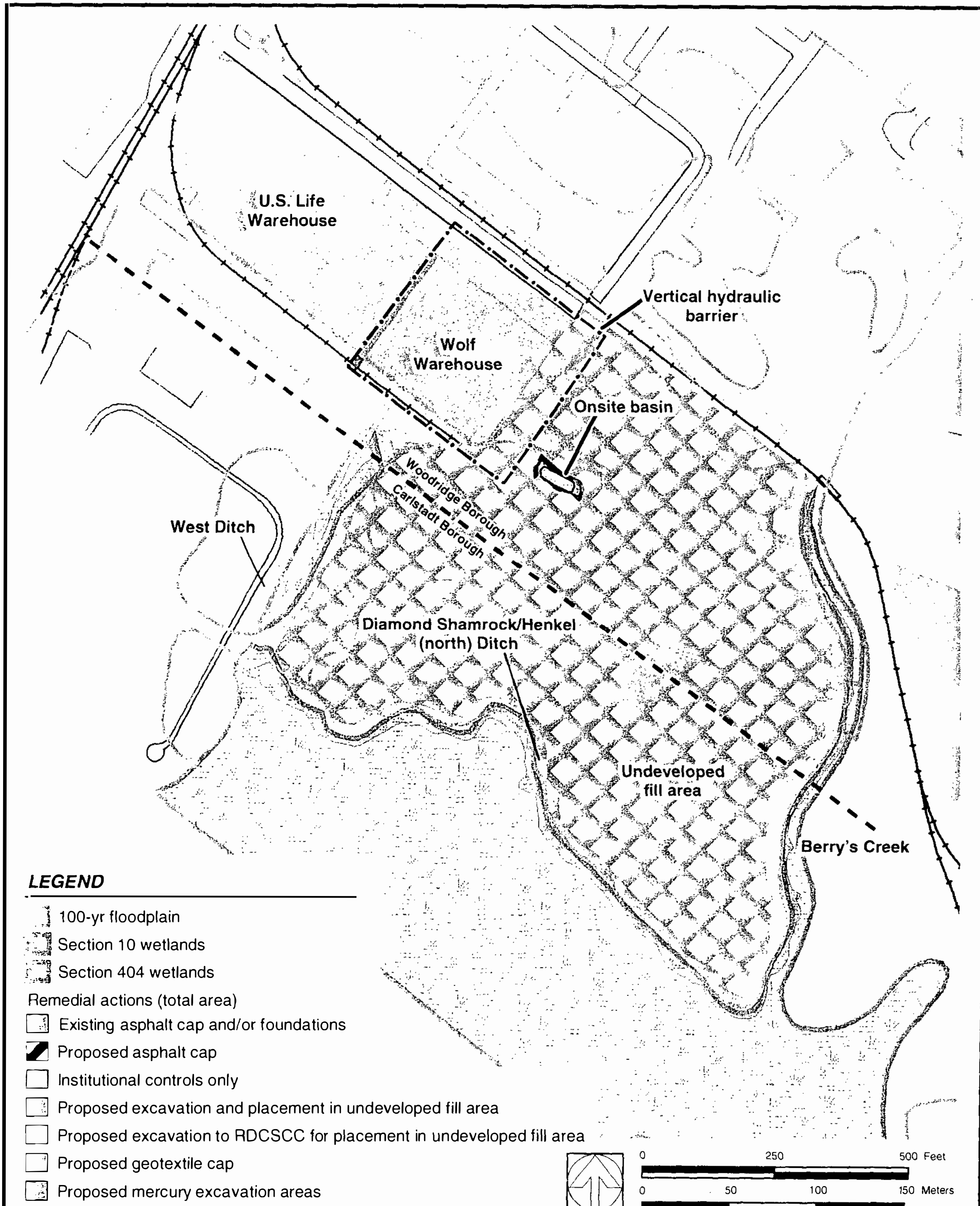


Figure 1. Selected remedial alternative with wetlands and 100-yr floodplain

Exponent

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NJDEP Ecological Screening Criteria

Toxic Substance	CAS Number	Surface Water (ug/L)						Sediment (mg/kg)				Soil (mg/kg)					
		Fresh Water (FW2) Criteria			Saline Water (SE & SC) Criteria			Fresh Water Criteria		Saline Water Criteria		Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[20]			
		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
Acenaphthene	83-32-9		38[8]	670(h)			990(h)	See Saline Criteria[3] 0.00671[8]		0.016	0.500	20[9]					
Acenaphthylene	208-96-8		4840[8]					See Saline Criteria[3] 0.00587[8]		0.044	0.640	682[8]					
Acrolein	107-02-8		0.19[8]	6.1(h)			9.3(h)	0.00000152[8]				5.27[8]					
Acrylonitrile	107-13-1		66[8]	0.051(hc)			0.25(hc)	0.0012[8]				0.0239[8]					
Aldrin	309-00-2	3	0.017[8]	0.000049(hc)	1.3		0.000050(hc)	0.002	8	See Freshwater Criteria[6]		0.00332[8]					
Aluminum	7429-90-5							2.55%[15]			1.8%[15]		50				
Ammonia, un-ionizec	7664-41-7	See N.J.A.C. 7:9B-1.14(e)			See N.J.A.C. 7:9B-												
Anthracene	120-12-7		0.035[8]	8,300(h)			40,000(h)	0.22 0.0572[8]	370	0.085	1.1	1,480[8]					
Antimony	7440-36-0		80[8]	5.6(h)(T)			640(h)(T)		3[15]		9.3[15]	5[9]	5		78		0.27
Arsenic	7440-38-2	340(d)(s)	150(d)(s)	0.017(hc)(T)	69(d)(s)	36(d)(s)	0.061(hc)(T)	6 9.9790[8]	33	8.2	70	9.9[9,10]	10	18		43	46
Asbestos	1332-21-4			$7x10^6$ fibers/L >10um(h)													
Barium	7440-39-3		220[8]	2,000(h)(T)							48[15]	283[11]	500		330		2,000
Benz(a)anthracene	56-55-3		0.025[8]	0.038(hc)			0.18(hc)	0.320 0.108[8]	1,480	0.261	1.6	5.21[8]					
Benzene	71-43-2		114[8] 824[16]	0.15(hc)			3.3(hc)	See Saline Criteria[3] 0.142[8]		0.34[7]		0.255[8]					
Benzidine	92-87-5			0.000086(hc)			0.00020(hc)										
3,4-Benzofluoranthene (Benzo(b)fluoranthene)	205-99-2		9.07[8]	0.038(hc)			0.18(hc)	10.4[8]			1.800[15]	59.8[8]					
Benzo(k)fluoranthene	207-08-9			0.38(hc)			1.8(hc)	0.240	1,340	See Freshwater Criteria[6]		148[8]					
Benzo(g,h,i)perylene	191-24-2		7.64[8]					0.170	320	See Freshwater Criteria[6]		119[8]					
Benzo(a)pyrene (BaP)	50-32-8		0.014[8]	0.0038(hc)			0.018(hc)	0.37 0.150[8]	1,440	0.430	1.6	1.52[8]					
Beryllium	7440-41-7		3.6[8]	6.0(h)(T)			42(h)(T)					10[9]	10		40		21
BHC (Benzohexachloride)								0.003	12	See Freshwater Criteria[6]							
alpha-BHC (alpha-HCH)	319-84-6		12.4[8]	0.0026(hc)			0.0049(hc)	0.006	10			0.0994[8]					
beta-BHC (beta-HCH)	319-85-7		0.495[8]	0.0091(hc)			0.017(hc)	0.005	21			0.00398[8]					
gamma-BHC (gamma-HCH/Lindane)	58-89-9	0.95	0.026[8]	0.98(h)	0.16		1.8(h)	0.003	1			0.00500[8]					
Biphenyl	92-52-4											60[9]					
Bis(2-chloroethyl) ether	111-44-4		1900[8]	0.030(hc)			0.53(hc)	3.520[8]				23.7[8]					
Bis(2-chloroisopropyl) ether	108-60-1			1,400(h)			65,000(h)					19.9[8]					
Bis(2-ethylhexyl) phthalate	117-81-7		0.3[8]	1.2(hc)			2.2(hc)	0.182[8]	0.750[15]	0.18216[15]	2.64651[15]	0.925[8]					
Boron	7440-42-8											0.5[9]	0.5				
Bromine	7726-95-6											10[9]	10				
Bromodichloromethane (Dichlorobromomethane)	75-27-4			0.55(hc)			17(hc)					0.540[8]					
Bromoform	75-25-2		230[8]	4.3(hc)			140(hc)	0.492[8]				15.9[8]					

NJDEP Ecological Screening Criteria

Toxic Substance	CAS Number	Surface Water (ug/L)						Sediment (mg/kg)				Soil (mg/kg)					
		Fresh Water (FW2) Criteria			Saline Water (SE & SC) Criteria			Fresh Water Criteria		Saline Water Criteria		Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[20]			
		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
Butyl benzyl phthalate	85-68-7		23[8]	150(h)			190(h)	1.970[8]			0.063[15]	0.239[8]					
Cadmium	7440-43-9	(a)	(a)	3.4(h)(T)	40(d)(s)	8.8(d)(s)	16(h)(T)	0.6 0.990[8]	10	1.2	9.6	4[9,11]	4	32	140	0.77	0.36
Carbon tetrachloride	56-23-5		240[8]	0.33(hc)			2.3(hc)	1.450[8]				2.98[8]					
Chlordane	57-74-9	2.4	0.0043	0.00010(hc)	0.09	0.004	0.00011(hc)	0.007 0.00324[8]	6	See Freshwater Criteria[6]		0.224[8]					
Chloride	16887-00-6	860,000	230,000	250,000													
Chlorine Produced Oxidants (CPO)	7782-50-5	19	11		13	7.5											
3-Chloroaniline	108-42-9											20[9]	20				
Chlorobenzene	108-90-7		47[8]	210(h)			2,500(h)	0.291[8]				40[12] 13.1[8]					
Chloroform	67-66-3		140[8]	68(h)			2,100(h)	0.121[8]				1.19[8]					
2-Chloronaphthalene	91-58-7		0.396[8]	1,000(h)			1,600(h)	0.417[8]				0.0122[8]					
2-Chlorophenol	95-57-8		24[8]	81(h)			150(h)	0.0319[8]			0.008[15]	0.243[8]					
3-Chlorophenol	108-43-0											7[12]	7				
Chlorpyrifos	2921-88-2	0.083	0.041		0.011	0.0056											
Chromium	7440-47-3		42[8]	92(h)(T)			750(h)(T)	26 43.4[8]	110	81	370	0.4[12]	1				
Chromium+3	16065-83-1	(a)	(a)													26	34
Chromium+6	18540-29-9	15(d)(s)	10(d)(s)		1,100(d)(s)	50(d)(s)											130
Chrysene	218-01-9			3.8(hc)			18(hc)	0.34 0.166[8]	460	0.384	2.8	4.73[8]					
Cobalt	7440-48-4		24[8]					50[8]			10[15]	20[9] 0.14[8]	20	13		120	230
Copper	7440-50-8	(a)	(a)	1,300(h)(T)	4.8(d)(s)	3.1(d)(s)		16 31.6[8]	110	34	270	60[12] 5.4[8]	100	70	80	28	49
Cyanide (Total)	57-12-5	22(fc)	5.2(fc)	140(h)	1.0(fc)	1.0(fc)	140(h)	0.0001[8]				1.33[8]					
4,4'-DDD (p,p'-TDE)	72-54-8			0.00031(hc)			0.00031(hc)	0.008 0.00488[8]	6	0.002[15]	0.02[15]	0.758[8]					
4,4'-DDE	72-55-9		0.00000000451[8]	0.00022(hc)			0.00022(hc)	0.005 0.00316[8]	19	0.0022	0.027	0.596[8]					
4,4'-DDT	50-29-3	1.1	0.001	0.00022(hc)	0.13	0.001	0.00022(hc)	0.008 0.00416[8]	71	0.001[15]	0.007[15]	0.0035[8]					
DDT (Total)								0.007	12	0.0016	0.046					0.093[21]	0.021[21]
Demeton	8065-48-3		0.1			0.1											
Dibenz(a,h)anthracene	53-70-3			0.0038(hc)			0.018(hc)	0.06 0.033[8]	130	0.063	0.26	18.4[8]					
Dibromochloromethane (Chlorodibromomethane)	124-48-1			0.40(hc)			13(hc)					2.05[8]					
Di-n-butyl phthalate	84-74-2		9.7[8]	2,000(h)			4,500(h)	1.114[8]	0.110[15]		0.058[15]	200[9] 0.15[8]					
1,2-Dichlorobenzene	95-50-1		14[8]	2,000(h)			6,200(h)	0.294[8]			0.013[15]	2.96[8]					
1,3-Dichlorobenzene	541-73-1		38[8]	2,200(h)			8,300(h)	1.315[8]				37.7[8]					
1,4-Dichlorobenzene	106-46-7		9.4[8]	550(h)			2,200(h)	0.318[8]			0.110[15]	20[12] 0.546[8]					
3,3'-Dichlorobenzidine	91-94-1		4.5[8]	0.021(hc)			0.028(hc)	0.127[8]				0.646[8]					
1,2-Dichloroethane	107-06-2		910[8]	0.29(hc)			28(hc)	0.260[8]				21.2[8]					
1,1-Dichloroethylene	75-35-4		65[8]	4.7(h)			100(h)	0.0194[8]				8.28[8]					
trans-1,2-Dichloroethylene	156-60-5		970[8]	590(h)			43,000(h)	0.654[8]				0.784[8]					

NJDEP Ecological Screening Criteria

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		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
2,4-Dichlorophenol	120-83-2		11[8]	77(h)			290(h)	0.0817[8]			0.005[15]	87.5[8]					
3,4-Dichlorophenol	95-77-2											20[9,12]	20				
1,2-Dichloropropane	78-87-5		360[8]	0.50(hc)			15(hc)	0.333[8]				32.7[8]					
1,3-Dichloropropene (cis and trans)	542-75-6			0.34(hc)			21(hc)										
Dieldrin	60-57-1	0.24	0.056	0.000052(hc)	0.71	0.0019	0.000054(hc)	0.002 0.0019[8]	91	See Freshwater Criteria[6]		0.00238[8]				0.022	0.0049
Diethyl phthalate	84-66-2		110[8]	17,000(h)			44,000(h)	0.295[8]			0.006[15]	100[9] 24.8[8]					
2,4-Dimethyl phenol	105-67-9		100[8]	380(h)			850(h)	0.304[8]				0.010[8]					
4,6-Dinitro-o-cresol	534-52-1			13(h)			280(h)										
2,4-Dinitrophenol	51-28-5		19[8]	69(h)			5,300(h)	0.00621[8]				20[9] 0.0609[8]	20				
2,4-Dinitrotoluene	121-14-2		44[8]	0.11(hc)			3.4(hc)	0.0144[8]				1.28[8]					
1,2-Diphenylhydrazine	122-66-7			0.036(hc)			0.20(hc)										
Endosulfans (alpha and beta)	115-29-7	0.22	0.056	62(h)	0.034	0.0087	89(h)										
Endosulfan sulfate	1031-07-8		2.22[8]	62(h)			89(h)	0.0346[8]				0.0358[8]					
Endrin	72-20-8	0.086	0.036	0.059(h)	0.037	0.0023	0.060(h)	0.003 0.00222[8]	130	See Freshwater Criteria[6]		0.0101[8]					
Endrin aldehyde	7421-93-4		0.15[8]	0.059(h)			0.060(h)	0.480[8]				0.0105[8]					
Ethylbenzene	100-41-4		14[8] 81[16]	530(h)			2,100(h)	See Saline Criteria[3] 0.175[8]		1.4[7]		5.16[8]					
Fluoranthene	206-44-0		1.9[8]	130(h)			140(h)	0.75 0.423[8]	1,020	0.600	5.1	122[8]					
Fluorene	86-73-7		19[8]	1,100(h)			5,300(h)	0.19 0.0774[8]	160	0.019	0.54	122[8]					
Fluorine	7782-41-4											200[9]	200				
Furan	110-00-9											600[9]					
Guthion	86-50-0		0.01			0.01											
Heptachlor	76-44-8	0.52	0.0038	0.000079(hc)	0.053	0.0036	0.000079(hc)	0.0006[8]	0.010[15]		0.0003[15]	0.00598[8]					
Heptachlor epoxide	1024-57-3	0.52	0.0038	0.000039(hc)	0.053	0.0036	0.000039(hc)	0.005 0.00247[8]	5	See Freshwater Criteria[6]		0.152[8]					
Hexachlorobenzene	118-74-1		0.0003[8]	0.00028(hc)			0.00029(hc)	0.020	24	See Freshwater Criteria[6]		0.199[8]					
Hexachlorobutadiene	87-68-3		0.053[8]	0.44(hc)			18(hc)	0.0265[8]			0.0013[15]	0.0398[8]					
Hexachlorocyclopentadiene	77-47-4		77[8]	40(h)			1,100(h)	0.901[8]				10[9] 0.755[8]					
Hexachloroethane	67-72-1		8[8]	1.4(hc)			3.3(hc)	0.584[8]			0.073[15]	0.596[8]					
Indeno(1,2,3-cd)pyrene	193-39-5		4.31[8]	0.038(hc)			0.18(hc)	0.200	320	See Freshwater Criteria[6]		109[8]					
Iodine	7553-56-2											4[9]	4				
Isophorone	78-59-1		920[8]	35(hc)			960(hc)	0.432[8]				139[8]					
Lead	7439-92-1	38(d)(s)	5.4(d)(s)	5.0(h)(T)	210(d)(s)	24(d)(s)		31 35.8[8]	250	47	218	40.5[11] 0.0537[8]	50	120	1,700	11	56
Lithium	7439-93-2											2[9]	2				
Malathion	121-75-5		0.1			0.1											
Manganese	7439-96-5						100(h)(T)	630[15]	1,100[15]		260[15]		500	220	450	4,300	4,000
Mercury	7439-97-6	1.4(d)(s)	0.77(d)(s)	0.050(h)(T)	1.8(d)(s)	0.94(d)(s)	0.051(h)(T)	0.2 0.174[8]	2	0.15	0.71	0.00051[11] 0.1[8]	0.3				

NJDEP Ecological Screening Criteria

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		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
Methoxychlor	72-43-5		0.03	40(h)		0.03		0.0136[8]				0.0199[8]					
Methyl bromide (bromomethane)	74-83-9		16[8]	47(h)			1,500(h)	0.00137[8]				0.235[8]					
Methyl t-butyl ether (MTBE)	1634-04-4	151,000[17]	51,450[16] 51,000[17]	70(h)	53,000[17]	18,000[17]											
Methylene chloride	75-09-2		940[8]	2.5(hc)			310(hc)	0.159[8]				4.05[8]					
2-Methylnaphthalene	91-57-6		330[8]					See Saline Criteria[3] 0.0202[8]		0.070	0.67	3.24[8]					
Mirex	2385-85-5		0.001			0.001		0.007	130	See Freshwater Criteria[6]							
Molybdenum	7439-98-7											2[9]	2				
Naphthalene	91-20-3		13[8]					See Saline Criteria[3] 0.176[8]		0.16	2.1	0.0994[8]					
Nickel	7440-02-0	(a)	(a)	500(h)(T)	64(d)(s)	22(d)(s)	1,700(h)(T)	16 22.7[8]	75	21	52	30[9] 13.6[8]	30	38	280	210	130
Nitrate (as N)	14797-55-8			10,000(h)													
Nitrobenzene	98-95-3		220[8]	17(h)			690(h)	0.145[8]				1.31[8]					
4-Nitrophenol	100-02-7		60[8]					0.0133[8]				7[12] 5.12[8]					
N-Nitrosodi-n-butylamine	924-16-3			0.0063(hc)			0.22(hc)										
N-Nitrosodiethylamine	55-18-5		768[8]	0.00023(hc)			0.13(hc)	0.0228[8]				0.0693[8]					
N-Nitrosodimethylamine	62-75-9			0.00069(hc)			3.0(hc)					0.0000321[8]					
N-Nitrosodiphenylamine	86-30-6			3.3(hc)			6.0(hc)					0.545[8]					
N-Nitrosodi-n-propylamine (Di-n propylnitrosamine)	621-64-7			0.0050(hc)			0.51(hc)										
N-Nitrosopyrrolidine	930-55-2			0.016(hc)			34(hc)					0.0126[8]					
Parathion	56-38-2	0.065	0.013					0.000757[8]				0.00034[8]					
Pentachlorobenzene	608-93-5		0.019[8]	1.4(h)			1.5(h)	0.024[8]				20[12] 0.497[8]					
Pentachlorophenol	87-86-5	(b)	(b)	0.27(hc)	13	7.9	3.0(hc)	23[8]			0.017[15]	3[9] 0.119[8]	3	5.0	31	2.1	2.8
Phenanthrene	85-01-8		3.6[8]					0.56 0.204[8]	950	0.240	1.5	45.7[8]					
Phenol	108-95-2		180[8]	10,000(h)			860,000(h)	0.0491[8]	0.048[15]		0.130[15]	30[12] 120[8]					
Phosphorous (yellow)	7723-14-0					0.1											
PCB Aroclor 1016								0.007	53	See Freshwater Criteria[6]							
PCB Aroclor 1248								0.030	150	See Freshwater Criteria[6]							
PCB Aroclor 1254								0.060	34	See Freshwater Criteria[6]							
PCB Aroclor 1260								0.005	24	See Freshwater Criteria[6]							
Polychlorinated biphenyls (PCBs)	1336-36-3		0.014	0.000064(hc)		0.03	0.000064(hc)	0.07 0.0598[8]	530	0.023	0.180	0.371[10] 0.000332[8]	40				
Pyrene	129-00-0		0.30[8]	830(h)			4,000(h)	0.490 0.195[8]	850	0.665	2.6	78.5[8]					

NJDEP Ecological Screening Criteria

Toxic Substance	CAS Number	Surface Water (ug/L)						Sediment (mg/kg)				Soil (mg/kg)					
		Fresh Water (FW2) Criteria			Saline Water (SE & SC) Criteria			Fresh Water Criteria		Saline Water Criteria		Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[20]			
		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
Selenium	7782-49-2	20(s)	5.0(s)	170(h)(T)	290(d)(s)	71(d)(s)	4,200(h)(T)				1[15]	0.21[13] 0.0276[8]	1	0.52	4.1	1.2	0.63
Silver	7440-22-4	(a)	0.12[8]	170(h)(T)	1.9(d)(s)		40,000(h)(T)	See Saline Criteria[3] 0.5[8]		1.0	3.7	2[9] 4.04[8]	2	560		4.2	14
Styrene	100-42-5		32[8]					0.254[8]				300[9] 4.69[8]	300				
Sulfide-hydrogen sulfide (undissociated)	7783-06-4		2			2											
TCDF												0.00084[14]					
Technetium	7440-26-8											0.2[9]	0.2				
tert-Butyl alcohol (TBA)	75-65-0		355,000[16]														
2,3,5,6-Tetrachloroaniline	3481-20-7											20[9]	20				
1,2,3,4-Tetrachlorobenzene	634-66-2											10[9]					
1,2,4,5-Tetrachlorobenzene	95-94-3		3[8]	0.97(h)			1.1(h)	1.252[8]				2.02[8]					
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6		0.000000003[8]	0.0000000050(hc)			0.0000000051(hc)	0.00000012[8]	0.0000088[15]		0.0000036[15]	0.00000315[10] 0.000000199[8]					
1,1,2,2-Tetrachloroethane	79-34-5		380[8]	4.7(h)			110(h)	0.850[8]				0.127[8]					
Tetrachloroethylene	127-18-4		45[8]	0.34(hc)			1.6(hc)	See Saline Criteria[3] 0.990[8]		0.45[7]		9.92[8]					
2,3,4,5-Tetrachlorophenol	4901-51-3											20[12]					
Thallium	7440-28-0		10[8]	0.24(h)(T)			0.47(h)(T)					1[9]	1				
Tin	7440-31-5		180[8]								>3.4[15]	50[9]	50				
Toluene	108-88-3		253[8] 822[16]	1,300(h)			15,000(h)	See Saline Criteria[3] 1.220[8]		2.5[7]		200[9]	200				
Toxaphene	8001-35-2	0.73	0.0002	0.00028(hc)	0.21	0.0002	0.00028(hc)	0.000077[8]				0.119[8]					
2,4,5-Trichloroaniline	636-30-6											20[9]	20				
1,2,3-Trichlorobenzene	87-61-6											20[12]					
1,2,4-Trichlorobenzene	120-82-1		30[8]	21(h)			42(h)	5.062[8]			>0.0048[15]	20[12]					
1,1,1-Trichloroethane	71-55-6		76[8]	120(h)			2,600(h)	0.213[8]				29.8[8]					
1,1,2-Trichloroethane	79-00-5		500[8]	13(h)			350(h)	0.518[8]				28.6[8]					
Trichloroethylene	79-01-6		47[8]	1.0(hc)			12(hc)	See Saline Criteria[3] 0.112[8]		1.6[7]		12.4[8]					
2,4,5-Trichlorophenol	95-95-4			1,800(h)			3,600(h)				0.003[15]	9[12]	4				
2,4,6-Trichlorophenol	88-06-2		4.9[8]	0.58(hc)			1.0(hc)	0.208[8]			0.006[15]	4[9]					
Uranium	7440-61-1											5[9]	5				
Vanadium	7440-62-2		12[8]								57[15]	2[9]	2			7.8	280
Vinyl chloride	75-01-4		930[8]	0.082(hc)			8.1(hc)	0.202[8]				0.646[8]					
Xylene	1330-20-7		27[8] 296[16]					See Saline Criteria[3] 0.433[8]		>0.12[7]		10[8]					
Zinc	7440-66-6	(a)	(a)	7,400(h)(T)	90(d)(s)	81(d)(s)	26,000(h)(T)	120 121[8]	820	150	410	8.5[11] 6.62[8]	50	160	120	46	79
Low Molecular Weight PAHs[18]															29		100
High Molecular Weight PAHs[19]															18		1.1

NJDEP Ecological Screening Criteria

Toxic Substance	CAS Number	Surface Water (ug/L)						Sediment (mg/kg)				Soil (mg/kg)					
		Fresh Water (FW2) Criteria			Saline Water (SE & SC) Criteria			Fresh Water Criteria		Saline Water Criteria		Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[20]			
		Aquatic		Human Health	Aquatic		Human Health	Lowest Effects Level (LEL)[1]	Severe Effects Level (SEL)[2]	Effects Range Low (ER-L)[4]	Effects Range Medium (ER-M)[5]			Plants	Soil Invertebrates	Avian	Mammalian
		Acute	Chronic		Acute	Chronic											
Total PAHs								4.0	10,000	4.0	45.0						

(a) Criteria as listed at (f)3 below as formula
(b) Criteria as listed at (f)4 below as formula
(d) Criterion is expressed as a function of the Water Effect Ratio (WER). For criterion in the table, WER equates to the default value of 1.0.
(fc) Criteria expressed as free cyanide (as CN)/L
(h) Human health noncarcinogen
(hc) Human health carcinogen
(s) Dissolved criterion
(T) Total recoverable criterion
1 Lowest Effects Levels (LELs) indicate concentrations at which adverse benthic impact may begin to occur (level tolerated by most benthic organisms). Water column species and wildlife are at potential risk via bio-magnification (food chain toxicity) if site-related sediment concentrations of PCBs, organochlorine pesticides, or mercury are at or above the LEL. Other known biomagnifiers without ESC warrant case-by-case evaluation.
2. Severe Effects Levels (SELs) are also provided, but the SEL is not a BEE screening value. Contamination at this level indicates severe impacts to the benthic community in most cases studied. For non-polar organics (PAHs, organochlorine pesticides, PCBs), the SEL is calculated from a site-specific TOC level. Since the table SEL is based on 100% organic carbon, the calculated site-specific number is lower.
3. Refer to Estuarine/Marine Screening Criteria when a freshwater parameter has no corresponding value. Since the biological activity of non-polar organics is not expected to differ greatly in the estuarine/marine environment, these screens can be used as surrogates. While uncertainty associated with the use of estuarine/marine metal screens as freshwater surrogates is greater than with non-polar organics, one surrogate metal (silver) is provided.
4. Effects Range-Low (ER-L) represents a concentration at which adverse benthic impacts are found in approximately 10% of studies. Water column species and wildlife are at potential risk via biomagnification (food chain toxicity) if site-related sediment concentrations of PCBs, organochlorine pesticides, or mercury are at or above the ER-L. Other known biomagnifiers without NOAA screening numbers (dioxins, furans, other chlorinated organics, and selenium) warrant case-by-case evaluation.
5. The Effects Range-Median (ER-M) is also provided. The ER-M is not a BEE screening value. Contamination greater than the ER-M value indicates adverse benthic impacts in more than 50% of cases studie

6. Refer to Freshwater Sediment Screening Criteria when a Estuarine/Marine parameter has no corresponding value and for individual Aroclor values. Since the biological activity of non-polar organics is not expected to differ greatly in the fresh water environment, freshwater screens can be used as surrogates.
7. Screening values were developed for the protection of marine receptors; however, for the purpose of this document they are considered surrogates for freshwater systems.
8. USEPA Region 5, RCRA Ecological Screening Levels (ESLs) represent a protective benchmark (e.g., water quality criteria, sediment quality guidelines/ criteria, and chronic no adverse effect levels) for 223 contaminants and are not intended to serve as cleanup levels, but are intended to function as screeni levels. http://www.epa.gov/reg5rcra/ca/ESL.pdf
9. Wildlife Preliminary Remediation Goal based on plant study.
10. Wildlife Preliminary Remediation Goal based on shrew study.
11. Wildlife Preliminary Remediation Goal based on woodcock study.
12. Wildlife Preliminary Remediation Goal based on earthworm study.
13. Wildlife Preliminary Remediation Goal based on mouse study.
14. Wildlife Preliminary Remediation Goal based on hawk study.
15. Sediment value from NOAA Screening Quick Reference Tables (SQuiRTs).
16. Westhollow Technical Center Levels were developed by Shell Oil for surface water and were approved for use by NJDEP with the following conditions: 1) the source area is removed, 2) these levels are on the fringe of the contamination area, and 3) active remediation is occurring. These levels are applicable to surface water and wetland areas.
17. USEPA Ambient Water Quality Criteria Update for Methyl Tertiary-Butyl Ether (MTBE) http://www.epa.gov/waterscience/criteria/mtbe-fs.html
18. Low Molecular Weight PAHs are defined as compounds composed of fewer than four rings.
19. High Molecular Weight PAHs are defined as compounds composed of four or more rings.
20. Guidance for Developing Ecological Soil Screening Levels, OSWER Directive 9285.7-55, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1200 Pennsylvania Avenue, N.W., Washington, DC 20460, November 2003, Revised February 2005, http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf
21. Value applies to DDT and metabolites.

NOTE: See Page 7/7 (SW Calculations tab) for Surface Water Calculator for metals.

NJDEP Ecological Screening Criteria

(f)3 Freshwater aquatic criteria for cadmium, chromium III, copper, nickel, silver, and zinc are expressed as a function of water hardness. Criteria can be calculated at any hardness using these equations as listed below. Criteria thus calculated are multiplied by appropriate conversion factor (CF) to convert total recoverable metal into dissolved metal and by the default Water Effect Ratio (WER) of 1.0.

General formula: WER [e(V[ln (hardness)] + ln A - V[ln Z])] CF

where:
V = pooled slope
A = FAV at given hardness
Z = selected value of hardness

Cadmium:
Acute dissolved criterion WER $[e^{(1.0166 (\ln [hardness])-3.924)}]$ 0.651
Chronic dissolved criterion WER $[e^{(0.7409 (\ln [hardness])-4.719)}]$ 0.651

Chromium III:
Acute dissolved criterion WER $[e^{(0.819 (\ln [hardness])+3.7256)}]$ 0.277
Chronic dissolved criterion WER $[e^{(0.819 (\ln [hardness])+0.6848)}]$ 0.277

Copper:
Acute dissolved criterion WER $[e^{(0.9422 (\ln [hardness])-1.7)}]$ 0.908
Chronic dissolved criterion WER $[e^{(0.8545 (\ln [hardness])-1.702)}]$ 0.908

Nickel:
Acute dissolved criterion WER $[e^{(0.846 (\ln [hardness])+2.255)}]$ 0.846
Chronic dissolved criterion WER $[e^{(0.846 (\ln [hardness])+0.0584)}]$ 0.846

Silver:
Acute dissolved criterion WER $[e^{(1.72 (\ln [hardness])-6.59)}]$ 0.85

Zinc:
Acute or dissolved criterion WER $[e^{(0.8473 (\ln [hardness])+0.884)}]$ 0.950
Chronic dissolved criterion WER $[e^{(0.8473 (\ln [hardness])+0.884)}]$ 0.950

(f)4 Freshwater criteria for pentachlorophenol are expressed as a function of pH. Criteria are derived in accordance with the formula set forth below:

Acute criterion = $e^{(1.005[pH]-4.869)}$
Chronic criterion = $e^{(1.005[pH]-5.134)}$

2013

Fish Smart, Eat Smart

A guide to Health Advisories for Eating Fish and Crabs Caught in New Jersey Waters

New Jersey Department of Environmental Protection

New Jersey Department of Health

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The New Jersey Department of Environmental Protection and the New Jersey Department of Health can provide more information on the advisories and the health effects of chemical contaminants in the fish. To stay current with advisory updates and to request additional information, please contact the NJDEP Office of Science, at 1-609-984-6070 or check the website www.FishSmartEatSmartNJ.org or the NJDOH at 609 826-4935.

Introduction

This 2013 update uses the results of a study involving the analysis of 260 samples of 15 fish species collected in 28 water bodies in the Delaware River Region including those lakes, rivers, ponds and reservoirs that flow into the upper and lower portions of the Delaware River. This information was used to support the continuation of current fish consumption advisories and the need for additional fish consumption advisories in this region of the state.

This booklet summarizes the marine, estuarine and fresh water fish consumption advisories for New Jersey including new fish consumption advisories for the Delaware River Region. It provides you with information on how to reduce your risk by avoiding or limiting consumption of certain fish. It also offers guidance in how to prepare the fish you eat from local waters in ways that reduce your exposure to PCBs, dioxins and mercury.

Fishing provides enjoyable and relaxing recreation. Many people enjoy cooking and eating their own catch. Fish are an excellent source of protein, minerals and vitamins, are low in fat and cholesterol and play an important role in maintaining a healthy, well-balanced diet. The American Heart Association recommends people eat fish regularly. Fish are also one of the few foods that are rich in the omega-3 fatty acids needed for proper development of the brain and nervous system in the fetus and infants and may reduce the risk of heart attack. Fish are an excellent substitute for other protein foods that are higher in saturated fats and cholesterol. Health professionals recommend that you include fish in your diet.

However, certain fish may contain contaminants, such as polychlorinated biphenyls (PCBs), dioxins and mercury from the water they live in and the food they eat. Contaminants such as dioxin and PCBs are classified by the U.S. Environmental Protection Agency as probable cancer causing substances in humans. Elevated levels of mercury can pose health risks to the human nervous system, particularly to developing fetuses. Therefore, it is a good idea to follow a few precautions in consuming recreationally caught fish and crabs, particularly if you eat them often.

Since 1982, when research began to show elevated levels of potentially harmful contaminants in certain fish and crabs in some New Jersey waters, fish consumption advisories were adopted to guide citizens on safe consumption practices. Fish consumption advisories are developed through a scientific process that includes collecting samples of fish from waters throughout the state and analyzing them for various chemical contaminants, such as dioxin, PCBs and mercury. The contaminant levels in the fish are then evaluated using federal guidelines for protecting human health.

The New Jersey Department of Environmental Protection (NJDEP) and Department of Health (NJDOH) provide advice on consuming those species of fish in which high levels of dioxin, PCBs and mercury have been found. Since levels of contaminants may vary from one location to another and from one fish species to another, the advisories are also separated by site. So be sure to check which guidelines refer to your fishing location.

2013 Fish Consumption Advisories for PCBs, Dioxin and Mercury

The advisory table in this booklet provides statewide, regional, and water body-specific advisory information for various fish species. The table lists the recommended fish consumption frequencies for the **General Population** and **High-risk Individuals** for waters statewide and for specific water bodies.

High Risk Individuals: Includes infants, children, pregnant women, nursing mothers and women of childbearing age.

General Population: Includes all others not in the high-risk category. PCB advisories for the General Population are presented in meal frequencies (for example: one meal per month or four meals per year). This range is based on an estimated 1 in 10,000 risk of cancer during your lifetime from eating fish at the advisory level. This means that one additional cancer may occur in 10,000 people eating fish at the advisory level for a lifetime.

By using this advisory, you have the necessary information to make an informed choice on the number of meals of fish to consume. You can reduce your risk further by eating less than the advisory meal frequency, however, this need to be balanced with the health benefits of eating fish.

The limits that follow each species assume that no other contaminated fish are being eaten. If you eat more than one species of fish listed in the advisory, the total consumption of fish should not exceed the recommended frequency as a guideline for consumption. The best approach is to use the lowest recommended frequency as a guideline for consumption. **Example: If you fish Union Lake, you can eat four meals of white perch or you can eat one meal of Largemouth Bass over the course of a month, but not both.**

If your specific fishing location is not mentioned within the advisories on the following pages, this does not mean the fish are free of contamination. Not all New Jersey waters or fish species have been tested, and not all fish species were found in all locations, or in some cases available data were insufficient to list a species for a specific water body. **Follow the statewide advisory for the listed species if your fishing area is not mentioned in the guidelines, or follow the statewide advisory of one meal per week for (general Population) or one meal per month (high-risk individuals) for freshwaters.**

General Consumption Guidelines

Fish Species: Contaminant levels may vary from species to species. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants. Try to focus your consumption on those species of fish that have lower levels of contaminants, such as fluke or flounder.

Fish Size: Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because contaminants tend to build up in the fish over time. It is advisable to eat smaller fish (of legal size) more often than larger fish.

High-risk Individuals: Infants, children, pregnant women, nursing mothers and women of childbearing age are considered to be at higher risk from contaminants in fish than members of the general public. People within this category should be particularly careful about following the advisories, because of the greater potential for PCBs, dioxin and mercury to affect the development of the fetus, infant, and young child.

Health Effects from Consumption of Contaminated Fish and Crabs

General Advice

Exposure to low levels of some contaminants in the environment may have long lasting health effects on people. Mercury, PCBs and dioxins are among the major contaminants found in some New Jersey fish in portions of the state. These contaminants can be especially harmful to women of childbearing age, pregnant women and nursing mothers. Trace amounts of these contaminants may remain in your body for a period of time after eating. Should you become pregnant during this time, these contaminants can be passed along to your fetus, potentially affecting the development of the nervous system. Children are also at risk of developmental and neurological problems if exposed to these chemicals.

Mercury

Mercury is a toxic metal that has been commonly used in a number of products (e.g., thermometers, electrical switches). There are many sources of mercury in the environment, natural and man-made; primary sources include burning of fossil fuels such as coal, incineration of wastes, and metal processing/manufacturing.

Mercury discharged to the environment can end up in local water bodies. Mercury accumulates in fish muscle tissue through the aquatic food chain from the food that fish eat. Above certain levels, mercury can damage the nervous system, particularly in unborn and young children, resulting in learning and developmental delays. Regular consumption, of even low amounts of mercury may cause subtle effects on the central nervous system in both children and adults. In addition, long-term consumption of fish with elevated levels of mercury by adults and older children may result in adverse health effects, including neurological damage. For more information go to: www.epa.gov/mercury.

NJ has taken aggressive action to reduce sources of mercury in the state. Levels of mercury from in-state air sources have been reduced by over 90% since the 1990s. Current sources of mercury to NJ are primarily from other states' air emissions (e.g., coal power plants) and natural emissions.

PCBs

Polychlorinated biphenyls (PCBs) were commercially produced for industrial application in heat transfer systems, hydraulic fluids and electrical equipment. They were later incorporated into other uses such as printing inks, paints and pesticides. The manufacture of PCBs was stopped in 1979 as a result of evidence that PCBs build up in the environment and cause harmful effects. PCBs tend to stay mostly in soil and sediment, but are also found in the air and water.

Once they enter the food chain, they have a tendency to absorb into fat tissue. PCBs build up in fish to levels that are hundreds of thousands of times higher than the levels in the surrounding water. When people consume fish that have already accumulated PCBs, the PCBs then accumulate in their bodies.

PCBs have been shown to cause cancer in animals, and there is evidence that PCBs may cause cancer in

exposed humans. PCBs have also been shown to cause a number of serious health effects besides cancer in humans and animals, including effects on the nervous system of the developing fetus, the immune system, and the reproductive system. Studies have shown that unborn and young children are most at risk to PCB exposure. Because PCBs take a long time to leave the body after they accumulate, women who plan to become pregnant should follow the more restrictive consumption advice before becoming pregnant. For more information go to:
www.epa.gov/ebtpages/ pollutants.html

Dioxin

Dioxin is the most toxic member of a large chemical family of related dioxins and furans. Dioxin is an unwanted industrial byproduct formed through numerous processes, including production of chlorinated phenol products such as herbicides, the incineration of municipal solid waste, and creation of paper products using bleach. Most of what we know about dioxin has been obtained through animal toxicity testing in the laboratory and representative wildlife species. Dioxin produces a number of effects in animal testing, including suppression of the immune system, impaired reproduction, birth defects in some species tested, a skin condition called chloracne, alterations in liver function, and cancer. The federal Environmental Protection Agency (EPA) has classified dioxin as a probable human carcinogen. For more information go to: www.epa.gov/ebtpages/pollutants.html

Preparation and Cooking Methods for Fish and Crabs under Advisory

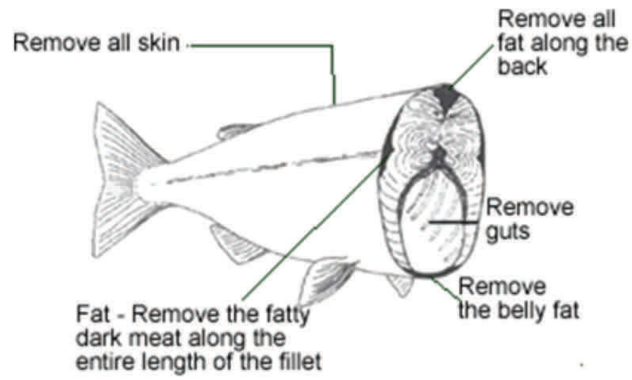
The best way to reduce exposure to contaminants in fish is to learn what fish species are affected and either limit or avoid consumption. However, if you must eat those species under advisories, there are steps you can take to reduce your exposure. Contaminants tend to concentrate in the fatty tissue of the fish you catch. Proper cleaning and cooking techniques, which remove some of the fat from the fish, can significantly reduce levels of PCBs, dioxins and other organic chemicals. **Please note, however, that these techniques will not reduce or remove unsafe levels of *mercury* from these fish.** Mercury occurs in the flesh. There is no way to remove mercury through cooking. The best way to reduce mercury exposure is to select those species of fish which are known to have lower levels of mercury.

Fish Preparation Methods

Proper fish cleaning and cooking techniques may reduce PCB levels by approximately 50 percent when compared to raw fish fillets. A meal size is considered to be an uncooked 8 ounce fillet.

Eat only the fillet portions. Do not eat whole fish or steak portions.

Many chemical contaminants, like PCBs and pesticides (but not mercury), are stored in the fatty portions of fish. To reduce the levels of these chemicals, skin the fish and trim any of the dark meat (lateral line), back strap and belly flap. The following diagram illustrates those body portions.



Do not eat the heads, guts or liver, because PCBs usually concentrate in those body parts. Also, avoid consumption of any reproductive parts such as eggs roe.

Fish Cooking Methods

Use a cooking method such as baking, broiling, frying, grilling, or steaming that allows the fats and juices to drain away from the fish. When possible, cook the fish on an elevated rack that allows fats and juices to drain to the pan below.

Avoid batter, breading or coatings that can hold in the juices that may contain contaminants. The juices should be thrown away since they contain the PCBs and other chemicals that were in the fat. Do not pour these juices over the fish as a sauce or to moisten the fish. Butter, margarine or other liquids can be added to the fish for this purpose once the juices have been poured off. After cooking, **discard all liquids and frying oils.** Do not reuse.

Do not use heads, skin, trimmed fatty portions in soups, stews, chowders, boils, broth or for fish stock. If you make stews or chowders, only use skinless fillet parts.

Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites. This also helps to reduce the level of many chemical contaminants.

Crab Preparation Methods

Eating, selling or taking (harvesting) blue crabs from Newark Bay Complex and the tidal Passaic River is prohibited. The Newark Bay Complex is located in northeastern New Jersey. It includes the Newark Bay, tidal Hackensack River, Arthur Kill, Kill Van Kull and tidal tributaries. (See chart on page 8.) If blue crabs are taken from water bodies other than the Passaic River/ Newark Bay Complex, the following preparation techniques can be followed to reduce exposure to some contaminants.

The highest levels of chemical contaminants are found in the hepatopancreas, commonly known as the tomalley or green gland. It is the yellowish green gland under the gills. This material is found next to the lump meat (backfin) portion of the crab. Chill and break the crabs immediately before cooking. Care must be taken to remove all of the hepatopancreas before cooking.

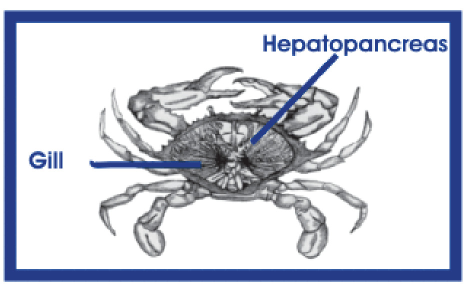
There is no specific cooking method available to reduce the chemical contaminant levels in blue crabs. The following steps for proper preparation are key to reducing your exposure to harmful chemical contaminants.

⁕ Do not eat the green gland (hepatopancreas).

⁕ Remove green gland (hepatopancreas) before cooking.

⁕ After cooking, discard the cooking water.

⁕ Do not use cooking water or green gland (hepatopancreas) in any juices, sauces, bisques or soups.



Federal Advice on Fish Consumption

The following is provided as general information and advice from the federal government.

Fish and shellfish are an important part of a healthy diet. Fish and shellfish contain high quality protein and other essential nutrients, are low in saturated fat, and contain omega-3 fatty acids. A well-balanced diet that includes a variety of fish and shellfish can contribute to heart health and children's proper growth and development. So, women and young children in particular, should include fish or shellfish in their diets due to the many nutritional benefits.

However, nearly all fish and shellfish contain traces of mercury. For most people, the risk from mercury by eating fish and shellfish is not a health concern. Yet, some fish and shellfish contain higher levels of mercury that may harm an unborn baby or young child's developing nervous system. The risks from mercury in fish and shellfish depend on the amount of fish and shellfish eaten and the levels of mercury in the fish and shellfish. Therefore, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) are advising women who may become pregnant, pregnant women, nursing mothers, and young children to avoid some types of fish and eat fish and shellfish that are lower in mercury.

By following these 3 recommendations for selecting and eating fish or shellfish, women and young children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury.

1. Do not eat Shark, Swordfish, King Mackerel, or Tilefish because they contain high levels of mercury.

2. Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.

⁕ Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish.

⁕ Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your two meals of fish and shellfish, you may eat up to 6 ounces (one average meal) of albacore tuna per week.

3. Check local advisories about the safety of fish caught by family and friends in your local lakes rivers, and coastal areas. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch from local waters, but don't consume any other fish during that week.

Follow these same recommendations when feeding fish and shellfish to your young child, but serve smaller portions.

Additional information on mercury in seafood can be found at the FDA's web site: http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/FoodbornePathogensContaminants/default.htm

For more information on EPA freshwater fish consumption advisories, go to http://water.epa.gov/scitech/swguidance/fishshellfish/fishadvisories/index.cfm

2013 NEW JERSEY FISH CONSUMPTION ADVISORIES

(Note: New or Updated Advisories are noted next to species)

STATEWIDE ESTUARINE AND MARINE WATERS

Applies To All Coastal Waters Except the WATERBODY SPECIFIC ADVISORIES

Species	General Population- Eat No More Than: (2,3)	High Risk Population- (1) Eat No More Than: (2,3)
Striped Bass	One meal per month	Do Not Eat
American Eel	Four meals per year	Do Not Eat
Bluefish—(greater than 6lbs./24 inches)	Six meals per year	Do Not Eat
Bluefish—(less than 6lbs./24 inches)	One meal per month	Do Not Eat
American Lobster	Do No Eat the Green Gland (a.k.a., Tomalley or Hepatopancreas)	Do No Eat the Green Gland (a.k.a., Tomalley or Hepatopancreas)

(1) High-Risk Individuals include infants, children, pregnant women, nursing mothers and women of childbearing age.

(2) One meal is defined as an eight-ounce serving.

(3) Eat only the fillet portions of the fish. Use proper trimming techniques to remove fat, and cooking methods that allow juices to drain from the fish (e.g., baking, broiling, frying, grilling, and steaming). See text for full description.

(4) Sunfish includes bluegill, pumpkinseed, and redbreast sunfish species.

(5) No harvest means no taking or attempting to take any blue crabs from these waters.

* = Selling these species for human consumption from designated New Jersey waters is prohibited.

Notes: Not all fish species available were collected and/or analyzed from all waterways

WATERBODY SPECIFIC ADVISORIES
ESTUARINE and MARINE WATERS

ALSO SEE ALL STATEWIDE ESTUARINE AND MARINE ADVISORIES

Newark Bay Complex

Including Newark Bay, tidal Hackensack River, Arthur Kill, Kill Van Kull and all tidal tributaries

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Blue Crab*	Do not Harvest or Eat [5]	Do not Harvest or Eat [5]
Striped Bass*	Four meals per year	Do Not Eat
White Perch	Do Not Eat	Do Not Eat
White Catfish	One meal per year	Do Not Eat
American Eel	Do Not Eat	Do Not Eat

Passaic River (Tidal)

From the head of tide at Garfield to Newark Bay and all tidal Tributaries

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Blue Crab*	Do not Harvest or Eat [5]	Do not Harvest or Eat [5]
All Finfish & Shellfish*	Do Not Eat	Do Not Eat

Hudson River

From the NY-NJ borderline (near Alpine, NJ) downstream of the NY-NJ borderline on the Upper New York Bay (at Bayonne, NJ)

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Striped Bass*	Four meals per year	Do Not Eat
White Perch	One meal per year	Do Not Eat
White Catfish	Do Not Eat	Do Not Eat
American Eel *	One meal per year	Do Not Eat
Blue Crab	One meal of 7 crabs per week - Do not eat Green Gland (hepatopancreas) Discard cooking liquid	One meal of 7 crabs per week - Do not eat Green Gland (hepatopancreas) Discard cooking liquid
Winter Flounder	One year per month	One year per month

WATERBODY SPECIFIC ADVISORIES
ESTUARINE and MARINE WATERS

ALSO SEE ALL STATEWIDE ESTUARINE AND MARINE ADVISORIES

Raritan Bay Complex

Includes the Raritan Bay, tidal Raritan River (up to the Rt. 1 bridge) and all tidal tributaries)

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Summer Flounder (Fluke)	One meal per week	One meal per week
Striped Bass	One meal per month	Do Not Eat
White Perch (also see below—South River)	One meal per year	Do Not Eat
American Eel	One meal per year	Do Not Eat
Blue Crab	One Meal of 7 Crabs per month Do not eat Green Gland (hepatopancreas) Discard cooking liquid	One Meal of 7 Crabs per month Do not eat Green Gland (hepatopancreas) Discard cooking liquid
Weakfish	One meal per month	Do Not Eat
Winter Flounder	One meal per month	One meal per month
Porgy	One meal per month	One meal per month
American Lobster	One Meal per week Do not eat Green Gland (hepatopancreas) Discard cooking liquid	One Meal per week Do not eat Green Gland (hepatopancreas) Discard cooking liquid

Raritan River and South River

(Tidal portion) upstream of Rt 35 Bridge and tidal South River

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	Four meals per year	Do Not Eat
White Catfish	Four meals per year	Do Not Eat

Sandy Hook Bay & Lower Bay

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Summer Flounder (Fluke)	One meal per week	One meal per week

WATERBODY SPECIFIC ADVISORIES
ESTUARINE and MARINE WATERS

ALSO SEE ALL STATEWIDE ESTUARINE AND MARINE ADVISORIES

Barnegat Bay at Manahawkin Bay

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Weakfish	One meal per week	One meal per month

Barnegat Bay at Toms River

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Striped Bass	No restrictions	One meal per month

Atlantic Ocean—Sandy Hook to Sea Bright

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Summer Flounder (Fluke)	One meal per week	One meal per week

Atlantic Coastal Tributaries

Including the Navesink River, Shrewsbury River, Shark River, Toms River & Mullica River

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	One meal per month	One meal per month

Atlantic Ocean—Sea Isles City to Cape May

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Weakfish	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
ESTUARINE and MARINE WATERS

ALSO SEE ALL STATEWIDE ESTUARINE AND MARINE ADVISORIES

Lower Delaware River—Tidal Section

Trenton downstream to the Delaware/Pennsylvania border, including all tributaries to the head of tide. - See all location specific Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Hybrid Striped Bass	No restrictions	One meal per week
Striped Bass	Four meals per year	Do Not Eat
White Perch	Four meals per year	Do Not Eat
White Catfish	One meal per month	Do Not Eat
Channel Catfish	One meal per year	Do Not Eat
American Eel	One meal per year	Do Not Eat

Delaware River at Trenton/Crosswicks Creek

See all Lower Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	One meal per month	One meal per month
American Eel	One meal per month	Do Not Eat
Channel Catfish	One meal per month	One meal per month

Delaware River at Tacony Palmyra Bridge

See all Lower Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	Four meals per year	Do Not Eat
Channel Catfish	Four meals per year	Do Not Eat

Delaware River at Raccoon Creek

See all Lower Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	One meal per year	Do Not Eat
American Eel	One meal per year	Do Not Eat
Channel Catfish	Four meals per year	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
ESTUARINE and MARINE WATERS

ALSO SEE ALL STATEWIDE ESTUARINE AND MARINE ADVISORIES

Delaware River at Woodbury Creek/Fort Mifflin

See all Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	One meal per month	Do Not Eat
American Eel	One meal per year	Do Not Eat
Channel Catfish	One meal per year	Do Not Eat

Delaware River at Salem River

See all Delaware River Advisories

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
White Perch	One meal per week	Do Not Eat
Channel Catfish	Four meals per year	Do Not Eat

Delaware River Estuary

(NJ/Delaware/PA/ borderline downstream to Chesapeake & Delaware (C&D) Canal

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
All Finfish	**One meal per year** ***Updated 11/2013**	Do Not Eat

Delaware Estuary & Delaware Bay

Chesapeake & Delaware (C&D) Canal out to the mouth of Delaware Bay

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Striped Bass	One meal per year	Do Not Eat
White Perch	One meal per year	Do Not Eat
White Catfish	One meal per year	Do Not Eat
Channel Catfish	One meal per year	Do Not Eat
America Eel	One meal per year	Do Not Eat
Bluefish	Do Not Eat fish larger than 6lbs or 24 inches– One meal per year of fish less than 6lbs. Or less than 24 inches	Do Not Eat
Weakfish	One meal per week	One meal per month

Delaware Bay Tributaries

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	One meal per month	Four meals per year

GENERAL FRESHWATER ADVISORIES

Applies to all freshwater fish and waters NOT covered by consumption advisories:

General population—Eat no more than one meal per week

High-risk individuals—Eat not more than one meal per month

STATEWIDE FRESHWATER ADVISORIES

Applies To All Except PINELANDS REGION and WATERBODY SPECIFIC ADVISORIES

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per week	One meal per month
Sunfish (4)	No restrictions	One meal per week
Brown Bullhead	No restrictions	One meal per month
Yellow Bullhead	No restrictions	One meal per month

PINELANDS REGION FRESHWATER ADVISORIES

Except WATERBODY SPECIFIC ADVISORIES: FRESHWATER LOCATIONS (Pinelands)

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Smallmouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per month	Do Not Eat
Sunfish (4)	No restrictions	One meal per month
Brown Bullhead	One meal per week	Do Not Eat
Yellow Bullhead	One meal per week	Do Not Eat

(1) High-Risk Individuals include infants, children, pregnant women, nursing mothers and women of childbearing age.

(2) One meal is defined as an eight-ounce serving.

(3) Eat only the fillet portions of the fish. Use proper trimming techniques to remove fat, and cooking methods that allow juices to drain from the fish (e.g., baking, broiling, frying, grilling, and steaming). See text for full description.

(4) Sunfish includes bluegill, pumpkinseed, and redbreast sunfish species.

(5) No harvest means no taking or attempting to take any blue crabs from these waters.

* = Selling these species for human consumption from designated New Jersey waters is prohibited.

Notes: Not all fish species available were collected and/or analyzed from all waterways

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Allamuchy Pond at Allamuchy

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
American Eel	One meal per week	One meal per week

Alycon Lake at Glassboro

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	One meal per month
Black Crappie	No restrictions	One meal per month

Assunpink Creek at Windsor

Mercer\Monmouth Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week

Assunpink Lake at Roosevelt

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Atlantic City Reservoir at Pomona

Atlantic County

NO FISHING ALLOWED

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	Do Not Eat	Do Not Eat
Chain Pickerel	Do Not Eat	Do Not Eat
Yellow Perch	Do Not Eat	Do Not Eat

Atsion Lake at Atsion

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Yellow Bullhead	One meal per week	Do Not Eat

Batsto Lake at Batsto

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	One meal per week	Do Not Eat
Bluegill Sunfish	One meal per week	One meal per month
Brown Bullhead	No restrictions	One meal per month
Yellow Bullhead	No restrictions	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Big Timber Creek
West Deptford at Runnemede
Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	Do Not Eat	**New - 2013**
White Perch	One meal per month	Do Not Eat	**New - 2013**
Brown Bullhead	No restrictions	No restrictions	
White Catfish	No restrictions	One meal per week	
Channel Catfish	Four meals per year	Do Not Eat	**New - 2013**

Blue Mountain Lake at Five Points
Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week

Bound Brook—Entire Lake
(Including Spring Lake)
Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
All Fish Species	Do Not Eat	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Bound Brook at New Market Pond
(at South Plainfield)
SomersetCounty

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
All Fish Species	Do Not Eat	Do Not Eat

Branch Brook Park Lake at Newark
Essex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Bluegill Sunfish	No restrictions	One meal per week
Common Carp	One meal per month	Do Not Eat

Budd Lake at Budd Lake
Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Northern Pike	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions
White Catfish	One meal per month	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Butterfly Bogs Pond at Vanhiseville

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat
Brown Bullhead	No restrictions	One meal per week

Canistear Reservoir at Sockholm

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week

Carnegie Lake at Princeton

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
White Perch	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	No restrictions
Brown Bullhead	No restrictions	One meal per week
Channel Catfish	No restrictions	One meal per month

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Catfish Pond at Hardwick

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	One meal per week	Do Not Eat
Yellow Perch	One meal per week	One meal per month

Cedar Lake at Cedarville

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	One meal per week	Do Not Eat

Cedarville Ponds at Cedarville

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat
Yellow Perch	No restrictions	One meal per month

Clementon Lake at Clementon

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Clinton Reservoir at West Milford

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Rock Bass	No restrictions	One meal per month
Redbreast Sunfish	No restrictions	One meal per month
Yellow Bullhead	One meal per week	One meal per month
White Sucker	No restrictions	One meal per month

Columbia Lake at Columbia

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Striped Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Walleye	One meal per week	One meal per month
American Eel	One meal per month	One meal per month

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Cooper River Park Lake at Collingswood

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	Do Not Eat	**New - 2013**
Black Crappie	No restrictions	One meal per week	
Bluegill Sunfish	One meal per month	Do Not Eat	**New - 2013**
Brown Bullhead	One meal per month	Do Not Eat	**New - 2013**
Common Carp	Four meals per year	Do Not Eat	

Cooper River at Hopkins Pond

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Brown Bullhead	One meal per month	Four meals per year

Cooper River, Below Evans Pond

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Bluegill Sunfish	One meal per week	One meal per month
Common Carp	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Cranberry Lake at Byram

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	
Hybrid Striped Bass	One meal per week	One meal per month	
Chain Pickerel	One meal per week	Do Not Eat	
Yellow Perch	No restrictions	One meal per month	
Brown Bullhead	One meal per week	One meal per week	

Crater Lake at Five Points

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Yellow Perch	One meal per week	Do Not Eat	
Brown Bullhead	One meal per week	One meal per month	

Crosswicks Creek at Bordentown

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	**New - 2013**
White Perch	One meal per month	Do Not Eat	**New - 2013**
White Catfish	No restrictions	One meal per week	
Channel Catfish	One meal per month	Do Not Eat	**New - 2013**

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Crystal Lake at Fieldsboro

Burlington County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions

Davidsons Mill Pond at Deans

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
American Eel	One meal per month	One meal per month

Deal Lake at Asbury Park

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per week
White Perch	One meal per month	One meal per month
American Eel	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Delaware & Raritan Canal—Entire Length

See D-R Canal locations specific advisories

All Counties along Delaware River & Raritan Canal

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Channel Catfish	One meal per month	Do Not Eat
American Eel	One meal per month	Do Not Eat

Delaware & Raritan Canal at Lambertville

Also see Advisories for the entire length of the Delaware & Raritan Canal

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Common Carp	One meal per month	One meal per month

Delaware & Raritan Canal at West Trenton

Also see Advisories for the entire length of the Delaware & Raritan Canal

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Walleye	One meal per month	Do Not Eat
Common Carp	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Delaware & Raritan Canal at Port Mercer

Also see Advisories for the entire length of the Delaware & Raritan Canal

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Common Carp	One meal per year	Do Not Eat

Delaware & Raritan Canal at Griggstown

Also see Advisories for the entire length of the Delaware & Raritan Canal

Middlesex/Somerset Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Brown Bullhead	No restrictions	One meal per week

Delaware & Raritan Canal at Bound Brook

Also see Advisories for the entire length of the Delaware & Raritan Canal

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Yellow Perch	No restrictions	One meal per month
Common Carp	Four meals per year	Do Not Eat

Delaware Lake at Columbia

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
American Eel	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Delaware River—NY Borderline to Water Gap

Warren\Sussex Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Smallmouth Bass	One meal per week	One meal per week	
Muskellunge	No restrictions	One meal per month	
Channel Catfish	No restrictions	One meal per month	
White Sucker	One meal per month	One meal per month	

Delaware River at Milford/Montague

See Delaware River—NY Borderline to Water Gap Advisories

Sussex Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Smallmouth Bass	One meal per week	One meal per week	**New - 2013**
White Sucker	One meal per week	One meal per week	**New - 2013**
Walleye	One meal per week	One meal per month	**New - 2013**
American Eel	One meal per month	One meal per month	**New - 2013**

Delaware River—Delaware Watergap to Phillipsburg

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Smallmouth Bass	No restrictions	One meal per month	
Walleye	No restrictions	One meal per week	
White Catfish	One meal per week	Do Not Eat	
Channel Catfish	No restrictions	One meal per month	

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Delaware River at Phillipsburg/Easton

See Delaware River—Water Gap to Phillipsburg Advisories

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Smallmouth Bass	One meal per week	One meal per week	
White Sucker	One meal per week	One meal per week	
American Eel	One meal per month	Do Not Eat	

Delaware River—Phillipsburg to Trenton

Hunterdon\Mercer Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per month	
Smallmouth Bass	One meal per week	One meal per month	
Striped Bass	Four meals per year	Do Not Eat	
Channel Catfish	Four meals per year	Do Not Eat	
White Sucker	One meal per month	Do Not Eat	
American Eel	One meal per month	Do Not Eat	

Delaware River at Lambertville

See Delaware River—Phillipsburg to Trenton Advisories

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Smallmouth Bass	One meal per week	One meal per week	**New - 2013**
White Sucker	One meal per week	One meal per month	**New - 2013**
American Eel	One meal per month	Do Not Eat	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Delaware River at Trenton

See Delaware River—Phillipsburg to Trenton Advisories

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
American Eel	One meal per month	Do Not Eat	**New - 2013**

DeVeo Lake at Spotswood

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	One meal per week	One meal per month
Brown Bullhead	One meal per week	One meal per week

DOD Lake at Penns Grove

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Common Carp	One meal per week	One meal per week

Double Trouble Lake at Double Trouble State Park

Pinelands Region

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
Yellow Bullhead	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Duhernal Lake at Spotswood

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per week

East Creek Pond at Eldora

Cape May County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Chain Pickerel	One meal per month	Do Not Eat
Yellow Perch	One meal per month	Do Not Eat
Pumpkinseed Sunfish	One meal per week	One meal per month
Brown Bullhead	One meal per month	Do Not Eat
Yellow Bullhead	One meal per month	Do Not Eat
America Eel	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Echo Lake Reservoir at West Milford

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week

Enno Lake at Bennetts Mills

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
American Eel	One meal per week	One meal per month

Evans Lake at Haddonfield

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Farrington Lake at Milltown

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per month

Furnace Lake at Oxford

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
Brown Bullhead	No restrictions	No restrictions

Green Brook at Madison Ave Bridge

Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Green Turtle Pond at Hewitt

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per week
Yellow Perch	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	One meal per month

Greenwood Lake at West Milford

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Walleye	No restrictions	One meal per month
White Perch	No restrictions	No restrictions
Bluegill Sunfish	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week

Grovers Mill Pond at Princeton Junction

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Hainesville Pond at Hainesville

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per week

Harrisville Lake at Harrisville

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
Yellow Bullhead	One meal per month	Do Not Eat

Horicon Lake at Lakehurst

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
Yellow Bullhead	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Jersey City Reservoir at Boonton

Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	Four meals per year	Do Not Eat
Smallmouth Bass	Four meals per year	Do Not Eat
Rock Bass	No restrictions	One meal per month
Brown Bullhead	No restrictions	No restrictions
White Catfish	One meal per week	One meal per month

Kirkwood Lake at Lindenwold

Camden County

Updated - 2013

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
Common Carp	Four meals per year	Do Not Eat

Lake Aeroflex at Andover

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions
America Eel	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Lake Carasaljo at Lakewood

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	Do Not Eat	
Chain Pickerel	One meal per week	One meal per month	

Lake Hopatcong—Entire Lake

Morris\Sussex Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per month	
Chain Pickerel	No restrictions	One meal per month	
Walleye	One meal per week	One meal per month	
Yellow Perch	No restrictions	One meal per month	
Bluegill Sunfish	No restrictions	No restrictions	
Brown Bullhead	One meal per week	One meal per week	

Lake Hopatcong at Woodport

Also See Entire Lake Advisories

Morris\Sussex Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per week	**New - 2013**
Chain Pickerel	No restrictions	One meal per week	**New - 2013**
Walleye	One meal per week	One meal per month	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Lake Manahawkin at Manahawkin

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
American Eel	One meal per month	Do Not Eat

Lake Mercer at Edinburg

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
Channel Catfish	One meal per week	One meal per month
American Eel	One meal per week	One meal per week

Lake Musconetcong at Stanhope

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per month
Brown Bullhead	One meal per week	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Lake Nummy at Woodbine

Cape May County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat
Yellow Perch	One meal per week	Do Not Eat
Yellow Bullhead	No restrictions	One meal per month

Lake Oswego at Jenkins Neck

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
American Eel	One meal per week	Do Not Eat

Lake Tappen at Old Tappen

Bergen County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Smallmouth Bass	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
Yellow Bullhead	No restrictions	One meal per week
Common Carp	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Lamington River at Lamington

Hunterdon\Somerset Counties

Species	General Population-Eat No More Than:	High Risk Population-Eat No More Than:
Brown Trout	No restrictions	One meal per week
Smallmouth Bass	No restrictions	One meal per week
Redbreast Sunfish	No restrictions	One meal per week
American Eel	One meal per week	One meal per month

Lefferts Lake at Matawan

Monmouth County

Species	General Population-Eat No More Than:	High Risk Population-Eat No More Than:
Chain Pickerel	No restrictions	One meal per week
Yellow Perch	No restrictions	One meal per week
Brown Bullhead	No restrictions	One meal per week

Lenape Lake at Mays Landing

Atlantic County

Pinelands Region

Species	General Population-Eat No More Than:	High Risk Population-Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Chain Pickerel	One meal per week	Do Not Eat
American Eel	One meal per week	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Linden Lake at Lindenwold

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per month	

Little Timber Creek at Brooklawn

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	Do Not Eat	**New - 2013**
White Perch	One meal per month	Do Not Eat	**New - 2013**
Brown Bullhead	No restrictions	No restrictions	
Channel Catfish	Four meals per week	Do Not Eat	**New - 2013**

Malaga Lake at Franklin

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	
Chain Pickerel	One meal per week	One meal per month	

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Manalapan Lake at Jamesburg

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Black Crappie	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	No restrictions
American Eel	One meal per month	One meal per month

Manasquan Reservoir at Howell Twp

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Chain Pickerel	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per week
Black Crappie	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per month
Brown Bullhead	No restrictions	One meal per week
American Eel	One meal per month	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Mantua Creek at Paulsboro

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Striped Bass	One meal per year	Do Not Eat	**New - 2013**
White Perch	One meal per year	Do Not Eat	**New - 2013**
Channel Catfish	One meal per year	Do Not Eat	**New - 2013**

Maple Lake at Estell Manor

Atlantic County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
American Eel	One meal per week	Do Not Eat

Marlton Lake at Marlton

Burlington County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month

Marlu Lake at Thompson County Park

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week
Common Carp	One meal per month	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Maskells Mill Lake at Canton

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per week	One meal per month
Black Crappie	No restrictions	One meal per month
Brown Bullhead	One meal per week	One meal per month

Menantico Sand Ponds at Millville

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
American Eel	One meal per week	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Merrill Creek Reservoir at Stewartsville

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Lake Trout	One meal per week	One meal per month
Yellow Perch	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	No restrictions
Brown Bullhead	No restrictions	One meal per week
Rainbow Trout	No restrictions	One meal per week

Metedeconk River—North Branch at Siloam

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	Four meals per week	Four meals per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Millstone River at Manville

Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Common Carp	Four meals per week	Do Not Eat

Mirror Lake at Browns Mills

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per month
Brown Bullhead	No restrictions	One meal per week
American Eel	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Monksville Reservoir at Ringwood

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	Do Not Eat	
Smallmouth Bass	No restrictions	One meal per month	
Chain Pickerel	One meal per month	Do Not Eat	
Walleye	One meal per week	Do Not Eat	
White Perch	One meal per week	Do Not Eat	
Yellow Perch	No restrictions	One meal per week	
Bluegill Sunfish	No restrictions	One meal per week	
Pumpkinseed Sunfish	No restrictions	One meal per month	
Brown Bullhead	No restrictions	One meal per week	

Mountain Lake at Buttzville

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per month	**Updated - 2013**
Muskellunge	No restrictions	One meal per week	**New - 2013**
Bluegill Sunfish	No restrictions	One meal per week	**New - 2013**
Common Carp	One meal per week	One meal per month	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Mullica River—Green Bank to Batsto

Burlington\Atlantic Counties

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
White Perch	One meal per week	One meal per month
Pumpkinseed Sunfish	One meal per week	One meal per month
Brown Bullhead	One meal per week	One meal per month
White Catfish	No restrictions	One meal per month
American Eel	No restrictions	One meal per month

New Brooklyn Lake at Sicklerville

Camden County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per week	Do Not Eat
Black Crappie	No restrictions	One meal per month
Pumpkinseed Sunfish	No restrictions	One meal per month
Yellow Bullhead	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Newton Creek—North

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Brown Bullhead	No restrictions	No restrictions	
Channel Catfish	No restrictions	One meal per week	

Newton Creek—South

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	Do Not Eat	
Brown Bullhead	No restrictions	One meal per week	

Newton Lake at Collingswood

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	**Updated - 2013**
Black Crappie	One meal per week	One meal per month	
Bluegill Sunfish	One meal per week	One meal per month	**New - 2013**
Brown Bullhead	One meal per week	One meal per month	
Common Carp	Four meals per year	Do Not Eat	**Updated - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Oak Ridge Reservoir at Oak Ridge

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	Do Not Eat	
Chain Pickerel	No restrictions	One meal per month	
Bluegill Sunfish	No restrictions	One meal per month	
Brown Bullhead	No restrictions	No restrictions	
Yellow Bullhead	No restrictions	One meal per month	

Oldmans Creek at Route 130 Bridge

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
White Perch	One meal per month	One meal per month	**New - 2013**
Channel Catfish	Four meals per year	Do Not Eat	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Oradell Reservoir at Oradell

Bergen County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
Yellow Bullhead	No restrictions	No restrictions
Common Carp	No restrictions	No restrictions
American Eel	No restrictions	No restrictions

Overpeck Creek at Ridgefield Park

Bergen County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	Four meals per year	Do Not Eat
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions
Common Carp	Four meals per year	Do Not Eat
American Eel	Four meals per year	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Parvin Lake at Pittsgrove

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
American Eel	One meal per week	One meal per month

Passaic River—Route 280 to confluence of Pompton River at Two Bridges

Morris\Essex\Passaic\ Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Northern Pike	One meal per week	One meal per month
Black Crappie	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per month
Redbreast Sunfish	One meal per week	One meal per month
Pumpkinseed Sunfish	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week
Common Carp	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Passaic River—Elmwood Park to Dundee Lake at Garfield

Passaic\Bergen Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Bluegill Sunfish	One meal per month	Do Not Eat
Redbreast Sunfish	One meal per week	Four meals per year
Brown Bullhead	One meal per week	Four meals per year
Yellow Bullhead	One meal per week	One meal per month
Common Carp	One meal per month	Do Not Eat
American Eel	One meal per month	Do Not Eat

Paulinskill Lake at Newton

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	No restrictions	One meal per week	**New - 2013**
Yellow Perch	No restrictions	One meal per week	**New - 2013**
Common Carp	One meal per month	One meal per month	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Peddie Lake at Hightstown

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	**New - 2013**
Bluegill Sunfish	No restrictions	One meal per week	
American Eel	Four meals per year	Do Not Eat	

Pennsauken Creek at Forked Landing Road

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	One meal per month	**Updated - 2013**
White Perch	Four meals per year	Do Not Eat	**New - 2013**
Bluegill Sunfish	One meal per month	Four meals per year	
Pumpkinseed Sunfish	No restrictions	One meal per month	
White Catfish	One meal per month	One meal per year	
Channel Catfish	One meal per month	Do Not Eat	**New - 2013**
Common Carp	Four meals per year	Do Not Eat	

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Pohatcong Lake at Tuckerton

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Yellow Perch	One meal per week	One meal per week
American Eel	One meal per week	Do Not Eat

Pompton Lake at Pompton Lake

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Bluegill Sunfish	No restrictions	One meal per month
Common Carp	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Pompton River at Lincoln Park

Passaic\Morris Counties

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Northern Pike	One meal per week	Do Not Eat
Yellow Perch	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per month
Rock Bass	One meal per week	Do Not Eat
Redbreast Sunfish	One meal per week	Four meals per year
Common Carp	Four meals per year	Do Not Eat

Raccoon Creek at Bridgeport

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Rahway River at Milton Lake

Union County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Bluegill Sunfish	One meal per week	One meal per month
Brown Bullhead	One meal per week	One meal per month
Common Carp	Four meals per year	Do Not Eat

Rahway River at Valley Road Pond

Union County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Brown Bullhead	One meal per month	One meal per month
Common Carp	One meal per month	Do Not Eat

Ramapo River Lake at Oakland

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Brown Bullhead	No restrictions	One meal per month

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Ramapo River at Pompton/Wayne
(a.k.a. Pompton Feeder)
MorrisCounty

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	Do Not Eat	
Smallmouth Bass	One meal per week	Do Not Eat	
Black Crappie	One meal per week	One meal per month	
Rock Bass	One meal per week	Do Not Eat	
Redbreast Sunfish	One meal per week	One meal per month	
Pumpkinseed Sunfish	One meal per week	Do Not Eat	
Yellow Bullhead	One meal per week	Do Not Eat	

Rancocas Creek at Centerton
Burlington County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	Do Not Eat	**New - 2013**
White Catfish	One meal per month	Do Not Eat	**New - 2013**
Common Carp	Four meals per year	Do Not Eat	**New - 2013**

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Rancocas Creek at Riverside

Burlington County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per month	One meal per month	**New - 2013**
White Catfish	One meal per month	One meal per month	**New - 2013**
Channel Catfish	One meal per month	Do Not Eat	**New - 2013**

Raritan River—North Branch at Branchburg

Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Smallmouth Bass	No restrictions	One meal per month
Redbreast Sunfish	No restrictions	One meal per week
Yellow Bullhead	One meal per week	One meal per month
American Eel	One meal per week	One meal per month

Raritan River—South Branch at Long Valley, Clairmont Section

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Brown Trout	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Raritan River—South Branch at High Bridge

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Redbreast Sunfish	No restrictions	One meal per week
American Eel	One meal per month	Do Not Eat

Raritan River—South Branch at Flemington

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Brown Trout	No restrictions	One meal per week
Smallmouth Bass	One meal per week	One meal per week
Redbreast Sunfish	No restrictions	One meal per week
Yellow Bullhead	One meal per week	One meal per month
American Eel	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Raritan River—South Branch at Neshanic Station

Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per week
Smallmouth Bass	One meal per week	One meal per month
Rock Bass	No restrictions	One meal per month
Redbreast Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	One meal per week
Common Carp	One meal per week	One meal per month
American Eel	One meal per month	Do Not Eat

Raritan River—Confluence of the Millstone River at Millstone

Somerset County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	No restrictions	One meal per month
Redbreast Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions
White Catfish	No restrictions	One meal per month
Channel Catfish	One meal per month	Do Not Eat
Common Carp	One meal per month	Do Not Eat
American Eel	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Rockaway River at Powerville

Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	No restrictions	One meal per month
Rock Bass	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Yellow Bullhead	No restrictions	One meal per week

Rockaway River at Whippany

Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Black Crappie	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Rosedale Lake at Pennington

Mercer County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	No restrictions
Common Carp	One meal per week	One meal per month

Round Valley Reservoir at Lebanon

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Lake Trout	One meal per month	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
White Catfish	No restrictions	One meal per week
Channel Catfish	One meal per month	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Salem River at Salem River WMA

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	**New - 2013**
Bluegill Sunfish	One meal per week	One meal per week	**New - 2013**
Common Carp	One meal per month	One meal per month	**New - 2013**

Saw Mill Lake at Colesville

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Northern Pike	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions
American Eel	One meal per week	One meal per week

Shadow Lake at Red Bank

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Shenandoah Lake at Lakewood

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
American Eel	One meal per month	One meal per month

Sheppards Lake at Ringwood

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Rock Bass	No restrictions	One meal per week
Redbreast Sunfish	No restrictions	One meal per month
Brown Bullhead	No restrictions	One meal per week

Speedwell Lake at Morristown

Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Chain Pickerel	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	One meal per week
Common Carp	No restrictions	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Splitrock Reservoir at Marcella

Morris County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per week
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	No restrictions	No restrictions

Spring Lake at Spring Lake

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Common Carp	No restrictions	No restrictions

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Spruce Run Reservoir at Clinton

Hunterdon County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Hybrid Striped Bass	One meal per month	One meal per month
Northern Pike	No restrictions	One meal per month
Channel Catfish	One meal per week	One meal per month
Common Carp	One meal per week	One meal per month

Stafford Forge Main Line, Stafford Forge

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat

Steenykill Lake at Colesville

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per week
Chain Pickerel	No restrictions	One meal per month
American Eel	One meal per week	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Stewart Lake at Woodbury

Camden County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	Four meals per year	Four meals per year
Bluegill Sunfish	One meal per week	One meal per month
Brown Bullhead	One meal per week	Do Not Eat
Common Carp	One meal per month	Do Not Eat

Stow Creek at Canton

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
American Eel	One meal per week	One meal per month

Strawbridge Lake at Moorestown

Burlington County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	One meal per year
Black Crappie	No restrictions	One meal per year
Bluegill Sunfish	One meal per month	One meal per year
Brown Bullhead	One meal per week	Four meals per year
Common Carp	Four meals per year	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Success Lake at Colliers Mill

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat

Sunset Lake at Bridgton

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month

Swartswood Lake at Swartswood

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Smallmouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per week
Walleye	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	No restrictions
American Eel	One meal per week	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Little Swartswood Lake at Swartswood

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:	
Largemouth Bass	One meal per week	One meal per month	**New - 2013**
Chain Pickerel	No restrictions	One meal per month	**New - 2013**
Brown Bullhead	No restrictions	One meal per week	**New - 2013**

Swimming River Reservoir at Lincroft

Monmouth County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
American Eel	One meal per month	One meal per month

Toms River at Ridgeway Branch

Ocean County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per month	Do Not Eat
Brown Bullhead	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Turn Mill Pond at Colliers Mill

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
American Eel	One meal per week	One meal per week

Maurice River downstream of Millville

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
White Perch	One meal per week	One meal per month
White Catfish	One meal per month	Do Not Eat
Channel Catfish	One meal per month	Do Not Eat

Union Lake at Millville

Cumberland County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Chain Pickerel	One meal per month	Do Not Eat
White Perch	One meal per week	Do Not Eat
Bluegill Sunfish	One meal per week	One meal per month
Brown Bullhead	One meal per week	Do Not Eat

WATERBODY SPECIFIC ADVISORIES FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Wading River at Wading River

Burlington County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat
Brown Bullhead	One meal per week	Do Not Eat
Yellow Bullhead	One meal per month	Do Not Eat
White Catfish	One meal per week	Do Not Eat

Wanaque Reservoir at Wanaque

Passaic County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Smallmouth Bass	One meal per week	One meal per month
Chain Pickerel	One meal per week	Do Not Eat
White Perch	One meal per week	One meal per month
Bluegill Sunfish	No restrictions	One meal per month
Brown Bullhead	No restrictions	No restrictions
Yellow Bullhead	No restrictions	One meal per week
White Catfish	No restrictions	One meal per month

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Wawayanda Lake at Highland Lakes

Sussex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per month
Yellow Bullhead	One meal per week	One meal per month

Weequahic Park Lake at Newark

Essex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	One meal per month
White Perch	No restrictions	One meal per week
Bluegill Sunfish	One meal per week	One meal per week
Brown Bullhead	No restrictions	No restrictions
Common Carp	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Weston Mill Pond at New Brunswick

Middlesex County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Yellow Perch	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
Brown Bullhead	One meal per week	One meal per month
American Eel	One meal per month	Do Not Eat

White Lake at Blairstown

Warren County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	One meal per month
Chain Pickerel	No restrictions	One meal per month
Bluegill Sunfish	No restrictions	One meal per week
American Eel	One meal per week	One meal per week

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Whitesbog Pond at Whitesbog

Ocean County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Chain Pickerel	One meal per week	Do Not Eat

Willow Grove Lake at Malaga

Cumberland County

Pinelands Region

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per week	Do Not Eat
Chain Pickerel	One meal per week	Do Not Eat
Brown Bullhead	No restrictions	One meal per month
Yellow Bullhead	One meal per week	Do Not Eat

Wilson Lake at Fries Mills

Gloucester County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	One meal per month	Do Not Eat
Chain Pickerel	One meal per month	Do Not Eat
Yellow Perch	One meal per month	Do Not Eat
Pumpkinseed Sunfish	One meal per month	Do Not Eat

WATERBODY SPECIFIC ADVISORIES
FRESHWATER LOCATIONS

ALSO FOLLOW ALL GENERAL AND STATEWIDE ADVISORIES OR PINELANDS REGION ADVISORIES

Woodstown Memorial Lake at Woodstown

Salem County

Species	General Population- Eat No More Than:	High Risk Population- Eat No More Than:
Largemouth Bass	No restrictions	One meal per month
Black Crappie	No restrictions	One meal per month

(1) High-Risk Individuals include infants, children, pregnant women, nursing mothers and women of childbearing age.

(2) One meal is defined as an eight-ounce serving.

(3) Eat only the fillet portions of the fish. Use proper trimming techniques to remove fat, and cooking methods that allow juices to drain from the fish (e.g., baking, broiling, frying, grilling, and steaming). See text for full description.

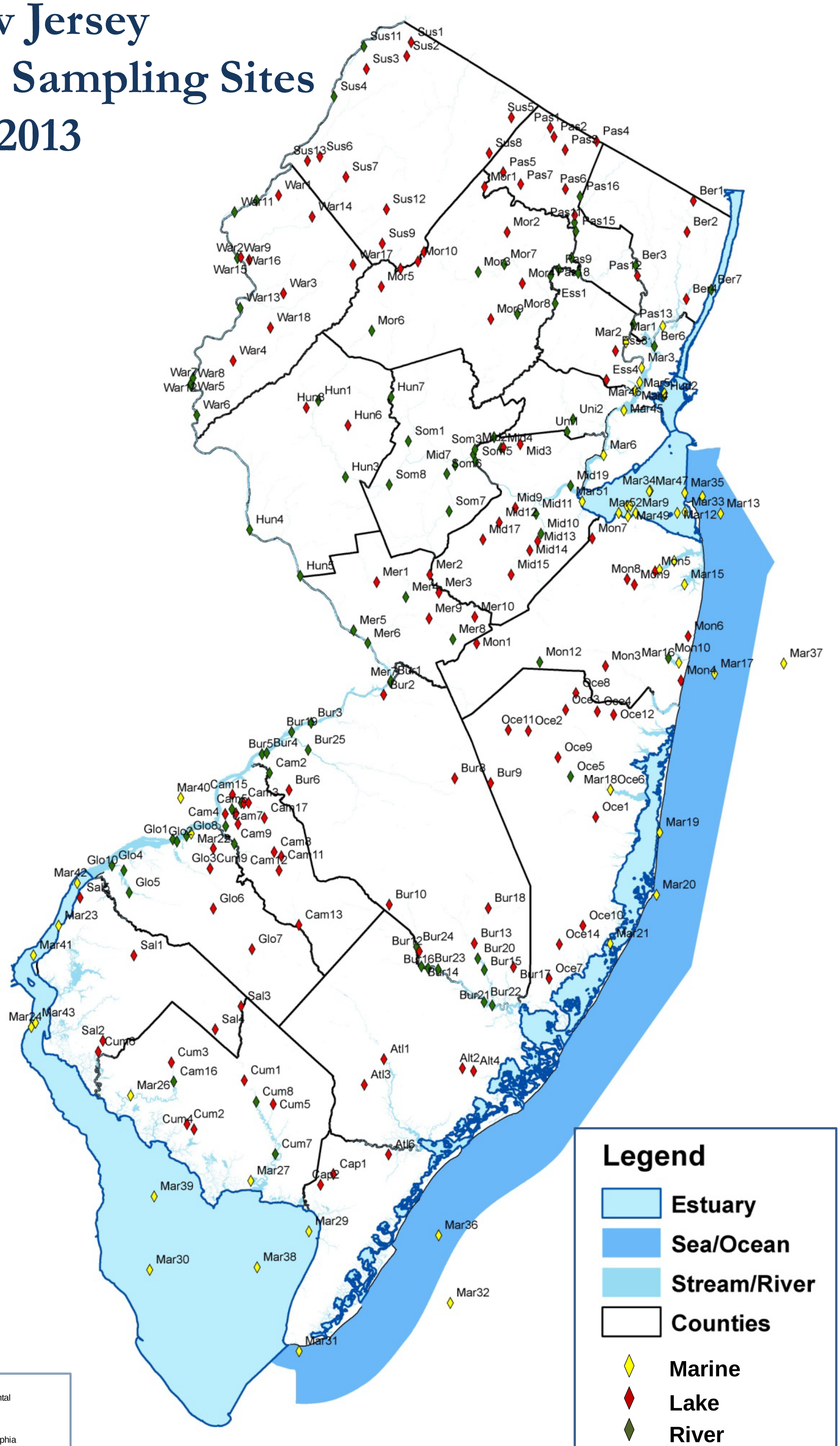
(4) Sunfish includes bluegill, pumpkinseed, and redbreast sunfish species.

(5) No harvest means no taking or attempting to take any blue crabs from these waters.

* = Selling these species for human consumption from designated New Jersey waters is prohibited.

Notes: Not all fish species available were collected and/or analyzed from all waterways

New Jersey
Fish Tissue Sampling Sites
2013



Sampling Performed By:
New Jersey Department of Environmental Protection
Office of Science
Division of Fish and Wildlife
Academy of Natural Sciences, Philadelphia

Map: Terri Tucker, Office of Science, 2013

Sampling Sites by County

Name	County #	Type
Atlantic County		
Atlantic City Reservoir Lower @ Pomona	Alt4	♦ (red)
Atlantic City Reservoir Upper @ Pomona	Alt2	♦ (red)
Corbin City Impoundment # 3 @ Corbin City	Atl6	♦ (red)
Lake Lenape	Atl1	♦ (red)
Maple Lake	Atl3	♦ (red)
Bergen County		
Hackensack River @ Laurel Hill	Ber6	♦ (green)
Hudson River, Alpine to Upper NY Bay	Ber7	♦ (green)
Lake Tappan	Ber1	♦ (red)
Oradell Reservoir	Ber2	♦ (red)
Overpeck Creek Lake	Ber4	♦ (red)
Passaic River at Elmwood Park	Ber3	♦ (green)
Burlington County		
Atsion Lake	Bur10	♦ (red)
Batsto Lake	Bur12	♦ (red)
Crystal Lake	Bur2	♦ (red)
Delaware River at Crosswicks Creek	Bur1	♦ (green)
Delaware River at Riverton	Bur4	♦ (green)
Delaware River at Palmyra	Bur5	♦ (green)
Delaware River, Trenton to Camden	Bur19	♦ (green)
Delaware River mouth of Neshaminy Creek	Bur3	♦ (green)
Harrisville Pond	Bur13	♦ (red)
Lake Absegami	Bur17	♦ (red)
Mirror Lake	Bur8	♦ (red)
Mullica River from Atsion to Pleasantville	Bur24	♦ (green)
Mullica River below Batsto Dam @ Sweetwater	Bur23	♦ (green)
Mullica River @ Green Bank	Bur20	♦ (green)
Mullican River between Green Bank and Batsto	Bur16	♦ (green)
Mullica River @ New Gretna	Bur21	♦ (green)
Mullica River @ Swan Point WMA	Bur22	♦ (green)
Mullica River upstream of Conf. W/ Batsto River	Bur14	♦ (green)
Rancocas Creek @ Delran	Bur25	♦ (green)
Oswego Lake	Bur18	♦ (red)
Strawbridge Lake	Bur6	♦ (red)
Wading River	Bur15	♦ (green)
Whitesbog Pond	Bur9	♦ (red)

Name	County #	Type
Camden County		
Big Timber Creek @ Runnemede	Cam9	♦ (green)
Clementon Lake	Cam12	♦ (red)
Cohansey River @ Bridgeton	Cam16	♦ (green)
Cooper River @ Camden	Cam15	♦ (red)
Cooper River ar Cooper River Lake	Cam3	♦ (green)
Copper River Park Lake @ Launch Ramp	Cam1	♦ (red)
Cooper River Park Lake @ Marina	Cam14	♦ (red)
Evans Pond	Cam17	♦ (red)
Haddon Lake	Cam6	♦ (red)
Kirkwood Lake @ Lindenwold	Cam8	♦ (red)
Linden Lake	Cam11	♦ (red)
Little Timber Creek	Cam7	♦ (green)
New Brooklyn Lake	Cam13	♦ (red)
Newton Creek	Cam5	♦ (green)
Newton Lake @ Collingswood	Cam18	♦ (red)
Newton Lake @ Gloucester City	Cam4	♦ (red)
Pennsauken Creek at Forked Landing	Cam2	♦ (green)
Cape May County		
East Creek Pond	Cap2	♦ (red)
Lake Nummy	Cap1	♦ (red)
Cumberland County		
Cedar Lake	Cum2	♦ (red)
Cedarville Ponds	Cum4	♦ (red)
Marlton Lake @ Marlton	Cum9	♦ (red)
Maurice River @ Mauricetown	Cum7	♦ (green)
Maurice River downstream from Millville	Cum8	♦ (green)
Menantico Sand Ponds	Cum5	♦ (red)
Stow Creek Canton	Cum6	♦ (red)
Sunset Lake	Cum3	♦ (red)
Union Lake @Millville	Cum1	♦ (red)
Essex County		
Branchbrook Park Lake	Ess3	♦ (red)
Passaic River @ Hatfield Swamp (West Caldwell)	Ess1	♦ (green)
Weequahic Lake	Ess4	♦ (red)

Sampling Sites by County

Name	County #	Type
Gloucester County		
Alcyon Lake	Glo6	♦ (red)
Delaware River at Mantua Creek	Glo2	♦ (green)
Delaware River at Paulsboro	Glo1	♦ (green)
Delaware River @ West Deptford	Glo8	♦ (green)
Racoon Creek @ Bridgeport	Glo10	♦ (green)
Raccoon Creek Mouth & Bridgeport	Glo4	♦ (green)
Rancocas Creek @ Swedesboro	Glo5	♦ (green)
Stewart Lake	Glo3	♦ (red)
Wilson Lake	Glo7	♦ (red)
Hunterdon County		
Delaware River at Byram	Hun4	♦ (green)
Delaware -Raritan Canal @ Lambertville	Hun5	♦ (green)
Lamington River @ Lamington	Hun7	♦ (green)
Raritan River South @ Flemington	Hun3	♦ (green)
Raritan River South @ High Bridge	Hun1	♦ (green)
Round Valley Reservoir	Hun6	♦ (red)
Spruce Run Reservoir @ Clinton	Hun8	♦ (red)
Mercer County		
Assunpink Creek @ Windsor	Mer8	♦ (green)
Carnegie Lake	Mer2	♦ (red)
Crosswicks Creek	Mer7	♦ (green)
Delaware -Raritan Canal @ Port Mercer	Mer4	♦ (green)
Delaware -Raritan Canal @ Trenton	Mer5	♦ (green)
Delaware River at Trenton	Mer6	♦ (green)
Grovers Mill Pond	Mer3	♦ (red)
Lake Mercer @ Edinburg	Mer9	♦ (red)
Peddie Lake @ Highstown	Mer10	♦ (red)
Rosedale Lake	Mer1	♦ (red)
Middlesex County		
Bound Brook @ New Market Pond Dam	Mid4	♦ (green)
Davidson Millpond @ Deans Pond	Mid17	♦ (red)
DeVoe Lake @ Spotswood	Mid14	♦ (red)
Duhernal Lake	Mid13	♦ (red)
Farrington Lake	Mid12	♦ (red)
Lake Manalapan	Mid15	♦ (red)
New Market Pond @ South Plainfield	Mid2	♦ (red)
Raritan River @ Millstone River	Mid7	♦ (green)
Raritan River @ Rt 35 Victory Bridge	Mid19	♦ (green)

Name	County #	Type
Middlesex County (continued)		
Spring Lake	Mid3	♦ (red)
South River at Old Bridge	Mid10	♦ (green)
South River at Sayreville	Mid11	♦ (green)
Westons Mill Pond	Mid9	♦ (red)
Monmouth County		
Assunpink Lake	Mon1	♦ (red)
Deal Lake @ Interlaken	Mon6	♦ (red)
Lake Lefferts	Mon7	♦ (red)
Manasquan Reservoir	Mon3	♦ (red)
Marlu Lake	Mon8	♦ (red)
Metedeconk R. North Branch @ Siloam	Mon12	♦ (green)
Shadow Lake	Mon5	♦ (red)
Shark River @ Brighton Ave Bridge	Mon10	♦ (green)
Spring Lake	Mon4	♦ (red)
Swimming River Reservoir	Mon9	♦ (red)
Morris County		
Boonton Reservoir @Boonton	Mor4	♦ (red)
Budd Lake	Mor5	♦ (red)
Lake Hopatcong @ Lake Hopatcong SP	Mor10	♦ (red)
Oak Ridge Reservoir	Mor1	♦ (red)
Raritan River South-@ Clairemont Stretch	Mor6	♦ (green)
Rockaway River	Mor3	♦ (green)
Rockaway River @ Powerville	Mor7	♦ (green)
Rockaway/ Whippany River	Mor8	♦ (green)
Speedwell Lakes @ Morristown(Lake Pocahontas)	Mor9	♦ (red)
Splitrock Reservoir	Mor2	♦ (red)
Ocean County		
Butterfly Pond	Oce3	♦ (red)
Double Trouble State Park Lake	Oce1	♦ (red)
Enno Lake (Bennetts Pond)	Oce8	♦ (red)
Horicon Lake	Oce9	♦ (red)
Lake Carasaljo	Oce4	♦ (red)
Lake Manahawkin	Oce10	♦ (red)
Lake Shenandoah	Oce12	♦ (red)
Pohatcong Lake	Oce7	♦ (red)
Ridgeway Branch of Toms River	Oce5	♦ (green)
Stafford Forge Lake	Oce14	♦ (red)
Success Lake	Oce2	♦ (red)
Toms River	Oce6	♦ (green)
Turn Mill Lake	Oce11	♦ (red)

Sampling Sites by County

Name	County #	Type
Passaic County		
Clinton Reservoir	Pas5	◆ (red)
Dundee Lake	Pas12	◆ (red)
Echo Lake	Pas7	◆ (red)
Greenwood Lake	Pas1	◆ (red)
Green Turtle Lake	Pas2	◆ (red)
Monksville Reservoir	Pas3	◆ (red)
Passaic River - Great Piece	Pas9	◆ (green)
Passaic River @ Lyndhurst	Pas13	◆ (green)
Passaic River @ Pomption River (Two Bridges)	Pas17	◆ (green)
Passaic River, Rt 280 to Two Bridges	Pas18	◆ (green)
Pompton Lake @ Pompton Lake	Pas10	◆ (red)
Pompton River at Lincoln Park	Pas14	◆ (green)
Ramapo Lake @ Wanaque	Pas16	◆ (green)
Ramapo River at Pompton	Pas11	◆ (green)
Ramapo River @ Pompton Plains (Pompton feeder)	Pas15	◆ (green)
Sheppard Pond	Pas4	◆ (red)
Wanaque Reservoir	Pas6	◆ (red)
Salem County		
DOD Lake @ Penns Grove	Sal5	◆ (red)
Maskells Millspond	Sal2	◆ (red)
Parvin Lake	Sal4	◆ (red)
Willow Grove Lake	Sal3	◆ (red)
Woodstown Memorial Lake @ Woodstown	Sal1	◆ (red)
Somerset County		
Bound Brook at Bound Brook	Som4	◆ (green)
Bound Brook @ Shepard Rd.	Som3	◆ (green)
Delaware -Raritan Canal @ Griggstown	Som7	◆ (green)
Delaware -Raritan Canal @ South Bound Brook	Som5	◆ (green)
Green Brook @ Madison Ave. Bridge	Som2	◆ (green)
Millstone River @Manville	Som6	◆ (green)
Raritan River at Neshanic Station	Som8	◆ (green)
Raritan River North Branch at Branchburg	Som1	◆ (green)
Sussex County		
Blue Mountain Lake @ Five Points	Sus13	◆ (red)
Canistear Reservoir	Sus8	◆ (red)
Cranberry Lake	Sus9	◆ (red)
Crater Lake	Sus6	◆ (red)
Delaware River @ Montague	Sus11	◆ (green)
Delaware River Upstream of Water Gap	Sus4	◆ (green)

Name	County #	Type
Sussex County (continued)		
Hainsville Pond	Sus3	◆ (red)
Lake Aeroflex @ Andover (New Wawayanda Lake)	Sus12	◆ (red)
Lake Hopatcong	Sus10	◆ (red)
Lake Musconetcong @ Stanhope	Sus14	◆ (red)
Sawmill Pond @ Colesville	Sus2	◆ (red)
Steeny Kill Lake	Sus1	◆ (red)
Swartswood Lake	Sus7	◆ (red)
Wawayanda Lake	Sus5	◆ (red)
Union County		
Rahway River at Milton Lake	Uni1	◆ (green)
Rahway River at Valley Road Pond	Uni2	◆ (green)
Warren County		
Allamuchy Pond @ Allamuchy	War17	◆ (red)
Catfish Pond	War1	◆ (red)
Columbia Lake @ Columbia Wma	War16	◆ (red)
Delaware Lake @ Columbia	War15	◆ (red)
Delaware River at Easton	War7	◆ (green)
Delaware River - Upstream of Easton	War11	◆ (green)
Delaware River Upstream of Easton	War12	◆ (green)
Delaware River at Lehigh River	War5	◆ (green)
Delaware River @ Phillipsburg	War8	◆ (green)
Delaware River, Phillipsburg to Water Gap	War13	◆ (green)
Delaware River Phillipsburg to Water Gap	War2	◆ (green)
Delaware River @ Portland	War9	◆ (green)
Delaware River at Raubsville	War6	◆ (green)
Delaware River @ Smithfield Beach	War10	◆ (green)
Furnace Lake	War18	◆ (red)
Merrill Creek Reservoir	War4	◆ (red)
Mountain Lake @Buttsville	War3	◆ (red)
White Lake @ Blairstown	War14	◆ (red)

Sampling Sites by County

Name	Marine #	Type
Marine		
Arthur Kill	Mar6	◊
Atlantic Ocean about 1 mile S. of Cape May	Mar31	◊
Atlantic Ocean about 12 miles E. of Belmar	Mar37	◊
Atlantic Ocean at Barnegat Light	Mar20	◊
Atlantic Ocean at Island Beach State Park	Mar19	◊
Atlantic Ocean east of Sea Isle City	Mar36	◊
Atlantic Ocean just N of Sandy Hook	Mar11	◊
Atlantic Ocean just N.W. of Sandy Hook	Mar35	◊
Atlantic Ocean North	Mar13	◊
Atlantic Ocean off Belmar	Mar17	◊
Atlantic Ocean, Sea Isle City to Cape May	Mar32	◊
Barnegat Bay @ Manahawkin Bay	Mar21	◊
Barnegat Bay at Toms River	Mar18	◊
Cohansey River at Greenwich	Mar26	◊
Delaware Bay @ Shoals	Mar38	◊
Delaware Bay at Bower's Beach, DE	Mar30	◊
Delaware Bay C&D Canal -Cape May	Mar39	◊
Delaware Bay West of Reeds Beach, SE of Thompsons	Mar29	◊
Delaware River @ Fort Mifflin	Mar40	◊
Delaware River at Deepwater	Mar23	◊
Delaware River at National Park	Mar22	◊
Delaware River at Port Penn	Mar24	◊
Delaware River from DE-PA to C&D Canal	Mar41	◊
Delaware River, Camden to DE-PA Line	Mar42	◊
Delaware River/Bay @ Reedy Island	Mar43	◊
E. Raritan Bay at Keansburg	Mar10	◊
Hackensack River @ Rt3 Bridge	Mar1	◊
Maurice River at Port Norris	Mar27	◊
Navesink River at Fairhaven	Mar14	◊
Nevesink River@ Red Bank	Mar44	◊
New York Bight @Mud Hole	Mar53	◊
Newark Bay @ Port Newark	Mar4	◊
Newark Bay @ Turnpike Bridge	Mar46	◊
Newark Bay at Shooter Island	Mar45	◊
Passaic River by Kearny	Mar2	◊
Passaic River Lower @ Newark Bay	Mar3	◊

Name	Marine #	Type
Marine (continued)		
Raritan Bay @ Keansburg	Mar50	◊
Raritan Bay @ Keansburg Area	Mar49	◊
Raritan Bay @ Lower Bay	Mar47	◊
Raritan Bay at Lower Bay	Mar34	◊
Raritan Bay @ South Amboy	Mar51	◊
Raritan Bay @ Union Beach	Mar52	◊
Raritan Bay Lower at Union Beach	Mar9	◊
Sandy Hook Bay @ Sandy Hook	Mar33	◊
Sandy Hook Bay Near Earle Pier	Mar12	◊
Shark River at Belmar	Mar16	◊
Shrewsbury River at Oceanport	Mar15	◊
Upper Bay	Mar5	◊

Fishing Access Locations on Trout Waters County Listing

The table below was compiled to assist in locating public access to water stocked with trout by the NJ Division of Fish and Wildlife. Waters are grouped by county; where multiple listings for a stream or river are given they are listed from upstream to downstream. This list is also available with waters listed alphabetically.

Please note that this is only a partial list of major fishing access sites. Other locations and waterbodies will be stocked as well.

For more information on trout fishing in New Jersey see the Trout Information page. Also - We would like to evaluate the angler use of this fishing access list. Please e-mail the Lebanon Fisheries Office at njfwfish@dep.nj.gov to let us know how helpful it was to you and/or if you find any errors.

Atlantic
Bergen
Burlington
Camden
Cape May
Cumberland
Cumberland/Salem
Essex
Gloucester
Hudson
Hunterdon
Hunterdon/Warren
Mercer
Middlesex
Monmouth
Morris
Morris/Union
Ocean
Passaic
Salem
Somerset
Somerset/Morris
Sussex
Union
Warren
Warren/Hunterdon
Warren/Morris

County	Name	Township	Location	Directions
Atlantic	Birch Grove Park Pond	Northfield City	Birch Grove Park	Garden State Parkway to exit for Rt. 563 South. Right onto Burton Ave. Make right into park entrance.
	Hammonton Lake	Hammonton Town	Hammonton State Park	White Horse Pike (Rt. 30) in Hammonton. Turn onto 561 (N), turn into Hammonton State Park on right.
	Heritage Pond	Absecon	Heritage Park	Garden State Parkway to exit 40 to E. White Horse Pike (Rt. 30). Left on Mill Rd. Park entrance on left just past New Jersey Avenue. Parking lot in park.
Bergen	Dahnert's Lake	Garfield	Dahnert's Lake County Park	I-80 take exit 61,south on River Dr., left onto Outwater Lane and right on Midland Ave.
	Hackensack River	Old Tappan	Old Tappan Rd.	Garden State Pkwy exit 168 to Washington Ave. East to Westwood Ave., changes to Demerest Avenue to Cedar Lane (N) to Piermont Ave. (E) to Rivervale Road (N) to Old Tappan Rd. (Rt. 116) - dirt parking area at 90 degree bend in road.
	Hackensack River	Rivervale	Rivervale Rd.	Garden State Pkwy exit 168 to Washington Ave. (E) to Westwood Ave., changes to Demerest Ave. to Cedar Lane (N) to Piermont Ave. (E) to Rivervale

			Road (S), past library parking lot, down hill to ballfield.
Hohokus Brook	Ridgewood	Graydon Park	At the intersection of Linwood Ave. and N. Maple Ave.,
Hohokus Brook	Waldwick	Police pistol range in Boro park	Wycoff Ave.(Rt.502) to Hopper Ave. to Sherman Ave. - several parking lots at end of road
Indian Lake	Little Ferry Boro	Indian Lake	Rt. 46 to traffic light circle with Bergen Turnpike, proceed North on Bergen Tpke (Rt. 121) for 1/4 mile, turn left on Lakeview. Indian Lake on right.
Mill Pond	Park Ridge Boro	Mill Pond	Pascack Road (Rt. 63) North in Park Ridge. Bear right on Mill Rd, pond on right immediately following curve. Mill Pond is also known as Silver Lake.
Pascack Creek	Hillsdale	Hillsdale Ave.	Garden State Pkwy exit 168 to Washington Ave. (E) to Pascack Rd. (N) to Hillsdale Ave.(Rt. 112) (E) - dirt parking area opposite church.
Pascack Creek	Westwood	Lake Street Park	Garden State Pkwy exit 168 to Washington Ave. (E) to Westwood Ave. (Rt. 110) to Kinderkamack Ave. (N) to Lake St. East to park.
Pascack Creek	Westwood	Unnamed Park	Garden State Pkwy exit 168 to Washington Ave. (E) to Westwood Ave. (Rt. 110) - in park
Potash Lake	Oakland Boro	Potash Lake	Rt. 287 (exit 57) or Rt. 202 to West Oakland Ave. Entrance on West Oakland Ave.
Ramapo River	Mahwah	Bergen County Reservation	Rt. 202, Mahwah in the Bergen County Reservation, - very large paved parking lot.
Ramapo River	Mahwah / Oakland	Midvale Mt. Rd Bridge	Rt. 202 to Midvale Mt. Rd Bridge (Glen Gray Rd), small dirt lot and street parking.
Ramapo River	Oakland	Roosevelt Blvd.	from Rt. 202, take Navajo Way to Lake Shore Dr. to Lenape Lane to Roosevelt Blvd. - soccer field at end
Ramapo River	Oakland	River Rd. & Oak St.	Rt. 287 (exit 58), Rt. 202 S. to Oak St., large dirt lot on River Rd. & Oak St.
Saddle River	Ho-ho-kus	Hollywood Ave. Park	Intersection of East Saddle River Rd. (Rt. 75) and Hollywood Ave. - large dirt parking lot
Saddle River	Ridgewood	Saddle River County Park: Wild Duck Pond Area	In Saddle River County Park: Wild Duck Pond Area - off Ridgewood Ave., paved parking area
Saddle River	Paramus	Saddle River County Park: Dunkerhook Area	Saddle River County Park: Dunkerhook Area - Old Dunkerhook Rd. Bridge: off Paramus Rd. - paved parking area
Tenakill Creek	Demarest	Hardenburgh Ave. Bridge	Intersection of Hardenburgh Ave. and County Road. - paved parking area
Tenakill Creek	Demarest	Park off Wakelee Dr.	Hardenburgh Ave. to Wakelee Dr. near Demarest Post Office to Park - small dirt lot and roadside parking

	Whites Pond	Waldwick Boro	Whites Pond	Wykoff Ave.(Rt 502) in Waldwick. Turn on Hopper Ave. Parking lot on left at the dam.
	Whites Pond	Waldwick Boro	Whites Pond	Wykoff Ave (Rt. 502) in Waldwick. Turn on Hopper Ave., make left onto Sherman. Lake at end of Sherman Ave.
Burlington	Crystal Lake	Willingboro	Crystal Lake	Rt. 31 S to Rts. 95 / 295 S. to Rt. 295 S. Exit at Rt. 130 S. Follow for several miles into town of Willingboro. Make left on Rancocas Rd. Turn right on Industrial Dr. Lake is straight ahead.
	Laurel Pond	Mount Laurel	Laurel Pond	Located on Rt. 607 (Church St.) in Mt. Laurel, halfway between Birchfield Dr. and Academy Rd.
	Pemberton Lake	Pemberton	Pemberton Lake	In town of Pemberton, go south on Rt. 644 (Magnolia). Lake on left, parking area and fishing pier.
	Rancocas Creek	Medford	Medford Park	From intersection of Trimble and Mill Streets, take Mill St. to access road to baseball fields and parking.
	Sylvan Lakes	Burlington	Sylvan Lake	Rt. 635 (Rancocas Ave.) to Seventeenth St. to end, Lake Ave - upper lake on right, lower lake on left. Boat ramp on lower lake.
Camden	Gloucester City Pond	Gloucester City	Gloucester City Pond	Rt. 130 (in Gloucester City) to Market Street, turn right onto Sparks Ave. Follow to end. Pond at intersection of Sparks Ave., and Klemm.
	Haddon Lake	Audubon Boro	Haddon Lake	Rt. 70 to Ellisburg Circle. Take Kings Highway SW toward Haddon Heights. In Haddon Heights make a right onto East Lake Drive. Lake is 1/4 mile down on left. First lake you reach.
	Oak Pond	Winslow	Oak Pond	Rt. 73 to New Brooklyn-Blue Anchor Rd. (Rt. 720), make left. Approx. 2 miles turn left onto dirt road (sign for Oak Pond). If you pass Division's Southern Region Office you just missed it. Follow dirt road down to pond.
	Rowands Pond	Clementon Boro	Rowands Pond - WMA	Rt. 295 South to exit 29. Take Rt. 30 East into Lindenwold. Bear right onto White Horse Ave. At intersection of Chews Landing/Clementon Rd. (Rt. 683) turn left. Continue to Higgins Ave. Turn left. Lake is 1/4 mile down on right.
Cape May	Tuckahoe Lake	Upper Twp	Tuckahoe WMA	Take exit 25 toward Ocean City/Marmora/Co Rd 52. Merge onto Vernon Rd. Turn right at Roosevelt Blvd. Continue onto Tuckahoe Rd. Turn right at Woods Rd, take the 2nd right onto Washington Ave. Take the 1st right. Destination will be on the right.
	Ponderlodge Pond	Villas	Ponderlodge Property	From US-9 S, continue onto Garden State Pkwy S. Merge onto Delsea Dr/NJ-47 N via the ramp to Rio Grande. Turn left at Fulling Mill Rd. Turn left at Bayshore Rd. Turn right at Shawmont Ave. Take Shawmont Ave to end of road - enter Ponderlodge area.

Cumberland	Cohansey River	Bridgeton	Silver Lake Road	Beebe Run Rd. to Silver Lake Road - roadside parking
	Giampietro Park Lake	Vineland City	Giampietro Park	Rt. 655 (Lincoln Ave.) in Vineland City. Park entrance to Giampetro Memorial Park.
	Mary Elmer Lake	Bridgeton City	Mary Elmer Lake	Rt. 49 to N. West Ave., just pass high school on right, pond located on left.
	Shaws Mill Pond	Downe	Shaws Mill Pond	Rt. 47 into Millville. Take Rt. 610 S. Turn left on Rt. 629. Pond located on left aprrox. 1 mile.
	South Vineland Park Pond	Vineland	South Vineland Park	From Rt 47 (S. Delsea Dr.) Turn onto West Elmer Rd. Proceed to South Vineland Park entrance.
Cumberland / Salem	Maurice River	Vineland	Garden Rd. Bridge	Rt. 55 exit 35 to Garden Rd. (W) to bridge, parking on shoulder.
	Maurice River	Pittsgrove	Eppinger Rd. Beach	Rt. 55 to exit 32 to Landis Ave. (W) to Gershal Ave. (N) to Eppinger Rd. (E) to end - pull-off parking
	Maurice River	Vineland	Almond Rd. Bridge	Rt. 55 to exit 32 to Landis Ave. (W) to Maurice River Pkwy. (N) to Almond Rd. (W) to bridge, pull-off parking
	Maurice River	Vineland	Landis Ave. Bridge	Rt. 55 to exit 32 to Landis Ave. (W) to bridge, pull-off parking
Essex	Branch Brook Park Lake	Newark	Branch Brook Park	Bloomfield Ave., past 6th Street intersection. Turn right into park entrance.
	Diamond Mill Pond	Millburn	Diamond Mill Pond	Rt. 78 to Millburn/Main St. exit. Proceed north on Main St. Bear right on Brookside Dr. 1st pond located on right. Dirt parking lot.
	Verona Park Pond	Verona Boro	Verona Park	Rt. 280 to Verona/Pleasant Valley exit 8, make right on Pleasant Valley Way. Turn right onto Bloomfield. Make 1st right. Parking lot.
Gloucester	Greenwich Lake	Greenwich	Greenwich Lake	Rt. 295, right onto Tomlin Station Rd. (Rt. 607). Right into lake and parking area.
	Grenloch Lake	Grenloch	Grenloch Lake	Located on Rt. 168 (Blackhorse Pike) in Blackwood. Turn on Woodbury-Turnersville Rd. Make right on Park Ave. Boat ramp access and parking are found on Park Ave. More parking available off Blackhorse Pike.
	Iona Lake	Franklin	Iona Lake	Rt. 40 to Porchtown - Williamstown Rd. (Rt. 612). Lake on left.
	Swedesboro Lake	Swedesboro Boro	Swedesboro Lake	Rt. 295 exit onto Old Ferry Road (Rt. 620). Left onto Auburn Rd. (Rt. 551). Right onto Lake St. (Rt. 666) Quick right onto Lakeview Road.
	Westville Lake	Westville Boro	Westville Lake	From the North: Take Rt. 295 S. Exit 25 B (Westville) to Rt. 47 N. Make left on E.Olive St. Make right on Boundary Ln. From the South via Rt. 295; Take 295 N. Take exit 23 to Rt.130 N. Make right on Olive St. Left on Boundary Ln. Parking areas along Lane.
Hudson		Harrison		

	West Hudson County Park Pond		West Hudson County Park	I-80 East to I-280 East exit onto Cleveland Avenue. At end of exit ramps, make a left onto Cleveland Ave. Make a left on N.4th St. Go one block and make a right onto Hamilton St. Follow to Schugler Ave and make a left. Park entrance past RR Tracks on left
	Woodcliff Lake	North Bergen	James J. Braddock Park	Rt. 1 & 9 North, make a right on 79th St. Enter at 79th St. where it crosses Bergenline Ave. lake straight ahead after entering park.
Hunterdon	Alexauken Creek	Lambertville	Alexauken Creek Rd	From Flemington, take Rt. 202 south. Then take Rt. 179 south (Lambertville exit). Right on Mt. Airy/Queen Rd. (Rt. 605). Left on Alexauken Creek Rd.
	Amwell Lake	East Amwell	Amwell Lake WMA	Rt. 31 - dirt road with sign for lake opposite Linvale - Harbourton Rd. (Rt. 579)
	Beaver Brook	Annandale	Miller's Tavern	Rt. 78 W, exit 18 - Beaver Ave., Annandale. Make 1st right onto East St. Make immediate right (Pump Station Sign). Make right into parking lot (behind Miller's Tavern). Stream on left side of parking area.
	Beaver Brook	Clinton	Rt.173 / Old Rt.22	Various access points and parking behind stores along Rt. 173 / Old Rt. 22 within the town of Clinton.
	Beaver Brook	Clinton	Riverside Drive	Rt. 173 / Old Rt. 22 to Leigh St. Make right onto Riverside Dr. Park at end of cul-de-sac.
	Capoolong Creek	Franklin (Sidney)	Rt. 617 (Sydney Rd.) Bridge	Rt. 78 to exit 15 Rt. 173 (Pittstown Rd.) South for approx. 1/2 mile. Left on Sidney Rd. to bridge (approx. 1.5 miles). Large pull-off just across bridge on left.
	D&R Feeder Canal	Delaware	Route 29 Bull's Island State Park.	Rt. 29 in Raven Rock, turn into Bull's Island State Park, bear left into lower dirt parking area.
	D&R Feeder Canal	Delaware	Route 29 - Lockatong Crk. Bridge	Route 29 in Raven Rock, 1.125 miles south of main entrance to Bull's Island State Park. Dirt parking lot at Lockatong Creek confluence area
	D&R Feeder Canal	Delaware	Route 29 - Lockatong Creek	Route 29, 0.75 miles south of Lockatong Crk. Bridge, park on shoulder or grass.
	D&R Feeder Canal	Delaware	Route 29 -Prallsville Mill	Prallsville Mill located on Route 29 in Stockton. Canal is located behind the Mill and parking lot.
	D&R Feeder Canal	Delaware	Bridge Street - Stockton	Route 29 in Stockton to Bridge St. - street parking.
	D&R Feeder Canal	Delaware	Route 29 - Stockton Quarry	Rt. 29, approx. 1 mile south of Stockton Borough, park on shoulder across from quarry. Railroad trestle & bridge across the canal allowing access
	D&R Feeder Canal	Delaware	Route 29 - at Route 202 bridge crossing	Rt. 29 in Lambertville just past the Rt. 202 bridge crossing, turn in to Holcombe-Jimison Farmstead, parking lot allows access to the canal .
	D&R Feeder Canal	Lambertville		Rt. 29 in Lambertville, turn in on Elm St. Niece Lumber on right at end of Elm St.,

		West End of Elm St.- Niece Lumber.	gravel parking behind Neice Lumber allows access to canal.
D&R Feeder Canal	Lambertville	Coryell Street - Canal Bridge.	Rt. 29 in Lambertville, turn in on Elm St., then south on Union St. Make right on Coryell St. parking lot on western side of bridge over canal.
D&R Feeder Canal	Lambertville	Lambertville Station restaurant.	Rt. 29 (Main St.) in Lambertville, to Bridge St., last left before river bridge. -Park at south end of restaurant lot.
D&R Feeder Canal	Lambertville	Mount Hope St. & below lock near wingdam.	Rt. 29 (Main St.) in Lambertville, to Mt. Hope St. - street parking. Additional access to canal, walk south along canal to canal lock.
D&R Feeder Canal	Lambertville	Route 29 - Fireman's Eddy	Rt. 29, approx. 1 1/2 miles south of Lambertville, pull in road across from Golden Nugget Flea Market.- Bridge over canal to parking area
Hakihokake Creek	Holland	Intersection of Javes and Miller Park Rd.	Rt. 519 to Rt. 614 to Javes Rd. to intersection of Javes and Miller Park Rd., pull-off parking.
Hakihokake Creek	Holland	Miller Park Rd.	Rt. 519 to Rt. 614 to Javes Rd. to Miller Park Rd., many pull-offs for parking.
Lockatong Creek	Kingwood	Union Rd. Bridge	Rt. 519 (Kingwood Rd.) to Union Rd. to bridge. - parking lot
Manny's Pond	Union Twp.	Hoffman Park	From I-78, take Exit 11, head south on Route 614, must make immediate left onto road adjacent to interchange, then bear right on Baptist Church Road. Make left at Hoffman Park entrance. Manny's Pond is the largest pond in the park. It is visible from the main parking lot if you look downhill over the meadow. Manny's Pond has a small island in its center.
Mountain Farm Pond	Teetertown	Teetertown Ravine Nature Preserve	From Route 31, head north on Route 513 through Highbridge. Proceed 6.5 miles, and turn left just past the A&P store in Califon, onto Sliker Road. Proceed 1.5 miles up the hill on and turn right onto Pleasant Grove Road. Proceed 0.6 miles to park entrance sign & black mailbox at #30 Pleasant Grove Road, on the right.
Mulhockaway Creek	Union (Perryville)	Clinton WMA - Charlestown Rd.	Rt. 78 W exit 13, (Service Rd.) Bear left on Rt. 173 W, at light turn right onto Charlestown Rd. (Rt. 635). Gravel Fish and Wildlife parking lot located on right. Creek located short walk down road to bridge.
Mulhockaway Creek	Union (Perryville)	Clinton WMA - Rt. 173	Rt. 78 West, exit 13 (Service Rd.) Bear left on Rt. 173 W. Proceed approx. 2 miles, gravel Fish and Wildlife parking lot on corner of Rt. 173 and Van Syckels Corner Rd.
Neshanic River	Raritan	Kuhl Road	Rt. 31 N bound south lane of Flemington, turn on Kuhl Rd. Follow Kuhl Rd. to sharp bend, dirt parking at bend (old bridge over river)
		Creek Rd.	

Nishisakawick Creek	Alexandria Twp. & Frenchtown Boro		Rt. 519 (Palmyra Corner Rd.) to Creek Rd. - pull-off parking
Raritan River S/B	Lebanon	Vernoy Rd.	Rt. 513 to Valley Brook Rd. (E) to Vernoy Rd., several small pull-off areas along Vernoy Rd.
Raritan River S/B	Califon Boro	Califon Park	Rt. 513 to Main St.(Rt. 512) to Bank St. to park entrance, river is located across field
Raritan River S/B	Lebanon	Ken Lockwood Gorge WMA-Trout Conservation Area (TCA)	Rt. 31 to Rt. 513 to Hoffman's Crossing Rd. to 1st. right after bridge, follow into Fish and Wildlife access - several pull-offs along dirt access road - PROCEED WITH CAUTION (DEEP RUTS). - TROUT CONSERVATION AREA
Raritan River S/B	High Bridge	Arch Street	Rt. 31 to Rt. 513 to Arch Street, parking on corner of Arch St. and Rt. 513, additional parking on Arch St. on left and in park area on right.
Raritan River S/B	High Bridge	Gronsky's Milk House	Rt. 31 to Rt. 513 to Gronsky's Milk House. Parking in lot and large pull off.
Raritan River S/B	Clinton	Halstead St. Bridge	Rt. 31 to Halstead St.(across from Arrow Mill Plaza), parking lot on right just before bridge. Additional parking on Center St.- turn right on Center St. after bridge - lot on left.
Raritan River S/B	Clinton	Rt.173 / Clinton Dam	Rt. 173 (Old Rt. 22), turn into Main St. (Clinton House Restaurant.) - street parking along Main St. after bridge.
Raritan River S/B	Clinton	Riverside Dr.	Rt. 173 (Old Rt. 22) to Leigh St., make 1st. right on Riverside Dr., park at end of cul-de-sac. - access to Raritan River S/B and Beaver Brook.
Raritan River S/B	Clinton	Service Road to Clinton STP	Rt. 78 exit 15 to Pittstown Rd.(Rt. 513) turn left into Wal-Mart Plaza continue past Cracker Barrel. Parking available outside of gate of sewage treatment facility.
Raritan River S/B	Clinton	Hamden Rd.	Rt.173 (Old Rt. 22) to Leigh St., make right onto Hamden Rd., take to end. - parking at end of Hamden and corner of Landsdowne Rd., along closed section.
Raritan River S/B	Clinton	Pine Hill Rd.	Rt. 617 to Sidney School Rd., make right on Pine Hill Rd., Make right on River Rd. Small pull-off areas along bridges over river.
Raritan River S/B	Franklin	"Sunnyside" Picnic Area - Kiceniuk Rd.	Rt. 617, to Spring Hill Rd., make right on River Rd., paved parking area at intersection of River and Kiceniuk Rds.
Raritan River S/B	Franklin	Stanton Station Rd. Bridge	Rt. 31 to Stanton Station Road, approx. 1/4 mile cross over bridge, parking area on left. Foot path follows along river for additional access.
Raritan River S/B	Raritan	Rt. 523	Rt. 31 to Bartle's Corner Rd.(Rt. 612) proceed straight, becomes Rt. 523. Large dirt pull-off area on left across from Raritan Industrial Center (Old Lipton Tea company).
	Readington	River Rd.	

	Raritan River S/B			Rt. 31 to Bartles Corner Rd. make right onto Rt. 523 S (River Rd.) proceed approx. 1.5 miles, river comes close to road-several dirt pull-off areas in vicinity of Flemington Industrial Park.
	Raritan River S/B	Three Bridges	Main St.	Pull-off located around bridge, additional parking in County Park area on south side of bridge.
	Raritan River S/B	Raritan Twp	South Branch Reservation - Three Bridges	Rt. 202 N, in Three Bridges area, turn right onto Old York Road, towards Three bridges. Turn right onto Main Street (Rt. 613). Parking located on South Branch Reservation area to the left, after crossing over the river.
	Raritan River S/B	Hillsborough	Neshanic Station	Rt. 202, Centerville area, proceed south on Rt. 629 (Pleasant Run Rd). Go straight, becomes Rt. 567. Follow into Neshanic Station, becomes River Rd. Pull offs at bridge crossings and street parking.
	Raritan River S/B	Hillsborough	Riverside Drive	From Neshanic Station, becomes River Road. Pull off at bridge crossings and street parking.
	Raritan River S/B	South Branch	River Road	Rt. 202, Centerville area, proceed south on Rt. 629. Turn left onto South Branch Road. Go app. 3 miles, make right on Studdiford Dr. Turn right onto River Rd - pull off on River Road.
	Rockaway Creek	Readington (Whitehouse)	Lamington Road Bridge	Rt.22 to Old Rt.28 to Lamington Road to bridge. - pull-off parking
	Rockaway Creek S/B	Readington	Rt. 22	Rt. 22, in Readinton Twp, parking at Green Acres Access area - East bound lane - mile marker 24.5 - short section of creek along Rt. 22.
	Round Valley Res.	Clinton Town	Round Valley Reservoir - WMA	Rt. 78 east to Rt. 22 east, 3rd light onto Round Valley Access Rd. Make 1st left and then boat ramp area immediately on right.
	Spruce Run Creek	Glen Gardner Boro	School Street	Rt. 31 to School Street. Immediately on the right, parking area for playground.
	Spruce Run Creek	Lebanon	Rt. 31	On Rt. 31, small pull-off areas along creek from Glen Gardener down to Van Syckels Rd.
	Spruce Run Creek	Lebanon	Van Syckel's Corner Road	Rt. 31 to Van Syckel's Corner Rd.(look for signs to Spruce Run Recreation Area). - Parking area located on left just over bridge.
	Sydney Brook	Union	Race Street	Rt.513(Pittstown Rd.) to Race Street - Church Parking lot
	Wichecheoke Creek	Delaware	Lower Creek Road	Rt. 519 (Kingwood - Stockton Rd.) to Lower Creek Road - pull-off parking
Hunterdon / Warren	Musconetcong River	Hampton	Hampton Boro Park	Rt. 31 to Main St. to Valley Rd. to Park entrance to end, dirt/gravel parking lot.
	Musconetcong River	Bloomsbury Boro	Fish & Wildlife Access - Willow Ave.	Rt. 78 / Rt. 22 (exit 7) to Rt. 173 S. to Rt. 579 to Willow Ave to Fish and Wildlife parking lot.
		Holland		

	Musconetcong River		Fish & Wildlife Property	Rt. 78 / Rt. 22 (exit 7) to Rt. 173 W. to Warren Glen - Bloomsbury Rd. (Rt. 639) to Rt. 519 / Rt. 627 to Warren Glen Rd. (Rt. 627) to Mt Joy Rd., DFW property (old Christmas tree farm) off Mt. Joy Rd. - dirt lane to parking lot.
Mercer	Assunpink Creek	Washington	Rt. 130	Rt. 195, exit onto Rt. 130. Proceed north for app. 3.5 miles to bridge over Assunpink Creek. Parking for app. 20 vehicles.
	Assunpink Creek	Washington	Old Trenton Road	Rt. 295, exit 5 onto Rt. 130 North for app. 1 mile. Left onto Rt. 526 Robbinsville-Allentown Road for 3.3 miles. Right onto Rt. 535 Old Trenton Road to bridge crossing. Parking for 6 to 10 cars.
	Assunpink Creek	Hamilton	Mercerville-Quakerbridge Rd.	Take Rt. 295, exit 65 to Sloan Ave, east for 0.7 miles. Left onto Rt. 533 Mercerville-Quakerbridge Road, 1.7 miles to Assunpink Creek bridge. Parking at bridge for app. 3 cars. Additional parking at nearby fields, app. 200 yds. from creek.
	Assunpink Creek	Lawrence	Carnegie Road	Rt. 295, exit 67, onto Rt. 1 south for 1.3 miles. Take jug handle to cross Rt. 1 onto Carnegie Road. 1/2 mile to Assunpink Creek. Parking at bridge for app. 10 cars.
	Colonial Lake	Lawrence	Colonial Lake	Rt. 31 south to I- 95 N (I- 295 S) to exit 67 onto Rt. 1 south. When Rt. 1 splits, stay straight onto Rt. 1 Business, go a short distance and make a left onto Lake Rd. lake is on your left.
	D&R Canal	Lawrence	Carnegie Road Bridge	Rt. 1 North Lawrence Township, right onto Carnegie Road to parking at bridge over canal. 15 car capacity.
	D&R Canal	Princeton	Provinceline Road	From Rt. 1 North, left onto Quaker Bridge Rd., cross bridge over canal and make left to former Beef-a-lo Farm access road. - park along gravel roadway
	D&R Canal	Plainsboro	Quaker Bridge Road	From Rt. 1 North, left onto Quaker Bridge Road to bridge over canal. Parking lot holds 10 cars.
	D&R Canal	Plainsboro	Bend at Quaker Bridge Road	Rt. 1 to Quaker Bridge Rd. (N) to Quaker Rd.(Rt. 533), small parking area at bend. Gravel parking area for about 5 cars
	D&R Canal	Princeton	South of Alexander Road bridge	From Rt. 1 North, left onto Alexander Road. 20 car parking lot.
	D&R Canal	Lawrence	Whitehead Road Bridge (Rt. 516)	Rt. 1 to Whitehead Road Bridge Route 516. Parking for about 4 cars.
	D&R Feeder Canal Upper	Hopewell	Route 29 - south of Pleasant Valley Rd.	Rt. 29, south of Pleasant Valley Rd., gravel pull off area - hot dog wagon.
	D&R Feeder Canal Upper	Hopewell		Rt. 29 Washington Crossing area, turn toward Delaware River bridge - make

			Route 29 - Washington's Crossing Park	immediate right at bend in road BEFORE bridge. (DO NOT GO OVER BRIDGE) - enter Washington Crossing Park.
	D&R Feeder Canal Upper	West Trenton	Route 29 - Scudders Falls	Rt. 29, West Trenton area, before Rt. 95 turn right over bridge over canal. Gravel parking area - Scudders Falls.
	D&R Feeder Canal Upper	West Trenton	Lower Ferry Road	Rt. 29 Trenton area, take Lower Ferry Road, limited parking at Lower Ferry Road bridge over canal.
	D&R Feeder Canal Upper	Trenton	Cadwalader Park	Take West State Street to Parkside Avenue traffic light; (there is a red brick school building on right and baseball fields on left). Turn left and at next light go left into Cadwalader Park. Footbridge in park allows access to the canal.
	Rosedale Lake	Hopewell	Rosedale Lake	Rt. 31 to Main St. (Pennington) Left onto Federal City Rd., bear left onto Pennington-Rocky Hill Rd. Right onto Elm Ridge Rd., and right into Rosedale Park.
	Stony Brook	Hopewell	Stony Brook Rd.	Rt.31 to Mine Rd.(E) to Stony Brook Rd. - roadside parking.
	Stony Brook	Princeton	Johnson park School	Rosedale Rd.(Rt.604) to Gen. Johnson Access Rd. - Good parking and plenty of good water up and down stream from the parking area.
Middlesex	Hooks Creek Lake	Old Bridge	Hooks Creek Lake	Garden State Parkway exit 120. Right onto Cliffwood Ave. Right on Gordon Rd. to T intersection, left at the T intersection, lake on left with parking area.
	Ireland Brook	South Brunswick	Ireland Brook County Park	Rt.1 to Rt.171 S (Old Georges Road) to Washington Place, which turns into Hardenburg Lane, to Oakmont Ave., take Rive Ave. south to park - small parking lot in Park.
	Lake Papaianni	Edison	Lake Papaianni	From Rt. 529 in Edison turn right onto Central Ave. (1st right after crossing railroad tracks). Make right onto Stoney Rd., Quick left onto Chestnut, then left onto Andre. Park entrance and parking lot located at end.
	Lawrence Brook	Milltown	Behind factory off Ford St.- Milltown	Rt.1 to N. Main St., make right onto Ford Ave., parking behind factory.
	Manalapan Lake	Jamesburg/Monroe Twps.	Thompson Park	From Rt. 1 take 130 South. Take Rt. 32 East which turns into Forsgate Dr. Go through traffic light at Perrineville Rd. Park is on the right.
	Roosevelt Park Pond	Edison	Roosevelt Park	Rt. 1 in Edison, turn into Roosevelt Park. Sign for park on highway.
Monmouth	Echo Lake	Howell	Echo Lake (Southhard)	From Rt. 195, take the exit for Rt. 9 South and continue for approx. 3 miles. Take the jug handle for Lanes Mills Road and head east. Make the first left onto Maxim-Southhard Road to Echo Lake on the left.
		Englishtown		

Englishtown Mill Pond		Englishtown Mill Pond	Rt. 9 to Rt. 522 (Freehold - Englishtown Rd.), go north approx. 4 miles into Englishtown, make left onto Main St., left onto Park Ave. - Pond on left, street parking
Franklin Lake	West Long Branch	Lakeview Ave.	From Monmouth Park Hwy. (Rt. 36 East), turn right onto Broadway/CR-537. Turn right onto Halsey Pl. Turn left onto Lakeview Ave. Parking on street. Lake is on the right. Additional parking: continue on Lakeview Ave. and turn right onto Locust Ave.CR-15. Turn right onto Throckmorton Ave. Park on street.
Garvey's Pond	Navesink	Garvey's Pond	Route 35 in Middletown, take Kings Highway East for 3.2 miles. It becomes Monmouth Rd., continue for 1.4 miles. Right onto Locust Point Rd. Make the second left onto Lakeside Ave. Street parking and small pull-off at end of lake.
Hockhocksen Brook	Shrewsbury	Green Acres Access on north side of Tinton Ave. Bridge	From exit 109 on the Garden State Pkwy., go east on Newman Springs Rd., south on Shrewsbury Ave., west on Sycamore. Green Acres Access - gravel parking lot.
Holmdel Park Pond	Holmdel	Holmdel Park	Holmdel Rd.(Rt. 4) to Longstreet Rd., Park entrance on left - parking area
Mac's Pond	Manasquan	Mac's Pond	Rt. 195 to Rt. 34 South for 2.6 miles. Left onto Atlantic Ave. for 3 miles, left onto North Main Street. Pond on left; street parking.
Manasquan River	Wall	Hospital Road	Rt. 524 East (Atlantic Avenue) make right turn on Hospital Road. Parking on right before the bridge crossing the river.
Manasquan River	Wall	Brice Park	Rt. 524 East, bear right onto Westside Dr. to Allenwood/Lakewood Road, just before Manasquan River bridge crossing, look for and enter Brice Park.
Mingamahone Brook	Wall	Atlantic Ave. (white bridge)	From the intersection of Rt. 547 & Rt. 524, take Route 524 East (Atlantic Avenue) for I/4 mile to a white bridge. After white bridge, make right into parking area.
Mohawk Pond	Red Bank	Mohawk Pond	Garden State Parkway exit 109. Newman Springs Road east for 2 miles, left on Henry Street to pond. Street parking.
Shark River	Ocean	Shark River Park	From Garden State Parkway, exit 100, to Rt. 33 east, to School House Road, Look for entrance for Shark River Park. From parking lot follow trail to river.
Spring Lake	Spring Lake	Spring Lake	Route 195 to Route 34 south for 2 miles. East on Rt. 524 (Allaire Rd.) for 2.4 miles, bear right onto Warren St. to West Lake Ave; street parking.
Topanemus Lake	Freehold	Pond Rd.	Rt. 9 to exit for Pond road, go south approx. 1 1/2 mile to park entrance - dirt lot
Yellow Brook	Colt's Neck		

			Creamery Road Bridge	North on Rt 34 to Traffic Light (Phalanx Road), make right hand turn, then make first right, (Creamery Road), go to bridge.
Morris	Beaver Brook	Rockaway	Ford Rd. Bridge	Rt. 80 to Green Pond Rd. to Morris Ave. to Ford Rd. - roadside parking
	Black River	Chester	Hacklebarney State Park	Rt. 206 to Rt. 24(Washington Tpke.) to State Park Rd. to park entrance & parking lot - follow hiking trail to river.
	Burnham Park Pond	Morristown Town	Burnham Park	Rt. 80 W to Rt. 287 S. Get off at Madison Ave. exit. Make a right onto Madison Ave.. Follow to Rt. 24 and make a right onto South St. (Rt. 24). Follow through Morristown which turns to Washington St. (Rt. 24). Park on left, just outside of Morristown.
	Drakes Brook	Mt. Olive (Flanders)	Ironia Rd. Bridge	Rt.206 to Flanders-Bartley Rd.(E) changes to Ironia Rd. to bridge. - roadside parking
	Hibernia Brook	Rockaway	Hibernia Firehouse	Rt. 80 to Green Pond Rd. (Rt. 513), approx. 6 miles to firehouse and parking lot.
	India Brook	Mendham	Mendham Boro Park	Rt. 24 (Rt. 510) in Mendham Boro to Ironia Rd. to Mountainside Rd. to Mendham Boro Park.
	India Brook	Mendham	Patriot's Path	Rt. 24 (Rt. 510) in Mendham Boro to Ironia Rd., turn on first road after bridge (access to sewege treatment plant), pull-off parking
	India Brook	Mendham	Ironia Rd.	Rt. 24 (Rt. 510) in Mendham Boro to Ironia Rd., pull-off near bridge
	India Brook	Mendham	Roxciticus Rd.	Rt. 24 (Rt. 510) in Mendham Boro to Roxciticus Rd. (N), dirt pull-off at bridge
	Lake Hopatcong	Hopatcong Boro	Lake Hopatcong State Park	Rt. 80 West to exit 28. Make right onto Shippenport Rd. Make a left onto Lakeside Blvd. State park is on your right.
	Lake Musconetcong	Roxbury	Lake Musconetcong State Park	Rt. 80 to Rt. 206 North to Rt. 183 South. Make a left onto Musconetcong Rd. State park will be on your left.
	Mt. Hope Pond	Rockaway	Mt. Hope Park	Rt. 80 (exit 36) to Mount Hope Rd. for approx. 2 miles. Pond on left. - roadside parking and small pull-offs
	Musconetcong River	Hopatcong Heights	Hopatcong State Park off Brooklyn Rd.	Rt. 80 (Exit 28) to Landing Rd. to Lakeside Blvd.(CR. 602) to Brooklyn Rd. to entrance of park - large paved lot.
	Musconetcong River	Mt. Olive	Seber's Park	Rt. 46 to Drakestown Rd. to Mine Hill Rd. to River Rd. (Stephens Park Rd.) or (Grove Lane) to dirt road entrance to Park (not marked) to end.
	Passaic River	Chatham Boro	Sheppard Kollock Park.	Main St. to Parrott Mill Rd. to Henderson Rd., enter Sheppard Kollock Park., large parking lot.
	Raritan River S/B	Mount Olive	Flanders-Drakestown Rd. Bridge	Route 46 to Wolfe Rd. to Flanders-Drakestown Rd. (S) - next bridge, pull-off parking.
		Washington		

	Raritan River S/B		Bartley Rd. - Fish & Wildlife Access	Route 206 to Flanders - Bartley Rd. or Chester Rd. to Bartley (Bartley - Longvalley) Rd. access area on right just past bridge over Drakes Brook (small sign), parking lot.
	Raritan River S/B	Washington / Long Valley	Claremont Stretch - Trout Conservation Area	Route 24, at light in Long Valley, north on Schooley's Mt. Rd., 1st. Right on Fairview, parking area approx. 1 mile on right. Follow path to river. - TROUT CONSERVATION AREA
	Raritan River S/B	Washington / Long Valley	Scott Park	Rt. 513 - straight through light in Long Valley going south - approx. 3/4 mile on right - dirt parking area, short walk down to river.
	Rockaway River	Jefferson	Longwood Lake Dam	Blue Road (very small sign) downstream of Longwood Lake Dam - off Berkshire Valley Rd. in the Rockaway River WMA (Wildlife Management Area), small dirt parking lot.
	Rockaway River	Jefferson	Rockaway River WMA - fire road	Look for dirt road upstream of Berkshire Valley Rd. bridge, turn in and follow to small dirt parking lot.
	Rockaway River	Jefferson	Berkshire Valley Rd.	Dirt pull off located upstream of Berkshire Valley Rd. bridge.
	Rockaway River	Jefferson	Berkshire Valley Rd. Bridge	Rt. 15 to Berkshire Valley Rd. to bridge - large dirt lot near bridge
	Rockaway River	Jefferson	Taylor Road	Berkshire Valley Road to Taylor Road in the Rockaway River WMA, good roadside parking (also off Rt. 15 N just above Berkshire Valley Road).
	Rockaway River	Wharton	Wharton Park Waterworks	W. Dewey Ave. (Rt. 642) to W. Central Ave. to Park - midsize dirt lot.
	Rockaway River	Dover	Dover Waterworks	Enter at Rutgers St., off Princeton Ave. good parking in park.
	Rockaway River	Rockaway Boro	Jackson Avenue Park	Main St., to Jackson Ave., to Park; roadside parking.
	Rockaway River	Denville	Gardner Park	Rt. 80, (exit 38/39) to Rt.46 to Savage Rd., to Park; parking lot.
	Rockaway River	Denville	McCarter Park	Rt. 80, (exit 38/39) to Rt.46 to Broadway Ave.; street parking.
	Rockaway River	Boonton Twp.	Tourne Park	Old Boonton Rd. (Rt. 603) to Old Denville Rd. to Park, small dirt lot.
	Rockaway River	Boonton Town	Grace Lord Park	Rt. 287 (exit 44) to Main St. (Rt. 624) to Plane St, dirt parking lot.
	Russia Brook	Jefferson	Weldon Rd.	Berkshire Valley Rd. to Dover - Milton Rd. to Weldon Rd. - small pull-off parking
	Speedwell Lake	Morristown Town	Speedwell Lake	Rt. 80 east to Rt. 202 South. Continue on Rt. 202 past Rt. 10, then make a left onto Speedwell Ave., Make a right onto Ames Rd.
	Whippany River	Mendham	Lewis Morris County Park	Rt. 24. Large dirt parking area across from Sunrise Lake
	Whippany River	Mendham	Lewis Morris County Park	Rt.24, Gravel pull-off to stream 200 yards east of entrance to Sunrise Lake.
		Morris		

	Whippany River		Inamere Rd Bridge	Sussex Ave., to Inamere Rd., street parking.
	Whippany River	Morristown	Park off Center St.	Spring St. to Center St., paved parking lot.
	Whippany River	Morristown	Abbett Ave. Park	Rt. 287 (S) exit 36 to Ridgedale Ave. to Abbet Ave. to Park. (or) Rt. 287(N) exit 36 to Morris Ave. (W) to Ridgedale Ave. to Abbet Ave. to Park. Parking in park
Morris / Union	Passaic River	Summit	Passaic River Park	Mt. Vernon Ave., to Stanley Ave. Or (in Chatham Boro) Watchung Ave. to River Rd. to Stanley Ave., large dirt lot.
Ocean	Lake Shenandoah	Lakewood	Lake Shenandoah Park	Rt. 9 to Rt. 88 (Main St.), turns into Ocean Ave., Park entrance is approx. 1 mile on right. - parking lot.
	Metedeconk River S/B	Lakewood	Pine Park	W. County Line Rd.(Rt. 526) to Country Club Road, take right on Country Club Drive to Pine Park.
	Metedeconk River S/B	Lakewood	Hope Chapel Road Bridge (Rt. 639)	W. County Line Rd. (Rt. 526) to Hope Chapel Road (Rt. 639) to pull off access near bridge over Metedeconk.
	Metedeconk River S/B	Lakewood	Southlake Drive	W. County Line Rd. (Rt. 526) to Hope Chapel Road (Rt. 639) to Southlake Drive. Street parking.
	Pohatcong Lake	Tuckerton	Pohatcong Lake	Along Rt. 9, shoreline access.
	Prospertown Lake	Jackson	Prospertown Lake	Rt. 195 to Rt. 537 (Monmouth Rd.), entrance to lake approx. 1 mile past Great Adventure.
	Toms River	Jackson	State Forestry Research & Education Center	NJ FREC - Rt. 195 (exit 21) to Rt. 527 / Rt. 528 S. (Cedar Swamp Rd.) to entrance of NJ FREC, follow sand road to river and parking.
	Toms River	Dover	Riverwood Park	Rt. 195 (exit 21) to Rts. 527/528 S. (Cedar Swamp Rd./ Veterans Hwy.) to Rt. 527 S. (Whitesville Rd.) to Riverwood Dr. to entrance of park. Or Rt. 9 (in Dover) to Riverwood Dr. to entrance of park
Passaic	Barbours Pond	West Patterson	Garret Mountain Reservation	Rt. 80 to exit 56 (Squirrelwood Rd.) Right on Rifle Camp Rd., Left on Mountain Ave. Entrance to park on Mountain Ave. Pond located on right after entering park. Parking lots.
	Clinton Reservoir	West Milford	Newark Watershed	Rt.23 to Clinton Rd. North for approx. 2 miles. Pull-offs located at various locations along Clinton Road along Clinton Reservoir and boat launch at upper end of reservoir. HOLDOVER TROUT LAKE
	Green Turtle Pond	West Milford	Wanaque WMA	Greenwood Lake Turnpike to Awosting Rd. Entrance to pond approx. 1 mile on right. Parking and boat ramp at end of access road.
	Oldham Pond	North Haledon	Oldham Pond	Rt. 504 (Hamburg Turnpike) in Haledon to Pompton Rd. Stay left in fork and merge onto Church St. Church St. becomes High Mountain Rd. Entrance to

				pond approx. 1/4 mile on left. Street parking. Shorline access from sidewalk
	Pequannock River	West Milford	Rt. 23	Under Rt. 23 overpass - small dirt parking lot. - TROUT CONSERVATION AREA (downstream boundry)
	Pequannock River	Bloomingdale	Sloan Park	Paterson-Hamburg Turnpike to parking lot between Methodist church and park.
	Pequannock River	Riverdale	Appelt Park	Paterson-Hamburg Tpke.(Riverdale Ave.),1/2 mile west of Rt. 287 to Park - large dirt parking lot.
	Pompton River	Pequannock	Pompton Plains Cross Road (Jackson Ave.)	Rt. 23 to Pompton Plains Cross Road (Jackson Ave.)(Rt. 680) - large paved lot behind shopping center.
	Pompton River	Pequannock	Regency Motel	Rt. 23 - Regency Motel - behind motel large parking lot.
	Pompton River	Pequannock	Riverside Park	Newark - Pompton Turnpike to Riverside Dr. to Park at end. Small dirt lot and roadside parking.
	Ramapo River	Wayne	Mc Cobb's Family Restaurant	2391 Hamburg Tpk - Rt. 287 to Exit 53, right onto Paterson Hamburg Tpk. Park in restaurant lot.
	Ringwood Brook	Ringwood	Ringwood State Park	Greenwood Lake Turnpike (Rt. 511) to entrance off Sloastburg Rd - several parking lots and pull-offs along brook in Park.
	Shepherd Lake	Ringwood Boro	Ringwood State Park	Greenwood Lake Turnpike to Sloatsburg Rd. Right on Morris, then left on Shepherd Pond Road. Entrance at end of Shepherd Pond Road. Parking lot, and boat ramp in park.
	Wanaque River	West Milford	East Shore Drive.	Greenwood Lake Turnpike (Rt. 511) to East Shore Drive., in the Wanaque WMA, many small pull offs and small dirt lots along road.
	Wanaque River	Pompton Lakes	Riddles Bar & VFW	Rt. 287 exit 53 to Paterson Hamburg Turnpike (W) to Wanaque Ave. Behind stores off Wanaque Ave., park in parking lot
	Wanaque River	Pompton Lakes	Hershfield Park	Rt. 287 exit 53 to Paterson Hamburg Turnpike (W) to Ramapo Ave. (S) to Hershfield Park Road, park in parking lot.
Salem	Harrisonville Lake	South Harrision	Harrisonville Lake	Rt. 45 to Harrisonville Rd. (South Harrison) Make right on Main St. Make right on Eldridges Hill Rd. Make left on Lake Street. Lake is on left. Dirt parking area is on right. Shoreline fishing along road is on left.
	Schadler's Sand Wash Pond	Penns Grove	Schadler's Sand Wash Pond	Rt. 40 W., bear right onto Rt. 48, go 1.8 miles to left on Game Creek Rd. lake is on left - parking along road.
Somerset	Lamington River	Bedminister	Burnt Mills Road	Rattlesnake Road, make left on Burnt Mills Rd. Turn right on Minor Rd. Turn Right onto Burnt Mills Road - pull-off just on other side of bridge.
	Lamington River	Branchburg	Burnt Mills Rd. bridge	

				Rt. 22 to Rt. 28 (Easton Trpk.) to Burnt Mills Rd., approx. 2.5 miles to bridge, pull-off parking.
	Middle Brook E/Br.	Martinsville	Brookside Dr.	Rt.22 to Vosseller Ave.(N) to Brookside Dr. - pull-off parking
	Middle Brook E/Br.	Martinsville	Vosseller Ave.	Rt.22 to Vosseller Ave.(N) to bridge - dirt roadside parking at bridge
	Middle Brook E/Br.	Martinsville	Washington Co. Park	Rt.22 to Vosseller Ave.(N) to Gilbride Rd. to Park. - plenty of parking in Park
	Passaic River	Bernards	Lord Stirling Road Bridge.	Rt. 287 exit 30 to N. Maple Ave. (S) to S. Maple Ave. to Lord Sterling Road, Small dirt lot and roadside parking.
	Passaic River	Bernards	So. Maple Ave. Bridge.	Rt. 287 exit 30 to N. Maple Ave.(S) to S. Maple Ave. to bridge, roadside parking on Pond Hill Road, and S. Maple Ave.
	Peapack Brook	Peapack / Gladstone	St. Bridgerds Parish Center	Rt. 206 to Pottersville Rd., left on Main St. to parish center, parking lot.
	Raritan River	Bridgewater	Duke Island Park	Rt. 206 in Raritian to E. Somerset St., becomes Old York Rd. Entrance to Duke Island park approx. 2.5 miles on left. Multiple parking lots along river. More access along river to dam via footpath.
	Raritan River	Raritan	Canal Street Park	Route 206 to Orlando Dr., becomes Canal St., approx. 3/4 mile. Canal Street Park is at the end of Canal St. Additional pull-offs along Mill and Nevis St. near river just before Canal Street Park.
	Raritan River N/B	Raritan	Old Fair Grounds	Rt. 206 N and bear right onto Rt. 202 N. Make right onto Main St. Make left onto Peapack Rd. Turn into Old Fair Grounds. Access behind ballfields
	Raritan River N/B	North Branch	Green Acres Access	Rt. 22, just east of Town of North Branch. Turn right, at light, onto Rt. 28 (Easton Tpke). Large paved parking area, on left, just over bridge over river.
	Raritan River N/B	Bridgewater / Branchburg	North Branch Park	Rt. 22, in North Branch, to Milltown Rd., bear right under narrow railroad bridge. Turn right into North Branch Park.
	Raritan River N/B	Hillsborough	Old York Road	Rt. 202, just South of Milltown, turn onto Old York Rd (Rt. 567). Bear right at intersection. Pull of at bridge.
	Rock Brook	Montgomery	Camp Meeting Rd.	Rt.206 to Georgetown - Franklin Turnpike(W) to Hollow Rd. to Camp Meeting Rd. - access at municipal playground - gravel parking lot
	Spooky Brook Park Pond	Franklin	Spooky Brook Park	Rt. 287 exit 12, to West Canal Rd. (towards Manville), make left before canal bridge onto Weston Rd., make right onto Metlers Lane. Park entrance is approx. 1/4 mile on left. second pond - parking lots.
Somerset / Morris	Passaic River	Basking Ridge / Millington	River Road	Rt. 78 exit 36, King George Rd. (N) to Valley Rd. to River Rd. pull over approx. 200 yds. downstream of Haas Rd. bridge. roadside parking.
Sussex	Alms House Pond	Hampton	Alms House Pond	Rt. 519 N, in Newton, (off Rts. 206./.94), to Rt. 655 North. Pond is

			located 1/4 mile, next to library, on right.
Andover Jct. Brook	Andover	A & P shopping center	junction of Rt's 206 & 517 - behind shopping center
Big Flat Brook	Montague	Stokes State Forest - Crigger Rd. Bridge	Rt. 206 (Culver's Gap) to Sunrise Mountain Rd..(one way road) to Crigger Rd. bridge; or take Flatbrookville Rd. North off Rt. 206, to Grau Rd., right onto Crigger Rd., parking lot before bridge (do not go further -rd is one way from opposite direction).
Big Flat Brook	Sandyston	Stokes State Forest - Lk. Ocquittunk Campground	Rt. 206, to Flatbrook Rd.(N. of entrance to Stokes State Forest) to Campground.
Big Flat Brook	Sandyston	Stokes State Forest - Flatbrookville Rd.	Pull-offs and parking lots located off Flatbrookville Rd., between Rt. 206 and Lake Ocquittunk Campground.
Big Flat Brook	Sandyston	Rt. 206 bridge	Rt. 206 bridge - Hainesville. Parking area by bridge. Upstream boundary of Fly Fishing Area.
Big Flat Brook	Sandyston	County Rt. 560 bridge (Schaffers bridge) & adjacent roads	Parking lot by bridge. Dirt/gravel roads upstream (un-named) and downstream (Brooks Rd.) of bridge parallel the stream have pull-offs. Fly Fishing Area.
Big Flat Brook	Sandyston	Flatbrook-Roy WMA - Three Bridges Parking Lot	From intersection at Peters Valley, take Walpack Rd. (Flatbrookville Rd.) south approx. 3/4 mile. At sharp bend in road, go straight onto a gravel road - 1/4 mile to river (or can take Brook Road off Rt. 560). HANDICAPPED ACCESS POINT - dirt parking lot. Blewitt Tract immediately upstream - Fly Fishing Area.
Big Flat Brook	Sandyston	Flatbrook-Roy WMA - parking lot at Roy Bridge	Rt. 206 (Tuttles Corner) to Rt. 560 to Ennis Rd. (Rt. 615) to Kuhn Rd. to Walpack Rd. - 1 1/2 miles south of Peters Valley off Walpack Rd (Rt. 615 / Flatbrookville Rd.). Dirt parking lot. Downstream boundary of Fly Fishing Area.
Big Flat Brook	Walpack Twp.	Main Street Bridge	Walpack Center - Main Street bridge off Rt. 615 (Flatbrookville Rd.). Pull-offs around bridge.
Big Flat Brook	Walpack	Walpack Valley Campground	Off Rt. 615 (Flatbrookville Rd.) - public angling allowed (parking fee may be charged).
Big Flat Brook	Walpack	Along Rt. 615, between Walpack & Flatbrookville Rd. bridge	Numerous pull-offs and parking lots along road, in Walpack WMA and Delaware Water Gap National Recreation Area.
Blue Mountain Lake	Walpack	Delaware Water Gap National Recreation Area	Rt 80, take last exit in NJ before bridge, (Old Mine Rd.). Take Old Mine Road through Millbrook Village (app. 11 miles) Continue north on Old Mine Rd., make right on Flatbrookville-Stillwater Rd.

			Proceed 1-2 miles, parking lot on left. Walk in access only
Clove Brook	Wantage	Rt. 23 -American Legion post	Rt. 23, North of Sussex Boro. Stream behind post.
Clove Brook	Wantage	Glenbrook Inn	Rt. 23, north of Sussex Boro.
Culver's Creek	Frankford	Rt. 206 Fish and Wildlife Access	Rt. 206, app. 1 mile North of Branchville, Fish and Wildlife parking area (sign) on left.
Dry Brook	Branchville	Branchville Boro Park	Rt. 206 to Kemah Lake Rd., right on Main St., left on Wantage Ave., right on Maple Ave., parking in park.
Franklin Pond Creek	Hardyston (Beaver Lake)	Hamburg Mt. WMA	Rt. 23 to Hamburg Mt. Wildlife Management Area - parking lot at bridge crossing.
Glenwood Brook	Vernon	Glenwood Mountain Road	Rt. 23 to Rt. 565 North (Glenwood Rd.) Left on Glenwood Mountain Road. Pull-off on grass.
Lake Aeroflex	Andover Boro	Kittatiny Valley State Park	Rt. 206, in Andover Boro, to Rt. 669 (Limecrest Road), Kittatiny Valley State park entrance at southern end of lake. Boat ramp and ample parking within park. - HOLDOVER TROUT LAKE; landlocked salmon
Lake Ocquittunk	Sandyston	Stokes State Forest	Rt. 206, to Flatbrook Rd. (N. of entrance to Stokes State Forest) to Campground.
Little Flat Brook	Sandyston	Flatbrook - Roy WMA	Rt. 206 (Tuttles Corner) to Rt. 560 to Ennis Rd.(Rt. 615), parking lot at Flatbrook - Roy WMA.
Little Swartswood Lake	Hampton	Little Swartswood Lake	Rt. 519, in Newton (off Rts. 206 / 94), to Rt. 622 West. Entrance to boat ramp and parking area app. 4.5 miles on right.
Lubber's Run	Byram	Heminover / Carpenter Road	Rt. 206, North of Stanhope, to Lackawanna Road (Rt. 607). Make right onto Heminover/Carpenter Rd. to bridge. Street parking.
Lubber's Run	Byram	Byram Municipal Park-Mansfield Drive	Rt. 206, north of Stanhope, to Lake Lackawanna Rd (Rt. 607). Make right onto Manfield Drive to Neil Gylling park by bridge.
Lubber's Run	Byram	Stoney Brook Road	Rt. 206, just north of Stanhope, to Brookwood Road. Turn on Stoney Brook Rd., take to end. Street parking
Lubber's Run	Byram	Rt. 206 Bridge	Rt. 206, just north of Stanhope. Parking on side roads.
Lubber's Run	Byram	Waterloo Road Bridge	Rt. 206, Stanhope area, to Waterloo Rd (Rt. 604 S) to bridge over creek, app.1 mile. Parking on shoulder.
Neldon Brook	Hampton	Rt. 622 Bridge	Rt. 519, in Newton, (off Rts. 206 / 94) to Rt. 622 West. Pass entrance to Little Swartswood Lake to bridge.
Papakating Creek	Frankford and Wantage	Rt. 565 Bridge	Rt. 565 bridge and old railroad bridge with yellow gate. Dirt pull-off for parking.
Papakating Creek W/B	Wantage	Rt. 565 Bridge	Rt. 565 Bridge (McCoy's Corner). Large dirt lot.

Paulins Kill River- East Branch	Sparta	Limecrest Rd. Bridge (Rt. 648)	Rt. 206 to Limecrest Rd.(Rt. 669), for approx. 6 m. to Rt. 648 to bridge, pull-off parking.
Paulins Kill River- East Branch	Lafayette	Garrison Rd.	Rt. 94 to Rt. 616 to Rt. 663 for approx. 3 m. to Garrison Rd. to bridge, pull-off parking.
Paulins Kill River	Frankford	DFW property at Augusta Hill Rd. bridge	From intersection of Rt. 15 and Rt.206 - Rt. 206 W to Augusta Hill Rd. to bridge, pull-off parking.
Paulins Kill River	Stillwater	Rt. 610 pull-off above bridge	Rt. 521(Stillwater Rd.) to CR. 610 (Main Fredon Rd.) to bridge, pull-off parking.
Pond Brook	Stillwater	below dam at Swartzwood Lake	West Shore Dr.(Rt.521) - parking at Mill Pond below dam at Swartzwood Lake
Saw Mill Pond	Montague	High Point State Park	Rt. 23, midway between Colesville and Port Jervis, High Point State park area, turn onto Sawmill Road 2 miles to lake on left. Car top launch.
Silver Lake	Hardyston	Hamburg Mountain WMA	Rt. 23, midway between Franklin and Stockholm, take Silver Grove Rd. to Silver Lake Rd. Parking lot, and car top launch by dam.
Stony Lake	Sandyston	Stokes State Forest	Rt. 206, several miles north in Branchville to state park entrance at Coursen Rd. Follow signs to Stony Lake - app. 2 miles.
Swartswood Lake	Swartswood	State Park	Rt. 622 West to Rt. 619 South to park entrance. Boat livery and parking.
Swartswood Lake	Swartswood	Boat Ramp	Rt. 619 South, past State Park entrance, app. 1/2 mile on right. Sign marks parking area for boat ramp.
Swartswood Lake	Hampton	Rt. 619 Hendershot's Point	Rt. 619, App. 1 mile south of boat ramp entrance, parking lot on right.
Swartswood Lake	Hampton	South End of Lake - Mill Pond and House	Rt. 521 (West Shore Drive). Parking Lot.
Swartswood Lake	Hampton	Rt. 524- Cartop Launch Area	App. 1/4 mile north on Rt. 521, from Mill Pond, parking area and cartop launch on right.
Swartswood Lake	Hampton	Rt. 521 - Pull Off	Rt. 521, dirt pull off, app. 1 mile north from car top launch where lake comes close to road.. - HOLDOVER TROUT LAKE
Trout Brook (Middlebrook)	Stillwater	farm pasture & culvert	Rt.521 & Rt.612 - roadside parking
Wallkill River	Sparta	Station Park	Rt. 15 to exit for CR..517.(N) to Station Rd. to Park. Multiple parking lots in park.
Wallkill River	Hamburg	Rt.94 - bridge & Park	Rt. 94 N. towards Hamburg, make left at first road across bridge, parking lot.
Wawayanda Creek	Vernon	Prices Switch Road Bridge	Rt. 94 to Rt. 515 (Prices Switch Rd.) to bridge. - pull-off parking.
Wawayanda Creek	Vernon	Canal Road Bridge	Rt. 94 to Maple Grange Rd. to Canal Rd. to bridge.
Wawayanda Lake	Vernon	Wawayanda State Park	Take Route 23 north to Union Valley Road. Follow Union Valley Road about 6 miles to stop sign. From stop sign, go to

				second traffic light. Turn left, travel to fork in road (about 2 miles) go left about 1/2 mile to Warwick Turnpike. Turn left. The park entrance is four miles on the left. HOLDOVER TROUT LAKE & landlocked salmon.
Union	Green Brook	Watchung Boro	New Providence Rd.	Rt. 22 to New Providence Rd., many pull-offs along road, parking lot available at Seely's Pond.
	Green Brook	Watchung	New Providence Rd.	Rt. 78 E to Berkley Heights exit 41. Make left at intersection. Cross over highway. At light, turn right on Plainfield Ave. At light cross over Valley Rd. onto Bonnie Burn Rd. At light, make left on New Providence Rd. Pass quarry - 2 pull off areas.
	Lower Echo Park Pond	Mountainside	Echo Lake Park - Lower	Rt. 22 (Springfield Ave) in Mountainside. Park entrance on right.
	Milton Lake	Rahway	Milton Lake	Rt. 275 for approx. 1 mile, turn right on Maple Ave. Cross Madison onto Midwood Drive.
	Nomahegan Park Pond	Cranford	Nomahegan Park	From Route 22 take S. Springfield Ave./CR-577. Keep straight onto Springfield Ave./CR-509. Keep right to stay on Springfield Ave./CR-615. Arrive at Union County's Nomahegan Park on left.
	Rahway River	Springfield	Springfield Park	Rt. 78 W to exit 49A (Springfield Ave), make a left at light onto Morris Ave. Turn left into Springfield Park. - parking lot.
	Rahway River	Clark	Nomahegan Park	Rt. 22 to Springfield Ave.(S) [CR. 509 spur], bear right at intersection to stay on Springfield Ave. Make left on Park Dr., just past park entrance, parking on Park Dr.
	Rahway River	Cranford	Riverside Dr.	Rt. 22 to Springfield Ave.(S) [CR. 509 spur]. bear right at intersection to stay on Springfield Ave., turn left on Normandie PL., then left on Riverside Dr. - street parking.
	Rahway River	Cranford	Droescher's Mill	Rt. 28 to Centennial Ave., quick right on Lincoln Park East. Access behind mill at end of Lincoln Park East. - street parking.
	Rahway River	Cranford	Crane Parkway footbridge	Rt. 28 to Centennial Ave., cross R.R. tracks, make right on Hillside Ave., to Crane Pkwy. - street parking.
	Rahway River	Clark	Rahway River Park	Garden State Parkway exit 136, go south on Stiles St., make right onto Valley Rd., Park entrance approx. 1/4 mile on right & left. Union Co. Pkwy / Parkway Dr. parallels river. - parking lots & street parking.
	Rahway River - West Branch	Millburn	Below Campbell's Pond to the Glen Avenue bridge	From Interstate 78E, merge onto Route 124/Springfield Avenue via the Route 82/Route 124W exit 49A to Springfield/Union. Turn right at Main Street. Turn right on Brookside

				Drive/Paper Mill Way. The West Branch of the Rahway River will be on your left as you drive north on Brookside Drive.
	Seeleys Pond	Scotch Plains	Seeleys Pond	Rt. 78 exit 41. Make left at intersection, cross over highway. At light turn right on Plainfield Ave. At light cross over Valley Rd. onto Bonnie Burn. At light make left on New Providence Rd. Pond located approx. 3/4 mile on right. Dirt pull off at dam.
	Warinanco Park Pond	Roselle	Warinanco Park	Rt. 27 (St. Georges Ave.) - park entrance on left between Thompton Ave., and Watson Ave.
Warren	Beaver Brook (Warren)	Hope	Lake Just-it Rd. Bridge	Rt. 519 to Lake Just-It Rd, first bridge. (state property near church property) - parking.
	Blair Creek	Hardwick	Below Stone Bridge	Rt. 94 in Marksboro to Spring Valley Rd. Right on Slabtown Creek Rd. for approx. 1 mile. Roadside parking.
	Blair Creek	Hardwick	Slabtown Creek Rd.	Rt.94 to Millbrook Rd.(Rt.602) to Tannery Rd. to Slabtown Creek Rd.(S) - roadside parking
	Blair Creek	Blairstown	Millbrook Rd. Bridge	Rt.94 to Millbrook Rd.(Rt.602) - pull-off parking
	Blair Lake	Blairstown	Blair Lake	Rt. 94 to Main St., bear left onto Blair Place before Millbrook Rd. Small pull-offs along Millbrook Rd. adjacent to lake.
	Brookaloo Swamp	Hope	Wooden Bridge on Kostenbader Road	Rt. 46 in Bridgeville to Rt.519 (Bridgeville Rd.). Left on Kostenbader Rd. Roadside parking.
	Buckhorn Creek	Harmony	Reeder Rd.	Rt.519 to Reeder Rd. - roadside parking
	Buckhorn Creek	Harmony	Reeder Rd. Bridge	Rt. 519 to Reeder Rd. Dirt pull-off parking around bridge.
	Columbia Lake	Knowlton	Columbia Lake - WMA	I- 80 to Rt. 94 North. Stay straight and merge onto Warrington Rd. Right onto Columbia Lake Rd. Pull-off available along Columia Lake Rd., and parking lot at the end of road.
	Furnace Brook	Oxford	Across from Oxford Elementary School.	Rt.31 to Kent St. to Church St. to Elementary School. - parking in lot after hours.
	Furnace Brook	Oxford	Ball Field behind Oxford Post Office	Rt. 31 in Oxford. Parking behind post office at ball field.
	Furnace Brook	Oxford	Across from Oxford Elementary School	Rt. 31 in Oxford to Kent Street. Parking lot across from school.
	Furnace Lake	Oxford	Furnace Lake Park	Rt. 31 in Oxford to Kent St., left on Washington Ave., bear right onto Jonestown Rd. Right onto Kauffman Dr. Parking area and boat launch at end of Kauffman Dr.
	Jacksonburg Creek	Blairstown	Jacksonburg Rd. Bridge	Rt. 94 to Jacksonburg Rd. Parking near bridge.

Jacksonburg Creek	Blairstown	Jacksonburg Rd.	Rt. 94 West of Blairstown to Jacksonburg Rd. Roadside parking near bridge.
Jacksonburg Creek	Blairstown	Rt.94 Bridge	Rt.94 - parking nearby
Lopatcong Creek	Lopatcong Township	Rt. 519 Bridge	From Rt. 519 bridge (north of Rt. 22) to Rt. 57 bridge pull-offs near county-owned property.
Lopatcong Creek	Phillipsburg	Lock St.	Rt. 22 to CR. 519 (St. James Ave., changes to S. Main St.) to Lock St. (before R.R. trestle), many pull-offs along Lock St. and a parking lot at Lock & Chestnut.
Merrill Creek Reservoir	Stewartsville	Merrill Creek Reservoir	Rt. 57 in (Stewartsville) to Montana Rd. Follow Montana Rd. to Richline Rd, make left then another left onto Merrill Creek Rd. Parking at end of Merrill Creek Rd.
Mountain Lake	Liberty Twp.	Lakeside Dr. West	Take Rt. 46 West from Rt. 31 intersection. Turn right onto Green Pond Rd./CR-617. Turn right on Mountain Lake Rd./CR-617- becomes Lakeside Dr. West. Arrive at lake on right.
Musconetcong River	Hackettstown	Stephens State Park	Rt. 46 to Willow Grove Rd.(CR. 604), in Hackettstown, changes to Waterloo Rd., to Stephens State Park, parking lot.
Musconetcong River	Hackettstown	Alumni Field	Rt. 46 to Willow Grove Rd.(CR. 604), in Hackettstown, to Alumni Field; gravel parking lot.
Musconetcong River	Beattystown (Washington Twp.)	"The Billboards"	Rt. 46 to 57 S. to former site of two billboards; dirt road on right side of hedgerow across from Hazen Rd. (Watters Rd.), down dirt road; parking near river.
Paulins Kill River	Blairstown/ Hardwick	Paulins Kill Rd. pull-off and E.Crisman Rd. Bridge	From Blairstown, Rt. 94 N to E. Crisman Rd. to Paulins Kill Rd., pull-off parking.
Paulins Kill River	Blairstown	Lambert Rd. Bridge.	From Blairstown, Rt. 94 S to Lambert Rd. to bridge. Parking along DPW driveway on south side of bridge.
Pequest River	Belvidere	Orchard St. Bridge	Rt. 46 to Water St.(CR. 620) to Orchard St. to bridge, pull-off parking.
Pequest River	White	Rt. 46 - Fish & Wildlife access	Across from Luigi's Rest., just east of Belvidere on Rt. 46. - dirt lot.
Pequest River	White	S. Bridgeville (Rt. 519) Bridge	Rt. 31 to Rt. 46 W to Rt. 519 South to concrete bridge. Fish and Wildlife dirt parking lot.
Pequest River	Oxford	Rt.46 - Fish and Wildlife access	Rt. 46, just east of intersection with Rt. 31 - dirt lot.
Pequest River	White	Pull-off just downstream of Pequest Furnace Rd.	Rt. 31 to Rt. 46 E to first pull-off downstream of Pequest Furnace Rd.
Pequest River	White	Pequest Furnace Rd. Bridge	Rt. 31 to Rt. 46 E to Pequest Furnace Rd. Bridge.
Pequest River	Liberty	Pequest Trout Hatchery	Rt. 31 to Rt. 46 E, approx. 4 m. to Pequest Trout Hatchery, paved parking

				lot - SEASONAL TROUT CONSERVATION AREA.
	Pohatcong Creek	Washington	Arboretum	Rt. 31 to Jackson Valley Rd. (E) to Mine Hill Rd. (N) to Arboretum on right. Gravel parking lot.
	Pohatcong Creek	Greenwich	Ravine Rd.	Rt. 78 to Rt. 173 W at exits 6/7 to Ravine Rd. Many pull-offs along Ravine Rd.
	Pohatcong Creek	Pohatcong	Creek Rd.	Rts. 78 / 22 (exit 7) to Rt. 173 W. to Warren Glen - Bloomsbury Rd.(CR. 639) to CR. 519 N. to Creek Rd., many pull-offs along Creek Rd.
	Pophandusing Creek	Belvidere	7th St. - Alumitek	Rt.519 to Rt.623(Brass Castle Rd.) to 5th St. to Hardwick St.(S) to 7th St. - Alumitek parking lot
	Pophandusing Creek	Belvidere Town	7th Street	Rt. 46 to Water St. (White Twp.). Left on Hardwick St. to 7th St. Parking lot on 7th St.
	Trout Brook	Hackettstown	Baldwin Street	Rt. 46 (Main St.) in Hackettstown to Baldwin St. Trout Brook bridge is at the intersection of Baldwin and 1st St. Street parking.
	Trout Brook (Hacketts.)	Hackettstown	First Street & Baldwin Street	Rt.46 to Baldwin Street - street parking
	White Lake	Hardwick	Stillwater Road	Rt. 94 in Blairstown to Stillwater Rd. North for approx. 3 miles, entrance to White Lake on right. Large parking lot. - HOLDOVER TROUT LAKE
Warren / Hunterdon	Musconetcong River	Penwell (Mansfield Twp.)	Penwell Rd. Bridge	Rt. 31 to Rt. 57 N. to Penwell Rd., off street parking. - YEAR ROUND TROUT CONSERVATION AREA (upstream boundry)
	Musconetcong River	Mansfield / Lebanon	Point Mt. Rd. Bridge	Rt. 31 to Rt. 57 N. to Point Mt. Rd.(Rt. 629) to bridge, small parking lot on Hunterdon County side. - YEAR ROUND TROUT CONSERVATION AREA (downstream boundry)
	Musconetcong River	Washington / Lebanon	Butler Park Rd. Bridge	Rt. 31 to Rt. 57 N. to Butler Park Rd. to bridge., parking on Hunterdon Co. side (Mowder Rd.)
	Musconetcong River	Washington / Lebanon	Changewater Rd. Bridge	Rt. 31 to Rt. 57 N. to Changewater Rd. (Rt. 645) to bridge, pull-off parking.
	Musconetcong River	Franklin	Main St. Bridge (Asbury)	Rt. 31 to W. Asbury Anderson Rd. (Rt. 632) to Main St. (Asbury), south to bridge, roadside parking
Warren / Morris	Musconetcong River	Allamuchy	Allamuchy State Park	Rt. 80 (exit 25) to Rt. 206 (N/W) to Waterloo Rd. (CR. 604), parking lot of former restaurant.
	Musconetcong River	Allamuchy	Saxton Falls	Rt. 46 to Willow Grove Rd. (CR. 604), in Hackettstown, changes to Waterloo Rd., go past Steven State Park, large parking lot at Saxton Falls.
	Musconetcong River	Hackettstown	Fish & Wildlife access - Rt. 57	Rt. 46 to Rt. 57 to access just past Dairy Queen, (marked with sign) Fish and Wildlife dirt lot.
	Musconetcong River	Stephensburg (Washington Twp.)	Old Turnpike Rd	

				Rt. 46 to Rt. 57 to Cement slab parking lot at Old Turnpike Rd. or Stephensburg Rd. bridge.

Department of Environmental Protection
P. O. Box 402
Trenton, NJ 08625-0402

Last Updated: March 2, 2015

Hackensack River too dirty to host oysters

JULY 2, 2011 LAST UPDATED: SATURDAY, JULY 2, 2011, 9:53 AM
BY JAMES M. O'NEILL
STAFF WRITER |
THE RECORD

Print

The Hackensack River is still so heavily polluted that oysters placed in the water to help filter out contamination have either died or become deformed.

Test oysters introduced into the Hackensack River to help filter out contamination have either died outright or grown malformed, tumor-laden tissue and unusually thin shells.

Test oyster beds that scientists placed in the river have been growing malformed tissue embedded with tumors, as well as unusually thin shells, said Beth Ravit, a Rutgers University professor who has been studying the oysters. Some had died out completely.

In addition, while year-old oysters generally are male and then change gender to female, none of the Hackensack test oysters have been able to switch genders, Ravit said.

"It seems the Hackensack system is not yet ready for oyster restoration," said Ravit, who has been running the oyster project for nearly five years. "The waters are getting cleaner, but they are in no way clean enough."

Officials and scientists had been hoping to reintroduce the once ubiquitous oyster to the river as a natural way to help clean polluted waters. Oysters can be used to filter pollution because they distinguish between food and other particles flowing through their gills, combining the inedible particles — such as pollutants — with a mucus-like substance to form pellets that drop to the sea floor.

The oysters can therefore filter pollutants out of the water, which then allows more sunlight through. That, in turn, fosters growth of sea grasses, improving fish habitat.

Oyster offspring also attach to the shells of the adults, building vertical reefs that reduce shoreline erosion and serve as a place for fish to live and hide from predators.

The Hudson River Foundation, NY/NJ Baykeeper, and state and federal agencies plan to create 500 acres of new oyster reefs in the New York Harbor estuary by 2012, and 5,000 acres by 2050. The coalition built the first of six reefs in the harbor area in October off of Governors Island, and plan to add more off Staten Island, in Jamaica Bay, in the Bay Ridge Flats and elsewhere.

Learning experience

The disappointing results for the Hackensack River oysters have not discouraged Ravit.

"Knowing more about what works and where in the estuary will contribute to our ability to pick sites for oyster reefs that will be successful, instead of investing a lot of resources and time to sites that won't work," Ravit said.

The oysters were placed at various locations in the Hackensack, including sites near Lyndhurst, Secaucus and Jersey City.

Juvenile oysters purchased from the same source were deposited in both the Hackensack and in Raritan Bay in 2009. While the Raritan oysters appeared to be growing healthy shells and tissue, many of the Hackensack oysters died outright — including all the oysters at a site near the New Jersey Turnpike in Lyndhurst. The survivors at other sites developed abnormal gill, digestive and reproductive tissue, as well as tumors and thin shells.

To determine the cause, Ravit analyzed the level of heavy metals in tissue samples from both locations, but that did not appear to be the cause. She said volatile organic pollution in the sediment of the Hackensack could be disrupting the oysters' endocrine systems.

One of the locations of the Hackensack test oysters is at a bend in the river lined by an old landfill and heavily polluted former industrial sites. Pollution migrating from those sites could have bonded to the river sediment, and as the oysters filter it through their systems, it acts to disrupt their development, Ravit said.

The contaminated sites include Standard Chlorine in Kearny, a former mothball factory and now a federal Superfund site contaminated with PCBs, chromium, dioxins, dichlorobenzenes, naphthalene, benzene and volatile organic compounds. Sampling conducted between 1992 and 2002 indicated that some of the on-site pollution was released into the Hackensack, according to the federal Environmental Protection Agency.

Danger to humans

PCBs and dioxins stick to river bottom sediments and get taken up by shellfish, according to the U.S. Department of Health and Human Services. In humans, PCBs and dioxins can cause skin rashes and liver damage; in animals, PCBs can cause liver, stomach and thyroid injuries, and dioxins can disrupt the endocrine system, weaken the immune system and cause reproductive damage. PCBs and dioxins are considered likely human carcinogens.

The industrial sites are currently getting cleaned up, but the cleanup does not extend to the river sediment, aside from a 50-foot reach out from the shoreline bulkhead, said Hackensack Riverkeeper Bill Sheehan. He said parties responsible for cleaning up the Standard Chlorine and adjacent sites conducted a river study as part of their remedial plan, and core samples are being studied.

"We're looking at the data carefully," Sheehan said.

Ravit said the oxygen and salinity levels of the Hackensack indicate it might support oysters, and she has spotted small wild oysters growing naturally along the river. She would like to sample the wild oysters and conduct tissue analysis to see if they are being affected in the same way as her test oysters.

If the wild oysters are healthy, it could indicate they have adapted successfully to the conditions in the river and could be bred as stock for reef restoration.

"It would be terrific to be able to use wild oysters to rebuild the oyster reefs in the estuary," Ravit said.

E-mail: oneillj@northjersey.com

Tags:
News | **Environment** | **NJ State News** | **Lyndhurst** | **North Arlington** | **Secaucus** | **Bergen County, N.J.** | **Hudson County, N.J.** |

Hackensack RIVERKEEPER®
HackensackRiverkeeper.org

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February 10, 2015

RE: Petition for Preliminary Assessment for the Hackensack River

Dear Mr. Pedersen:

In October of 2013, we met with DEP staff to discuss ways to address toxic pollution in the sediment of the Hackensack River. We had previously met with EPA staff on the same issue, and had subsequent, less formal discussions on the matter with both the Department and the Agency. We left our meeting with DEP believing that our organizations, the Department, and the Agency all shared the common goal of addressing toxic sediments in the River, and we continue to believe that all parties ultimately agree that the Hackensack River ought to be listed to the National Priorities List.

As a result of that meeting, we conclude that DEP favors one method to achieve the listing, while EPA favors another. We understand DEP favors expanding the jurisdiction of existing NPL sites on the river to as far as science justifies. Presumably, the contamination in the river is significant enough to warrant listing from at least the mouth of the river to the Oradell Dam. EPA, on the other hand, believes that the river should be listed on its own merits, and should be treated as its own site, rather than as an expansion of the Standard Chlorine or Berry's Creek sites. If our understanding of either the Department or the Agency's positions is incorrect, we would like to have remedied our misunderstanding at a joint meeting.

Because Hackensack Riverkeeper believes both of these approaches have merit, our intention was to arrange a meeting with representatives of both the Department and the Agency to see if we could settle these minor differences and move forward. Despite our efforts, we were unable to get all of the parties together for a meeting at any time during the past year.

Consequently, we feel it best to proceed independently. 40 CFR § 300.420(5) allows that "Any person may petition the lead federal agency ... to perform a (Preliminary Assessment) of a release when such person is, or may be, affected by a release of a hazardous substance, pollutant, or contaminant." Hackensack Riverkeeper has filed a petition with EPA Region 2 to perform a Preliminary Assessment on the Hackensack River, I attach a copy of that petition to this letter.

I hope that the information generated by the Preliminary Assessment will help inform how and to what extent the river should be added to the National Priorities List. I regret that we were unable to bridge the divide between DEP and EPA before taking this step, but I hope that we can work together more productively in the future.

Sincerely,

Bill Sheehan

Hackensack Riverkeeper

HackensackRiverkeeper.org

Captain Bill Sheehan
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Hackensack Riverkeeper Inc.
231 Main Street
Hackensack, NJ 07601

Judith Enck
Regional Administrator
Environmental Protection Agency Region 2
290 Broadway
New York, NY 10007-4575

February 10, 2015

RE: Petition for Preliminary Assessment for Hackensack River

Dear Ms. Enck:

On behalf of Hackensack Riverkeeper, Inc., I petition that the Environmental Protection Agency perform a Preliminary Assessment of the Hackensack River for future inclusion on its National Priorities Listing under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. § 103 *et seq.* Consequently, the Agency should begin a Remedial Preliminary Assessment as soon as possible pursuant to 40 C.F.R. § 300.420(a)(5). The toxic pollutants contained within the river and its sediments continually affect the Hackensack River watershed, its wildlife and the humans who live in or visit the watershed. These effects will continue until your office adds the river to the National Priorities List and oversees the removal of its toxic pollutants.

Hackensack Riverkeeper has standing to bring this petition. I Founded Hackensack Riverkeeper in 1997 and since that time my business has served as an advocate for the river and its watershed. My staff and I work every day to preserve, protect, and restore the river. Hackensack Riverkeeper is the environmental advocate for the Hackensack River. We also provide the adjoining communities with educational opportunities, conservation programs, and water-based activities. Through our work, we see firsthand how the river we oversee is negatively affected by toxic pollution. We operate two paddling concessions on the river and offer eco-cruises throughout the warm weather months; I firmly believe my business opportunities are limited by the presence of toxic contaminants in the river and the general perception of the river as unsafe for recreation.

The toxic pollutants within the river's waters and sediment cripple Hackensack Riverkeeper's ability to restore the and our water-based businesses. Throughout the warm months, we offer Eco-Cruises, kayak and canoe rentals, and guided paddles. Toxic pollution in the river limits the number of people willing to venture onto the water for fear of contact with harmful pollutants. The paddlers and cruisers who do venture onto the water are unable to thoroughly enjoy the experience because the high levels of contamination in the river mean they can't eat the fish they catch or see the full biodiversity a healthy ecosystem would offer.

Toxicity of the sediment negatively affects our conservation efforts and makes it impossible to fully restore the river. It is more difficult, for example, to restore a tract in the Meadowlands because of legitimate fears that disturbing sediment will increase toxic pollution in the water column.

We are aware of existing Superfund sites along the river, but I am certain that the effects from these sites extend far beyond the boundaries EPA has drawn in its remedial actions. Berry's Creek, for example, has numerous NPL sites and is one of the most Mercury contaminated waterbodies in the world. There is no reason to think that mercury from these sites has not entered the mainstem of the river. Likewise, the former industrial sites on the lower produced a number of organic chlorides, polycyclic aromatic hydrocarbons, heavy metals and petroleum products.

These pollutants contaminated the properties extensively, and there is no reason to think that contamination did not enter the river.

The Hackensack, like the Passaic, is a tidal river. River currents do not control its water and sediment; rather tidal action sloshes them back and forth. My extensive experience on the river leads me to believe that the tides transport pollutants up and down from their sources, but generally do not wash the contaminants out to sea. Thus, I believe pollutants from these sites and innumerable others are still in the river sediments and will indefinitely remain unless the Agency acts.

But unlike the Passaic, there is no dominant polluter responsible for the majority of the toxic contamination. Therefore, it makes no sense to me to expand the jurisdiction of an existing Superfund site throughout the river. We request that the Agency list the entire river to the NPL. No other remedy is likely to result in the fishable and swimmable Hackensack that my organization demands and New Jerseyans deserve. A Preliminary Assessment of the Hackensack River is the crucial first step toward reaching a solution.

Petition:

This petition is sufficient to require you to initiate a Preliminary Assessment under the terms of 40 C.F.R. § 300.420. 40 C.F.R. § 300.420(5) allows "any person (to) petition (EPA) to preform a Preliminary Assessment of a release when such person is, or may be, affected by a release of a hazardous substance, pollutant or contaminant."

40 C.F.R. § 300.420(5)(i) requires petitioners to sign the petition and to contain:

(A) The full name, address and phone number of the petitioner

Captain Bill Sheehan
Riverkeeper and Executive Director
Hackensack Riverkeeper, Inc.
231 Main Street
Hackensack, NJ 07601

(B) A description, as precisely as possible, of the location of the release

The Hackensack River, below the Oradell Dam, has been subject to innumerable discharges of numerous toxic chemicals. These include: Federally listed Superfund sites including Pierson's Creek, PJP Landfill, Standard Chlorine, Scientific Chemical Processing, Universal Oil Products and Ventron Velsicol; leachate from the abandoned Malanka Landfill in Secaucus and other abandoned landfills in the region; and various contaminants from the hundreds of New Jersey Department of Environmental Protection known contaminated sites within the watershed.

(C) How the petitioner is or may be affected by the release

As stated above, Hackensack Riverkeeper operates a business on the river whose success is limited by contaminants in the river and the public perception of the river as contaminated. Further, as a non-profit organization, Hackensack Riverkeeper seeks to preserve, protect and restore the river. We cannot achieve this goal while the river's sediments are contaminated with toxic pollution.

40 C.F.R. § 300.420(5)(ii) petitions should also contain the following information to the extent available:

(A) What type of Substances were or may be released

The Hackensack is listed under New Jersey's Clean Water Act §303(d) list as being water quality limited for some or all of the following toxic contaminants: polychlorinated biphenyls (PCBs), Arsenic, Dichlorodiphenyldichloroethane (DDD), dichlorodiphenyltrichloroethane (DDT), Dichlorodiphenyldichloroethylene (DDE), Chlordane, Mercury, Dioxins, Dieldrin, Polycyclic Aromatic Hydrocarbons, Cyanide, Hexachlorobenzene, Ammonia, Lead, Cadmium, Chromium, Copper and Benzene. These contaminants as well as others are likely present in Hackensack River sediments.

(B) The nature of activities that have occurred where the release is located

The lower Hackensack River has been the site of many industrial activities – including waste disposal, chemical manufacture, energy production, and many others – for over 100 years. These activities in aggregate have lead to levels of many toxic pollutants in the sediment that threaten human health and the environment.

(C) Whether local and state authorities have been contacted about the release

My organization has met many times with state and federal regulators about these issues. We feel that all parties agree that some level of listing is appropriate, but that the New Jersey Department of Environmental Protection feels that it would be more appropriate to expand the jurisdiction of existing sites than it would be to simply list the river. For a variety of reasons, we feel that listing the entire river is the quickest and fairest way to address toxic pollution in the river.

Thank you for accepting this petition. Please contact me if you require any additional information or if my staff or I can contribute to the process in any way. The people of New Jersey have been denied the full use of their river for too long. We look forward to the day when the River is once again safe for all uses.

Sincerely,

Captain Bill Sheehan
Riverkeeper and Executive Director
Hackensack Riverkeeper, Inc.
231 Main Street
Hackensack, NJ 07601

cc. Mark Pedersen, NJDEP

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Using a Sediment Quality Triad Approach to Evaluate Benthic Toxicity in the Lower Hackensack River, New Jersey

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Abstract. A Sediment Quality Triad (SQT) study consisting of chemical characterization in sediment, sediment toxicity and bioaccumulation testing, and benthic community assessments was performed in the Lower Hackensack River, New Jersey. Chemistry data in sediment and porewater were evaluated based on the equilibrium partitioning approach and other published information to investigate the potential for chemical effects on benthic organisms and communities. Relationships were supported by laboratory toxicity and bioaccumulation experiments to characterize chemical effects and bioavailability. Benthic community results were evaluated using a regional, multimetric benthic index of biotic integrity and four heterogeneity indices. Evidence of slight benthic community impairment was observed in five of nine sediment sample stations. Severe lethal toxicity to amphipods (*Leptocheirus plumulosus*) occurred in four of these five stations. Although elevated total chromium concentrations in sediment (as high as 1900 mg/kg) were the rationale for conducting the investigation, toxicity was strongly associated with concentrations of polycyclic aromatic hydrocarbons (PAHs) rather than total chromium. PAH toxic units (ΣPAH TU) in sediment and ΣPAH concentrations in laboratory organisms from the bioaccumulation experiment showed a clear dose–response relationship with toxicity, with 0% survival observed in sediments in which ΣPAH TU > 1–2 and ΣPAH concentrations in *Macoma nasuta* were >2 μmol/g, lipid weight. Metals detected in sediment and porewater, with the possible exception of copper, did not correlate with either toxicity or levels in tissue, likely because acid-volatile sulfide levels exceeded concentrations of simultaneous extracted metals at all sample locations. The study reinforces the value of using multiple lines of evidence approaches such as the SQT and the importance of augmenting chemical and biological analyses with modeling and/or other approaches to evaluate chemical bioavailability and toxicity of sediments.

The Sediment Quality Triad (SQT) approach uses multiple lines of evidence based on the results of benthic community assessments, sediment toxicity, and sediment chemistry to evaluate the relationship between sediment-associated chemicals and biological community quality (Long and Chapman 1985; Chapman 1990; Chapman 1996; Borgmann *et al*. 2001; Hall *et al*. 2005). The combination of potential cause (chemistry) and effect (toxicology and ecology) measurements makes the SQT one of the most effective tools available to establish the extent and significance of pollution-induced degradation.

The Hackensack River, New Jersey is one of two large tributaries that flow into the northern portion of Newark Bay, which is commonly included as part of the larger New York/New Jersey Harbor Estuary. Sediments along the eastern shore of the river near the confluence with Newark Bay are known to contain chromium, which is attributable, in part, to a 0.14-km^2 former waterfront commercial property that was used for disposal of approximately 800,000 m^3 chromate ore processing residue (COPR) from 1905 to 1954. The property is located on Route 440 in Jersey City, New Jersey and designated as "Study Area 7" in the New Jersey Department of Environmental Protection (NJDEP) Hudson County Chromate Project. Sediment sampling conducted along the eastern shore of Droyer's Point Reach revealed the presence of elevated concentrations of total chromium (as high as 9190 mg/kg in surficial sediments), with approximately one fourth of the sediment samples containing total chromium above the effects range median sediment benchmark value of 370 mg/kg (Long *et al*. 1995).

In addition to total chromium, sediment sampling in Droyers Point Reach and adjacent coves along the eastern shore revealed the presence of a wide variety of other metals and organic chemicals. This is not unexpected because combined sewer outfalls (CSOs) and permitted industrial discharges

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continue to be a source of chemicals to the entire Newark Bay estuary and are recognized in the literature as significant ongoing sources of chemical contamination (Crawford *et al*. 1995; Shear *et al*. 1996; Huntley *et al*. 1997; Iannuzzi *et al*. 1997; Adams *et al*. 1998). The estuary is surrounded by one of the most heavily urbanized and industrial areas on the eastern U.S coast, and supports the third largest shipping port in North America. According to Crawford *et al*. (1995), CSOs and storm water runoff may contribute as much as 40% of the total annual metals load to Newark Bay. Connell (1982) estimated that storm water runoff contributes almost 40% of the annual load of total PAHs to the Hudson-Raritan Estuary. The history of urbanization and industrialization of the Passaic River and Newark Bay by Iannuzzi *et al*. (2002) provides considerable evidence of the long history of significant biological, chemical, and physical impacts due to anthropogenic activities for more than two centuries.

This paper presents the results of an SQT analysis conducted using sediments collected offshore in the vicinity of the waterfront property used for COPR disposal located along the eastern shore of Droyers Point Reach in the Lower Hackensack River. The purpose of the investigation was to characterize causal relationships between chemical stressors and local benthic communities. Multiple lines of evidence were evaluated in the SQT framework using co-located biological community surveys, laboratory sediment toxicity tests, and chemical information from analysis of surface sediments. The traditional SQT framework was augmented with lines of evidence that account for chemical bioavailability (Borgmann *et al*. 2001), including chemical analysis of benthic organisms exposed during laboratory bioaccumulation experiments and equilibrium partitioning (EqP) analyses of sediment chemistry data to characterize bioavailability of sediment-associated chemicals. Results also were compared to those reported by Becker *et al*. (2006), who investigated sediment toxicity at a similar COPR-affected site located approximately 7 km upstream of Study Area 7 in the Hackensack River. The information gleaned from this analysis represents an important line of evidence contributing to the evaluation of remediation strategies for sediments in the vicinity of the Study Area 7 site.

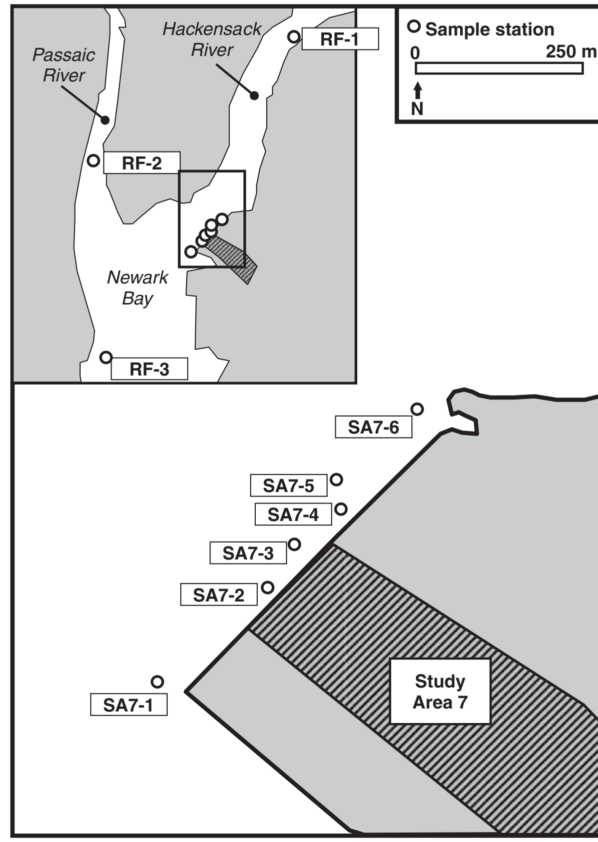

Fig. 1. Location of Study Area 7 (large map) and reference area sample stations (inset) in Upper Newark Bay, New Jersey

Methods

Field Collection of Sediment and Benthic Macroinvertebrates

Sediment and benthic invertebrate samples were collected from nine sample stations in November 2003 (Fig. 1), including six stations (SA7-1 through SA7-6) in the immediate vicinity of Study Area 7 and three reference stations (RF-1 through RF-3) located in comparable sediment environments not influenced by activities at the site. It should be noted that the selection of the locations for reference stations was based on similarity to Study Area 7, both in terms of benthic physical habitat and immediate nearby land uses, with the ultimate goal of characterizing baseline conditions of the local estuary. Reference stations in this study are not intended to represent pristine or ideal benthic habitats. Because Study Area 7 lies within the tidally influenced portion of the New York/New Jersey Estuary, and waters from Newark Bay, Passaic River, and Hackensack River are likely to influence the site, reference stations were selected both upstream and downstream of the site. Reference stations were located approximately 2 km south in Newark Bay, 1.5 km northwest in Passaic River, and 2.5 km north in Hackensack River and were offshore of areas with similar land uses (industrial) to Study Area 7. Because benthic communities are affected by depth and salinity in estuaries (Chapman and Wang 2001), sediment and benthic invertebrate samples were collected from similar depths (1.3–4.6 m) and interstitial water salinities (11–16 g/L).

Sediment was collected from the top 15 cm of sediment using a 0.1-m^2 Van Veen grab sampler. Subsamples of each grab were preserved in commercial laboratory–supplied glass sample containers and shipped at 4°C for chemical and physical analyses. Remaining sediment was placed in food-grade polypropylene bags, shipped at 4°C to a commercial laboratory, stored for 4–5 weeks, and sieved (2000-μm) to remove large debris before use in laboratory experiments. Epibenthic and infaunal invertebrates at each station were collected from three additional grabs, which were sieved (500-μm sieve) in the field to collect organisms. Organisms were preserved in a 10% (w/w) buffered formalin solution followed by a 70% (w/w) ethanol solution and identified by taxonomists to the lowest practical taxonomic level (typically genus or species) and enumerated. Invertebrates from the three grabs were pooled and weighed to determine total biomass on a wet weight (ww) basis, which was converted to a dry weight (dw) basis, assuming a moisture content of 75% (USEPA 1993c).

Sediment Chemical and Physical Analyses

Sediments were analyzed for chemical and physical parameters by certified analytical laboratories according to standard protocols (*e.g.*,

Table 1. Analytical methods used for chemical analyses of sediment, sediment porewater, and tissue.

Constituent[a]	Analysis Method	Sediment	Sediment Porewater	Tissue
Total Metals	USEPA 6010B; 7471 (Hg)	•	—	•
Dissolved Metals	USEPA E200.7; 6010 (Cr); C245.1 (Hg)	—	•	—
Hexavalent Chromium	USEPA 7199	•	—	—
AVS/SEM	Allen *et al.* (1993)/USEPA 6010B	•	—	—
Organotins	OR 560, NOAA Technical Memo 130	•	—	•
SVOCs	USEPA 8270C	•	—	•
Coplanar PCBs	USEPA 1668	•	—	•
PCB Homologues	USEPA 1668	•	—	—
PCDDs/PCDFs	USEPA 8290.	•	—	—
PBDEs	USEPA 1614	•	—	—
Pesticides	USEPA 8081	•	—	•
pH	USEPA 9045	•	—	—
TOC	ASTM D2579, modified	•	—	—
Ammonia	USEPA 350.1−350.2	•	•	—
Grain size	ASTM D422	•	—	—
Lipid content	NOAA (1998), modified	—	—	•

[a] AVS = acid volatile sulfide, SEM = simultaneously extracted metal, SVOC = semi-volatile organic compound, PCB = polychlorinated biphenyl, PCDD = polychlorinated dibenzo(*p*)dioxin, PCDF = polychlorinated dibenzofuran, PBDE = polybrominated diphenyl ether, TOC = total organic carbon

USEPA 2003a; Table 1). Sediment porewater was extracted by centrifugation (ASTM 2001) and analyzed for 24 total and dissolved metals (including total chromium). Chemical and physical testing of sediments and biota tissues was performed by Columbia Analytical Services (Rochester, NY) and Severn Trent Laboratories (Edison, NJ).

Laboratory Toxicity and Bioaccumulation Testing

The study design included four laboratory experiments with whole sediment: a 10-d survival experiment with amphipods (*Leptocheirus plumulosus*), a 28-d survival and growth experiment with polychaetes (*Neanthes arenaceodentata*), a 28-d survival and bioaccumulation experiment with clams (*Macoma nasuta*), and a 28-d survival and bioaccumulation experiment with polychaetes (*Nereis virens*). Experimental conditions (Table 2) were in accordance with standard procedures for toxicity and bioaccumulation experiments (USEPA and USACE 1991; USEPA 1993a; USACE 1998; USEPA and USACE 1998; ASTM 2003a, 2003b). Laboratory testing was conducted by MEC Analytical Laboratory Systems (Carlsbad, CA). Ancillary overlying water quality (temperature, salinity, O_2, pH, and ammonia) was monitored in all replicates at the initiation of exposure (Day 0) and daily in one replicate per treatment for the remainder of the experiments. All parameters were within acceptable ranges as specified in protocols, except for salinity, which exceeded acceptable ranges by approximately 5 g/L in the *N. arenaceodentata* toxicity test. Organism responses in this experiment showed no evidence of effects related to the higher salinity. Overlying water and sediment porewater ammonia concentrations were measured at the experiment initiation in all replicates and weekly in one replicate per treatment in *N. arenaceodentata* and *L. plumulosus* tests and were within acceptable ranges as specified in protocols. Sediments obtained from Booth Bay Harbor, MA (*N. arenaceodentata*, *L. plumulosus*, and *M. nasuta* experiments) and Discovery Bay, WA (*N. virens* experiment) were known to provide organisms with adequate substrate for survival and growth and served as control sediments.

Upon termination of each experiment, sediments were sieved to enable collection and enumeration of survivors. *N. arenaceodentata* survivors were rinsed, blotted dry, placed in a pre-weighed container, dried for 24 h, and weighed to 0.01 mg, dw. Growth during the experiment was calculated using final weights and average weight of 30 juvenile polychaetes measured at the initiation of the test. *M. nasuta* and *N. virens* survivors were placed in sediment-free containers for 24 h to allow organisms to purge gut contents. After gut purging, tissues were placed in clean glass jars with Teflon-lined lids, frozen, homogenized, and analyzed for 13 metals (including total chromium), 4 organotins, 21 pesticides, 12 polychlorinated biphenyls (PCBs), 16 polycyclic aromatic hydrocarbons (PAHs), and percent lipids (determined by hexane extraction) by a certified analytical laboratory (Severn Trent Laboratories–Burlington, Colchester, VT) according to standard protocols (NOAA 1998; USEPA 2003a; Table 1).

Data Analysis

All chemicals detected in at least one of the sediment or porewater samples were evaluated using a cause–effect approach to identify chemicals or chemical classes likely to contribute to toxicity in laboratory experiments. Aquatic toxicity data (USEPA 2002a, 2002b, 2003b, 2003c) were used to derive site-specific sediment quality benchmarks for most organic compounds and metals using the EqP approach (Di Toro *et al.* 1991; USEPA 1993b; Di Toro *et al.* 2000a, 2000b; USEPA 2003b, 2003c, 2005). Using USEPA (2003b) methodology, PAH mixtures in sediment were assessed using an additive model in which porewater concentrations of each PAH (estimated by EqP) were divided by its corresponding EqP benchmark to yield PAH toxic units (TU). Toxic units for each sample were summed to yield ΣPAH TU. A site-specific adjustment factor of 1.6 (i.e., ΣPAH TU × 1.6) was applied to estimate ΣPAH TU derived from alkylated PAHs, which were not analyzed as part of this study. The site-specific adjustment factor was estimated from the ratio of alkylated ΣPAH TU to unsubstituted ΣPAH TU in sediment collected from the same sample stations during July 2005. A modified EqP approach (Fuchsman 2003) was used to evaluate organic compounds with Log K_{OW} <3. Sediment toxicity test results from previously published laboratory and field studies and published EqP models were used to screen chlorinated benzenes (Fuchsman *et al.* 1999), phthalate esters (Call *et al.* 2001a, 2001b), dibenzofuran (Di Toro *et al.* 2000a), DDT and its metabolites (Swartz *et al*. 1994; Ferraro and Cole 1997), PCB mixtures (Fuchsman *et al.* 2006), dioxin (Barber *et al.* 1998), and tributyltin (Meador *et al.* 2002).

Table 2. Experimental design and conditions for toxicity and bioaccumulation experiments

Parameter	*L. plumulosus* survival	*N. arenaceodentata* survival and growth	*N. virens* survival and bioaccumulation	*M. nasuta* survival and bioaccumulation
Exposure media	2-cm sediment layer (~150 ml) plus 900 ml gently-aerated overlying water	1-cm sediment layer (~50 ml) plus 150 ml gently-aerated overlying water	4-cm sediment layer (~5 L) plus 10 L gently-aerated overlying water	5-cm sediment layer (~5 L) plus 10 L gently-aerated overlying water
Water renewal	None	Static renewal: 60% every 7 d	Flow through: 20.0–25.0 ml/min	Flow through: 21.4–25.0 ml/min
Test chamber	1-L glass jars	250-ml glass jars	22-L fiberglass trays	22-L fiberglass trays
Replicates/treatment	5	10	5	5
Organisms/replicate	20	1	10	25
Feeding	None	Slurry containing 2 mg fish food flakes and 1 mg alfalfa added every 3.5 d	None	None
Organism age	30 d	Juveniles	Adults	Adults
Test photoperiod (hours light:dark)	24:0	12:12	16:8	16:8
Method reference	USEPA and USACE 1998; ASTM 2003b	USACE 1998; ASTM 2003a	USEPA and USACE 1991; USEPA 1993a	USEPA and USACE 1991; USEPA 1993a

In addition to estimating standard heterogeneity indices (Shannon-Wiener [H'], Margalef Species Richness [SR], Pielou's Evenness [J'], and Swartz's Dominance Index [SDI; minimum number of taxa comprising 75% of abundance]), benthic community data were interpreted using a Benthic Invertebrate Index of Biotic Integrity (B-IBI) developed for the New York/New Jersey Estuary by USEPA (Adams *et al*. 1998). The B-IBI is a multimetric index based on the IBI originally developed by Karr (1981) to examine the ecological health of fish communities. Benthic community data from reference and Study Area 7 stations were expressed as five metrics (number of taxa, biomass, total abundance, abundance of pollution-indicative taxa, and abundance of pollution-sensitive taxa), each of which was scored according to the scoring scheme given in Adams *et al*. (1998). Classification of pollution-indicative and pollution-tolerant taxa were based on local criteria developed in USEPA Environmental Monitoring and Assessment Program for estuaries (Adams *et al*. 1998). Scores of 1 (impaired), 3 (slightly impaired), or 5 (unimpaired) were assigned to the five metrics at each sample station, based on deviation of the metric from values indicative of ecologically healthy reference sites (Adams *et al*. 1998). The five individual metric scores were averaged to calculate composite B-IBI scores, which were interpreted according to Adams *et al*. (1998): <2 indicated an impaired benthic community; ≥ 2 and <3 indicated a slightly impaired benthic community; and ≥ 3 indicated an unimpaired benthic community. Mean composite B-IBI scores and heterogeneity indices for the nine sample stations were compared statistically using Tukey-Kramer Honestly Significant Difference (HSD) ($\alpha = 0.05$).

Laboratory toxicological data generated during each of the four experiments were compared statistically using Tukey-Kramer HSD ($\alpha = 0.05$; Newman 1995), to compare results among all samples. Dunnett's test was used to confirm results of the Tukey-Kramer HSD specifically for comparisons to control results (Newman 1995). Prior to statistical tests, mortality data were arcsine square root transformed (Newman 1995), and *N. arenaceodentata* growth data were $\log_{10}$ transformed. Sediments were identified as toxic if mean responses were significantly less than mean control response. The results of these statistical tests are also compared to minimum significant difference criteria identified for survival endpoints (80% of control; Thursby *et al*. 1997) and *N. arenaceodentata* growth (44% of control; Phillips *et al.* 2001). Median lethal dose (LC_{50}) estimates were calculated via the Trimmed Spearman-Karber method (Hamilton *et al.* 1977) using ΣPAH TU as the measure of exposure. A dose–response relationship was confirmed using a nonlinear Gompertz model (Newman 1995). Relationships between toxicity and chemical concentrations were also explored using parametric and nonparametric correlation, partial correlation, and multiple regression analyses.

Results and Discussion

Benthic Community

Benthic community indices and B-IBI scoring for the reference and Study Area 7 sample stations were typical of the values observed in a 2003 Newark Bay study (Table 3; Adams *et al.* 1998). The high abundance of pollution-indicative species (*e.g.*, *Streblospio benedicti*, Oligochaetes, *Mulinia lateralis*, and *Polydora cornuta*) and low abundance of sensitive species (*e.g.*, *Acteocina canaliculata*, *Tellina* sp., Ampharetidae, and *Nephtys* sp.) indicated impairment at all reference and Study Area 7 stations. The number of taxa, total abundance, and total biomass of invertebrates indicated less evidence of impairment and were more variable among stations. Composite B-IBI scores (Table 3) suggested that benthic communities of two of the three reference stations (RF-1 and RF-2) were slightly impaired. Benthic communities at all Study Area 7 stations were scored as slightly impaired, except for stations SA7-1 and SA7-5, which were scored as unimpaired.

By comparison, several stations measured by Adams *et al.* (1998) were within approximately 1–2 km of Study Area 7 (in Passaic River, Hackensack River, and Upper Newark Bay), with composite B-IBI scores of 1.0–2.6, similar to or lower than most of the composite B-IBI values estimated in this study. One of the Adams *et al*. (1998) stations was within approximately 0.5 km of RF-3, but indicated a higher level of benthic community impairment (composite B-IBI of 1.8).

The use of abundance and biomass metrics in the B-IBI developed by Adams *et al.* (1998) is a source of uncertainty in this analysis. Some benthic invertebrate community indices exclude the use of abundance and biomass metrics (DeShon

Table 3. Mean (SD) benthic community values and Benthic Index of Biotic Integrity (B-IBI) scores (Adams *et al.,* 1998) for reference and Study Area 7 stations

Station	Number of Taxa (number)		Abundance (number/m^2)		Biomass (g dw/m^2, pooled replicates)		Abundance of Pollution-indicative Taxa (%)		Abundance of Pollution-sensitive Taxa (%)		Composite B-IBI Score
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	
Reference Stations											
RF-1	15	3.0	6,703	5.0	1.1	3	77	1.0	0.1	1.0	2.6 [a,b]
(*n* = 3)	(0.6)	(0)	(1,914)	(0)			(7.9)	(0)	(0.2)	(0)	(0)
RF-2	20	3.7	4,977	4.3	0.93	1	39	2.3	2.8	1.7	2.6 [a,b]
(*n* = 3)	(2.5)	(1.2)	(2,589)	(1.2)			(3.1)	(1.2)	(2.6)	(1.2)	(0.4)
RF-3	28	5.0	16,640	1.7	3.7	5	40	2.3	0.0	1.00	3.0 [a]
(*n* = 3)	(4.4)	(0)	(10,820)	(1.2)			(8.1)	(1.2)	(0.1)	(0)	(0.4)
Study Area 7 Stations											
SA7−1	21	3.7	7,577	4.3	4.7	5	69	1.0	1.4	1.0	3.0 [a]
(*n* = 3)	(3.2)	(1.2)	(3,453)	(1.2)			(2.1)	(0)	(1.2)	(0)	(0.4)
SA7-2	26	5.0	10,983	3.7	27	3	81	1.0	0.4	1.0	2.7 [a,b]
(*n* = 3)	(3.1)	(0)	(2,552)	(1.2)			(7.6)	(0)	(0.3)	(0)	(0.2)
SA7-3	18	3.0	8,580	5.0	1.4	3	87	1.0	0.2	1.0	2.6 [a,b]
(*n* = 3)	(1.0)	(0)	(970)	(0)			(4.8)	(0)	(0.3)	(0)	(0)
SA7-4	21	4.3	12,757	3.0	4.9	5	66	1.0	1.5	1.0	2.9 [a,b]
(*n* = 3)	(2.1)	(1.2)	(2,179)	(0)			(3.2)	(0)	(0.4)	(0)	(0.2)
SA7-5	23	4.3	4,443	5.0	5.9	5	64	1.0	1.3	1.0	3.3 [a]
(*n* = 3)	(3.1)	(1.2)	(1,630)	(0)			(10.6)	(0)	(0.7)	(0)	(0.2)
SA7-6	11	1.0	4,420	4.0	1.4	3	72	1.0	0.2	1.0	2.4 [b]
(*n* = 2)	(2.8)	(0)	(2,489)	(1.4)			(13.0)	(0)	(0.2)	(0)	(0.3)
Newark Bay (Adams *et al.* 1998)											
Various	14	1	11,000	3	5.4	5	65	1	0.3	1	2.2
(*n* = 28)	(2.6)		(47,000)		(2)		(7.1)		(0.3)		—

Composite B-IBI scores with the same superscript are not significantly different (Tukey-Kramer Honestly Significant Difference, α = 0.05); mean scores <3 and ≥3 indicated slightly impaired and unimpaired communities, respectively. Mean (90% CI) benthic community values for Newark Bay (Adams *et al*., 1998) were scored and provided for reference.

1995; USEPA 1999) because they are difficult to interpret. A typical model of abundance/biomass response to sediment toxicity assumes one of four conditions: (1) nontoxic conditions support intermediate abundance/biomass; (2) slightly toxic conditions may support unusually high abundance/ biomass of tolerant species; (3) intermediate toxicity can cause a return to intermediate abundance/biomass; and (4) severely toxic conditions support only low abundance/biomass (Rakocinski *et al.* 2000). The uncertainty lies, for example, in distinguishing condition 1 from condition 3, because both are associated with intermediate abundance and biomass. Also, biomass can be strongly affected by the presence of a few large individuals (*e.g.*, large bivalves), as occurred at station SA7-2.

In addition to examining composite B-IBI scores and constituent metrics, heterogeneity indices (diversity, species richness, dominance, and evenness) were used as additional lines of evidence to support conclusions regarding benthic community health. Although low values for heterogeneity indices are often a consequence of pollution and suggest impairment (Newman and Unger 2003), the absolute values of the indices themselves cannot be used to rate benthic communities at each station as impaired, slightly impaired, or unimpaired. For each index, stations were separated into three groups based on statistical significance (Fig. 2). Although relative statistically significant differences do not necessarily imply ecologically significant differences, conclusions from this approach provided an additional line of evidence to support the B-IBI conclusions. In general, the results of this approach agreed with the results of the B-IBI scoring. For example, stations RF-1, SA7-3, and SA7-6 were consistently in the lowest groupings for two to four of the heterogeneity indices (Fig. 2), suggesting possible relative impairment. This concurred with the B-IBI score of slightly impaired for these stations (Table 3). Stations RF-2, SA7-2, and SA7-4 were ranked in the moderate grouping for three of the four heterogeneity indices, providing some additional evidence to support the B-IBI scores of slightly impaired. Heterogeneity indices for stations RF-3, SA7-1, and SA7-5 were consistently within the high groupings for two to four of the indices, suggesting that relative impairment was minor, concurring with the B-IBI scoring as unimpaired.

Toxicity

Distinct differences in toxic responses were observed among test species, with the estuarine amphipod *L. plumulosus* exhibiting the greatest sensitivity and polychaetes (*N. arenaceodentata* and *N. virens)* exhibiting the least sensitivity (Fig. 3). Survival of *L. plumulosus* was significantly reduced in all sediments compared to controls, with the exception of SA7-4 (81% mean survival; Figure 3a). Severe toxicity (0–5% mean survival) was observed for *L. plumulosus* exposed to sediment

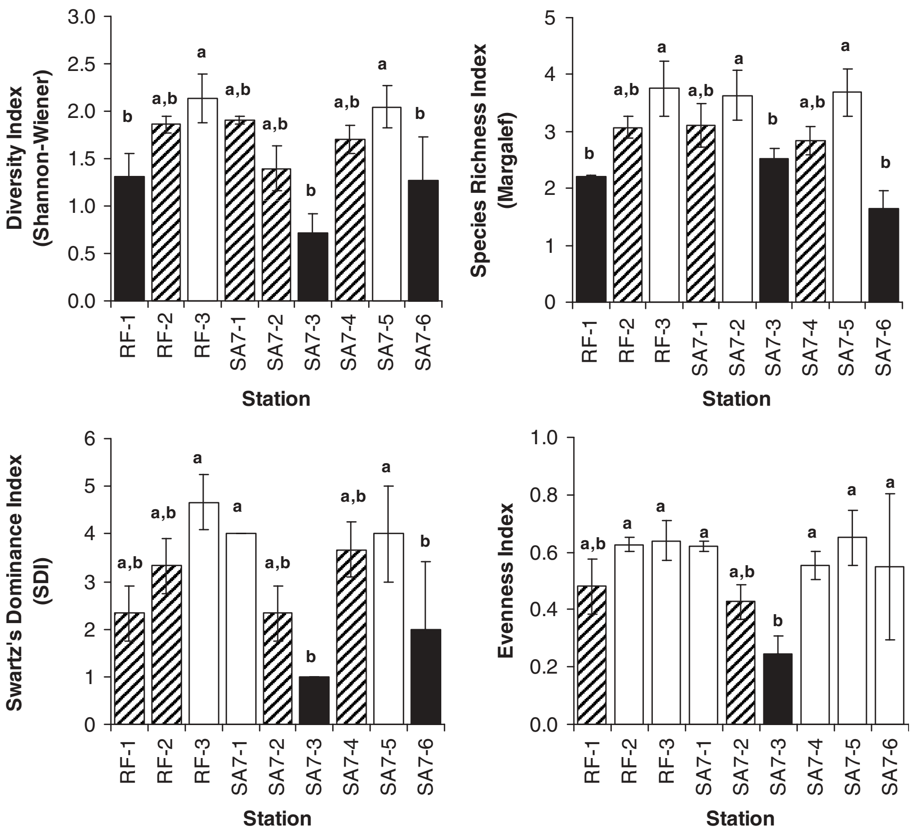

Fig. 2. Mean benthic heterogeneity indices for reference (RF-1, RF-2, RF-3) and Study Area 7 stations (SA7-1 through SA7-6). Error bars represent one standard deviation. Columns with the same letter are not significantly different (Tukey-Kramer Honestly Significant Difference, $\alpha = 0.05$). Heterogeneity indices represented by unshaded columns indicate the stations with the highest values. Striped and solid columns represent moderate and lower values, respectively, suggestive of higher relative levels of impairment

from four sample stations (RF-1, SA7-2, SA7-3, and SA7-6) and moderate toxicity (32–74% mean survival) was observed at three sample stations (RF-2, RF-3, SA7-1, and SA7-5). Significant reductions in *M. nasuta* survival were observed at two stations (RF-1 and SA7-6; Figure 3d), although the magnitude of effect was less than that observed in the amphipod tests at the same stations. Although no significant differences were observed in survival among sample stations for either polychaete species (Fig. 3b and 3c), growth of *N. arenaceodentata* in SA7-5 sediment (52% of control growth) was significantly lower than controls ($p = 0.012$, Figure 3e). The biological significance of this effect is uncertain and may be slight because of the high inherent variability in *N. arenaceodentata* growth data. In many bioassays involving field-collected sediment, significant sublethal toxic effects are only clearly evident for this test endpoint when means are less than 44% of control growth (Phillips *et al.* 2001). For the survival endpoint in all four test species, the results of statistical comparisons were consistent with the minimum significant difference (80% of control) identified by Thursby *et al*. (1997).

Sediment and Tissue Chemistry

Maximum sediment concentrations of six chemical constituents exceeded cause–effect screening sediment benchmarks (Table 4). PAHs appear to have the strongest link with observed toxicity. ΣPAH concentrations in sediment were as high as 7000 μg/g organic carbon, with ΣPAH TU ranging from 0.5 to 16. Stations in which ΣPAH TU were >2 were lethally toxic to *L. plumulosus*, with a clear dose–response relationship evident in the data (Fig. 4a). The LC_{50} (95% CI) based on ΣPAH TU was 1.2 (1.07–1.24) and did not differ greatly from the theoretical chronic threshold of 1 TU (USEPA 2003b). Sediments in which *M. nasuta* accumulated tissue ΣPAH concentrations of ≥ 2 μmol/g lipid were lethally toxic to *L. plumulosus* (Fig. 4b), a value similar to the tissue ΣPAH concentration threshold of 2.24 μmol/g lipid associated with chronic toxicity (USEPA 2003b). The measured tissue ΣPAH concentrations are a lower limit of the actual concentrations, because only detected PAHs were considered, and concentrations were not corrected for unmeasured alkylated PAHs. Given the strong dose–response relationship between modeled estimates of PAH exposure and measured accumulation of PAHs in tissue to toxic thresholds, it is likely that PAHs accounted for a significant portion of the observed toxicity. PAHs are a widespread chemical contaminant of industrial and urban waterways (van Metre *et al.* 2000; USEPA 2004), and the presence of bioavailable PAHs at toxic concentrations is not surprising given the numerous current and historical sources of PAHs and uses of the Lower Hackensack River and its watershed. In *N. virens*, ΣPAH concentrations were below detection limits (approximately 0.1 μmol/g lipid) for all stations except for RF-1.

Of the remaining chemicals implicated in Table 4, only heptachlor epoxide is likely to have contributed significantly to toxicity, though only at one location. Heptachlor epoxide was detected at station SA7-6 in sediment at a concentration 4–5 times higher than its cause–effect sediment benchmark; this sediment was severely toxic to *L. plumulosus* and significantly toxic to *M. nasuta*. Heptachlor epoxide was also detected in *N. virens* exposed to sediment from the same location. Thus, heptachlor epoxide was evidently bioavailable

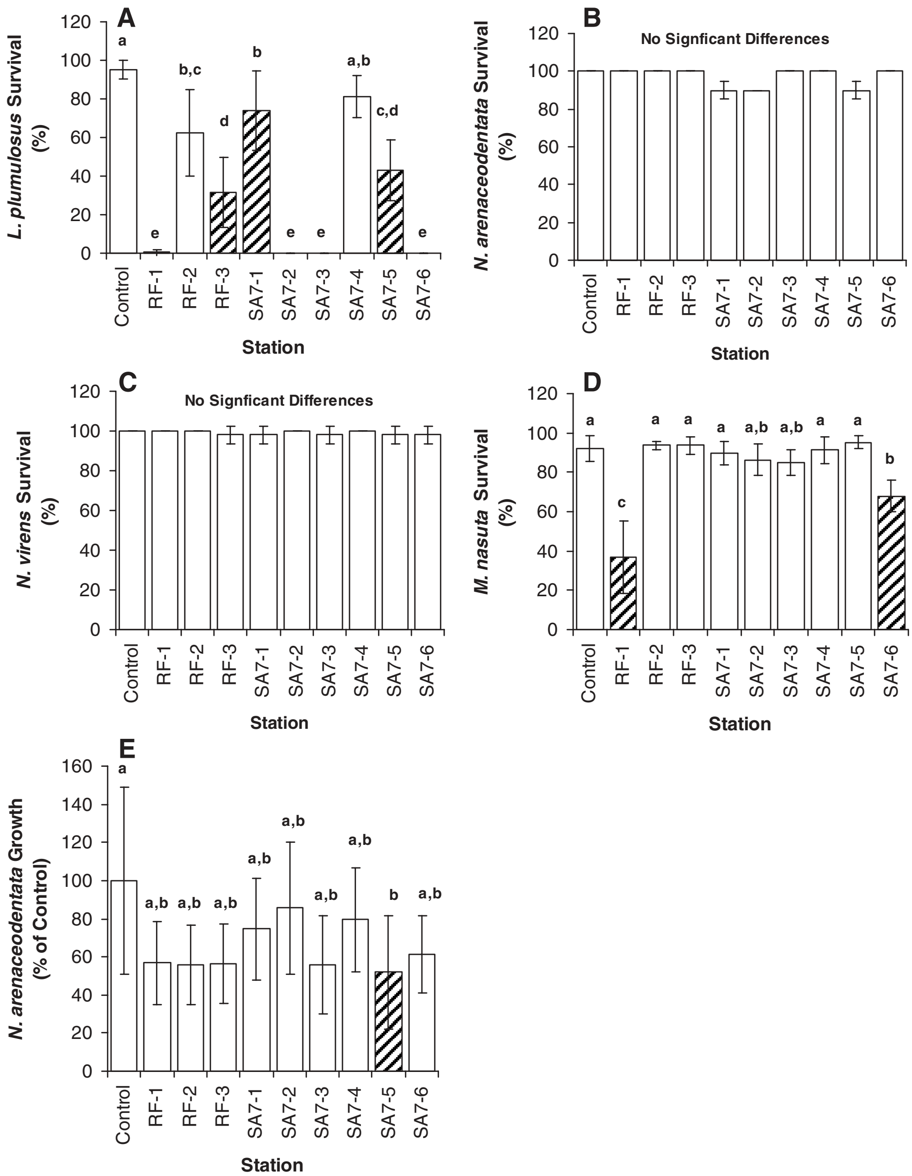

Fig. 3. Mean percent survival for *Leptocheirus plumulosus* (**a**), *Neanthes arenaceodentata* (**b**), *N. virens* (**c**), and *Macoma nasuta* (**d**) and growth for *N. arenaceodentata* (**e**) exposed to laboratory control sediment and sediments collected from reference (RF-1, RF-2, RF-3) and Study Area 7 stations (SA7-1 through SA7-6). Error bars represent one standard deviation. Columns with the same letter are not significantly different (Tukey-Kramer Honestly Significant Difference, $\alpha = 0.05$). Survival values represented by unshaded columns indicate no significant toxicity, and striped columns indicate intermediate toxicity

and may have contributed to the toxicity observed in sediment from this station.

Cationic metals detected in sediment porewater are unlikely to have contributed to toxicity, because acid volatile sulfide (AVS) was found to exceed concentrations of simultaneously extracted metals (SEM) at each of the triad sampling locations (Di Toro *et al.* 2000b; USEPA 2005). Although copper and lead concentrations in sediment porewater exceeded saltwater ambient water quality criteria (USEPA 2002a) at station SA7-3 (lead) and all stations except for RF-2 and RF-3 (copper), the maximum SEM/AVS ratio was 0.21 (stations SA7-2 and RF-3), suggesting that toxicity was not likely due to metals. Additionally, metals in porewater can overstate risks due to overextraction during centrifugation (USEPA 2001) or inability to distinguish bioavailable metals from unavailable metals sorbed to dissolved organic carbon or bound to inorganic ligands such as hydroxides and carbonates (Di Toro *et al.* 2000b; Evangelou 1998; USEPA 2005).

It is possible that AVS may have decreased in shallow sediment layers because of continual aeration of the overlying water during the laboratory toxicity tests, thereby releasing labile metals (*e.g.*, copper, lead, and zinc) into porewater and overlying water (Carbonaro *et al.* 2005). However, experiments performed to investigate the potential for release of metals during extreme physical disturbances of Study Area 7 sediments (for example by dredging, ship propellers, or by river currents and tides generated during severe weather events) indicated that this does not occur (ENVIRON 2006; unpublished data). Sediments collected from Study Area 7 and vigorously mixed with overlying water and aerated to saturated dissolved oxygen conditions for up to 24 h did not result in significantly elevated dissolved metal concentrations. Despite small decreases in AVS concentrations (<50%), only slight increases in concentrations of dissolved copper and lead in the sediment elutriate were observed. In contrast, hexavalent chromium was not detected in elutriate either before or after aggressive mixing and aeration of the sediment.

Table 4. Cause–effect evaluation of chemicals detected in Study Area 7 and reference sediment and porewater (N = 9)

Constituent	Units	Range	Cause–effect screening benchmark	Number of samples ≥ benchmark	Benchmark source
Metals (sediment)					
Cadmium, copper, lead, nickel, zinc, mercury	μmol excess SEM/g OC	<0	130	0	USEPA (2005)
Chromium	NA	AVS detected in all samples	AVS presence/ absence[a]	0	USEPA (2005)
Metals (porewater)					
Arsenic	μg/L	<7 – **52.5**	36	3	USEPA (2002a)
Total Chromium	μg/L	<3 – 17.1	50	0	USEPA (2002a; hexavalent Cr)
Copper	μg/L	<2 – **21.2**	3.1	2	USEPA (2002a)
Lead	μg/L	<2 – **20.9**	8.1	1	USEPA (2002a)
Mercury	μg/L	<0.1 – 0.34	0.94	0	USEPA (2002a)
Zinc	μg/L	12 – 73	81	0	USEPA (2002a)
SVOCs					
PAHs	ΣTU	0.5 – **16**	1	6	USEPA (2003b)
Chlorinated benzenes	ΣTU	<0.001 – 0.012	1	0	Fuchsman *et al.* (1999)
Bis(2-chloroethyl)ether	mg/kg	<0.05 – 0.31	29	0	Di Toro *et al.* (1991); USEPA (2002b); Fuchsman (2003)
Bis(2-ethylhexyl)phthalate	μg/g OC	<13 – 310	> 65,000	0	Call *et al.* (2001a); Call *et al.* (2001b)
Carbazole	μg/g OC	1.2 – 28	190	0	Di Toro *et al.* (1991); USEPA (2002b)
4-Chloroaniline	mg/kg	0.02 – 0.11	0.012	4	Di Toro *et al.* (1991); USEPA (2002b); Fuchsman (2003)
Dibenzofuran	μg/g OC	1.7 – 134	1,650	0	Di Toro *et al.* (2000a)
4-Methylphenol	mg/kg	<0.02 – **0.11**	6.2	0	Di Toro *et al.* (1991); USEPA (2002b); Fuchsman (2003)
Nitrobenzene	mg/kg	<0.05 – 0.36	7.7	0	Di Toro *et al.* (1991); USEPA (2002b); Fuchsman (2003)
Pesticides					
Total DDT	μg/g OC	<1 – 7.1	30 – 300	0	Ferraro and Cole (1997); Swartz *et al.* (1994)
Endrin ketone	μg/g OC	<0.3 – 0.58	5.4	0	USEPA (2003c)
Heptachlor epoxide	μg/g OC	<0.4 – **0.48**	0.11	1	Di Toro *et al.* (1991); USEPA (1980)
Other Constituents					
Total PCBs	μg/g OC	0.1 – 22	400 – 1,100	0	Fuchsman *et al.* (2006)
Total PCDD/PCDFs	μg/g OC	0.04 – 1.1	>1.4	0	Barber *et al.* (1998; 2,3,7,8-TCDD)
Total PBDEs	μg/g OC	0.06 – 24	80	0	Di Toro *et al.* (1991); Wollenberger *et al.* (2002)
Total Organotins	μg/g OC	<0.1 – 0.27	0.6 – 6	0	Meador *et al.* (2002)

Maximum concentrations in bold indicate values greater than cause-effect screening benchmark.
[a] Chromium toxicity is not expected if AVS is detectable.

In the sediment triad study, some indication of bioavailable lead was noted in the *M. nasuta* bioaccumulation test; lead concentrations were significantly different among the sediments, ranging from 0.2 mg/kg, ww in controls to 1.1 mg/kg in clams exposed to RF-2 sediment. However, mean tissue concentrations of *M. nasuta* exposed to the four lethally toxic sediments (0.4–0.7 mg/kg, ww) were not statistically different from concentrations of *M. nasuta* exposed to only sediment with no toxicity (SA7-4, 0.8 mg/kg, ww). Thus, although bioavailable lead was present, elevated levels of bioavailable lead were not related to toxicity. There were no significant differences in the concentration of lead in *N. virens* (0.4–0.6 mg/kg, ww). For copper, no significant differences were found among *M. nasuta* (1.9–2.6 mg/kg) or *N. virens* (1.9–3.2 mg/kg, ww) tissues. However, it is unclear whether tissue concentrations in these organisms would indicate increases in copper bioavailability, because there is conflicting evidence regarding the potential for physiological regulation in bivalves exposed to elevated copper concentrations (Cain and Luoma 1990; Mersch *et al.* 1996). Two sediment samples, SA7-2 and SA7-3, exceeded the cause–effect screening benchmark for copper in porewater (Table 4) and were both lethally toxic to *L. plumulosus* (Fig. 3a). Thus, although the contribution of lead to toxicity in the *L. plumulosus* experiment can be discounted, it is possible that copper may have contributed to toxicity in two of the sediments in this study.

Although elevated total chromium concentrations in sediment (as high as 1900 mg/kg in SA7-6) were the rationale for conducting the investigation, dissolved total chromium was detected in pore water at trace concentrations that were well below the chronic saltwater ambient water quality criterion for hexavalent chromium (50 μg/L). The hexavalent chromium criterion was used because USEPA has not designated a trivalent chromium saltwater criterion. Therefore, total chro-

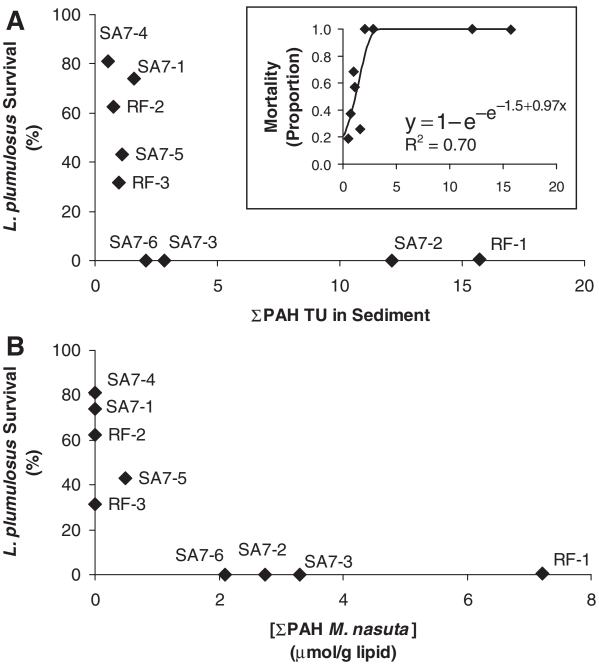

Fig. 4. Relationship between *Leptocheirus plumulosus* survival and ΣPAH Toxic Units (TU) in sediment **(a)** and ΣPAH concentrations in *Macoma nasuta* exposed to sediment **(b)**. Labels indicate reference (RF-1, RF-2, and RF-3) and Study Area 7 (SA7-1 through SA7-6) stations. The inset figure in (a) illustrates a nonlinear dose–response model (Gompertz) fit of the mortality data, using ΣPAH TU as a measure of dose

mium was unlikely to contribute to toxicity to benthic organisms in these laboratory experiments. The presence of AVS and additional indicators of reducing conditions (*e.g.*, ferrous iron, divalent manganese) in the sediment (Martello *et al.* 2007) are strong indicators of reducing conditions, which according to several studies precludes the presence hexavalent chromium in favor of the less toxic, less soluble trivalent chromium species (Berry *et al.* 2004; Besser *et al.* 2004; Becker *et al.* 2006).

Becker *et al.* (2006) also confirmed the low bioavailability of trivalent chromium and limited presence of hexavalent chromium in sediments containing AVS collected further upstream on the Hackensack River at locations potentially impacted by a different COPR site. In that study, *L. plumulosus* exhibited no significant mortality at the highest chromium concentration tested (3970 mg/kg), and the amphipod *Ampelisca abdita* exhibited no significant mortality at chromium concentrations up to 1490 mg/kg in sediment (Becker *et al.* 2006).

Furthermore, the relative sensitivity of benthic species to sediments in the present study is not consistent with the known relative sensitivity to chromium. Specifically, several polychaetes (including *N. virens* and *N. arenaceodentata*) are among the most sensitive species to hexavalent chromium, whereas various amphipods exhibit intermediate sensitivity, and the clam *Macoma balthica* (closely related to *M. nasuta*) is the least-sensitive species known (USEPA 1985, 2002b).

N. virens and *M. nasuta* tissue analysis results following the bioaccumulation study showed the presence of total chromium, as would be expected for this essential nutrient. While there was variability in chromium tissue concentrations between locations, the variability was not explained by concentrations of total or hexavalent chromium in sediment or total chromium in porewater (r^2 = <0.0001−0.05). For example, location SA7-6 had the maximum detected total chromium concentration in sediment (1900 mg/kg), but had *M. nasuta* mean (SD) total chromium in biological tissues of 1.5 (0.3) mg/kg, ww, and *N. virens* mean (SD) total chromium in biological tissues of 2.8 (1.4) mg/kg, ww. Both values were moderate in comparision to tissue concentrations observed at other locations. In constrast, location RF-1 with the third highest concentration of total chromium in sediment (238 mg/kg), had the highest mean (SD) concentrations of total chromium in *M. nasuta* tissue, 45 (38) mg/kg, ww. RF-1 *N. virens* total chromium tissue concentrations 1.8 (1.6) mg/kg, ww were comparable to those seen at SA7-6, but both RF-1 and SA7-6 were less than the *N. virens* concentrations seen at RF-2 (4.2 (4.2) mg/kg, ww). Differences among chromium concentrations in *N. virens* are minor, as concentrations did not differ significantly ($p = 0.24$) among controls, reference stations, and Study Area 7 stations. Not including RF-1 results, mean chromium concentrations in *M. nasuta* ranged from 1.2 (RF-2) to 1.3 (RF-3) mg/kg, ww in reference stations, from 1.0 (SA7-5) to 5.8 (SA7-3) mg/kg, ww in Study Area 7 stations, and 0.7 mg/kg, ww in controls. Mean concentrations were statistically different among sample stations. Five groups could be distinguished using Tukey-Kramer HSD (from highest to lowest): SA7-3 > SA7-1 ≥ SA7-2 ≥ SA7-6 ≥ RF-3, RF-2, SA7-4, SA7-5, and controls. However, these relationships show no statistically significant relationship to total chromium concentrations in sediment, as location SA7-6 is within the center of these groups (with total chromium concentrations in mg/kg noted in parentheses after each sample location): RF-1 (238), SA7-3 (223), SA7-1 (171), SA7-2 (329), SA7-6 (1900), RF-3 (148), RF-2 (157), SA7-4 (192), SA7-5 (139).

N. virens sediment toxicity testing results showed 98 to 100% survival at each location, but *L. plumulosus* and *M. nasuta* showed some degree of toxic response at a variety of locations. Although four of the five stations (including RF-1) with the highest levels of total chromium concentrations in *M. nasuta* were severely toxic to *L. plumulosus* (0% survival), there was no relationship between toxicity and bioavailability (Fig. 5). It is unlikely that total chromium concentrations in whole tissue approached toxic levels, because concentrations were similar to those measured in the mussel *Mytilus edulis* (5–9 μg/g, ww) exposed to very low

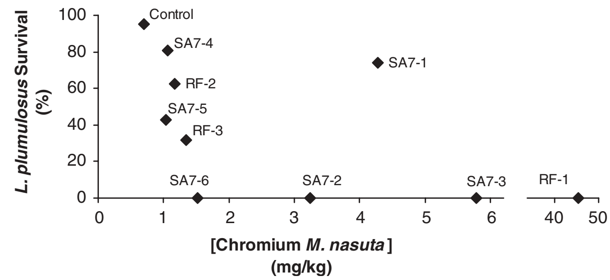

Fig. 5. Relationship between *Leptocheirus plumulosus* survival and chromium concentrations in *Macoma nasuta* exposed to sediment. Labels indicate laboratory control, reference (RF-1, RF-2, and RF-3), and Study Area 7 (SA7-1 through SA7-6) stations

(nontoxic) levels of chromium (5–10 μg/L hexavalent chromium in seawater) (Zaroogian and Johnson 1983). The majority of chromium in marine mussels is thought to be derived from the ingestion of trivalent chromium associated with particulate matter (Wang *et al*. 1997). In this study, however, chromium concentrations in the clam *M. nasuta* were not associated with concentrations of total chromium in sediment, hexavalent chromium in sediment, or total chromium in porewater (r^2 = < 0.0001–0.05). Physiological stress related to PAH exposure may have disrupted internal regulation of chromium concentrations in *M. nasuta*, because chromium concentrations in *M. nasuta* tissue were positively correlated with ΣPAH TU ($r^2 = 0.62$, $p = 0.0119$). Mean (SD) concentrations of total chromium in *N. virens* did not differ significantly ($p = 0.24$) among controls, reference stations, and Study Area 7 stations, with tissue concentrations ranging from 0.6 (0.09) mg/kg, ww in sample RF-3 to 9.3 (10.0) mg/kg, ww in the controls.

Arsenic concentrations in sediment porewater also exceed the USEPA's (2002a) water quality criterion at stations SA7-3 and SA7-6, two of the four sample stations exhibiting severe toxicity to *L. plumulosus* (Fig. 3). SEM/AVS relationships cannot be used to confirm or refute the porewater arsenic data, because in contrast to copper and lead, arsenic does not form insoluble sulfide complexes. However, the bioavailability of arsenic in marine sediments under anoxic conditions is very low, similar to chromium (Neff 1997). Not surprisingly, tissue concentrations of arsenic in the *M. nasuta* and *N. virens* bioaccumulation tests did not suggest significant levels of bioavailable arsenic. Although mean (SD) arsenic concentrations in *M. nasuta* controls (1.8 (0.33) mg/kg, ww) were significantly lower than concentrations observed in animals exposed to sediment from reference and Study Area 7 stations, which ranged from 2.2 (0.40) mg/kg, ww in SA7-5 to 3.0 (0.49) mg/kg, ww in SA7-3, arsenic concentrations were not significantly different among reference and Study Area 7 stations. Mean (SD) arsenic concentrations in *N. virens* did not differ significantly among control sediments (1.7 (0.12) mg/kg) or Study Area 7 and reference sediments, which ranged from 1.4 (0.12) mg/kg in RF-3 to 1.8 (0.12) mg/kg in SA7-5. Thus, there was no evidence for elevated levels of bioavailable arsenic sufficient to explain the pattern of toxicity among reference and Study Area 7 stations.

Although 4-chloroaniline was detected in sediment at concentrations significantly above the cause–effect screening sediment benchmark in four of the reference and Study Area 7 sediments (RF-2, RF-3, SA7-4, and SA7-5), these sediments were moderately or insignificantly toxic (Fig. 3). The aquatic toxicity data identified from the USEPA's ECOTOX database for 4-chloroaniline were highly variable (USEPA 2002b), and the screening value provided in Table 4 is based on data for a freshwater species. Saltwater organisms may be much less sensitive to 4-chloroaniline than freshwater species (WHO 2003).

Correlation analyses were performed to further investigate the relationship between *L. plumulosus* toxicity and chemicals that exceeded sediment-screening benchmarks (Table 4). Relationships between heptachlor epoxide and 4-chloroaniline could not be elucidated because of the low number of detections (1 and 4, respectively). Among the remaining chemicals (arsenic, copper, lead, and PAHs), all were significantly negatively correlated with survival ($p < 0.05$), based on both parametric and nonparametric tests. However, chemical concentrations were also correlated with one another (cross correlation), preventing a clear understanding of the relationships between toxicity and chemical concentrations. A partial correlation analysis was conducted to analyze the relationships between each variable and survival while holding the other variables constant. The only significant negative partial correlation between survival and chemical concentration was for ΣPAH TUs ($p < 0.0001$), suggesting that among the variables in this analysis, PAHs were the single chemical variable most strongly associated with toxicity. However, this approach does not account for the possibility of mixture effects among the chemicals.

Stepwise multiple regression analysis conducted to identify models involving more than one chemical variable indicated that the optimal multiple regression model was a two-variable model utilizing ΣPAH TUs and arsenic, where survival = (–3.1 × ΣPAH TUs) + (–0.48 × arsenic) + 56 (adjusted $R^2 = 0.47$, $p < 0.0001$). The addition of arsenic to the model represented only a modest improvement in fit (R^2 of 0.30 based on a single-variable, linear model using ΣPAH TUs to an adjusted R^2 of 0.47 using the two-variable model). This modest improvement suggests that arsenic may be only a minor contributor to toxicity. As discussed above, the bioaccumulation experiments did not suggest that arsenic was bioavailable. In contrast, the evidence provided by this correlation analysis complements multiple lines of evidence that identify PAHs as a primary source of toxicity, including the presence of bioavailable PAHs (Fig. 4b) and observations of significant toxicity at the theoretical threshold of ΣPAH TU = 1 (Fig. 4a). It is important to note, however, that partial correlation and stepwise regression analyses require the use of parametric methods, which assume linearity, whereas a nonlinear model provided a better fit for understanding the contribution of ΣPAH TU to sediment toxicity (Fig. 4a).

Sediment Quality Triad Assessment

The benthic community, laboratory toxicity and bioaccumulation tests, and chemical lines of evidences were combined in a SQT approach (Chapman 1990, 1996) to yield inferences regarding chemical impairment to benthic communities at six locations in the Lower Hackensack River and three reference locations elsewhere in Newark Bay (Table 5). Strong or possible evidence for benthic community impairment was observed in four of the six Study Area 7 stations (SA7-2, SA7-3, SA7-4, and SA7-6), and one of the three reference stations (RF-1). With the exception of SA7-4, significant toxicity was observed in toxicity tests with *L. plumulosus*. Toxicity was strongly associated with elevated concentrations of toxic and bioavailable PAHs, with possible influence of heptachlor epoxide in sediment from station SA7-6 and copper in SA7-2 and SA7-3. The strong association between benthic community impairment and chemical impacts was also found in Newark Bay by Adams *et al*. (1998), who concluded that the bay exhibited the most degraded benthos and highest levels

Table 5. Sediment quality triad inferences for the reference and Study Area 7 lines of evidence

Station	Line of evidence[a]			Triad inference[c]
	Toxic and bioavailable chemicals	Laboratory toxicity	Community impairment[b]	
Reference stations				
RF-1	+ Sediment ΣPAH TU > 2; [*M. nasuta* ΣPAH] > 2 μmol/g lipid	+ Severe (*L. plumulosus*); Intermediate (*M. nasuta*)	+ Slightly impaired (B-IBI); heterogeneity indices suggest highest relative impairment	Toxic chemicals (PAHs) are stressing the system and may be sufficient to significantly impair the community
RF-2	− Sediment ΣPAH TU < 1	+/− Intermediate (*L. plumulosus*)	+/− Slightly impaired (B-IBI); heterogeneity indices suggest moderate relative impairment	Evidence that there may be pollution-induced impairment, potentially due to unmeasured chemicals or conditions
RF-3	− Sediment ΣPAH TU < 1	+/− Intermediate (*L. plumulosus*)	− Unimpaired (B-IBI); heterogeneity indices suggest lowest relative impairment	Evidence that there is little or no pollution-induced impairment, although unmeasured chemicals or conditions may exist with the potential to cause impairment
Study Area 7 Stations				
SA7-1	+/− Sediment ΣPAH TU 1-2	+/− Intermediate (*L. plumulosus*)	− Unimpaired (B-IBI); heterogeneity indices suggest lowest relative impairment	Evidence that there is no pollution-induced impairment; however, PAHs, unmeasured conditions, or unmeasured chemicals may have the potential to cause impairment
SA7-2	+ Sediment ΣPAH TU > 2; [*M. nasuta* ΣPAH] > 2 μmol/g lipid	+ Severe (*L. plumulosus*)	+/− Slightly impaired (B-IBI); heterogeneity indices suggest moderate relative impairment	Possible evidence of pollution-induced impairment due to presence of PAHs and possibly copper
SA7-3	+ Sediment ΣPAH TU > 2; [*M. nasuta* ΣPAH] > 2 μmol/g lipid	+ Severe (*L. plumulosus*)	+ Slightly impaired (B-IBI); heterogeneity indices suggest highest relative impairment	Toxic chemicals (PAHs and possibly copper) are stressing the system and may be sufficient to significantly impair the community
SA7-4	− Sediment ΣPAH TU < 1	− Insignificant	+/− Slightly impaired (B-IBI); heterogeneity indices suggest moderate relative impairment	Possible evidence that there is impairment; however, alteration of benthic community is not due to chemicals
SA7-5	+/− Sediment ΣPAH TU 1-2	+/− Intermediate (*L. plumulosus*); Slight to Intermediate (*N. arenaceodentata* growth)	− Unimpaired (B-IBI); heterogeneity indices suggest lowest relative impairment	Evidence that there is no pollution-induced impairment; however, PAHs, unmeasured conditions, or unmeasured chemicals may have the potential to cause impairment
SA7-6	+ ΣPAH TU > 2; [*M. nasuta* ΣPAH] > 2 Σmol/g lipid; heptachlor epoxide present	+ Severe (*L. plumulosus*); Intermediate (*M. nasuta*)	+ Slightly impaired (B-IBI); heterogeneity indices suggest highest relative impairment	Toxic chemicals (PAHs and heptachlor epoxide) are stressing the system and may be sufficient to significantly impair the community

[a] Line of evidence present (+), absent (−), or inconclusive (+ /−)
[b] Benthic-Invertebrate Index Of Biotic Integrity scores (Table 3) and four heterogeneity indices (Fig. 2) were used to provide evidence of benthic community impairment. For each of the four heterogeneity indices, stations were placed into 3 groups (low, moderate, high) according to statistical significance, with stations with the lowest values hypothesized to exhibit possible impairment
[c] Based on Chapman (1990) and Chapman (1996).

of elevated chemical and incidences of toxicity anywhere in the New York/New Jersey Estuary. In only one case in which benthic impairment was suggested (station SA7-4), impairment could not be linked to chemical impacts because of the absence of both toxicity and chemicals at concentrations in sediment or porewater indicative of toxicity.

Although an important motivation for this investigation was the presence of total chromium associated with historical industrial activities, chemical-induced impairment of biological communities and the observed sediment toxicity was most strongly associated with PAHs. There was no indication using multiple lines of evidence that total chromium contributed to toxicity to benthic organisms in the four laboratory experiments or to biological community impairment. Additional work is needed to more fully understand the sources of PAHs to the Lower Hackensack River.

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The Hackensack River Watershed, New Jersey/ New York:

Wetland Characterization, Preliminary Assessment of Wetland Functions, and Remotely-sensed Assessment of Natural Habitat Integrity

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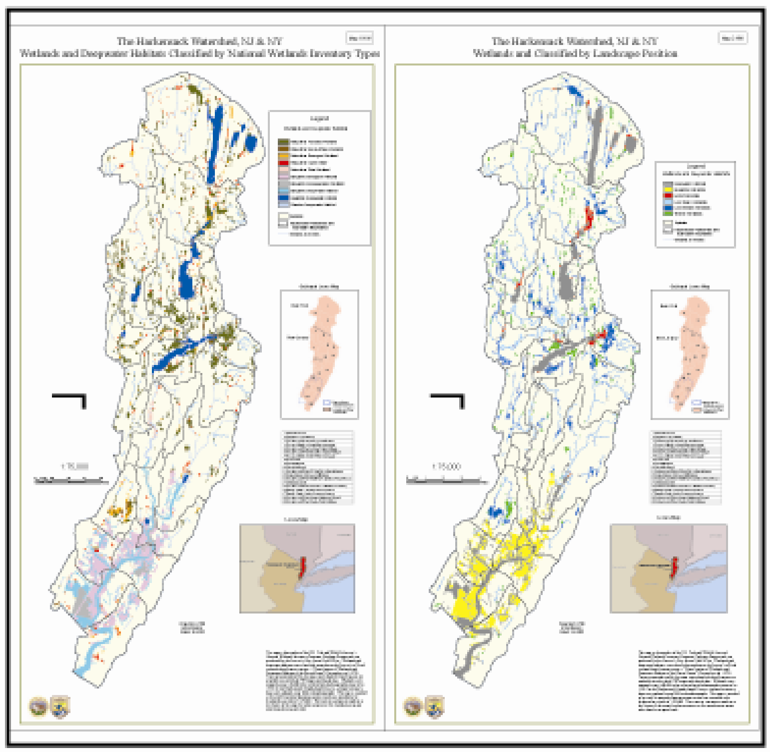

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Introduction

Since the late 1970s, the U.S. Fish and Wildlife Service has been conducting fairly detailed wetland inventories through its National Wetlands Inventory Program (NWI). The maps and data produced from the NWI have been used to aid and strengthen efforts in wetland protection, conservation, and management. During the past 15 years, there has been significant progress made in the development of geographic information system (GIS) technology, availability of digital geospatial data, and knowledge of the relationships between wetland functions and characteristics. The Service's NWI Program now has the capability to use its extensive wetland geospatial database to produce wetland characterizations, functional assessments, and assessments of other natural resources for individual watersheds to support restoration planning and other activities.

The typical wetlands inventory characterizes wetlands mainly by their vegetation and expected hydrology (water regime), with other modifiers used to indicate human activities (e.g., diked/impounded, excavated, farmed, and partly drained) and beaver influence. In order to use the inventory data to predict functions (e.g., surface water detention, nutrient transformation, streamflow maintenance, and provision of fish and wildlife habitat), additional information on the hydrogeomorphic characteristics of wetlands is required. One needs to know where the wetland is located and its association with a waterbody. The Service has developed a set of attributes to better describe wetlands by landscape position, landform, water flow path, and waterbody type (LLWW descriptors; Tiner 2003a). When added to the NWI data, the enhanced NWI data have a predictive capability regarding wetland functions (Tiner 2003b, 2005a). In addition to the development of a preliminary wetland functional assessment tool, a set of remotely-sensed "natural habitat integrity indices" have been developed to characterize the general status of natural resources in watersheds through remote sensing techniques (Tiner 2004).

The Service's New Jersey Field Office (NJFO) is actively engaged with other federal and state agencies and others in natural resource conservation in the Hackensack River watershed including the Hackensack Meadowlands. NWI mapping in this area was recently updated and enhanced as part of a Service-wide strategic mapping initiative focused on updating wetland data for areas where mapping was older than 20 years and/or where significant wetland resources remain vulnerable to development. Given that New Jersey was the first state completed by the NWI with late 1970s aerial photography, the NWI maps and data were over 25 years old and in dire need of updating. Much has changed in this heavily populated state since then and the original mapping is of limited value for today's natural resource managers. Although the area had been remapped, no analysis of the data had been performed.

This report documents the findings of our watershed-wide assessment for the Hackensack River watershed including the results of the updated and enhanced NWI, a preliminary assessment of wetland functions, and an assessment of the overall extent of "natural habitat" in the watershed ("natural habitat integrity").

Study Area

The Hackensack River watershed covers a 197-square mile area in northeastern New Jersey and southern New York (Figure 1). Most (58%) of the watershed occurs in Bergen County, New Jersey, with 32 percent in Rockland County, New York and the remaining 10 percent in Hudson County, New Jersey. The uppermost portion of the watershed is less developed than the highly urbanized lower portion. The tidal reach of this watershed is mostly comprised by the Hackensack Meadowlands.

The watershed contains 19 subbasins (Figure 2): 1) De Forest Lake, 2) Upper Pascack Brook, 3) Hackensack-Nauranshaun Confluence, 4) Pascack Brook above Westwood gage, 5) Hackensack River above Tappan Bridge, 6) Hackensack River- Oradell to Tappan Bridge, 7) Pascack Brook below Westwood gage, 8) Dwars Kill, 9) Tenakill Brook, 10) Hirshfeld Brook, 11) Hackensack River – Fort Lee Road to Oradell gage, 12) Coles Brook-Van Saun Mill Brook, 13) Hackensack River – Bellman's Creek to Ft. Lee Road, 14) Overpeck Creek, 15) Hackensack River – Route 3 to Bellman's Creek, 16) Berry's Creek above Paterson Avenue, 17) Berry's Creek below Paterson Avenue, 18) Hackensack River – Amtrak bridge to Route 3, and 19) Hackensack River below Amtrack bridge. The latter nine subbasins are subject to tidal influence. Tidal action in the Coles Brook/Van Saun Mill Brook subbasin is limited to freshwater tidal fluctuations.

Figure 1. Major waterbodies and municipalities within the Hackensack River watershed. (Illustration copyright (c) 1996 by Karen L. Siletti)

Figure 2. Subbasins of the Hackensack watershed: 1) De Forest Lake, 2) Upper Pascack Brook, 3) Hackensack-Nauranshaun Confluence, 4) Pascack Brook above Westwood gage, 5) Hackensack River above Tappan Bridge, 6) Hackensack River- Oradell to Tappan Bridge, 7) Pascack Brook below Westwood gage, 8) Dwars Kill, 9) Tenakill Brook, 10) Hirshfeld Brook, 11) Hackensack River – Fort Lee Road to Oradell gage, 12) Coles Brook-Van Saun Mill Brook, 13) Hackensack River – Bellman's Creek to Ft. Lee Road, 14) Overpeck Creek, 15) Hackensack River – Route 3 to Bellman's Creek, 16) Berry's Creek above Paterson Avenue, 17) Berry's Creek below Paterson Avenue, 18) Hackensack River – Amtrak bridge to Route 3, and 19) Hackensack River below Amtrack bridge.

Methods

Classification and Characterization

One of the objectives of this project was to expand data in an up-to-date inventory of wetlands to include attributes for landscape position, landform, water flow path, and waterbody type (LLWW descriptors). For the updated NWI inventory, 1:40,000 color infrared photography acquired from 1994-1996 was interpreted following standard NWI procedures (1995 for New Jersey; 1994-1996 for New York).

After identifying and classifying wetlands according to the Service's official wetland classification system (Cowardin et al. 1979), three main descriptors (landscape position, landform, and water flow path) were applied to each wetland by interpreting available map information, and in some cases, consulting aerial photographs. "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a; http://library.fws.gov/wetlands/dichotomouskeys0903.pdf) was used to classify these features. Other modifiers were added to depict features such as headwater, drainage-divide, and human-impacted wetlands; waterbodies (e.g., ponds and lakes) were also classified in more detail.

Landscape position defines the relationship between a wetland and an adjacent waterbody if present. For the Hackensack River watershed, four landscape positions were possible (map codes are given in parentheses): 1) estuarine (ES; along salt and brackish tidal waters), 2) lotic (along rivers [LR] and streams [LS] and on their active floodplains), 3) lentic (LE; along lakes and reservoirs), and 4) terrene (TE; typically surrounded by upland, but including wetlands serving as sources of streams). Lotic wetlands were divided into lotic river and lotic stream wetlands by their width on a 1:24,000-scale map. Watercourses mapped as linear (single-line) features on NWI maps and on U.S. Geological Survey topographic maps (1:24,000) were designated as streams, whereas two-lined channels (polygonal features on the maps) were classified as rivers. All lotic wetlands are in contact with streams or rivers and periodically inundated by overflow. Wetlands on floodplains surrounded by upland (nonhydric soil) were classified as terrene wetlands as were nontidal wetlands completely surrounded by dryland and wetlands that were the source of streams. Lentic wetlands were divided into two categories: natural and dammed, with the latter type separating wetlands associated with reservoirs from those along other controlled lakes, when possible.

Landform is the physical form or shape of a wetland. Six landform types were recognized in the study area: 1) basin (BA), 2) flat (FL), 3) slope (SL), 4) floodplain (FP), 5) island (IL), and 6) fringe (FR) (Table 1). The floodplain landform was restricted to wetlands bordering perennial rivers, while fringe wetlands are mostly associated with estuarine waters and semipermanently flooded vegetated wetlands elsewhere. Where an estuarine wetland is located behind a causeway (road or railroad) or otherwise partially cut off from the mainbody of a fringing wetland, the wetland was classified as a basin wetland. Other basin wetlands were depressional wetlands and seasonally flooded wetlands along streams. Flat wetlands occur on nearly level landforms and typically have a seasonally saturated or temporarily flooded water regime.

Table 1. Definitions and examples of landform types (Tiner 2003a).

Landform Type (code)	**General Definition**	**Examples**
Basin (BA)*	a depressional (concave) landform including artificially created ones by impoundments, causeways, and roads	lakefill bogs; wetlands in the saddle between two hills; wetlands in closed or open depressions, including narrow stream valleys; tidally restricted estuarine wetlands
Slope (SL)	a landform extending uphill (on a slope; typically crossing two or more contours on a 1:24,000 map)	seepage wetlands on hillside; wetlands along drainageways or mountain streams on slopes
Flat (FL)*	a relatively level landform, often on broad level landscapes	wetlands on flat areas with high seasonal ground-water levels; wetlands on terraces along rivers/streams; wetlands on hillside benches; wetlands at toes of slopes
Floodplain (FP)	a broad, generally flat landform occurring on a landscape shaped by fluvial or riverine processes	wetlands on alluvium; bottomland swamps
Fringe (FR)	a landform occurring within the banks of a nontidal waterbody (not on a floodplain) and often but not always subject to near permanent inundation and a landform along an estuary subject to unrestricted tidal flow or a regularly flooded landform along a tidal freshwater river or stream	buttonbush swamps; aquatic beds; semipermanently flooded marshes; river and stream gravel/sand bars; salt and brackish marshes and flats; regularly flooded tidal fresh marsh or flat
Island (IL)	a landform completely surrounded by water (including deltas)	deltaic and insular wetlands; floating bog islands

*May be applied as sub-landforms within the Floodplain landform (FPba and FPfl).

Water flow path descriptors characterize the flow of water associated with wetlands. Six patterns of flow were recognized for wetlands and ponds in the Hackensack watershed: 1) bidirectional-tidal flow (BT), 2) throughflow (TH), 3) outflow (OU), 4) bidirectional-nontidal flow (BI), 5) inflow (IN), and 6) isolated (IS). Bidirectional-tidal flow reflects tidal influence. Throughflow wetlands have either a watercourse (e.g., stream) or another type of wetland above and below it, so water passes through them (usually by way of a river or stream, but sometimes by ditches). The water flow path of lotic wetlands associated with perennial streams is throughflow. Lentic wetlands crossed by streams were also designated as throughflow, while those located in embayments or coves with no stream inflow were classified as bidirectional-nontidal flow since fluctuating lake or reservoir water levels appear to be the primary surface water source affecting their hydrology. Outflow wetlands have water leaving them all year-long, moving downstream via a watercourse (e.g., stream) or a slope wetland. (Note: Some outflow wetlands have intermittent flow and may be classified as Outflow Intermittent, but this was not done for this project.) Inflow wetlands or ponds are sinks where no outlet exists, yet water enters via an intermittent stream or seepage from an upslope wetland. Isolated wetlands are essentially closed depressions (geographically isolated) where water comes from surface water runoff and/or groundwater discharge. For this project, surface water connections are emphasized (e.g., mapped streams), since it is not possible to determine ground water linkages (especially outflow) without hydrologic investigations. Consequently, wetlands designated as isolated may have groundwater connections.

Other modifiers were applied to wetlands in the NWI database. The headwater descriptor (hw) was applied to lotic wetlands along intermittent streams and first- and second-order perennial streams and to terrene wetlands that are the sources of these streams. The pond modifer (pd) was applied to any wetland in contact with a pond. The pond may exert influence on the wetland vegetation or may simply have little or no influence on the wetland (e.g., where a pond represents only a small portion of the wetland such as bog eyelet pond or where an artificial pond was excavated within a vegetated wetland). Wetlands bordering ponds that were mapped by NWI as impounded should be significantly influenced by pond hydrology.

GIS Analysis and Data Compilation

The geographic information system (GIS) used for this project was Arc GIS 9.0. Several GIS analyses were performed to produce wetland statistics (acreage summaries), a preliminary assessment of wetland functions, the remotely-sensed indices of “natural habitat integrity,” and thematic maps. Tables summarizing the results of the inventory were prepared to show the extent of different wetland types by NWI classifications and by LLWW descriptors and to portray differences among the subbasins in these features, wetland functions and natural habitat integrity. NWI and LLWW wetland acreage totals differ because palustrine open water wetlands (NWI) were treated as ponds and, in some cases, as lakes according to LLWW.

Preliminary Functional Assessment

Ten functions were evaluated using the expanded NWI database: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment and other particulate retention, 5) coastal storm surge detention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity.

General Scope and Limitations of the Preliminary Wetland Functional Assessment

At the outset, it is important to emphasize that the functional assessment presented in this report is a preliminary evaluation based on wetland characteristics interpreted through remote sensing and using available data and the best professional judgment of the senior author with input from NJFO personnel and others. Wetlands believed to be providing potentially significant levels of performance for a particular function were highlighted. As the focus of this report is on wetlands, the assessment of waterbodies (e.g., lakes, rivers, and streams) at providing the listed functions was not done, despite their rather obvious significant performance of functions such as fish habitat, waterfowl and waterbird habitat, and surface water detention. No attempt was made to produce a more qualitative ranking for each function or for each wetland based on multiple functions since this was beyond the scope of the current study. For a technical review of wetland functions, see Mitsch and Gosselink (2000); for a broad overview of wetlands, see Tiner (2005b).

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis, considering observed features relative to those required to perform certain functions or by actual measurement of performance and compared to reference standards. The present study does not seek to replace the need for such assessments as they are the ultimate assessment of the functions for individual wetlands. For initial planning purposes, a more generalized assessment is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position and vegetation lifeform. Subsequently, these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition or other purposes. Current aerial photography may also be examined to aid in further evaluations (e.g., condition of wetland/stream buffers or adjacent land use) that can supplement the preliminary assessment.

This study employs a watershed assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance based on their predicted level of performance of various functions. To accomplish this objective, the relationships between wetlands and various functions must be simplified into a set of practical criteria or observable characteristics. Such assessments could also be further expanded to consider the condition of the associated waterbody and the neighboring upland or to evaluate the opportunity a wetland has to perform a particular function.

W-PAWF does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, two wetlands of equal size and like vegetation may be in the right landscape position to retain sediments. One, however, may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The first wetland is likely to trap more water-borne sediments than the latter at the present time, however should the forest above the latter wetland be cleared, the latter wetland will likewise trap any water-borne sediments. The W-PAWF is therefore designed to reflect the potential for a wetland to provide a function. W-PAWF also does not consider the condition of the adjacent upland (e.g., level of outside disturbance) or the actual water quality of the associated waterbody, both of which affect wetland functions and habitat quality. Collection and analysis of these data were beyond the scope of the study.

This preliminary assessment does not obviate the need for more detailed assessments of the various functions. It should be viewed as a starting point for more rigorous assessments, as it attempts to cull out wetlands that may likely produce significant levels of performance for certain functions based on generally accepted principles and the source information used for this analysis. This type of assessment is most useful for regional or watershed planning purposes.

It is also important to recognize limitations derived from source data including conservative interpretations of forested wetlands (especially evergreen types) and drier-end wetlands (e.g., wet meadows, especially those used as pastures; see Tiner 1997b for additional information), and the omission of small or narrow wetlands and small streams. Some wetlands classified as isolated types may actually be connected by a small stream that was not shown on a topographic map or digital hydrography layer. Wetlands directly across the road from other wetlands were assumed to be connected by a culvert or similar structure. Despite limitations of source data, the NWI dataset created for this project represents the most current database on the distribution, extent, and type of wetlands in the watershed. NWI data for this study were based on 1994-1996 aerial photography (1995 for New Jersey and variable photo dates for the New York portion).

Rationale for the Preliminary Wetland Functional Assessment

The criteria used for identifying wetlands of significance for these functions were taken from "Correlating Enhanced National Wetlands Inventory Data With Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands" (Tiner 2003b; http://www.fws.gov/nwi/pubs_reports/HGMReportOctober2003.pdf), but were modified for the Hackensack Meadowlands due to the predominance of common reed (Phragmites australis). The abundance of this species may reduce certain functions, especially for fish and shellfish and waterfowl and waterbird habitat (see below). A list of the wetland types designated as significant for each function is presented in Table 2.

Treatment of Common Reed Marshes

Common reed is the number one invasive plant threatening estuarine wetlands in the northeastern United States. It has replaced typical salt marsh plants such as smooth cordgrass (Spartina alterniflora), salt hay grass (Spartina patens), salt grass (Distichlis spicata), and black rush (Juncus gerardii) in areas where tidal flow has been significantly restricted and where fill has been deposited in wetlands. Common reed is a good disturbance indicator as it readily colonizes exposed soils in the coastal areas and even inland areas along highways (see Marks et al. 1994; Chambers et al. 1999). Although common reed is native to North America, the spread of this species since the 1950s has been attributed to a non-native variety (Saltonstall 2002). Natural stands were typically limited to the edges of estuarine wetlands (Orson et al. 1987). With the advance of common reed into the marsh interior and even along creekbanks, the basic structure of salt marshes has changed from a low-lying grassland to a veritable thicket of tall reeds often with a thick mat of decomposed plant material on the surface. Plant diversity usually declines with the invasion of Phragmites as this species commonly forms monotypic stands, especially in brackish waters (Meyerson et al. 2000). Given the extent of common reed in today's estuarine environments, there has been considerable recent attention given to the habitat function of this species in comparision to that of the pre-existing salt marsh (e.g., Meyerson et al. 2000). Changes in plant composition typically alter the habitat use by many species. A brief summary of the state-of-our-knowledge on the uses of common reed as habitat follow. For more detailed information, refer to the specific articles referenced.

Common reed is a productive plant and its biomass exceeds that of most marsh species it replaces. Recognizing that one of the major ecological functions of salt marshes is to produce material for the detrital food web of estuaries, the export and decomposition of plant materials is important. Common reed leaves decompose rapidly, but the stems take longer to decompose than the plants it replaces (Meyerson et al. 2000). Stem and stem litter remain on the marsh for years. This has given Phragmites an edge in carbon and other nutrient sequestration over other species. The presence of this species at sewage outfalls is testimony to its competitive advantage over other plants in occupying eutrophied sites (Freeman undated manuscript; Levine et al. 1998) and its high potential for nutrient transformation.

There is general agreement that pure Phragmites stands generally yield poorer quality wildlife habitat than the marshes they replace, while they may be important for some species (Roman et al. 1984; Kiviat 1987). The tall, dense reeds restrict wildlife movement and also adversely affect hydrology with negative impacts on aquatic species. Over 50 species of birds have been found in common reed marshes (Meyerson et al. 2000). Despite this usage, there are no birds that depend solely on these wetlands. Common birds in the east include marsh wren, red-winged blackbird, and swamp sparrow. Ringed-necked pheasant and American bittern have been observed (R. Tiner, personal observations). The average number of bird species may be lower in Phragmites wetlands than in salt marshes (Benoit and Askins 1999). Phragmites in mixed stands, common reed marshes along large pools, and the edges of reed marshes seem to be better bird habitats than the marsh interior (Buchsbaum 1997; Cross and Fleming 1999, Meyerson et al. 2000). Given this, regularly flooded mixed and pure stands dominated by Phragmites and irregularly flooded reed marshes that are contiguous with estuarine waters will be rated as moderate for the provision of waterfowl and waterbird habitat. Pure stands of irregularly flooded Phragmites separated from water ("interior marsh") will not be rated as significant for waterfowl and waterbirds, although their value to other birds is recognized under the "other wildlife habitat" function. (Note: Many reed marshes are adjacent to water and will therefore be rated as moderate; recognize, however, that the interior portions of these marshes are used less by waterfowl and waterbirds than the shoreline sections.)

Marsh flooding provides access for fish and nektonic invertebrate use and anything reducing this process will have a negative impact on its use by these organisms. Common reed is known to accelerate the buildup of the marsh surface and reduce drainage density by filling in small ditches and creeks (Weinsten and Balleto 1999), thereby restricting access to the marshes by fishes and transient shellfish. Reducing the frequency of tidal flooding has obvious negative consequences for aquatic species. Fish and shellfish density in Phragmites stands vary with hydrology and wetland geomorphology (Hanson et al. 2002). They noted that high stem density and litter accumulation may reduce tidal flow rates, leading to a reduction in the depth of tidal flooding. From the surface of a brackish Phragmites marsh along the Hudson River, they collected common mummichog (Fundulus heteroclitus), herrings (Alosa spp.), grass shrimp (Palaemonetes pugio), and blue crab (Callinectes sapidus). Most of the individuals were captured in the marsh near the creekbanks and only a few in the marsh interior. Depositional sites produced the most individuals and greatest biomass, but other studies have not yielded similar findings (Rozas 1992). Some studies have found a greater abundance of mummichog in Spartina marshes than in neighboring Phragmites marshes (Able and Hagan 2003, Hanson et al. 2002). Regularly flooded reed marshes will be ranked as having moderate potential for fish and shellfish; irregularly flooded Phragmites marshes contiguous with estuarine open water will be similarly rated as will nontidal, semipermanently flooded reed marshes contiguous to an open waterbody. Interior reed marshes (not bordering a waterbody) will not be viewed as potentially significant fish and shellfish habitat.

Table 2. List of wetlands of potential significance for ten functions for use in the Hackensack River Watershed. (Source: Adapted from Tiner 2003b). See Appendix A for LLWW coding. NWI codes: L2 = lacustrine littoral, P = palustrine, E2 = estuarine intertidal, AB = aquatic bed, EM = emergent, EM1 = persistent emergent, EM5 = Phragmites, SS = scrub-shrub, FO = forested, US = unconsolidated shore, RS = rocky shore, SB = streambed, H = permanently flooded, F = semipermanently flooded, E = seasonally flooded/saturated, C = seasonally flooded, A = temporarily flooded, B = saturated, L = subtidal, N = regularly flooded (tidal), P = irregularly flooded (tidal), R = seasonally flooded-tidal, T = semipermanently flooded-tidal, S = temporarily flooded-tidal.

Function	Level of Function	Wetland Types
Surface Water Detention	High	ESFR, ESBA, ESIL, LEBA, LEFR, LEFL (in reservoir and dammed areas only), LEIL, LSBA, LRBA, LSFP, LRFP, LSFR, LRFR, LRIL, MAFR, MAIL, PDTH, TEFRpdTH, TEBApdTH, PDBI, PDBT, TEBApdBT, TEBATH. TEBATI
	Moderate	LRFL, LSFL, LEFL, TEIF, TEBA (other than above), PD (other except PD2f), TE__pd (other), TEFP__
Coastal Storm Surge Detention	High	ESBA, ESFR, ESIL, LR5FR, LR5FP (=LR5BA and LR5FL), LR5IL, MAFR
Streamflow Maintenance	High	hw (not dr = not ditched)
	Moderate	hwdr, LR1FP, PDTH, TE__pdTH, PDOU, TE__pdOU, TEOU (not hw but associated with streams not rivers), LE wetlands associated with throughflow lakes (LK__TH)
Nutrient Transformation	High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)E, P__(AB, EM, SS, FO and mixes)F, P__(AB, EM, SS, FO and mixes)R, P__(AB, EM, SS, FO and mixes)T, P__(AB, EM, SS, FO and mixes)N, P__(AB, EM, SS, FO and mixes)H, P__(AB, EM, SS, FO and mixes)L, E2EM, E2SS, E2FO, P__(AB, EM, SS, FO and mixes)B (not on coastal plain or glaciolacustrine plain)
	Moderate	P__(AB, EM, SS, FO and mixes)B (on coastal plain or glaciolacustrine plain), P__(AB, EM, SS, FO)A, P__(AB, EM, SS, FO and mixes)S
Sediment and Other Particulate Retention	High	ES__(vegetated), LEBA, LEFR(vegetated), LEIL(veg), LSBA, LRBA, LSFP, LRFP, LRFR(veg), LSFR(veg), LRIL (veg), PDTH, TE__pdTH (including __pq), PDBI, TE__pdBI (including __pq), PDBT, TE__pdBT, TEBATH, TEBATI,

		TEIFbaTH, TEIFbaTI
	Moderate	E2__(US, SB, excluding RS), LSFL(not PSS_Ba or PFO_Ba), LRIL (nonveg), LRFR(nonveg), LSFR (nonveg), M2US, TEBA(not PSS_Ba or PFO_Ba), PD (not c, d, e, f, g, j types), TE__pd(not PSS_Ba or FO_Ba), TEFP__
Shoreline Stabilization	High	E2__(AB, EM, SS, FO and mixes), E2RS (not ESIL), M2RS(not MAIL), LR_(AB, EM, SS, FO and mixes; not LRIL), LS_(AB, EM, SS, FO and mixes), LE__(AB, EM, SS, FO and mixes; not LEIL)
	Moderate	TE__pd (AB, EM, SS, FO and mixes), TE__OUhw (AB, EM, SS, FO and mixes)
Fish and Shellfish Habitat	High	E2EM (including mixes with other types where EM1 or EM2 predominates; excluding E2EM5P__ and mixes where EM5 predominates and mixed communities dominated by E2FO or E2SS), E2US, E2RF, E2AB, E2RS (vegetated with macroalga; may be classified as E2AB1), L2_F, L2AB, L2UB/__(AB, EM, SS, FO), LE__ (vegetated; AB, EM, SS, FO) and NWI water regime = H (permanently flooded), M2AB, M2RS, M2US, M2RF (vegetated with macroalga; may be classified as M2AB1), P__F <u>and</u> adjacent to PD, LK, RV (all except RV4), ST (all except ST4), or EY waters, PAB, PUB/__(AB, EM, SS, FO), P__(EM, SS, FO)H, PEM__(N,R,T, or L, except EM5), PD <u>associated with</u> P__(AB, EM, SS, FO)F, R1EM, R1US(except S)
	Moderate	LE__ <u>and</u> PEM1E, LR__ <u>and</u> PEM1E (and mixes), LS__ <u>and</u> PEM1E (and mixes), PEM5F <u>and</u> adjacent to LK, RV (except RV4), ST(except ST4) and EY, E2EM5N (and mixes), PEM5N (and mixes), E2EM5P__ <u>and</u> adjacent to the estuary (and mixes, but not "interior" E2EM5P_), E2FO/EM__ (not EM5), E2SS/EM__ (not EM5), LR5__ and PFO/EM_R or T (not EM5), LS5__ <u>and</u> PFO/EM_R or T (not EM5), PD (except c, d, e, f, g, j types), EY; PD (except c, d, e, f, g, j types); TEFRpd (along these ponds)
	Stream Shading	LS (not LS4) <u>and</u> PFO, LS (not LS4) <u>and</u> PSS (not PSS_Ba)
Waterfowl and Waterbird Habitat	High	E2EM1 or E2EM2 (includes mixes where they predominate), E2US__ M, N, P, and T water regimes (not S water regime), E2RF, E2AB, E2RS, L2_F (vegetated, AB, EM, SS, FO and mixes with nonvegetated), L2AB (and mixes with nonvegetated), L2US_(F,E, or C), L2_H (vegetated, AB, EM, SS, FO and mixes with nonvegetated), M2AB, M2RS, M2US, M2RF, P__F (excluding EM5-

		dominated wetlands) and adjacent to PD, LK, RV(not RV4) ST(not ST4), or EY waters; PAB, P__H (vegetated, EM, SS, FO including mixes with UB), P__Eh, P__Eb; LS__ and PEM1E (including mixes), LR__ and PEM1E (including mixes), TE__ hw and PEM1E;, PEM__N,R,T, or L (includes mixes, but excludes Phragmites-dominanted EM5), PD associated with P__(AB, EM, SS, FO)F, PEM1R (and mixes), PEM1T (and mixes), PUB__b, R1EM, R1US (except S water regime)
	Moderate	E2EM5N (and mixes), E2EM5P (and mixes) and contiguous with open water (not "interior" marshes), PEM5__E,F, R, or T and adjacent to PD, LK, RV(not RV4), ST(not ST4), or EY, other L2UB (not listed as high), Other PD (except c, d, e, f, g, j types), PEM1E__ (including mixes) and associated with PD, LK, RV(not RV4), or ST(not ST4)
	Wood Duck	LS(1,2, or 5)BA and P__ (FO or SS and mixes), LS(1,2, or 5)FR and P__ (FO or SS and mixes), LR(1,2, or 5)FPba and P__(FO or SS and mixes), LR(1,2, or 5)BA and P__(FO or SS and mixes), LRFPba and PFO/EM, LRFPba and PUB/FO; PFO_R, T, or L (and mixes) and contiguous with open water, PSS_R, T, or L (and mixes) and contiguous with open water
Other Wildlife Habitat	High	Any wetland complex ≥ 20 acres, wetlands 10-20 acres with 2 or more classes (excluding EM5), small isolated wetlands in dense cluster in a forest matrix (restrict to forest regions of U.S. with woodland vernal pools)
	Moderate	Other vegetated wetlands
Conservation of Biodiversity	Regional significant for Northeast U.S	E2EM1N, E2EM1P6, R1EM, R1US, PEM1N, PEM1R, PEM2N, PEM2R, PSS_R, PSS_T, PFO4__g (Atlantic white cedar), PEM__i (herbaceous fen), PSS__i (shrub fen), PFO__i (treed fen), PFO2__ (bald cypress), E1AB__ (eelgrass and SAV beds), LS__FR, LR__FR, PD1m (woodland vernal pool; small ponds surrounded by forest), forested wetlands within >7410-acre forest, very large wetland complexes (≥ 100 acres)
	Locally significant in the Northeast	Beaver-influenced wetlands, Estuarine emergent wetlands (except Phragmites), contiguous wetlands within the Meadowlands District, headwater wetlands, Lentic fringe and basin wetlands (> 10 acres), Lotic River or Stream wetland complexes

Natural Habitat Integrity Assessment

For this assessment, a geospatial database covering the entire Hackensack River watershed was created. Wetland data were obtained from the updated NWI database. Land use and land cover data for upland areas in the watershed were created through photointerpretation of the 1994-1996 aerial photography. The Anderson et al. (1976) land use and land cover (LULC) classification system was used to classify upland areas. The following categories were among those identified: developed land, agricultural land, forests, wetlands (from NWI data), transitional land (moving toward some type of development or agricultural use, but future status unknown), and water. This update focused on changes between "natural" habitat and developed land and, therefore, does not represent a comprehensive revision of all LULC categories. Stream data came from USGS 1:24,000 digital hydrography data and many small streams (especially intermittent ones in hilly and mountainous terrain) are often not designated. These data were not improved since stream mapping was not part of the project and this method typically uses the best available recent data on land use/cover, streams, and wetlands for assessment.

We applied the remotely sensed indices of "natural habitat integrity" (Tiner 2004) to the geospatial dataset for the Hackensack watershed. These indices were designed to meet four of the following requirements: 1) derived from air photointerpretation and/or satellite image processing for contemporary data and from maps for historical data, 2) suitable for frequent updating and rapid assessment, 3) consist of metrics that could efficiently and cost effectively be updated for large geographic areas, 4) present a broad view of the condition of "natural habitat," and 5) provide a historic perspective on the extent of wetlands and open waterbodies. Such indices represent coarse-filter variables for assessing the overall condition of watersheds. They were intended to augment, not supplant, other more rigorous, fine-filter approaches for describing the ecological condition of watersheds (e.g., Index of Biological Integrity for instream macroinvertebrates and fish, and the extent of invasive species) and for examining human impacts on natural resources.

Eleven indices were calculated for this assessment. Six indices address habitat extent (i.e., the amount of natural habitat occurring in the watershed and along wetlands and waterbodies) and four indices deal with habitat disturbances (emphasizing human alterations to streams, wetlands, and terrestrial habitats), whereas the remaining index is a composite index integrating results from the other ten indices and reflecting the overall natural condition of the watershed. The six "natural" habitat extent indices are "natural" cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. The four "habitat disturbance indices" involve dammed stream flowage, channelized stream flowage, wetland disturbance, and habitat fragmentation by roads. The last index - "composite natural habitat integrity index" - is comprised of the weighted sum of all the other indices, with the disturbance indices subtracted from the habitat extent indices to yield an overall "natural habitat integrity" score for a watershed or subbasin. All indices have a maximum value of 1.0 and a minimum value of zero. For the habitat extent indices, the higher the value, the more habitat available. For the disturbance indices, the higher the score, the more disturbance.

For purposes of this study, "natural habitats" are defined as areas where significant human activity is limited to activities such as nature observation, hiking, hunting, fishing, or timber harvest, and where vegetation is allowed to grow for many years without annual harvesting of vegetation or fruits and berries for commercial purposes. While natural habitats are essentially plant communities represented by forests, meadows, shrub thickets, and wetlands where resident and migratory wildlife find food, shelter, and water, they are not restricted to pristine habitats and may include managed habitats (e.g., commercial forests and wildlife impoundments), and forests, fields, and thickets adjoining residential properties, plus wetlands now colonized by invasive species (e.g., Phragmites australis or Lythrum salicaria). “Natural vegetation” is the plant community growing in these habitats.

Natural habitat integrity is broadly defined as conditions where “natural habitat” is typically allowed to exist for many years, without great disturbance or alteration by humans. This is quite different from the concept of biological integrity proposed by Angermeier and Karr (1994) emphasizing conditions with little or no human influence. The indices do not include certain qualitative information on the condition of existing habitats as reflected by the presence, absence, or abundance of invasive species or the degree of forest fragmentation, or contaminant concentration and availability. The level of effort required to inject more qualititative data into the analysis may preclude their use in remotely-sensed ecological assessments. Weighting of natural woodlands versus commercial forests may be a practical option for this type of assessment, but it was not explored. Another consideration would be establishment of minimum size thresholds to determine what constitutes a viable “natural habitat” for analysis (e.g., 0.04 hectare/0.1 acre patch of forest or 0.4 hectare/1 acre minimum?). Other indices (e.g., index of ditching density for agricultural and silvicultural lands) may also be useful for water quality assessments.

Habitat Extent Indices

These indices provide an assessment of the amount of “natural vegetation” or “natural habitat” that occurs in a watershed, including strategic locations important for water quality and aquatic/wetland wildlife. Data for the indices come from analyses of the land use/cover and wetlands geospatial data for the watershed. The following areas are emphasized: the entire watershed, stream and river corridors, vegetated wetlands and their buffers, and pond and lake buffers. The extent of standing waterbodies is also included to provide information on the quantity of aquatic habitat in the watershed.

The *Natural Cover Index* (I_{NC}) is the proportion of a watershed that is wooded or “natural” open land (e.g., emergent wetlands, “old fields,” or sand dunes, but not cropland, hayfields, lawns, turf, or pastures), excluding open water.

> $I_{NC} = A_{NV}/A_W$, where A_{NV} (area in “natural” vegetation) equals the area of the watershed♣s land surface in ■natural• vegetation and A_W is the total land surface area of the watershed (excluding open water).
>
> Significance of index: provides information on how much of a watershed is not developed and may be serving as important wildlife habitat.

The *River-Stream Corridor Integrity Index* (I_{RSCI}) is derived by considering the condition of the land bordering perennial rivers and streams.

> $I_{RSCI} = A_{VC}/A_{TC}$, where A_{VC} (vegetated river-stream corridor area) is the area of the river-stream corridor that is colonized by ■natural vegetation• and A_{TC} (total river-stream corridor area) is the total area of the river-stream corridor.
>
> Significance of index: provides information on the status of vegetated riparian corridors.

The width of the river-stream corridor may be varied to suit project goals, but a 200-meter corridor (100m on each bank of the river or stream) was used for this study due to interest in wildlife habitat. Note that these corridors include banks of impounded sections of rivers and streams, so that a continuous river or stream corridor is evaluated. The corridor area does not include the waterbody. For the Hackensack watershed, the index was applied to nontidal rivers and streams for assessing the composite natural habitat integrity index.

The *Wetland Buffer Integrity Index* (I_{WB}) measures the condition of wetland buffers within a specified distance (e.g., 100m) of mapped vegetated wetlands for a watershed.

> $I_{WB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.
>
> Significance of index: provides information on vegetated buffers around wetlands that are important for wildlife and for reducing impacts to wetland water quality from surface runoff.

This buffer is drawn around existing vegetated wetlands and while the buffer zone may include open water, the buffer index focuses on land areas that are capable of supporting free-standing vegetation. For the Hackensack watershed, a 100m buffer was examined.

The *Pond and Lake Buffer Integrity Index* (I_{PLB}) addresses the status of buffers of a specified width around these standing waterbodies (excluding instream impoundments that are part of the river-stream corridor integrity index):

> $I_{PLB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.
>
> Significance of index: documents the condition of vegetation in a zone surrounding these waterbodies which is important for both water quality and aquatic life (buffer from impacts associated with adjacent urban/suburban development, agriculture, and other human actions).

Vegetated ponds are mapped as a vegetated wetland type and their buffers are not included in this analysis, but instead are evaluated as wetland buffers. For the Hackensack River watershed analysis, a 100m buffer was examined.

The *Wetland Extent Index* (I_{WE}) compares the current extent of vegetated wetlands (excluding nonvegetated, open-water wetlands) to the estimated historic extent.

$I_{WE} = A_{CW}/A_{HW}$, where A_{CW} is the current area of vegetated wetland in a watershed and A_{HW} is the historic vegetated wetland area in the watershed.

Significance of index: gives historical perspective on wetland loss.

The I_{WE} is an approximation of the extent of the original wetland acreage remaining in a watershed. Farmed wetlands are included where cultivation is during droughts only, since they are likely to support ■natural vegetation• during normal and wet years. Where farmed wetlands are cultivated more or less annually, they are not included in the area of vegetated wetland, since they lack "natural vegetation" in most years and only minimally function as wetland. Hydric soil data are used to generate the historic extent of wetlands. To calculate the wetland extent index for the watershed and subbasins hydric soils data were available for all counties portion of the watershed except Hudson; a historic map of the Hackensack Meadowlands from 1889 was used for this area (Tiner et al. 2002).

The *Standing Waterbody Extent Index* (I_{SWE}) addresses the current extent of standing fresh waterbodies (e.g., lakes, reservoirs, and open-water wetlands - ponds) in a watershed relative to the historic area of such features.

$I_{SWE} = A_{CSW}/A_{HSW}$, where A_{CSW} is the current standing waterbody area and A_{HSW} is the historic standing waterbody area in the watershed.

Significance of index: gives perspective on changes in waterbody area (historic vs. today).

From a practical standpoint, this index is estimated. For most areas, including the Hackensack watershed, a net gain in ponds and impoundments has occurred over time. Every national wetland trend study (Frayer et al. 1983, Tiner 1984, Dahl and Johnson 1991, Dahl 2000) has shown an increase in pond area as ponds are constructed for a multitude of purposes. For these situations, the I_{SWE} value is 1.0+ indicating a gain in this aquatic resource and no specific calculations necessary; a value of 1.0 is then used for determining the composite natural habitat integrity index for the study area. In geographic areas where significant loss of open water has occurred, an estimate will need to be derived from available sources (including historic maps).

<u>Habitat Disturbance Indices</u>

A set of four indices have been developed to address alterations to natural habitats. For these indices, a value of 1.0 is assigned when all of the streams or existing wetlands have been modified.

The *Dammed Stream Flowage Index* (I_{DSF}) highlights the direct impact of damming on rivers and streams in a watershed.

> $I_{DSF} = L_{DS}/L_{TS}$, where L_{DS} is the length of perennial streams impounded by dams (combined pool length) and L_{TS} is the total length of perennial streams in the watershed (including the length of instream pools).
>
> Significance of index: reveals how much of the stream system has been dammed.

Note that the total stream length used for this index will be greater than that used in the channelized stream length index, since the latter emphasizes existing streams and excludes dammed segments. For this project, this index was applied only to linear streams (not rivers); in the future, this index should be expanded to include the entire river-stream length (i.e., the Dammed River-Stream Flowage Index).

The *Channelized Stream Length Index* (I_{CSL}) is a measure of the extent of stream channelization within a watershed.

> $I_{CSL} = L_{CS}/L_{TS}$, where L_{CS} is the channelized stream length and L_{TS} is the total stream length for the watershed.
>
> Significance of index: documents the magnitude of stream channelization.

Since this index addresses channelization of existing streams, it focuses on the linear streams. The index will usually emphasize perennial streams as it does for the Hackensack study, but could be expanded to include intermittent streams, if desirable. The total stream length does not include the length of: 1) artificial ditches excavated in farm fields and forests, 2) dammed sections of streams, and 3) polygonal portions of rivers. Channelization of the latter may be represented by a separate index or combined with this index to form a Channelized River/Stream Length Index.

The *Wetland Disturbance Index* (I_{WD}) focuses on alterations within existing wetlands. As such, it is a measure of the extent of existing wetlands that are diked/impounded, ditched, excavated, or farmed.

> $I_{WD} = A_{DW}/A_{TW}$, where A_{DW} is the area of disturbed or altered wetlands and A_{TW} is the total wetland area in the watershed.
>
> Significance of index: identifies the degree to which existing wetlands have been altered by human actions.

Wetlands are represented by both vegetated and nonvegetated (e.g., shallow ponds) types including natural and created wetlands. Since the focus of analysis is on ■natural habitat,• diking or excavating wetlands (or portions thereof) is viewed as an adverse action. It is recognized, however, that many such wetlands serve as valuable wildlife habitats (e.g., waterfowl impoundments), despite such alteration.

The *Habitat Fragmentation by Road Index* (I_{HF}) attempts to address habitat fragmentation by roads.

> $I_{HF} = A_R/A_W \times 16$, where A_R is the area of roads (interstates, state/county and other roads) and A_W is the total land area of the watershed.
>
> Significance of index: indicates habitat fragmentation by roads, but likely reflects degradation of water quality, and terrestrial and aquatic ecosystems from associated development.

Since road area will never equal 100 percent of a watershed, a multiplier was created to increase the index value to a level of relevance for the composite index (remotely-sensed index of natural habitat integrity). A multiplier of 16 was established based on examination of road density in a portion of Jersey City, NJ with extremely high road density (0.06 road area/city area); multiplying by 16 would yield an index value near 1.0 (the estimated maximum road area/unit area). If this multiplier yields an index value greater than 1.0, use 1.0 for the value when computing the composite index. (Note: This would only happen if an entire watershed or subbasin had higher road density than Jersey City, NJ which would be a rare situation.)

While limited to road fragmentation, this index serves a surrogate for habitat fragmentation and degradation. Two watersheds may have the same amount of natural habitat, but may differ in the extent of roads. Although not the only human action that causes habitat fragmentation, road density is closely correlated to degraded ecosystems (Miller et al. 1996, Quigley and Arbelbide 1997, Forman and Alexander 1998, Forman 2000, and Trombulak and Frissell 2000). Moreover, adverse impacts from other development (e.g., urban and suburban) are likely related to the extent of roads, especially paved roads. More detailed assessments of habitat fragmentation, including mean patch size, patch density, edge density, and total core area, could be performed, if necessary.

For the Hackensack watershed study, we used the same road widths used in prior studies (Tiner 2004) to calculate A_R: interstates (2 lanes/direction) - 12.1m, state roads (2 lanes; 1 lane/direction) - 12.1m, county/local roads (2 lanes; 1 lane/direction) - 11.5m, and dirt roads (2-lanes) - 6.7m. These widths tended to match well with similar roads in the Hackensack watershed. Road widths were applied to road lengths to calculate area of roads for the study area.

Composite Habitat Integrity Index for the Watershed

The *Composite Natural Habitat Integrity Index* (I_{CNHI}) is a combination of the preceding indices. It seeks to express the overall condition of a watershed in terms of its potential ecological integrity or the relative intactness of ▪natural• plant communities and waterbodies, without reference to specific qualitative differences among these communities and waters. Variations of I_{CNHI} may be derived by considering buffer zones of different widths around wetlands and other aquatic habitats (e.g., $I_{CNHI\ 100}$ or $I_{CNHI\ 200}$) and by applying different weights to individual indices or by separating or aggregating various indices (e.g., stream corridor integrity index, river corridor integrity index, or river-stream corridor integrity index). The weighting of the indices come from Tiner (2004) and although subjective, the results of this analysis are comparable among the subbasins examined. The same weighting scheme must be used whenever comparisons of this index are made between and within watersheds.

For the analysis of Hackensack River watershed, the following formula was used to determine this composite index:

> $I_{CNHI\ 100} = (0.5 \text{ x } I_{NC}) + (0.125 \text{ x } I_{RSCI200}) + (0.125 \text{ x } I_{WB100}) + (0.05 \text{ x } I_{PLB100}) + (0.1 \text{ x } I_{WE})$, $+ (0.1 \text{ x } I_{SWE}) - (0.1 \text{ x } I_{DSF}) - (0.1 \text{ x } I_{CSL}) - (0.1 \text{ x } I_{WD}) - (0.1 \text{ x } I_{HF})$, where the condition of a 100m buffer is used throughout.
>
> Significance of index: gives an overview of the condition of the watershed relative to the existence of “natural” habitat and a measure that can be compared with other watersheds.

The indices were applied to the watershed as a whole and to individual subbasins.

Appropriate Use of this Report

The report provides a basic wetland characterization, a preliminary assessment of wetland functions, and a remotely-sensed assessment of “natural habitat” integrity for the Hackensack River watershed. Keeping in mind the limitations mentioned previously, the results are an initial screening of the watershed's wetlands to designate wetlands that may have a significant potential to perform different functions and to assess the general condition or state of “natural habitat” throughout the basin. The targeted wetlands have been predicted to perform a given function at a significant level presumably important to the watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated.

While the results are useful for gaining an overall perspective of a watershed's wetlands and their relative importance in performing certain functions, the report does not identify differences among wetlands of similar type and function. The latter information is often critical for making decisions about wetland acquisition and designating certain wetlands as more important for preservation versus others with the same classification.

The report is useful for general natural resource planning, as a screening tool for prioritization of wetlands (for acquisition or strengthened protection), as an educational tool (e.g., helping the public and nonwetland specialists better understand the functions of wetlands and the relationships between wetland characteristics and performance of individual functions), and for characterizing the differences among wetlands in terms of both form and function within a watershed.

Results

The results are presented for the entire watershed and for each of its 19 subbasins. The watershed findings consist of a summary of wetland types, a preliminary assessment of functions for wetlands in the Hackensack watershed, and an assessment of the "natural habitat integrity" derived from remote sensing techniques. Data for corresponding subbasins are summarized in this section while the detailed results presented in tabular form in Appendix B.

Maps

Maps are presented in a separate folder and are hyperlinked to the report. A series of 16 maps was produced for the Hackensack River watershed with subbasin boundaries shown. All maps were produced at a scale of 1:75,000 for this report. A list of the 16 maps follows: Map 1 - Wetlands and Deepwater Habitats Classified by NWI Types, Map 2 - Wetlands Classified by Landscape Position, Map 3 - Wetlands Classified by Landform, Map 4 - Wetlands Classified by Landscape Position and Landform, Map 5 – Potential Wetlands of Significance for Surface Water Detention, Map 6 - Potential Wetlands of Significance for Streamflow Maintenance, Map 7 - Potential Wetlands of Significance for Nutrient Transformation, Map 8 - Potential Wetlands of Significance for Sediment and Other Particulate Retention, Map 9 – Potential Wetlands of Significance for Coastal Storm Surge Detention, Map 10 - Potential Wetlands of Significance for Shoreline Stabilization, Map 11 - Potential Wetlands of Significance for Fish and Shellfish Habitat, Map 12 - Potential Wetlands of Significance for Waterfowl/Waterbird Habitat, Map 13 - Potential Wetlands of Significance for Other Wildlife Habitat, Map 14 – Potential Wetlands of Significance for the Conservation of Biodiversity, Map 15 – Extent of "Natural Cover" in the Hackensack River Watershed, and Map 16 – Condition of River and Stream Corridors.

Watershed Findings

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Hackensack watershed had nearly 9,650 acres of wetlands (including ponds) (Table 3; Map 1). Estuarine emergent wetlands were the predominant wetland type comprising 42 percent of the watershed's wetlands. Palustrine forested wetlands were next ranked in abundance, accounting for 33 percent of all wetlands. Tidal flats (estuarine unconsolidated shore) associated with the Hackensack Meadowlands were third-ranked with about 13 percent of the acreage.

Wetlands by LLWW Types

The wetland acreage based on LLWW classification was 9,268 acres (excluding ponds) or 9,623.5 acres including ponds (Table 4). Some waterbodies in the 10-20 acre size range that were classified as palustrine unconsolidated bottoms on the NWI maps were reclassified as lakes since they are likely deeper than 6.6 feet at low water. This reduced the wetland acreage of the Hackensack watershed by about 27 acres (see Table 3).

Since the Hackensack Meadowlands is the most prominent wetland in the watershed, it was not surprising that most (56%) of the wetland acreage was associated with the estuary (estuarine landscape position; Map 2). This figure included tidal freshwater wetlands contiguous with salt and brackish marshes of the estuary. Nearly 25 percent ot the watershed's wetland acreage was associated with rivers and streams and almost 5 percent contiguous with lakes (lentic). Eleven percent of the wetland acreage was represented by terrene wetlands (headwater stream source and isolated types), with the remaining 4 percent being ponds.

From the landform perspective, basin wetlands were most extensive, accounting for 57 percent of the wetland acreage (excluding ponds; Map 3 and Map 4). Many of these wetlands were estuarine wetlands whose tidal sheet flow has been diminished somewhat due to road construction (causeways and bridges). Fringe wetlands were second-ranked comprising 26 percent of the acreage. Flats made up 12 percent of the landform acreage, while floodplains associated with rivers accounted for four percent and slopes comprised one percent.

Considering water flow path, 61 percent of the wetland acreage was bidirectional-tidal and 26 percent was throughflow. Outflow types accounted for only seven percent of the acreage and nearly five percent was isolated. Almost two percent of the acreage was classified as bidirectional (associated with lakes/reservoirs) while 276 acres of the throughflow ponds were associated with lake/reservoir basins.

For the 347 ponds identified (355.7 acres), nearly 70 percent of the acreage was either throughflow or isolated (31.7% throughflow-perennial, 2.8% throughflow-intermittent, and 34.5% isolated). About 16 percent of the pond acreage had bidirectional water flow and all but 0.2 acres of this was tidally influenced. Outflow ponds accounted for 14 percent of the pond acreage and only one percent of the pond acreage was subjected to inflow.

Table 3. Wetlands classified by NWI types for the Hackensack River watershed.

NWI Wetland Type	Acreage	% of Total Acreage
Estuarine Wetlands		
Emergent	4,019.9	
Emergent/Scrub-Shrub	13.8	
(subtotal Emergent)	*(4,033.7)*	41.8
Scrub-Shrub	1.6	<0.1
Unconsolidated Shore	1,212.1	12.6
---------------------------------------	--------------	------
Estuarine Subtotal	5,247.4	54.4
Palustrine Wetlands		
Emergent	483.7	
Emergent/Scrub-Shrub	116.7	
(subtotal Emergent)	*(600.4)*	13.6
Forested, Broad-leaved Deciduous	3,033.5	
Forested, Mixed	2.6	
Forested, Needle-leaved Evergreen	2.6	
Forested, Dead	80.3	
Forested/Scrub-Shrub	49.0	
Forested/Emergent	29.6	
(subtotal Forested)	*(3,197.5)*	33.1
Scrub-Shrub, Deciduous	102.8	
Scrub-Shrub/Emergent	43.3	
Scrub-Shrub/Forested	75.2	
(subtotal Scrub-Shrub)	*(221.3)*	2.3
Unconsolidated Bottom	375.6	
Unconsolidated Shore	7.3	
(subtotal nonvegetated)	*(382.9)*	4.0
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Palustrine Subtotal	4,402.1	45.6
GRAND TOTAL (ALL WETLANDS)	9,649.5	

Table 4. Wetlands in the Hackensack River watershed classified by LLWW types.

Landscape Position	Landform	Water Flow	Acreage
Estuarine (ES)	Fringe (FR)	Bidirectional-tidal (BT)	2,185.7
	Basin (BA)	Bidirectional-tidal (BT)	3,193.9
	Island (IL)	Bidirectional-tidal (BT)	1.8
	Total Estuarine		*5,381.4*
Lentic (LE)	Basin (BA)	Bidirectional (BI)	55.5
		Throughflow (TH)	135.8
		(subtotal)	*(191.3)*
	Flat (FL)	Bidirectional (BI)	62.9
		Isolated (IS)	3.3
		Throughflow (TH)	75.4
		(subtotal)	*(141.6)*
	Fringe (FR)	Bidirectional (BI)	55.7
		Throughflow (TH)	61.1
		(subtotal)	*(116.8)*
	Total Lentic		*449.7*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	382.7
	Fringe (FR)	Bidirectional-tidal (BT)	79.5
		Throughflow (TH)	6.9
	Total Lotic River		*469.1*
Lotic Stream (LS)	Basin (BA)	Bidirectional-tidal (BT)	126.7
		Throughflow (TH)	1,140.5
		(subtotal)	*(1,267.2)*
	Flat (FL)	Bidirectional-tidal (BT)	35.5
		Throughflow (TH)	592.1
		(subtotal)	*(627.6)*
	Fringe (FR)	Throughflow (TH)	5.1
	Slope (SL)	Throughflow (TH)	7.7
	Total Lotic Stream		*1,907.6*
Terrene (TE)	Basin (BA)	Isolated (IS)	270.1
		Outflow (OU)	368.9
		(subtotal)	*(639.0)*
	Flat (FL)	Isolated (IS)	107.8
		Outflow (OU)	229.9
		(subtotal)	*(337.7)*
	Slope (SL)	Isolated (IS)	42.4
		Outflow (OU)	40.9
		(subtotal)	*(83.3)*
	Total Terrene		*1,060.0*
TOTAL LLWW Types*			9,267.8

*Does not include 347 ponds that totaled 355.7 acres.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Hackensack River watershed are given in Table 5. Refer to the maps for locations of these wetlands.

Nearly all of the remaining wetland acreage (>95%) in the watershed was deemed potentially significant for surface water detention and sediment and other particulate retention. Three of the other functions were predicted to be performed by more than 80 percent of the acreage: nutrient transformation (84%), provision of other wildlife habitat (83%), and conservation of biodiversity (82%), with a fourth function – provision of fish and shellfish habitat – rated just below 80 percent (79.5%). Over half of the conservation of biodiversity function was attributed to the presence of the Hackensack Meadowlands – one of the largest remaining urban wetlands in the northeastern United States and one that is located in a key position along the Atlantic Flyway and therefore vitally important for migratory birds. Over 250 species of birds have been observed in these wetlands. Other wetlands recognized as important for biodiversity included large complexes greater than 100 acres, headwater wetlands, beaver-influenced wetlands, lakeside wetlands, wetlands in large complexes along rivers and streams, freshwater tidal wetlands, and potential woodland vernal pools. The Hackensack watershed wetlands also provided habitat for waterfowl and other waterbirds at significant levels (71%). An additional 1,744 acres along streams (18% of the acreage) were rated as important for fish and shellfish by providing shade over streams. Over 70 percent of the wetland acreage was predicted to be important for shoreline stabilization, while 58 percent was significant for coastal storm surge detention. Only 30 percent of the wetland acreage was located in headwater positions that serve to maintain streamflow.

Table 5. Predicted wetland functions for the Hackensack River watershed. Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention (Map 5)	High	7740.1	80.4
	Moderate	1746.7	18.2
	Total	*9486.8*	*98.6*
Streamflow Maintenance (Map 6)	High	1118.4	11.6
	Moderate	1795.9	18.7
	Total	*2914.3*	*30.3*
Nutrient Transformation (Map 7)	High	6687.5	69.5
	Moderate	1367.0	14.2
	Total	*8054.5*	*83.7*
Sediment and Other Particulate Retention (Map 8)	High	6998.3	72.7
	Moderate	2204.4	22.9
	Total	*9202.7*	*95.6*
Coastal Storm Surge Detention (Map 9)	High	5623.1	58.4
Shoreline Stabilization (Map 10)	High	7034.6	73.1
	Moderate	38.1	0.4
	Total	*7072.7*	*73.5*
Fish and Shellfish Habitat (Map 11)	High	1751.8	18.2
	Moderate	4132.8	42.9
	Shading	1774.6	18.4
	Total	*7659.2*	*79.5*
Waterfowl and Waterbird Habitat (Map 12)	High	1907.5	19.8
	Moderate	3827.8	39.8
	Wood Duck	1122.5	11.7
	Total	*6857.8*	*71.3*
Other Wildlife Habitat (Map 13)	High (large complex)	5790.3	60.2
	High (small diverse wetland)	864.3	9.0
	Moderate	1401.7	14.6
	Total	*8056.3*	*83.8*

Table 5 (cont'd).

Conservation of Biodiversity (Map 14)	100-acre + wetland complex	721.7	7.5
	Beaver-influenced wetland	14.1	0.1
	Meadowlands wetlands	5238.5	54.4
	Estuarine emergent wetland (not Phragmites)	5.1	0.1
	Headwater wetland	1004.4	10.4
	Lentic Fringe or Basin wetland	220.7	2.3
	Lotic wetland complex	593.6	6.2
	Seasonally flooded-tidal wetland (not Phragmites)	85.3	0.9
	Possible vernal pool	2.5	<0.1
	Total	*7885.9*	*81.9*

Remotely-sensed Indices of "Natural Habitat Integrity"

The generally poor condition of the Hackensack watershed is reflected in the natural habitat integrity index scores (Table 6). The composite index score of 0.20 indicates a significantly modified watershed which is no surprise given that three-quarters of the watershed is urbanized (Map 15). The overall landscape is typically devoid of natural vegetation, with only 25 percent of the watershed in some kind of "natural cover" in 1995 (natural cover index score of 0.25). The remaining vegetated regions of the watershed are located in the Meadowlands, around Oradell Reservoir, around a number of streams (including Overpeck Creek), and in headwater positions in the northern portion of the watershed.

The predominant urban-suburban landscape generated low scores for the habitat extent indices (Table 6). About 35 percent of the 100m river-stream corridor was colonized by vegetation (Map 16), whereas 27 percent of the 100m buffer around mapped wetlands was in natural cover. The pond and lake buffer appeared to be in somewhat better condition with 44 percent vegetated. The watershed has lost an estimated 64 percent of its original wetlands and as of 1995, only 36 percent of pre-settlement wetland acreage remained (as reflected by the wetland extent index score of 0.36). In contrast, waterbodies have increased due to human activities (as reflected by a standing waterbody extent index score of 1.0). Numerous ponds, reservoirs (e.g., Oradell Reservoir), and dammed lakes have been built in the watershed since European settlement.

As expected, the aquatic resources within the watershed have been significantly disturbed and the high disturbance index scores for wetland disturbance and habitat fragmentation by roads bear this out. Fifty-nine percent of the wetlands altered to some degree. Road construction and accompanying urban and suburban development has left the Hackensack watershed a fragmented landscape with only remnants of its original natural habitat in place. In addition, 16 percent of the river/stream miles have been dammed and 33 percent of the stream miles have been channelized.

Table 6. Scores for remotely-sensed indices of "natural habitat integrity" for the Hackensack River watershed. *Note: The scores for these indices reflect the percent of the subject area that is in "natural vegetation."

Index	**Score**
Habitat Extent Indices	
Natural Cover Index (Map 15)*	0.25
River/Stream Corridor Integrity Index (Map 16)*	0.35
Wetland Buffer Integrity Index*	0.27
Pond/Lake Buffer Integrity Index*	0.44
Wetland Extent Index	0.36
Standing Waterbody Extent Index	1.00
Habitat Disturbance Indices	
Dammed River/Stream Flowage Index (Map 16)	0.16
Channelized Stream Length Index	0.33
Wetland Disturbance Index	0.59
Habitat Fragmentation by Road Index	0.51
Composite Index	0.20

Subbasin Findings

The detailed findings for each subbasin are given in a series of tables in Appendix B. Subbasins are listed alphabetically. Highlights are given below and in Tables 7 through 11. (Note: Totals for each subbasin may differ from those reported in an earlier report on the Hackensack Meadowlands District wetlands because the subbasins may include an area slightly larger than that contained within the District).

Wetland Characterization

Wetlands by NWI Types

Three subbasins contained the majority of the watershed's wetland acreage due to the abundance of estuarine wetlands: Hackensack River Route 3 to Bellman's Creek, Hackensack River Amtrak Bridge to Route 3, and Berry's Creek below Paterson Avenue (Table 7). Combined these subbasins accounted for 40 percent of the total wetland acreage and 72 percent of the salt and brackish wetland acreage. Palustrine wetlands were best represented in three subbasins with each having more than 500 acres of these types: Hackensack-Nauranshaun Confluence, Hackensack River Oradell to Tappan Bridge, and De Forest Lake. Their freshwater wetland acreage comprised 37 percent of the watershed's palustrine acreage.

Wetlands by LLWW Types

The Hackensack-Nauranshaun Confluence subbasin had the most acreage of wetlands associated with reservoirs and lakes (lentic wetlands) and also ranked high in the extent of streamside wetlands (lotic stream) and terrene wetlands (Table 8). Lotic river wetlands were best represented in three subbasins: Hackensack River above Tappan Bridge, Pascack Brook above Westwood Gage, and Hackensack River Fort Lee to Oradell Gage. They accounted for 76 percent of the watershed's riverside wetlands. Four subbasins had more than 200 acres of streamside wetlands (lotic stream), with Berry's Creek above Paterson Avenue will just slightly fewer acres (196). Terrene wetlands were most extensive in Hackensack River Oradell to Tappan Bridge while three other subbasins had more than 100 acres of these types. Estuarine wetlands were most abundant in three subbasins (same as listed by NWI types).

Table 7. Wetland acreage summaries by NWI system for subbasins of the Hackensack River watershed. The percent of each subbasin occupied by wetlands is given along with the percent of the Hackensack's wetlands that these wetlands represent and a ranking of subbasins relative to wetland acreage.

Subbasin	**Estuarine Acreage**	**Palustrine Acreage**	**Total Acreage**	**Percent of Subbasin**	**Percent of Hackensack Wetland Area**	**Rank**
Berry's Creek above Paterson Avene	83.8	379.5	463.3	12.1	4.8	9
Berry's Creek below Paterson Avenue	909.3	42.1	951.4	24.8	9.9	3
Coles Brook/Van Saun Mill Brook	--	123.7	123.7	2.8	1.3	16
De Forest Lake	--	506.0	506.0	2.9	5.2	8
Dwars Kill	--	408.0	408.0	11.6	4.2	10
Hackensack-Nauranshaun Confluence	--	596.4	596.4	5.5	6.2	6
Hackensack R. – Amtrak Bridge to Rt. 3	1431.3	47.9	1479.2	23.2	15.3	1
Hackensack R. – Bellman's Creek to Fort Lee Road	651.7	55.6	707.3	11.3	7.3	4
Hackensack R. below Amtrak Bridge	563.1	89.9	653.0	9.6	6.8	5
Hackensack R. – Ft. Lee to Oradell Gage	--	118.0	118.0	3.0	1.2	17
Hackensack R. – Rt. 3 to Bellman's Creek	1445.6	9.6	1455.2	28.4	15.1	2
Hackensack R. above Tappan Bridge	--	397.4	397.4	5.3	4.1	11
Hackensack R. – Oradell to Tappan Bridge	--	510.6	510.6	6.5	5.3	7
Hirshfeld Brook	--	30.0	30.0	1.0	0.3	19
Overpeck Creek	162.6	149.5	312.1	2.8	3.2	13
Pascack Brook above Westwood Gage	--	301.7	301.7	3.3	3.1	14
Pascack Brook below Westwood Gage	--	337.6	337.6	6.2	3.5	12
Tenakill Brook	--	202.3	202.3	3.6	2.1	15
Upper Pascack Brook	--	96.4	96.4	2.1	1.0	18

Table 8. Wetlands by landscape position for subbasins of the Hackensack River watershed.

Subbasin	**Estuarine Acreage**	**Lentic Acreage**	**Lotic River Acreage**	**Lotic Stream Acreage**	**Terrene Acreage**	**Total Acres**
Berry's Creek above Paterson Avene	102.6	--	3.0	196.3	157.0	458.9
Berry's Creek below Paterson Avenue	922.9	--	--	--	1.7	924.6
Coles Brook/Van Saun Mill Brook	--	--	3.9	92.6	19.8	116.3
De Forest Lake	--	45.1	--	280.0	114.0	439.1
Dwars Kill	--	84.8	--	240.8	77.3	402.9
Hackensack-Nauranshaun Confluence	--	211.5	23.9	204.2	120.2	559.8
Hackensack R. – Amtrak Bridge to Rt. 3	1447.4	--	--	1.6	13.5	1462.5
Hackensack R. – Bellman's Creek to Fort Lee Road	675.9	--	--	16.7	5.6	698.2
Hackensack R. below Amtrak Bridge	609.1	--	--	--	9.1	618.2
Hackensack R. – Ft. Lee to Oradell Gage	1.0	--	79.8	13.5	15.4	109.7
Hackensack R. – Rt. 3 to Bellman's Creek	1453.7	--	--	--	--	1453.7
Hackensack R. above Tappan Bridge	--	5.8	148.2	145.2	71.0	370.2
Hackensack R. – Oradell to Tappan Bridge	--	3.3	31.4	248.3	205.8	488.8
Hirshfeld Brook	--	--	--	26.34	--	26.3
Overpeck Creek	168.8	1.3	0.5	82.0	30.2	282.8
Pascack Brook above Westwood Gage	--	27.6	36.7	132.7	80.4	277.4
Pascack Brook below Westwood Gage	--	41.8	129.6	123.4	26.2	321.0
Tenakill Brook	--	28.6	11.6	102.7	43.9	186.8
Upper Pascack Brook	--	--	0.6	1.3	68.9	70.8

Preliminary Assessment of Wetland Functions

It is no surprise that subbasins with the most wetland acreage tended to have the most acreage of wetlands significant for wetland functions, especially those comprising the bulk of wetlands in the Hackensack Meadowlands: Hackensack River Amtrak Bridge to Route 3, Hackensack River Route 3 to Bellman's Creek, and Berry's Creek below Paterson Avenue. Wetlands located in headwater positions are important for streamflow maintenance. These wetlands were most abundant in the Hackensack-Nauranshaun Confluence and De Forest Lake subbasins; they represented about 30 percent of the wetlands important for this function. Other subbasins with substantial acreage of headwater wetlands included Hackensack River 0radell to Tappan Bridge, Hackensack River above Tappan Bridge, Pascack Brook below Westwood Gage, and Dwars Kill which when combined accounted for 44 percent of the wetlands important for streamflow maintenance. Wetlands in the Hackensack River Ft. Lee to Oradell Gage subbasin represented 12 percent of the wetlands predicted as significant for sediment and other particulate retention.

Remotely-sensed Indices of "Natural Habitat Integrity"

Examining the composite index scores, five subbasins have more "natural habitat" relative to their size than the rest (Table 11): Dwars Kill, Hackensack River Oradell to Tappan Bridge, De Forest Lake, Hackensack-Nauranshaun Confluence, and Hackensack River above Tappan Bridge. All of these subbasins had composite score of 0.30 or more. Dwars Kill had the highest composite score (0.53) which was approaching twice the value of the next ranked subbasin (Hackensack River Oradell to Tappan Bridge). Six subbasins had more than 30 percent of their land area in natural vegetation (NC score $\geq$ 0.30). Hackensack River Amtrak Bridge to Route 3 and Dwars Kill had the highest scores. River and stream corridor integrity was best in Dwars Kill, but also was fairly good in six other subbasins having scores $\geq$ 0.40. Wetland buffers were in the best condition in six subbasins having scores near 0.50 and above. Hackensack River above Tappan Bridge had the highest rating (0.60) with 60 percent of its 100m buffer being vegetated. Four subbasins had pond and lake buffer scores above 0.50, with Dwars Kill ranked first. The wetland extent index scores were high for many subbasins, especially Tenakill Brook, Pascack Brook below Westwood Gage, and Coles Brook/Van Saun Mill Brook with scores above 0.80. Surprisingly, the Hackensack River Fort Lee to Oradell Gage subbasin appeared to have all of its historic wetlands (based on a comparison with the 1880s data). The standing waterbody extent index was assumed to be 1.0 for all subbasins.

For the disturbance indices, Hackensack River Fort Lee to Oradell Gage had the most dammed stream flowage with all of its streams dammed (Table 11). Three others had dammed stream flowage index scores above 0.24. Three subbasins had all their streams channelized: Berry's Creek above Paterson Avenue, Hackensack River Amtrak Bridge to Route 3, and Hackensack River below Amtrak Bridge. Numerous subbasins had more than 50 percent of their wetlands altered by ditching, impoundment, or excavation, with Berry's Creek below Paterson Avenue being most impacted (WD score of 0.87). The least wetland disturbance was noted in subbasins of the upper Hackensack watershed: Dwars Kill, Coles Brook/Van Saun Mill Brook and Hackensack River Fort Lee to Oradell Gage. Habitat fragmentation of the watershed by roads was extensive in most subbasins. Those with the lowest level of fragmentation included Dwars Kill and Hackensack River above Tappan Bridge.

Table 9. Acreage of wetlands identified as potentially significant for various functions within each subbasin. Numbers are rounded off to nearest acre. (See Appendix B for details)

Subbasin	**Acres of Wetlands Predicted as Significant for Specific Functions**									
	SWD	**SFM**	**NT**	**SPR**	**CSD**	**SS**	**FSH**	**WWH**	**OWH**	**CB**
Berry's Creek above Paterson Avenue	449	6	458	447	265	294	216	246	458	432
Berry's Creek below Paterson Avenue	951	--	924	951	923	924	911	920	924	873
Coles Brook/Van Saun Mill Brook	124	117	116	112	2	96	68	19	116	90
De Forest Lake	490	416	438	474	--	348	296	302	438	327
Dwars Kill	393	267	403	344	--	326	230	139	403	374
Hackensack-Nauranshaun Confluence	596	431	560	573	--	449	351	327	560	302
Hackensack R. – Amtrak Bridge to Rt. 3	1476	5	687	1476	1447	673	1451	1401	687	1438
Hackensack R. – Bellman's Creek to Ft.Lee Road	707	17	569	705	676	563	670	627	569	666
Hackensack R. below Amtrak Bridge	647	--	618	650	609	611	619	584	618	533
Hackensack R. – Ft. Lee to Oradell Gage	118	22	110	110	79	93	100	97	110	87
Hackensack R. – Rt. 3 to Bellman's Creek	1455	--	1163	1455	1454	1163	1450	1375	1163	1421
Hackensack R. above Tappan Bridge	394	350	370	354	--	309	297	217	370	332
Hackensack R. – Oradell to Tappan Bridge	445	353	489	380	--	324	203	62	489	282
Hirshfeld Brook	30	30	26	30	--	26	25	22	26	23
Overpeck Creek	312	113	269	307	169	237	249	121	269	135
Pascack Brook above Westwood Gage	298	241	277	265	--	200	132	107	278	134
Pascack Brook below Westwood Gage	338	304	321	325	--	293	227	214	321	279
Tenakill Brook	178	177	187	169	--	143	106	29	187	127
Upper Pascack Brook	86	65	71	74	--	2	16	50	71	30

Codes: **SWD**-surface water detention, **SFM**-streamflow maintenance, **NT**-nutrient transformation, **SPR**-sediment and other particulate retention, **CSD**-coastal storm surge detention, **SS**-shoreline stabilization, **FSH**-provision of fish and shellfish habitat, **WWH**-provision of waterfowl and waterbird habitat, **OWH**-provision of other wildlife habitat, and **CB**-conservation of biodiversity.

Table 10. Percent of watershed's wetlands identified as significant for various functions that are located in each subbasin.

Subbasin	Percent of Hackensack Watershed's Significant Wetlands for Functions									
	SWD	**SFM**	**NT**	**SPR**	**CSD**	**SS**	**FSH**	**WWH**	**OWH**	**CB**
Berry's Creek above Paterson Avenue	4.7	0.2	5.7	4.9	4.7	4.2	2.8	3.6	5.7	5.5
Berry's Creek below Paterson Avenue	10.0	--	11.5	10.3	16.4	13.1	11.9	13.4	11.5	11.1
Coles Brook/Van Saun Mill Brook	1.3	4.0	1.4	1.2	<0.1	1.4	0.9	0.3	1.4	1.1
De Forest Lake	5.2	14.3	5.4	5.2	--	4.9	3.9	4.4	5.4	4.1
Dwars Kill	4.1	9.2	5.0	3.7	--	4.6	3.0	2.0	5.0	4.7
Hackensack-Nauranshaun Confluence	6.3	14.8	7.0	6.2	--	6.3	4.6	4.8	6.9	3.8
Hackensack R. – Amtrak Bridge to Rt. 3	15.6	0.2	8.5	16.0	25.7	9.5	18.9	20.4	8.5	18.2
Hackensack R. – Bellman's Creek to Ft. Lee Road	7.5	0.6	7.1	7.7	12.0	8.0	8.7	9.1	7.1	8.4
Hackensack R. below Amtrak Bridge	6.8	--	7.7	7.1	10.8	8.6	8.1	8.5	7.7	6.8
Hackensack R. – Ft. Lee to Oradell Gage	1.2	0.8	1.4	12.0	1.4	1.3	1.3	1.4	1.4	1.1
Hackensack R. – Rt. 3 to Bellman's Creek	15.3	--	14.4	15.8	25.9	16.4	18.9	20.0	14.4	18.0
Hackensack R. above Tappan Bridge	4.2	12.0	4.6	3.8	--	4.4	3.9	3.2	4.6	4.2
Hackensack R. – Oradell to Tappan Bridge	4.7	12.1	6.1	4.1	--	4.6	2.6	0.9	6.1	3.6
Hirshfeld Brook	0.3	1.0	0.3	0.3	--	0.3	0.3	0.3	0.3	0.3
Overpeck Creek	3.3	3.9	3.3	3.3	3.0	3.4	3.3	1.8	3.3	1.7
Pascack Brook above Westwood Gage	3.1	8.2	3.4	2.9	--	2.8	1.7	1.6	3.4	1.7
Pascack Brook below Westwood Gage	3.6	10.4	4.0	3.5	--	4.1	3.0	3.1	4.0	3.5
Tenakill Brook	1.9	6.1	2.3	1.8	--	2.0	1.4	0.4	2.3	1.6
Upper Pascack Brook	0.9	2.2	0.9	0.8	--	--	0.2	0.7	0.8	0.4

Codes: **SWD**-surface water detention, **SFM**-streamflow maintenance, **NT**-nutrient transformation, **SPR**-sediment and other particulate retention, **CSD**-coastal storm surge detention, **SS**-shoreline stabilization, **FSH**-provision of fish and shellfish habitat, **WWH**-provision of waterfowl and waterbird habitat, **OWH**-provision of other wildlife habitat, and **CB**-conservation of biodiversity.

Table 11. Remotely-sensed indices of "natural habitat integrity" for subbasins.

Subbasin	**Index Scores**										
	NC	**RSC**	**WB**	**PLB**	**WE**	**SWE**	**DSF**	**CSL**	**WD**	**HFR**	**COMP**
Berry's Creek above Paterson Avene	0.16	0.40	0.12	0.16	0.31	1.00	0.00	1.00	0.61	0.61	0.06
Berry's Creek below Paterson Avenue	0.31	0.00	0.14	0.10	0.35	1.00	0.00	0.00	0.87	0.72	0.15
Coles Brook/Van Saun Mill Brook	0.08	0.18	0.11	0.15	0.83	1.00	0.00	0.13	0.10	0.58	0.18
De Forest Lake	0.39	0.44	0.51	0.56	0.39	1.00	0.30	0.29	0.66	0.34	0.32
Dwars Kill	0.44	0.64	0.56	0.68	0.70	1.00	0.00	0.09	0.07	0.26	0.53
Hackensack-Nauranshaun Confluence	0.33	0.41	0.47	0.56	0.54	1.00	0.24	0.29	0.41	0.58	0.31
Hackensack R. – Amtrak Bridge to Rt. 3	0.45	0.03	0.04	0.22	0.16	1.00	0.00	1.00	0.55	0.56	0.15
Hackensack R. – Bellman's Creek to Fort Lee Road	0.13	0.10	0.07	0.28	0.45	1.00	0.00	0.88	0.72	0.77	0.01
Hackensack R. below Amtrak Bridge	0.16	0.10	0.33	0.41	0.27	1.00	0.00	1.00	0.77	0.82	0.02
Hackensack R. – Ft. Lee to Oradell Gage	0.07	0.33	0.11	0.07	1.00	1.00	1.00	0.03	0.10	0.54	0.13
Hackensack R. – Rt. 3 to Bellman's Creek	0.31	0.00	0.21	0.15	0.40	1.00	0.00	0.00	0.69	0.91	0.17
Hackensack R. above Tappan Bridge	0.24	0.45	0.61	0.45	0.74	1.00	0.33	0.19	0.72	0.26	0.30
Hackensack R. – Oradell to Tappan Bridge	0.27	0.47	0.50	0.54	0.73	1.00	0.06	0.24	0.63	0.31	0.33
Hirshfeld Brook	0.04	0.12	0.11	0.08	0.73	1.00	0.03	0.36	0.12	0.54	0.12
Overpeck Creek	0.12	0.22	0.34	0.27	0.36	1.00	0.09	0.56	0.36	0.69	0.11
Pascack Brook above Westwood Gage	0.23	0.41	0.26	0.39	0.59	1.00	0.09	0.09	0.41	0.41	0.27
Pascack Brook below Westwood Gage	0.16	0.35	0.19	0.27	0.84	1.00	0.05	0.45	0.18	0.36	0.24
Tenakill Brook	0.15	0.27	0.29	0.33	0.99	1.00	0.01	0.43	0.45	0.38	0.23
Upper Pascack Brook	0.20	0.08	0.49	0.36	0.24	1.00	0.08	0.67	0.34	0.40	0.17

Index Codes: **NC**-natural cover, **RSC**-river and stream corridor integrity, **WB**-wetland buffer integrity, **PLB**-pond and lake buffer integrity, **WE**-wetland extent, **SWE**-standing waterbody extent, **DSF**-dammed stream flowage, **CSL**-channelized stream length, **WD**-wetland disturbance, **HFR**-habitat fragmentation by road, and **COMP**-composite habitat integrity.

Conclusions

The Hackensack River watershed had nearly 9,650 acres of wetlands (including ponds), with over half (5,445 acres) located in the Hackensack Meadowlands. Estuarine emergent wetlands were the predominant wetland type comprising 42 percent of the watershed's wetlands. Palustrine forested wetlands were next ranked in abundance, accounting for a third of all wetlands.

From the landscape perspective, about 56 percent of the wetland acreage was associated with the estuary due to the prominence of the Hackensack Meadowlands. Nearly one-quarter of the wetland acreage was associated with rivers and streams (roughly 5% and 20%, respectively) and almost 5 percent contiguous with lakes. Eleven percent of the wetland acreage was represented by terrene wetlands (headwater stream source and isolated types), with the remaining four percent being ponds.

From the landform perspective, basin wetlands were most extensive, accounting for 57 percent of the wetland acreage (excluding ponds). Many of these wetlands were estuarine wetlands whose tidal sheet flow has been diminished somewhat due to road construction (causeways and bridges). Fringe wetlands were second-ranked comprising 26 percent of the acreage. Flats made up 12 percent of the acreage, while floodplains associated with rivers accounted for four percent and slopes comprised one percent.

Considering water flow path, 61 percent of the wetland acreage was bidirectional-tidal and 26 percent was throughflow. Outflow types (associated mostly with headwater wetlands in the upper watershed) accounted for only seven percent of the acreage. Nearly five percent of the wetland acreage was isolated and almost two percent of the acreage was classified as bidirectional (associated with lakes/reservoirs).

Functionally, nearly all of the remaining wetland acreage (>95%) in the watershed was rated as potentially significant for surface water detention (e.g., flood storage) and sediment and other particulate retention (e.g., water quality renovation). Four other functions were predicted to be performed by 80 percent or more of the acreage: provision of other wildlife habitat, nutrient transformation, conservation of biodiversity, and provision of fish and shellfish habitat. Over half of the conservation of biodiversity function was attributed to the presence of the Hackensack Meadowlands – one of the largest remaining urban wetlands in the northeastern United States. Other wetlands recognized as important for biodiversity included large complexes greater than 100 acres, headwater wetlands, beaver-influenced wetlands, lakeside wetlands, wetlands in large complexes along rivers and streams, freshwater tidal wetlands, and potential woodland vernal pools. About 70 percent of the Hackensack watershed wetlands also provided habitat for waterfowl and other waterbirds at significant levels and were rated as important for shoreline stabilization, while 58 percent was significant for coastal storm surge detention. Only 30 percent of the wetland acreage was located in headwater positions that serve to maintain streamflow.

Analysis of land use patterns in the watershed documented the generally poor condition of the Hackensack River watershed which is no surprise given that 75 percent of the watershed is urbanized. Over three centuries of population growth and land and water development in the watershed have taken their toll on the watershed's natural resources. The overall landscape is largely devoid of natural vegetation, with only 25 percent of the watershed in some kind of "natural cover" in 1995. As anticipated given the urban-suburban landscape, stream corridors and wetland buffers are generally devoid of vegetation: about 35 percent of the 100m river-stream corridor was colonized by vegetation, whereas 27 percent of the 100m buffer around mapped wetlands was in natural cover. By 1995, the watershed lost 64% of its original wetlands and the functions they provided. In contrast, waterbodies have increased due to construction of ponds, reservoirs, and dammed lakes. The aquatic resources within the watershed have been significantly altered: 16 percent of the river/stream miles have been dammed, 33 percent of the stream miles channelized, and 59 percent of the wetlands altered to some degree; pollution by runoff, discharge of municipal and industrial wastewaters, and other operations have further degraded the quality of the watershed's aquatic resources. Road construction and accompanying urban and suburban development have left the Hackensack watershed a fragmented landscape with only remnants of its original natural habitat in place.

Information from this study was used to help the Service prepare a conservation strategy for the Hackensack Meadowlands ecosystem (U.S. Fish and Wildlife Service 2007). Some key recommendations of this conservation plan were: 1) protect wetlands and their buffers in the upper Hackensack River watershed, 2) development of a comprehensive remediation and restoration plan is critical to address problems confronting the Meadowlands ecosystem, 3) increase the extent and connectivity of upland buffers, and 4) consider designating the Meadowlands as a marine/estuarine protected area.

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Appendices

Appendix A. Coding for LLWW descriptors from "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a).

Section 4. Coding System for LLWW Descriptors

The following is the coding scheme for expanding classification of wetlands and waterbodies beyond typical NWI classifications. When enhancing NWI maps/digits, codes should be applied to all mapped wetlands and deepwater habitats (including linears). At a minimum, landscape position (including lotic gradient), landform, and water flow path should be applied to wetlands, and waterbody type and water flow path to water to waterbodies. Wetland and deepwater habitat data for specific estuaries, lakes, and river systems could be added to existing digital data through use of geographic information system (GIS) technology.

Codes for Wetlands

Wetlands are typically classified by landscape position, landform, and water flow path. Landforms are grouped according to Inland types and Coastal types with the latter referring to tidal wetlands associated with marine and estuarine waters. Use of other descriptors tends to be optional. They would be used for more detailed investigations and characterizations.

Landscape Position

ES	Estuarine
LE	Lentic
LR	Lotic river
LS	Lotic stream
MA	Marine
TE	Terrene

Lotic Gradient

1	Low	
2	Middle	
3	High	
4	Intermittent	
5	Tidal	
6	Dammed	
a		lock and dammed
b		run-of-river dam
c		beaver
d		other dammed
7	Artificial (ditch)	

Lentic Type

1	Natural deep lake (see also Pond codes for possible specific types)	
a		main body
b		open empbayment
c		semi-enclosed embayment
d		barrier beach lagoon
2	Dammed river valley lake	
a		reservoir
b		hydropower
c		other
3	Other dammed lake	
a		former natural
b		artificial
4	Excavated lake	
a		quarry lake
5	Other artificial lake	

Estuary Type

1	Drowned river valley estuary	
a		open bay (fully exposed)
b		semi-enclosed bay
c		river channel
2	Bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	River-dominated estuary	
4	Rocky headland bay estuary	
a		island protected
5	Island protected estuary	
6	Shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	Tectonic	
a		fault-formed
b		volcanic-formed
8	Fjord	
9	Other	

Inland Landform

SL	Slope
SLpa	Slope, paludified
IL	Island*
ILde	Island, delta
ILrs	Island, reservoir
ILpd	Island, pond
FR	Fringe*
FRil	Fringe, island*
FRbl	Fringe, barrier island
FRbb	Fringe, barrier beach
FRpd	Fringe, pond
FRdm	Fringe, drowned river mouth
FP	Floodplain
FPba	Floodplain, basin
FPox	Floodplain, oxbow
FPfl	Floodplain, flat
FPil	Floodplain, island
IF	Interfluve
IFba	Interfluve, basin
IFfl	Interfluve, flat
BA	Basin
BAcb	Basin, Carolina bay
BApo	Basin, pocosin
BAcd	Basin, cypress dome
BApp	Basin, prairie pothole
BApl	Basin, playa
BAwc	Basin, West Coast vernal pool
BAid	Basin, interdunal
BAwv	Basin, woodland vernal
BApg	Basin, polygonal
BAsh	Basin, sinkhole
BApd	Basin, pond
BAgp	Basin, grady pond
BAsa	Basin, salt flat
BAaq	Basin, aquaculture (created)
BAcr	Basin, cranberry bog (created)
BAwm	Basin, wildlife management (created)

BAip	Basin, impoundment (created)
BAfe	Basin, former estuarine wetland
BAff	Basin, former floodplain
BAfi	Basin, former interfluve
BAfo	Basin, former floodplain oxbow
BAdm	Basin, drowned river-mouth

FL Flat

FLsa	Flat, salt flat
FLff	Flat, former floodplain
FLfi	Flat, former interfluve

*Note: Inland slope wetlands and island wetlands associated with rivers, streams, and lakes are designated as such by the landscape position classification (e.g., lotic river, lotic stream, or lentic), therefore no additional terms are needed here to convey this association.

Coastal Landform

IL Island

ILdt	Island, delta
ILde	Island, ebb-delta
ILdf	Island, flood-delta
ILrv	Island, river
ILst	Island, stream
ILby	Island, bay

DE Delta

DEr	Delta, river-dominated
DEt	Delta, tide-dominated
DEw	Delta, wave-dominated

FR Fringe

FRal	Fringe, atoll lagoon
FRbl	Fringe, barrier island
FRbb	Fringe, barrier beach
FRby	Fringe, bay
FRbi	Fringe, bay island
FRcp	Fringe, coastal pond
FRci	Fringe, coastal pond island
FRhl	Fringe, headland
FRoi	Fringe, oceanic island
FRlg	Fringe, lagoon
FRrv	Fringe, river

FRri Fringe, river island
FRst Fringe, stream
FRsi Fringe, stream island

BA Basin
BAaq Basin, aquaculture (created)
BAid Basin, interdunal (swale)
BAst Basin, stream
BAsh Basin, salt hay production (created)
BAtd Basin, tidally restricted/road (not a management area)
BAtr Basin, tidally restricted/railroad (not a management area)
BAwm Basin, wildlife management (created)
BAip Basin, impoundment (created)

Water Flow Path

PA Paludified
IS Isolated
IN Inflow
OU Outflow
OA Outflow-artificial*
OP Outflow-perennial
OI Outflow-intermittent
TH Throughflow
TA Throughflow - artificial*
TN Throughflow - entrenched
TI Throughflow - intermittent
BI Bidirectional Flow - nontidal
BT Bidirectional Flow - tidal

*Note: To be used with wetlands connected to streams by ditches.

Other Modifiers (apply at the end of the code as appropriate)

br barren
bv beaver
ch channelized flow
cl coastal island (wetland on an island in an estuary or ocean including barrier islands)
cr cranberry bog
dd drainage divide
dr partly drained
ed freshwater wetland discharging directly into an estuary
fe former estuarine wetland
fg fragmented
fm floating mat

gd groundwater-dominated (apply to Water Flow Path only)
hi severely human-induced
hw headwater
li lake island (wetland associated with a lake island)
md freshwater wetland discharging directly into marine waters
ow overwash
pi pond island border
ri river island (wetland associated with a river island)
sd surface water-dominated (apply to Water Flow Path only)
sf spring-fed
ss subsurface flow
td tidally restricted/road
tr tidally restricted/railroad

(Note: "ho" was formerly used to indicate human-induced outflow brought about by ditch construction; now this is addressed by the water flow path "OA" Outflow-Artificial.)

Codes for Waterbodies

Besides Waterbody Type, waterbodies can be classified by water flow path (for lakes and ponds), estuary hydrologic type (for estuaries), and tidal range types (for estuaries and oceans).

Waterbody Type

RV River
- 1 low gradient
  - a connecting channel
  - b canal
- 2 middle gradient
  - a connecting channel
- 3 high gradient
  - a waterfall
  - b riffle
  - c pool
- 4 intermittent gradient
- 5 tidal gradient
- 6 dammed gradient
  - a lock and dammed
  - b run-of-river dammed
  - c other dammed

ST Stream
- 1 low gradient
  - a connecting channel
- 2 middle gradient

a connecting channel
3 high gradient
a waterfall
b riffle
c pool
4 intermittent gradient
5 tidal gradient
6 dammed
a lock and dammed
b run-of-river dammed
c beaver dammed
d other dammed
7 artificial
a connecting channel
b ditch

LK Lake
1 natural lake (*see also Pond codes for possible specific types*)
a main body
b open empbayment
c semi-enclosed embayment
d barrier beach lagoon
2 dammed river valley lake
a reservoir
b hydropower
c other
3 other dammed lake
a former natural
b artificial
4 other artificial lake

(Consider using a modifier to highlight specific lakes as needed, especially the Great Lakes, e.g., LK1E for Lake Erie or LK2O for Lake Ontario, and Lake Champlain, LK1C)

EY Estuary
1 drowned river valley estuary
a open bay (fully exposed)
b semi-enclosed bay
c river channel

2 bar-built estuary
a coastal pond-open
b coastal pond-seasonally closed
c coastal pond-intermittently open
d hypersaline lagoon
3 river-dominated estuary

4 rocky headland bay estuary
a island protected
5 island protected estuary
6 shoreline bay estuary
a open (fully exposed)
b semi-enclosed
7 tectonic
a fault-formed
b volcanic-formed
8 fjord
9 other

Note: If desired, you can also designate river channel (rc), stream channel (sc),and inlet channel (ic) by modifiers. *Examples*: EY1rc = Drowned River Valley Estuary river channel; EY2ic= Bar-built estuary inlet channel. If not, simply classify all estuarine water as a single type, e.g., EY1 for Drowned River Valley or EY2 for Bar-built Estuary.

OB Ocean or Bay
1 open (fully exposed)
2 semi-protected oceanic bay
3 atoll lagoon
4 other reef-protected waters
5 fjord

PD Pond
1 natural
a bog
b woodland-wetland
c woodland-dryland
d prairie-wetland (pothole)
e prairie-dryland (pothole)
f playa
g polygonal
h sinkhole-woodland
i sinkhole-prairie
j Carolina bay
k pocosin
l cypress dome
m vernal-woodland
n vernal-West Coast
o interdunal
p grady
q floodplain
r other
2 dammed/impounded
a agriculture

a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
o		other
q		floodplain
3	excavated	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
j		mining
j1		sand/gravel
j2		coal
o		other
q		floodplain
4	beaver	
5	other artificial	

Water Flow Path

IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow-artificial*
TI	Throughflow-intermittent*
TN	Throughflow-entrenched
BI	Bidirectional-nontidal
IS	Isolated
MI	Microtidal
ME	Mesotidal
MC	Macrotidal

*Note: OA and TA are human-caused by ditches; TI is to be used along intermittent streams.

Estuarine Hydrologic Circulation Type

SW	Salt-wedge/river-dominated type
PM	Partially mixed type
HO	Homogeneous/high energy type

Other Modifiers (apply at end of code)

ch	Channelized or Dredged
dv	Diverted
ed	freshwater stream flowing directly into an estuary
fv	Floating vegetation (on the surface)
lv	Leveed
md	freshwater stream flowing directly into marine waters
sv	Submerged vegetation

Appendix B. Study findings for individual subbasins. Subbasins are listed alphabetically. A series of tables of four tables are given for each subbasin: 1) wetland acreage summary by NWI types, 2) wetland acreage summary by LLWW types, 3) preliminary assessment of wetland functions, and 4) natural habitat integrity indices.

Subbasin: Berry's Creek above Paterson Avenue

Table 1. Wetlands classified by NWI types for the Berry's Creek above Paterson Avenue subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	78.03
Emergent/Scrub-Shrub	3.15
(subtotal Emergent)	*81.18*
Scrub-Shrub	1.63
Unconsolidated Shore	0.97
Estuarine Subtotal	*83.78*
Palustrine Wetlands	
Emergent	182.45
Emergent/Scrub-Shrub	8.66
(subtotal Emergent)	*191.11*
Forested, Broad-leaved Deciduous	102.35
Scrub-Shrub, Deciduous	13.14
Scrub-Shrub/Emergent	4.73
Scrub-Shrub/Forested	63.87
(subtotal Scrub-Shrub)	*81.74*
Unconsolidated Bottom	4.33
Palustrine Subtotal	*379.53*
Riverine Wetlands	3.40
GRAND TOTAL (ALL WETLANDS)	*466.71*

Table 2. Wetlands in the Berry's Creek above Paterson Avenue subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Basin	Bidirectional-tidal (BT)	--	102.63
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	2	2.96
Lotic Stream (LS)	Basin (BA)	Bidirectional-tidal (BT)	4	126.69
		Throughflow (TH)	4	20.83
		(subtotal)	*(8)*	*(147.52)*
	Flat (FL)	Bidirectional-tidal (BT)	4	35.51
		Throughflow (TH)	2	13.27
		(subtotal)	*(6)*	*(48.8)*
	Subtotal Lotic Stream		14	196.30
Terrene (TE)				
	Basin (BA)	Isolated (IS)	6	14.44
		Outflow (OU)	5	126.43
		(subtotal)	*(11)*	*(140.87)*
	Flat (FL)	Isolated (IS)	3	1.91
		Outflow (OU)	2	1.46
		(subtotal)	*(5)*	*(3.37)*
	Slope (SL)	Outflow (OU)	1	12.84
	Subtotal Terrene		17	157.08
TOTAL LLWW Types*			33+	458.97

*Does not include 4 ponds that totaled 4.33 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages in database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Berry's Creek above Paterson Avenue subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	255.20
	Moderate	193.47
	Total	*448.67*
Streamflow Maintenance	High	5.85
	Moderate	--
	Total	*5.85*
Nutrient Transformation	High	393.01
	Moderate	65.00
	Total	*458.01*
Sediment and Other Particulate Retention	High	421.62
	Moderate	25.47
	Total	*447.09*
Coastal Storm Surge Detention	High	264.83
Shoreline Stabilization	High	294.18
	Moderate	--
	Total	*294.18*
Fish and Shellfish Habitat	High	17.93
	Moderate	168.99
	Shading	28.84
	Total	*215.76*
Waterfowl and Waterbird Habitat	High	30.42
	Moderate	186.40
	Wood Duck	29.04
	Total	*245.86*
Other Wildlife Habitat	High	389.19 (large complexes)
	High	26.61 (small diverse wetlands)
	Moderate	42.66
	Total	*458.46*
Conservation of Biodiversity	100acre+ complexes	164.00
	Meadowlands	265.37
	Headwater wetlands	2.96
	Total	*432.33*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Berry’s Creek above Paterson Avenue subbasin.

Index	Score
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.40
Wetland Buffer Integrity Index	0.12
Pond/Lake Buffer Integrity Index	0.16
Wetland Extent Index	0.31
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.61
Habitat Fragmentation by Road Index	0.61
Composite Index	0.06

Subbasin: Berry's Creek below Paterson Avenue

Table 1. Wetlands classified by NWI types for the Berry's Creek below Paterson Avenue subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	904.13
Emergent/Scrub-Shrub	4.13
Unconsolidated Shore	1.07
Estuarine Subtotal	909.33
Palustrine Wetlands	
Emergent	2.87
Emergent/Scrub-Shrub	5.85
Forested, Broad-leaved Deciduous	1.85
Scrub-Shrub/Forested	4.69
Unconsolidated Bottom	26.84
Palustrine Subtotal	42.10
Riverine Wetlands	0.49
GRAND TOTAL (ALL WETLANDS)	951.92

Table 2. Wetlands in the Berry's Creek below Paterson Avenue subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands*	Acreage
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	18.58
	Basin	Bidirectional-tidal (BT)	--	904.33
	(Subtotal Estuarine)			*922.91*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	1	1.66
TOTAL LLWW Types*			1+	924.57

*Does not include 11 ponds that totaled 26.83 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages in the database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Berry's Creek below Paterson Avenue subbasin. Click on maps to view potential wetlands of significance for each function.

Function	**Level**	**Acreage**
Surface Water Detention	High	943.97
	Moderate	7.47
	Total	*951.41*
Streamflow Maintenance	High	--
	Moderate	--
	Total	--
Nutrient Transformation	High	919.07
	Moderate	4.43
	Total	*923.50*
Sediment and Other Particulate Retention	High	942.90
	Moderate	8.52
	Total	*951.42*
Coastal Storm Surge Detention	High	922.91
Shoreline Stabilization	High	921.84
	Moderate	1.66
	Total	*923.50*
Fish and Shellfish Habitat	High	7.63
	Moderate	903.45
	Shading	--
	Total	*911.08*
Waterfowl and Waterbird Habitat	High	7.63
	Moderate	908.04
	Wood Duck	4.41
	Total	*920.08*
Other Wildlife Habitat	High	873.20
	Moderate	50.30
	Total	*923.50*
Conservation of Biodiversity	Meadowlands	872.77

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Berry’s Creek below Paterson Avenue subbasin.

Index	**Score**
Natural Cover Index	0.31
River/Stream Corridor Integrity Index	0.00
Wetland Buffer Integrity Index	0.14
Pond/Lake Buffer Integrity Index	0.10
Wetland Extent Index	0.35
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.00
Wetland Disturbance Index	0.87
Habitat Fragmentation by Road Index	0.72
Composite Index	0.15

Subbasin: Coles Brook/Van Saun Mill Brook

Table 1. Wetlands classified by NWI types for the Coles Brook/Van Saun Mill Brook subbasin.

NWI Wetland Type	**Acreage**
Palustrine Wetlands	
Emergent	2.10
Emergent/Scrub-Shrub	4.67
Forested, Broad-leaved Deciduous	109.42
Unconsolidated Bottom	7.55
Palustrine Subtotal	123.74
Riverine Wetlands	3.73
GRAND TOTAL (ALL WETLANDS)	127.47

Table 2. Wetlands in the Coles Brook/Van Saun Mill Brook subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	1	2.15
	Fringe (FR)	Bidirectional-tidal (BT)	2	1.65
	(Subtotal Lotic River)		*3*	*3.80*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	4	30.84
	Flat (FL)	Throughflow (TH)	11	61.75
	(Subtotal Lotic Stream)		*15*	*92.59*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	1	0.53
		Outflow (OU)	1	7.83
		(subtotal)	*(2)*	*(8.36)*
	Flat (FL)	Isolated (IS)	3	2.99
		Outflow (OU)	2	6.91
		(subtotal)	*(5)*	*(9.90)*
	Slope (SL)	Isolated (IS)	1	1.55
	(Subtotal Terrene)		*8*	*19.81*
TOTAL LLWW Types*			26	116.20

*Does not include 4 ponds that totaled 7.55 acres.
Note: Subtotals may be slightly different than the sum of acreages in the database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Coles Brook/Van Saun Mill Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	38.64
	Moderate	85.09
	Total	*123.73*
Streamflow Maintenance	High	89.50
	Moderate	27.21
	Total	*116.71*
Nutrient Transformation	High	40.84
	Moderate	75.34
	Total	*116.18*
Sediment and Other Particulate Retention	High	90.49
	Moderate	21.80
	Total	*112.29*
Coastal Storm Surge Detention	High	1.65
Shoreline Stabilization	High	96.39
	Moderate	--
	Total	*96.39*
Fish and Shellfish Habitat	High	1.65
	Moderate	7.55
	Shading	58.90
	Total	*68.10*
Waterfowl and Waterbird Habitat	High	1.65
	Moderate	7.55
	Wood Duck	9.60
	Total	*18.81*
Other Wildlife Habitat	High	59.29
	Moderate	56.89
	Total	*116.19*
Conservation of Biodiversity	Headwater wetlands	88.12
	Tidal fresh wetlands	1.65
	Total	*89.77*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Coles Brook/Van Saun Mill Brook subbasin.

Index	**Score**
Natural Cover Index	0.08
River/Stream Corridor Integrity Index	0.18
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.15
Wetland Extent Index	0.83
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.13
Wetland Disturbance Index	0.10
Habitat Fragmentation by Road Index	0.58
Composite Index	0.18

Subbasin: De Forest Lake

Table 1. Wetlands classified by NWI types for the De Forest Lake subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	56.92
Emergent/Scrub-Shrub	10.92
(subtotal Emergent)	*67.84*
Forested, Broad-leaved Deciduous	330.14
Forested, Needle-leaved Evergreen	2.59
Forested/Scrub-Shrub	7.98
Forested/Emergent	6.68
(subtotal Forested)	*347.39*
Scrub-Shrub, Deciduous	20.78
Scrub-Shrub/Emergent	1.99
(subtotal Scrub-Shrub)	*22.77*
Unconsolidated Bottom	66.84
Unconsolidated Shore	1.12
--	------------
Palustrine Subtotal	505.96
Riverine Wetlands	6.83
GRAND TOTAL (ALL WETLANDS)	512.79

Table 2 Wetlands in the De Forest Lake subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	7	10.45
		Throughflow (TH)	3	23.83
		(subtotal)	*10*	*34.28*
	Flat (FL)	Bidirectional (BI)	4	6.50
		Isolated (IS)	1	3.27
		(subtotal)	*5*	*9.77*
	Fringe (FR)	Bidirectional (BI)	1	1.08
	(Subtotal Lentic)		*16*	*45.13*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	28	264.09
	Flat (FL)	Throughflow (TH)	7	15.69
	Fringe (FR)	Throughflow (TH)	1	0.19
	(Subtotal Lotic Stream)		*36*	*279.97*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	34	35.01
		Outflow (OU)	9	63.67
		(subtotal)	*43*	*98.68*
	Flat (FL)	Isolated (IS)	3	2.95
		Outflow (OU)	5	12.38
		(subtotal)	*8*	*15.33*
	(Subtotal Terrene)		*51*	*114.01*
TOTAL LLWW Types*			103	439.11

*Does not include 73 ponds that totaled 50.80 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the De Forest Lake subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	325.23
	Moderate	164.35
	Total	*489.58*
Streamflow Maintenance	High	142.61
	Moderate	273.60
	Total	*416.21*
Nutrient Transformation	High	397.21
	Moderate	40.79
	Total	*438.00*
Sediment and Other Particulate Retention	High	322.38
	Moderate	151.88
	Total	*474.26*
Shoreline Stabilization	High	334.38
	Moderate	13.10
	Total	*347.75*
Fish and Shellfish Habitat	High	2.18
	Moderate	51.91
	Shading	241.66
	Total	*295.75*
Waterfowl and Waterbird Habitat	High	17.96
	Moderate	59.73
	Wood Duck	223.97
	Total	*301.66*
Other Wildlife Habitat	High	207.33 (large complexes)
	High	118.52 (small diverse wetlands)
	Moderate	112.16
	Total	*438.01*
Conservation of Biodiversity	100acre+ complexes	171.50
	Headwater wetlands	143.88
	Lentic basins/fringes	11.29
	Possible vernal pool	0.39
	Total	*327.06*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the DeForest Lake subbasin.

Index	Score
Natural Cover Index	0.39
River/Stream Corridor Integrity Index	0.44
Wetland Buffer Integrity Index	0.51
Pond/Lake Buffer Integrity Index	0.56
Wetland Extent Index	0.39
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.30
Channelized Stream Length Index	0.29
Wetland Disturbance Index	0.66
Habitat Fragmentation by Road Index	0.34
Composite Index	0.32

Subbasin: Dwars Kill

Table 1. Wetlands classified by NWI types for the Dwars Kill subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	3.19
Forested, Broad-leaved Deciduous	374.40
Forested/Scrub-Shrub	2.36
Forested/Emergent	5.23
(subtotal Forested)	*381.99*
Scrub-Shrub, Deciduous	6.16
Scrub-Shrub/Emergent	8.48
Scrub-Shrub/Forested	3.13
(subtotal Scrub-Shrub)	*17.77*
Unconsolidated Bottom	5.08
---	------------
Palustrine Subtotal	408.03
Riverine Wetlands	6.94
GRAND TOTAL (ALL WETLANDS)	414.97

Table 2. Wetlands in the Dwars Kill subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)				
	Basin (BA)	Throughflow (TH)	6	31.46
	Flat (FL)	Bidirectional (BI)	4	8.92
		Throughflow (TH)	6	44.41
		(subtotal)	*10*	*53.33*
	(Subtotal Lentic)		*16*	*84.79*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	10	135.25
	Flat (FL)	Throughflow (TH)	12	105.58
	(Subtotal Lotic Stream)		*22*	*240.83*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	5	12.60
		Outflow (OU)	2	0.70
		(subtotal)	*7*	*13.30*
	Flat (FL)	Isolated (IS)	6	36.33
		Outflow Intermittent (OI)		
		Outflow (OU)	6	27.42
		(subtotal)	*12*	*63.75*
	Slope (SL)	Isolated (IS)	1	0.28
	(Subtotal Terrene)		*19*	*77.33*
TOTAL LLWW Types*			57	402.83

*Does not include 5 ponds that totaled 5.07 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Dwars Kill subbasin.

Function	Level	Acreage
Surface Water Detention	High	224.47
	Moderate	168.14
	Total	*392.61*
Streamflow Maintenance	High	33.67
	Moderate	233.01
	Total	*266.68*
Nutrient Transformation	High	180.02
	Moderate	222.93
	Total	*402.95*
Sediment and Other Particulate Retention	High	263.75
	Moderate	80.25
	Total	*344.00*
Shoreline Stabilization	High	325.84
	Moderate	--
	Total	*325.84*
Fish and Shellfish Habitat	High	--
	Moderate	5.08
	Shading	225.13
	Total	*230.21*
Waterfowl and Waterbird Habitat	High	0.13
	Moderate	5.08
	Wood Duck	133.32
	Total	*138.53*
Other Wildlife Habitat	High	306.09 (large complexes)
	High	23.04 (small diverse wetlands)
	Moderate	73.81
	Total	*402.94*
Conservation of Biodiversity	100 acre+ wetlands	346.68
	Headwater wetlands	26.83
	Total	*373.51*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Dwars Kill subbasin.

Index	**Score**
Natural Cover Index	0.44
River/Stream Corridor Integrity Index	0.64
Wetland Buffer Integrity Index	0.56
Pond/Lake Buffer Integrity Index	0.68
Wetland Extent Index	0.70
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.09
Wetland Disturbance Index	0.07
Habitat Fragmentation by Road Index	0.26
Composite Index	0.53

Subbasin: Hackensack River - Amtrak Bridge to Route 3

Table 1. Wetlands classified by NWI types for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	655.62
Unconsolidated Shore	775.72
Estuarine Subtotal	1431.33
Palustrine Wetlands	
Emergent	21.40
Forested, Broad-leaved Deciduous	2.00
Scrub-Shrub, Deciduous	7.84
Unconsolidated Bottom	13.21
Unconsolidated Shore	3.46
Palustrine Subtotal	47.91
Riverine Wetlands	2.39
GRAND TOTAL (ALL WETLANDS)	1,481.63

Table 2. Wetlands in the Hackensack River - Amtrak Bridge to Rt. 3 subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands*	Acreage
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	962.33
	Basin	Bidirectional-tidal (BT)	--	484.36
	Island	Bidirectinal-tidal (BT)	--	0.75
	(Subtotal Estuarine)			*1447.44*
Lotic Stream (LS)				
	Flat (FL)	Throughflow (TH)	1	1.63
	(Subtotal Lotic Stream)			*1.63*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	3	2.36
		Outflow (OU)	4	8.01
		(subtotal)	*7*	*10.37*
	Flat (FL)	Outflow (OU)	1	3.14
	(Subtotal Terrene)		*8*	*13.51*
TOTAL LLWW Types*			9+	1462.58

*Does not include 14 ponds that totaled 16.67 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	1453.45
	Moderate	22.34
	Total	*1475.79*
Streamflow Maintenance	High	1.63
	Moderate	3.69
	Total	*5.32*
Nutrient Transformation	High	682.09
	Moderate	4.77
	Total	*686.86*
Sediment and Other Particulate Retention	High	682.30
	Moderate	793.80
	Total	*1476.10*
Coastal Storm Surge Detention	High	1447.44
Shoreline Stabilization	High	673.36
	Moderate	--
	Total	*673.36*
Fish and Shellfish Habitat	High	1030.90
	Moderate	418.69
	Shading	1.63
	Total	*1451.22*
Waterfowl and Waterbird Habitat	High	1023.32
	Moderate	377.28
	Wood Duck	0.39
	Total	*1400.99*
Other Wildlife Habitat	High	622.59 (large complexes)
	High	3.23 (small diverse wetlands)
	Moderate	61.04
	Total	*686.86*
Conservation of Biodiversity	Meadowlands	1436.29
	Headwater wetlands	1.63
	Tidal fresh wetlands	0.39
	Total	*1438.31*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

Index	**Score**
Natural Cover Index	0.45
River/Stream Corridor Integrity Index	0.03
Wetland Buffer Integrity Index	0.04
Pond/Lake Buffer Integrity Index	0.22
Wetland Extent Index	0.16
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.55
Habitat Fragmentation by Road Index	0.56
Composite Index	0.15

Subbasin: Hackensack River above Tappan Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River above Tappan Bridge subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	6.68
Emergent/Scrub-Shrub	4.38
(subtotal Emergent)	*11.06*
Forested, Broad-leaved Deciduous	345.59
Forested/Scrub-Shrub	12.63
(subtotal Forested)	*358.22*
Scrub-Shrub, Deciduous	0.87
Unconsolidated Bottom	27.27
Palustrine Subtotal	397.42
Riverine Wetlands	4.20
GRAND TOTAL (ALL WETLANDS)	401.62

Table 2. Wetlands in the Hackensack River above Tappan Bridge subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	3	2.09
		Throughflow (TH)	2	3.31
		(subtotal)		
	Fringe (FR)	Bidirectional (BI)	1	0.38
	(Subtotal Lentic)		*6*	*5.78*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	8	148.15
	(Subtotal Lotic River)			*148.15*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	19	107.37
	Flat (FL)	Throughflow (TH)	15	37.83
	(Subtotal Lotic Stream)		*34*	*145.20*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	12	10.73
		Outflow (OU)	6	19.78
		(subtotal)	*18*	*30.51*
	Flat (FL)	Isolated (IS)	4	3.54
		Outflow (OU)	3	6.40
		(subtotal)	*7*	*9.94*
	Slope (SL)	Isolated (IS)	1	13.80
		Outflow (OU)	5	16.76
		(subtotal)	*6*	*30.56*
	(Subtotal Terrene)		*31*	*71.01*
TOTAL LLWW Types*			79	370.14

*Does not include 33 ponds that totaled 27.26 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River above Tappan Bridge subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	277.05
	Moderate	117.13
	Total	*394.19*
Streamflow Maintenance	High	155.33
	Moderate	195.15
	Total	*350.48*
Nutrient Transformation	High	235.35
	Moderate	134.80
	Total	*370.15*
Sediment and Other Particulate Retention	High	296.96
	Moderate	56.72
	Total	*353.68*
Shoreline Stabilization	High	299.14
	Moderate	10.27
	Total	*309.41*
Fish and Shellfish Habitat	High	0.38
	Moderate	27.45
	Shading	269.03
	Total	*296.86*
Waterfowl and Waterbird Habitat	High	2.80
	Moderate	29.88
	Wood Duck	184.66
	Total	*217.34*
Other Wildlife Habitat	High	173.79 (large complexes)
	High	90.06 (small diverse wetlands)
	Moderate	106.30
	Total	*370.15*
Conservation of Biodiversity	Headwater wetlands	147.65
	Lotic complexes	184.73
	Total	*332.38*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River above Tappan Bridge subbasin.

Index	**Score**
Natural Cover Index	0.24
River/Stream Corridor Integrity Index	0.45
Wetland Buffer Integrity Index	0.61
Pond/Lake Buffer Integrity Index	0.45
Wetland Extent Index	0.74
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.33
Channelized Stream Length Index	0.19
Wetland Disturbance Index	0.72
Habitat Fragmentation by Road Index	0.26
Composite Index	0.30

Subbasin: Hackensack River – Bellman's Creek to Fort Lee Road

Table 1. Wetlands classified by NWI types for the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	516.01
Emergent/Scrub-Shrub	6.47
(Subtotal Emergent)	522.48
Unconsolidated Shore	129.18
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Estuarine Subtotal	651.66
Palustrine Wetlands	
Emergent	10.06
Emergent/Scrub-Shrub	5.64
(subtotal Emergent)	*15.70*
Forested, Broad-leaved Deciduous	27.87
Scrub-Shrub/Emergent	2.85
Unconsolidated Bottom	9.19
---	------------
Palustrine Subtotal	55.61
Riverine Wetlands	1.76
GRAND TOTAL (ALL WETLANDS)	709.03

Table 2. Wetlands in the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	324.30
	Basin	Bidirectional-tidal (BT)	--	351.55
	(Subtotal Estuarine)			*675.85*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	3	16.11
	Flat (FL)	Throughflow (TH)	1	0.56
	(Subtotal Lotic Stream)		*4*	*16.67*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	2	3.60
	Flat (FL)	Isolated (IS)	2	1.96
	(Subtotal Terrene)		4	5.56
TOTAL LLWW Types*			8+	698.08

*Does not include 5 ponds that totaled 9.19 acres. Number of estuarine wetlands not determined. Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin.

Function	Level	Acreage
Surface Water Detention	High	692.05
	Moderate	15.23
	Total	*707.28*
Streamflow Maintenance	High	16.67
	Moderate	--
	Total	*16.67*
Nutrient Transformation	High	566.38
	Moderate	2.52
	Total	*568.90*
Sediment and Other Particulate Retention	High	588.44
	Moderate	116.87
	Total	*705.31*
Coastal Storm Surge Detention	High	675.86
Shoreline Stabilization	High	563.34
	Moderate	--
	Total	*563.34*
Fish and Shellfish Habitat	High	138.44
	Moderate	525.46
	Shading	6.13
	Total	*670.03*
Waterfowl and Waterbird Habitat	High	148.50
	Moderate	456.83
	Wood Duck	21.84
	Total	*627.17*
Other Wildlife Habitat	High	523.95 (large complexes)
	High	20.72 (small diverse wetlands)
	Moderate	24.22
	Total	*568.89*
Conservation of Biodiversity	Meadowlands	649.31
	Headwater wetlands	16.67
	Total	*665.98*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin.

Index	**Score**
Natural Cover Index	0.13
River/Stream Corridor Integrity Index	0.10
Wetland Buffer Integrity Index	0.07
Pond/Lake Buffer Integrity Index	0.28
Wetland Extent Index	0.45
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.88
Wetland Disturbance Index	0.72
Habitat Fragmentation by Road Index	0.77
Composite Index	0.01

Subbasin: Hackensack River below Amtrak Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River below Amtrak Bridge subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	562.70
Unconsolidated Shore	0.39
---	---------
Estuarine Subtotal	563.09
Palustrine Wetlands	
Emergent	47.23
Emergent/Scrub-Shrub	7.08
(subtotal Emergent)	*54.31*
Forested, Broad-leaved Deciduous	0.21
Scrub-Shrub, Deciduous	0.53
Unconsolidated Bottom	32.12
Unconsolidated Shore	2.75
--	------------
Palustrine Subtotal	89.92
Riverine Wetlands	0.17
GRAND TOTAL (ALL WETLANDS)	653.18

Table 2. Wetlands in the Hackensack River below Amtrak Bridge subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	99.45
	Basin	Bidirectional-tidal (BT)	--	509.62
	(Subtotal Estuarine)			*609.07*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	7	3.47
	Flat (FL)	Isolated (IS)	3	5.60
	(Subtotal Terrene)		10	9.07
TOTAL LLWW Types*			10+	618.14

*Does not include 35 ponds that totaled 34.87 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

<u>Note</u>: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River below Amtrak Bridge subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	626.18
	Moderate	21.17
	Total	*647.35*
Streamflow Maintenance	High	--
	Moderate	--
	Total	--
Nutrient Transformation	High	605.08
	Moderate	12.67
	Total	*617.75*
Sediment and Other Particulate Retention	High	628.54
	Moderate	21.78
	Total	*650.32*
Coastal Storm Surge Detention	High	609.07
Shoreline Stabilization	High	608.47
	Moderate	2.91
	Total	*611.38*
Fish and Shellfish Habitat	High	8.64
	Moderate	610.38
	Shading	--
	Total	*619.02*
Waterfowl and Waterbird Habitat	High	17.26
	Moderate	565.68
	Wood Duck	0.74
	Total	*583.68*
Other Wildlife Habitat	High	549.80 (large complexes)
	High	0.74 (small diverse wetlands)
	Moderate	67.60
	Total	*618.14*
Conservation of Biodiversity	Estuarine emergent (not Phragmites)	4.98
	Meadowlands	527.24
	Tidal fresh wetlands	0.74
	Total	*532.96*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River below Amtrak Bridge subbasin.

Index	Score
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.10
Wetland Buffer Integrity Index	0.33
Pond/Lake Buffer Integrity Index	0.41
Wetland Extent Index	0.27
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.77
Habitat Fragmentation by Road Index	0.82
Composite Index	0.02

Subbasin: Hackensack River – Fort Lee to Oradell Gage

Table 1. Wetlands classified by NWI types for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	22.59
Emergent/Scrub-Shrub	17.67
Forested, Broad-leaved Deciduous	69.35
Unconsolidated Bottom	8.42
--	------------
Palustrine Subtotal	118.02
GRAND TOTAL (ALL WETLANDS)	118.02

Table 2. Wetlands in the Hackensack River – Ft. Lee to Oradell Gage subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands*	Acreage
Estuarine (ES)	Basin	Bidirectional-tidal (BT)	--	0.97
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	1	1.97
	Fringe (FR)	Bidirectional-tidal (BT)	23	77.83
	(Subtotal Lotic River)		*24*	*79.80*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	1	9.32
	Flat (FL)	Throughflow (TH)	2	4.14
	(Subtotal Lotic Stream)		*3*	*13.46*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	3	7.71
	Flat (FL)	Isolated (IS)	2	1.02
		Outflow (OU)	2	6.64
		(subtotal)	*4*	*7.66*
	(Subtotal Terrene)			*15.37*
TOTAL LLWW Types*			7+	109.60

*Does not include 5 ponds that totaled 8.42 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	90.70
	Moderate	27.32
	Total	*118.02*
Streamflow Maintenance	High	10.05
	Moderate	12.01
	Total	*22.06*
Nutrient Transformation	High	94.35
	Moderate	15.25
	Total	*109.60*
Sediment and Other Particulate Retention	High	94.84
	Moderate	15.52
	Total	*110.36*
Coastal Storm Surge Detention	High	78.8
Shoreline Stabilization	High	93.26
	Moderate	--
	Total	*93.26*
Fish and Shellfish Habitat	High	38.57
	Moderate	8.42
	Shading	49.55
	Total	*96.54*
Waterfowl and Waterbird Habitat	High	38.57
	Moderate	8.42
	Wood Duck	49.55
	Total	*96.54*
Other Wildlife Habitat	High	45.37 (small diverse wetlands)
	Moderate	64.23
	Total	*109.60*
Conservation of Biodiversity	Headwater wetlands	10.05
	Tidal fresh wetlands	77.31
	Total	*87.36*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

Index	**Score**
Natural Cover Index	0.07
River/Stream Corridor Integrity Index	0.33
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.07
Wetland Extent Index	1.00
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	1.00
Channelized Stream Length Index	0.03
Wetland Disturbance Index	0.10
Habitat Fragmentation by Road Index	0.54
Composite Index	0.13

Subbasin: Hackensack River-Nauranshaun Confluence

Table 1. Wetlands classified by NWI types for the Hackensack River-Nauranshaun Confluence subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	61.09
Emergent/Scrub-Shrub	21.26
(subtotal Emergent)	*82.35*
Forested, Broad-leaved Deciduous	361.64
Forested, Dead	80.30
Forested/Scrub-Shrub	6.05
Forested/Emergent	15.96
(subtotal Forested)	*463.95*
Scrub-Shrub, Deciduous	12.44
Scrub-Shrub/Emergent	1.14
(subtotal Scrub-Shrub)	*13.57*
Unconsolidated Bottom	36.50
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Palustrine Subtotal	596.38
Riverine Wetlands	9.19
GRAND TOTAL (ALL WETLANDS)	605.57

Table 2. Wetlands in the Hackensack River-Nauranshaun Confluence subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	10	32.53
		Throughflow (TH)	4	49.53
		(subtotal)	*14*	*82.06*
	Flat (FL)	Bidirectional (BI)	3	6.01
		Throughflow (TH)	1	8.08
		(subtotal)	*4*	*14.09*
	Fringe (FR)	Bidirectional (BI)	5	54.23
		Throughflow (TH)	3	61.10
		(subtotal)	*8*	*115.33*
	(Subtotal Lentic)		*26*	*211.48*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	5	17.05
	Fringe (FR)	Throughflow (TH)	1	6.88
	(Subtotal Lotic River)		*6*	*23.93*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	24	151.30
	Flat (FL)	Throughflow (TH)	13	50.79
	Fringe (FR)	Throughflow (TH)	1	2.15
	(Subtotal Lotic Stream)		*38*	*204.24*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	49	69.32
		Outflow (OU)	14	23.29
		(subtotal)	*63*	*92.61*
	Flat (FL)	Isolated (IS)	12	12.26
		Outflow Intermittent (OI)		
		Outflow (OU)	4	7.67
		(subtotal)	*16*	*19.93*
	Slope (SL)	Isolated (IS)	7	4.49
		Outflow (OU)	1	3.19
		(subtotal)	*8*	*7.68*
	(Subtotal Terrene)		*87*	*120.22*
TOTAL LLWW Types*			157	559.87

*Does not include 44 ponds that totaled 36.51 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River-Nauranshaun Confluence subbasin.

Function	Level	Acreage
Surface Water Detention	High	405.68
	Moderate	190.30
	Total	*595.98*
Streamflow Maintenance	High	98.96
	Moderate	331.65
	Total	*430.61*
Nutrient Transformation	High	451.11
	Moderate	108.76
	Total	*559.87*
Sediment and Other Particulate Retention	High	438.56
	Moderate	134.15
	Total	*572.71*
Shoreline Stabilization	High	439.65
	Moderate	9.27
	Total	*448.92*
Fish and Shellfish Habitat	High	124.22
	Moderate	43.48
	Shading	183.24
	Total	*350.94*
Waterfowl and Waterbird Habitat	High	155.68
	Moderate	49.07
	Wood Duck	122.29
	Total	*327.04*
Other Wildlife Habitat	High	292.39 (large complexes)
	High	132.64 (small diverse wetlands)
	Moderate	134.84
	Total	*559.87*
Conservation of Biodiversity	Beaver wetlands	11.33
	Headwater wetlands	93.47
	Lentic basins/fringes	195.22
	Possible vernal pool	1.59
	Total	*301.61*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River-Nauranshaun Confluence subbasin.

Index	**Score**
Natural Cover Index	0.33
River/Stream Corridor Integrity Index	0.41
Wetland Buffer Integrity Index	0.47
Pond/Lake Buffer Integrity Index	0.56
Wetland Extent Index	0.54
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.24
Channelized Stream Length Index	0.29
Wetland Disturbance Index	0.41
Habitat Fragmentation by Road Index	0.58
Composite Index	0.31

Subbasin: Hackensack River – Oradell to Tappan Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River – Oradell to Tappan Bridge subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	9.37
Forested, Broad-leaved Deciduous	452.21
Forested/Scrub-Shrub	10.68
Forested, Deciduous and Evergreen Mixed	0.58
(subtotal Forested)	*463.47*
Scrub-Shrub, Deciduous	15.48
Scrub-Shrub/Emergent	0.51
(subtotal Scrub-Shrub)	*15.99*
Unconsolidated Bottom	21.81
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Palustrine Subtotal	510.64
Riverine Wetlands	4.40
GRAND TOTAL (ALL WETLANDS)	515.04

Table 2. Wetlands in Hackensack River – Oradell to Tappan Bridge subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	1	0.27
	Flat (FL)	Bidirectional (BI)	4	3.05
	(Subtotal Lentic)		*5*	*3.32*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	9	31.40
	(Subtotal Lotic River)		*9*	*31.40*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	15	119.62
	Flat (FL)	Throughflow (TH)	15	128.66
	(Subtotal Lotic Stream)		*30*	*248.28*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	22	40.04
		Outflow (OU)	21	34.31
		(subtotal)	*43*	*74.35*
	Flat (FL)	Isolated (IS)	10	14.48
		Outflow (OU)	6	116.88
		(subtotal)	*16*	*131.36*
	Slope (SL)	Isolated (IS)	1	0.12
	(Subtotal Terrene)		*60*	*205.81*
TOTAL LLWW Types*			104	488.81

*Does not include 28 ponds that totaled 21.81 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Oradell to Tappan Bridge subbasin.

Function	Level	Acreage
Surface Water Detention	High	168.23
	Moderate	277.112
	Total	*445.35*
Streamflow Maintenance	High	138.13
	Moderate	215.25
	Total	*353.38*
Nutrient Transformation	High	198.60
	Moderate	290.23
	Total	*488.83*
Sediment and Other Particulate Retention	High	202.97
	Moderate	176.89
	Total	*379.86*
Shoreline Stabilization	High	322.66
	Moderate	0.69
	Total	*324.35*
Fish and Shellfish Habitat	High	--
	Moderate	21.81
	Shading	181.07
	Total	*202.88*
Waterfowl and Waterbird Habitat	High	1.13
	Moderate	21.12
	Wood Duck	39.53
	Total	*61.78*
Other Wildlife Habitat	High	276.67 (large complexes)
	High	80.71 (small diverse wetlands)
	Moderate	131.45
	Total	*488.83*
Conservation of Biodiversity	100-acre + wetlands	10.90
	Headwater wetlands	157.85
	Lotic complexes	112.97
	Total	*281.72*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River – Oradell to Tappan Bridge subbasin.

Index	**Score**
Natural Cover Index	0.27
River/Stream Corridor Integrity Index	0.47
Wetland Buffer Integrity Index	0.50
Pond/Lake Buffer Integrity Index	0.54
Wetland Extent Index	0.73
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.06
Channelized Stream Length Index	0.24
Wetland Disturbance Index	0.63
Habitat Fragmentation by Road Index	0.31
Composite Index	0.33

Subbasin: Hackensack River – Route 3 to Bellman's Creek

Table 1. Wetlands classified by NWI types for the Hackensack River – Rt. 3 to Bellman's Creek subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	1154.76
Unconsolidated Shore	290.83
Estuarine Subtotal	1445.59
Palustrine Wetlands	
Emergent	4.17
Forested, Broad-leaved Deciduous	3.93
Unconsolidated Bottom	1.48
Palustrine Subtotal	9.58
Riverine Wetlands	0.14
GRAND TOTAL (ALL WETLANDS)	1455.31

Table 2. Wetlands in the Hackensack River – Rt. 3 to Bellman's Creek subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	758.64
	Basin	Bidirectional-tidal (BT)	--	694.00
	Island (IL)	Bidirectional-tidal (BT)	--	1.04
	(Subtotal Estuarine)			*1453.68*
TOTAL LLWW Types*				1453.68

*Does not include 4 ponds that totaled 1.49 acres. Number of estuarine wetlands not determined.

<u>Note</u>: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Rt. 3 to Bellman's Creek subbasin.

Function	Level	Acreage
Surface Water Detention	High	1454.16
	Moderate	1.01
	Total	*1455.17*
Streamflow Maintenance	High	--
	Moderate	0.23
	Total	*0.23*
Nutrient Transformation	High	1162.85
	Moderate	--
	Total	*1162.85*
Sediment and Other Particulate Retention	High	1163.33
	Moderate	291.84
	Total	*1455.17*
Coastal Storm Surge Detention	High	1453.68
Shoreline Stabilization	High	1162.85
	Moderate	--
	Total	*1162.85*
Fish and Shellfish Habitat	High	376.18
	Moderate	1074.05
	Shading	--
	Total	*1450.23*
Waterfowl and Waterbird Habitat	High	376.18
	Moderate	994.60
	Wood Duck	3.93
	Total	*1374.71*
Other Wildlife Habitat	High	1117.47 (large complexes)
	Moderate	45.99
	Total	*1163.46*
Conservation of Biodiversity	Meadowlands	1417.55
	Tidal fresh wetlands	3.93
	Total	*1421.48*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River – Rt. 3 to Bellman’s Creek subbasin.

Index	**Score**
Natural Cover Index	0.31
River/Stream Corridor Integrity Index	0.00
Wetland Buffer Integrity Index	0.21
Pond/Lake Buffer Integrity Index	0.15
Wetland Extent Index	0.40
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.00
Wetland Disturbance Index	0.69
Habitat Fragmentation by Road Index	0.91
Composite Index	0.17

Subbasin: Hirshfeld Brook

Table 1. Wetlands classified by NWI types for the Hirshfeld Brook subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	5.14
Forested, Broad-leaved Deciduous	21.13
Unconsolidated Bottom	3.72
Palustrine Subtotal	29.98
GRAND TOTAL (ALL WETLANDS)	29.98

Table 2. Wetlands in the Hirshfeld Brook subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	4	20.01
	Flat (FL)	Throughflow (TH)	3	6.25
	(Subtotal Lotic Stream)		*7*	*26.26*
TOTAL LLWW Types*			7	26.26

*Does not include 1 pond that totaled 3.72 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hirshfeld Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	23.72
	Moderate	6.25
	Total	*29.97*
Streamflow Maintenance	High	26.44
	Moderate	3.53
	Total	*29.97*
Nutrient Transformation	High	20.01
	Moderate	6.25
	Total	*26.26*
Sediment and Other Particulate Retention	High	29.98
	Moderate	--
	Total	*29.98*
Shoreline Stabilization	High	26.26
	Moderate	--
	Total	*26.26*
Fish and Shellfish Habitat	High	--
	Moderate	3.72
	Shading	21.01
	Total	*24.73*
Waterfowl and Waterbird Habitat	High	3.53
	Moderate	3.72
	Wood Duck	14.76
	Total	*22.01*
Other Wildlife Habitat	High	14.87 (small diverse wetlands)
	Moderate	11.39
	Total	*26.26*
Conservation of Biodiversity	Headwater wetlands	22.73

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Hirshfeld Brook subbasin.

Index	**Score**
Natural Cover Index	0.04
River/Stream Corridor Integrity Index	0.12
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.08
Wetland Extent Index	0.73
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.03
Channelized Stream Length Index	0.36
Wetland Disturbance Index	0.12
Habitat Fragmentation by Road Index	0.54
Composite Index	0.12

Subbasin: Overpeck Creek

Table 1. Wetlands classified by NWI types for the Overpeck Creek subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	148.64
Unconsolidated Shore	13.98
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Estuarine Subtotal	162.63
Palustrine Wetlands	
Emergent	8.29
Emergent/Scrub-Shrub	0.37
(subtotal Emergent)	*8.67*
Forested, Broad-leaved Deciduous	102.45
Scrub-Shrub, Deciduous	9.07
Unconsolidated Bottom	29.30
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Palustrine Subtotal	149.49
Riverine Wetlands	7.99
GRAND TOTAL (ALL WETLANDS)	320.11

Table 2. Wetlands in the Overpeck Creek subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	22.32
	Basin	Bidirectional-tidal (BT)	--	146.51
	(Subtotal Estuarine)			*168.83*
Lentic (LE)	Flat (FL)	Bidirectional (BI)	1	1.25
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	1	0.47
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	5	28.36
	Flat (FL)	Throughflow (TH)	8	53.68
	(Subtotal Lotic Stream)		*13*	*82.04*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	5	3.11
		Outflow (OU)	5	22.20
		(subtotal)		*25.31*
	Flat (FL)	Outflow (OU)	4	4.91
	(Subtotal Terrene)		*14*	*30.22*
TOTAL LLWW Types*			29+	282.81

*Does not include 16 ponds that totaled 29.30 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Overpeck Creek subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	210.43
	Moderate	101.51
	Total	*311.94*
Streamflow Maintenance	High	52.57
	Moderate	60.06
	Total	*112.63*
Nutrient Transformation	High	208.51
	Moderate	60.31
	Total	*268.82*
Sediment and Other Particulate Retention	High	250.40
	Moderate	56.63
	Total	*307.03*
Coastal Storm Surge Detention	High	168.83
Shoreline Stabilization	High	237.29
	Moderate	--
	Total	*237.29*
Fish and Shellfish Habitat	High	15.88
	Moderate	164.36
	Shading	68.80
	Total	*249.04*
Waterfowl and Waterbird Habitat	High	16.31
	Moderate	80.12
	Wood Duck	25.04
	Total	*121.47*
Other Wildlife Habitat	High	90.98 (large complexes)
	High	40.48 (small diverse wetlands)
	Moderate	137.37
	Total	*268.83*
Conservation of Biodiversity	Estuarine emergent (not Phragmites)	0.15
	Meadowlands	69.96
	Headwater wetlands	63.74
	Tidal fresh wetlands	1.32
	Total	*135.17*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Overpeck Creek subbasin.

Index	**Score**
Natural Cover Index	0.12
River/Stream Corridor Integrity Index	0.22
Wetland Buffer Integrity Index	0.34
Pond/Lake Buffer Integrity Index	0.27
Wetland Extent Index	0.36
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.09
Channelized Stream Length Index	0.56
Wetland Disturbance Index	0.36
Habitat Fragmentation by Road Index	0.69
Composite Index	0.11

Subbasin: Pascack Brook above Westwood Gage

Table 1. Wetlands classified by NWI types for the Pascack Brook above Westwood Gage subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	2.38
Forested, Broad-leaved Deciduous	259.54
Forested/Scrub-Shrub	6.92
Forested, Deciduous and Evergreen Mixed	2.03
(subtotal Forested)	*268.49*
Scrub-Shrub, Deciduous	4.18
Scrub-Shrub/Emergent	0.93
Scrub-Shrub/Forested	1.36
(subtotal Scrub-Shrub)	*6.47*
Unconsolidated Bottom	24.40
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Palustrine Subtotal	301.74
Riverine Wetlands	2.50
GRAND TOTAL (ALL WETLANDS)	304.24

Table 2. Wetlands in the Pascack Brook above Westwood Gage subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	2	10.11
		Throughflow (TH)	2	3.92
		(subtotal)		*14.03*
	Flat (FL)	Bidirectional (BI)	3	13.53
	(Subtotal Lentic)		*7*	*27.56*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	18	36.73
	(Subtotal Lotic River)		*18*	*36.73*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	1	110.24
	Flat (FL)	Throughflow (TH)	10	19.69
	Fringe (FR)	Throughflow (TH)	1	2.75
	(Subtotal Lotic Stream)		*12*	*132.68*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	13	21.04
		Outflow (OU)	9	26.17
		(subtotal)	*22*	*47.21*
	Flat (FL)	Isolated (IS)	2	12.37
		Outflow (OU)	2	1.67
		(subtotal)	*4*	*14.04*
	Slope (SL)	Isolated (IS)	16	15.69
		Outflow (OU)	3	3.44
		(subtotal)	*19*	*19.13*
	(Subtotal Terrene)		*45*	*80.38*
TOTAL LLWW Types*			82	277.35

*Does not include 30 ponds that totaled 24.40 acres.
<u>Note</u>: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Pascack Brook above Westwood Gage subbasin.

Function	Level	Acreage
Surface Water Detention	High	194.26
	Moderate	103.89
	Total	*298.15*
Streamflow Maintenance	High	133.47
	Moderate	107.52
	Total	*240.99*
Nutrient Transformation	High	198.22
	Moderate	79.13
	Total	*277.35*
Sediment and Other Particulate Retention	High	194.34
	Moderate	70.64
	Total	*264.98*
Shoreline Stabilization	High	196.97
	Moderate	--
	Total	*196.97*
Fish and Shellfish Habitat	High	--
	Moderate	24.40
	Shading	107.18
	Total	*131.58*
Waterfowl and Waterbird Habitat	High	3.39
	Moderate	24.40
	Wood Duck	79.07
	Total	*106.86*
Other Wildlife Habitat	High	33.01 (large complexes)
	High	82.30 (small diverse wetlands)
	Moderate	162.25
	Total	*277.56*
Conservation of Biodiversity	Beaver wetlands	2.75
	Headwater wetlands	131.07
	Possible vernal pool	0.55
	Total	*134.37*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Pascack Brook above Westwood Gage subbasin.

Index	**Score**
Natural Cover Index	0.23
River/Stream Corridor Integrity Index	0.41
Wetland Buffer Integrity Index	0.26
Pond/Lake Buffer Integrity Index	0.39
Wetland Extent Index	0.59
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.09
Channelized Stream Length Index	0.09
Wetland Disturbance Index	0.41
Habitat Fragmentation by Road Index	0.41
Composite Index	0.27

Subbasin: Pascack Brook below Westwood Gage

Table 1. Wetlands classified by NWI types for the Pascack Brook below Westwood Gage subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	32.45
Emergent/Scrub-Shrub	1.60
(subtotal Emergent)	*34.05*
Forested, Broad-leaved Deciduous	275.19
Forested/Scrub-Shrub	2.35
Forested/Emergent	1.68
(subtotal Forested)	*279.22*
Scrub-Shrub, Deciduous	1.43
Scrub-Shrub/Emergent	6.29
(subtotal Scrub-Shrub)	*7.72*
Unconsolidated Bottom	16.56
Palustrine Subtotal	337.55
Riverine Wetlands	1.70
GRAND TOTAL (ALL WETLANDS)	339.25

Table 2. Wetlands in the Pascack Brook below Westwood Gage subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)	Basin (BA)	Throughflow (TH)	5	14.23
	Flat (FL)	Bidirectional (BI)	4	27.52
	(Subtotal Lentic)		*9*	*41.75*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	49	129.64
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	18	114.58
	Flat (FL)	Throughflow (TH)	5	8.80
	(Subtotal Lotic Stream)		*23*	*123.38*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	7	11.27
		Outflow (OU)	2	2.79
		(subtotal)	*9*	*14.06*
	Flat (FL)	Isolated (IS)	1	2.05
	Slope (SL)	Isolated (IS)	4	6.48
		Outflow (OU)	1	3.63
		(subtotal)	*5*	*10.11*
	(Subtotal Terrene)		*15*	*26.22*
TOTAL LLWW Types*			96	320.99

*Does not include 16 ponds that totaled 16.56 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Pascack Brook below Westwood Gage subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	292.56
	Moderate	45.00
	Total	*337.56*
Streamflow Maintenance	High	118.83
	Moderate	185.47
	Total	*304.30*
Nutrient Transformation	High	237.50
	Moderate	83.50
	Total	*321.00*
Sediment and Other Particulate Retention	High	266.72
	Moderate	58.68
	Total	*325.40*
Shoreline Stabilization	High	292.53
	Moderate	--
	Total	*292.53*
Fish and Shellfish Habitat	High	--
	Moderate	19.44
	Shading	207.46
	Total	*226.90*
Waterfowl and Waterbird Habitat	High	26.18
	Moderate	19.44
	Wood Duck	168.57
	Total	*214.19*
Other Wildlife Habitat	High	182.23 (large complexes)
	High	93.45 (small diverse wetlands)
	Moderate	45.32
	Total	*321.00*
Conservation of Biodiversity	Headwater wetlands	34.97
	Lentic basins/fringes	14.23
	Lotic complexes	230.12
	Total	*279.32*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Pascack Brook below Westwood Gage subbasin.

Index	**Score**
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.35
Wetland Buffer Integrity Index	0.19
Pond/Lake Buffer Integrity Index	0.27
Wetland Extent Index	0.84
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.05
Channelized Stream Length Index	0.45
Wetland Disturbance Index	0.18
Habitat Fragmentation by Road Index	0.36
Composite Index	0.24

Subbasin: Tenakill Brook

Table 1. Wetlands classified by NWI types for the Tenakill Brook subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	0.31
Forested, Broad-leaved Deciduous	160.92
Scrub-Shrub, Deciduous	7.03
Scrub-Shrub/Emergent	16.44
Scrub-Shrub/Forested	2.15
(subtotal Scrub-Shrub)	*25.62*
Unconsolidated Bottom	15.40
Palustrine Subtotal	202.26
Riverine Wetlands	8.18
GRAND TOTAL (ALL WETLANDS)	210.44

Table 2. Wetlands in the Tenakill Brook subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)				
	Basin (BA)	Throughflow (TH)	1	9.55
	Flat (FL)	Throughflow (TH)	3	19.06
	(Subtotal Lentic)		*4*	*28.61*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	6	11.60
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	6	11.21
	Flat (FL)	Throughflow (TH)	7	91.53
	(Subtotal Lotic Stream)		*13*	*102.74*
Terrene (TE)	Basin (BA)	Isolated (IS)	4	6.10
		Outflow (OU)	2	4.07
		(subtotal)	*6*	*10.17*
	Flat (FL)	Isolated (IS)	3	5.92
		Outflow (OU)	3	26.78
		(subtotal)	*6*	*32.70*
	Slope (SL)	Outflow (OU)	1	1.05
	(Subtotal Terrene)		*13*	*43.92*
TOTAL LLWW Types*			36	186.87

*Does not include 17 ponds that totaled 15.40 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Tenakill Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	56.78
	Moderate	120.98
	Total	*177.76*
Streamflow Maintenance	High	43.73
	Moderate	133.45
	Total	*177.18*
Nutrient Transformation	High	38.60
	Moderate	148.26
	Total	*186.86*
Sediment and Other Particulate Retention	High	112.48
	Moderate	56.03
	Total	*168.51*
Shoreline Stabilization	High	142.94
	Moderate	--
	Total	*142.94*
Fish and Shellfish Habitat	High	--
	Moderate	15.40
	Shading	90.44
	Total	*105.84*
Waterfowl and Waterbird Habitat	High	2.03
	Moderate	14.91
	Wood Duck	11.76
	Total	*28.70*
Other Wildlife Habitat	High	122.97 (large complexes)
	High	6.72 (small diverse wetlands)
	Moderate	57.17
	Total	*186.86*
Conservation of Biodiversity	100-acre + wetlands	28.61
	Headwater wetlands	32.51
	Lotic complexes	65.79
	Total	*126.91*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Tenakill Brook subbasin.

Index	**Score**
Natural Cover Index	0.15
River/Stream Corridor Integrity Index	0.27
Wetland Buffer Integrity Index	0.29
Pond/Lake Buffer Integrity Index	0.33
Wetland Extent Index	0.99
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.01
Channelized Stream Length Index	0.43
Wetland Disturbance Index	0.45
Habitat Fragmentation by Road Index	0.38
Composite Index	0.23

Subbasin: Upper Pascack Brook

Table 1. Wetlands classified by NWI types for the Upper Pascack Brook subbasin.

NWI Wetland Type	**Acreage**
Palustrine Wetlands	
Emergent	5.08
Emergent/Scrub-Shrub	28.60
(subtotal Emergent)	*33.68*
Forested, Broad-leaved Deciduous	33.25
Scrub-Shrub, Deciduous	3.86
Unconsolidated Bottom	25.60
Palustrine Subtotal	96.39
Riverine Wetlands	0.95
GRAND TOTAL (ALL WETLANDS)	97.34

Table 2. Wetlands in the Upper Pascack Brook subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	2	0.60
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	1	1.34
Terrene (TE)				
	Basin (BA)	Isolated (IS)	16	27.14
		Outflow (OU)	3	29.65
		(subtotal)	*19*	*56.79*
	Flat (FL)	Isolated (IS)	6	4.37
		Outflow (OU)	1	7.69
		(subtotal)	*7*	*12.06*
	(Subtotal Terrene)		*26*	*68.85*
TOTAL LLWW Types*			29	70.79

*Does not include 9 ponds that totaled 15.53 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Upper Pascack Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	7.32
	Moderate	78.99
	Total	*86.31*
Streamflow Maintenance	High	50.96
	Moderate	14.06
	Total	*65.02*
Nutrient Transformation	High	58.73
	Moderate	12.06
	Total	*70.79*
Sediment and Other Particulate Retention	High	7.32
	Moderate	66.93
	Total	*74.25*
Shoreline Stabilization	High	1.94
	Moderate	0.20
	Total	*2.14*
Fish and Shellfish Habitat	High	--
	Moderate	15.52
	Shading	--
	Total	*15.52*
Waterfowl and Waterbird Habitat	High	34.84
	Moderate	15.52
	Wood Duck	--
	Total	*50.36*
Other Wildlife Habitat	High	28.60 (large complexes)
	High	25.54 (small diverse wetlands)
	Moderate	16.65
	Total	*70.79*
Conservation of Biodiversity	Headwater wetlands	30.26

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Upper Pascack Brook subbasin.

Index	**Score**
Natural Cover Index	0.20
River/Stream Corridor Integrity Index	0.08
Wetland Buffer Integrity Index	0.49
Pond/Lake Buffer Integrity Index	0.36
Wetland Extent Index	0.24
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.08
Channelized Stream Length Index	0.67
Wetland Disturbance Index	0.34
Habitat Fragmentation by Road Index	0.40
Composite Index	0.17

The Hackensack Meadowlands District: Wetland Inventory and Remotely-sensed Assessment of "Natural Habitat" Integrity

Produced by the U.S. Fish and Wildlife Service
National Wetlands Inventory Program
Ecological Services, Northeast Region
Hadley, MA

May 2005

**The Hackensack Meadowlands District:
Wetland Inventory and Remotely-sensed
Assessment of "Natural Habitat" Integrity**

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Appendix
Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors (Tiner 2003a)

Maps (on compact disk-version of report)

Introduction

The U.S. Fish and Wildlife Service's Northeast Region is providing information to the New Jersey Meadowlands Commission on wetlands and other environmental resources within the Hackensack Meadowlands District (HMD) This work is being directed by the New Jersey Ecological Services Field Office (NJFO), Pleasantville, New Jersey. The NJFO contacted the Region's National Wetlands Inventory Program (NWI) about collecting and analyzing information on wetlands and related resources. The NWI portion of this work involved conducting an inventory of current natural resources within the District through photointerpretation techniques. Work included a wetlands inventory and an assessment of the overall extent of "natural habitat" in this area.

The typical wetlands inventory characterizes wetlands mainly by their vegetation and expected hydrology (water regime), with other modifiers used to indicate human or beaver activities (e.g., diked/impounded, excavated, partly drained, and beaver-influenced). In order to use the NWI data to predict functions (e.g., surface water detention, nutrient transformation, streamflow maintenance, and provision of fish/wildlife habitat) and get a better sense of the relationship between wetlands and waterbodies, additional information on the hydrogeomorphic characteristics of wetlands is required. The Service has developed a set of attributes to better describe wetlands by landscape position, landform, water flow path, and waterbody type (LLWW descriptors; Tiner 2003a). When added to the NWI data, the enhanced NWI data have a predictive capability regarding wetland functions (Tiner 2003b). To characterize the general status of natural resources through remote sensing techniques, the Service developed a set of remotely sensed "natural habitat integrity indices" (Tiner 2004). The land use/cover information needed for calculating these indices were collected as part of this project. This report documents the findings for the Meadowlands District.

Study Area

The Meadowlands District is located at the mouth of the Hackensack River in northeastern New Jersey (Figure 1). The District contains more than 16,000 acres (25 square miles). The Meadowlands is one of the largest urban wetlands in the state and is the largest estuarine wetland in the Newark metropolitan area. The Hackensack River is tidal in this area and most of the District's wetlands are subject to tidal flooding on a less than daily basis. Nontidal wetlands is this urban area have been largely filled, with few remaining. Besides the Hackensack River, Berry's Creek, Overpeck Creek, and Bellman's Creek are the major waterways in the Meadowlands. Eight subbasins have been identified: 1) Berry's Creek above Paterson Avenue, 2) Berry's Creek below Paterson Avenue, 3) Hackensack River from the Amtrak bride to Route 3, 4) Hackensack River from Bellman's Creek to Fort Lee Road, 5) Hackensack River below the Amtrak bridge, 6) Hackensack River from Route 3 to Bellman's Creek, 7) Overpeck Creek, and 8) Lower Passaic River from Newark Bay to the 4th Street Bridge (Figure 1).

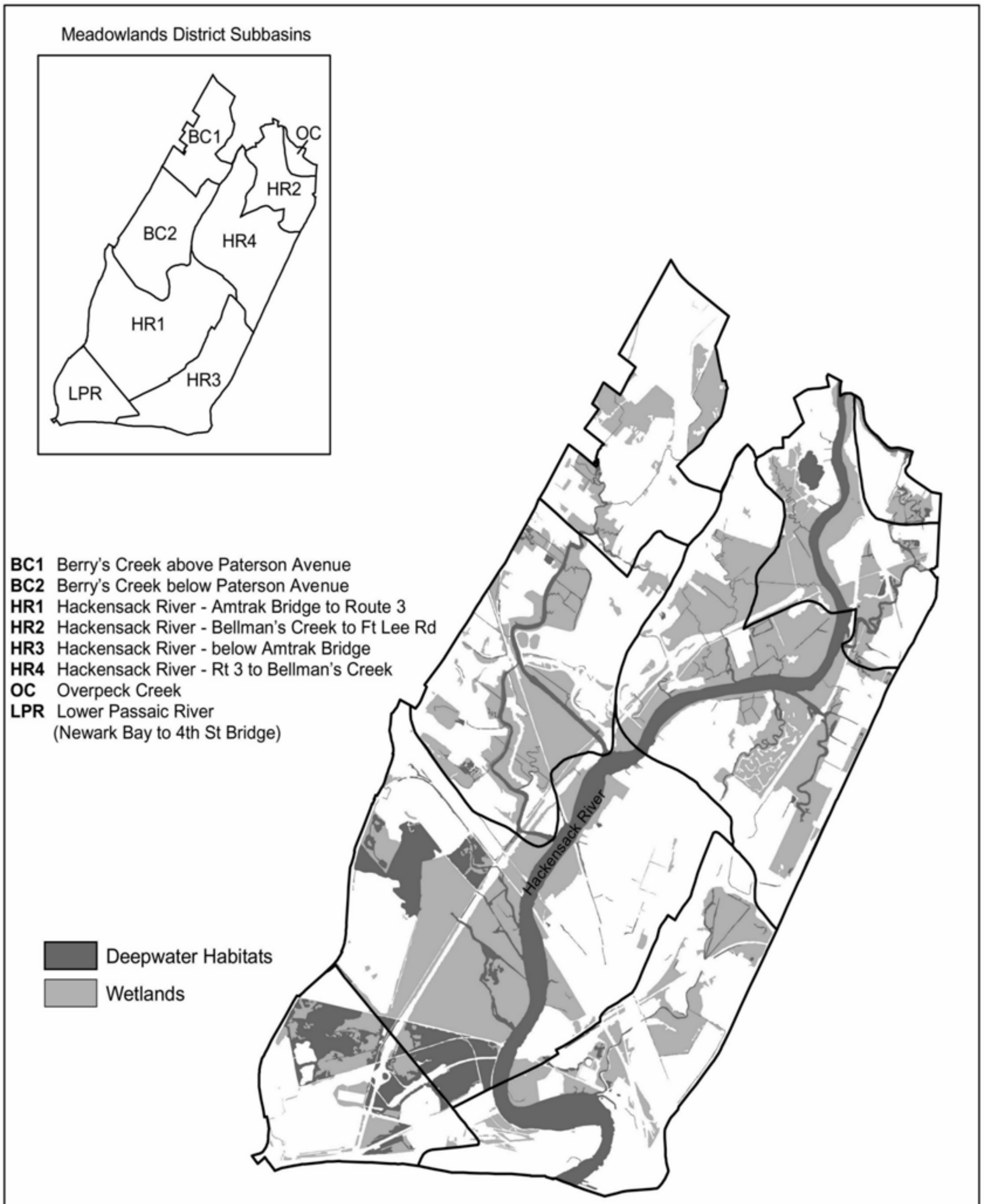

Figure1. The Meadowlands and its subbasins.

Methods

Wetland Classification and Inventory

One of the objectives of this project was to create an up-to-date inventory of wetlands and to add attributes for landscape position, landform, water flow path, and waterbody type (LLWW descriptors) to each mapped wetland and deepwater habitat, as appropriate. For the inventory, NWI data based on 1995-1:40,000 color infrared photography was updated through a heads-up (on-screen) interpretation process using 2002 color orthophotography and 2003 black and white orthophotography for the Meadowlands. The 1995 NWI data were matched to the orthophotographs and adjusted accordingly, and then updated through heads-up photointerpretation procedures. A special effort was made to map the full extent of open ditches in the District within the constraints of the aerial photography.

The predominance of common reed (Phragmites australis) and the occurrence of many impoundments and road and railroad crossings complicated wetland classification. Instead of calling the entire Meadowlands simply estuarine, we attempted to pull out areas where freshwater influence was more significant. We did this by applying the oligohaline water chemistry modifier ("6") to wetlands behind roads and highways and tidal wetlands enclosed by dikes. Such areas have reduced tidal flow (e.g., sheet flow restricted by causeways and railroad embankments, and dikes), greater freshwater influence due to these structures, and some communities were mixtures of common reed and cattail (Typha) – evidence of lower salinities than estuarine portions of the Meadowlands where smooth cordgrass (Spartina alterniflora) is establishing. Marshes along the mainstem of the Hackensack River were considered to be more brackish or saline. These interpretations provided consistent results.

After completing the basic inventory, three main descriptors (landscape position, landform, and water flow path) were applied to each wetland by interpreting available map information, and in some cases, aerial photography was consulted. "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a; Appendix) was initally used to classify these features. Other modifiers were added to depict features such as headwater, drainage-divide, and human-impacted wetlands.

Landscape position defines the relationship between a wetland and an adjacent waterbody if present. For the Meadowlands, four landscape positions were possible: 1) estuarine (along salt and brackish tidal waters), 2) lotic (along rivers and streams), 3) lentic (along lakes and reservoirs), and 4) terrene (typically surrounded by upland or serving as the source of a stream). Lotic wetlands may be divided into lotic river and lotic stream wetlands by their width on a 1:24,000-scale map. Watercourses mapped as linear (single-line) features on NWI maps and on U.S. Geological Survey topographic maps (1:24,000) were designated as streams, whereas two-lined channels (polygonal features on the maps) were classified as rivers. All lotic wetlands are in contact with streams or rivers. Wetlands on floodplains surrounded by upland (nonhydric soil) were classified as terrene wetlands as were nontidal wetlands completely surrounded by dryland and wetlands that were the source of streams. Lentic wetlands were divided into two categories: natural and dammed, with the latter type separating wetlands associated with reservoirs from those along other controlled lakes, when possible.

Landform is the physical form or shape of a wetland. Five landform types were recognized in the study area: 1) basin, 2) flat, 3) slope, 4) island, and 5) fringe (Table 1). Fringe wetlands are mostly associated with estuarine waters and semipermanently flooded vegetated wetlands elsewhere. Where an estuarine wetland is located behind a causeway (road or railroad) or otherwise partially cut off from the mainbody of a fringing wetland, the wetland was classified as a basin wetland. Other basin wetlands were depressional wetlands and seasonally flooded wetlands along streams. Flats are wetlands on nearly level landforms; they typically have a seasonally saturated or temporarily flooded water regime.

Water flow path descriptors characterize the flow of water associated with wetlands. Four patterns of flow were recognized for wetlands in the Meadowlands: 1) bidirectional-tidal (all tidal wetlands), 2) throughflow, 3) outflow, and 4) isolated. Throughflow wetlands have either a perennial watercourse (e.g. stream) or another type of wetland above and below it, so water passes through them (usually by way of a river or stream, but sometimes by ditches). The water flow path of lotic wetlands associated with perennial streams is throughflow. Outflow wetlands discharge water year-long or nearly so. Isolated wetlands are essentially closed depressions (geographically isolated) where water comes from surface water runoff and/or groundwater discharge. For this project, surface water connections are emphasized, since it is not possible to determine ground water linkages (especially outflow) without hydrologic investigations. Consequently, wetlands designated as isolated may have groundwater connections and may not be “hydrologically isolated.”

The headwater descriptor ("hw") was applied to wetlands along intermittent streams and first- and second-order perennial streams and to terrene wetlands that are the sources of these streams.

The pond modifer ("pd") was applied to any wetland in contact with a pond. The pond may exert influence on the wetland vegetation or may simply have little or no influence on the wetland (e.g., where a pond represents only a small portion of the wetland such as bog eyelet pond or where an artificial pond was excavated from an existing wetland). Wetlands bordering ponds that were mapped by NWI as impounded ("h") should be significantly influenced by pond hydrology.

Table 1. Definitions and examples of landform types (Tiner 2003a).

Landform Type	General Definition	Examples
Basin*	a depressional (concave) landform including artificially created ones by impoundments, causeways, and roads	lakefill bogs; wetlands in the saddle between two hills; wetlands in closed or open depressions, including narrow stream valleys; tidally restricted estuarine wetlands
Slope	a landform extending uphill (on a slope; typically crossing two or more contours on a 1:24,000 map)	seepage wetlands on hillside; wetlands along drainageways or mountain streams on slopes
Flat*	a relatively level landform, often on broad level landscapes	wetlands on flat areas with high seasonal ground-water levels; wetlands on terraces along rivers/streams; wetlands on hillside benches; wetlands at toes of slopes
Floodplain**	a broad, generally flat landform occurring on a landscape shaped by fluvial or riverine processes	wetlands on alluvium; bottomland swamps
Fringe	a landform occurring within the banks of a nontidal waterbody (not on a floodplain) and often but not always subject to near permanent inundation and a landform along an estuary subject to unrestricted tidal flow or a regularly flooded landform along a tidal freshwater river or stream	buttonbush swamps; aquatic beds; semipermanently flooded marshes; river and stream gravel/sand bars; salt and brackish marshes and flats; regularly flooded tidal fresh marsh or flat
Island	a landform completely surrounded by water (including deltas)	deltaic and insular wetlands; floating bog islands

*May be applied as sub-landforms within the Floodplain landform.
**This landform is applied only to wetlands on floodplains along "rivers" (polygonal watercourses); it is not applied to wetlands along streams because alluvial soils are not consistently mapped in these locations; the latter wetlands are classified as basins or flats.

Land Use/Cover Mapping and Geodatabase Construction

For this assessment, a geospatial database covering the entire Meadowlands District needed to be created. ARC GIS 9.0 was the format for the geospatial database. The updated NWI data and land use/cover data from the New Jersey Meadowlands Commission served as base data for this phase of the project. Coding of the latter source was simplified for our use and the classifications refined where necessary. The Anderson et al. (1976) land use and land cover (LULC) classification system was used to classify upland areas, with the following categories being among those identified: developed land, agricultural land, forests, wetlands (from NWI data), transitional land (moving toward some type of development or agricultural use, but future status unknown), and water. This update focused on major areas of land use change and, therefore, did not represent a comprehensive revision of all LULC categories. Changes between ”natural“ habitat and land use (mainly development for this study area) were emphasized.

Natural Habitat Integrity Assessment

We applied the remotely sensed indices of "natural habitat integrity" (Tiner 2004) to the geospatial dataset for the Meadowlands District. These indices were designed to meet four of the following requirements: 1) be derived from air photointerpretation and/or satellite image processing for contemporary data and from maps for historical data, 2) be suitable for frequent updating and rapid assessment, 3) consist of metrics that could efficiently and cost effectively updated for large geographic areas, 4) present a broad view of the extent of “natural habitat,” and 5) provide a historic perspective on the extent of wetlands and open waterbodies. Such indices would be coarse-filter variables for assessing the overall condition of watersheds. They were intended to augment, not supplant, other more rigorous, fine-filter approaches for describing the ecological condition of watersheds (e.g., IBIs for instream macroinvertebrates and fish and the extent of invasive species) and for examining relationships between human impacts and natural resources. While the indices were designed for use in larger watersheds, they may be applied to subbasins as they were for the Meadowlands District. The indices were calculated for each of the eight subbasins.

The variables chosen for indexing included: 1) extent of “natural” habitat, 2) condition of river and stream corridors, 3) condition of buffers around vegetated wetlands, 4) condition of pond and lake buffers, 5) present extent of wetlands relative to historic area, 6) present extent of standing waterbodies relative to historic area, 7) amount of stream channelization, 8) extent of river/stream damming, 9) the amount of wetland disturbance (i.e., drained, excavated, impounded, and farmed wetlands), and 10) the degree of habitat fragmentation by roads. While there are undoubtedly other features that can be monitored, these variables represent features important to natural resource managers attempting to lessen the impact of human development on the environment.

Eleven indices were created: six addressing habitat extent (i.e., the amount of natural habitat occurring in the watershed and along wetlands and waterbodies), four dealing with habitat disturbances (emphasizing human-induced alterations to streams, wetlands, and terrestrial habitats), and one composite index. The six “natural” habitat extent indices are “natural” cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. The four “habitat disturbance indices“ involve dammed stream flowage, channelized stream flowage, wetland disturbance, and habitat fragmentation by roads. The last index - “composite natural habitat integrity index” - is comprised of the weighted sum of all the other indices, with the disturbance indices subtracted from the habitat extent indices to yield an overall “natural habitat integrity“ score for a watershed or subbasin. All indices have a maximum value of 1.0 and a minimum value of zero. For the habitat extent indices, the higher the value, the more habitat available. For the disturbance indices, the higher the score, the more disturbance.

For purposes of this study, ”natural habitats" are defined as areas where significant human activity is limited to activities such as nature observation, hunting, fishing, or timber harvest, and where vegetation is allowed to grow for many years without annual harvesting of vegetation or fruits and berries for commercial purposes. Natural habitats are not restricted to pristine habitats; they include managed habitats such as commercial forests and wildlife impoundments, but they are not cultivated or subjected to heavy human traffic (except perhaps along hiking trails). They are essentially plant communities represented by forests, meadows, shrub thickets, and wetlands where resident and migratory wildlife find food, shelter, and water. They are not developed sites (e.g., impervious surfaces, lawns, turf, cropland, pastures, or mowed hayfields). ”Natural habitat“ therefore includes habitats ranging from pristine wilderness to wetlands now colonized by invasive species (e.g., <u>Phragmites</u> <u>australis</u> or <u>Lythrum</u> <u>salicaria</u>) or pine plantation forests. “Natural vegetation” is the plant community growing in these habitats. Natural habitat integrity is broadly defined as conditions where “natural habitat” is typically allowed to exist for many years, without great disturbance by humans. This is quite different from the concept of biological integrity proposed by Angermeier and Karr (1994) that emphasizes conditions with little or no human influence. Clearly, the urban environment surrounding the Meadowlands has greatly reduced the amount of "natural habitat" outside of the remaining wetlands.

The indices do not include certain qualitative information on the condition of existing habitats as reflected by the presence, absence, or abundance of invasive species or the degree of forest fragmentation, for example. Fragmentation of the Meadowlands by roads is not as useful a statistic as it is in less developed watersheds, since the density of roads in some areas of the District are among the highest possible due to urban development. The level of effort required to inject more qualititative data into the analysis may preclude the rapid assessment objective for this remotely-sensed ecological assessment. For most watersheds, weighting of natural woodlands versus commercial forests may be a practical option for this type of assessment, but it was not explored. Another consideration would be establishment of minimum size thresholds to determine what constitutes a viable ”natural habitat“ for analysis (e.g., 0.04 hectare/0.1 acre patch of forest or 0.4 hectare/1 acre minimum?). Other indices may also need to be developed to further aid in water quality assessments (e.g., index of ditching density for agricultural and silvicultural lands).

<u>Habitat Extent Indices</u>

These indices mainly attempt to provide an assessment of the amount of “natural vegetation” or “natural habitat” that occurs in a watershed, including strategic locations important for water quality and aquatic/wetland wildlife. The following areas are emphasized: the entire watershed, stream and river corridors, vegetated wetlands and their buffers, and pond and lake buffers. The extent of standing waterbodies is also included to provide information on the quantity of aquatic habitat in the watershed relative to their historic extent.

A Note on Buffers: Before discussing the indices, a comment on what the buffer includes is relevant. The indices include assessments of the 100m buffer around vegetated wetlands and waterbodies (ponds, lakes, rivers, and streams). Vegetated buffers are recognized as important to maintaining habitat and water quality. For this project, a 100m buffer was drawn around all vegetated wetlands and the buffer of interest was the upland portion (not open water in this zone). Along waterbodies, the 100m buffer included both vegetated wetlands and uplands. For this study, buffer areas within the District's subbasins were assessed. If the buffer fell outside the District that area was not included in the analysis. If a portion of the buffer fell outside the subbasin but within another subbasin of the District, that portion of the buffer was included in the analysis for latter but not the former subbasin.

The *Natural Cover Index* (I_{NC}) is the proportion of a watershed that is wooded or "natural" open land (e.g., emergent wetlands, "old fields," or sand dunes, but not cropland, hayfields, lawns, turf, or pastures), excluding open water.

> $I_{NC} = A_{NV}/A_W$, where A_{NV} (area in "natural" vegetation) equals the area of the watershed's land surface in "natural" vegetation and A_W is the total land surface area of the watershed (excluding open water).
>
> Significance of index: provides information on how much of a watershed is not developed and may be serving as important wildlife habitat.

The *River-Stream Corridor Integrity Index* (I_{RSCI}) is derived by considering the condition of the land bordering perennial rivers and streams.

> $I_{RSCI} = A_{VC}/A_{TC}$, where A_{VC} (vegetated river-stream corridor area) is the area of the river-stream corridor that is colonized by "natural vegetation" and A_{TC} (total river-stream corridor area) is the total area of the river-stream corridor.
>
> Significance of index: provides information on the status of vegetated riparian corridors.

A 200-meter corridor (100m on each bank of the river or stream) is the recommended minimum. Note that these corridors include banks of impounded sections of rivers and streams, so that a continuous river or stream corridor is evaluated. The corridor area does not include the waterbody. It might be worthwhile to separate linear segments (streams) from polygonal segments (rivers) as the latter may be more frequently surrounded by wetland rather than upland, especially in tidal reaches. For the Meadowlands District, the index was applied to nontidal perennial rivers and streams; only a few such watercourses exist in the District.

The *Vegetated Wetland Buffer Integrity Index* (I_{VWB}) measures the condition of wetland buffers within a specified distance (e.g., 100m) of mapped vegetated wetlands for a watershed.

$I_{VWB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

Significance of index: provides information on vegetated buffers around wetlands that are important for wildlife and for reducing impacts to wetland water quality from surface runoff.

This buffer is drawn around all existing vegetated wetlands, therefore such wetlands are excluded from the buffer. While the buffer zone may include open water, the buffer index focuses on upland areas that are either capable of supporting free-standing vegetation or in some type of land use. For the Meadowlands District, a 100m buffer was examined.

The *Pond and Lake Buffer Integrity Index* (I_{PLB}) addresses the status of buffers of a specified width around these standing waterbodies (excluding instream impoundments that are part of the river-stream corridor integrity index):

$I_{PLB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

Significance of index: documents the condition of vegetation in a zone surrounding these waterbodies which is important for both water quality and aquatic life (buffer from impacts associated with adjacent urban/suburban development, agriculture, and other human actions).

Ponds are shallow waterbodies mapped as palustrine unconsolidated bottoms and unconsolidated shores by NWI. Vegetated ponds are mapped as a vegetated wetland type and their buffers are not included in this analysis, but instead are evaluated as wetland buffers. For this project, a 100m buffer was examined.

The *Vegetated Wetland Extent Index* (I_{VWE}) compares the current extent of vegetated wetlands to the estimated historic extent.

$I_{VWE} = A_{CW}/A_{HW}$, where A_{CW} is the current area of vegetated wetland in a watershed and A_{HW} is the historic vegetated wetland area in the watershed.

Significance of index: gives historical perspective on wetland loss.

The I_{VWE} is an approximation of the extent of the original vegetated wetland acreage remaining in a watershed. Farmed wetlands are included where cultivation is during droughts only, since they are likely to support “natural vegetation” during normal and wet years. Where farmed wetlands are cultivated more or less annually such as in much of the Northeast region, they are not included in the area of vegetated wetland, since they lack “natural vegetation” in most years and only minimally function as wetland at best. In most cases, hydric soil data are used to help generate the historic extent of wetlands. For the Meadowlands, we used data from a 1880s map from a prior study (Tiner et al. 2002) to determine historic wetlands.

The *Standing Waterbody Extent Index* (I_{SWE}) addresses the current extent of standing fresh waterbodies (e.g., lakes, reservoirs, and open-water wetlands - ponds) in a watershed relative to the historic area of such features.

$I_{SWE} = A_{CSW}/A_{HSW}$, where A_{CSW} is the current standing waterbody area and A_{HSW} is the historic standing waterbody area in the watershed.

Significance of index: gives perspective on changes in waterbody area (historic vs. today).

From a practical standpoint, this index is estimated. For most areas, a net gain in ponds and impoundments has occurred over time. Every national wetland trend study (Frayer et al. 1983, Tiner 1984, Dahl and Johnson 1991, Dahl 2000) has shown an increase in pond area as ponds are constructed for a multitude of purposes. For these situations, the I_{SWE} value is 1.0+ indicating a gain in this aquatic resource and no specific calculations necessary; a value of 1.0 is then used for determining the composite natural habitat integrity index for the study area. In geographic areas where significant loss of open water has occurred, an estimate will need to be derived from available sources (including historic maps).

Habitat Disturbance Indices

A set of four indices have been developed to address alterations to natural habitats. For these indices, a value of 1.0 is assigned at maximum disturbance, e.g., when all of the streams or existing wetlands have been modified.

The *Dammed Stream Flowage Index* (I_{DSF}) highlights the direct impact of damming on rivers and streams in a watershed.

$I_{DSF} = L_{DS}/L_{TS}$, where L_{DS} is the length of perennial streams impounded by dams (combined pool length) and L_{TS} is the total length of perennial streams in the watershed (including the length of instream pools).

Significance of index: reveals how much of the stream system has been dammed.

Note that the total stream length used for this index will be greater than that used in the channelized stream length index, since the latter emphasizes existing streams and excludes dammed segments. This index should be expanded to include the entire river-stream length (i.e., the Dammed River-Stream Flowage Index) or represented as two separate indices.

The *Channelized Stream Length Index* (I_{CSL}) is a measure of the extent of stream channelization within a watershed.

$I_{CSL} = L_{CS}/L_{TS}$, where L_{CS} is the channelized stream length and L_{TS} is the total stream length for the watershed.

Significance of index: documents the magnitude of stream channelization.

Since this index addresses channelization of existing streams, it focuses on the linear streams. The index will usually emphasize perennial streams, but could include intermittent streams, if desirable. The total stream length does not include the length of: 1) artificial ditches excavated in farm fields and forests, 2) dammed sections of streams, and 3) polygonal portions of rivers. Channelization of the latter may be represented by a separate index or preferably combined with this index to form a Channelized River/Stream Length Index.

The *Wetland Disturbance Index* (I_{WD}) focuses on alterations within existing wetlands. As such, it is a measure of the extent of existing wetlands that are diked/impounded, ditched, excavated, or farmed. It also includes wetlands in urban areas that are cut off from rivers by roads, causeways, and development. For the Meadowlands, all wetlands except those contiguous to the mainstem of the Hackensack River were considered disturbed and even some of the latter were classified as disturbed due to ditching and other factors. All wetlands (vegetated and nonvegetated, natural and created) were included in this index.

> $I_{WD} = A_{DW}/A_{TW}$, where A_{DW} is the area of disturbed or altered wetlands and A_{TW} is the total wetland area in the watershed.
>
> Significance of index: identifies the degree to which existing wetlands have been altered by human actions.

Since the focus of analysis is on "natural habitat," diking or excavating wetlands (or portions thereof) is viewed as an adverse action. It is recognized, however, that many such wetlands serve as valuable wildlife habitats (e.g., waterfowl impoundments) despite such alteration.

The *Habitat Fragmentation/Road Index* (I_{HF}) attempts to address habitat fragmentation by roads.

> $I_{HF} = A_R/A_W \times 16$, where A_R is the area of roads (interstates, state/county and other roads) and A_W is the total land area of the watershed.
>
> Significance of index: indicates habitat fragmentation by roads, but likely reflects degradation of water quality, and terrestrial and aquatic ecosystems from associated development.

Since road area will never equal 100 percent of a watershed, a multiplier was created to increase the index value to a level of relevance for the composite index (remotely-sensed index of natural habitat integrity). A multiplier of 16 was established based on examination of road density in a portion of Jersey City, NJ with extremely high road density (0.06 road area/city area); multiplying by 16 would yield an index value near 1.0 (the estimated maximum road area/unit area). If this multiplier yields an index value greater than 1.0, use 1.0 for the value when computing the composite index. (Note: This would only happen if an entire watershed or subbasin had higher road density than Jersey City, NJ which would be a rare situation. It is most likely to happen in very small subbasins in urban areas such as the subbasins of the Meadowlands District.)

While limited to road fragmentation, this index serves a surrogate for habitat fragmentation and degradation. Two watersheds may have the same amount of natural habitat, but one may have many roads and the other few. Although not the only human action that causes habitat fragmentation, road density is closely correlated to degraded ecosystems (Miller et al. 1996, Quigley and Arbelbide 1997, Forman and Alexander 1998, Forman 2000, and Trombulak and Frissell 2000). Moreover, adverse impacts from other development (e.g., urban and suburban) are likely related to the extent of roads, especially paved roads. More detailed assessments of habitat fragmentation, including mean patch size, patch density, edge density, and total core area, could be performed, if necessary.

In an assessment study for Delaware's Nanticoke River watershed, the following road widths were used to calculate A_R: interstates (2 lanes/direction) - 12.1m, state roads (2 lanes; 1 lane/direction) - 12.1m, county/local roads (2 lanes; 1 lane/direction) - 11.5m, and dirt roads (2-lanes) - 6.7m (Kevin Canning, Delaware Department of Transportation, pers. comm. 2003). The above numbers are estimates as actual road width depends on numerous conditions. These widths were applied to the orthophotoquad of the Meadowlands District and appeared to match up well, so no changes were necessary. Road widths were applied to road lengths to calculate area of roads for the study area; they provide perspective on the area of road surface in a watershed.

Composite Habitat Integrity Index for the District

The *Composite Natural Habitat Integrity Index* (I_{CNHI}) is a combination of the preceding indices. It seeks to express the overall condition of a watershed in terms of its potential ecological integrity or the relative intactness of “natural” plant communities and waterbodies, without reference to specific qualitative differences among these communities and waters. Variations of I_{CNHI} may be derived by considering buffer zones of different widths around wetlands and other aquatic habitats (e.g., $I_{CNHI\ 100}$ or $I_{CNHI\ 200}$) and by applying different weights to individual indices or by separating or aggregating various indices (e.g., stream corridor integrity index, river corridor integrity index, or river-stream corridor integrity index). While the weighting of the indices is debatable, the results of this analysis are comparable among the subbasins examined. The same weighting scheme must be used whenever comparisons of this index are made between and within watersheds.

For the analysis of the Meadowlands District, the following formula was used to determine this composite index:

> $I_{CNHI\ 100} = (0.5 \times I_{NC}) + (0.125 \times I_{RSCI200}) + (0.125 \times I_{VWB100}) + (0.05 \times I_{PLB100}) + (0.1 \times I_{WE}), + (0.1 \times I_{SWE}) - (0.1 \times I_{DSF}) - (0.1 \times I_{CSL}) - (0.1 \times I_{WD}) - (0.1 \times I_{HF})$, where the condition of a 100m buffer is used throughout.
>
> Significance of index: gives an overview of the condition of the watershed relative to the existence of “natural” habitat and a measure that can be compared with other watersheds.

The indices were applied to the District’s subbasins.

GIS Analysis and Data Compilation

The geographic information system (GIS) used for this project was ARC GIS 9.0. Several GIS analyses were performed to produce wetland statistics (acreage summaries) and the remotely-sensed indices of "natural habitat integrity." Tables summarizing the results of the inventory were prepared to show the extent of different wetland types by NWI classifications and by LLWW descriptors and to portray differences among subbasins with respect to the natural habitat integrity indices.

Maps

A series of four maps was produced to show the study findings: 1) wetlands and deepwater habitats classified by NWI types, 2) wetlands and deepwater habitats classified by landscape position, 3) land use and land cover, and 4) upland land use and land cover within 100 meters of wetlands and deepwater habitats. All maps were produced at a scale of 1:30,000 for this report. A template showing subbasin boundaries is included on each map.

Results

The results are presented for the Meadowlands District as a whole and for the eight subbasins. Data are organized by the District and then for the subbasins. Maps are presented in a separate folder contained on the compact disk (CD) version of the report and are hyperlinked to the report; they are not included in the hardcopy version of this report. One set of hardcopy maps were printed and given to NJFO.

District Totals

Wetland Classification and Inventory

Wetlands by NWI Types

According to the NWI, the Meadowlands District had over 5,800 acres of wetlands (including ponds) (Table 2; Map 1). Estuarine emergent wetlands were the predominant wetland type with over 4,100 acres inventoried, accounting for 70% of the wetlands in the District. Estuarine unconsolidated shores (e.g., tidal mudflats) wetlands were next in abundance with nearly 1,200 acres, representing 20% of the wetlands. Thus, estuarine wetlands overall accounted for roughly 91% of the District's wetlands. Palustrine (freshwater) wetlands comprised the remaining 9% (540 acres).

Wetlands by LLWW Types

Most (93%) of the wetland acreage was associated with the Hackensack River estuary (Table 3; Map 2). This figure included some tidal freshwater wetland contiguous to brackish marshes of the estuary. Terrene and lotic wetlands each represented about 2.7% of the wetlands. The rest of the wetlands were ponds.

From the landform perspective, fringe and basin wetlands were most extensive, accounting for 57% and 43% of the wetland acreage, respectively. Less than 1% was made up of flat and island landforms. Wetlands along the mainstem of the Hackensack River were classified as fringe, whereas estuarine wetlands behind the New Jersey Turnpike and other highways and roads were identified as basin types.

Considering water flow path, it was no surprise that 94% of the wetland acreage had bidirectional-tidal flow. Three percent of the wetlands had throughflow, 2% outflow, and 1% isolated. These numbers include wetlands and ponds.

Table 2. Wetlands classified by NWI types for the Meadowlands District.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	4,115.8
Scrub-Shrub	1.6
Unconsolidated Shore	1,186.9
-----------------------------	-----------
Subtotal	5,304.3
Palustrine Wetlands	
Emergent	247.0
Emergent/Scrub-Shrub	27.6
Forested, Broad-leaved Deciduous	90.4
Scrub-Shrub, Deciduous	12.7
Scrub-Shrub/Emergent	7.6
Scrub-Shrub/Forested	66.0
Unconsolidated Bottom	82.4
Unconsolidated Shore	6.2
---	------------
Palustrine Subtotal	539.9
GRAND TOTAL (ALL WETLANDS)	5,844.2

Table 3. Wetlands in the Meadowlands District classified by LLWW types (including ponds).

Landscape Position	Landform	Water Flow	Acreage
Estuarine (ES)			
	Fringe	Bidirectional-tidal (BT)	3,303.4
	Basin	Bidirectional-tidal (BT)	2,127.5
	Island	Bidirectional-tidal (BT)	14.5
	(Subtotal Estuarine)		*5,445.4*
Lotic Stream (LS)			
	Basin (BA)	Throughflow (TH)	137.2
	Flat (FL)	Throughflow (TH)	19.0
	(Subtotal Lotic Stream)		*156.2*
Terrene (TE)			
	Basin (BA)	Isolated (IS)	14.2
		Outflow (OU)	122.8
		(subtotal)	*137.0*
	Flat (FL)	Isolated (IS)	2.9
		Outflow (OU)	1.5
		(subtotal)	*4.4*
	Slope (SL)	Outflow (OU)	12.9
	(Subtotal Terrene)		*154.3*
Pond (PD)*			
		Bidirectional-tidal (BT)	46.3
		Isolated (IS)	40.1
		Outflow (OU)	2.2
	(Subtotal Pond)		*88.6*
TOTAL LLWW Types			5,844.5

*Ponds are a type of basin wetland, but have been reported separately since they typically are permanently flooded (or nearly so).

Subbasin Totals

Wetland Classification and Inventory

The results of the inventory for all subbasins are presented in Tables 4 and 5. The former summarizes findings by NWI types, whereas the latter reports acreage data by LLWW types.

Two subbasins had more than half (54%) of the District's estuarine wetlands: HR1 (Hackensack River below the Amtrak bridge) and HR4 (Hackensack River from Rt. 3 to Bellman's Creek). These subbasins had more than 1,400 acres of these wetlands. Subbasin BC2 (Berry's Creek below Paterson Avenue) also had substantial estuarine acreage (910 acres), accounting for 17% of these wetlands in the District. Fifty-seven percent of the palustrine wetlands (including ponds) in the District were associated with a single subbasin: BC1 (Berry's Creek above Paterson Avenue). Lotic and terrene wetlands each accounted for 29% of the District's freshwater wetlands, while 36% were located behind estuarine wetlands. The remaining 16% were associated with freshwater ponds.

Natural Habitat Integrity Assessment

The findings are summarized below in the following subsections and in Table 6.

Natural Cover

Values for natural cover indices ($I_{NC)}$ varied from a high of 0.46 for subbasin LPR (Lower Passaic River,(Newark Bay to 4th St. Bridge) to a low of 0.25 for the Overpeck Creek subbasin (Table 6). Other subbasins with more than 40% of their "land" area in "natural vegetation" included BC2 (Berry's Creek below Paterson Avenue) subbasin and two Hackensack River subbasins HR4 and HR2 (Route 3 to Bellman's Creek and Bellman's Creek to Fort Lee Road, respectively). Map 3 shows the distribution of "natural habitats" as well as various land uses in the District.

Freshwater River/Stream Corridors

Only three subbasins had freshwater rivers and streams (Table 6). Of these the Hackensack River subbasin from Bellman's Creek to Ft. Lee Road (HR2) and the Berry's Creek subbasin above Paterson Avenue (BC1) had river/stream corridor integrity values above 0.45. The other one (HR3) had only 11% of their corridors covered with natural vegetation. No freshwater streams or stream buffers were located in five subbasins (BC2, HR1, HR4, OC, and LPR). The I_{RSC} value for "not applicable" ("na") was evaluated two ways for comparison, since the composite values are significantly affected by the I_{RSC} value. We found that by giving "na" a value of 1.0 the composite value goes up by 0.12 or 0.13 over that generated when giving "na" a value of 0.0. Given the results, we decided that it was more appropriate to give them a value of 1.0 rather than 0.0, for the latter would suggest that all of the corridor is developed while in reality, there was none and hence no impact. Map 4 shows the condition of buffers along wetlands and deepwater habitats.

Table 4. Wetland acreage in subbasins of the Meadowlands District. Subbasins: BC1 (Berry's Creek above Paterson Avenue), BC2 (Berry's Creek below Paterson Avenue), HR1 (Hackensack River - Amtrak bridge to Route 3), HR2 (Hackensack River - Bellman's Creek to Fort Lee Road), HR3 (Hackensack River - below Amtrak bridge), HR4 (Hackensack River - Route 3 to Bellman's Creek), OC (Overpeck Creek), and LPR (Lower Passaic River -Newark Bay to 4th Street Bridge). Wetland types: US - unconsolidated shore, EM - emergent, EM-t - emergent-tidal, EM-nt - emergent-nontidal, SS – scrub-shrub, OV - other vegetated (t - tidal; nt - nontidal). % of HMD = percent of the District's wetlands (estuarine, palustrine, and total)

	Estuarine Wetlands			**Subtotal**	**Palustrine Wetlands**					**Subtotal**	**Total**
Subbasin	**US**	**EM**	**SS**	**Acreage (% of HMD)**	**UB***	**EM-t**	**EM-nt**	**OV-t**	**OV-nt**	**Acreage (% of HMD)**	**Acreage (% of HMD)**
BC1	1.0	81.2	1.5	83.7 (1.6)	3.4	108.6	51.8	52.3	92.6	308.7 (57.2)	392.4 (6.7)
BC2	1.1	908.5	--	909.6 (17.1)	26.3	6.6	0.5	4.4	0.5	38.3 (7.1)	947.9 (16.2)
HR1	776.1	655.9	--	1,432.0 (27.0)	16.3	14.7	5.6	--	0.4	37.0 (6.9)	1,469.0 (25.1)
HR2	103.7	522.7	--	626.4 (11.8)	0.7	5.6	0.1	18.6	--	25.0 (4.6)	651.4 (11.1)
HR3	0.4	529.9	--	530.3 (10.0)	18.2	40.8	6.7	--	--	65.7 (12.2)	596.0 (10.2)
HR4	291.0	1,155.3	-	1,446.3 (27.3)	1.5	4.2	--	3.9	--	9.6 (1.8)	1,455.9 (24.9)
OC	8.3	51.3	--	59.6 (1.1)	0.2	0.4	--	4.5	--	5.1 (0.1)	64.7 (1.1)
LPR	5.5	210.9	--	216.4 (4.1)	22.1	23.6	5.7	--	--	51.4 (9.5)	267.8 (4.6)

Table 5. Wetland acreage (including ponds) by LLWW types for subbasins of the Meadowlands District. See preceding table for subbasin names. FR – fringe, BA – basin, IL – island, SL – slope, TH – throughflow, IS – isolated, OU – outflow, and BT – bidirectional-tidal.

	Estuarine (ES)			**Lotic Stream (LS)**		**Terrene (TE)**					**Pond (PD)**		
Subbasin	**BA**	**FR**	**IL**	**BATH**	**FLTH**	**BAIS**	**BAOU**	**FLIS**	**FLOU**	**SLOU**	**BT**	**IS**	**OU**
BC1	95.9	--	--	123.1	33.1	3.6	119.1	--	1.5	12.9	2.1	1.3	--
BC2	902.4	18.6	--	--	--	--	--	--	--	--	21.1	5.2	--
HR1	470.1	963.1	13.5	--	--	2.3	3.7	--	--	--	9.1	7.2	--
HR2	351.7	298.9	--	--	--	0.1	--	--	--	--	0.1	0.6	--
HR3	491.6	79.9	--	--	--	3.3	--	2.9	--	--	9.2	7.0	2.0
HR4	694.4	759.0	1.0	--	--	--	--	--	--	--	0.5	0.8	0.2
OC	58.5	6.0	--	--	--	--	--	--	--	--	0.2	--	--
LPR	238.6	2.0	--	--	--	4.9	--	--	--	--	4.2	17.9	--

Table 6. Natural habitat integrity indices for subbasins of the Meadowlands District. na = not applicable (see ** below).

	Natural Habitat Extent Indices						**Disturbance Indices**				**Composite Index***
Subbasin	$\mathbf{I_{NC}}$	$\mathbf{I_{RSC}}$	$\mathbf{I_{VWB}}$	$\mathbf{I_{PLB}}$	$\mathbf{I_{VWE}}$	$\mathbf{I_{SWE}}$	$\mathbf{I_{DSF}}$	$\mathbf{I_{CSL}}$	$\mathbf{I_{WD}}$	$\mathbf{I_{HF}}$	$\mathbf{I_{CNHI}}$
BC1	0.28	0.46	0.13	0.04	0.27	1.00+	0.00	1.00	1.00	0.70	0.14
BC2	0.43	na (1.0)	0.14	0.06	0.35	1.00+	0.00 (0.0)	na	1.00	1.00	0.29**
HR1	0.28	na (1.0)	0.18	0.03	0.16	1.00+	0.00 (0.0)	na	0.67	1.00	0.24**
HR2	0.44	0.48	0.07	0.48	0.44	1.00+	0.00	1.00	0.85	0.97	0.17
HR3	0.30	0.11	0.15	0.26	0.26	1.00+	0.00	1.00	1.00	0.96	0.02
HR4	0.45	na (1.0)	0.12	0.08	0.40	1.00+	0.00 (0.0)	na	0.83	1.00	0.33**
OC	0.25	na (1.0)	0.03	0.00	0.26	1.00+	0.00 (0.0)	na	0.87	1.00	0.19**
LPR	0.46	na (1.0)	0.24	0.33	0.14	1.00+	0.00 (0.0)	na	0.99	1.00	0.32**

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* $I_{CNHI\ 100} = (0.5 \text{ x } I_{NC}) + (0.125 \text{ x } I_{RSCI200}) + (0.125 \text{ x } I_{VWB100}) + (0.05 \text{ x } I_{PLB100}) + (0.1 \text{ x } I_{VWE}), + (0.1 \text{ x } I_{SWE}) - (0.1 \text{ x } I_{DSF}) - (0.1 \text{ x } I_{CSL}) - (0.1 \text{ x } I_{WD}) - (0.1 \text{ x } I_{HF})$.

**No freshwater streams or stream buffers were located in these subbasins, composite values differ greatly depending on how the index I_{RSC} is treated; when assigned a value of 1.0 to this index for a "na", the composite value goes up by 0.12 or 0.13 vs. when the I_{RSC} for a "na" is given a value of 0.0. Given these results, it appears that assigning I_{RSC} a value of 1.0 for a "na" is better than a zero, for the latter would suggest that the entire corridor is developed while in reality, there was none. The index value for "na" under I_{CSL} is assigned a value of zero as to indicate no impact.

Vegetated Wetland Buffers

Buffers around vegetated wetlands were in poor shape (Map 4), with all index values less than 0.25 (Table 6). This means that less than 25% (one-quarter) of the 100m upland border was vegetated with "natural vegetation."

Pond and Lake Buffers

Pond and lake buffers were in the best shape in the subbasin covering the Hackensack River from Bellman's Creek to Ft. Lee Road (HR2) (Table 6). About 48% of its buffer was vegetated (Map 4). Two other subbasins had more than 25% of their pond/lake buffers covered by natural vegetation: Lower Passaic River (LPR) and the Hackensack River below the Amtrak bridge (HR3).

Historic Wetland Trends

Over 70% of the wetlands in the Meadowlands have been destroyed since the late 1800s, so there was no surprise to find rather low values regarding wetland extent. For individual subbasins, wetlands are still abundant, with both Hackensack River from Bellman's Creek to Fort Lee Road (HR2) and from Route 3 to Bellman's Creek (HR4) having index values above 0.40 (Table 6). The lowest values were recorded for the Hackensack from the Amtrak bridge to Route 3 (HR1) and the Lower Passaic River (LPR) subbasins.

Standing Waterbody Trends

Each subbasin in the District had created ponds while some had significant areas of diked open water. Consequently, the I_{SWE} for each subbasin was recorded as 1.0+.

River/Stream Damming and Channelization

No dams were located in the District and all streams were mapped as channelized, so the index values for dammed stream flowage index (I_{DSF}) are 0.0 for all subbasins, while the channelized stream length index (I_{CSL}) is 1.0 for all subbasins that had streams inventoried (Table 6). Five subbasins did not have any streams mapped (BC2, HR1, HR4, OC, and LPR), so none were channelized and their I_{CSL} was 0.0.

Altered Wetlands

Given that the Meadowlands is surrounded by one of the most densely populated metropolitan areas, the wetland disturbance index (I_{WD}) values were expected to be high. The stats for individual subbasins support this expectation (Table 6); all had index values above 0.66.

Road Fragmentation

As expected, the fragmentation by road index (I_{HF}) values is variable due to the conditions within the subbasins. Road density outside the wetlands in the District is extremely high. In all but one of the subbasins (BC1 exception), the index values were maximum (i.e., 1.0) or near maximum (>0.95) (Table 6).

Composite Index of Remotely-sensed "Natural Habitat Integrity"

Results of the composite index (I_{CNHI}) for the subbasins support our knowledge that the environment of the District is highly disturbed and stressed due to urban impacts. For reference, a pristine area would have a value of 1.0. All of the District's subbasins had composite index values at or below 0.33, with most having a value $\geq$ 0.19 (Table 6). The lowest value was recorded for subbasin HR3 (Hackensack River below the Amtrak bridge).

Discussion

The Meadowlands, Degraded but Valuable Wildlife Habitat

It seems paradoxical that a natural area can be severely degraded but still serve as valuable habitat…such is the Meadowlands. The assessment of natural habitat integrity clearly pointed out the level of destruction and degradation of wetlands, streams, and other natural habitats in the District. The results are not surprising given the amount of development that has taken place over the past 150 years in this metropolitan area. After all, the Meadowlands is only a fraction of its original size. By 1995, only 28 percent of the wetland area that occurred in the late 19th Century remained (Tiner et al. 2002).

While all subbasins have been significantly impacted by development and the value of the wetlands have been compromised, the wetlands still support significant fish and wildlife populations. The Meadowlands is the largest remaining estuarine wetland complex in northern New Jersey. Estuarine wetlands are among the nation's most valuable wetlands even when surrounded by developed upland as the tidal connection and fluctuating hydrology is the lifeblood of their ecology. The dominance of common reed (Phragmites australis) over other salt and brackish species also has likely reduced the value of this marshland to many species, yet many birds still uses the Meadowlands, especially the tidal flats and open water areas.

Common reed is widely recognized as the number one invasive plant threatening estuarine wetlands in the northeastern United States. It has replaced typical salt marsh plants in areas where tidal flow has been significantly restricted and where fill has been deposited in wetlands; both conditions apply to the Meadowlands. Common reed is a good disturbance indicator as it readily colonizes exposed soils in the coastal zone and even inland areas along highways (Marks et al. 1994). Plant diversity usually declines with the invasion of Phragmites as this species typically forms monotypic stands, especially in brackish waters (Meyerson et al. 2000). Changes in plant composition alter the habitat use by some to many species. There is general agreement that pure Phragmites stands generally yield poorer quality wildlife habitat than the marshes they replace, while they may be important habitat for some species (Roman et al. 1984; Kiviat 1987). The tall, dense reeds restrict wildlife movement and also adversely affect hydrology with negative impacts on aquatic species.

Over 50 species of birds have been found in common reed marshes (Meyerson et al. 2000). Despite this usage, there are no birds that depend solely on these wetlands. Common birds using Phragmites marshes include marsh wren, red-winged blackbird, and swamp sparrow. Ringed-necked pheasant and American bittern have been observed (R. Tiner, personal observations). The Meadowlands contains a mixture of emergent marsh types (Phragmites, cattails, and smooth cordgrass), tidal flats, and open water. The diversity and juxtaposition of these habitats and the location of the Meadowlands along the Atlantic Flyway make it an attractive habitat despite being surrounded by densely populated and highly industrialized areas. More than 265 species of birds use the Meadowlands, including numerous breeding species of concern, such as black-crowned night heron, blue-winged teal, northern harrier, common moorhen, American coot, and spotted sandpiper (U.S. Fish and Wildlife Service et al. 2000). The Meadowlands is recognized as a major link along the Atlantic Flyway for migratory species (especially shorebirds) and an important overwintering area for species including canvasback, redhead, bufflehead, lesser scaup, greater scaup, ruddy duck, hooded merganser, and common merganser. This urban wetland complex also provides significant natural aesthetics to the surrounding built-up landscape and offers opportunities to millions of people in the New York-Newark metropolitan area to see waterfowl (ducks, Canada geese, common moorhen, and American coot), wading birds (herons, egrets, glossy ibis, and occasionally the secretive least bittern), shorebirds, and numerous passerines (especially red-winged blackbird). Muskrats, raccoons, and other wildlife reside in the Meadowlands.

From the aquatic organism perspective, marsh flooding provides access for fishes and nektonic invertebrates and anything reducing this process will have a negative impact on their use of the marshes. Common reed is known to accelerate the buildup of the marsh surface and reduce drainage density by filling in small ditches and creeks (Weinstein and Balletto 1999), thereby restricting access to the marshes by fishes and transient shellfish. Reducing the frequency of tidal flooding has obvious negative consequences for aquatic species. Fish and shellfish density in Phragmites stands vary with hydrology and wetland geomorphology (Hanson et al. 2002). They noted that high stem density and litter accumulation may reduce tidal flow rates, leading to a reduction in the depth of tidal flooding. From the surface of a brackish Phragmites marsh along the Hudson River, they collected common mummichog (Fundulus heteroclitus), herrings (Alosa spp.), grass shrimp (Palaemonetes pugio), and blue crab (Callinectes sapidus). Most of the individuals were captured in the marsh near the creekbanks and only a few in the marsh interior. Depositional sites produced the most individuals and greatest biomass, but other studies have not yielded similar findings (Rozas 1992) Some studies have found a greater abundance of mummichog in Spartina (smooth cordgrass) marshes than in neighboring Phragmites marshes (Hanson et al. 2002). The Meadowlands serves as an important food source for the detritus-based food web of the New York/New Jersey Harbor Estuary ecosystem (U.S. Fish and Wildlife Service et al. 2000).

Future Considerations

Urban watersheds present an interesting challenge for assessment of natural habitat integrity given the amount and nature of development. For example, to further describe habitat fragmentation in urban watersheds, we might also want to address the actual fragmentation of designated "natural habitats" by roads and railroads in addition to reporting on the amount of road surfaces in a watershed or subbasin. This may give a better picture of the extent to which roads and railroads cross the remaining natural habitats. Different statistics could be reported for both wetlands and upland natural habitats. The extent of development in a watershed or subbasin is already characterized by the "natural cover index" which reports on the area of natural habitat relative to the land area of the watershed or subbasin. We also might want to report the size distribution of natural habitats in a given area as that statistic will provide another important property of the remaining natural habitats and likely show significance size reduction in wetlands, forests, and other natural habitats.

Our applications of the natural habitat integrity indices to date have been limited and we are still in a learning phase. Here are some lessons learned from our Meadowlands study.

1. Vegetated Wetland Buffer Index. To date, the buffer of vegetated wetlands has been one of our main focuses while nonvegetated wetlands were not included. This was because nonvegetated wetlands were bordered by vegetated wetland plus we wanted to treat ponds (the predominant nonvegetated freshwater wetland in the Northeast) separately and have given them their own index. In the Meadowlands, the level of disturbance with diking has created nonvegetated wetlands along uplands. For the District, the area that would be added to the buffer was minimal, so we applied the original formula that focused on the upland buffer around vegetated wetlands. However in thinking more broadly, we realize that nonvegetated wetlands also lie along uplands especially in macrotidal areas such as the Gulf of Maine, so the wetland buffer index will be modified in future studies (including the forthcoming assessment for the Hackensack River watershed) to include the upland border of all wetlands (excluding ponds) not just the vegetated wetlands. Inclusion of nonvegetated wetlands in the buffer analysis will also be important in arid regions where these wetland types are extensive. In future studies, vegetated and nonvegetated wetlands will be combined into a single data layer and then buffered for analysis. The aim of this buffer assessment is to determine the condition of the surrounding upland as certain land use practices have a significant impact on the quality of wetlands and their use by wildlife, hence the buffer should remain restricted to the upland.

The revised index will be called the *Wetland Buffer Integrity Index* (I_{WBI}) and the formula will be:

> $I_{WBI} = A_{VB}/A_{TB}$, where A_{VB} (area of upland buffer around wetlands excluding ponds) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

2. Pond Buffer Integrity Index. As noted earlier, ponds are considered separately since in many areas of the country, ponds are artificial waterbodies constructed within agricultural or developed landscapes; a separate index addresses their buffers. In areas where there are significant numbers of both natural ponds and artificial ponds, it would be worth developing separate indices to analyze and report on the buffer around natural ponds versus that around created ponds. The current pond and lake buffer index will be separated into at least two, and possibly four indices: 1) pond buffer integrity index (with the option of separating natural from artificial ponds for analysis) and 2) lake buffer integrity index (with the option of separating natural lakes from artificial lakes/reservoirs/large impoundments).

The *Pond Buffer Integrity Index* (I_{PBI}) addresses the status of buffers of a specified width around ponds (excluding instream impoundments that are part of the river-stream corridor integrity index). In this case, the buffer will include both wetlands and uplands, but will exclude open water.

> $I_{PBI} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

The *Lake Buffer Integrity Index* (I_{LBI}) addresses the status of buffers of a specified width around lakes. The buffer includes both vegetated wetlands that are seasonally flooded or drier and uplands. Semipermanently flooded wetlands in the lake should be considered part of the lake proper since they are in water for virtually all of the growing season and are more of an aquatic habitat than semiaquatic or terrestrial.

> $I_{LBI} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

3. River/Stream Corridor Integrity Index. This index has a dual purpose: 1) to identify the condition of riparian corridors ("naturally" vegetated or in some type of land use) and 2) to be able to identify wooded corridors that help moderate water temperatures as well as provide organic matter (leaf litter) for aquatic productivity. It may be best to separate stream corridors from river corridors for indexing purposes as streams and rivers represent different types of aquatic systems. It may also be worth separating tidal rivers from nontidal rivers as well as perennial from intermittent for the latter, due to ecological differences. All of this separation gives more specific information about ecologically different resources and helps pinpoint potential land use impacts that may have a negative effect on water quality and aquatic biota. Also, if desirable, impounded sections could be culled out and included in the pond/lake buffer integrity index or as a separate index (impounded river/stream corridor integrity index).

The *River Corridor Integrity Index* (I_{RCI}) is derived by considering the condition of the land bordering perennial rivers and streams.

> $I_{RCI} = A_{VC}/A_{TC}$, where A_{VC} (vegetated river corridor area) is the area of the river corridor that is colonized by "natural vegetation" and A_{TC} (total river corridor area) is the total area of the river corridor. This index may be calculated separately for tidal, perennial nontidal, and intermittent nontidal rivers, if desirable.

The *Stream Corridor Integrity Index* (I_{SCI}) is derived by considering the condition of the land bordering perennial rivers and streams.

> $I_{SCI} = A_{VC}/A_{TC}$, where A_{VC} (vegetated stream corridor area) is the area of the stream corridor that is colonized by "natural vegetation" and A_{TC} (total stream corridor area) is the total area of the stream corridor. This index may be calculated separately for tidal, perennial nontidal, and intermittent nontidal streams, if desirable.

See comments under #5 below regarding assigning values to corridor index when no streams (or corridors) are present in a subbasin; this would be an extremely rare situation.

4. Wetland Disturbance Index. Currently only wetlands classified as diked/impounded, excavated, partly drained, or farmed are included as "disturbed wetlands." In enhancing the NWI data, a fragmented code ("fg") is applied to wetlands separated by roads or railroads. The section that is separated from the main body of the wetland should be considered disturbed also. If the crossing does not cut off a small section, but simply crosses a large wetland and does not "isolate" a section of wetland, such as a road across most estuarine and lotic wetlands, the wetlands would not be designated as disturbed. Moreover, relict wetlands completely surrounded by development or nearly so should also be considered disturbed; these wetlands

may have to be culled from the database as currently they do not have a unique code. Similarly, the fragmented wetlands will also have to be reviewed, but at least they are highlighted with the unique “fg” code. If interested in knowing level of disturbance to certain types of wetlands, the analysis could be done to report on the level of disturbance to certain types. This would be in addition to reporting the wetland disturbance index and could be reported in terms of percent of acreage of a given type that is disturbed in various ways (e.g., % of lotic wetland acreage that is ditched or fragmented by roads and railroads or the % of terrene wetlands that are surrounded by development).

5. Composite Index. The Meadowlands’ subbasins were so small that five lacked freshwater streams and therefore did not have calculated values for stream corridor integrity. The composite index is not really applicable to situations where there are no values for a given subbasin or watershed, especially when doing a comparison between them. Since the composite index weights all indices for comparison among subbasins, a value needed to be developed for the “not applicable” indices. This should not be a problem in other subbasins as they are larger units and should contain at least one stream because their boundaries are in large part determined by the location of streams and their contributing area; the stream system (including rivers) is the focal point. The Meadowlands District is largely an estuarine tidal wetland complex and represented a unique set of circumstances in that no freshwater streams were mapped in five subbasins. If the I_{RSC} value (stream corridor integrity) was treated as zero, it would signify an impact and would result in lowering their composite score. If instead, the “not applicable” (na) was treated as 1.0, the composite index would be higher by 0.12 or 0.13. If this situation ever arises again, the “na” under a habitat extent index should be given a value of 1.0 (no alteration), while a “na” under a disturbance index should be rated as 0.0 (no impact).

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Appendix

Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors (Tiner 2003a)

U.S. Fish and Wildlife Service

Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors

September 2003

Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors

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Section 1. Introduction

A wide variety of wetlands have formed across the United States. To describe this diversity and to inventory wetland resources, government agencies and scientists have devised various wetland classification systems (Tiner 1999). Features used to classify wetlands include vegetation, hydrology, water chemistry, origin of water, soil types, landscape position, landform (geomorphology), wetland origin, wetland size, and ecosystem form/energy sources.

The U.S. Fish and Wildlife Service's wetland and deepwater habitat classification (Cowardin et al. 1979) is the national standard for wetland classification. This classification system emphasizes vegetation, substrate, hydrology, water chemistry, and certain impacts (e.g., partly drained, excavated, impounded, and farmed). These properties are important for describing wetlands and separating them into groups for inventory and mapping purposes and for natural resource management. They do not, however, include some abiotic properties important for evaluating wetland functions (Brinson 1993). Moreover, the classification of deepwater habitats is limited mainly to general aquatic ecosystem (marine, estuarine, lacustrine, and riverine) and bottom substrate type, with a few subsystems noted for riverine deepwater habitats. The Service's classification system would benefit from the application of additional descriptors that more fully encompass the range of characteristics associated with wetlands and deepwater habitats.

In the early 1990s, Mark Brinson created a hydrogeomorphic (HGM) classification system to serve as a foundation for wetland evaluation (Brinson 1993). He described the HGM system as "a generic approach to classification and not a specific one to be used in practice" (Brinson 1993, p. 2). This system emphasized the location of a wetland in a watershed (its geomorphic setting), its sources of water, and its hydrodynamics. The system was designed for evaluating similar wetlands in a given geographic area and for developing a set of quantifiable characteristics for "reference wetlands" rather than for inventorying wetland resources (Smith et al. 1995). A series of geographically focused models or "function profiles" for various wetland types have been created and are in development for use in functional assessment (e.g., Brinson et al. 1995, Ainslie et al. 1999, Smith and Klimas 2002).

Need for New Descriptors

The Service's National Wetlands Inventory (NWI) Program has produced wetland maps for 91 percent of the coterminous United States and 35 percent of Alaska. Digital data are available for 46 percent of the former area and for 18 percent of the latter. Although these data represent a wealth of information about U.S. wetlands, they lack hydrogeomorphic and other characteristics needed to perform assessments of wetland functions over broad geographic areas. Using geographic information system (GIS) technology and geospatial databases, it is now possible to predict wetland functions for watersheds - a major natural resource planning unit. Watershed managers could make better use of NWI data if additional descriptors (e.g., hydrogeomorphic-type attributes) were added to the current NWI database. Watershed-based preliminary assessments of wetland functions could be performed. This new information would also permit more detailed characterizations of wetlands for reports and for developing scientific studies and lists of potential reference wetland sites.

Background on Development of Keys

Since the Cowardin et al. wetland classification system (1979) is the national standard and forms the basis of the most extensive wetland database for the country, it would be desirable to develop additional modifiers to enhance the current data. This would greatly increase the value of NWI digital data for natural resource planning, management, and conservation. Unfortunately, Brinson's "A Hydrogeomorphic Classification of Wetlands" (1993) was not designed for use with the Service's wetland classification. He used some terms from the Cowardin et al. system but defined them differently (e.g., Lacustrine and Riverine). Consequently, the Service needed to develop a set of hydrogeomorphic-type descriptors that would be more compatible with its system. Such descriptors would bridge the gap between these two systems, so that NWI data could be used to produce preliminary assessments of wetland functions based on characteristics identified in the NWI digital database. In addition, more descriptive information on deepwater habitats would also be beneficial. For example, identification of the extent of dammed rivers and streams in the United States is a valuable statistic, yet according to the Service's classification dammed rivers are classified as Lacustrine deepwater habitats with no provision for separating dammed rivers from dammed lacustrine waters. Differentiation of estuaries by various properties would also be useful for national or regional inventories.

Recognizing the need to better describe wetlands from the abiotic standpoint in the spirit of the HGM approach, the Service developed a set of dichotomous keys for use with NWI data (Tiner 1997b). The keys bridge the gap between the Service's wetland classification and the HGM system by providing descriptors for landscape position, landform, water flow path and waterbody type (LLWW descriptors) important for producing better characterizations of wetlands and deepwater habitats. The LLWW descriptors for wetlands can be easily correlated with the HGM types to make use of HGM profiles when they become available. The LLWW attributes were designed chiefly as descriptors for the Service's existing classification system (Cowardin et al. 1979) and to be applied to NWI digital data, but they can be used independently to describe a wetland or deepwater habitat. Consequently, there is some overlap with Cowardin et al. since some users may wish to use these descriptors without reference to Cowardin et al.

The first set of dichotomous keys was created to improve descriptions of wetlands in the northeastern United States (Tiner 1995a, b). They were initially used to enhance NWI data for predicting functions of potential wetland restoration sites in Massachusetts (Tiner 1995a, 1997a). Later, the keys were modified for use in predicting wetland functions for watersheds nationwide (Tiner 1997b, 2000). A set of keys for waterbodies was added to improve the Service's ability to characterize wetland and aquatic resources for watersheds.

The keys are periodically updated based on application in various physiographic regions. This version is an update of an earlier set of keys published in 1997 and 2000 (Tiner 1997b, 2000).

Relatively minor changes have been made, including the following: 1) added "drowned river-mouth" modifier to the Fringe and Basin landforms (for use in areas where rivers empty into large lakes such as the Great Lakes where lake influences are significant), 2) added "connecting channels" to river type (to address concerns in the Great Lakes to highlight such areas), 3) added "Throughflow-intermittent" water flow path (to separate throughflow wetlands along intermittent streams from those along perennial streams), 4) added "Throughflow-artificial" and "Outflow-artificial" to water flow path (to identify former "isolated" wetlands or fragmented wetlands that are now throughflow or outflow due to ditch construction), 5) revised the lake key to focus on permanently flooded deepwater sites (note: shallow and seasonally to intermittently flooded sites are wetlands) and added "open embayment" modifier, and 6) revised the estuary type key (consolidated some types). This version also clarifies that a terrene wetland may be associated with a stream where the stream does not periodically flood the wetland. In this case, the stream has relatively little effect on the wetland's hydrology. This is especially true for numerous flatwood wetlands. It also briefly discusses how the term "isolated" is applied relative to surface water and ground water interactions. In the near future, illustrations will be added to this document to aid users in interpretations.

Use of the Keys

Two sets of dichotomous keys (composed of pairs of contrasting statements) are provided - one for wetlands and one for waterbodies. Vegetated wetlands (e.g., marshes, swamps, bogs, flatwoods, and wet meadows) and periodically exposed nonvegetated wetlands (e.g., mudflats, beaches, and other exposed shorelines) should be classified using the wetland keys, while the waterbody keys should be used for permanent deep open water habitats (subtidal or >6.6 feet deep for nontidal waters). Some sites may qualify as both wetlands and waterbodies. A good example is a pond. Shallow ponds less than 20 acres in size meet the Service's definition of wetland, but they are also waterbodies. Such areas can be classified as both wetland and waterbody, if desirable. However, we recommend that ponds be classified using the waterbody keys. Another example would be permanently flooded aquatic beds in the shallow water zone of a lake. We have classified them using wetland hydrogeomorphic descriptors, yet they also clearly represent a section of the lake (waterbody). This approach has worked well for us in producing watershed-based wetland characterizations and preliminary assessments of wetland functions.

Uses of Enhanced Digital Database

Once they are added to existing NWI digital data, the LLWW characteristics (e.g., landscape position, landform, water flow path, and waterbody type) may be used to produce a more complete description of wetland and deepwater habitat characteristics for watersheds. The enhanced NWI digital data may then be used to predict the likely functions of individual wetlands or to estimate the capacity of an entire suite of wetlands to perform certain functions in a watershed. Such work has been done for several watersheds including Maine's Casco Bay watershed and the Nanticoke River and Coastal Bays watersheds in Maryland, the Delaware portion of the Nanticoke River, and numerous small watersheds in New York (see Tiner et al.

1999, 2000, 2001; Machung and Forgione 2002; Tiner 2002; see sample reports on the NWI website:http://wetlands.fws.gov for application of the LLWW descriptors). These characterizations are based on our current knowledge of wetland functions for specific types (Tiner 2003) and may be refined in the future, as needed, based on the applicable HGM profiles and other information. The new terms can also be used to describe wetlands for reports of various kinds including wetland permit reviews, wetland trend reports, and other reports requiring more comprehensive descriptions of individual wetlands.

Organization of this Report

The report is organized into seven sections: 1) Introduction, 2) Wetland Keys, 3) Waterbody Keys, 4) Coding System for LLWW Descriptors (codes used for classifying and mapping wetlands), 5) Acknowledgments, 6) References, and 7) Glossary.

Section 2. Wetland Keys

Three keys are provided to identify wetland landscape position and landform for individual wetlands: Key A for classifying the former and Keys B and C for the latter (for inland wetlands and coastal wetlands, respectively). A fourth key - Key D - addresses the flow of water associated with wetlands.

Users should first identify the landscape position associated with the subject wetland following Key A-1. Afterwards, using Key B-1 for inland wetlands and Key C-1 for salt and brackish wetlands, users will determine the associated landform. The landform keys include provisions for identifying specific regional wetland types such as Carolina bays, pocosins, flatwoods, cypress domes, prairie potholes, playas, woodland vernal pools, West Coast vernal pools, interdunal swales, and salt flats. Key D-1 addresses water flow path descriptors. Various other modifiers may also be applied to better describe wetlands, such as headwater areas; these are included in the four main keys.

Besides the keys provided, there are numerous other attributes that can be used to describe the condition of wetlands. Some examples are other descriptors that address resource condition could be ones that emphasize human modification, (e.g., natural vs. altered, with further subdivisions of the latter descriptor possible), the condition of wetland buffers, or levels of pollution (e.g., no pollution [pristine], low pollution, moderate pollution, and high pollution). Addressing wetland condition, however, was beyond our immediate goal of describing wetlands from a hydrogeomorphic standpoint.

Key A-1: Key to Wetland Landscape Position

This key allows characterization of wetlands based on their location in or along a waterbody, in a drainageway, or in isolation ("geographically isolated" - surrounded by upland).

1. Wetland is completely surrounded by upland (non-hydric soils)....................................**Terrene**
1. Wetland is not surrounded by upland but is connected to a waterbody of some kind................2

2. Wetland is located in or along tidal salt or brackish waters (i.e., an estuary or ocean) including its periodically inundated shoreline (excluding areas formerly under tidal influence)...................3
2. Wetland is not periodically inundated by salt or brackish tides...4

3. Wetland is located in or along the ocean..**Marine**
Go to Key C-1 for coastal landform
3. Wetland is located in or along an estuary (typically a semi-enclosed basin or tidal river where fresh water mixes with sea water)..**Estuarine**
Go to Key E-2 for Estuary Type, then to Key C-1 for coastal landform

> Note: If area was formerly connected to an estuary but now is completely cut-off from tidal flow, consider as one of inland landscape positions - Terrene, Lentic, or Lotic, depending on current site characteristics. Such areas should be designated with a modifier to identify such wetlands as "former estuarine wetland." Lands overflowed infrequently by tides such as overwash areas on barrier islands are considered Estuarine. Tidal freshwater wetlands contiguous to salt/brackish/oligohaline tidal marshes are also considered Estuarine, whereas similar wetlands just upstream along strictly fresh tidal waters are considered Lotic.

4. Wetland is located in or along a lake or reservoir (permanent waterbody where standing water is typically much deeper than 6.6 feet at low water), including streamside wetlands in a lake basin and wetlands behind barrier islands and beaches with open access to a lake............**Lentic**
Go to Key C-2 for Lake Type
Then *Go to Key B-1 for inland landform*

> Note: Lentic wetlands consist of all wetlands in a lake basin (i.e., the depression containing the lake), including lakeside wetlands intersected by streams emptying into the lake. The upstream limit of lentic wetlands is defined by the upstream influence of the lake which is usually approximated by the limits of the basin within which the lake occurs. The streamside lentic wetlands are designated as "Throughflow," thereby emphasizing the stream flow through these wetlands. Other lentic wetlands are typically classified as "Bidirectional-nontidal" since water tables rise and fall with lake levels during the year. Tidally-influenced freshwater lakes have "Bidirectional-tidal" flow.

Modifiers: Natural, Dammed River Valley, Other Dammed - see Key C-2 for others.

4. Wetland does not occur along this type of waterbody...5

5. Wetland is located in a river or stream (including in-stream ponds), within its banks, or on its active floodplain and is periodically flooded by the river or stream...6
5. Wetland is not located in a river or stream or on its active floodplain............................**Terrene**

Note: These wetlands may occur: (1) on a slope or flat, or in a depression (including ponds, potholes, and playas) lacking a stream but contiguous to a river or stream, (2) on a historic (inactive) floodplain, or (3) in a landscape position crossed by a stream (e.g., an entrenched stream), but where the stream does not periodically inundate the wetland.

Go to Key B-1 for inland landform

6. Wetland is the source of a river or stream but this watercourse does not extend through the wetland...**Terrene**

Modifiers: May include Headwater for wetlands that are sources of streams and Estuarine Discharge or Marine Discharge for wetlands whose outflow goes directly to an estuary or the ocean, respectively.

6. Wetland is located in a river or stream, within its banks, or on its active floodplain..................7

7. Wetland is associated with a river (a broad channel mapped as a polygon or 2-lined watercourse on a 1:24,000 U.S. Geological Survey topographic map) or its active floodplain........
....**Lotic River**

Go to Couplet "a" below

(Also see note under first couplet #3 - Lentic re: streamside wetlands in lake basins)

7. Wetland is associated with a stream (a.linear or single-line watercourse on a 1:24,000 U.S. Geological Survey topographic map) or its active floodplain...................................**Lotic Stream**

Go to Couplet "a" below

(Also see note under first couplet #3 - Lentic re: streamside wetlands in lake basins)

Note: Artificial drainageways (i.e., ditches) are not considered part of the Lotic classification, whereas channelized streams are part of the Lotic landscape position.

Modifiers: Headwater (wetlands along first-order streams and possibly second-order streams and large wetlands in upper portion of watershed believed to be significant groundwater discharge sites) and Channelized (excavated stream course).

a. Water flow is under tidal influence (freshwater tidal wetlands)..............**Tidal Gradient**

Go to Key B-1 for inland landform

a. Water flow is not under tidal influence (nontidal)...b

b. Water flow is dammed, yet still flowing downstream, at least seasonally.........................
....**Dammed Reach**

Go to Key B-1 for inland landform

Modifiers: Lock and Dammed, Run-of-River Dam, Beaver Dam, and Other Dam (see Waterbody Key B-2 for further information).

b. Water flow is unrestricted..c

c. Water flow is intermittent during the year..................................**Intermittent Gradient**

Go to Key B-1 for inland landform

c. Water flow is perennial (year-round)...d

d. Water flow is generally rapid due to steep gradient; typically little or no floodplain development; watercourse is generally shallow with rock, cobbles, or gravel bottoms; first- and second-order "streams" in hilly to mountainous terrain; part of Cowardin's Upper Perennial Subsystem..**High Gradient**

Go to Key B-1 for inland landform

d. Watercourse characteristics are not so; "stream" order greater than 2 in hilly to mountainous terrain...e

e. Water flow is generally slow; typically with extensive floodplain; water course shallow or deep with mud or sand bottoms; typically fifth and higher order "streams", but includes lower order streams in nearly level landscapes such as the Great Lakes Plain (former glacial lakebed) and the Coastal Plain, and ditches; the lower order streams may lack significant floodplain development); Cowardin's Lower Perennial subsystem....................
....**Low Gradient**

Go to Key B-1 for inland landform

e. Water flow is fast to moderate; with little to some floodplain; usually third-, fourth- and higher order "streams" associated with hilly to mountainous terrain; part of Cowardin's Upper Perennial Subsystem..**Middle Gradient**

Go to Key B-1 for inland landform

Key B-1: Key to Inland Landforms

1. Wetland occurs on a noticeable slope (e.g., greater than a 2 percent slope)........**Slope Wetland**
Go to Key D-1 for water flow path

Modifiers can be applied to Slope Wetlands to designate the type of inflow or outflow as Channelized Inflow or Outflow (intermittent or perennial, stream or river), Nonchannelized Inflow or Outflow (wetland lacking stream, but connected by observable surface seepage flow), or Nonchannelized-Subsurface Inflow or Outflow (suspected subsurface flow from or to a neighboring wetland upslope or downslope, respectively).

1. Wetland does not occur on a distinct slope..2

2. Wetland forms an island...**Island Wetland**
(*Go to Key D-1 for water flow path*)

Note: Can designate an island formed in a delta at the mouth of a river or stream as a Delta Island Wetland; other islands are associated with landscape positions (e.g., lotic river island wetland, lotic stream island wetland, lentic island wetland, or terrene island pond wetland). Vegetation class and subclass from Cowardin et al. 1979 should be applied to characterize the vegetation of these wetland islands; vegetation is assumed to be rooted unless designated by a *modifier* - "Floating Mat" to indicate a floating island.

2. Wetland does not form an island...3

3. Wetland occurs within the banks of a river or stream or along the shores of a pond, lake, or island, or behind a barrier beach or island, and is either: (1) vegetated *and* typically permanently inundated, semipermanently flooded (including their tidal freshwater equivalents plus seasonally flooded-tidal palustrine emergent wetlands which tend to be flooded frequently by the tides) or otherwise flooded for most of the growing season, or permanently saturated due to this location or (2) a nonvegetated bank or shore that is temporarily or seasonally flooded ......**Fringe Wetland**

Go to Couplet "a" below for Types of Fringe Wetlands
Then *Go to Key D-1 for water flow path*

Attention: *Seasonally to temporarily flooded vegetated wetlands along rivers and streams (including tidal freshwater reaches) are classified as either Floodplain, Basin, or Flat landforms - see applicable categories.*

a. Wetland forms along the shores of an upland island within a lake, pond, river, or stream...b
a. Wetland does not form along the shores of an island..d

b. Wetland forms behind a barrier island or beach spit along a lake..............Lentic Barrier Island Fringe Wetland or Lentic Barrier Beach Fringe Wetland

Modifier: Drowned River-mouth

b. Wetland forms along another type of island...c

c. Wetland forms along an upland island in a river or stream..................Lotic River Island Fringe Wetland or Lotic Stream Island Fringe Wetland

c. Wetland forms along an upland island in a lake or pond..................Lentic Island Fringe Wetland or Terrene Pond Island Fringe Wetland

d. Wetland forms in or along a river or stream..........................Lotic River Fringe Wetland or Lotic Stream Fringe Wetland

d. Wetland forms in or along a pond or lake..e

e. Wetland forms along a pond shore...f

e. Wetland forms along a lake shore..Lentic Fringe Wetland

Modifier: Drowned River-mouth

f. Wetland occurs along an in-stream pond..Lotic River or Stream Fringe Pond Wetland Throughflow

f. Wetland occurs in another type of pond............................Terrene Fringe Pond Wetland

Note: Vegetation is assumed to be rooted unless designated by a *modifier* to indicate a floating mat (Floating Mat).

3. Wetland does not exist along these shores...4

4. Wetland occurs on an active floodplain (alluvial processes in effect)........................**Floodplain Wetland*** (could specify the river system, if desirable). *Go to Key D-1 for water flow path* Sub-landforms are listed below.

a. Wetland forms along the shores of a river island....................Floodplain Island Wetland

a. Wetland is not along an island...b

b. Wetland forms in a depressional feature on a floodplain.........Floodplain Basin Wetland or Floodplain Oxbow Wetland (a special type of depression)

b. Wetland forms on a broad nearly level terrace...........................Floodplain Flat Wetland

*Note: Questionable floodplain areas may be verified by consulting soil surveys and locating the presence of alluvial soils, e.g., Fluvaquents or Fluvents, or soils with Fluvaquentic subgroups. While most Floodplain wetlands will have a Throughflow water flow path; others may be designated, e.g., Inflow, Outflow, or Isolated. Former floodplain wetlands are classified as Basins or Flats and designated as former floodplain.

Modifiers: Partly Drained; Confluence wetland - wetland at the intersection of two or more streams; River-mouth or stream-mouth wetland - wetland at point where a river and stream empties into lake; Meander scar wetland - floodplain basin wetland, the remnant of a former river meander.

4. Wetland does not occur on an active floodplain...5

5. Wetland occurs on an interstream divide (interfluve)..................................**Interfluve Wetland** or specify *regional types* of interfluve wetlands, for example: *Carolina Bay Interfluve Wetland*, *Pocosin Interfluve Wetland*, and *Flatwood Interfluve Wetland* (Southeast). Sub-landforms are listed below. *Go to Key D-1 for water flow path*

a. Wetland forms in a depressional feature.................................. Interfluve Basin Wetland

a. Wetland forms on a broad nearly level terrace ....Interfluve Flat Wetland

Modifiers: Partly Drained.

5. Wetland does not occur on an interfluve...6

6. Wetland exists in a distinct depression in various positions on the landscape (i.e., surrounded by upland, along smaller rivers and streams, along in-stream ponds, along lake shores, or on former floodplains or interfluves)........... **Basin Wetland** or **Basin Wetland Former Floodplain** (including *Basin Oxbow Wetland Former Floodplain*) or **Basin Wetland Former Interfluve**. Can specify regional types: *Carolina Bay Basin Wetland* and *Pocosin Basin Wetland* (Atlantic Coastal Plain), *Cypress Dome Basin Wetland* (Florida), *Prairie Pothole Basin Wetland* (Upper Midwest), *"Salt Flat" Basin Wetland* (arid West), *Playa Basin Wetland* (Southwest), *West Coast Vernal Pool Basin Wetland* (California and Pacific Northwest), *Interdunal Basin Wetland* (sand dunes), *Woodland Vernal Pool Basin Wetland* (forests throughout the country), *Polygonal Basin Wetland* (Alaska), *Sinkhole Basin Wetland* (karst/limestone regions), *Pond Wetland Basin* (throughout country), or some type of *Island Basin Wetland* for basin wetlands on islands.

Go to Key D-1 for water flow path

Modifiers may be applied to indicate artificially created basins due to beaver activity or human actions or artificially drained basins including: Beaver (beaver-created); wetlands created for various purposes or unintentionally formed due to human activities - may want to specify purpose like Aquaculture (e.g., fish and crayfish), Wildlife management (e.g., waterfowl impoundments), and Former floodplain, or to designate former salt marsh that is now nontidal (Former estuarine wetland). Other *modifiers* may be applied to designate the type of inflow or outflow as Channelized (intermittent or perennial, stream or river), Nonchannelized-wetland (contiguous wetland lacking stream), or Nonchannelized-subsurface flow (suspected subsurface flow to neighboring wetland), or to identify a headwater basin (Headwater) or a drainage divide wetland that discharges into two or more watershed (Drainage divide), or to denote a spring-fed wetland (Spring-fed), a wetland bordering a pond (Pond basin wetland) and a wetland bordering an upland island in a pond (Pond island border). For lotic basin wetlands, consider additional modifiers such as Confluence wetland - wetland at the intersection of two or more streams; River-mouth or Stream-mouth wetland - wetland at point where a river and a stream empties into a lake. For lentic basins associated with the Great Lakes, possibly identify Drowned River-mouth wetlands where mouth extends into the lake basin. Partly drained may be used for ditched/drained wetlands.

6. Wetland exists in a relatively level area..**Flat Wetland** or specify *regional types* of flat wetlands, for example: **Salt Flat Wetland** (in the Great Basin) or flats that are fragments of once-larger interfluve flats or former floodplains: **Flat Wetland, Former Interfluve** or **Flat Wetland, Former Floodplain**.

Go to Key D-1 for water flow path

Note: If desirable, a *modifier* for drained flats can be applied (Partly drained). Other modifiers can be applied to designate the type of inflow or outflow as Channelized (intermittent or perennial, stream or river), Nonchannelized-wetland (contiguous wetland lacking stream), or Nonchannelized-subsurface flow (suspected subsurface flow to neighboring wetland). For lotic flat wetlands, consider additional modifiers such as confluence wetland - wetland at the intersection of two or more streams; river-mouth or stream-mouth wetland - wetland at point where a river and a stream empties into a lake.

Key C-1: Key to Coastal Landforms

1. Wetland forms a distinct island in an inlet, river, or embayment........................**Island Wetland**

Go to Key D-1 for water flow path

a. Occurs in a delta..Delta Island Wetland
(Could identify flood delta and ebb delta islands for tidal inlets if desirable.)
a. Occurs elsewhere either in a river or an embayment ....b

b. Occurs in a river..River Island Wetland
b. Occurs in a coastal embayment..Bay Island Wetland

1. Wetland does not form such an island, but occurs behind barrier islands and beaches, or along the shores embayments, rivers, streams, and islands...2

2. Wetland occurs along the shore, contiguous with the estuarine waterbody.......**Fringe Wetland**

Go to Key D-1 for water flow path

a. Occurs behind a barrier island or barrier beach spit...........Barrier Island Fringe Wetland or Barrier Beach Fringe Wetland [*Modifier* for overwash areas: Overwash]
a. Occurs elsewhere..b

b. Occurs along a coastal embayment or along an island in a bay.........Bay Fringe Wetland or Bay Island Fringe Wetland or Coastal Pond Fringe Wetland (a special type of embayment, typically with periodic connection to the ocean unless artificially connected by a bulkheaded inlet) or Coastal Pond Island Fringe Wetland

b. Occurs elsewhere..c

c. Occurs along a coastal river or along an island in a river................River Fringe Wetland or River Island Fringe Wetland

c. Occurs elsewhere..d

d. Occurs along an oceanic island..Ocean Island Fringe Wetland

d. Occurs along the shores of exposed rocky mainland...............Headland Fringe Wetland

2. Wetland is separated from main body of marsh by natural or artificial means; the former may be connected by a tidal stream extending through the upland or by washover channels (e.g., estuarine intertidal swales), whereas the latter occurs in an artificial impoundment or behind a road or railroad embankment where tidal flow is at least somewhat restricted........**Basin Wetland**

Go to Key D-1 for water flow path

Modifiers may be applied to separate natural from created basins (managed fish and wildlife areas; aquaculture impoundments; salt hay diked lands; tidally restricted-road, and tidally restricted-railroad), and for other situations, as needed.

Key D-1: Key to Water Flow Paths

1. Wetland is periodically flooded by tides...**Bidirectional-tidal**
   See Key F-2 for additional descriptors based on tidal ranges (i.e., macrotidal, mesotidal, and microtidal).
1. Wetland is not flooded by tides..2

2. Water levels fluctuate due to lake influences or to variable river levels, but water does not flow through this wetland..**Bidirectional-nontidal**

Note: Lentic wetlands with streams running through them are classified as Throughflow to emphasize this additional water source, while lentic wetlands located in coves or fringing the high ground would typically be classified as Bidirectional-Nontidal. Similarly, many floodplain wetlands are throughflow types, while some are connected to the river through a single channel in which water rises and falls with changing river levels. The water flow path of the latter types is best classified as bidirectional-nontidal.

2. Wetland is not subject to lake influences..3

3. Wetland is formed by paludification processes where in areas of low evapotranspiration and high rainfall, peat moss moves uphill creating wetlands on hillslopes (i.e., wetland develops upslope of primary water source)...**Paludified**
3. Wetland is not formed by paludification processes...4

4. Wetland receives surface or ground water from a stream, other waterbody or wetland (i.e., at a higher elevation) and surface or ground water passes through the subject wetland to a stream, another wetland, or other waterbody at a lower elevation; a flow-through system....**Throughflow**, **Throughflow-intermittent***, **Throughflow-entrenched***, or **Throughflow-artificial***

> *Modifiers*: Groundwater-dominated throughflow wetlands can be separated from Surface water-dominated throughflow wetlands.
>
> *Note: **Throughflow-intermittent** is to be used with throughflow wetlands along intermittent streams; **Throughflow-entrenched** indicates that stream flow is through a wetland but the stream is deeply cut and does not overflow into the wetland (therefore the stream is, for practical purposes, separate from the wetland) - this water flow path is intended to be used with Terrene wetlands in this situation; **Throughflow-artificial** is used to designate wetlands where throughflow is human-caused - usually to indicate connection of Terrene wetlands to other Terrene wetlands and waters by ditches and not by streams either natural or channelized

4. Water does not pass through this wetland to other wetlands or waters...................................5

5. There is no surface or groundwater inflow from a stream, other waterbody, or wetland (i.e., no documented surface or ground water inflow from a wetland or other waterbody at a higher elevation) and no observable or known outflow of surface or ground water to other wetlands or waters..**Isolated**

Attention: *In most applications, isolation is interpreted as "geographically isolated" since groundwater connections are typically unknown for specific wetlands. For practical purposes then," isolated" means no obvious surface water connection to other wetlands and waters. If hydrologic data exist for a locale that documents groundwater linkages, such wetlands should be identified as either outflow. inflow, or throughflow with a "Groundwater-dominated" modifier and not be identified as isolated unless the whole network of wetlands is not connected to a stream or river. In the latter case, the network is a collection of interconnected isolated wetlands.*

5. Wetland is not hydrologically or geographically isolated...6

6. Wetland receives surface or ground water inflow from a wetland or other waterbody

(perennial or intermittent) at a higher elevation and there is no observable or known significant outflow of surface or ground water to a stream, wetland or waterbody at a lower elevation ....**Inflow**

Modifiers: Groundwater-dominated inflow wetlands can be separated from Surface water-dominated inflow wetlands; Human-caused (usually to indicate connection of Terrene wetlands to other Terrene wetlands and waters [e.g., Inflow human-caused] by ditches and not by streams either natural or channelized).

6. Wetland receives no surface or ground water inflow from a wetland or permanent waterbody at a higher elevation (may receive flow from intermittent streams only) and surface or ground water is discharged from this wetland to a stream, wetland, or other waterbody at a lower elevation...**Outflow** or **Outflow-artificial***

Modifiers: Groundwater-dominated outflow wetlands can be separated from Surface water-dominated outflow wetlands. Might consider separating perennial outflow (**Outflow-perennial**) from intermitttent outflow (**Outflow-intermittent**), if interested.

*Note: Outflow-artificial is usually used to indicate outflow from formerly isolated wetlands resulting by ditches.

Section 3. Waterbody Keys

These keys are designed to expand the classification of waterbodies beyond the system and subsystem levels in the Service's wetland classification system (Cowardin et al. 1979). Users are advised first to classify the waterbody in one of the five ecosystems: 1) marine (open ocean and associated coastline), 2) estuarine (mixing zone of fresh and ocean-derived salt water), 3) lacustrine (lakes, reservoirs, large impoundments, and dammed rivers), 4) riverine (undammed rivers and tributaries), and 5) palustrine (e.g., nontidal ponds) and then apply the waterbody type descriptors below.

Five sets of keys are given. Key A-2 helps describe the major waterbody type. Key B-2 identifies different stream gradients for rivers and streams. It is similar to the subsystems of Cowardin's Riverine system, but includes provisions for dammed rivers to be identified as well as a middle gradient reach similar to that of Brinson's hydrogeomorphic classification system. The third key, Key C-2, addresses lake types, while Keys D-2 and E-2 further define ocean and estuary types, respectively. Key F-2 is a key to water flow paths of waterbodies. Key G-2 is for describing general circulation patterns in estuaries. The coastal terminology applies concepts of coastal hydrogeomorphology.

Besides the keys provided, there are numerous other attributes that can be used to describe the condition of waterbodies. Some examples are other descriptors that address resource condition could be ones that emphasize human modification, (e.g., natural vs. altered, with further subdivisions of the latter descriptor possible), the condition of waterbody buffers (e.g., stream corridors), or levels of pollution (e.g., no pollution [pristine], low pollution, moderate pollution, and high pollution).

Key A-2. Key to Major Waterbody Type

1. Waterbody is predominantly flowing water..2
1. Waterbody is predominantly standing water..7

> Note: Fresh waterbodies may be tidal; if so, waterbody is classified as a Tidal Lake or Tidal Pond using criteria below to separate lakes from ponds.

2. Flow is unidirectional and waterbody is a river, stream, or similar channel..............................3
2. Flow is tidal (bidirectional) at least seasonally; waterbody is an ocean, embayment, river, stream, or lake...4

3. Waterbody is a polygonal feature on a U.S. Geological Survey map or a National Wetlands Inventory Map (1:24,000/1:25,000)...**River**
3. Waterbody is a linear feature on such maps...**Stream**
Go to River/Stream Gradient Key - Key B-2 - for other modifiers

4. Waterbody is freshwater..5
4. Waterbody is salt or brackish...6

5. Waterbody is a polygonal feature on a U.S. Geological Survey map or a National Wetlands Inventory Map (1:24,000/1:25,000)...**River**
5. Waterbody is a linear feature on such maps...**Stream**
Go to River/Stream Gradient Key - Key B-2 - for other modifiers

6. Part of a major ocean or its associated embayment (Marine system of Cowardin et al. 1979) ....**Ocean**

Go to Ocean Key - Key D-2

6. Part of an estuary where fresh water mixes with salt water (Estuarine system of Cowardin et al. 1979)..**Estuary**

Go to Estuary Key - Key E-2

7. Waterbody is freshwater..8
7. Waterbody is salt or brackish and tidal..10

8. Waterbody is permanently flooded and deep (>than 6.6 ft at low water), excluding small

"kettle or bog ponds" (i.e., usually less than 5 acres in size and surrounded by bog vegetation)..**Lake**

Go to Lake Key - Key C-2

8. Waterbody is shallow (< 6.6 ft at low water) or a small "kettle or bog pond" (with deeper water)...9

9. Waterbody is small (< 20 acres)..**Pond**

Separate natural from artificial ponds, then add other modifiers like the following. Some *examples* of modifiers for ponds: beaver, alligator, marsh, swamp, vernal, Prairie Pothole, Sandhill, sinkhole/karst, Grady, interdunal, farm-cropland, farm-livestock, golf, industrial, sewage/wastewater treatment, stormwater, aquaculture-catfish, aquaculture-shrimp, aquaculture-crayfish, cranberry, irrigation, aesthetic-business, acid-mine, arctic polygonal, kettle, bog, woodland, borrow pit, Carolina bay, tundra, coastal plain, tidal, and in-stream.

Note: Wetlands associated with ponds are typically either Terrene basin wetlands, such as a Cypress dome or cypress-gum pond, or Terrene pond fringe wetlands, such as semipermanently flooded wetlands along margins of pond. In-stream ponds are in the Lotic landscape position.

9. Waterbody is large (≥20 acres)..**Lake**
Go to Lake Key - Key C-2

10. Part of a major ocean or its associated embayment (Marine system of Cowardin et al. 1979) ....**Ocean**

Go to Ocean Key - Key D-2

10. Part of an estuary where fresh water mixes with salt water (Estuarine system of Cowardin et al. 1979)...**Estuary**

Go to Estuary Key - Key E-2

Key B-2. River/Stream Gradient and Other Modifiers Key

Please note that the river/stream gradient extends from the freshwater tidal zone through the intermittent reach. The limits of the latter are typically defined by drainageways with well-defined channels that discharge water seasonally. From a practical standpoint, the limits of the lotic system are displayed on 1:24,000 U.S. Geological Survey topographic maps or similar digital data. Intermittent streams, certain dammed portions of rivers plus lock and dammed canal systems may be classified as rivers using the descriptors presented in these keys. In the Cowardin et al. system, they may be classified as Riverine Intermittent Streambed or Lacustrine Unconsolidated Bottom, respectively.

1. Water flow is under tidal influence..**Tidal Gradient**

> *Type of tidal river or stream*: 1) natural river, 2) natural stream, 3) channelized river, 4) channelized stream, 5) canal (artificial polygonal lotic feature), 6) ditch (artificial linear lotic feature), 7) restored river segment (part of river where restoration was performed), and 8) restored stream segment (part of stream where restoration was performed).

1. Water flow is not under tidal influence (nontidal)..2

2. Water flow is dammed, yet still flowing downstream at least seasonally..........**Dammed Reach**

> *Type of dammed river*: 1) lock and dammed (canalized river, a series of locks and dams are present to aid navigation), 2) run-of-river dammed (low dam allowing flow during high water periods; often used for low-head hydropower generation), and 3) other dammed (unspecified, but not major western hydropower dam as such waterbodies are considered lakes, e.g., Lake Mead and Lake Powell).

2. Water flow is unrestricted...3

3. Water flow is perennial (year-round); perennial rivers and streams...4
3. Water flow is seasonal or aperiodic (intermittent); Cowardin's Intermittent Subsystem ....
....**Intermittent Gradient***

4. Water flow is generally rapid due to steep gradient; typically little or no floodplain development; watercourse is generally shallow with rock, cobbles, or gravel bottoms; first and second order "streams"; part of Cowardin's Upper Perennial subsystem..............**High Gradient***
4. Water flow is not so; some to much floodplain development...5

5. Water flow is generally slow; typically with extensive floodplain; water course shallow or deep with mud or sand bottoms; typically fifth and higher order "streams", but includes lower order streams in nearly level landscapes such as the Great Lakes Plain (former glacial lakebed) and the Coastal Plain (the latter streams may lack significant floodplain development); Cowardin's Lower Perennial subsystem ....**Low Gradient***
5. Water flow is fast to moderate; with little to some floodplain; usually third and fourth order "streams"; part of Cowardin's Upper Perennial subsystem................................**Middle Gradient***

**Type of river or stream* - additional modifiers that may be applied as desired: 1) natural river-single thread (one channel), 2) natural river-multiple thread (braided) (multiple, wide, shallow channels), 3) natural river-multiple thread (anastomosed) (multiple, deep narrow channels), 4) natural stream-single thread, 5) channelized river (dredged/excavated), 6) channelized stream, 7) canal (artificial polygonal lotic feature), 8) ditch (artificial linear lotic feature), 9) restored river segment (part of river where restoration was performed), 10) restored stream segment (part of stream where restoration was performed), and 11) connecting channel (joins two lakes). Other possible descriptors: 1) for perennial rivers and streams - riffles (shallow, rippling water areas), pools (deeper, quiet water areas), and waterfalls (cascades), 2) for water depth of perennial rivers - deep rivers ($\geq$6.6 ft at low water) from shallow rivers (<6.6 ft at low water), 3) nontidal river or stream segment emptying into an estuary, ocean, or lake (estuary-discharge, marine-discharge, or lake-discharge), 4) classification by stream order (1st, 2nd, 3rd, etc. for perennial segments), and 5) channels patterns (straight, slight meandering, moderate meandering, and high meandering).

Key C-2. Key to Lakes.

The lake designation is for permanently flooded deep waters (>6.6 feet). Some classification systems include shallow waterbodies or periodically exposed areas as "lakes." The Cowardin et al. system considers standing waterbodies larger than 20 acres to be part of the lacustrine system (regardless of water depth; shallow = wetlands; >6.6 feet = deepwater habitat), and smaller ones typically part of the palustrine wetlands. For our purposes, "shallow lakes" and "seasonal or intermittent lakes" are considered some type of terrene or lotic wetland depending on the presence and location of a stream. Lentic wetlands are associated with permanently flooded standing waterbodies deeper than 6.6 feet at low water.

1. Waterbody is not dammed or impounded..**Natural Lake**

> *Modifiers*: Main body, Open embayment, Semi-enclosed embayment, Barrier beach lagoon, Seiche-influenced, River-fed and Stream-fed descriptors. Can also use applicable modifiers listed under Pond (see Key A-2).
>
> *Can use additional modifiers listed under Pond (see Key A-2) and others (e.g., crater, lava flow, aeolian, fjord, oxbow, other floodplain, glacial, alkali, and manmade), as appropriate.

1. Waterbody is dammed, impounded, or excavated 2

2. Waterbody is dammed or impounded..3
2. Waterbody is excavated...**Excavated Lake**

3. Dammed river valley..**Dammed River Valley Lake**

> *Modifiers*: Reservoir, Hydropower, and Seiche-influenced; also River-fed and Stream-fed descriptors.

Note: When the dam inundates former floodplains and other low-lying areas, the waterbody is considered a Dammed River Valley Lake. If the dam crosses a higher gradient river and increase water depth in an channel without significant flooding of much neighboring "land," the waterbody is considered the dammed reach of a river.

3. Dammed natural lake or other landscape..**Other Dammed Lake**

Modifiers: Former natural lake, Artificial lake, River-fed and Stream-fed descriptors.

Key D-2. Ocean Key.

1. Waterbody is completely open, not protected by any feature.................................**Open Ocean**
(Can further identify open bays if desirable.)
1. Waterbody is somewhat protected..2

2. Associated with coral reef or island 3

2. Not associated with coral reef or island..4

3. Open but protected by coral reef ....**Reef-protected Waters**
3. Protected by a coral island...**Atoll Lagoon**

4. Deep embayment cut by glaciers, with an underwater sill at front end, restricting circulation; associated with rocky headlands...**Fjord**
4. Other semi-protected embayment..**Semi-protected Oceanic Bay**

Modifiers for all types above: Submerged vegetation (e.g., eelgrass or turtle-grass) or Floating vegetation (e.g., macroalgae such as kelp beds).

Key E-2. Estuary Key.

The following types should encompass most of the estuaries located in the United States. There may be estuaries that do not fit within this classification. Such types should be brought to the attention of the author.

1. Estuary is surrounded by rocky headlands and shores...2
1. Estuary is not surrounded by rocky headlands and shores..4

2. Deep embayment cut by glaciers, with an underwater sill at front end, restricting circulation

(e.g., Puget Sound)..**Fjord Estuary**
2. Not so, either open or semi-enclosed..3

3. Protected by islands.....................................**Island Protected Rocky Headland Bay Estuary**
3. Not protected by islands..**Rocky Headland Bay Estuary**

Modifiers: Open or Semi-enclosed

4. Estuary is tectonically formed (e.g., San Francisco Bay), including volcanic activity.................
....**Tectonic Estuary**

Modifiers: Fault-formed and Volcanic-formed

4. Estuary is not tectonically formed or is formed by volcanic activity..5

5. Estuary is river-dominated with very little tidal range and a delta formed at the mouth of the river where it enters the sea (e.g., Mississippi River Delta)..................**River-dominated Estuary**
5. Estuary is not river-dominated...6

6. Estuary is a drowned river valley (e.g., Chesapeake Bay)........**Drowned River Valley Estuary**

Modifiers: Open Bay, River Channel, and Semi-enclosed Bay

6. Estuary is not a drowned river valley..7

7. Estuary formed behind and is protected by sandy barrier islands or barrier beaches (spits)..**Bar-built Estuary**

Modifiers: Coastal Pond (oligohaline to saline) and Hypersaline Lagoon (hypersaline)

7. Estuary is not behind sandy barrier islands or beaches...8

8. Estuary is protected by reefs or other islands....................................**Island Protected Estuary**
8. Estuary is an open or semi-enclosed embayment...................................**Shoreline Bay Estuary**

Modifiers for all estuarine waterbodies: Inlet (includes any ebb- or flood- deltas that are completed submerged), Stabilized Inlet, Shoal (shallow water area), Submerged vegetation (e.g., eelgrass or turtle-grass) or Floating vegetation (e.g., macroalgae such as kelp beds).

Key F-2. Key to Water Flow Paths

1. Water flow is tidally influenced...2
1. Water flow is not under the influence of the tides...4

2. Tide range is greater than 4m (approx. >12 feet) ....**Macrotidal**
2. Tidal range is less than 4m 3

3. Tidal range is 2-4m (approx. 6-12 feet) ....**Mesotidal**
3. Tidal range is less than 2m (approx. < 6 feet) ....**Microtidal**

4. Water flows out of the waterbody via a river, stream, or ditch, with little or no inflow (inflow could be from intermittent streams or ground water only) ....**Outflow**

> *Modifier*: Human-caused for inflow via a ditch network. Might consider separating perennial outflow (**Outflow-perennial**) from intermitttent outflow (**Outflow-intermittent**), if interested.

4. Water flow is not so...5

5. Water enters waterbody from river, stream, or ditch, flows through it, and continues to flow downstream...**Throughflow** or **Throughflow-intermittent**

> *Modifier*: Human-caused for throughflow via a ditch network
>
> Note: Throughflow intermittent is applied to intermittent streams

5. Water flow is not throughflow...6

6. Water flows in and out of the waterbody through the same channel; it does not flow through the waterbody...**Bidirectional-nontidal**

6. Water flow is not bidirectional...7

7. Water flow enters via a river, stream, or ditch, but does not exit pond, lake or reservoir; waterbody serves as a sink for water..**Inflow**

> *Modifier*: Human-caused for inflow via a ditch network.

7. No apparent channelized inflow, source of water either by precipitation or by underground sources...**Isolated**

Attention: *In most applications, isolation is interpreted as "geographically isolated" since groundwater connections are typically unknown for specific waterbodies. For practical* *purposes then," isolated" means no obvious surface water connection to other wetlands and waters. If hydrologic data exist for a locale that document groundwater linkages, such waterbodies should be identified as either outflow. inflow, or throughflow with a "Groundwater-dominated" modifier added and not be identified as isolated unless the whole network of waterbodies is not connected to a stream or river. In the latter case, the network is a collection of interconnected isolated waterbodies.*

Key G-2. Key to Estuarine Hydrologic Circulation Types

1. Estuary is river-dominated with distinct salt wedge moving seasonally up and down the river; fresh water at surface with most saline waters at bottom; low energy system with silt and clay bottoms ....**Salt-wedge Estuary**
1. Estuary is not river-dominated 2

2. Estuarine water is well-mixed, no significant salinity stratification, salinity more or less the same from top to bottom of water column; high-energy system with sand bottom............... ....**Homogeneous Estuary**
2. Estuarine water is partially mixed, salinities different from top to bottom, but not strongly stratified; low energy system ....**Partially Mixed Estuary**

Section 4. Coding System for LLWW Descriptors

The following is the coding scheme for expanding classification of wetlands and waterbodies beyond typical NWI classifications. When enhancing NWI maps/digits, codes should be applied to all mapped wetlands and deepwater habitats (including linears). At a minimum, landscape position (including lotic gradient), landform, and water flow path should be applied to wetlands, and waterbody type and water flow path to water to waterbodies. Wetland and deepwater habitat data for specific estuaries, lakes, and river systems could be added to existing digital data through use of geographic information system (GIS) technology.

Codes for Wetlands

Wetlands are typically classified by landscape position, landform, and water flow path. Landforms are grouped according to Inland types and Coastal types with the latter referring to tidal wetlands associated with marine and estuarine waters. Use of other descriptors tends to be optional. They would be used for more detailed investigations and characterizations.

Landscape Position

ES	Estuarine
LE	Lentic
LR	Lotic river
LS	Lotic stream
MA	Marine
TE	Terrene

Lotic Gradient

1	Low	
2	Middle	
3	High	
4	Intermittent	
5	Tidal	
6	Dammed	
a		lock and dammed
b		run-of-river dam
c		beaver
d		other dammed
7	Artificial (ditch)	

Lentic Type

1	Natural deep lake (see also Pond codes for possible specific types)	
a		main body
b		open empbayment
c		semi-enclosed embayment
d		barrier beach lagoon
2	Dammed river valley lake	
a		reservoir
b		hydropower
c		other
3	Other dammed lake	
a		former natural
b		artificial
4	Excavated lake	
a		quarry lake
5	Other artificial lake	

Estuary Type

1	Drowned river valley estuary	
a		open bay (fully exposed)
b		semi-enclosed bay
c		river channel
2	Bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	River-dominated estuary	
4	Rocky headland bay estuary	
a		island protected
5	Island protected estuary	
6	Shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	Tectonic	
a		fault-formed
b		volcanic-formed
8	Fjord	
9	Other	

Inland Landform

SL	Slope	
SLpa		Slope, paludified
IL	Island*	
ILde		Island, delta
ILrs		Island, reservoir
ILpd		Island, pond
FR	Fringe*	
FRil		Fringe, island*
FRbl		Fringe, barrier island
FRbb		Fringe, barrier beach
FRpd		Fringe, pond
FRdm		Fringe, drowned river mouth
FP	Floodplain	
FPba		Floodplain, basin
FPox		Floodplain, oxbow
FPfl		Floodplain, flat
FPil		Floodplain, island
IF	Interfluve	
IFba		Interfluve, basin
IFfl		Interfluve, flat
BA	Basin	
BAcb		Basin, Carolina bay
BApo		Basin, pocosin
BAcd		Basin, cypress dome
BApp		Basin, prairie pothole
BApl		Basin, playa
BAwc		Basin, West Coast vernal pool
BAid		Basin, interdunal
BAwv		Basin, woodland vernal
BApg		Basin, polygonal
BAsh		Basin, sinkhole
BApd		Basin, pond
BAgp		Basin, grady pond
BAsa		Basin, salt flat
BAaq		Basin, aquaculture (created)
BAcr		Basin, cranberry bog (created)
BAwm		Basin, wildlife management (created)

BAip	Basin, impoundment (created)
BAfe	Basin, former estuarine wetland
BAff	Basin, former floodplain
BAfi	Basin, former interfluve
BAfo	Basin, former floodplain oxbow
BAdm	Basin, drowned river-mouth

FL Flat

FLsa	Flat, salt flat
FLff	Flat, former floodplain
FLfi	Flat, former interfluve

*Note: Inland slope wetlands and island wetlands associated with rivers, streams, and lakes are designated as such by the landscape position classification (e.g., lotic river, lotic stream, or lentic), therefore no additional terms are needed here to convey this association.

Coastal Landform

IL Island

ILdt	Island, delta
ILde	Island, ebb-delta
ILdf	Island, flood-delta
ILrv	Island, river
ILst	Island, stream
ILby	Island, bay

DE Delta

DEr	Delta, river-dominated
DEt	Delta, tide-dominated
DEw	Delta, wave-dominated

FR Fringe

FRal	Fringe, atoll lagoon
FRbl	Fringe, barrier island
FRbb	Fringe, barrier beach
FRby	Fringe, bay
FRbi	Fringe, bay island
FRcp	Fringe, coastal pond
FRci	Fringe, coastal pond island
FRhl	Fringe, headland
FRoi	Fringe, oceanic island
FRlg	Fringe, lagoon
FRrv	Fringe, river

FRri	Fringe, river island
FRst	Fringe, stream
FRsi	Fringe, stream island

BA	Basin
BAaq	Basin, aquaculture (created)
BAid	Basin, interdunal (swale)
BAst	Basin, stream
BAsh	Basin, salt hay production (created)
BAtd	Basin, tidally restricted/road (not a management area)
BAtr	Basin, tidally restricted/railroad (not a management area)
BAwm	Basin, wildlife management (created)
BAip	Basin, impoundment (created)

Water Flow Path

PA	Paludified
IS	Isolated
IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow - artificial*
TN	Throughflow - entrenched
TI	Throughflow - intermittent
BI	Bidirectional Flow - nontidal
BT	Bidirectional Flow - tidal

*Note: To be used with wetlands connected to streams by ditches.

Other Modifiers (apply at the end of the code as appropriate)

br	barren
bv	beaver
ch	channelized flow
cl	coastal island (wetland on an island in an estuary or ocean including barrier islands)
cr	cranberry bog
dd	drainage divide
dr	partly drained
ed	freshwater wetland discharging directly into an estuary
fe	former estuarine wetland

fg	fragmented
fm	floating mat
gd	groundwater-dominated (apply to Water Flow Path only)
hi	severely human-induced
hw	headwater
li	lake island (wetland associated with a lake island)
md	freshwater wetland discharging directly into marine waters
ow	overwash
pi	pond island border
ri	river island (wetland associated with a river island)
sd	surface water-dominated (apply to Water Flow Path only)
sf	spring-fed
ss	subsurface flow
td	tidally restricted/road
tr	tidally restricted/railroad

(Note: "ho" was formerly used to indicate human-induced outflow brought about by ditch construction; now this is addressed by the water flow path "OA" Outflow-Artificial.)

Codes for Waterbodies

Besides Waterbody Type, waterbodies can be classified by water flow path (for lakes and ponds), estuary hydrologic type (for estuaries), and tidal range types (for estuaries and oceans).

Waterbody Type

RV	River		
	1	low gradient	
	a		connecting channel
	b		canal
	2	middle gradient	
	a		connecting channel
	3	high gradient	
	a		waterfall
	b		riffle
	c		pool
	4	intermittent gradient	
	5	tidal gradient	
	6	dammed gradient	
	a		lock and dammed
	b		run-of-river dammed
	c		other dammed

ST Stream

1 low gradient
 a connecting channel
2 middle gradient
 a connecting channel
3 high gradient
 a waterfall
 b riffle
 c pool
4 intermittent gradient
5 tidal gradient
6 dammed
 a lock and dammed
 b run-of-river dammed
 c beaver dammed
 d other dammed
7 artificial
 a connecting channel
 b ditch

LK Lake

1 natural lake (*see also Pond codes for possible specific types*)
 a main body
 b open empbayment
 c semi-enclosed embayment
 d barrier beach lagoon
2 dammed river valley lake
 a reservoir
 b hydropower
 c other
3 other dammed lake
 a former natural
 b artificial
4 other artificial lake

(Consider using a modifier to highlight specific lakes as needed, especially the Great Lakes, e.g., LK1E for Lake Erie or LK2O for Lake Ontario, and Lake Champlain, LK1C)

EY Estuary

1 drowned river valley estuary
 a open bay (fully exposed)
 b semi-enclosed bay
 c river channel

2 bar-built estuary
 a coastal pond-open
 b coastal pond-seasonally closed
 c coastal pond-intermittently open
 d hypersaline lagoon
3 river-dominated estuary
4 rocky headland bay estuary
 a island protected
5 island protected estuary
6 shoreline bay estuary
 a open (fully exposed)
 b semi-enclosed
7 tectonic
 a fault-formed
 b volcanic-formed
8 fjord
9 other

Note: If desired, you can also designate river channel (rc), stream channel (sc),and inlet channel (ic) by modifiers. *Examples*: EY1rc = Drowned River Valley Estuary river channel; EY2ic= Bar-built estuary inlet channel. If not, simply classify all estuarine water as a single type, e.g., EY1 for Drowned River Valley or EY2 for Bar-built Estuary.

OB Ocean or Bay
1 open (fully exposed)
2 semi-protected oceanic bay
3 atoll lagoon
4 other reef-protected waters
5 fjord

PD Pond
1 natural
 a bog
 b woodland-wetland
 c woodland-dryland
 d prairie-wetland (pothole)
 e prairie-dryland (pothole)
 f playa
 g polygonal
 h sinkhole-woodland
 i sinkhole-prairie
 j Carolina bay
 k pocosin
 l cypress dome

m		vernal-woodland
n		vernal-West Coast
o		interdunal
p		grady
q		floodplain
r		other
2	dammed/impounded	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
o		other
q		floodplain
3	excavated	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf

h		wildlife management
i		other recreational
j		mining
j1		sand/gravel
j2		coal
o		other
q		floodplain
4	beaver	
5	other artificial	

Water Flow Path

IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow-artificial*
TI	Throughflow-intermittent*
TN	Throughflow-entrenched
BI	Bidirectional-nontidal
IS	Isolated
MI	Microtidal
ME	Mesotidal
MC	Macrotidal

*Note: OA and TA are human-caused by ditches; TI is to be used along intermittent streams.

Estuarine Hydrologic Circulation Type

SW	Salt-wedge/river-dominated type
PM	Partially mixed type
HO	Homogeneous/high energy type

Other Modifiers (apply at end of code)

ch	Channelized or Dredged
dv	Diverted
ed	freshwater stream flowing directly into an estuary
fv	Floating vegetation (on the surface)
lv	Leveed
md	freshwater stream flowing directly into marine waters
sv	Submerged vegetation

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Section 7. Glossary

Barrier Beach -- a coastal peninsular landform extending from the mainland into the ocean or large embayment or large lake (e.g., Great Lakes), typically providing protection to waters on the backside and allowing the establishment of salt marshes; similar to the barrier island, except connected to the mainland

Barrier Island -- a coastal insular landform, an island typically between the ocean (or possibly the Great Lakes) and the mainland; its presence usually promotes the formation of salt marshes on the backside

Basin -- a depressional (concave) landform; various types are further defined by the absence of a stream (isolated), by the presence of a stream and its position relative to a wetland (throughflow, outflow, inflow), or by its occurrence on a floodplain (floodplain basins include ox-bows and sloughs, for example)

Bay -- a coastal embayment of variable size and shape that is always opens to the sea through an inlet or other features

Carolina Bay -- a wetland formed in a semicircular or egg-shaped basin with a northwest to southeast orientation, found along the Atlantic Coastal Plain from southern New Jersey to Florida, and perhaps most common in Horry County, South Carolina

Channelization -- the act or result of excavating a stream or river channel to increase downstream flow of water or to increase depth for navigational purposes

Channelized -- water flow through a conspicuous drainageway, a stream or a river

Coastal Island - an island in marine and estuarine areas

Coastal Pond - pond and its associated wetlands that form behind a barrier beach and are subjected to varying tidal influence (intermittent to daily); the tidal connection for many coastal ponds has been stabilized by jetties; the ones that are only intermittently connected have low salinities

Connecting Channel - a river or stream that connects two adjacent lakes; lakes are typically close together considering their relative size; it is not any stream that occurs between two lakes in a drainage basin; perhaps the best examples are rivers connecting the Great Lakes, such as the St. Marys River connecting Lake Superior to Lake Huron, Detroit River connecting Lake St. Clair to Lake Erie, and the Niagara River connecting Lake Erie with Lake Ontario

Cypress Dome -- a wetland dominated by bald cypress growing in a basin that may be formed by the collapse of underlying limestone, forest canopy takes on a domed appearance with tallest trees in center and becoming progressively shorter as move toward margins of basin

Delta -- a typically lobed-shaped or fan-shaped landform formed by sedimentation processes at the mouth of a river carrying heavy sediment loads

Ditch – a linear, often shallow, artificial channel created by excavation with intent to improve drainage of or to irrigate adjacent lands

Drained, Partly -- condition where a wetland has been ditched or tiled to lower the ground water table, but the area is still wet long enough and often enough to fall within the range of conditions associated with wetland hydrology

Entrenched -- condition where a stream cuts through a wetland and does not periodically overflow into the wetland; the affected wetland may be a terrene wetland cut by a stream or it could be a lotic wetland along an entrenched stream (the latter would usually have to be identified in the field)

Estuarine -- the landscape of estuaries (salt and brackish tidal waterbodies, such as bays and coastal rivers) including associated wetlands, typically occurring in sheltered or protected areas, not exposed to oceanic currents

Flat -- a relatively level landform; may be a component of a floodplain or the landform of an interfluve

Flatwood -- forest of pines, hardwoods or mixed stands growing on interfluves on the Gulf-Atlantic Coastal Plain, typically with imperfectly drained soils; some flatwoods are wetlands, while others are dryland

Floodplain -- a broad, generally flat landform occurring in a landscape shaped by fluvial or riverine processes; for purposes of this classification limited to the broad plain associated with large river systems subject to periodic flooding (once every 100 years) and typically having alluvial soils; further subdivided into several subcategories: flat (broad, nearly level to gently sloping areas) and basin (depressional features such as ox-bows and sloughs)

Floodplain, active -- floodplain that is typically inundated once every 100 years by natural events

Floodplain, inactive -- floodplain that is no longer flooded once in 100 years due to human-alterations such as leveeing, diking, or altered river flow regimes or to natural processes such as changing river courses

Fringe -- a wetland occurring along a standing or flowing waterbody, i.e., a lake, pond, river, stream, estuary, or ocean, including tidal wetlands that are inundated frequently by tides, nontidal vegetated wetlands that are flooded for most of the growing season, and nonvegetated wetlands that form the banks of these waterbodies (such as cobble-gravel bars along river bends)

Ground Water -- water below ground, held in the soil or underground aquifers

Headland -- the seaward edge of the major continental land mass (North America), commonly called the mainland; not an island

High Gradient -- the fast-flowing segment of a drainage system, typically with no floodplain development; equivalent to the Upper Perennial and Intermittent Subsystems of the Riverine System in Cowardin et al. 1979

Inflow -- water enters; an inflow wetland is one that receives surface water from a stream or other waterbody or from significant surface or ground water from a wetland or waterbody at a higher elevation and has no significant discharge

Interdunal -- occurring between sand dunes, as in interdunal swale wetlands found in dunefields behind ocean and estuarine beaches and in sand plains like the Nebraska Sandhills

Interfluve -- a broad level to imperceptibly depressional poorly drained landform occurring between two drainage systems, most typical of the Coastal Plain

Island -- a landform completely surrounded by water and not a delta; some islands are entirely wetland, while others are uplands with or without a fringe wetland

Isolated -- lacking an apparent surface water connection to other wetlands and waterbodies; typically "geographically isolated" (surrounded by upland - nonhydric soils); may be connected to other wetlands and water via groundwater, but this is not known

Karst -- a limestone region characterized by sinkholes and underground caverns

Kettle -- a glacially formed depression typically created by a block of glacial ice left on the land by a retreating glacier; melting of the ice formed a kettle pond that may be quite deep, with bog vegetation frequently established along its perimeter

Lake Island - an island in a lake

Lentic -- the landscape position associated with large, deep standing waterbodies (such as lakes and reservoirs) and contiguous wetlands formed in the lake basin (excludes seasonal and shallow lakes which are included in the *Terrene* landscape position)

Lotic -- the landscape position associated with flowing water systems (such as rivers, creeks, perennial streams, intermittent streams, and similar waterbodies) and contiguous wetlands

Low Gradient -- the slow-flowing segment of a drainage system, typically with considerable floodplain development; equivalent to the Lower Perennial Subsystem of the Riverine System in Cowardin et al. 1979 plus contiguous wetlands

Marine -- the landscape position (or seascape) associated with the ocean's shoreline

Middle Gradient -- the segment of a drainage system with characteristic intermediate between the high and low gradient reaches, typically with limited floodplain development; equivalent to areas mapped as Riverine Unknown (R5) in the Northeast Region plus contiguous wetlands

Nonchannelized -- water exits through seepage, not through a river or stream channel or ditch

Outflow -- water exits naturally or through artificial means (e.g., ditches); an outflow wetland has water leaving via a stream, seepage, or ditch (artificial) to a wetland or waterbody at a lower elevation; it lacks an inflowing surface water source like an intermittent or perennial stream

Oxbow -- a former mainstem river bend now partly or completely cut off from mainstem

Paludified -- subjected to paludification, the process by which peat moss engulfs terrains of varying elevations due to an excess of water, typically associated with cold, humid climates of northern areas (boreal/arctic regions and fog-shrouded coasts)

Playa -- a type of basin wetland in the Southwest characterized by drastic fluctuations in water levels over the normal wet-dry cycle

Pocosin -- a shrub and/or forested wetland forming on organic soils in interstream divides (interfluves) on the Atlantic Coast Plain from Virginia to Florida, mostly in North Carolina

Pond -- a natural or human-made shallow open waterbody that may be subjected to periodic drawdowns

Prairie Pothole -- a glacially formed basin wetland found in the Upper Midwest especially in the Dakotas, western Minnesota, and Iowa

Reservoir -- a large, deep waterbody formed by a dike or dam created for a water supply for drinking water or agricultural purposes or for flood control, or similar purposes

River Island - an island within a river

Salt Pond -- a coastal embayment of variable size and shape that is periodically and temporarily cut off from the sea by natural accretion processes; some may be kept permanently open by jetties and periodic maintenance dredging

Salt Flat -- a broad expanse of alkaline wetlands associated with arid regions, especially the Great Basin in the western United States

Sinkhole -- a depression formed by the collapse of underlying limestone deposits; may be wetland or nonwetland depending on drainage characteristics

Slope -- a wetland occurring on a slope; various types include those along a sloping stream (fringe), those (paludified) formed by paludification -- the process of bogging or swamping of uplands by peat moss in northern climes (humid and cold), and those not designated as one of the above and typically called seeps

Stream – a natural drainageway that contains flowing water at least seasonally; different stream types: *perennial* where water flows continously in all years except drought or extremely dry years; intermittent where water flows only seasonally in most years; channelized where stream bed has been excavated or dredged

Subsurface Flow -- water leaves via ground water

Surface Water -- water occurring above the ground as in flooded or ponded conditions

Tectonic - changes in the earth's surface caused by landslides, faulting, and volcanic activity

Terrene -- wetlands surrounded or nearly so by uplands and lacking a channelized outlet stream; a stream may enter or exit this type of wetland but it does not flow through it as a channel; includes a variety of wetlands and natural and human-made ponds

Throughflow -- water entering and exiting, passing through; a throughflow wetland receives significant surface or ground water which passes through the wetland and is discharged to a stream, wetland or other waterbody at a lower elevation; throughflow may be perennial, intermittent, or associated with an entrenched stream

Tidal Gradient -- the segment of a drainage basin that is subjected to tidal influence; essentially the freshwater tidal reach of coastal rivers; equivalent to the Tidal Subsystem of the Riverine System in Cowardin et al. 1979 plus contiguous wetlands

Vernal Pool -- a temporarily flooded basin; woodland vernal pools are found in humid temperature regions dominated by trees, these pools are surrounded by upland forests, are usually flooded from winter through mid-summer, and serve as critical breeding grounds for salamanders and woodland frogs; West Coast vernal pools occur in California, Oregon, and Washington on clayey soils, they are important habitats for many rare plants and animals

Meadowlands Environmental Site Investigation Compilation (MESIC)

MESIC Report Table of Contents Sections Sites Maps

Existing Restoration, Preservation, and/or Mitigation Sites

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#4 Hess Mitigation Site
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#6 Mill Creek Marsh
#7 Saw Mill Creek Wildlife Management Area
#27 Secaucus High School
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B. ENCAP Mitigation Site
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Candidate Restoration Sites

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#12 Berrys Creek Marsh
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#33 Cromakill Creek
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#35 Hackensack River
#36 Kingsland Impoundment
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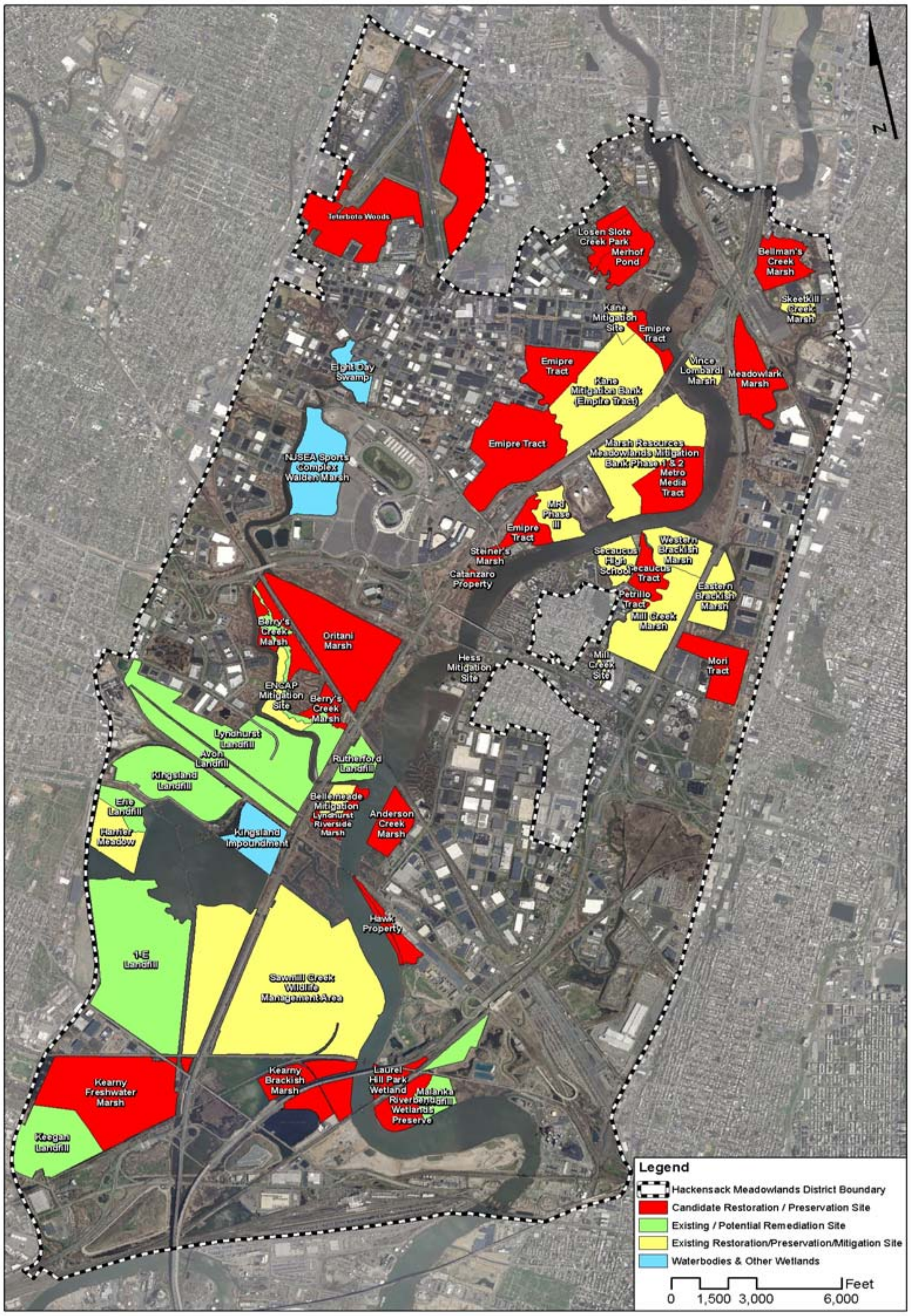

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New Jersey Meadowlands Commission : Meadowlands Environmental Site Information Compilation | Prepared by: *U.S. Army Corps of Engineers*

Download Print Version of MESIC Report

Site Review And Update

VENTRON/VELSICOL

WOOD-RIDGE BORO, BERGEN COUNTY, NEW JERSEY

CERCLIS NO. NJD980529879

AUGUST 27, 1992

REVISED

APRIL 20, 1993

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia

Site Review and Update: A Note of Explanation

The purpose of the Site Review and Update is to discuss the current status of a hazardous waste site and to identify future ATSDR activities planned for the site. The SRU is generally reserved to update activities for those sites for which public health assessments have been previously prepared (it is not intended to be an addendum to a public health assessment). The SRU, in conjunction with the ATSDR Site Ranking Scheme, will be used to determine relative priorities for future ATSDR public health actions.

REVISED SITE REVIEW AND UPDATE

VENTRON/VELSICOL

WOOD-RIDGE BORO, BERGEN COUNTY, NEW JERSEY

CERCLIS NO. NJD980529879

Prepared by:

Environmental Health Service
New Jersey Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

SUMMARY OF BACKGROUND AND HISTORY

The Ventron/Velsicol (also known as Berry's Creek) site is in a heavily industrialized section of Wood-Ridge and Carlstadt Township, Bergen County, New Jersey. From 1929 to 1974, the 40-acre site was used by a mercury processing/reclamation facility. Mercury wastes were landfilled on site and discharged directly into Berry's Creek, which is adjacent to the site (figure 1). Elemental mercury has been detected in on-site soils at levels as high as 195,000 ppm. It is estimated that as much as 160 tons of mercury waste are buried at the site. Mercury processing operations at the site have resulted in contamination of the Berry's Creek tidal ecosystem over a distance of several thousand feet downstream. Bioaccumulation of organic mercury at levels of public health concern in wetlands flora and fauna has been documented, and is the focus of continued investigation by the New Jersey Department of Environmental Protection and Energy (NJDEPE).

Structures of the former mercury processing facility were demolished, after which two warehouses were built on a seven-acre subdivision of the site in 1974. The warehouses did not house the mercury processing facility, as reported in the ATSDR preliminary health assessment of April 1989. One of the warehouses is used to store packaged cheeses and meats; the other stores office furniture. Indoor air of both warehouses has been sampled for mercury, but none was detected. The eastern warehouse (storing furniture) was built on the most heavily contaminated area of the site, and mercury vapor has been detected at vents in the building foundation at concentrations up to 0.1 mg/m^3. The western warehouse (food storage) was built on the most heavily contaminated area of the site.

Residential areas are approximately 600 feet northwest of the site. Nine residences where mercury concentrations in soils exceeded the NJDEPE cleanup objective of 14 ppm (maximum detected concentrations < 60 ppm) were the subject of a soil remediation action by the NJDEPE in 1990.

The ATSDR preliminary health assessment categorized the site as a public health concern based on the possibility of human exposure pathways associated with dermal exposure to contaminated soils, inhalation of mercury vapor, and ingestion of contaminated biota. Human exposure pathways associated with the ingestion of surface water and groundwater are unsupported in light of current site conditions and available information. An ATSDR consultation of the site was performed in July 1991. The consultation identified a potential human exposure pathway associated with volatilized mercury vapor in ambient air. The consultation recommended on- and off-site time weighted air monitoring of mercury vapor, but such sampling has not been conducted. Portable equipment (Jerome monitor) detected mercury vapor off site at concentrations up to 0.04 mg/m^3.

Community health concerns have focused on the potential health effects of mercury which has migrated off-site into soils at residences and the adjacent Wood-Ridge Wastewater Treatment Plant posing a risk to area residents and plant workers.

A full Remedial Investigation (RI) of the site has not yet been conducted although on- and off-site monitoring wells were installed in 1990 and 1991. According to the NJDEP, fieldwork for the RI should commence in the summer of 1993. The NJDEPE is also continuing to investigate the Ventron/Velsicol sites' impact on the salt water marsh environment of Berry's Creek and the Hackensack Meadowlands and their indigenous species.

CURRENT SITE CONDITIONS

NJDOH personnel, James Pasqualo, conducted a site visit in August 1992 with ATSDR representative, Joseph Little; ATSDR Regional Operations, Arthur Block; and EPA and NJDEPE representatives. Access to the site was partially restricted by fencing and warning signs posted along the site perimeter. Evidence of a makeshift shelter was reported within the site boundaries; although, no trespassers were encountered.

The Berry's Creek ecosystem contained a wide variety of plant and animal life, and reportedly supports various aquatic species that might directly enter the human food chain: fish, shellfish, and blue-claw crabs.

During the site visit, an inspection of the interior of the warehouses was conducted. The warehouse containing the cheese and meat products was refrigerated; all food products were prepackaged.

Conclusions of the preliminary health assessment regarding potential human exposure pathways associated with inhalation of mercury vapor, and dermal contact and/or ingestion of soils and sediments remain valid for those areas not remediated. However, concerns cited in the preliminary health assessment regarding potential exposure pathways associated with ingestion of groundwater are unsubstantiated because area residences are using municipal water supplies.

The preliminary health assessment is based on data from the 1983 hazard ranking package. In the interim, the NJDEPE has removed contaminated soil from adjacent residential areas, minimizing that exposure pathway. Physical conditions and environmental contamination associated with the site have remained constant since the preliminary health assessment was conducted.

CURRENT ISSUES

Past public health concerns associated with the site focused on residential exposures to mercury through soil and air. While residential soils have been remediated, there is insufficient data to substantiate or reject exposure via the air pathway.

Current community health concerns associated with the site focus on the municipal repair yard adjacent to the site. Mercury has been detected in concentration of over 600 ppm at the municipal repair yard and sewer treatment plant adjacent to the site. The area is used by municipal workers for a wide variety of tasks and is also the site of a small composting operation. The Borough is currently developing plans to convert this plant site to some future recreational use since the community is near complete development and severely lacking recreational space. The treatment plant is currently being decommissioned since the Borough tied into the Bergen County Regional Treatment Plant in 1992. Exposure of municipal workers to mercury in soils (and possibly to vapors emanating from the site) is possible until the area is remediated.

There are insufficient data to adequately ascertain the public health significance of mercury vapor volatilization from the site. Sampling events have been sporadic and not of a design appropriate to determine the magnitude of residential long term exposure.

CONCLUSIONS

Based on available information, the soils of the Ventron/Velsicol site are grossly contaminated with elemental mercury. Contamination has spread throughout the tidal marshland of the Berry's Creek ecosystem and has resulted in bioaccumulation of organic mercury compounds in flora and fauna of the area, some of which are species consumed directly by humans. There are limited data describing site-related contamination of other environmental media.

The great concentration of mercury in the area, and the vapor concentrations detected by portable equipment on and off site, suggest volatilization of mercury may be of sufficient magnitude to represent a human exposure pathway through inhalation of ambient air.

Conclusions in the preliminary health assessment regarding potential human exposures via ingestion of ground- and surface water, and inhalation of mercury vapor in the food warehouse are unfounded in light of current data. Conclusions in the preliminary health assessment regarding potential human exposure via ingestion of contaminated fish are supported by current site data. Inhalation of mercury vapor remains a potential exposure pathway until sufficient data are available for evaluation. Recommendations of the ATSDR preliminary health assessment to limit site access and sample the warehouses for mercury contamination have been satisfied by NJDEPE and EPA.

The Ventron/Velsicol site is considered by ATSDR and NJDOH to be an indeterminate public health hazard until environmental data become available for review and evaluation. A health consultation is needed to evaluate possible exposure to contaminated residential soils prior to NJDEPE remediation (IRM) and possible exposure of on-site municipal workers during remediation. In addition, a public health assessment is needed when additional RI/FS documents are available for review.

Data and information developed in the Site Review and Update have been evaluated to determine if follow-up actions are indicated. Further site evaluation is needed to determine public health actions.

RECOMMENDATIONS

Time weighted sampling of ambient air on and off site (residential areas and municipal maintenance yard) should be incorporated into the forthcoming remedial investigation of the site, or conducted independently if necessary, to determine the validity of potential human exposure to mercury vapor.

The recommendation in the preliminary health assessment for additional environmental data will be addressed by the upcoming Remedial Investigation/Feasibility Study.

A health consultation should be performed to evaluate the degree of exposure to residential soils prior to NJDEPE remediation, possible exposure of on-site municipal workers, and possible exposure of persons who consume area aquatic species. In addition, a public health assessment should be performed when additional RI/FS documents are available for review.

DOCUMENTS REVIEWED

1. Berry's Creek Study, Volume I: Nature of The Problem, Final Report. ERM-Southeast Inc. November 1985.

2. Mercury Levels In Berry's Creek. New Jersey Department of Environmental Protection, Office of Cancer and Toxic Substances Research. 1982.

3. Site Status Report. New Jersey Department of Environmental Protection and Energy. November 1991.

4. Preliminary Health Assessment. Ventron/Velsicol. ATSDR. April 1989.

5. Health Consultation. Ventron/Velsicol NPL Site. ATSDR. July 29, 1991.

Preparer of Report: James Pasqualo
Research Scientist I

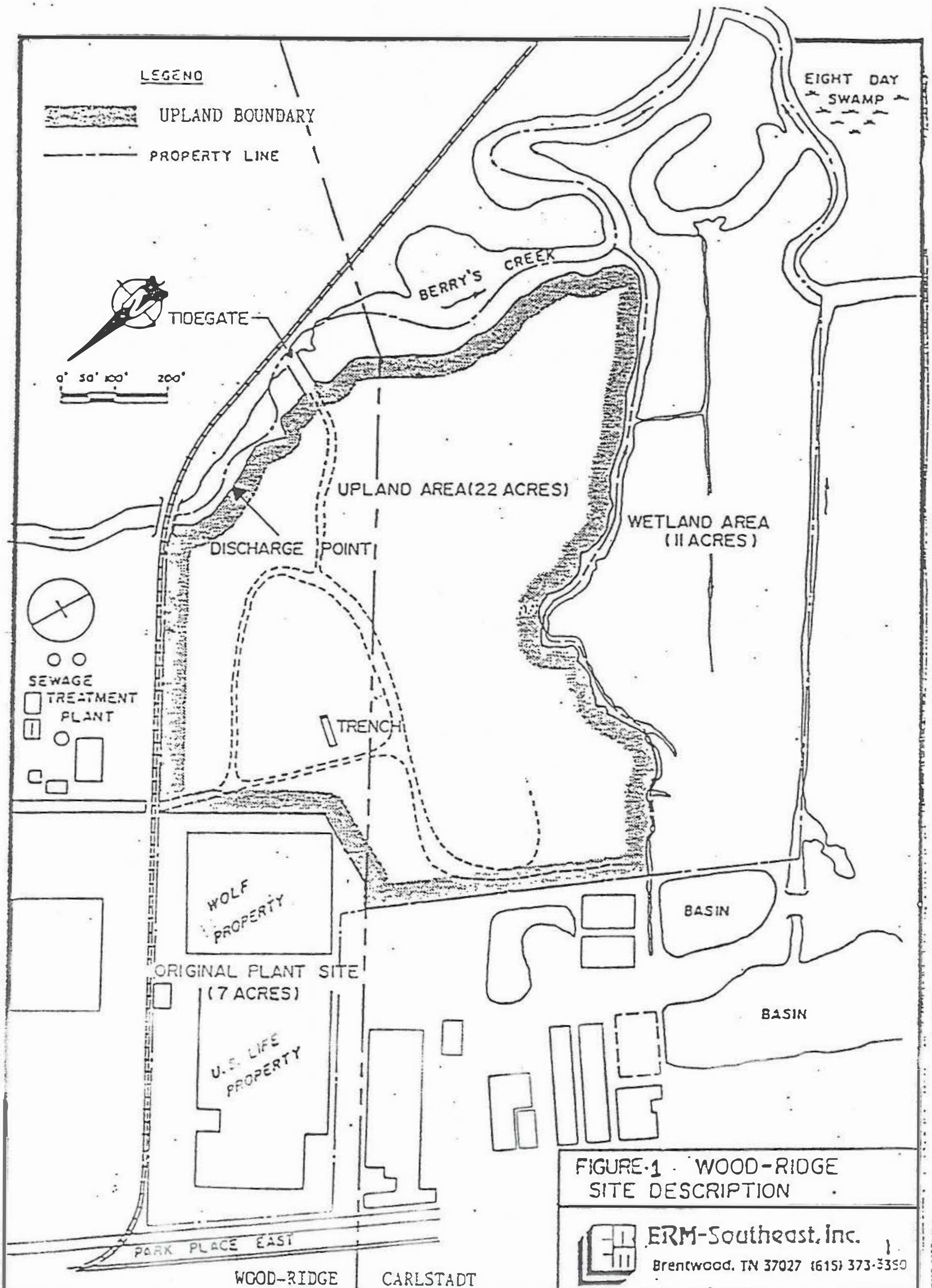


FIGURE 1 · WOOD-RIDGE SITE DESCRIPTION

ERM-Southeast, Inc.
Brentwood, TN 37027 (615) 373-3350

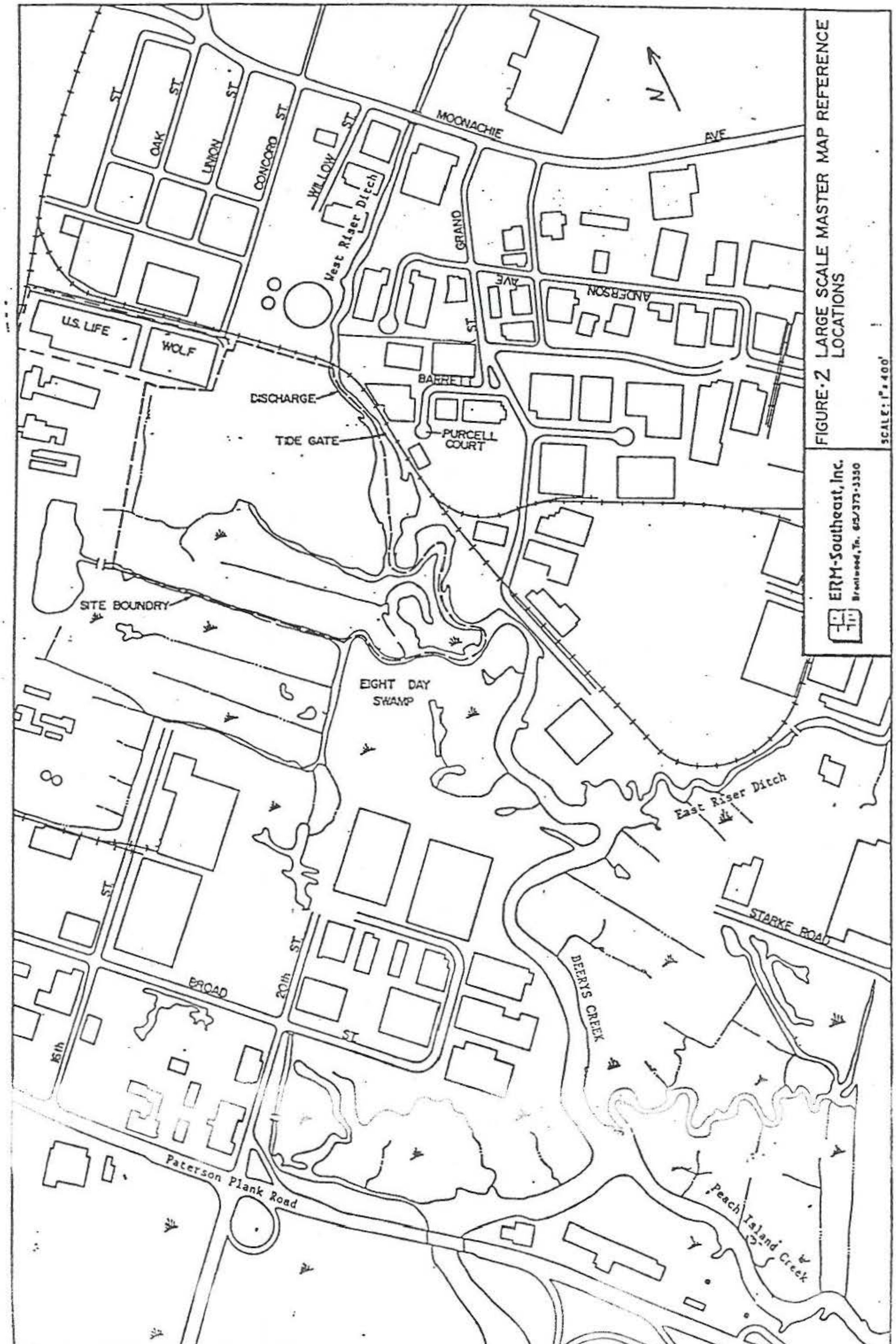


FIGURE-2 LARGE SCALE MASTER MAP REFERENCE LOCATIONS

SCALE: 1" = 400'

ERM-Southeast, Inc.
Brentwood, Tn. 615/373-3350

United States
Environmental Protection
Agency

Office of
Emergency and
Remedial Response

EPA/ROD/R02-93/206
September 1993

EPA

Superfund Record of Decision:

Universal Oil Products (Chemical Division), NJ

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/ROD/R02-93/206	2.	3. Recipient's Accession No.
4. Title and Subtitle SUPERFUND RECORD OF DECISION Universal Oil Products (Chemical Division), NJ First Remedial Action			5. Report Date 09/29/93
			6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address			10 Project Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460			13. Type of Report & Period Covered 800/800
			14.

15. Supplementary Notes

PB94-963806

16. Abstract (Limit: 200 words)

The 75-acre Universal Oil Products (Chemical Division) site is a chemical processing facility located in the Borough of East Rutherford, Bergen County, New Jersey. Land use in the area is predominantly residential, commercial, and light industrial, with wetlands in the form of undeveloped tidal marshes located on and near the site. A shallow aquifer located in the vicinity of the site has never been developed for potable water due to its low yield. Beginning 1932, Trubeck Laboratories operated the facility and constructed an aroma laboratory. In 1955, the company began operating a solvent recovery facility and handling waste chemicals, and constructed a wastewater treatment plant, which utilized two wastewater treatment lagoons. In 1960, Universal Oil acquired the facility and operated at the site until 1979. In 1971, the wastewater treatment plant and the two lagoons ceased operations. In 1979, site operations ceased, and, in 1980, all site structures were demolished. As a result of the release of various hazardous substances into the soil and shallow ground water due to the operation of wastewater lagoons and the routine handling of raw materials and wastes, a number of State investigations revealed PCB-, PAH-, VOC-, and lead-contaminated soil and VOC-contaminated leachate. This ROD addresses the interim remedial action for the contaminated uplands soil and leachate at the site, as OU1. Future RODs will address

(See Attached Page)

17. Document Analysis a. Descriptors

Record of Decision - Universal Oil Products (Chemical Division), NJ
First Remedial Action
Contaminated Media: soil, leachate
Key Contaminants: VOCs (1,1,2,2-TCE), other organics (PAHs, PCBs), metals (lead)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 68
	20. Security Class (This Page) None	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

Abstract (Continued)

the two wastewater lagoons, as OU2, and the stream channels, as OU3. The primary contaminants of concern affecting the soil and leachate are VOCs, including 1,1,2,2-TCE; other organics, including PAHs and PCBs; and metals, including lead.

The selected remedial action for this site includes placing a 2-foot deep soil cover over 4.9 acres and 6,800 yd^3 of the PCB/PAH-contaminated soil; treating 16,000 yd^3 of the highly PCB/PAH-contaminated soil, with PCB levels greater than 25 mg/kg and total PAH greater than 29 mg/kg, using thermal desorption with offsite destruction of vapor and liquid-phase residuals; treating 7,000 yd^3 of VOC-contaminated soil onsite using thermal desorption; placing a 2-foot deep soil cover and an impermeable cap over 3.7 acres of lead-contaminated soil; treating 5,600,000 gallons of VOC-contaminated leachate that collects in the excavation onsite, with discharge to ground water; excavating leachate collection pits and trenches; monitoring ground water; and implementing institutional controls, including deed restrictions. The estimated present worth cost for this remedial action is $9,600,000, which includes an estimated annual O&M cost of $1,025,200.

PERFORMANCE STANDARDS OR GOALS:

Soil and ground water cleanup goals are based on health-based criteria and State and EPA guidance. Chemical-specific surface soil goals include benzo(a)anthracene 4 mg/kg; benzo(b)fluoroethane 4 mg/kg; benzo(a)pyrene 0.66 mg/kg; benzo(k)fluoroethane 4 mg/kg; chrysene 40 mg/kg; dibenzo(a,h)anthracene 0.66 mg/kg; indeno(1,2,3-cd)pyrene 4 mg/kg; lead 600 mg/kg; PCBs 2 mg/kg; 1,1,2,2-TCE 21 mg/kg; VOCs (leachate) 10 mg/l; and VOCs (soil) 1,000 mg/kg.

ROD FACT SHEET

SITE

Name: Universal Oil Products
Location/State: East Rutherford, New Jersey
EPA Region: II
HRS Score (date): 54.63 (8/4/82)

ROD

Date Signed: September 30, 1993
Remedies: Containment of lead contaminated soils, treatment of volatile organic (VOC), polychlorinated biphenyl (PCB), and polynuclear aromatic hydrocarbon (PAH) contaminated soils with thermal desorption, collection and treatment of leacheate.

Operating Unit Number: OU-1

	Thermal Desorption & Soil Cover of PCB/PAH Contaminated Soils	ThermalDesorption of VOC Contaminated Soils	Cap and Soil Cover of Lead Contaminated Soils	Leacheate Collection and Treatment	TOTALS
Capital Costs:	$5.6M	$2M	$500,000	$1,300,000	$9.6M
Construction Completion:	10/97	1/97	8/95	1/96	
O & M in 1993:	0	0	0	0	0
O & M in 1994:	0	0	0	0	0
O & M in 1995:	0	0	0	0	0
O & M in 1996:	0	0	$2,600	$36,000	$38,600
Present Worth:	$5.6M	$2M	$532,000	$1,420,000	$9.6M

LEAD

Lead: New Jersey State Enforcement Lead
Primary contact: Gwen Barunas (609) 633-1455
Secondary contact: Roman Luzicky (609) 633-1455
Main PRP(s): Allied Signal
PRP Contact: Mark Kamilow (201) 455-2119

WASTE

Type: PCBs, PAHs, VOCs, Lead
Medium: Soils: PCBs, PAHs, and VOCs. Leacheate:VOCs
Origin: Chemical Processing Plant
Est. quantity: 5.6 million gallons of leacheate, 16,000 yd^3 of PBC/PAH contaminated soil, 7,000 yd^3 of VOC contaminated soil, 3.7 acre area of lead contaminated soil.

Declaration for the Record of Decision

Site Name and Location

Universal Oil Products (Chemical Division)
Borough of East Rutherford, Bergen County, New Jersey

Statement of Basis and Purpose

This decision document presents the selected interim remedial action for Operable Unit One at the Universal Oil Products (UOP) site, in the Borough of East Rutherford, Bergen County, which was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision document explains the factual and legal basis for selecting the remedy for this site and is based on the information contained in the administrative record for this site.

The N.J. Department of Environmental Protection and Energy serves as the lead regulatory agency at the UOP site. As the lead agency, the Department has directly overseen all activities at the site.

The U.S. Environmental Protection Agency (EPA) serves as the support agency at the UOP site. The EPA concurs with the selected remedy.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of the Selected Remedy

The response action described in this document represents an interim remedy for the first of three planned operable units at the site. Operable Unit One consists of the uplands soils and leachate at the site; Operable Unit Two includes the two wastewater lagoons; and Operable Unit Three consists of the site stream channels (see Figure 1). The selected interim action will address the threats due to contaminated soils and contaminated leachate, designated as Operable Unit One. It addresses the principle threats through treatment of the most highly contaminated materials and the lower level threats through containment. Since a portion of the selected remedy calls for the containment of contaminated soils, the remedial action for Operable Unit One will require long-term management.

The major components of the selected remedy include the following:

For Polychlorinated Biphenyl/Polycyclic Aromatic Hydrocarbon-Contaminated Soils:

- On-site thermal desorption of highly contaminated soil (6800 cubic yards), and placement of treated soils on site
- Soil cover for less contaminated soil (4.9 acres)
- Institutional controls

For Volatile Organic Compound-Contaminated Soils:

- On-site thermal desorption (7000 cubic yards), and placement of treated soils on site

For Lead-Contaminated Soils:

- Soil cover/cap (3.7 acres)
- Institutional controls

For Volatile Organic Compound-Contaminated Leachate

- Leachate collection trenches and pits (5.6 million gallons)
- On-site treatment of leachate
- Discharge of treated effluent to ground water

Declaration of Statutory Determinations

The selected interim remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action and is cost effective. In accordance with EPA "Guidance on Remedial Actions for Superfund Sites with PCB Contamination," a waiver of the Toxic Substances Control Act landfill requirements is being granted in this ROD for the UOP site. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable, and it satisfies the statutory preference for remedies that employ treatment that reduce toxicity, mobility, or volume as a principal element. Subsequent remedial actions are planned to address fully the principal threats posed by other operable units at this site. Because this remedy will result in hazardous substances remaining on site, a review will be conducted within five years after commencement of the remedial action to ensure that the interim remedy continues to provide adequate protection of human health and the environment.

[signature] for — 9/30/93

Jeanne M. Fox, Acting Commissioner
New Jersey Department of Environmental
Protection and Energy
Date

[signature] — 9/29/93

William J. Muszynski, P.E.
Acting Regional Administrator
U.S. Environmental Protection Agency
Region II
Date

Decision Summary for the Record of Decision

1. Site Name, Location, and Description

Universal Oil Products UOP is a 75 acre site located in the Borough of East Rutherford, Bergen County, New Jersey. A portion of the site is located in the Hackensack Meadowlands District, which is administered, in part, by the Hackensack Meadowlands Development Commission. It is bounded on the north primarily by a compressed gas facility, on the east by Berry's Creek, on the south by commercial properties, and on the west by New Jersey Route 17 (See Figure 1).

The UOP property is flat (elevations vary from 4 to 9 ft above mean sea level) and partly covered by tidal salt marsh. A system of natural and artificial surface-water channels crosses the property. The property was developed as an industrial facility in 1932. The property usage remained industrial until operations ceased in 1979.

The UOP property is surrounded by undeveloped tidal marshes, highways, and commercial and light industrial properties. Immediately to the north is the Matheson Air Products facility, a metal finishing facility, a truck and car repair shop, and a hotel. To the east are Berry's Creek and tidal marshes. To the south are commercial properties. To the west is New Jersey Route 17. West of Route 17 are a Becton Dickinson manufacturing facility and commercial properties. The closest residential area is approximately one-half mile to the west of Route 17.

The UOP site occupies part of the Berry's Creek drainage basin. An Environmental Impact Statement (EIS) was prepared for the adjacent New Jersey Sports and Exposition Complex (Jack McCormick and Associates, 1978). That report described the various natural resources found in the area of UOP. Many flora and fauna are found in the vicinity of the UOP site including dense stands of common reed grass, other various wetlands plant species, sixty-five kinds of birds, many mammals, one amphibian and three reptile species.

As stated above, the site is crossed by various man-made and natural channels, commonly referred to as Ackerman's Creek, that drains to Berry's Creek, a tributary to the Hackensack River. These surface water bodies are all tidally affected and have relatively high salinity concentrations.

Wetlands exist on site. Also due to its location, the site is regularly subject to tidal flooding.

Ground water at the site exists in two units. The upper unit consists of a layer of fill on top of an organic layer called meadow mat. This unit at UOP is isolated horizontally by the on-site surface water bodies and is generally brackish. Also, due to the nature of the fill material, aquifer yields are very low in this formation. For these reasons, the shallow aquifer in the vicinity of the site has never been developed for potable use. A deeper aquifer, located in the Brunswick formation, is separated from the shallow aquifer by approximately 100 feet of varved clay. Due to the site's location in the Hackensack Meadowlands, a regional discharge area, the vertical hydraulic gradient tends to be upward.

2. Site History and Enforcement Activities

The property was developed in 1932 by Trubeck Laboratories, which built an aroma chemicals laboratory. Trubeck began operating a solvent recovery facility and handling waste chemicals in 1955. In 1956 Trubeck constructed a wastewater treatment plant, and in 1959 began utilizing two wastewater holding lagoons. UOP Inc. acquired the property and facilities in 1960. Use of the waste treatment plant and wastewater lagoons ceased in 1971. All operations at the facility were terminated in 1979. In 1980 all structures, except concrete slabs and a pipe bridge over the railroad tracks, were demolished. During the years of operation, both the waste water lagoons and the routine handling of raw materials and wastes resulted in the release of various hazardous substances to the soils and shallow ground water.

The New Jersey Department of Environmental Protection and Energy (NJDEPE) has overseen activities at the UOP site since 1982 under various Administrative Consent Orders (ACOs). The site was listed on the National Priorities List (NPL) on September 8, 1983. Current site work is being performed under a May 23, 1986 ACO between NJDEPE and UOP. Activities performed under this ACO have included the investigations of Operable Unit One, the investigation of site stream channels (Operable Unit Three), and the removal of the two wastewater lagoons (Operable Unit Two) in 1990.

3. Highlights of Community Participation

The Remedial Investigation and Feasibility Study (RI/FS) Report and the Proposed Plan for the UOP site were released to the public for comment on August 10, 1992. These documents were made available to the public in both the administrative record and an information repository maintained at the NJDEPE offices in Trenton, NJ, the East Rutherford Municipal Building and the East Rutherford Municipal Library. The notice of availability for these documents was published in the *Herald News* on August 5, 1992. A public comment period on the documents was held from August 10, 1992 through September 8, 1992 (30 calendar days). In addition, a public meeting was held on August 13, 1992. At this meeting, representatives from the NJDEPE answered questions about problems at the site and the remedial alternatives under consideration. A response to the comments received during this period is included in the Responsiveness Summary, which is part of this Record of Decision ROD. During the public comment period, the U.S. Environmental

Protection Agency 0(EPA) suggested that several changes be made to the proposed plan that was issued on August 10, 1992. Based on these comments, a second proposed plan was released for public comment on May 3, 1993. A second public comment period was held for the revised proposed plan from May 3, 1993 through June 1, 1993 (30 calendar days). The notice for the second public comment period was placed in the *Herald News* on May 1, 1993. No public comments were received during the second public comment period.

4. Scope and Role of Operable Unit or Response Action Within Site Strategy

As with many Superfund sites, the problems at the UOP site are complex. As a result, NJDEPE has organized the remedial work into three operable units. This ROD selects the first planned remedial action at the site, addressing Operable Unit One. Operable Unit One consists of the uplands soils and leachate at the UOP site. The response action described in this ROD is an interim action that addresses all known soil contamination and leachate that serves as a source of ground water contamination. A final action for ground water will be selected after completion of this interim remedial action. A removal action was performed by the responsible parties with NJDEPE oversight in 1990 for Operable Unit Two that consisted of the excavation and off-site disposal of two waste lagoons. Presently, a remedial investigation is being performed for Operable Unit Three, the stream channels. Further remediation of the former waste lagoons, Operable Unit 2, is contingent upon the remedy selected for Operable Unit 3, since part of these waste lagoons adjoin the creek.

The remedial action selected in the Record of Decision addresses several principal threats posed by the UOP site. These principal threats are Polychlorinated Biphenyl (PCB)/Polycyclic Aromatic Hydrocarbon (PAH)-contaminated soils, lead-contaminated soils, Volatile Organic Compound (VOC)-contaminated soils, and VOC-contaminated leachate (source areas of ground water contamination).

5. Summary of Site Characteristics

To facilitate investigations, the UOP site has been divided into six areas: Areas 1, 1A, 2, and 5 are the uplands area of the site; Area 3 is the former waste lagoons associated with the waste water treatment plant; and Area 4 is the on-site stream channels (see Figure 1). The remedial investigation (RI) for the upland areas at the UOP site has been performed in three phases. Phase I investigations were performed in 1984, and Phase II investigations were performed in 1985. Phase I initially characterized contamination distribution at the site. Investigations performed subsequent to Phase I built upon information from previous phases and filled in any data gaps that existed. The results of the first two phases are considered in the 1988 or Phase III RI report. The 1988 RI report serves as the main RI document. Remedial activities related to Areas 3 and 4 are being performed separately due to their unique qualities including different geographical locations, contaminants of concern, and physical characteristics (i.e., stream beds could not be investigated/remediated in a manner similar to soils).

The remedial investigation of the uplands area included the installation of monitor wells and taking soil samples. The locations of these wells and samples are shown on Figures 2 and 3. The remedial investigations made several conclusions concerning site conditions at Areas 1, 1A, 2 and 5:

1. Area 1, 1A and 2 samples indicate the presence of VOCs in the following concentrations. Area 1 sampling results indicated that total VOCs in ground water ranged from Below Detection Limits (BDL) to 56 parts per million (ppm) and total VOCs in soil ranged from BDL to 74.8 ppm. Area 1A results demonstrated higher levels of total VOCs with ground water ranging from BDL to 66 ppm total VOCs and soil ranging from BDL to 1747 ppm. Area 2 had the highest total VOC levels with sampling indicating ground water levels from BDL to 210 ppm and soil levels ranging from BDL to 2108 ppm (See Figures 4, 5 and 6).

2. Base/neutral and acid-extractable (BNA) compounds were detected in ground water. These compounds were detected in areas also contaminated with VOCs. In general, these compounds occur at much lower concentrations than the VOCs. The highest concentrations were measured in Wells 13I, 21I, and 27I at 21 ppm, 10 ppm and 14 ppm, respectively (See Figure 3 for well locations).

3. Area 5 samples indicated that high levels of various base neutral compounds were present in surface soils. In particular, carcinogenic PAHs were detected in Area 5 soils (see Table 12 for list of carcinogenic PAHs). These carcinogenic PAHs were detected to levels of up to 1474 ppm (See Figure 8).

4. Area 5 samples also indicated that shallow soils were contaminated with PCBs. PCBs were detected at levels ranging from BDL to greater than 2000 ppm. The area with elevated levels of PCBs overlaps the area with elevated levels of carcinogenic PAHs. Also, a small portion of Area 2 was contaminated with PCBs (See Figure 7).

5. A separate portion of Area 5 has elevated levels of lead. Maximum levels of 14,100 ppm have been detected in Area 5. Lower levels of lead were detected in Areas 1 and 1A (See Figure 9).

In addition to the Remedial Investigation, a Seep/Sewer Investigation was performed in Areas 1, 1A, and 2 of the site. This investigation focused on an apparent seep discharging to Ackerman's Creek and the various sewers located in this portion of the site. A seep is an area where ground water is naturally discharged from an aquifer. The seep at

UOP was attributed to the presence of an old storm sewer. Sediments within the sewer system contained elevated levels of VOCs and PCBs.

Based on the results of analytical sampling, various pathways for contaminant migration were evaluated. One pathway consisted of soil and ground water contamination migrating to the adjacent surface water bodies. Once contamination was in the surface water body, various biota and human populations could become receptors. In addition to the possible receptors from surface water contamination, other exposure pathways including direct contact with soils and ground water were considered during the RI/FS.

6. Summary of Site Risks

A baseline risk assessment was conducted by the responsible party under the direction of the NJDEPE. The purpose of the baseline risk assessment is to determine what risks are or may potentially be present if no remedial action is taken at the site. For the UOP site, both human health and ecological baseline risk assessments were performed. The human health portion of the assessment concentrated on the possible health effects due to contamination on the uplands area of the site (Operable Unit One). The ecological risk assessment mainly focused on the contamination in the stream channels. This ecological assessment included a food chain assessment. The ecological risk assessment for the uplands portion of the site consisted of a preliminary ecological survey.

The baseline human health risk assessment was conducted in a four-step sequence. The steps consisted of the selection of indicator chemicals, the development of an exposure assessment, the development of a toxicity assessment and lastly, development of a site risk characterization.

The first step in the baseline human health assessment for the UOP site was the selection of indicator chemicals that would be representative of site risks. Selection of indicator chemicals was based on the analytical results of the Phase II and Phase III remedial investigations. The main criteria utilized for this selection were the relative concentration of substances at UOP and their relative toxicity. These criteria were utilized to calculate indicator scores for all potential indicator chemicals. Both the arithmetic mean and maximum concentration of contaminants were considered in developing the indicator scores. Upon completion of the indicator scores, further screening was conducted based on site-specific information to identify the indicator compounds. Indicator compounds were selected for ground water, surface soils and subsurface soils. The selected indicator chemicals and their frequency of detection are listed in Table 1.

The second step in conducting the baseline risk assessment at the UOP site was to develop an appropriate exposure assessment to be utilized in calculating potential risk. This exposure assessment included identifying the appropriate exposure pathways (i.e., the ingestion of contaminated soils, etc.), identifying potentially exposed populations, using monitoring and modeling data to characterize exposure-point concentrations, and determining the appropriate assumptions to use concerning exposure frequency.

The first portion of the exposure assessment determined the appropriate exposure pathways to evaluate. Humans may potentially be exposed to contaminants in air, water or solid media (soils and sediments) directly, or through the food chain. The route of intake may be by ingestion, inhalation, or dermal absorption. Five pathways were deemed to be appropriate at the UOP site. These pathways are described in Table 2.

Another portion of the exposure assessment identifies the potentially exposed populations. In order to make this determinations, the present and future land use of the site and area were considered. Three potentially exposed populations were identified. These were young people trespassing on the property, an adult employee work force that would be present if the site was developed, and a construction worker population that would be present for a short period of time during any construction project.

After exposure pathways and exposed populations are determined, it is necessary to determine the concentration of contaminants that may be present at the point of exposure. Maximum concentrations and arithmetic means of analytical data were used as a starting point for determining the concentration at the point of exposure. Various assumptions and predictive models were then used to develop the concentrations of contaminants that would be present in the air and soil and available for uptake by the exposed population.

The final portion of the exposure assessment consisted of determining the appropriate assumptions to make concerning the various exposed populations. For example it was assumed that a trespasser would be on the site one hour per week, twelve months out of the year, and would inhale one cubic meter of air.

The third step in conducting a baseline risk assessment is performing a toxicity assessment. The purpose of this assessment is to determine dose-response relationships for the indicator compounds present at the UOP site. For carcinogens, the dose-response relationship is translated to a slope factor. For non-carcinogenic substances, Reference Doses (Rfds) and Inhalation Concentrations (Rfcs) are developed that can be used to identify if an intake value is below the threshold value for an adverse effect to occur.

Cancer slope factors (CSFs) have been developed by EPA's Carcinogenic Assessment Verification Endeavor (CRAVE) for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CSFs, which are expressed in units of milligrams per kilogram per day $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CSF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer potency factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. The CPFs used for the UOP risk assessment are listed in Table 3.

Reference Doses (Rfds) and Inhalation Concentrations (Rfcs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. Rfds and Rfcs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals, that are not likely to be without an appreciable risk of adverse health effects. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the Rfds and Rfcs . Rfds and Rfcs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the Rfds and Rfcs will not underestimate the potential for adverse noncarcinogenic effects to occur. The Rfds and Rfcs used for the UOP risk assessment are listed in Table 3.

The final step of the risk assessment consists of estimating the risk present at a site. This is computed by utilizing the information gathered during the three previous steps of the risk assessment process. Both the carcinogenic are non-carcinogenic risks are quantified.

Excess lifetime cancer risks are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g., $1x10^{-6}$ or 1E-6). An excess lifetime cancer risk of $1x10^{-6}$ indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site. The total carcinogenic risk presented in the 1989 risk assessment ranged from $8.99x10^{-5}$ for the present site use scenario to $8.06x10^{-7}$ for the future site worker scenario. All individual and total carcinogenic risks associated with the site are listed on Tables 4, 5, and 6. All the calculated risks in the 1989 risk assessment were within or below EPA's acceptable risk range of 10^{-4} to 10^{-6}. Supplemental surface data collected in December 1989 and analyzed for PCBs and PAHs had higher levels of PCB and PAH contamination than earlier rounds. This new round elevated the maximum and average PCB and PAH concentrations (see Table 7). Based on this new data, risk levels were recalculated. The new risk levels ranged from $4.4x10^{-4}$ for the present use scenario to $1.28x10^{-5}$ for the construction worker scenario (see Table 8).

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the "hazard quotient" (HQ) or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's Rfd. By adding the HQ for all contaminants within a medium or across all media to which a given population may potentially be exposed, the Hazard Index (HI) can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. The calculated individual hazard indices and total hazard index are listed in Tables 9, 10, and 11.

Several sources of uncertainty exist in the risk assessment. These uncertainties generally can be placed into three categories:

1) Variance in analytical measurement techniques and the quality of the results
2) Uncertainty related to the human activities giving rise to exposure
3) Uncertainty related to dose-response extrapolation.

In order to minimize any underestimation of risk caused by these areas of uncertainty, many conservative assumptions were utilized in preparing the risk assessment.

The major finding of the risk assessment was that PCB and PAH contaminated soils presented unacceptable carcinogenic risk levels (up to 4.4×10^{-4}). In addition to the baseline risk assessment, some other factors indicate that human health and the environment may potentially be affected at the site. EPA performed an independent risk evaluation for some compounds at the UOP site. This evaluation indicated that levels of 1,1,2,2-tetrachloroethane in some site soils fell within the 10^{-4} to 10^{-6} risk range. Also, after completion of the risk assessment, additional samples were taken for lead. Results of these samples were a magnitude greater than previous samples with a maximum level of 14,100 ppm being detected. These levels of lead exceed EPA guidelines and NJDEPE's most recent general guidance. The New Jersey guidelines provide health based criteria designed to provide for the protection of human health across the State.

The Seep/Sewer Investigation evaluated the migration of VOCs and BNAs in ground water to surface water via ground water seeps related to the various sewer networks present at the UOP site. This study determined that relatively high levels of VOCs were present in the sewer system and were discharging to Ackerman's Creek. The study also demonstrated that while BNAs were present in the ground water, migration to the sewer system and stream is minimal.

In addition to human health risks, the risks to the environment were considered. A preliminary survey of terrestrial plants and wildlife on the site was conducted in October 1988. The survey of terrestrial animals and both woody and herbaceous vegetation indicated no differences between study and reference areas that might be associated with environmental impact. Based on the results of the preliminary survey, it was determined that no further studies were warranted. A more in-depth ecological risk assessment was performed for Operable Unit Three, the stream channels.

In summary, actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

7. Description of Alternatives

To aide in analyzing remedial alternatives for Operable Unit One, the UOP site was divided into four distinct remediation areas. These areas are based on contaminant type and media affected. The four areas are as follows:

- PCB/PAH-contaminated soil
- VOC-contaminated soil
- Lead-contaminated soil
- VOC-contaminated leachate

PCB/PAH-Contaminated Soil

The FS report provides a detailed evaluation of all options, referred to as remedial alternatives, to address PCB/PAH contaminated soils at the site. Detailed descriptions of all the remedial alternatives can be found in the FS report which is available in the Administrative Record repositories as previously noted in this decision document. The three most applicable PCB/PAH alternatives from the FS and the No Action alternative are presented here. Time to implement includes remedial design. Operation and Maintenance (O&M) costs are based on any maintenance costs associated with a potential remedy (e.g., cap maintenance) and general review costs. Remediation goals for PCB/PAH-contaminated soil are included on Table 12.

These alternatives are:

Alternative #P1: No Action

Capital Cost: $0.00
O & M Cost: $1300/year
Present Worth Cost: $40,000
Time to Implement: 0 months

The Superfund program requires that the "no-action" alternative be considered as a baseline for comparison of other alternatives. The no action alternative would be appropriate if the potential endangerment is negligible or if implementation of a remedial action would result in a greater potential risk.

Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #P2: Soil Cover

Capital Cost: $470,000
O & M Cost: $2,600
Present Worth Cost: $550,000
Time to Implement: 28 months

This alternative consists of constructing a soil cover over soils that exceed the remediation goal. Approximately 4.9 acres would require placement of the soil cover. The cap would be a minimum 2 foot depth to prevent contact with contaminated soils. The construction of the cover would have to meet wetlands and soil erosion requirements. Also, any relevant flood plain requirements would have to be met. Institutional controls would be required due to the presence of contaminants above remediation goals. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #P8: Soil Washing

Capital Cost: $8.2 M
O & M Costs: $2,600/year
Present Worth Cost: $8.3 M
Time to Implement: 50 months

Soil washing uses a solvent to separate contaminants from the soil. The contaminants can then be removed from the solvent, allowing the reuse of solvent and the destruction of contaminants off-site. 16,000 cubic yards of PCB/PAH-contaminated soil would be treated. This option would have to meet wetlands and soil erosion requirements during soil excavation. Treated soils will be returned to the excavation after treatment. Soil washing is considered an innovative technology. It may have some difficulty achieving remediation goals due to the high amount of clay and organic matter content in soils at the UOP site. A treatability study conducted for this technology verified this difficulty. Soils containing contaminant residues, perhaps at levels greater than the cleanup goals, may remain on-site. In the event that the PCB cleanup goal of 2 ppm is not met, a waiver of Toxic Substance Control Act (TSCA) chemical waste landfill requirements will be needed for this alternative. The presence of contaminants on-site would require that institutional controls be implemented. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #P9: Thermal Desorption

Capital Cost: $11.0 M
O & M Cost: $2,600/year
Present Worth Cost: $11.1 M
Time to Implement: 47 months

Thermal desorption separates PCB/PAH contamination from soil by heating the soil. The separate vapor or liquid phase contaminants will then be taken off-site and destroyed. Thermal desorption is a newer technology but is commonly used to remediate sites contaminated by organic compounds. 16,000 cubic yards of PCB/PAH-contaminated soil would be treated. Treated soils will be returned to the excavation after treatment. Due to the clay and organic matter content of soils, it is questionable whether this technology can meet the remediation goals at the UOP site. Treatability studies have indicated that remediation goals may be met using this technology. In the event that such goals are not met, contaminant residues will remain on treated soils, and institutional controls would be needed. A waiver of TSCA chemical waste landfill requirements may be needed for this alternative. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented to remove or treat the wastes. This remedy also would require that wetlands and soil erosion requirements be met.

VOC-Contaminated Soils

The FS report provides a detailed evaluation of all options, referred to as remedial alternatives, to address VOC contaminated soils at the site. Detailed descriptions of all the remedial alternatives can be found in the FS report which is available in the Administrative Record repositories as previously noted in this decision document. The five most applicable VOC alternatives from the FS and the No Action alternative are presented here. The remediation goals for VOC-contaminated soils are listed on Table 12.

These alternatives are:

Alternative #V1: No Action

Capital Cost: $0.00
O & M Cost: $1300/year
Present Worth Cost: $40,000
Time to Implement: immediate

See description under Alternative #P1

Alternative #V4: Bioremediation

Capital Cost: $2.1 M
O & M Cost: $2,600/year
Present Worth Cost: $2.2 M
Time to Implement: 40 months

Alternative #V4 considers the bioremediation of VOC-contaminated soil. 7000 cubic yards of soil would require treatment. Bioremediation is an innovative technology that involves the breakdown of organic contaminants by naturally-occurring microbes. Environmental factors, such as Ph, nutrient levels, and temperature, are controlled in a reactor to maximize the rate of degradation. Residual contamination may be present in the soils and water involved with the process, or air released from the process. All of these residuals would need to be properly managed. In the cases of water and air, applicable discharge requirements would need to be met. Relevant soil erosion and wetlands requirements due to the excavation of the contaminated soil would also have to be met. Institutional controls would be required. Because this alternative may result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented to remove or treat the wastes.

Alternatives #V7 and #V8:

Alternative #V7 **Soil Washing**
Capital Cost: $4.0 M
Present Worth Cost: $4.0 M
Time to Implement: 45 months

Alternative #V8 **Thermal Desorption**
Capital Cost: $5.1 M
Present Worth Cost: $5.1 M
Time to Implement: 41 months

Alternatives #V7 and #V8 consider the use of soil washing and thermal desorption, respectively, to treat soils contaminated with VOCs. The processes of these two technologies were described under the section on treating PCB/PAH contaminated soils.

While soil washing was considered an innovative technology for the removal of PCBs and PAHs, it is expected that soil washing will be able to treat the VOC-contaminated soils to levels well below the remediation goals. Similarly, for PCBs and PAHs, thermal desorption's effectiveness in achieving the necessary remediation goals is questioned, however, this technology is expected to achieve the VOC remediation goals since VOCs are more readily driven from soils upon thermal treatment than PCBs and PAHs. Like bioremediation, approximately 7000 cubic yards of VOC-contaminated soil require treatment. As with other alternatives, the excavation of the contaminated material would have to meet the necessary wetlands and soil erosion requirements. The thermal desorption unit would have to meet necessary air emission requirements. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #V9 *Ex situ* Vapor Extraction

Capital Cost: $1.9 M
Present Worth Cost: $1.9 M
Time to Implement: 47 months

Alternative #V9 would treat VOC-contaminated soils by *ex-situ* vapor extraction. Ex-situ vapor extraction first requires that soils be excavated. 7000 cubic yards of VOC-contaminated soil would be excavated. During excavation, wetlands and soil erosion requirements would need to be met. The excavated soils would then be placed in a controlled area, and air would be drawn through the soil to remove VOCs from the soil. Vapor extraction should decrease VOCs to below remediation goals. The process would produce VOC emissions that would be required to meet applicable air emission levels. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Lead-contaminated soils

The FS report evaluates, in detail, 7 remedial alternatives for addressing soils contaminated with lead. The top 4 alternatives from the Feasibility Study and the no action alternative are presented here. The remediation goal for lead-contaminated soils is listed on Table 12

Alternative #L1: No Action

Capital Cost: $0.00
O & M Cost: $1300/year
Present Worth Cost: $40,000
Time to Implement: immediate

See description under Alternative #P1.

Alternative #L2: Soil Cover

Capital Cost: $150,000
O & M Cost: $2600/year
Present Worth Cost: $230,000
Time to Implement: 28 months

Alternative #L2 consists of a soil cover over areas of lead greater than the remediation goal and the implementation of institutional controls. The soil cover would be 2 feet deep to prevent contact with the contaminated material. 3.7 acres require covering. Construction of the cover would have to meet any relevant wetlands or soil erosion requirements. Also, relevant flood plain requirements would be met. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #L3 Impermeable Cap

Capital Cost: $545,000
O & M Costs: $2,600/year
Present Worth: $660,000
Time to Implement: 28 months

Alternative #L3 considers various options for capping lead-contaminated soils to meet 10^{-7}permeability. Various cap types are considered. All of the capping options would prevent contact with contaminated material. Any cap would have to meet wetlands and soil erosion requirements. Also, any relevant flood plain requirements would need to be met. Institutional controls would be required due to the contamination remaining on-site. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented.

Alternative #L6 Solidification

Capital Cost: $2.8 M
O & M Costs: $1,900/year
Present Worth: $2.9 M
Time to Implement: 28 months

Alternative #L6 is the solidification of lead-contaminated soils. Solidification places lead-contaminated soil in a matrix with a binding material to prevent the migration of lead. 12,000 cubic yards of material would be solidified. This is a common technology for treating inorganic contamination. The implementation of this technology would have to consider its impact on soil erosion and wetlands. Because this alternative would result in contaminants remaining on-site, CERCLA requires that the site be reviewed every five years. If justified by the review, remedial actions may be implemented to remove or treat the wastes. Also, institutional controls would be implemented.

Alternative #L7: Excavation and Off-site Disposal

Capital Cost: $10.3 M
Present Worth Cost: $10.3 M
Time to Implement: 31 months

Alternative #L7 consists of excavation and off-site disposal of lead above the remediation goal. This alternative would have to meet wetlands and soil erosion requirements. Also, requirements pertaining to the transport of contaminated materials would have to be met. Approximately 12,000 cubic yards of contaminated soil would be excavated and disposed off-site.

VOC-Contaminated Leachate

The Feasibility Study evaluates, in detail, two remedial alternatives for treating leachate contaminated with VOCs at the site. The portion of the site that will be addressed with these alternatives consists of sections of Areas 1, 1A, and 2. Much of the background concerning these alternatives is contained in the document entitled IRM Work Plan. The area of VOC-contaminated leachate is defined on Table 12.

Alternative #LEACHATE1: No Action

Capital Cost: $0.00
O & M Cost: $3,500/year
Present Worth Cost: $100,000
Time to Implement: immediate

See description under Alternative #P1.

Alternative #LEACHATE2: Leachate Collection and Treatment

Capital Cost: $1.3 M
O & M Cost: $130,000

Present Worth Cost: $1.4 M
Time to Implement: 27 months

Alternative #LEACHATE2 consists of the excavation of leachate collection pits and trenches, treating leachate that collects in the excavation, and discharging the treated water to ground water. Approximately 5.6 million gallons of leachate would require treatment. This alternative would utilize conventional excavation, treatment (such as carbon adsorption) and discharge equipment. It is expected that levels of contamination in the leachate could be highly reduced. The excavation of the trenches and pits would have to meet soil erosion and wetlands criteria. The leachate treatment system and the discharge will meet applicable discharge requirements. If this alternative results in contaminants remaining on site, CERCLA requires that the site be reviewed every five years. A future review should determine if this source removal is protective of ground water and surface water or if further remedial actions for ground water are necessary.

8. Summary of Comparative Analysis of Alternatives

During the detailed evaluation of remedial alternatives, each alternative is assessed against the following nine evaluation criteria.

- o Overall protection of human health and the environment addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- o Compliance with applicable or relevant and appropriate requirements (ARARs) addresses whether or not a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes and requirements or provide grounds for invoking a waiver.

- o Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

- o Reduction of toxicity, mobility, or volume through treatment is the anticipated performance of the treatment technologies a remedy may employ.

- o Short-term effectiveness addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

- o Implementability is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- o Cost includes estimated capital and operation and maintenance costs, and net present worth costs.

- o EPA acceptance discusses if the support agency concurs with the remedy selected by the NJDEPE.

- o Community acceptance is assessed based on a review of the public comments received on the RI/FS reports and the Proposed Plan.

A comparative analysis of alternatives based upon the evaluation criteria noted above was performed for each remediation area.

PCB/PAH-Contaminated Soil

The analysis for remediating **PCB/PAH-contaminated** soils is presented first:

- o Overall Protection of Human Health and the Environment

Alternative #P1, no action, would not be protective of human health and the environment because contaminant concentrations pose an unacceptable risk to human health and the environment. Specifically, current levels of PCBs and PAHs at the UOP site pose and unacceptable level of risk. The No Action alternative would not address this risk. Alternative #P2, soil cover, would reduce risk by preventing contact with contaminated soils. However, the covering of contaminated soil would not permanently address contamination. Alternative #P8, soil washing, would permanently remove high levels of PCBs and PAHs from the soil. However, treatability studies have indicated it may be difficult to achieve remedial goals with soil washing. A bench-scale treatability study reduced PCBs in one sample from 850 ppm to 28 ppm and another sample from 360 ppm to 7.5. Alternative #P9, thermal desorption, will permanently remove PCBs/PAHs from the soil. Low levels of contamination may remain in the soil. However, based on the results of treatability studies, it is believed that thermal desorption may be more capable of consistently removing high levels of PCBs and PAHs than soil washing. Treatability studies show that PCB levels could be reduced below detection limits (i.e., 0.8ppm).

o Compliance with ARARs

There are three types of ARARs: action-specific, chemical specific, and location specific. Action-specific ARARs are technology or activity-specific requirements or limitations. Chemical-specific ARARs establish the amount or concentrations of a chemical that may be found in, or discharged to, the environment. Location-specific ARARs are restrictions placed on concentrations of hazardous substances found in a specific location, or the conduct of activities solely because they occur in a specific location. In the absence of an ARAR, the use of other criteria (i.e. To Be Considered or TBC) or risk-based levels may be evaluated.

Alternatives #P1 and #P2 would not meet the cleanup goal for the UOP site since no reduction in levels of PCBs and PAHs would be realized. Alternative #P8, soil washing, will not achieve the remediation goals for the site. Alternative #P9, thermal desorption, may have difficulty achieving cleanup goals for the site. All action alternatives would meet applicable soil erosion and wetlands requirements. Due to the site's location in a tidal flood plain, Alternative #P2 would need to be constructed in a manner to minimize its effect on flooding. Alternative #P9 would also meet the necessary air emission standards.

The Toxic Substances Control Act (TSCA) is a federal law which regulates the management and disposal of PCBs. In general, depending on the nature of the PCB containing material and the PCB concentration in the material, TSCA may require incineration or disposal in a chemical waste landfill approved for PCB disposal. PCBs that are required to be incinerated may also be treated by an approved alternate method that provides PCB destruction equivalent to incineration. The TSCA regulations are applicable to the management and disposal of the PCB contaminated soils once they have been excavated during cleanup.

Under TSCA, an alternative treatment method could be considered equivalent to incineration if it reduces PCBs to concentrations no greater than 2 ppm after treatment. Unless treatment of PCB contaminated soils reduces PCB concentrations to levels below 2 ppm, the residual from the treatment process must be disposed of in a TSCA chemical waste landfill unless a waiver is invoked.

o Long-Term Effectiveness and Permanence

The no action alternative will not affect the levels of PCBs/PAHs in the soil. Contamination will remain on site that presents an unacceptable risk. Alternative #P2, soil cover, could provide some long-term effectiveness provided that the cover is properly maintained. Alternative #P8, soil washing, offers some long-term effectiveness and permanence since it would remove contaminants from the soil. However, soil above the remediation goal may remain. Alternative #P9, thermal desorption, offers the highest degree of long-term effectiveness and permanence since the potential for residuals to be above the remediation goals is less than for Alternatives #P1, #P2 and #P8. All remedies would require five year reviews.

o Reduction in Toxicity, Mobility, or Volume

Both no action and soil cover do not use treatment to reduce toxicity, mobility or volume of contamination in the soil. Thermal desorption permanently reduces toxicity, mobility and volume of the contaminants. Thermal desorption is more likely to remove a greater portion of contaminants than soil washing, leaving less residual contamination in the soil.

o Short-Term Effectiveness

The no action alternative would have no short-term effects. However, current conditions of the site pose an unacceptable level of risk, and no action would not reduce this risk. Alternatives #P2, P8 and P9 share similar short-term effects. The potential short-term risks to human health and the environment are anticipated to be low for each of these alternatives. Specifically, workers implementing any of the three alternatives could be exposed to contamination, but this can be controlled by utilizing proper worker safety methods. All three alternatives may have short-term impacts on soil erosion and wetlands. However, the extent of this effect can be mitigated by compliance with appropriate requirements.

o Implementability

All alternatives discussed concerning PCB/PAH-contaminated soils are implementable. The no action alternative could be easily implemented. Alternative #P2, soil cover, utilizes common construction procedures which are also easily implementable. Although meeting soil erosion requirements would be simpler for Alternative #P2, they are readily achievable for Alternatives P8 and P9. Alternative #P8, soil washing, is an innovative technology. This technology involves a complex treatment and verification monitoring process. Both alternatives P8, and P9 are implementable. However treatability studies show that actual field conditions could warrant the washing of soils multiple times to meet the required soil cleanup levels due to the clay and organic matter content of soils. Alternative #P9, thermal desorption, may also encounter operational difficulties but is more likely to achieve ther remediation goals with less reprocessing.

o Cost

The least expensive remedial alternative that addresses PCB/PAH-contaminated soils is alternative #P1, no action. Its present worth cost is approximately $40,000. Alternative #P2's present worth cost is $550,000. Alternative #P8's present worth cost is $8.3 M. Alternative #P9's present worth cost is $11.1 M o EPA Acceptance

The EPA concurs with the selected interim remedy specified on page 25.

o Community Acceptance

Based on comments received during the two public comment periods and the public meeting, the community supports the selected remedy. Public comments and responses are detailed in the responsiveness summary.

Evaluation of Combined Alternatives

The National Contingency Plan sets forth EPA's expectation for the use of treatment at superfund sites. The Agency seeks to treat principal threats, while containment of low level threats is permissible. Examples of principal threats include source materials that are considered highly toxic or highly mobile that generally cannot be reliably contained. Low level threats are materials that can be reliably contained and would present only a low risk in the event of a release. The above section evaluated individual remedial alternatives. However, while evaluating the remedial alternatives for PCB/PAH-contaminated soil, it became apparent that a combination of PCB/PAH alternatives could provide adequate protection of human health while significantly reducing the overall cost of remediation. Specifically, treatment of principal threats and capping of low level threats (i.e., soils containing PCB contamination below 25 ppm) was considered. An analysis of these combinations of alternatives did demonstrate that such a combination can be protective of human health and the environment while decreasing remediation costs by as much as 50 percent. As an example, a combination of thermal desorption and soil cover is protective of human health and the environment; complies with ARARs; provides long-term effectiveness and permanence; reduces toxicity, mobility and volume through treatment; increases implementability, and decreases cost. The cost of the combined remedy, which reduces the volume of soil to be treated and increases the area of soil to be covered is 5.6 M compared to 11.1 M , which would involve treating PCB contaminated soils to 2ppm.

VOC-contaminated Soils

Following is the analysis for remediating **VOC-contaminated soils.**

o Overall Protection of Human Health and the Environment

VOCs are present in the soil above the health based levels. Alternative #V1, the no action alternative, would not reduce levels of VOCs in the soil and does not provide protection of human health and the environment because contaminants will continue to leach to ground water. Alternative #V4, bioremediation, may have some difficulty achieving cleanup goals due to its innovative nature. Alternatives #V7, soil washing, and #V8, thermal desorption, are capable of meeting remediation goals for VOCs. Alternative #V9, *ex situ* vapor extraction, also should achieve remediation goals.

o <u>Compliance with ARARs</u>

The No Action alternative would not comply with the remediation goal for the site. Alternatives V4,V7,V8, and V9 would have to meet applicable wetlands and soil erosion requirements. Alternatives V4,V8, and V9 will meet air emission requirements.

o <u>Long-Term Effectiveness and Permanence</u>

Alternative #V1, no action, will not affect the levels of VOCs in the soil and will not be effective in the long-term. Alternative #V4, bioremediation, will convert VOCs to carbon dioxide and water, permanently destroying the contaminants. Alternatives V7,V8, and V9 will remove VOCs from the soil. The separated VOCs can then be destroyed. With respect to the treatment alternatives, thermal desorption is a permanent and effective technology since it results in destruction of contaminants. Soil washing and biological treatment have the potential to permanently remediate the soils; however some uncertainties exist regarding the effectiveness with which these innovative technologies could remove contaminants from the soil at this site.

o <u>Reduction in Toxicity, Mobility, or Volume</u>

Alternative #V1, no action, does not utilize treatment to reduce the toxicity, mobility, or volume of VOCs in soil. Bioremediation, alternative #V4, will reduce toxicity, mobility and volume, however, the extent of reduction may be insufficient to meet the cleanup goal at the site. Alternatives V7,V8, and V9 reduce toxicity, mobility and volume by removing the VOCs from the soil allowing for their destruction. Alternative #V9, thermal desorption, provides the highest efficiency of removal of contaminants from the soil.

o <u>Short-Term Effectiveness</u>

No action will result in no change to current site conditions. All other alternatives may have to consider short-term effects on soil erosion and wetlands. Also, during implementation of all the alternatives, workers will be required to have proper training and equipment to prevent short-term exposure to VOCs.

o <u>Implementability</u>

The No Action Alternative does not pose an implementation problem, since no activities would be conducted. Both soil washing and thermal desorption are implementable. Thermal desorption would be more easily implemented since it employs fewer steps in its process when compared to soil washing. Soil washing involves a more complex treatment and verification monitoring process. Soils conditions at the UOP (i.e. high clay and organic matter content) could warrant the washing of soils multiple times to meet the required soil cleanup levels. Processing equipment for soil washing must be custom designed according to unique site specifications, whereas thermal desorption units and equipment are readily available for immediate use. For example, thermal units are commonly used for treating soils contaminated with gasoline associated with leaking underground storage tanks. The contaminants associated with these tanks are very similar to those found at UOP. Therefore, the thermal desorption alternative is more easily implemented than soil washing. Sampling of treated soil is necessary for both alternatives, however, the sampling requirements for soil washing are more extensive due to the use of solvents in the treatment process. Biological treatment has the potential to remediate the soils; however some uncertainties exist regarding its implementability at this site. Since bioremediation relies on the activity of naturally occurring or augmented populations of bacteria, it is necessary to maintain a strict environment for optimum performance. Such conditions may be difficult to maintain at the site. Alternative #V9, *ex situ* vapor extraction would be fairly easy to implement. The most difficult task with Alternative #V9 would be the capture of fugitive VOC emissions. However, this can be addressed fairly easily by containing the remediation system in some type of structure.

o Cost

The No Action alternative has a present worth cost of $40,000. Alternative #V4, bioremediation, has a present worth cost of $2.2 M. The present worth cost of Alternative #V7, soil washing, is $4.0 M. The present worth cost of Alternative #V8, thermal desorption is $5.1 M. The present worth cost of Alternative #V9, ex situ vapor extraction is $1.9 M. However, the costs of Alternatives V7 and V8 are much lower when implemented in conjunction with PCB/PAH treatment due to the single set of start-up costs associated with using the same remedial technology on different areas of the site. The cost associated with alternative #V9 when it is also utilized for PCB/PAH treatment is $1 M. The cost of alternative #V8 when it is also utilized for PCB/PAH treatment is $2 M.

o EPA Acceptance

The EPA concurs with the selected interim remedy specified on page 26.

o Community Acceptance

Based on comments received during the two public comment periods and the public meeting, the community supports the selected remedy. Public comments and responses are detailed in the responsiveness summary.

Lead-contaminated Soils

Following is the analysis for remediating **lead-contaminated soils.**

- o Overall Protection of Human Health and the Environment

Alternative #L1, no action, would not be protective of human health due to the presence of lead concentrations greater than those deemed acceptable by the EPA and NJDEPE. Alternative #L2, soil cover, would protect human health by preventing contact with lead at levels greater than the cleanup goal developed for the site. Alternative #L3, capping the contaminated area, prevents contact with contaminated soil. However, capping would require the permanent destruction of some wetlands. #L2 and #L3 require maintenance to perform adequately. Alternative #L6, solidification, provides protection of human health by preventing contact with lead-contaminated soil by placing the soil in a concrete-like matrix. Solidification would also require the permanent destruction of some wetlands. Alternative #L7 would remove all contaminated soils above the remediation objective. However, this alternative may have a significant effect on wetlands during implementation. All alternatives would require a five year review.

- o Compliance with ARARs

No action does not meet the remediation goal for the site. All action alternatives should meet the remediation goals for the site. All action alternatives would have to meet wetlands and soil erosion requirements.

- o Long-Term Effectiveness and Permanence

No action provides no long-term effectiveness and permanence. All other alternatives leave contaminants on-site, therefore requiring a five year review. If properly maintained all action alternatives should provide long-term effectiveness. Alternative #L2, soil cover, will remain effective, if properly maintained, by preventing contact with lead-contaminated soils. Alternative #L3, capping, prevents contact with contaminated soils, and, in addition, would mitigate the leaching of lead to ground water. For Alternative #L3, proper maintenance would be required to achieve this. Alternative #L7, excavation and off-site disposal, provides long-term effectiveness by removing all soils present on-site above the remediation goal. Due to the isolated and industrial nature of the area institutional controls should be fairly easy to implement and maintain.

- o Reduction in Toxicity, Mobility, or Volume

No action provides no reduction in toxicity, mobility or volume of contaminants. Alternatives #L2 and #L3 do not utilize treatment to reduce toxicity, mobility or volume. Alternative #L6 reduces mobility by placing lead in this solid matrix, but increases the total volume of material. Alternative #L7 does not utilize treatment to reduce toxicity, mobility, or volume.

- o <u>Short-Term Effectiveness</u>

No action does not provide short-term effectiveness due to the presence of lead above remediation goals at the site. All action alternatives will have to utilize proper worker safety procedures, and soil erosion and wetlands mitigation procedures to minimize any short-term impacts.

- o <u>Implementability</u>

All alternatives discussed concerning lead-contaminated soil are implementable. No action would be the simplest to implement. Soil cover would be the next simplest to implement. Action alternatives will have to meet wetlands and soil erosion requirements during implementation. Due to the nature of the area, a former municipal fill area which is now covered with well developed trees, implementing capping, solidification, and excavation alternatives may prove difficult due to limited access to the area. To gain access for the heavy equipment that would be required to implement this alternative, it would be necessary to destroy a large portion of the site's trees. Due to the industrial history of the site, the placement of use restrictions should be easy to implement.

- o <u>Cost</u>

The present worth value of the no action alternative is $40,000. Alternative #L2's present worth cost is $230,000. The present worth cost of capping, alternative #L3, is $645,000. The present worth cost of solidification is $2.9 M. The present worth cost of Alternative #L7 is $10.3 M.

- o <u>EPA Acceptance</u>

The EPA concurs with the selected interim remedy specified on page 26.

- o <u>Community Acceptance</u>

Based on comments received during the two public comment periods and the public meeting, the community supports the selected remedy. Public comments and responses are detailed in the responsiveness summary.

VOC-contaminated Leachate

Following is the analysis for remediating **VOC-contaminated leachate.**

o Overall Protection of Human Health and the Environment

No action would not reduce VOCs in the leachate to concentration levels that are protective of human health and the environment. Alternative #LEACHATE2 will achieve levels that are protective of human health and the environment by collecting leachate and treating the contaminated leachate. Final analysis if further remediation is needed to protect ground water and surface water will occur in the future.

o Compliance with ARARs

No action would not meet remediation goals for the site. Alternative #LEAC-HATE2 will meet the guidance, soil erosion and wetlands requirements, and ground water treatment and discharge requirements.

o Long-Term Effectiveness and Permanence

Alternative #LEACHATE1 provides no long-term effectiveness and permanence. Alternative #LEACHATE2 will permanently remove VOC leachate and will prevent leachate from entering the ground water.

o Reduction in Toxicity, Mobility, or Volume

No action will not reduce toxicity, mobility, or volume of VOCs in the ground water. Alternative #LEACHATE2 will reduce toxicity, mobility and volume by removing and treating VOCs in the leachate.

o Short-Term Effectiveness

No action is not effective in the short term due to the presence of VOCs above the remediation goal. Mitigation measures for soil erosion and wetlands may be necessary to minimize short-term effects for Alternative #LEACHATE2.

o Implementability

The no action alternative would be very easy to implement. Alternative #LEACHATE2 should be fairly simple to implement. It is expected that this will be fairly easy to implement because it utilizes standard technologies such as excavation and conventional treatment technologies. It would be required that all substantive permits requirements, such as discharge limits to groundwater, be met to proceed with this remedy.

o Cost

The present worth cost of no action is $100,000. The present worth cost of Alternative #LEACHATE2 is $1.4 M.

o EPA Acceptance

The EPA concurs with the selected interim remedy specified on page 26.

o Community Acceptance

Based on comments received during the two public comment periods and the public meeting, the community supports the selected remedy. Public comments and responses are detailed in the responsiveness summary.

9. Selected Remedy

For PCB/PAH-contaminated soils, the selected remedy is a combination of Alternatives #P2 and #P9:

- Thermal desorption for highly contaminated soils
- Soil cover for less contaminated soil
- Institutional controls.

Some TSCA equivalent levels will not be met in certain areas of the site. Soil cover will be placed over these areas containing residual contamination. Highly contaminated soils is defined as those soils with a PCB concentration greater than 25 mg/kg and total carcinogenic PAHs greater than 29 mg/kg. Treatment of these soils will reduce PCB concentrations to <10 ppm and carcinogenic PAHs <20 ppm. Remaining soils and treatment residuals that exceed the remediation goals will be placed under a two foot soil cover and be subject to deed restrictions on that portion of the site. It is the responsiblity of the state to ensure that the owner is aware of the deed restrictions. Figure 10 shows the PCB/PAH remediation area.

The selected remedy will excavate and treat approximately 6,800 yd^3 of contaminated soil and require a soil cover area of approximately 4.9 acres. The cost of the combined remedy is $5.6 million.

For VOC-contaminated soil, the selected remedy is Alternative #V8:

- Thermal Desorption

The cleanup goal for VOCs in soil is 1000 ppm. The selected remedy will excavate and treat approximately 7,200 yd^3 of soil at a cost of $2 M. The approximate area affected by this remediation is shown on Figure 11. In addition to the VOC-contaminated soil, this treatment will be utilized to treat contaminated sediment associated with the site sewer systems.

For lead-contaminated soils, a combination of Alternatives #L2 and #L3 was selected:

- Soil cover/impermeable cap
- Institutional controls.

The cleanup goal of 600 ppm is based on NJDEPE and EPA guidance. The lead contaminated soils will undergo toxicity characteristic leaching procedure (TCLP) testing to determine whether lead exhibits the characteristic of toxicity at the UOP site. Approximately 3.7 acres will be covered by a soil cover/impermeable cap. Figure 12 illustrates the location of soils above the remediation goal. The purpose of the soil cover/cap is to construct an low permeability layer to prevent surface water/stormwater infiltration through lead-contaminated material. Also, the cover/cap will be designed to prevent surficial contact with the contaminated material. The cap shall have a permeability equal to or less than 1×10^{-7} cm/sec. Institutional controls will be placed on the property through the use of deed restrictions. The present worth of this alternative is $550,000. This cost represents the cost of combining alternatives #L2 and #L3.

For VOC-contaminated leachate, Alternative #LEACHATE2 was selected:

- Leachate collection from trenches/pits
- On-site leachate treatment
- Discharge to ground water

The area of leachate removal is defined as 1 ppm individual VOC/10 ppm total VOCs. This area is illustrated in Figure 13. This removal is designed to protect Ackerman's Creek from the discharge of contaminated leachate. Implementation time of this portion of the remedy would be approximately 27 months. Implementation time includes remedial design, construction and operation periods. The system would operate for approximately four of those months. Upon completion of this portion of the remedy, it will be necessary to evaluate if this remedy removed levels of organic contamination that is protective of ground water and surface water. This evaluation should determine if contaminant mass reduction from the leachate removal was sufficient to protect the surface water quality of Ackerman's Creek. If it is not, further ground water remedial work would be required. It is estimated that this alternative will require the treatment of 5.6 million gallons of leachate. The present worth cost of this portion of the selected remedy is $1.3 million.

10. Statutory Determinations

Protection of Human Health and the Environment.

The selected remedy is protective of human health and the environment. Soils contaminated with high levels of PCBs and PAHs will be treated by thermal desorption. Soils contaminated with lower levels of PCBs and PAHs will be contained by a soil cover and controlled by institutional controls. This combination removes high level contamination and prevents exposure to low level contamination. For VOC-contaminated soils, soils above the cleanup goal will be treated by thermal desorption. Soils contaminated with lead will be contained by a soil cover/cap and controlled by institutional controls preventing contact with surficial contamination and the potential leaching of lead to ground water. VOC-contaminated leachate will be collected and treated.

This selected remedy will reduce contamination at the UOP site to within acceptable levels. An evaluation of the protectiveness of the leachate remedy to ground water and surface water will have to be conducted after completion of this remedy. Although some short-term risk is associated with these actions, proper mitigation procedures will keep short-term risks within an acceptable level.

Compliance with Applicable or Relevant and Appropriate Requirements.

The selected remedy will comply with federal and state Applicable or Relevant and Appropriate Requirements (ARARs) except the chemical waste landfill requirements which EPA is waiving in this ROD for the UOP site. These include:

Action Specific

- New Jersey Pollutant Discharge Elimination System (NJPDES)
  - Discharge to Ground Water Permit, N.J.A.C. 2.1 *et seq.* and 6.1 *et seq.*

- Permit to Construct/Install/Alter Air Quality Control Apparatus/Equipment, N.J.A.C. 7:27-8 *et seq.*

- National Ambient Air Quality Standards, 40 CFR Part 50 of the Clean Air Act

- Soil Erosion and Sediment Control Plan Certification, N.J.A.C. 2:90

Location Specific

- Section 404 and Executive Order 11990 require impacts to wetlands be avoided or minimized.

- Stream Encroachment, N.J.A.C. 7:8-3.15 *et seq.*

- Freshwater Wetlands Protection Act, N.J.A.C. 7:7A

- Hackensack Meadowlands Development Commission, N.J.S.A 13:17-1 *et seq.*

- Executive Order 11988 requires that a floodplains assessment must be completed for the site, including a mitigation plan. Additionally, since actions at CERCLA sites are considered "critical actions", the floodplain delineation/assessment must include consideration of the project's impacts on the 500-year floodplain.

- Coastal Zone Management Act 16 USC 1451

Chemical Specific

- New Jersey Soil Quality Criteria - The soil quality criteria are a To Be Considered. The soil quality criteria are risk based numbers designed to provide protection to human health and the environment.

The Toxic Substances Control Act (TSCA) is a federal law that regulates the disposal of PCBs. In general, depending on the nature of the PCB containing material and the PCB concentration in the material, TSCA may require incineration or disposal in a chemical waste landfill approved for PCB disposal. PCBs that are required to be incinerated may also be disposed of by an approved alternative method that provides PCB destruction equivalent to incineration. The TSCA regulations are applicable to the disposal of the soils once they have been excavated during cleanup.

TSCA regulations require that treatment of the soils must be equivalent to incineration and must therefore reduce PCBs to concentrations no greater than 2 ppm after treatment. Unless treatment of PCB contaminated soils reduces PCB concentrations to levels below 2 ppm, the residual from the treatment process will be disposed of in an on-site TSCA chemical waste landfill. EPA "Guidance on Remedial Actions for Superfund Sites with PCB Contamination" (OSWER Directive 9355.4-01, August 1990) allows the TSCA landfill requirements to be waived at Superfund Sites in the ROD provided that: there are low PCB concentrations; a protective cover system is designed and installed and PCB migration to groundwater and surface water is evaluated. Under an industrial use scenario, EPA considers 10 - 25 ppm of PCBs to be protective. This ROD is requiring the placement of a soil cover over the residual soils from the treatment system (i.e., soils with concentrations less than 10 ppm). The soil cover will prevent treated soils from becoming airborne and erosion of treated soils (including erosion into surface water). With respect to PCB migration to groundwater, the Directive states that generally, PCB concentrations that are protective of human health via direct contact exposure would be protective of the groundwater. Additionally, since the landfilled materials are residuals from a thermal treatment process, contaminants that might enhance PCB migration (e.g., volatile organics) would be driven off. As a result, EPA is waiving TSCA chemical waste landfill requirements at the UOP site for this ROD since the residuals (i.e., PCB levels less than 10 ppm) from the treatment process for this selected remedy do not present an unreasonable risk of injury to health or the environment from PCBs.

Cost-Effectiveness.

The combination of alternatives selected for this remedial action is cost effective and provides for the protection of human health and the environment. Two factors greatly increased the cost effectiveness of the selected remedy. First, the selection of the same technology for treating PCB/PAH-contaminated soils and VOC-contaminated soils greatly reduces the overall cost of the remediation. By utilizing one technology, only one set of start-up costs will be realized and the greater volume of material will help decrease unit costs. Also, the use of a combined alternative for treating PCB/PAH-contaminated soils will reduce the overall cost while still providing protectiveness.

Utilization of Permanent Solutions and Alternative Treatment (or resource recovery) Technologies to the Maximum Extent Practicable (MEP).

The selected remedy meets the statutory requirements to utilize permanent solutions and alternative treatment technologies to the maximum extent practical. Alternative treatment technologies will be utilized for PCB/PAH-contaminated soil, VOC-contaminated soil, and VOC-contaminated leachate. Due to the location, the lack of identifiable source areas, and the heterogenetic physical characteristics of the contaminated material, treatment alternatives were not practical for the lead-contaminated soil so, therefore, a containment alternative will be utilized.

For PCB/PAH-contaminated soils, Alternative #P9, thermal desorption, provides the most long-term effectiveness and permanence by treating the contaminated soils. Alternative #P8, soil washing, also provides long-term effectiveness and permanence by treating the contaminated soils. However, it is questionable whether soil washing can remove as great a level of contaminants as thermal desorption. Alternative #P2, soil cover does not remove any of the PCB/PAH contamination from the soil. However, if the soil cover is properly maintained over time, it should provide some long-term effectiveness. No action provides no long term effectiveness or permanence. The combination of Alternative #P9 and #P2 provides long-term effectiveness and permanence by treating the highly contaminated soils, but will require long-term maintenance of the soil cover to insure long-term effectiveness of the soil cover over less contaminated soils.

For VOC-contaminated soils, Alternative #V8, thermal desorption will provide long-term effectiveness and permanence by removing the VOC contamination from the soil. Alternative #V9, *ex situ* vapor extraction, would provide long-term effectiveness and permanence by removing the VOC contamination from the soil. Alternatives #V4 and #V8, bioremediation and soil washing, if implemented successfully, would also permanently remove VOCs from contaminated soils. However, some uncertainty does exist concerning these technologies ability to fully treat the soils. No action provides no long-term effectiveness or permanence.

For lead-contaminated soils, Alternative #L7, off-site disposal, would provide long-term effectiveness and permanence by removing all soils above the remediation goal. Alternative #L3, capping of contaminated material, would provide long-term effectiveness and permanence by preventing contact with the contaminated soils and preventing the potential leaching of lead contamination to the underlying ground water. Maintenance of the cap would be required to insure this long-term effectiveness. Alternative #L6, solidification, would provide long-term effectiveness and permanence by placing lead-contaminated soils in a solid matrix. This matrix would prevent the potential leaching of lead to ground water. However, due the extremely heterogenic nature of soils at the site, it is questionable whether such a matrix could provide long-term stability. Alternative #L2, soil cover would provide long-term effectiveness by preventing contact with contaminated soils. No action would provide no long-term effectiveness or permanence. A combination of alternatives #L2 and #L3, a modified soil cover/cap should provide long-term effectiveness by preventing contact with contaminated material and limiting the potential leaching of lead-contaminated material to ground water. This limiting of leaching as compared to the prevention of leaching provided by alternative #L3 should be sufficiently protective based on the low leaching potential of the lead contaminated material at UOP as demonstrated by the results of leachability testing.

For VOC-contaminated leachate, Alternative #LEACHATE2 provides long-term effectiveness and permanence by removing and treating VOCs present in the leachate. The protectiveness of this action to ground water and surface water will be evaluated upon completion of this source removal action. No action provides no long-term effectiveness or permanence.

Alternative #P9, thermal desorption reduces the toxicity, mobility and volume of PCB/PAH-contaminated soils through treatment. Thermal desorption separates contaminants from soil allowing for the easy destruction of those contaminants. Treatability studies have demonstrated that thermal desorption can effectively treat site soils. Alternative #P8, soil washing, also treats PCB/PAH-contaminated soils to reduce toxicity, mobility, and volume. Soil washing uses an organic solvent to remove the contaminants. A treatability study performed with the soil washing technology showed that it may have some difficulty removing low levels of contaminants. Alternatives #P1, no action, and #P2, soil cover, do not utilize treatment to reduce toxicity, mobility, or volume. The combination of alternatives #P2 and #P9 retains the use of treatment to reduce toxicity, mobility and volume.

Alternatives #V8, thermal desorption, and #V9, *ex situ* vapor extraction, reduce toxicity, mobility and volume by treatment. Both these technologies separate VOC contamination from soil which allows for easy destruction of the contaminant of concern. Alternative #V4, bioremediation, and #V7, soil washing, can reduce toxicity, mobility, and volume by treatment if they work effectively. However, both these technologies are innovative and some question exists if they could reduce levels of contamination to acceptable levels. No action does not provide any treatment.

Alternative #L6, solidification, does provide treatment to lead-contaminated soil. This treatment would reduce mobility of the lead, however, it would increase the volume of lead contaminated material. No other alternative provides treatment to the lead contaminated soil. Alternative #L3, capping, would reduce mobility by preventing the leaching of lead-contaminated materials. The combination of alternatives #L2 and #L3 would reduce the mobility of lead-contaminated material but not through treatment.

VOC-contaminated leachate will be treated in Alternative #LEACHATE2 reducing the toxicity, mobility and volume of the contaminants. Alternative #LEACHATE1 provides no treatment.

No action for PCB/PAH-contaminated soils would have no short-term effects but current levels of PCBs and PAHs on site provide an unacceptable level of risk. All action alternatives for PCB/PAH-contaminated soils may have some short-term adverse effects. Many of these relate to the exposure of remediation workers to site contaminants which can be minimized by following proper health and safety requirements when implementing the project. The action alternatives also can have short-term effects on soil erosion and wetlands. These effects can be minimized by following the proper mitigation procedures that are applicable to this project.

Similar short-term effects are seen for VOC-contaminated soils, lead-contaminated soils, and VOC-contaminated leachate. Like the PCB/PAH-contaminated soil, adverse short-term effects can be mitigated by following applicable guidelines and regulations.

No action is the most easily implemented alternative for PCB/PAH-contaminated soil. Alternative #P2, soil cover, would be fairly easy to implement. Soil erosion prevention would have to be considered during implementation. Alternative #P9, thermal desorption, is a fairly complex, innovative technology and could have some operational difficulties. However, thermal desorption is a quickly developing technology whose use is becoming fairly common-place. Alternative #P8, soil washing, also is an innovative technology. Soil washing utilizes a very complex treatment train that could lead to difficulty in its implementation. A combination of alternatives #P2 and #P9 should be as easy to implement as either alternative by itself.

No action is the most easily implemented alternative for VOC-contaminated soils. Alternative #V9, *ex situ* vapor extraction would be fairly easy to implement. The most difficult task with Alternative #V9 would be the capture of fugitive VOC emissions.

However, this can be addressed fairly easily by containing the remediation system in some type of structure. Alternative #V8, thermal desorption, is a technology commonly used to treat contaminants similar to those found in the VOC-contaminated soil. Alternative #V7, soil washing, could be difficult to implement for VOC-contaminated soils for the same reason it is difficult to implement for PCB/PAH-contaminated soils. Alternative #V4, bioremediation, is an innovative technology that relies on the activity of microbes to degrade organic contaminants. The amount of biological activity is highly dependent on maintaining a highly controlled environment for the microbes to function. The difficulty in maintaining this environment leads to difficulty in properly implementing this technology.

Alternative #L1, no action, is the easiest alternative to implement. Soil cover would also be fairly easy to implement. This alternative would need to meet wetland and soil erosion requirements during implementation. Alternative #L3 would also be fairly easy to implement and also would have to meet wetlands and soil erosion requirements. Alternative #L7, excavation and off-site disposal would be relatively easy to implement. In addition to the soil erosion and wetlands questions like that of alternatives #L2 and #L3, this alternative would have to consider the logistical questions related to the large number of trucks that would be required to implement this alternative. A combination of alternatives #L2 and #L3 should be no more difficult to implement than either of the individual alternatives.

The present worth cost of Alternative #P1 is $40,000. The present worth cost of Alternative #P2 is $550,000. Alternative #P8's present worth cost is $8.3 M. Alternative #P9's present worth cost is $11.1 M. The combined alternative of #P2 and #P9 has a present worth cost of $5.6 M.

The present worth of Alternative #V1 is $40,000. Alternative #V9, *ex situ* vapor extraction, has a present worth cost of $1.9 M. Alternative #V4, bioremediation, has a present worth cost of $2.2 M. The present worth cost of Alternative #V7, soil washing, is $4.0 M. The present worth cost of Alternative #V8, thermal desorption, is $5.1 M. If alternative #P9 is selected for treating PCB/PAH-contaminated soils, the cost of Alternative #V8 is reduced to $2 M.

All these criteria played some role in determining which alternatives were selected. For the selection of the combination of Alternative #P2 and Alternative #P9, cost played a very significant factor. It was determined that great cost saving could be realized using a combined alternative while still providing an ample margin of protectiveness, still utilize treatment, and be fairly easy to implement. For VOC-contaminated soil, cost also played a critical role. By selecting Alternative #V8, thermal desorption, the same technology selected for PCB/PAH contaminated soils, tremendous cost savings were realized while still providing protectiveness, treatment, and implementability. Long-term effectiveness provided the main thrust for selecting the combination of alternatives #L2 and #L3 for lead-contaminated soil. This combination was the remedy that appeared to have the greatest probability of providing long-term effectiveness and permanence. Like the selection of the lead alternative, long-term effectiveness and permanence was the main factor leading to the selection of Alternative #LEACHATE2.

The U.S. EPA played an important role in shaping the remedy presented here. Based on comments received from the EPA during the initial public comment period and during preparation of the second proposed plan several alterations were made to the selected remedy. The U.S. EPA concurs with the remedy selected in this ROD.

An opportunity for community involvement was provided in the remedy selection process detailed in this ROD. Comments received are addressed in the Responsiveness Summary.

Preference for Treatment as a Principal Element

The remedy selected in this ROD meets the statutory preference for treatment as a principle element. Treatment is utilized for several of the principal threats present at the site. Thermal desorption will be used to treat soils contaminated with high levels of PCBs and PAHs. Thermal desorption will also be used to treat soil contaminated with high levels of VOCs that act as a source of contamination to ground water and surface water. Also, treatment will be used for VOC-contaminated leachate that also acts as a source of contamination to ground water and surface water. Soil cover/capping, a containment remedy was the selected remedial alterative for lead-contaminated soil. A containment strategy was chosen over a treatment remedy because the cost associated with lead removal was high compared to the added risk reduction that would be achieved by this removal.

11. Documentation of Significant Changes

Several modification were made to the proposed plan that was issued in August 1992. These modifications were based on comments received from the U.S. EPA and discussions held between the NJDEPE and U.S. EPA. These modifications were all included in the proposed plan released on May 3, 1993. The modifications are as follows:

1. The remedy selected in this ROD is an interim remedy. Upon completion of the selected remedy, an evaluation will have to be performed to determine what final remedy will be selected for this operable unit of the site. This evaluation will determine if the VOC-contaminated soil treatment and leachate removal were sufficient to protect the surface water quality of Ackerman's Creek and ground water. If these actions were protective, no further action would be required. If these actions were not protective, further remedial actions pertaining to VOC-contaminated soil and ground water would be required.

2. The originally proposed plan included a ground water remedy. The second proposed plan and the ROD consider this remedy to be strictly for source areas/leachate. The need for a full ground water remedy will be determined upon completion of this source removal.

3. Notification that Toxic Substance and Control Act (TSCA) landfill requirements would be waived was explicitly stated in the second proposed plan.

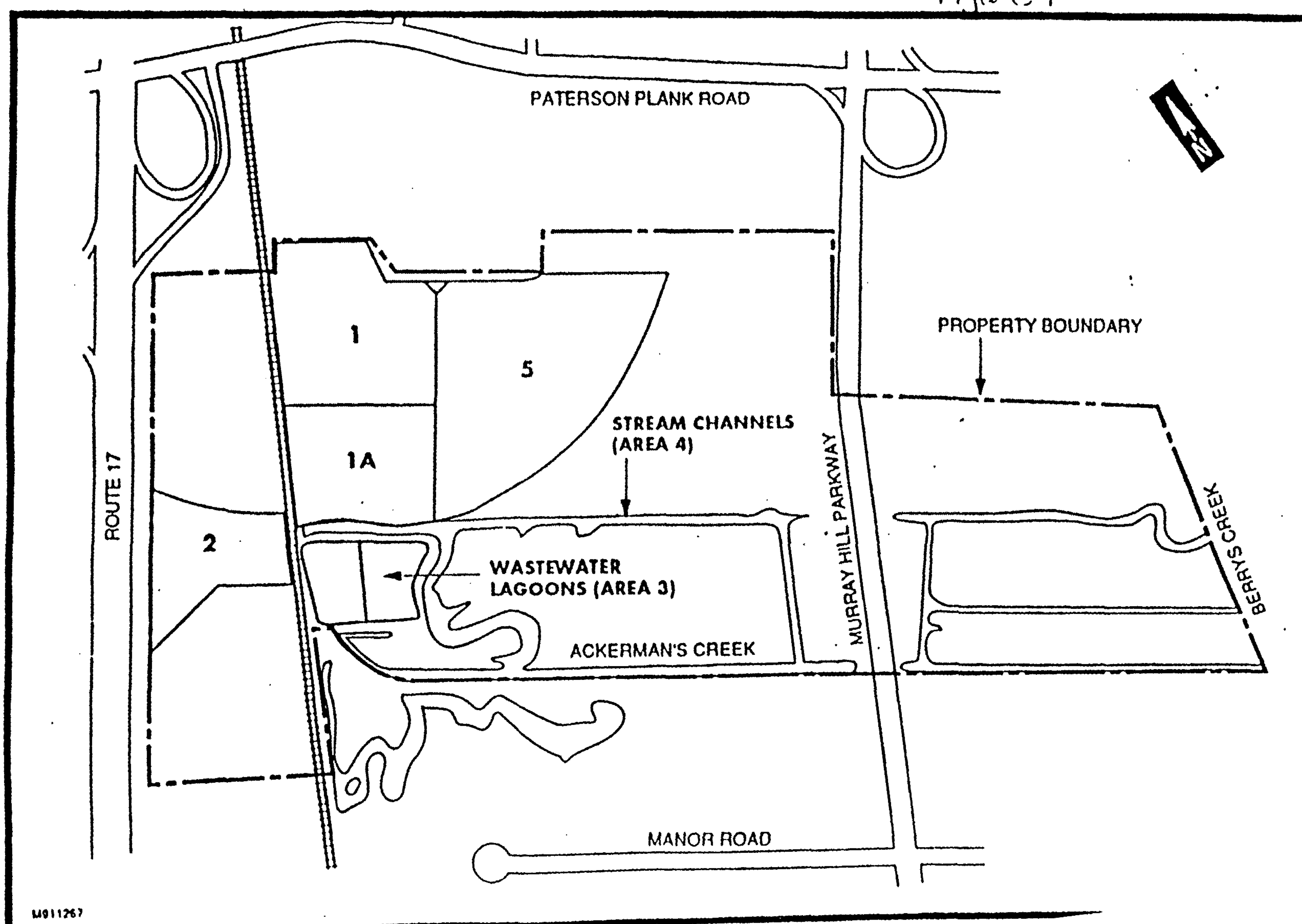
4. All lead-contaminated soil will be contained on-site. No lead-contaminated soil would be excavated and disposed off-site as included in the first proposed plan. It was determined that little added risk reduction would be achieved by this removal.

5. A risk-based remediation goal was established for 1,1,2,2-tetrachloroethane. This remediation level was developed by the U.S. EPA and was more stringent that the NJDEPE-developed cleanup goal.

Based on these changes, a second proposed plan was released to the public and a second public comment period was held. No public comments were received which warranted a change in the remedy presented in the second Proposed Plan.

Figure 1

ENSR



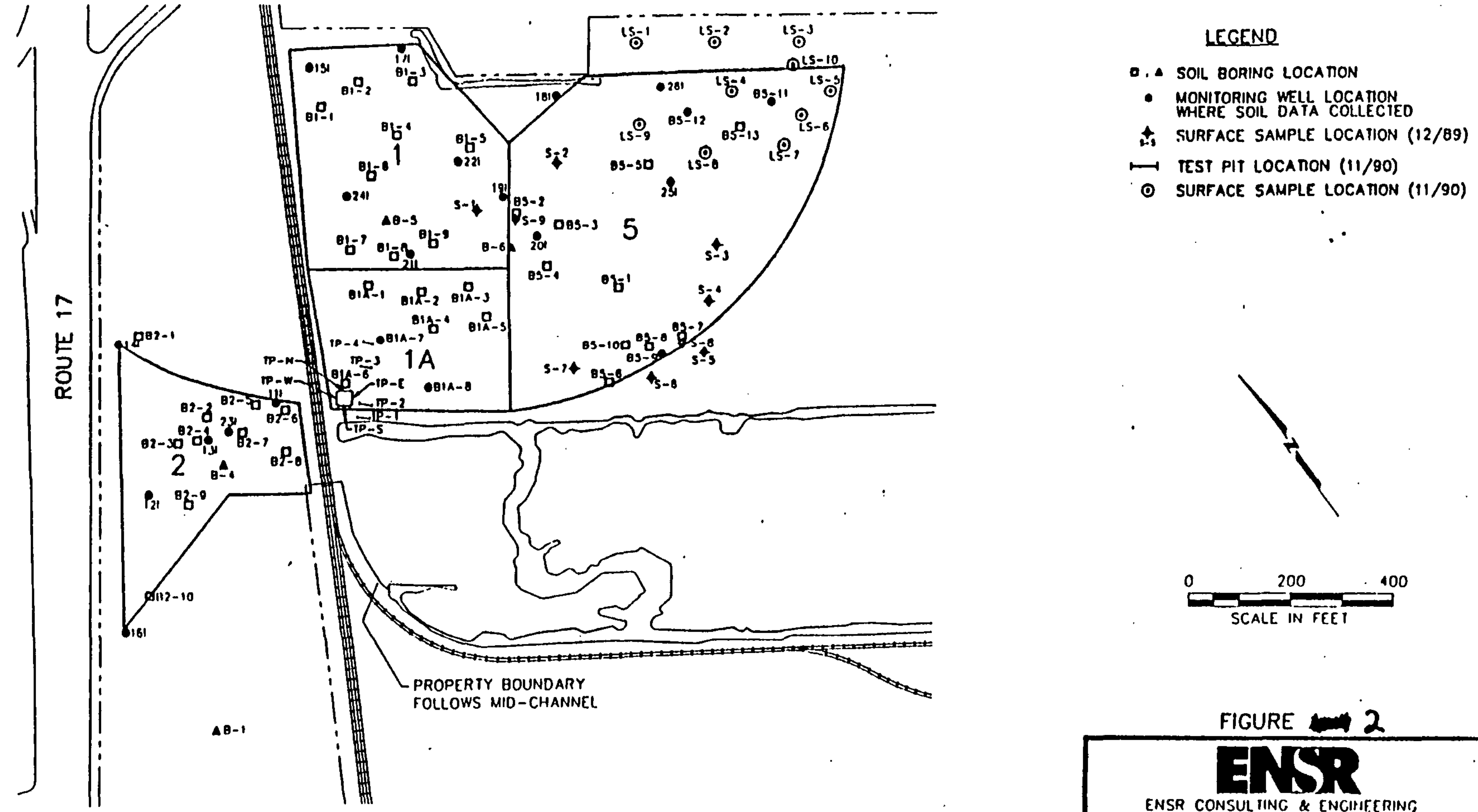


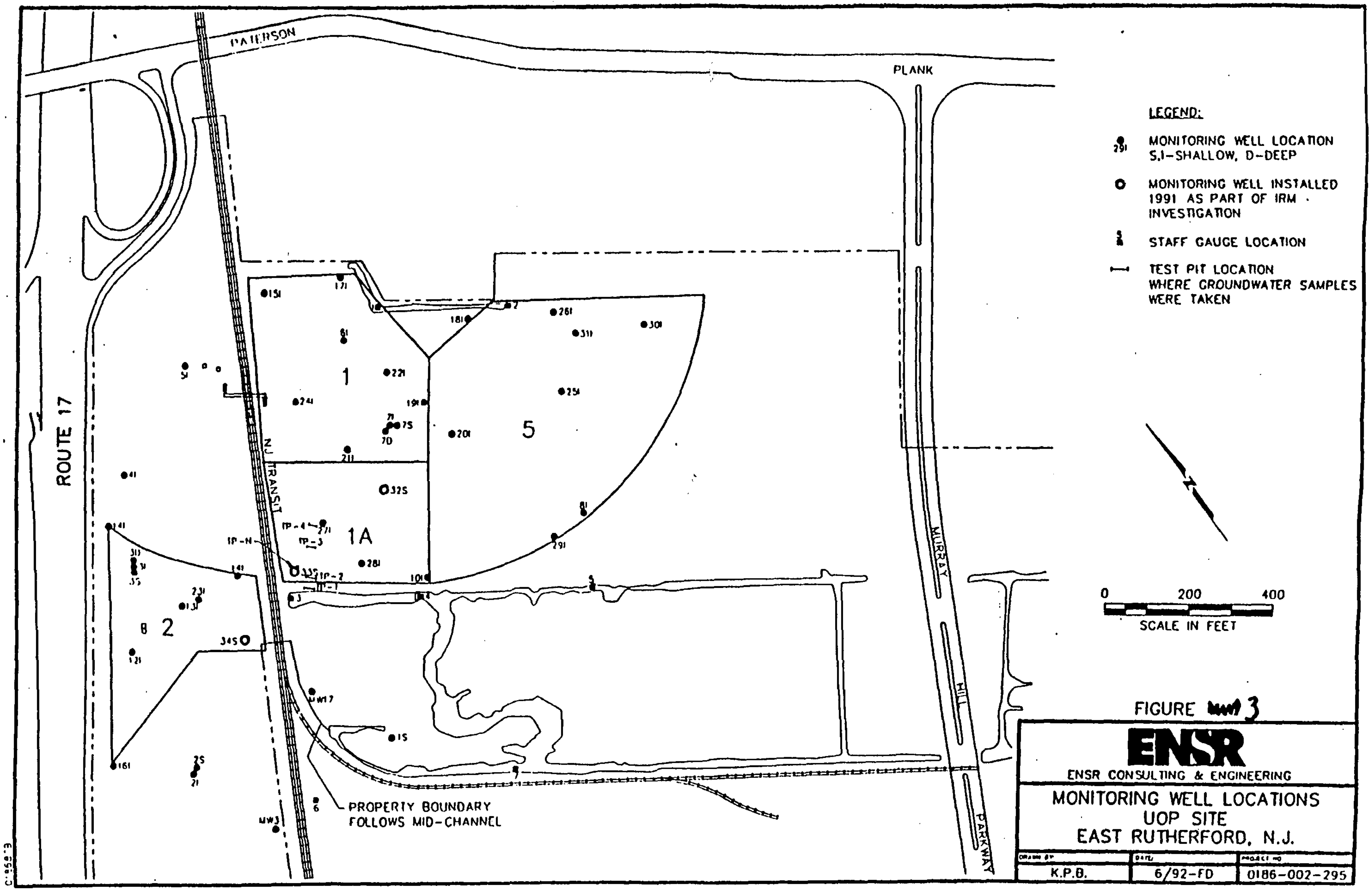
FIGURE 2

ENSR

ENSR CONSULTING & ENGINEERING

SOIL SAMPLE LOCATIONS
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY	DATE	PROJECT NO
J.E.B.	6/92-FD	0186-002-295


PATERSON
PLANK
ROUTE 17
NJ TRANSIT
MURRAY HILL PARKWAY
1
1A
2
5
PROPERTY BOUNDARY FOLLOWS MID-CHANNEL
LEGEND:
MONITORING WELL LOCATION S,I-SHALLOW, D-DEEP
MONITORING WELL INSTALLED 1991 AS PART OF IRM INVESTIGATION
STAFF GAUGE LOCATION
TEST PIT LOCATION WHERE GROUNDWATER SAMPLES WERE TAKEN
N
0
200
400
SCALE IN FEET
FIGURE 3
ENSR
ENSR CONSULTING & ENGINEERING
MONITORING WELL LOCATIONS
UOP SITE
EAST RUTHERFORD, N.J.
K.P.B.
6/92-FD
0186-002-295

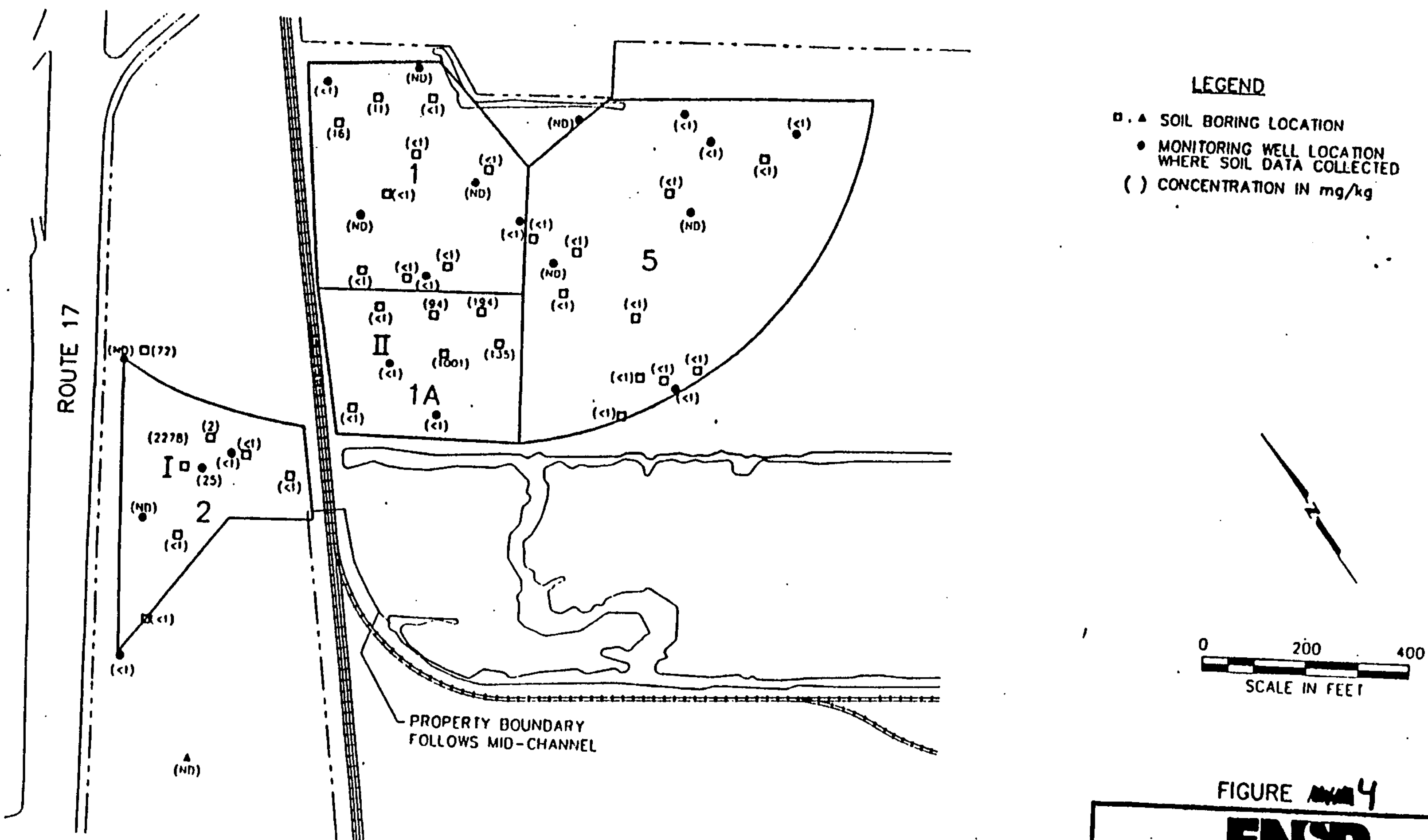


FIGURE 4

ENSR CONSULTING & ENGINEERING

CONCENTRATION OF TOTAL VOC IN SURFACE SOIL
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY	DATE	PROJECT NO
K.P.B.	6/92-FD	0186-002-295

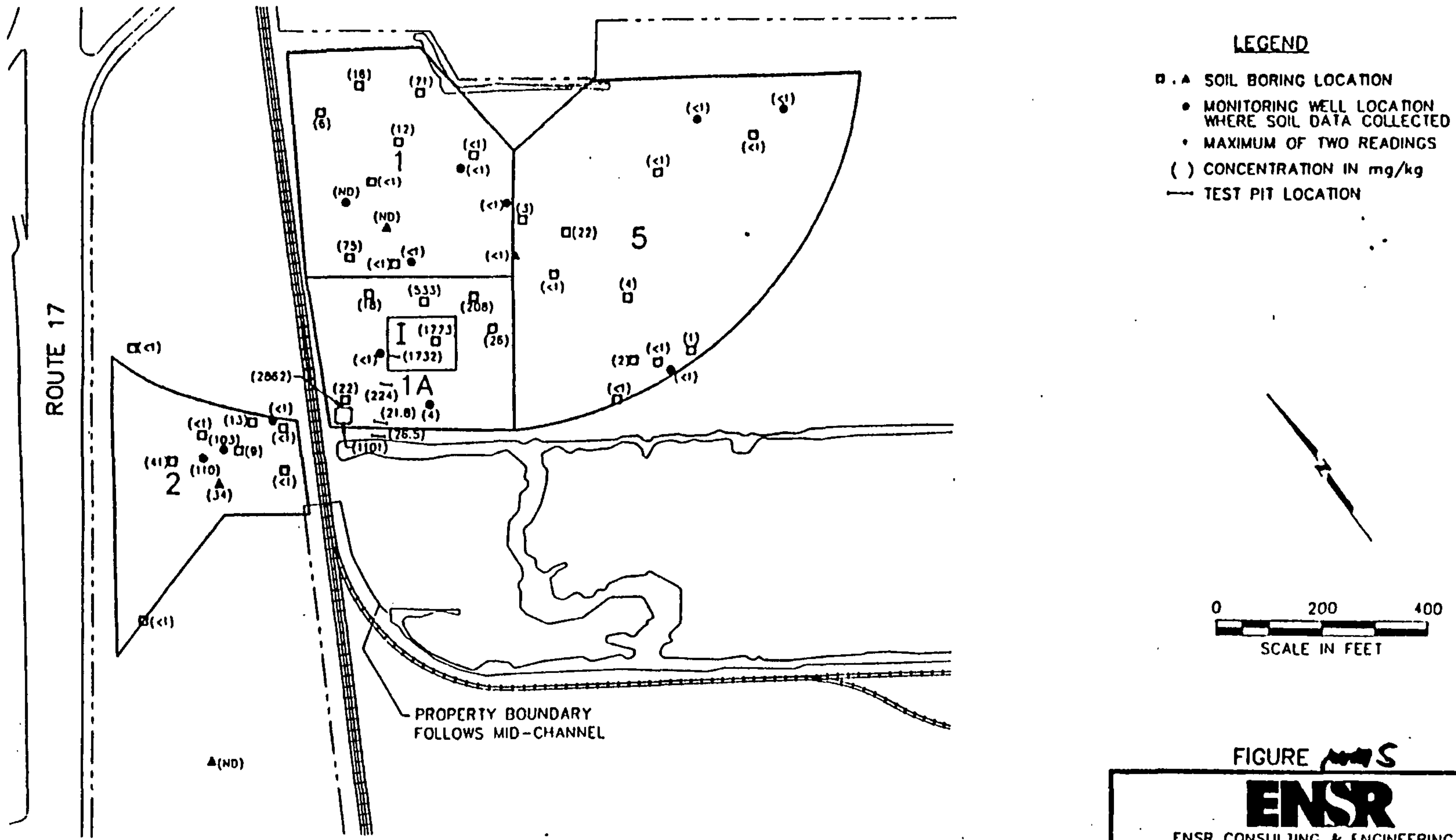


FIGURE 5

ENSR

ENSR CONSULTING & ENGINEERING

CONCENTRATION OF TOTAL VOC IN SUBSURFACE SOIL
UOP SITE
EAST RUTHERFORD, N.J.

K.P.B.	6/92-FD	0186-002-295

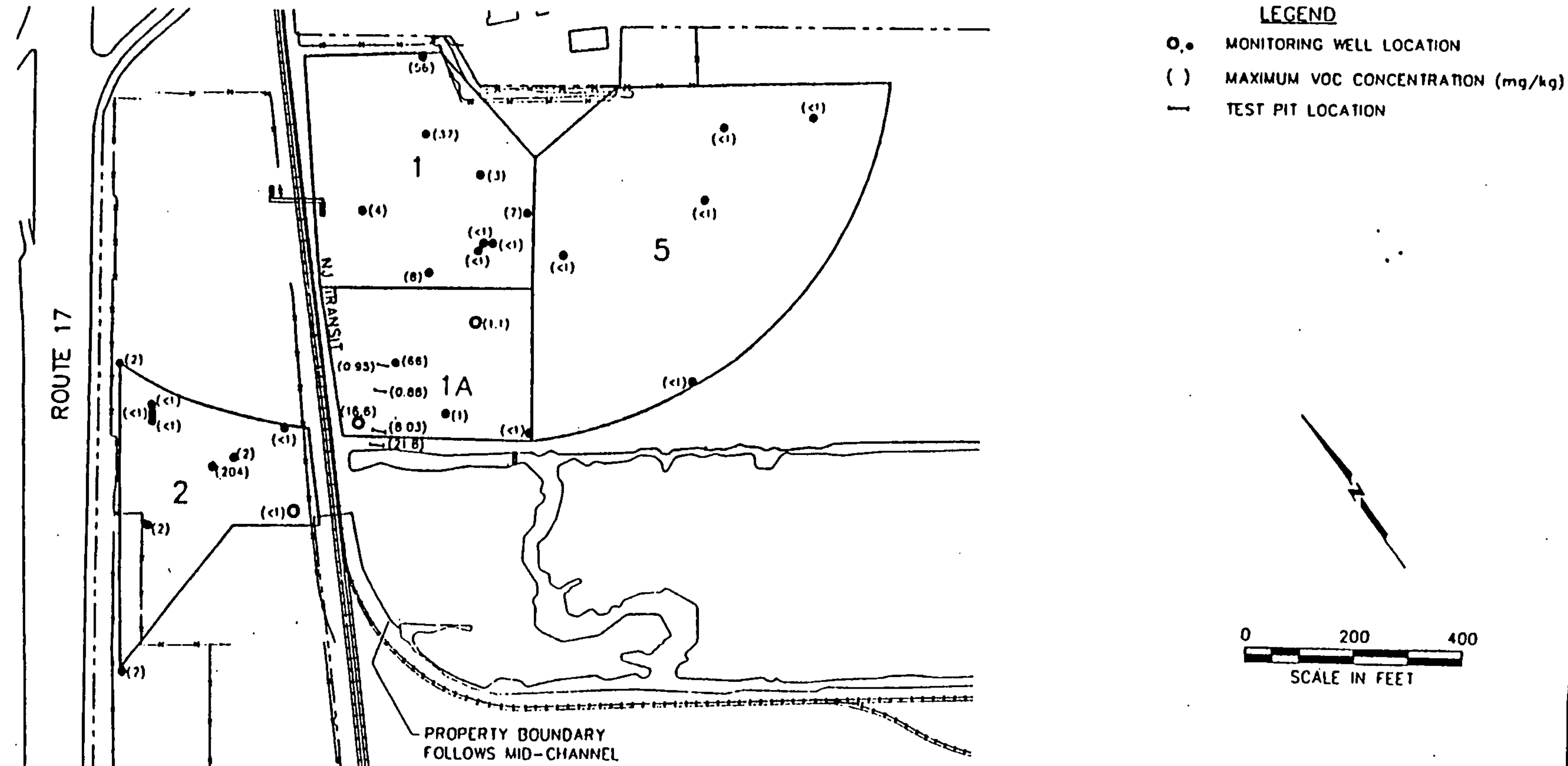


FIGURE 6

ENSR

ENSR CONSULTING & ENGINEERING

CONCENTRATIONS OF TOTAL VOCs
IN GROUNDWATER
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY	DATE	PROJECT NO.
J.E.B.	5/92	0186-002-295

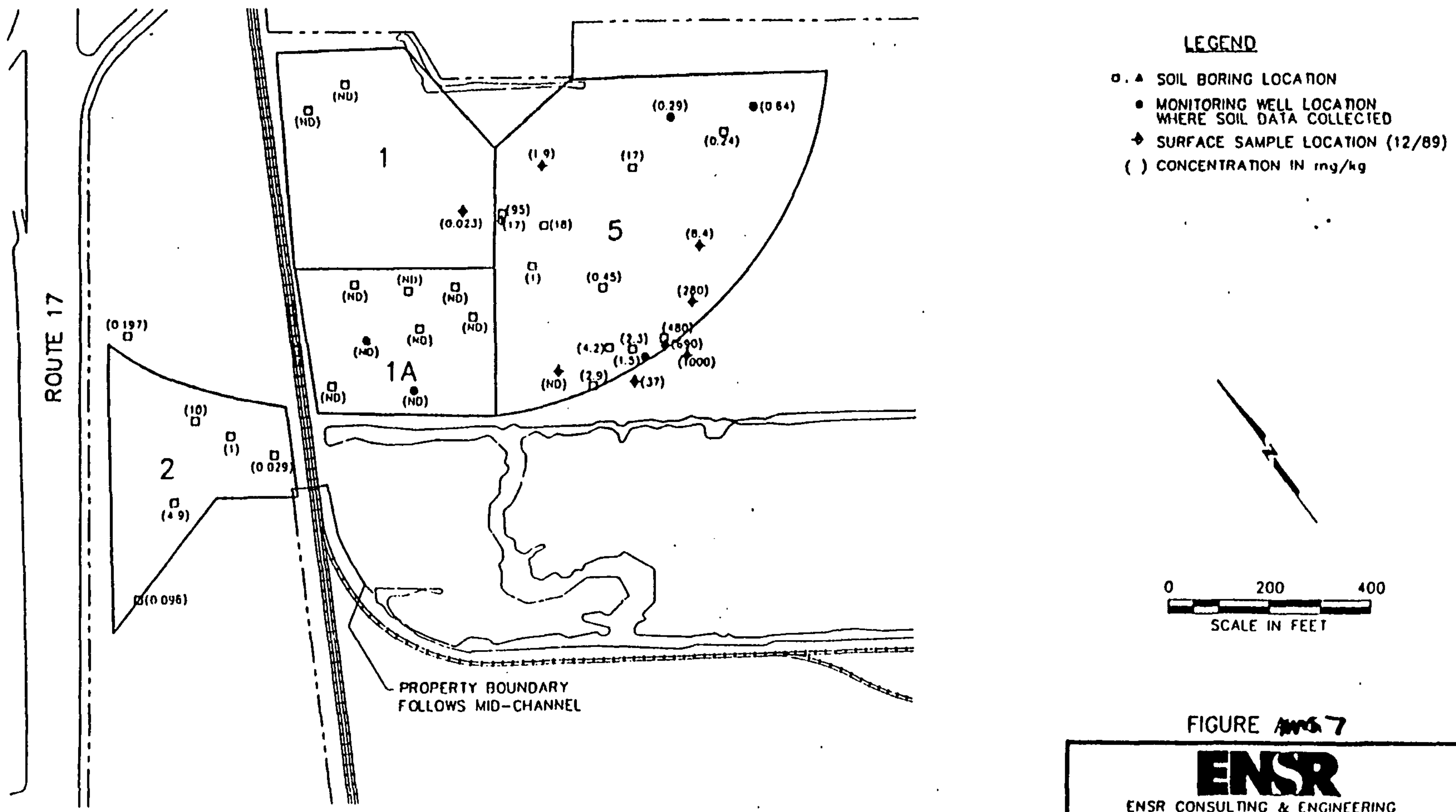


FIGURE 7

ENSR

ENSR CONSULTING & ENGINEERING

CONCENTRATION OF PCB IN SURFACE SOIL
UOP SITE
EAST RUTHERFORD, N.J.

J.E.B.	6/92-FD	0186-002-295

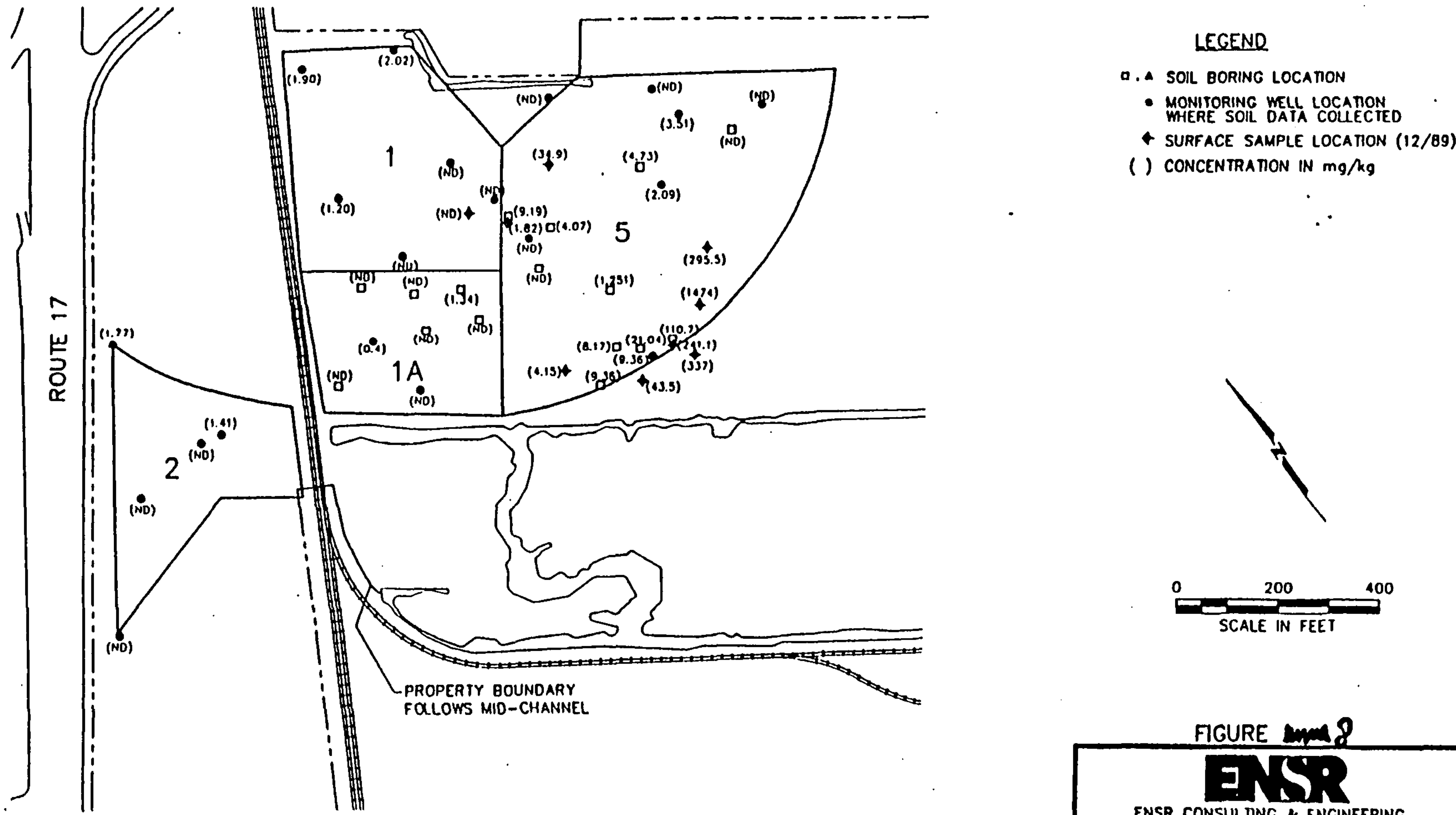


FIGURE 8

ENSR

ENSR CONSULTING & ENGINEERING

CONCENTRATION OF TOTAL CARCINOGENIC PAH IN SURFACE SOIL
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY	DATE	PROJECT NO.
J.E.B.	6/92-FD	0186-002-295

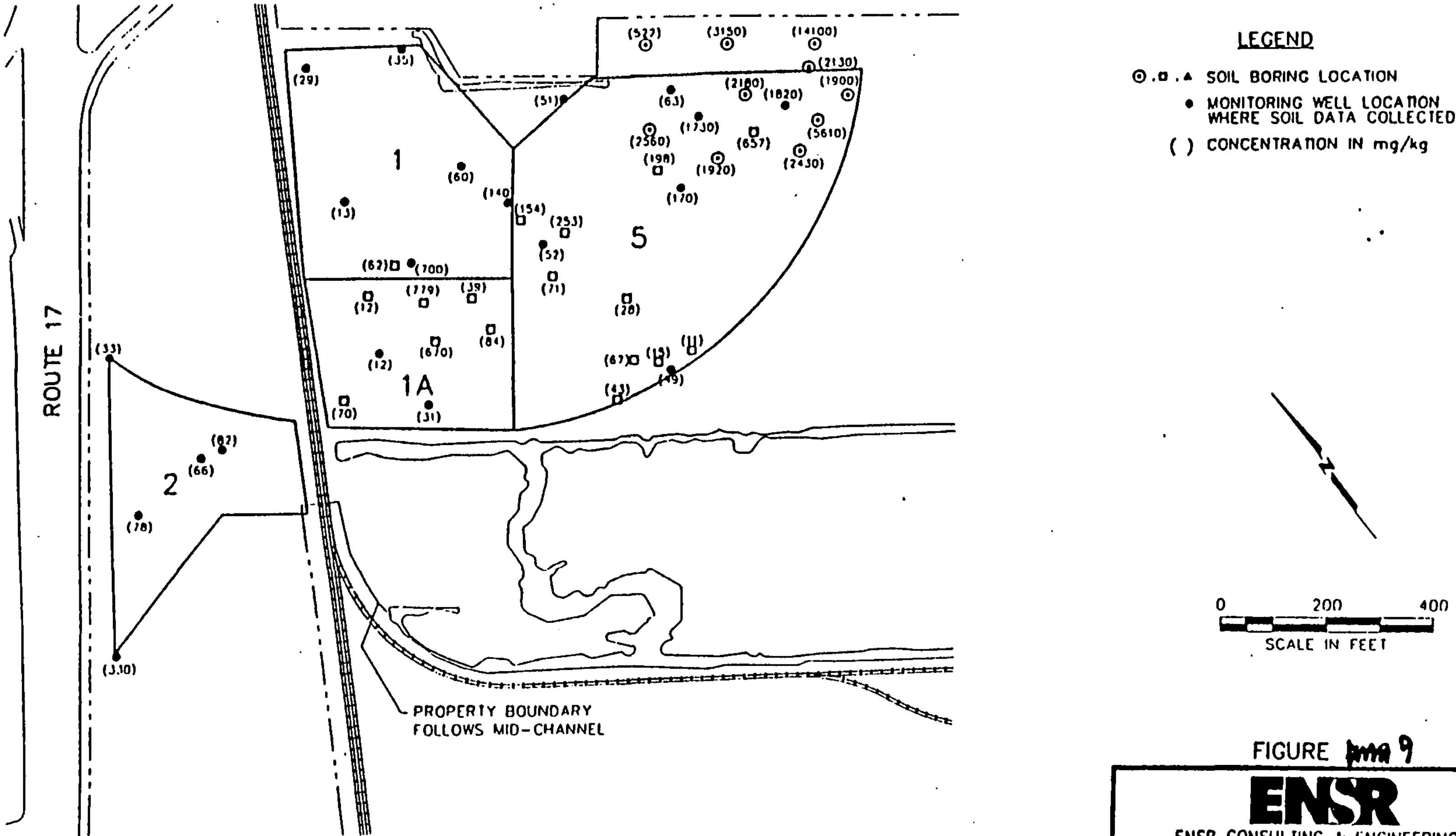


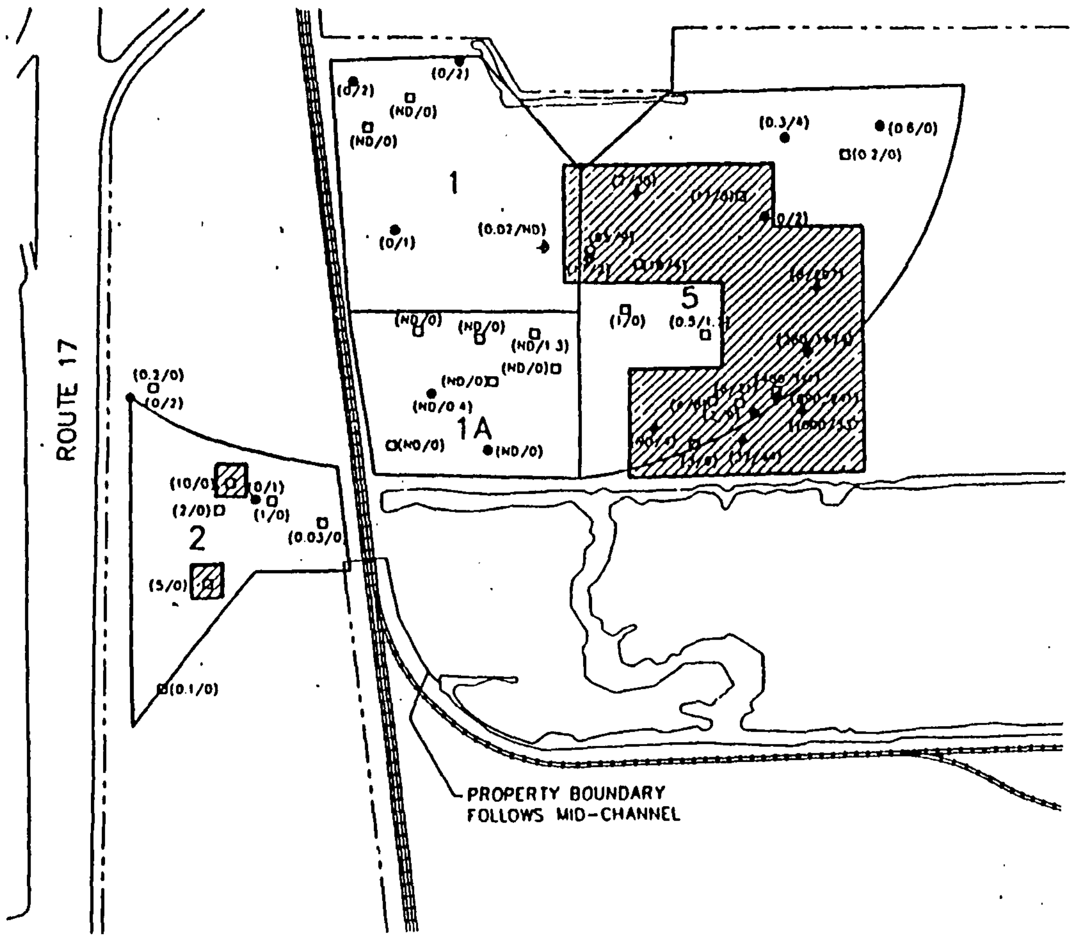
FIGURE 9

ENSR

ENSR CONSULTING & ENGINEERING

CONCENTRATIONS OF LEAD IN SURFACE SOIL
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY:	DATE:	PROJECT NO.
K.P.B.	6/92-FD	0186-002-295



LEGEND

- □ ▲ SOIL BORING LOCATION
- ● MONITORING WELL LOCATION
- ✦ SURFACE SAMPLE LOCATION
- (_/_) PCB/TOTAL CARCINOGENIC PAH CONCENTRATIONS (mg/kg)
- ▨ REMEDIATION AREA

0 200 400
SCALE IN FEET

FIGURE [redacted] 10

ENSR
ENSR CONSULTING & ENGINEERING

PCB/PAH REMEDIATION AREAS
UOP SITE
EAST RUTHERFORD, N.J.

FD	6/92	0106-002 79'

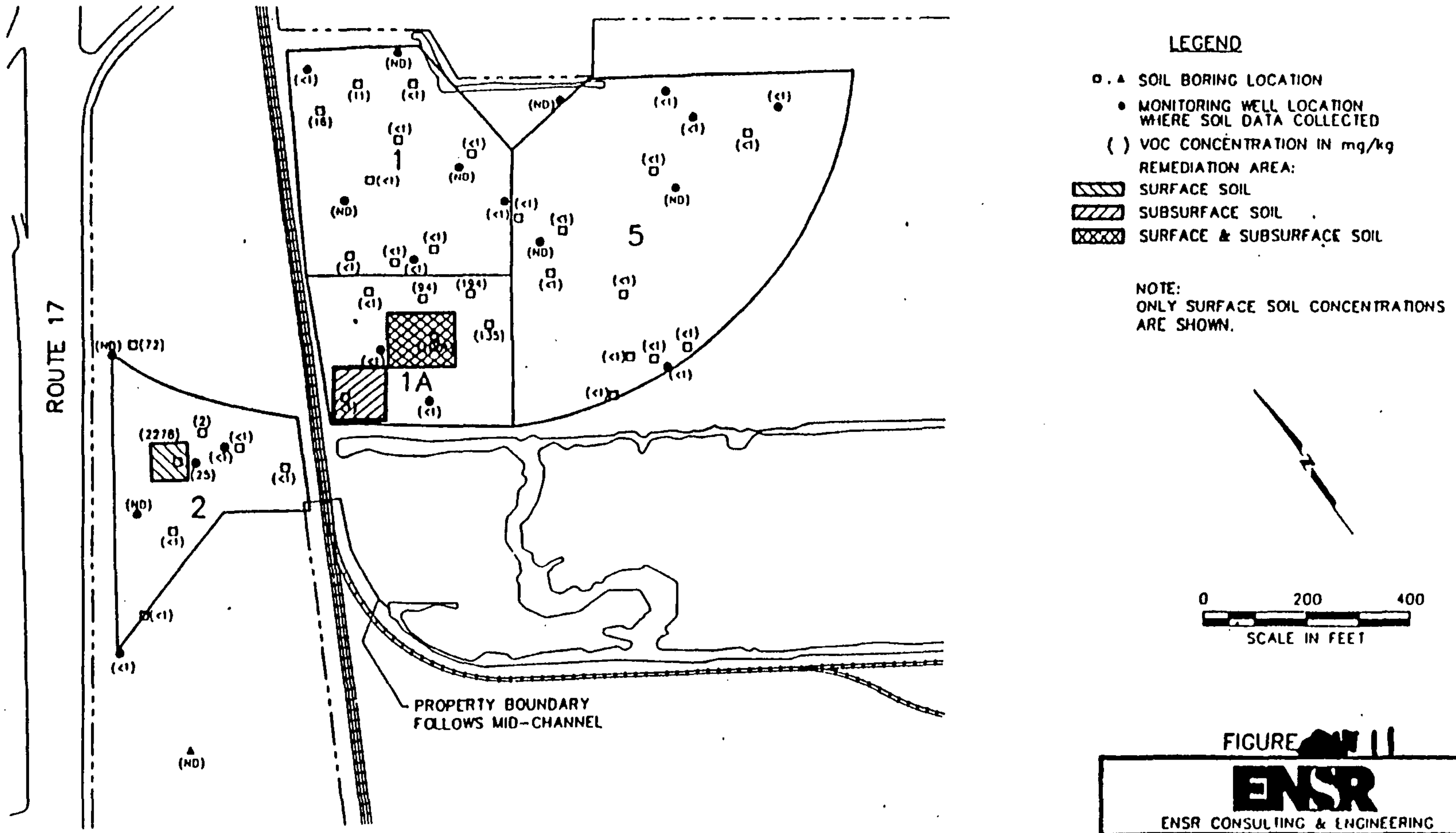


FIGURE [redacted] 11

ENSR

ENSR CONSULTING & ENGINEERING

VOC REMEDIATION AREAS
UOP SITE
EAST RUTHERFORD, N.J.

DRAWN BY	DATE	PROJECT NO
K.P.B.	6/92-FD	0186-002-795

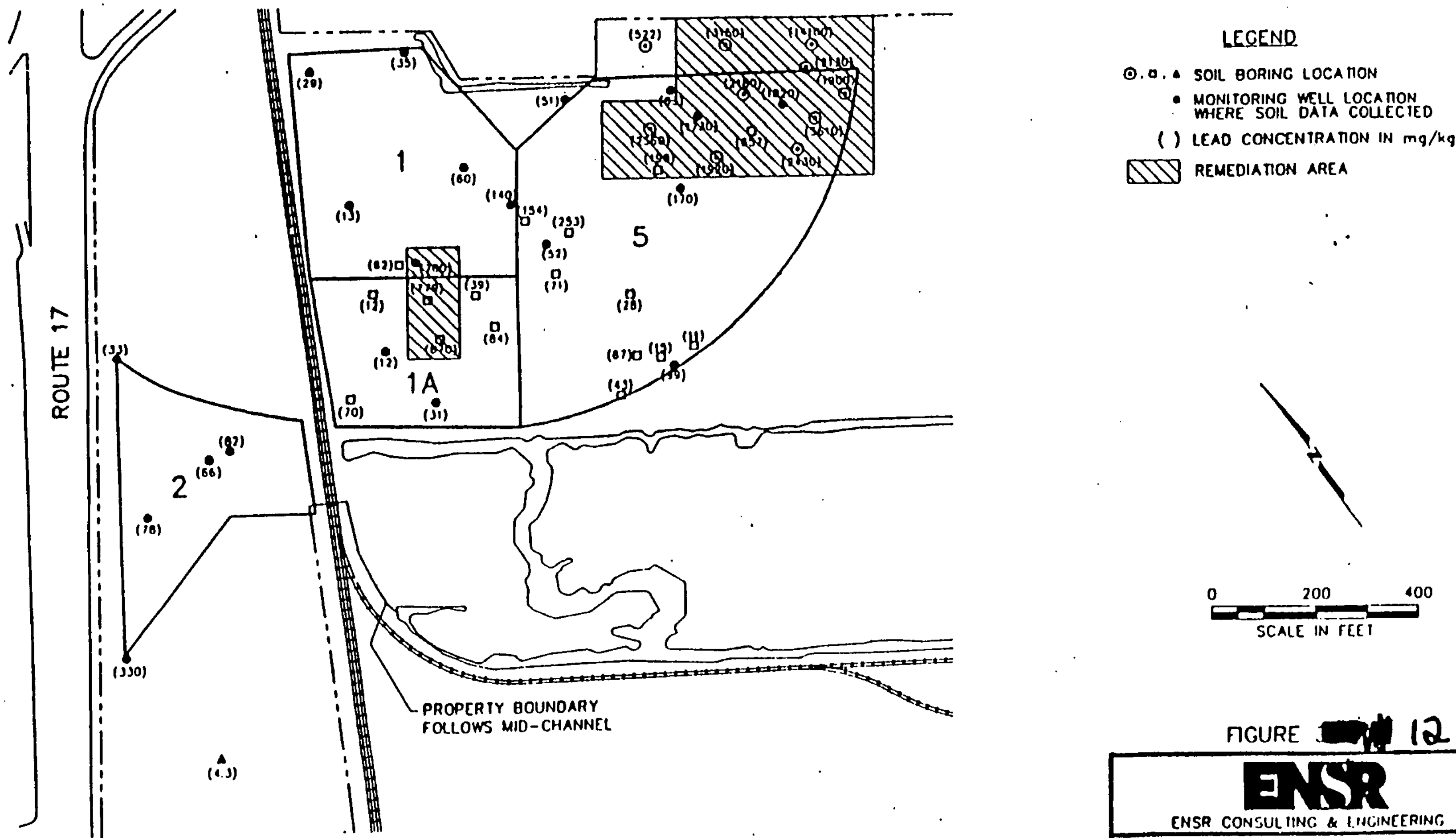


FIGURE [redacted] 12

ENSR

ENSR CONSULTING & ENGINEERING

LEAD REMEDIATION AREA
UOP SITE
EAST RUTHERFORD, N.J.

K.P.B.	6/92-FD	0186-002-29

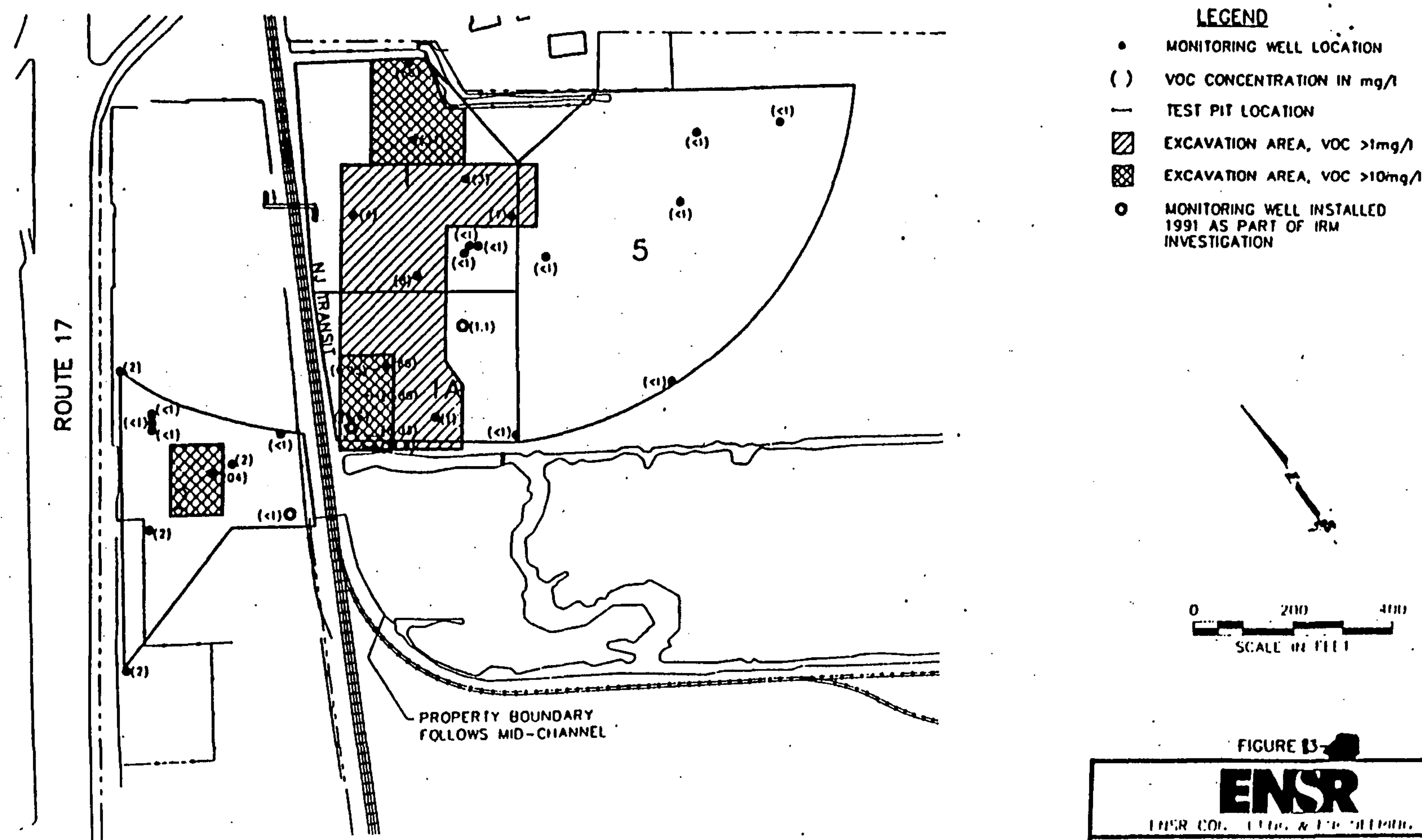


FIGURE 13

ENSR

GROUND WATER REMEDIATION AREA
UOP SITE
EAST RUTHERFORD, N.J.

TABLE 1[redacted]

SUMMARY: INDICATOR CHEMICALS UOP SITE,

EAST RUTHERFORD, N.J.

Compound	Ground Water		Surface Soil		Subsurface Soils	
	IS Rank[d]	Frequency of Detection	IS Rank[d]	Frequency of Detection	IS Rank[d]	Frequency of Detection
Carcinogens						
Arsenic	2	25/42	2	23/36	1	20/33
Benzene	3	25/42	7	11/52	9	13/50
Bis(2 ethylhexyl) phthalate	14	11/42	12	23/36	8	23/34
Carcinogenic PAH	-	not found	4,3,5	16/36, 4/36, 15/36	4,2,5	5/34, 7/34, 6/34
Chromium	c	12/42	c	47/47	c	45/45
1,2-Diphenylhydrazine	4	3/37	-	not found	-	not found
PCB	1	5/30	1	20/30	3	18/31
1,1,2,2-Tetrachloroethane	5	4/42	6	4/52	6	1/50
Non Carcinogens						
Cadmium	19	16/42	6	13/35	6	11/34
Chlorobenzene	3	19/42	12	14/52	10	22/50
Cyanide	c	8/27	c	22/35	c	21/34
1,2-Dichlorobenzene	12	9/42	7	14/37	9	13/36
Lead	16	29/42	1	37/37	3	35/35
Mercury	22	1/31	4	22/23	1	22/26
Nickel	8	4/15	-	not found	-	not found
Toluene	6	25/42	8	38/52	12	37/50
Zinc	14	37/42	5	38/38	5	35/35

a. Arsenic was present in soil at representative concentrations below New Jersey background concentrations.

b. Dibenzo[a,h]anthracene (soil ranks = 4,4), Benzo[a]pyrene (soil ranks = 3,2), and Benzo[a]anthracene (soil ranks = 5,5) were considered total "carcinogenic PAH" for the purposes of indicator compound selection.

c. Compounds do not have constants for use in the hazard calculation but will be considered due to the fact that these compounds were found more often than others.

d. IS rank based on maximum detected concentration.

TABLE 2
EXPOSURE ASSESSMENT FOR VISITORS AND TRESPASSERS
UOP SITE, EAST RUTHERFORD, NJ

Media	Exposure Pathway	Exposure Point	Indicator Chemicals of Concern
Air	Inhalation of volatiles	Near stream channels	Benzene, MCB, Toluene, 1,2,-diphenylhydrazine, 1,1,2,2-tetrachloroethane
	Inhalation of entrained soils	Non-vegetated, unpaved areas	BEHP, PAH Chromium, PCB, Arsenic, Mercury, Cyanide, 1,2-DCB, Lead, Zinc, Cadmium
Ground Water	Source of airborne volatiles	Stream channels	See air, volatiles
Soils	Ingestion	Soils	BEHP, PAH Chromium, PCB, Arsenic, Mercury, Cyanide, 1,2-DCB, Lead, Zinc, Cadmium
	Source of entrained materials	Non-vegetated, unpaved	See air, entrained soils

TABLE 3

DOSE-RESPONSE VALUES FOR INDICATOR CHEMICALS
UOP SITE, EAST RUTHERFORD, NJ

Compound	CARCINOGENIC ASSESSMENT Slope Ingestion $(mg/kg\ day)^{-1}$	Slope Inhalation $(mg/kg\ day)^{-1}$	OTHER TOXIC EFFECTS Rfd Ingestion (mg/kg day)	Rfc Inhalation (mg/kg day)
Arsenic	$1.5x10^{0}$	$1.8x10^{0}$	$1x10^{-3}$	---
Benzene	$2.9x10^{-2}$	$2.9x10^{-2}$	---	---
BEHP	$6.84x10^{-3}$	---	$2x10^{-2}$	---
Carcinogenic PAH	$1.15x10^{+1}$	$6.11x10^{0}$	---	---
Cadmium	---	$6.1x10^{0}$	$1x10^{-3}$(food)	---
Chromium (III)	---	---	$1x10^{0}$	$5.1x10^{-3}$
Chromium (IV)	---	$4.1x10^{+1}$	$5x10^{-3}$	---
PCB	$4.34x10^{0}$	---	---	---
MCB	---	---	$2.7x10^{-2}$	$5.7x10^{-3}$
Cyanide	---	---	$2x10^{-2}$	---
1,2 DCB	---	---	$9x10^{-2}$	$4x10^{-2}$
Lead	---	---	$1.4x10^{-3}$*	$4.3x10^{-4}$*
1,2-Diphenylhydrazine	$8x10^{-1}$	$8x10^{-1}$	---	---

TABLE 3 (continued)

Compound	CARCINOGENIC ASSESSMENT Slope Ingestion (mg/kg day)$^{-1}$	Slope Inhalation (mg/kg day)$^{-1}$	OTHER TOXIC EFFECTS Rfd Ingestion (mg/kg day)	Rfc Inhalation (mg/kg day)
1,1,2,2 Tetrachloroethane	$2x10^{-1}$	$2x10^{-1}$	---	---
Mercury(a)	---	---	$2x10^{-3}$	---
Nickel	---	$1.19x10^{0}$	$2x10^{-2}$	$5.1x10^{-5}$
Toluene	---	---	$3x10^{-1}$	$1x10^{0}$
Zinc	---	---	$2x10^{-1}$	$1x10^{-2}$

Reference source for each toxicity value is IRIS

* indicates New Jersey toxicity value number

TABLE [redacted] 4

CARCINOGENIC RISK FROM INDICATOR CHEMICALS[a]

PRESENT SITE USE SCENARIO

UOP SITE, EAST RUTHERFORD, N.J.

Compound	Risk: Soil[b] Maximum	Risk: Soil[b] Average	Risk: Air[c]	Risk: Total Maximum	Risk: Total Average
Benzene	d	d	4.7×10^{-11}	4.7×10^{-11}	4.7×10^{-11}
BEHP[f]	3.56×10^{-9}	3.74×10^{-10}	3.3×10^{-12}	3.56×10^{-9}	3.78×10^{-10}
Chromium (VI)	e	e	6.2×10^{-8}	6.2×10^{-8}	6.2×10^{-8}
PAH	2.74×10^{-5}	1.32×10^{-6}	5.2×10^{-9}	2.74×10^{-5}	1.32×10^{-6}
PCB[f]	6.13×10^{-5}	2.73×10^{-6}	2.0×10^{-8}	6.14×10^{-5}	2.75×10^{-6}
Arsenic	3.91×10^{-8}	g	g	3.91×10^{-8}	g
Cadmium	e	e	1.9×10^{-9}	1.9×10^{-9}	1.9×10^{-9}
1,2-diphenyl-hydrazine	d	d	8.0×10^{-11}	8.0×10^{-11}	8.0×10^{-11}
1,1,2,2-tetra-chloroethane	d	d	3.5×10^{-11}	3.5×10^{-11}	3.5×10^{-11}
			Total Cancer Risk:	8.99×10^{-5}	4.19×10^{-6}

a. Risk values should be regarded as excess chance of getting cancer, with unity being complete certainty. Thus 3×10^{-9} is three chances in 1,000,000,000.

b. Sum of ingestion and absorption intake. Maximum values calculated from maximum detected concentration of Indicator Chemical at the site. Average intake calculated using arithmetic mean of above-detection-limit samples from surface soil.

c. Because entrained material is assumed to be generated from a large area of the sige, a single intake value for dust was calculated using the arithmetic mean of the above-detection-limit surface soil samples.

d. Benzene, 1,2-diphenylhydrazine, and 1,1,2,2-tetrachloroethane were presumed not to be present in surface soil.

e. Chromium and cadmium are presumed to be non-carcinogenic by the oral route.

f. No potency slope is available for the inhalation route. The oral potency slope was used.

g. Only maximum arsenic level was assessed.

Present site use means visitor on site one hour per week twelve months out of each year.

TABLE [redacted] 5

CARCINOGENIC RISK FROM INDICATOR CHEMICALS[a]

FUTURE SITE USE SCENARIO

Compound	Risk: Dust[b]	Risk: Air	Risk: Total
Benzene	c.	$6.6x10^{-9}$	$6.6x10^{-9}$
BEHP	$7.49x10^{-11}$	$1.2x10^{-11}$(e)	$8.69x10^{-11}$
Chromium (VI)	d.	$2.3x10^{-7}$(e)	$2.3x10^{-7}$
PAH	$1.58x10^{-7}$	$1.9x10^{-8}$	$1.77x10^{-7}$
PCB	$2.96x10^{-7}$	$7.4x10^{-8}$	$3.70x10^{-7}$
Arsenic	f	f	f
Cadmium	d	$6.7x10^{-9}$(e)	$6.7x10^{-9}$
1,2-diphenyl-hydrazine	c	$1.1x10^{-8}$	$1.1x10^{-8}$
1,1,2,2-tetra-chloroethane	c	$4.9x10^{-9}$	$4.9x10^{-9}$
		Total Cancer Risk:	$8.06x10^{-7}$

a. Risk values are excess chance of getting cancer.

b. "Dust" risk calculated from the sum of ingestion and absorption intake. Because the outdoor soil which ultimately contributes to indoor dust is assumed to be transported from a large area of the site, only one "average" value of contaminant intake via dust and air was calculated for this scenario.

c. Benzene 1,2 diphenylhdadrazine, and 1,1,2,2, tetrachloroethene are not present in surface soil.

d. Chromium and cadmium are not carcinogenic by the oral route and not absorbed, dermally.

e. Oral potency slope used for inhalation exposures.

f. Only maximum arsenic concentration was assessed.

Future site use mean employee working at the site.

TABLE [redacted]6

CARCINOGENIC RISK FROM INDICATOR CHEMICALS[a]
CONSTRUCTION WORKER SCENARIO
UOP SITE, EAST RUTHERFORD, NJ

Compound	Risk: Soil[b] Maximum 10-Month	Risk: Soil[b] Maximum 2-Month	Risk: Soil[b] Average 10-Month	Risk: Soil[b] Average 2-Month	Risk: Air[c] 10-Month	Risk: Air[c] 2-Month	Risk: Total[e] Maximum	Risk: Total[e] Average
Benzene	f	8.17E-10	f	3.71E-11	2.59E-10	1.56E-08	1.66E-08	1.59E-08
BEHP	2.76E-10	6.37E-09	2.91E-11	2.40E-10	1.51E-12	2.46E-11	6.67E-09	2.95E-10
PAHs	1.78E-06	1.09E-06	2.76E-08	4.63E-08	2.38E-09	2.83E-09	2.87E-06	7.91E-08
PCBs	4.03E-06	2.11E-06	4.08E-08	1.02E-07	9.34E-09	1.18E-08	6.16E-06	1.64E-07
Arsenic	5.22E-08	9.47E-08	g	g	g	g	1.47E-07	g
Chromium (VI)	d	d	d	d	2.86E-08	1.96E-07	2.25E-07	2.25E-07
Cadmium	d	d	d	d	8.47E-10	1.09E-09	1.94E-09	1.94E-09
1,1,2,2-TCA	f	1.79E-09	f	3.57E-11	2.15E-10	2.29E-08	2.48E-08	2.32E-08
						Summed Risk =	9.45E-06	5.09E-07

[a]Risk values should be regarded as excess chance of getting cancer, with unity being complete certainty. Thus 3 x 10^{-9} is three chances in 1,000,000,000.

[b]Sum of ingestion and absorption intake. Maximum values calculated from maximum detected concentration of Indicator Chemical at the site. Average intake calculated using arithmetic mean of samples from surface soil (for 10 month) or the weighted average of the subsurface and surface soil (for 2 month).

[c]Because entrained material is assumed to be generated from a large area of the site, a single intake value for dust was calculated using the arithmetic mean of the surface soil samples (for 10 month) or the weighted average of the subsurface and surface soil (for 2 month).

[d]Chromium VI and cadmium are presumed to be carcinogenic via inhalation only.

[e]Total 12-month risk to construction workers (10 month and 2 month scenarios combined).

[f]Volatiles are assumed not to be present and available for ingestion and dermal absorption from the surface soil.

TABLE [redacted] 7
Surface Soil PCB and PAH Concentrations
With and Without December 1989 Samples
Area 5
UOP Site
East Rutherford, NJ

	Surface Soil Concentrations, mg/kg			
	Pre 1989[1]		Including 1989[2]	
Compound	Maximum	Representative	Maximum	Representative
PCB	480	21.4	1,000	68.6
Carcinogenic PAH	80.6	3.9	1,304	51.2

Notes: [1] Concentrations as reported in the Human Health Risk Assessment

[2] Concentrations include supplemental samples collected in December 1989

TABLE [redacted] 8
Carcinogenic PAH and PCB Risk Levels
UOP Site
East Rutherford, NJ

Compound	Scenario	Risk: Maximum Conc.	Risk: Average Conc.
Carç. PAH	Present	4.40×10^{-4}	1.73×10^{-5}
	Future	N/A	2.32×10^{-6}
	Const. Wkr.	4.64×10^{-5}	1.04×10^{-6}
PCB	Present	1.28×10^{-4}	8.82×10^{-6}
	Future	N/A	1.19×10^{-6}
	Const. Wkr.	1.28×10^{-5}	5.26×10^{-7}

N/A = Not Applicable

TABLE [redacted] 7

NON-CARCINOGENIC RISK FROM INDICATOR CHEMICALS[a]

PRESENT SITE USE SCENARIO

UOP SITE, EAST RUTHERFORD, N.J.

	Hazard Index Soil[b]		Hazard Index Air[c]	Hazard Index Total	
Compound	Maximum	Average		Maximum	Average
BEHP	4.17×10^{-5}	4.39×10^{-6}	2.0×10^{-8} (d)	4.17×10^{-5}	4.41×10^{-6}
Chromium III	1.13×10^{-3}	5.40×10^{-5}	7.9×10^{-5}	9.05×10^{-5}	1.33×10^{-4}
Chromium VI	1.18×10^{-2}	5.69×10^{-4}	3.0×10^{-7} (d)	5.10×10^{-7}	5.69×10^{-4}
MCB	e	e	2.7×10^{-6}	2.70×10^{-6}	2.70×10^{-6}
Cyanides	7.45×10^{-4}	5.19×10^{-5}	3.7×10^{-7} (d)	1.79×10^{-4}	5.23×10^{-5}
1,2-DCB	2.79×10^{-3}	8.34×10^{-5}	1.3×10^{-6}	2.79×10^{-3}	8.47×10^{-5}
Lead	5.33×10^{-1}	6.98×10^{-2}	1.7×10^{-3}	5.32×10^{-1}	7.15×10^{-2}
Mercury	2.09×10^{-3}	5.17×10^{-4}	3.8×10^{-6} (d)	2.09×10^{-3}	5.21×10^{-4}
Zinc	3.23×10^{-3}	4.05×10^{-4}	6.1×10^{-5}	3.29×10^{-3}	4.66×10^{-4}
Cadmium	6.56×10^{-3}	5.68×10^{-4}	3.0×10^{-7} (d)	6.56×10^{-3}	5.68×10^{-4}
Arsenic	3.58×10^{-4}	f	f	3.58×10^{-4}	f
Toluene	e	e	1.0×10^{-7}	1.0×10^{-7}	1.00×10^{-7}
Summed HI	5.62×10^{-1}	7.20×10^{-2}	1.85×10^{-3}	5.50×10^{-1}	7.39×10^{-2}

a. Risks are given as hazard indices. A value less than 1 indicates no risk.

b. Sum of ingestion and absorption intake. Maximum values calculated from maximum detected concentration of Indicator Chemical at the site. Average intake calculated using arithmetic mean of above-detection-limit samples from surface soil.

c. Because entrained material is assumed to be generated from a large area of the site, a single intake value for dust was calculated using the arithmetic mean of the above-detection-limit surface soil samples.

d. Oral AIC used for inhalation exposures.

e. MCB and toluene are assumed to not be present and available for contact in surface soil.

f. Only maximum concentration of arsenic was assessed.

TABLE iD

NON-CARCINOGENIC RISK FROM INDICATOR CHEMICALS[a]

FUTURE SITE USE SCENARIO

Compound	Hazard Index: Dust[b]	Hazard Index: Air[b]	Hazard Index: Total
BEHP	$8.76x10^{-7}$	$7.10x10^{-8}$(c)	$9.47x10^{-7}$
Chromium III	$7.42x10^{-7}$	$4.10x10^{-5}$	$4.17x10^{-5}$
Chromium VI	$7.79x10^{-6}$	$1.10x10^{-6}$(c)	$8.89x10^{-6}$
MCB	d	$5.40x10^{-5}$	$5.40x10^{-5}$
Cyanides	$1.49x10^{-6}$	$1.90x10^{-7}$(c)	$1.68x10^{-6}$
1,2-DCB	$4.23x10^{-6}$	$6.50x0^{-7}$	$4.88x10^{-6}$
Lead	$9.60x10^{-4}$	$8.80x10^{-4}$	$1.84x10^{-3}$
Mercury	$1.06x10^{-5}$	$2.00x10^{-6}$(c)	$1.26x10^{-5}$
Zinc	$4.21x10^{-6}$	$3.20x10^{-5}$	$3.62x10^{-5}$
Cadmium	$7.80x10^{-6}$	$1.10x10^{-6}$(c)	$8.90x10^{-6}$
Arsenic	e	e	e
Toluene	d	$2.06x10^{-6}$	$2.06x10^{-6}$
Summed HI	$9.98x10^{-3}$	$1.01x10^{-3}$	$2.01x10^{-3}$

a. Risk are given as hazard indices. A value less than 1 indicates no risk.

b. "Dust" risk calculated from sum of ingestion and absorption intake. Because the outdoor soil which ultimately contributes to indoor dust is assumed to be transported from a large area of the site, only one "average" value of contaminant intake via dust and air was calculated for this scenario.

c. Oral AIC used for inhalation exposures.

d. MCB and toluene are assumed to not be present and available for contact in surface soil.

e. Only maximum concentration of arsenic was assessed.

TABLE 11

HAZARD INDICES FOR INDICATOR CHEMICALS[a]

CONSTRUCTION WORKER SCENARIO

UOP SITE, EAST RUTHERFORD, NJ

Compound	Hazard Index: Soil[b]				Hazard Index: Air[c]		Hazard Index: Total[e]	
	Maximum		Average					
	10-Month	2-Month	10-Month	2-Month	10-Month	2-Month	Maximum	Average
MCB	f	4.55E-06	f	1.48E-07	8.27×10^{-5}	3.02×10^{-3}	3.11E-03	3.10E-03
Cyanides	1.14E-05	4.90E-06	7.97E-07	2.71E-07	8.56×10^{-7}	1.95×10^{-6}	1.91E-05	3.87E-06
1,2-DCB	4.01E-05	7.47E-06	1.70E-06	2.22E-07	2.89×10^{-6}	2.97×10^{-6}	5.34E-05	7.78E-06
Lead	8.53E-03	2.89E-03	8.30E-04	4.16E-04	3.90×10^{-3}	1.12×10^{-2}	2.65E-02	1.63E-02
Mercury	3.28E-05	1.36E-04	6.95E-06	8.51E-06	3.43×10^{-4}	2.59×10^{-3}	3.10E-03	2.95E-03
Zinc	5.02E-05	3.86E-05	4.83E-06	3.76E-06	1.39×10^{-4}	6.22×10^{-4}	8.50E-04	7.70E-04
Toluene	f	7.66E-06	f	1.88E-07	1.04×10^{-5}	2.08×10^{-4}	2.26E-04	2.18E-04
Chromium (III)	1.80E-05	1.35E-05	6.43E-07	7.71E-07	1.82×10^{-4}	1.25×10^{-3}	1.43E-03	1.43E-03
Chromium (VI)	1.89E-04	1.43E-04	6.77E-06	8.12E-06	d	d	3.32E-04	1.49E-05
Cadmium	1.05E-04	2.40E-05	6.74E-06	1.51E-06	d	d	1.29E-04	8.25E-06
					Summed Hazard Index =		3.58E-02	2.48E-02

[a]Risks are given as hazard indices. A value less than 1 indicates no risk.

[b]Sum of ingestion and absorption intake. Maximum values calculated from maximum detected concentration of Indicator Chemical at the site. Average intake calculated using arithmetic mean of samples from surface soil (for 10 month) or the weighted average of the surface and subsurface soils (for 2 month).

[c]Because entrained material is assumed to be generated from a large area of the site, a single intake value for dust was calculated using the arithmetic mean of the surface soil samples (for 10 month) and the weighted average of the surface and subsurface soil samples (for 2 month).

[d]Chromium (VI) and cadmium are presumed to be carcinogenic via inhalation.

[e]Total 12-month risk to construction workers (10 month and 2 month scenarios combined).

[f][illegible] for ingestion and dermal absorption from the surface soil

Table 12

Remediation Goals

Contaminant	Remediation Goal, ppm
For Surface Soil:	
Carcinogenic PAHs	
Benzo(b)fluoranthene	4
Benzo(a)anthracene	4
Benzo(a)pyrene	0.66
Benzo(k)fluoranthene	4
Chrysene	40
Dibenzo(a,h)anthracene	0.66
Indeno(1,2,3-cd)pyrene	4
PCB	2
Lead	600
For All Soils:	
VOCs (total)	1000
1,1,2,2-Tetrachloroethane	21

Leachate Delineation Area

Contaminant	Delineation Criteria, ppm
VOCs (total)	10 mg/l
VOCs (individual)	1 mg/l

HRS DOCUMENTATION RECORD COVER SHEET

Name of Site: Standard Chlorine Chemical Company, Inc.
EPA ID No. NJD002175057

Contact Persons

Documentation Record and Site Investigation: Kristin Dobinson (212) 637-4328
U.S. Environmental Protection Agency
New York, NY

Pathways, Components, or Threats Not Scored

Elevated levels of hazardous substances are present in the soil, air, and groundwater at this facility, however, there is not enough documentation at this time to score these pathways. Additionally, there are no documented drinking water targets within the TDL, therefore, it was not included in the score for the surface water pathway.

HRS DOCUMENTATION RECORD

Name of Site: Standard Chlorine Chemical Company, Inc.

EPA Region: 2

Date Prepared: April 2003

Street Address of Site: 1015-1035 Belleville Turnpike

City, County, State: Kearny, Hudson County, NJ 07032-4410

General Location in the State: Northern NJ

Topographic Map: Weehawken & Jersey City, NJ (Ref. 3)

Latitude: 40º 45' 00" North   Longitude: 74º 05 '50" West

Ref: 4

EPA ID No: NJD002175057

Scores

Air Pathway	Not Scored
Ground Water Pathway	Not Scored
Soil Exposure Pathway	Not Scored
Surface Water Pathway	100
HRS SITE SCORE	50.00

WORKSHEET FOR COMPUTING HRS SITE SCORE

		S	S^2
1.	Ground Water Migration Pathway Score (S_{gw}) (from Table 3-1, line 13)	Not Scored	__
2a.	Surface Water Overland/Flood Migration Component (from Table 4-1, line 30)	100	
2b.	Ground Water to Surface Water Migration Component (from Table 4-25, line 28)	Not Scored	
2c.	Surface Water Migration Pathway Score (S_{sw} Enter the larger of lines 2a and 2b as the pathway score.	100	10,000
3.	Soil Exposure Pathway Score (S_s (from Table 5-1, line 22)	Not Scored	__
4.	Air Migration Pathway Score (S_a) (from Table 6-1, line 12)	Not Scored	__
5.	Total of $S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2$		10,000
6.	**HRS Site Score** Divide the value on line 5 by 4 and take the square root	50	

TABLE 4-1
SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

Factor Categories and Factors	Maximum Value	Value Assigned
DRINKING WATER THREAT		
Likelihood of Release		
1. Observed Release	550	550
2. Potential to Release by Overland Flow		
2a. Containment	10	_
2b. Runoff	25	_
2c. Distance to Surface Water	25	_
2d. Potential to Release by Overland Flow (lines 2a x [2b + 2c])	500	_
3. Potential to Release by Flood		
3a. Containment (Flood)	10	_
3b. Flood Frequency	50	_
3c. Potential to Release by Flood (lines 3a x 3b)	500	_
4. Potential to Release (lines 2d + 3c, subject to a maximum of 500)	500	_
5. Likelihood of Release (higher of lines 1 and 4)	550	550
Waste Characteristics		
6. Toxicity/Persistence	a	_
7. Hazardous Waste Quantity	a	_
8. Waste Characteristics	100	_
Targets		
9. Nearest Intake	50	_
10. Population		
10a. Level I Concentrations	b	_
10b. Level II Concentrations	b	_
10c. Potential Contamination	b	_
10d. Population (lines 10a + 10b + 10c)	b	_
11. Resources	5	_
12. Targets (lines 9 + 10d + 11)	b	_

Factor Categories and Factors	Maximum Value	Value Assigned
DRINKING WATER THREAT (Concluded)		
Drinking Water Threat Score		
13. Drinking Water Threat Score ([lines 5 x 8 x 12]/82,500, subject to a maximum of 100)	100	_
HUMAN FOOD CHAIN THREAT		
Likelihood of Release		
14. Likelihood of Release (same value as line 5)	550	550
Waste Characteristics		
15. Toxicity/Persistence/Bioaccumulation	a	$5x10^7$
16. Hazardous Waste Quantity	a	100
17. Waste Characteristics	1,000	180
Targets		
18. Food Chain Individual	50	45
19. Population		
19a. Level I Concentrations	b	_
19b. Level II Concentrations	b	0.03
19c. Potential Human Food Chain Contamination	b	_
19d. Population (lines 19a + 19b + 19c)	b	0.03
20. Targets (lines 18 + 19d)	b	45.03
Human Food Chain Threat Score		
21. Human Food Chain Threat Score ([lines 14 x 17 x 20]/82,500, subject to a maximum of 100)	100	54.036

Factor Categories and Factors	Maximum Value	Value Assigned
ENVIRONMENTAL THREAT		
Likelihood of Release		
22. Likelihood of Release (same value as line 5)	550	550
Waste Characteristics		
23. Ecosystem Toxicity/Persistence/ Bioaccumulation	a	$5x10^7$
24. Hazardous Waste Quantity	a	100
25. Waste Characteristics	1,000	180
Targets		
26. Sensitive Environments		
26a. Level I Concentrations	b	_
26b. Level II Concentrations	b	125
26c. Potential Contamination	b	_
26d. Sensitive Environments (lines 26a + 26b + 26c)	b	125
27. Targets (value from 26d)	b	125
Environmental Threat Score		
28. Environmental Threat Score ([lines 22 x 25 x 27]/82,500, subject to a maximum of 60)	60	60
SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED		
29. Watershed Score[c] (lines 13 + 21 + 28, subject to a maximum of 100)	100	100
SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE		
30. Component Score (S_{of})[c], (highest score from line 29 for all watersheds evaluated, subject to a maximum of 100)	100	100

[a]Maximum= value applies to waste characteristics category.
[b]Maximum value not applicable.
[c]Do not round to nearest integer.

REFERENCES

Ref. No.	Description of the Reference
1.	U.S. Environmental Protection Agency (EPA). Hazard Ranking System, 40 CFR Part 300, Appendix A, 55 FR 51533. December 14, 1990. 165 pages.
2.	EPA. Superfund Chemical Data Matrix. June 1996. 9 pages.
3.	U.S. Geological Survey (USGS), Jersey City Quadrangle, Weehawken Quadrangle. 2 maps.
4.	EPA. Latitude and Longitude Calculation Worksheet. 3 pages.
5.	EPA, National Wetlands Inventory (NWI) map. March 2003. 1 map.
6.	Brown and Caldwell, Addendum to Volume IIA, Remedial Investigation (RI) Workplan, NJDEP Site Identification No. 116 (Standard Chlorine) Volume I -Report and Appendices A and C, for Chemical Land Holdings, Inc., July 2001. 293 pages.
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13.	Weston, Stage II and III Analysis Report for: Sampling and Analysis of Potentially Dioxin Contaminated Materials in Waste Lagoons, for Standard Chlorine Chemical Company, Inc., May 1988. 30 pages.
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15.	Dobinson, Kristin, EPA Region II, Project Note to Standard Chlorine File, Subject: TOC Normalized Data, 26 March, 2003. 5 pages.
16.	Boyle, Susan B., NJ Department of Environmental Protection (NJDEP), Letter to Director R. Caspe of EPA Re: NPL Listing Request - Standard Chlorine Chemical Company, 04 December, 2001. 3 pages.

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18. NJ Department of Environmental Protection (NJDEP), Public Health Advisories and Guidance on Fish Consumption for Recreational Fishing : 2003 Fish Consumption Advisories for PCBs and Dioxin http://www.nj.gov/dep/dsr/pcb-dioxin-chart.htm Accessed on 25 March, 2003. 5 pages.

19. Dobinson, Kristin, EPA Region II, Project Note to Standard Chlorine File, Subject: Fish Consumption Advisories, 25 March, 2003. 1 page.

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22. US Fish and Wildlife Service, Southern New England-New York Bight Coastal Ecosystems Program, Regionally Significant Habitats and Habitat Complexes of the New York Bight Watershed, November 1996. 38 pages.

23. NJDEP, Administrative Consent Order In the Matter of Standard Chlorine Chemical Corporation, Kearny, NJ, 20 October, 1989. 22 pages.

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SITE SUMMARY

The Standard Chlorine Chemical Company, Inc. (Standard Chlorine), site is located in an industrial area along the tidally-influenced Hackensack River in Kearny Township, New Jersey. The Standard Chlorine facility occupies approximately 25 acres in the Hackensack Meadowlands. Various forms of chemical manufacturing and/or processing have occurred at this facility since 1916 when the White Tar Company purchased lots on the eastern portion of the site. White Tar refined crude naphthalene at the site from 1916 to 1942, when Koppers Company, Inc. (Koppers) acquired the facility. Koppers processed approximately 11,000 tons per year of crude naphthalene and naphthalene oil and produced creosote disinfectants. In 1946, Koppers purchased adjacent property and opened the Tar Products Division - Meadows Plant, which included the storage and packaging of 1,4-dichlorobenzene moth preventatives and deodorizers in solid form (Ref. 6, pp. 1-1). The Thomas A. Edison Co., the Edison Storage Battery Co., and Emark Battery Corp. used acid and lead-lined acid equipment on site. Crown Rubber Products, Inc. and Keaton Rubber Co. were manufacturers of insulating raw rubber parts (Ref. 6, pp. 1-2). Tanatex Chemical Corp, a part of Sybron Chemicals, Inc. operated at the site between 1959 and 1962. Tanatex produced dye carriers involving the use of methylnaphthalenes, alkynated naphthalenes, chlorinated benzenes, and other common dye carrier solvents until the early 1960's (Ref. 6, pp. 1-2).

In 1962, part of the site was sold to Standard Chlorine and another part was sold to Standard Naphthalene Products, Inc. (SNP), a wholly owned subsidiary of Standard Chlorine. SNP processed liquid petroleum naphthalene at the site from 1963 to 1982 for the production of moth balls, flakes, and crystals From 1963 to 1993, Standard Chlorine carried out operations at this site under its own name and the name of Chloroben Corporation (Chloroben), a subsidiary of Standard Chlorine. Standard Chlorine manufactured moth crystals and flakes from dichlorobenzene isomers. Standard Chlorine separated dichlorobenzenes from 1963 to 1982. Standard Chlorine also separated and stored 1,2,4-trichlorobenzene from 1970 to 1980. After closing the dichlorobenzene operation in 1981, Standard Chlorine converted liquid naphthalene into mothballs, flakes and chips. This operation was discontinued in mid-1982 (Ref. 6, pp. 1-2). For a period extending until 30 April, 1993, Chloroben operated a batch formulation and blending operation at the site producing various solvents and inorganic chemicals for use in cleaning drains, sewers, and septic tanks (Ref. 6, pp. 1-2 - 1-3).

In 1989, an Administrative Consent Order (ACO) was entered into between the New Jersey Department of Environmental Protection (NJDEP) and Standard Chlorine. The ACO required Standard Chlorine to plan and implement several interim remedial measures (IRMs), a remedial investigation of the site, and an evaluation and selection of a remedial action (Ref. 16; 23).

Several potential source areas exist at the Standard Chlorine site. The primary areas of concern include contaminated soils and two lagoons located on the eastern portion of the facility property (Ref. 8, pp.5-2 - 5-3, 5-7 - 5-8, 5-17, 5-21- 5-24). These areas appear to ultimately drain into the Hackensack River via three probable points of entry: a drainage pipe along the northern property boundary, a drainage ditch that runs along the southern property boundary, and overland runoff that flows directly from the facility property to the river (Ref.8, pp. 5-24 - 5-25; Ref. 11, pp.10-11). Tanks and drums containing (or at one time contained) various site-related hazardous substances, such as dioxin and asbestos, also are present at the facility (Ref. 8, pp.3-4; 16; 17).

The predominant hazardous substances associated with the lagoons and surrounding contaminated soils include: benzene, dichlorobenzenes, chlorobenzene, trichlorobenzenes, trimethylbenzene, naphthalene, and dioxin (TCDD). In addition, PCB-1260 was detected at 9300 milligrams per kilogram (mg/kg) in concrete chips taken from the vicinity of the former transformer, and at lesser concentrations (0.12 to 0.29 mg/kg) in soil samples collected directly beneath the concrete pavement (Ref. 10, pp. 39).

Data from sampling events conducted between 1992 and 2002 indicate that a release of site-related hazardous substances has occurred to the Hackensack River and adjacent wetlands. Dioxins, dichlorobenzenes, 1,2,4-trichlorobenzene, naphthalene, benzene, and chlorobenzene, as well as several other semivolatile and volatile organic compounds, were detected at varying levels in these samples. During the 2002 EPA sampling event, dioxin (2,3,7,8-TCDD) was detected at 96.1 nanograms per kilogram (ng/kg) in a sediment sample taken from the Hackensack River (Ref. 14, pp. 93, 821, 923). Surface water samples taken from the outfall at the point of discharge to the Hackensack show concentrations of naphthalene at 45 μg/kg and 1,2,4-trichlorobenzene at 12 µg/kg (Ref. 14, pp. 8, 93, 644, 922). During the October 2002 EPA sampling event, a seep was observed entering the Hackensack River from the sediment southeast of the outfall where the southern drainage ditch confluences with the Hackensack River (Ref. 14, pp. 920). The seep was black in color with observed sediment (Ref. 14, pp. 920). Chemical analysis of the seep indicates the presence of 1,4-dichlorobenzene at 2 µg/kg (Ref. 14, pp. 542, 641, 920).

Historic records indicate that approximately 400 drums and seven plastic bags containing dioxin contaminated asbestos material previously removed from the distillation building had been stored in a "block" building in the lagoon area. In May 2000, the NJDEP directed Standard Chlorine to perform an inventory and evaluation of all drums, containers, aboveground tanks, etc that remained at the site which contained hazardous substances or hazardous waste. In August 2000, Standard Chlorine was directed to remove the drums containing dioxin contaminated asbestos material, to classify the contents of the drums containing tank bottoms and other material resulting from various site investigations, and to remove approximately 143 drums that were mostly empty or contained trash. Approximately 550 drums have been consolidated into six sea boxes and remain on site (Ref. 8, pp. 3-4; 16; 17).

In December 2001, NJDEP requested that EPA evaluate the Standard Chlorine site for listing on the National Priorities List due to the complex environmental issues present at the site and the inability of the responsible parties to address the issues. The NJDEP indicated that Standard Chlorine had not completed Remedial Investigation activities and was non-compliant with the terms of the 1989 ACO. While another ACO exists with Chemical Land Holdings (CLH), the scope of work is limited to chromium related issues and will not address the entire site. The NJDEP has terminated their ACO with Standard Chlorine (Ref. 16).

Warnings pertaining to the consumption of some fish (particularly crab) and a health advisory have been issued for the Hackensack River due to PCB and dioxin contamination, originating in part from the Standard Chlorine site (Ref. 18; 19). However, fishing still occurs along the river, and there is heavy recreational use of the river directly adjacent to the site (Ref. 20; 21). The site lies in the Hackensack Meadowlands which has been identified by the US Fish and Wildlife Service as a Significant Habitat Complex of the New York Bight Watershed at the request of the US EPA's New York - New Jersey Harbor Estuary Program, and is a habitat for some state or Federal designated endangered and/or threatened species (Ref. 22, pp. 26, 37; 27). Releases of site-related hazardous substances to ground water also have been documented since at least the early 1980s, and air releases pose a threat to a large population within 4 miles of the site (Ref. 23, pp.2-3; 8, pp. 1-7, 1-12 - 1-13; 11, pp.7).

2.2 SOURCE CHARACTERIZATION

2.2.1 SOURCE IDENTIFICATION

Name of source: Lagoons Number of source: 1

Source Type: Surface Impoundment

Description and Location of Source: Source 1 is a lagoon that encompasses an area of approximately 33,000 square feet and extends to an average depth of 6 feet below grade (Ref. 8, pp. 5-3). The lagoon is two contiguous units, designated as the east lagoon and west lagoon, containing a combined estimated volume of approximately 7,300 cubic yards of material. (Ref. 9, pp. 6; 23, pp. 1; 28, pp. 10). The lagoon bottom is at approximately 5 feet below mean sea level (msl) to 9 feet below msl and the base of the waste material is in contact with the water table (Ref. 10, pp. 10, Ref. 8, pp. 5-3). It is located on the eastern portion of the property, situated between the Hackensack River to the east, the Conrail right of way to the west, and the southern drainage ditch to the south (Ref. 9, pp. 18). The east lagoon is located approximately 25 feet from the Hackensack River (Ref. 23, pp. 1).

Residual wastes associated with the lagoon include sludge and viscous oils. The sludge is typically black and viscous, with a significant solids content. The oils, where observed, appear as free-phase liquids or DNAPL. Although two physically distinct layers of waste sludge were detected in the lagoons, the constituents detected in the sludge samples from both layers were fairly consistent. The chemical composition of the sludge has been identified from the analyses of four sludge samples collected as part of the Weston Remedial Investigation (RI) Report. The lagoons consist of two major layers of materials: 1-3 feet of white to brown material with bladed crystals, silt and fine sand; the lower layer consists of 3-4 feet of black tar material (Ref. 8, pp. 5-3). Samples were taken from each layer in the east (ELS1, ELS2) and west (WLS1, WLS2) sides of the lagoons (Ref. 8, fig.5-1). The most common VOCs present within the lagoon sludges include ethylbenzene, benzene, methylene chloride, and toluene (Ref. 9, pp. 25; Ref. 6 Table116-04, pp.1,4; 8, table 5-1). The most common SVOCs present within the lagoon sludges include naphthalene,1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene (Ref. 9, pp. 25; 6 Table116-04, pp. 10, 13; 8, table 5-1). The major constituent in each of the samples was naphthalene which accounted for between 30 and almost 99 percent of the sample content (Ref. 8, pp. 5-8).

In February and March 1987, a "Stage I" dioxin sampling event was conducted (Ref. 6, pp.2-2; 12; 23, pp.4). Samples were collected at four depths at a total of 20 locations (sample locations A through T). The first two shallow samples were analyzed and the two deeper core samples were archived to be analyzed for dioxin if the shallow samples revealed contamination (Ref. 12, pp. 19; 23, pp.4). The results of the re-analyzed samples are referred to as Stages II and III (Ref. 6, pp.2-2; 12, pp. 19; 13, pp. 11-12). These samples were taken in the lagoon area and show contamination of 2,3,7,8-TCDD (Ref. 6, pp. 2-3, fig. 116-2.8; 12, pp. 8-9, 21, 24; 13, pp. 13, 14-15, 24, 25).

2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE

Standard Chlorine operations at the site included manufacturing of moth crystals and flakes from dichlorobenzene. Standard Chlorine separated dichlorobenzenes at the site from 1963 to 1982. Standard Chlorine also separated and stored 1,2,4-trichlorobenzene at the site from 1970 to 1980. SNP processed liquid petroleum naphthalene at the site from 1963 until 1982. Raw materials were transported to the site by rail and tank truck for processing. Chloroben Chemical Corporation (Chloroben), a subsidiary of Standard Chlorine, operated a batch formulation and blending operation at the site for various drain cleaners known as "Chloroben". From 1963 until 1981, Chloroben products were made from 1,2-dichlorobenzene, after which they were produced from hydrochloric acid, sulfuric acid, and methyl benzoate (Ref. 23, pp.2; 6, pp. 1-2 - 1-3).

A New Jersey Department of Environmental Protection (NJDEP) Selected Substances Report dated August 1980 indicates that Standard Chlorine disposed of an estimated 12,000 lb/yr of waste from the processing of 1,2,4-trichlorobenzene into the lagoon system between 1975 and 1979 (Ref. 23, pp. 2; 6, pp. 1-7). Also listed as substances present at the site include 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, and naphthalene (Ref. 23, pp. 2).

An NJDEP inspection of the site on 23 June 1982 reported that the lagoon system was reported by Standard Chlorine to have been used for waste disposal by Koppers, a former property owner (Ref. 8, pp. 1-8).

In 1985, NJDEP conducted the Phase II Dioxin Investigation, which identified 23 sites in New Jersey suspected of contamination with halogenated dibenzo-p-dioxins, specifically 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, or dioxin). The Standard Chlorine site was included in the investigation because Standard Chlorine once produced and stored two dioxin related compounds at the site, 1,2,4-trichlorobenzene and 1,2-dichlorobenzene. Results from this sampling event prompted a more in-depth dioxin investigation by Standard Chlorine (Ref. 11,pp. 1, 7; 23, pp.3).

Historical aerial photos indicate piping had existed to allow discharge into the lagoons. The piping appears to originate from the building areas directly north of the lagoons (Ref. 25, pp. 34, 50)

- Source Samples:

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit* (µg/kg)	Reference
WLS-1	sediment	1/91	methylene chloride toluene ethylbenzene naphthalene	21,500 33,800 39,600 2,040,000,000	9,300 20,000 24,000 110,000	Ref. 8, pp.5-4, 5-5; 6, table T116-04, pp. 1, 4, 10, 13
WLS-2	sediment	1/91	methylene chloride toluene ethylbenzene naphthalene	6,090 15,300 15,200 300,000,000	2,600 5,600 6,700 150,000	Ref. 8, pp.5-4, 5-5; 6, table T116-04, pp. 1, 4, 10, 13
ELS-1	sediment	1/91	methylene chloride benzene toluene ethylbenzene 1,2-dichlorobenzene 1,4-dichlorobenzene naphthalene	438 896 3,050 2,580 22,100 40,000 815,000,000	4,200 670 910 1100 5,800 13,000 4,800	Ref. 8, pp.5-4, 5-5; 6, table T116-04, pp. 1, 4, 10, 13
ELS-2	sediment	1/91	methylene chloride benzene toluene ethylbenzene naphthalene	5,330 23,400 63,100 43,300 25,200,000,000	4,200 6,700 9,100 11,000 240,000	Ref. 8, pp.5-4, 5-5; 6, T116-04, pp. 1, 4, 10, 13

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit* (µg/kg)	Reference
WLS-1	West Lagoon surface water	1/91	1,3-dichlorobenzene 1,4-dichlorobenzene naphthalene 1,2,4-trichlorobenzene	4.6 10.5 12.7 7.1	1.9 4.5 1.6 1.9	Ref. 8, pp.5-4,5-5; 6, table T116-06, pp. 1, 3, 5
ELS-1	East Lagoon surface water	1/91	chlorobenzene 1,2-dichlorobenzene 1,3-dichlorobenzene 1,4-dichlorobenzene naphthalene 1,2,4-trichlorobenzene	77.6 1.9 10.2 23 3.1 18.5	30.0 1.9 1.9 4.5 1.6 1.9	Ref. 8, pp.5-4,5-5; 6, table T116-06, pp. 1, 3, 5
A-1	Stage1 core/spoon sample 0.5-1.5 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	2.6	0.001*	Ref. 12, pp. 21; 6 table T116-03, pp. 2
B-1	Stage1 core/spoon sample 0.4-1.2 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	8.20	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
C-1	Stage1 core/spoon sample 0.0-0.8 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	19.5	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
C-2H-SS	Stage 1 surface soil 1.2-2.1 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	0.23	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
E-1	Stage1 core/spoon sample 0.0-0.5 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	0.850	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
E-2-SS	Stage 1 surface soil 0.8-1.3 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	31.9	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
E-3-SS	Stage II, III surface soil 1.6-1.9ft bgs	3/87	2,3,7,8-TCDD (dioxin)	2.9	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 3

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit* (µg/kg)	Reference
E-4-SS	Stage II, III surface soil 2.0-2.3 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	1.2	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 3
F-1	Stage II, III core/spoon sample 0.0-0.6 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	2.3	0.001	Ref. 13, pp. 24; 6 T116-03, pp. 3
F-4-SS	Stage1 surface soil 5.0-5.5 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	4.3	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
G-1	Stage1 core/spoon sample 0.0-0.8 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	2.8	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
I-2-SS	Stage 1 surface soil 1.3-1.8 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	3.2	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
I-3-SS	Stage 1 surface soil 2.5-3.5 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	38.4	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 2
I-4-SS	Stage 1 surface soil 4.5-5.5 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	6.2	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 3
J-1H	Stage 1 core/spoon sample 0.1-1.1 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	11.2	0.001	Ref. 12 , pp. 21; 6 table T116-03, pp. 3
J-3-SS	Stage II, III surface soil 2.9-3.9 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	268	0.001	Ref. 13, pp. 24; 6 T116-03, pp. 3
J-3-SS	Stage II, III surface soil 2.9-3.9 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	237	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 3

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit* (µg/kg)	Reference
J-4-SS	Stage II, III surface soil 5.0-5.8 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	148	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 3
K-1H-SS	Stage1surface soil 0.1-1.1 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	69.6	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 3
K-2-SS	Stage 1 surface soil 1.7-2.2 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	2.7	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 3
K-3-SS	Stage II, III surface soil 2.4-3.1 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	6.1	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 4
K-4-SS	Stage II, III surface soil 4.6-5.6 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	3.7	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 4
L-1H-SS	Stage 1 surface soil 0.2-1.2 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	0.710	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 3
R-1-SS	Stage 1 surface soil 0.0-0.8 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	15.3	0.001	Ref. 12 , pp. 21; 6 table T116-03, pp. 3
R-2-SS	Stage 1 surface soil 2.5-3.2 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	62.1	0.001	Ref. 12, pp. 21; 6 table T116-03, pp. 3
R-3-SS	Stage II, III surface soil 4.2-5.0 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	190	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 4
R-4-SS	Stage II, III surface soil 6.0-6.7 ft bgs	3/87	2,3,7,8-TCDD (dioxin)	46	0.001	Ref. 13, pp. 24; 6 table T116-03, pp. 4

note: bgs (below ground surface)
*Detection Limits for dioxin data that were not reported non-detect is not available as the EPA CLP SOW DLM01.4 does not require the lab to report detection limits for hit samples. Therefore, the Contract Required Quantitation Limit (CRQL) of 1.0 ng/kg is being used for those samples where the sample specific detection limit is not available (Ref. 26).

2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Containment Description	Containment Factor Value	Ref.
Gas release to air:	NS	
Particulate release to air:	NS	
Release to ground water:	NS	
Release via overland migration and/or flood: In order to comply with the 1989 ACO, Standard Chlorine built up the low earthen berm surrounding the lagoons to provide a minimum of 2 ft freeboard in all areas. In addition, approximately 50 ft of the shoreline berm was stabilized using geotextile covered with stone rip rap. There is no liner and the base of the waste material is in contact with the water table.	9	Ref. 8, pp. 3-3, 5-3

Notes:
NS Not Scored

2.4.2 HAZARDOUS WASTE QUANTITY

2.4.2.1.1. Hazardous Constituent Quantity

Documentation is not sufficient to determine hazardous constituent quantity.

Hazardous Constituent Quantity Assigned Value: 0

2.4.2.1.2. Hazardous Wastestream Quantity

Documentation is not sufficient to determine hazardous wastestream quantity.

Hazardous Wastestream Quantity Assigned Value: 0

2.4.2.1.3. Volume

Description:

Source 1 is a lagoon that encompasses an area of approximately 33,000 square feet and extends to an average depth of 6 feet below grade (Ref. 10, pp.10). The lagoon is two contiguous bodies, designated as the east lagoon and west lagoon, containing a combined estimated volume of 7,300 cubic yards of material. (Ref. 10, pp.10; 9, pp.6; 23, pp.1)

Source Type	Description (# drums or dimensions)	Units (yd^3/gal)	References
surface impoundment	. 33,000 square feet by 6 feet deep	7,333.33 yd^3	Ref. 10, pp.10; 9, pp.6;

Sum (yd^3/gal): 7,333.33 yd^3
Equation for Assigning Value (Table 2-5): v/2.5

Volume Assigned Value: 2933.33

2.4.2.1.4. Area

Since the volume of the waste source can be determined, a value of 0 is given for area assigned value.

Area Assigned Value: 0

2.4.2.1.5. Source Hazardous Waste Quantity Value

Highest assigned value assigned from Table 2-5: 2933.33

2.2.1 SOURCE IDENTIFICATION

Name of source: Contaminated Soil Number of source: 2

Source Type: Contaminated Soil

Description and Location of Source:

During the field work for the 1993 Weston RI, a total of seventeen soil samples were collected. Ten surface soil samples (TSS-1 through TSS-10) were taken in the former above ground storage tank area around the distillation building north of the lagoons and analyzed for volatile organic compounds (VOCs) and Base neutrals and acids (BNAs) (Ref. 7, pp. 3; 8, pp.5-17). Samples were located near the ends of existing tanks near valves and joints. In areas where tanks were no longer present, samples were taken next to concrete cradles. The soil samples were obtained from a depth of one to two feet using a hand held bucket auger (Ref. 8, pp.4-15) Elevated levels of chlorobenzene were detected (highest concentration detected 99,600 µg/kg). Elevated levels of BNA compounds were detected, including naphthalene (2,370,000,000 µg/kg), 1,2-dichlorobenzene (4,680,000 µg/kg), 1,3-dichlorobenzene (1,270,000 µg/kg), 1,4-dichlorobenzene (4,840,000 µg/kg), and 1,2,4-trichlorobenzene (100,000,000 µg/kg) (Ref. 8, pp.5-17, fig 5-2). Background samples were not taken for these sample locations. However, each compound was either not detected or detected in at least one sample at levels less than three times background (Ref. 8, table 5-5). These samples were used to demonstrate that these manmade substances are not ubiquitous in the entire area.

Seven soil boring samples were taken at four boring locations adjacent to Building 2 and analyzed for VOCs, BNAs, pesticides/PCBs and metals. One of the samples was taken from the boring for monitoring well MW-2L adjacent to the active septic tank on the north side of Building 2. The other six samples (two per boring) were collected from three soil borings completed during the supplementary investigation near Building 2 (Ref. 8, pp.5-21, fig 5-1). One boring, Weston SB-2A/B, (location 2 on fig 5-1) was completed on the east side of Building 2 near monitoring well MW-15 and two additional borings, Weston SB-3A/B and Weston SB-4A/B, (locations 3 and 4) were completed to the west of Building 2 where in the past above ground storage tanks were located and chemicals for production or shipment were loaded (Ref. 8, pp.4-19, fig 5-1). One sample was taken from the shallow unsaturated zone (A) and one from the sandy sediments just above the clay horizon (B) (Ref. 8, pp.4-19, 5-21, fig 5-1). Elevated levels of chlorobenzene (220,000 µg/kg) were found in the soil samples. 1,2-dichlorobenzene (9,200,000 µg/kg), 1,3-dichlorobenzene (1,300,000 µg/kg), 1,4-dichlorobenzene (1,300,000 µg/kg) and 1,2,4-trichlorobenzene (34,000 µg/kg) were detected at elevated concentrations in all samples, but were highest in SB-2B located near MW-15L, between Buildings 2 and 4 (Ref. 8, pp-5-21, fig 5-1). Free phase product was observed in sample SB-2B from the sand just above the clay. Based on these results, it appears that the soils and free phase product in the vicinity of Building 2 are a continuing source of contamination. The origin of contamination appears to be from the handling of the materials shipped to and from the site (Ref. 8, pp. 5-24).

Soil borings were taken between August 5 and 16, 1996 during the Focused Remedial Investigation (FRI) performed by Environmental Resources Management (ERM) (Ref. 9, pp. 12). Thirteen soil borings, SB-2 through SB-14 were installed adjacent to the extent of the lagoons in the eastern portion of the site. Soil boring SB-01 was installed at the westernmost portion of the eastern portion of the site to help delineate the extent of the contamination (Ref. 9, pp.12). Eight of the soil samples were submitted for laboratory analysis. The samples were selected from borings in which waste material was encountered above the clay and/or where field screening of the sample head space indicated elevated organic vapor concentrations (Ref. 9, pp.13). Analysis indicates soil contamination in an area north of the lagoon area encompassing the eastern portion of the site. Using samples SB-01 taken on the western side of the drainage ditch, and SB-14 taken south of the lagoons as backgrounds, the samples collected indicated concentrations of site related contaminants at levels of magnitude higher than the background samples (Ref. 9, table 6A). These sample locations were chosen as backgrounds to demonstrate that the contamination is not ubiquitous in the area. These samples may also indicate the outer extent of the migration of the contamination (Ref. 9, pp.12). Contamination of the soils in this area of 1,2,3-trichlorobenzene (2,140,000 µg/kg), 1,2,4-trichlorobenzene (6,540,000 µg/kg), 1,2-dichlorobenzene (2,320,000 µg/kg), 1,3-dichlorobenzene

(1,700,000 µg/kg), 1,4-dichlorobenzene (1,630,000 µg/kg), and naphthalene (5,750,000 µg/kg), may be the result of leakage or spillage from aboveground storage tanks, or migration of contaminants from the lagoons through the soils (Ref. 9, pp.12, Ref. 25, pp. 61, 70, Ref. 8, pp. 5-8).

2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE

Unintentional releases by leaks or spills from pipes and aboveground product storage tanks represent a source of contamination to soils and groundwater in the former product handling and storage areas. All piping and all but five tanks in the building area north of the lagoons were removed after operations ceased. Analysis of the contents of the five remaining tanks indicates that they were used to store primarily trichlorobenzenes and dichlorobenzenes (Ref. 8, pp.3-3 - 3-4, 5-8 - 5-9, table 5-2). These tanks were cleaned out in 1990 (Ref. 8, pp.3-3,5-8). Historical area photographs and other evidence indicate the presence of former tank locations and a railroad spur entering the southeast corner of the property behind Building 2 where materials were handled and stored (Ref. 8, pp.5-8, 5-24; Ref. 25, pp-12, 36, 44-45, 52-53, 56-59,). These tanks did not appear to have secondary containment in 1963 (Ref. 25, pp.36). Historical aerial photographs and tank cradles in the process area north of the lagoons also indicate material storage in that area (Ref. 25, pp. 15-16, 22, 28, 34, 41, 43, 50-51,56-57, 61, 63). The 1985 Phase II Dioxin Investigation documented dichlorobenzene tanks at the western end of the property, dichlorobenzene and trichlorobenzene storage tanks on the eastern end of the site, and stained soil in several places on the site (Ref. 11, pp.10-11, fig. 2). Aerial photographs from 1995 indicate that dark toned ground stains were visible at the processing buildings north of the lagoons (Ref. 25, pp. 70-71). Historically, this area was used for naphthalene product production and this product was stored in this area over a longer period of time (Ref. 8, pp.5-8). An NJDEP inspection of the site on 31 August 1982 reported spillages of naphthalene and dichlorobenzenes on the ground surface at the site in several areas (Ref. 8, pp.1-8).

- Background Concentrations:

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
TSS-2	surface soil sample from tank area	12/90	chlorobenzene, tetrachloroethylene, trichloroethylene	ND** ND ND	8,700 5,900 2,800	Ref. 8, Table 5-5
TSS-3	surface soil sample from tank area	12/90	1,2,4-trichlorobenzene, methylene chloride trichloroethylene	6,360 ND ND	3,100 4.60 3.10	Ref. 8, Table 5-5
TSS-4	surface soil sample from tank area	12/90	methylene chloride tetrachloroethylene trichloroethylene	ND ND ND	2,100 3,100 1,400	Ref. 8, Table 5-5
TSS-5	surface soil sample from tank area	12/90	naphthalene	ND	4,100	Ref. 8, Table 5-5

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
TSS-6	surface soil sample from tank area	12/90	chlorobenzene	ND	100	Ref. 8, Table 5-5
TSS-8	surface soil sample from tank area	12/90	chlorobenzene 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene	ND ND ND ND	9.10 2,900 2,900 6,600	Ref. 8, Table 5-5
TSS-9	surface soil sample from tank area	12/90	naphthalene	ND	2,400	Ref. 8, Table 5-5
Weston SB-2A	soil boring sample - shallow	10/92	chlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene tetrachloroethylene benzene	ND 6,000J*** 6,800J 3,500J 3,400J 3 J ND	13 13,000 13,000 13,000 13,000 13 13	Ref. 8, Table 5-6
Weston SB-3B	soil boring sample - deep	10/92	chlorobenzene benzene	91 J 110 J	1500 1500	Ref. 8, Table 5-6
Weston SB-4B	soil boring sample-deep	10/92	1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, tetrachloroethylene	ND ND ND ND	12,000 12,000 12,000 2000	Ref. 8, Table 5-6
SB-01	soil boring, 15.5-16 ft bgs*	08/16/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	ND 2.1 BMDL**** 115 42.5 89.1 25.6	6.0[a]	Ref. 9, table 6A

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
SB-14	soil boring, 18.5-19 ft bgs	08/07/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	91.9 350 70.2 50.9 53.5 3.49 BMDL	6.1[a]	Ref. 9, table 6A

Note: *bgs = below ground surface
**ND = non detect. These samples have been chosen to demonstrate a background level for these contaminants. All substances found in this source are man-made substances not ubiquitous in the area.
***J = concentrations detected below detection limit. Contaminated samples were detected at levels above the detection limits of these samples.
****BMDL = Concentration detected below Method Detection Limit
[a] Detection limits for these samples are the Method Detection Limits

- Source Samples:

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
TSS-1	surface soil sample from tank area	12/90	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	99,600 75,000,000 3,850,000 1,210,000 2,230,000 2,370,000,000	38,000 12,000 12,000 12,000 27,000 10,000	Ref. 8, Table 5-5
TSS-2	surface soil sample from tank area	12/90	1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	3,040,000 4,680,000 738,000 4,840,000 167,000	2,700 2,700 2,700 6,400 2,300	Ref. 8, Table 5-5
TSS-3	surface soil sample from tank area	12/90	1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	12,100 14,500 54,600 191,000	3,100 3,100 7,200 2,600	Ref. 8, Table 5-5
TSS-4	surface soil sample from tank area	12/90	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	5,490 14,100,000 34,400 9,590 15,000 5,020	4,500 2,900 2,900 2,900 6,600 2,400	Ref. 8, Table 5-5

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
TSS-5	surface soil sample from tank area	12/90	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene tetrachloroethylene trichloroethylene methylene chloride	300 68,200,000 522,000 394,000 52,200 2,310 866 114	150 4,900 4,900 4,900 11,000 110 49 72	Ref. 8, Table 5-5
TSS-6	surface soil sample from tank area	12/90	1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene methylene chloride	30,100 10,800 9,500 15,700 51,800 70.8	3,300 3,300 3,300 7,600 2,700 48.0	Ref. 8, Table 5-5
TSS-7	surface soil sample from tank area	12/90	1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, naphthalene tetrachloroethylene trichloroethylene methylene chloride	25,400 3,780 6,400 7,310 12.5 29.2 6.57	3,200 3,200 3,200 2,700 6.9 3.2 4.7	Ref. 8, Table 5-5
TSS-8	surface soil sample from tank area	12/90	1,2,4-trichlorobenzene, naphthalene	28,300 16,700	2,900 2,400	Ref. 8, Table 5-5
TSS-9	surface soil sample from tank area	12/90	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, methylene chloride	33,500 100,000,000 4,340,000 1,270,000 876,000 7020	9,000 2,800 2,800 2,800 6,500 5200	Ref. 8, Table 5-5
TSS-10	surface soil sample from tank area	12/90	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene tetrachloroethylene	89.10 62,800 6,530 66,200 41,700 448,000 9.91	9.40 3,000 3,000 3,000 6,900 2,500 6.4	Ref. 8, Table 5-5

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
Weston SB-2B	soil boring sample - deep	10/92	chlorobenzene 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene benzene	220,000 9,200,000 1,300,000 1,300,000 48,000 J	71,000 1,200,000 1,200,000 1,200,000 71,000	Ref. 8, Table 5-6
Weston SB-3A	soil boring sample - shallow	10/92	chlorobenzene 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene benzene	15,000 34,000 400,000 410,000 430,000 320 J	1,400 12,000 12,000 12,000 12,000 1400	Ref. 8, Table 5-6
Weston SB-3B	soil boring sample - deep	10/92	tetrachloroethylene	16,000	1,500	Ref. 8. Table 5-6
Weston SB-4B	soil boring sample - deep	10/92	chlorobenzene	27,000	2000	Ref. 8, Table 5-6
ERM SB-03	Soil boring, 14.5-15 ft bgs	08/05/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	1,770,000 6,540,000 1,080,000 1,700,000 1,630,000 1,010,000	630,000[a]	Ref. 9, table 6A
ERM SB-04	Soil boring, 15-15.5 ft bgs	08/12/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	1,000,000 1,870,000 1,310,000 677,000 2,400,000	630,000[a]	Ref. 9, table 6A
ERM SB-09	Soil boring, 15-15.5 ft bgs	08/12/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	345,000 1,180,000 506,000 210,000 257,000 181,000	160,000[a]	Ref. 9, table 6A

Sample ID	Sample Type	Date	Hazardous Substance	Hazardous Substance Concentration (µg/kg)	Detection Limit (µg/kg)	Reference
ERM SB-10R	Soil boring, 16-16.5 ft bgs	08/16/96	1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene	2,140,000 2,290,000 2,320,000 557,000 1,160,000 5,750,000	290,000[a]	Ref. 9, table 6A

Note: *bgs = below ground surface
[a] Detection limits for these samples are the Method Detection Limits

2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Containment Description	Containment Factor Value	Ref.
Gas release to air:	NS	
Particulate release to air:	NS	
Release to ground water:	NS	
Release via overland migration and/or flood: There are no containment structures (ie: engineered cover, run-on control system, runoff management system, liners) associated with source 2. While an IRM of asphalt and stone covers have been placed over portions of the site by Chemical Land Holdings to fulfill their ACO with NJDEP, this cover was not placed over all the unpaved areas of the site and has been placed only to prevent human exposure to the chromium contaminated fill.	10	Ref. 6, pp.2-4; 14, pp. 11-12;

Notes:
NS Not Scored

2.4.2 HAZARDOUS WASTE QUANTITY

2.4.2.1.1. Hazardous Constituent Quantity

Documentation is not sufficient to determine hazardous constituent quantity.

Hazardous Constituent Quantity Assigned Value: 0

2.4.2.1.2. Hazardous Wastestream Quantity

Documentation is not sufficient to determine hazardous wastestream quantity.

Hazardous Wastestream Quantity Assigned Value: 0

2.4.2.1.3. Volume

Description

Based on analytical results of surface and subsurface soil samples taken during the sampling events conducted for the Weston 1993 Remedial Investigation Report and the ERM 1997 Focused Remedial Investigation Report, it is apparent that some amount of soil contamination is present at depth; however, the exact volume of contamination is unknown (Ref. 8, pp. 4-15, 4-19, 5-17, 5-21, 5-24, fig 5-1, 5-2, table 5-5, 5-6; 9, pp. 12-13, Table 6A). Therefore, a source volume of >0 but unknown will be assigned.

Source Type	Description (# drums or dimensions)	Units (yd^3/gal)	References
contaminated soil	contaminated soil indicated by soil samples TSS-1 though TSS-10; Weston SB-3A, SB-2B; ERM SB-03, SB-04, SB-09, SB-10R	yd3	Ref. 8, Tables 5-5, 5-6; 9, Table 6A

Sum (yd^3/gal): >0
Equation for Assigning Value (Table 2-5): V/2,500

Volume Assigned Value: >0

2.4.2.1.4. Area

Since the volume of the waste source can be determined, a value of 0 is given for area assigned value.

Area Assigned Value: 0

2.4.2.1.5. Source Hazardous Waste Quantity Value

Based on analytical results of surface and subsurface soil samples taken during the sampling events conducted for the Weston 1993 Remedial Investigation Report and the ERM 1997 Focused Remedial Investigation Report, it is apparent that some amount of soil contamination is present at depth; however, the exact volume of contamination is unknown (Ref. 8, pp. 4-15, 4-19, 5-17, 5-21, 5-24, fig 5-1, 5-2, table 5-5, 5-6; 9, pp. 12-13, Table 6A). Therefore, a source hazardous waste quantity of >0 but unknown will be assigned.

Highest assigned value assigned from Table 2-5: >0

SUMMARY OF SOURCE DESCRIPTIONS

Source No.	Source Hazardous Waste Quantity Value	Source Hazardous Constituent Quantity Complete? (Y/N)	Containment Factor Value by Pathway				
			Ground Water (GW) (Table 3-2)	Surface Water (SW)		Air	
				Overland/flood (Table 4-2)	GW to SW (Table 3-2)	Gas (Table 6-3)	Particulate (Table 6-9)
1	2933.33	N	NS	9	NS	NS	NS
2	>0	N	NS	10	NS	NS	NS

Description of Other Possible Sources

Building Discharges into Southern Drainage Ditch

Under New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Surface Water (DSW) Permit No. NJD0001856, Standard Chlorine was permitted to discharge septic tank overflow, boiler blowdown and stormwater runoff into the southern drainage ditch. The permit, effective 1 February 1986 through 31 January 1991, granted permission to discharge to the Hackensack River in accordance with effluent limitations and monthly monitoring requirements (Ref. 8, pp.1-8).

Analysis of historical aerial photographs show discharges into the drainage ditch near Building 2 (Ref. 25, pp. 24, 30, 36, 42, 52, 56, 62, 72).

SC-SED-19 was taken below a drainage pipe entering the drainage ditch at Building 2 (Ref. 14, pp. 19, 956). This sample was the most heavily contaminated with 250,000 µg/kg of chlorobenzene, 6,000,000 µg/kg of 1,4-dichlorobenzene, 3,900,000 µg/kg of 1,3-dichlorobenzene, 5,300,000 µg/kg of 1,2-dichlorobenzene, 2,900,000 µg/kg of 1,2,4-trichlorobenzene, and 23,000 µg/kg of naphthalene (Ref. 14, pp. 626, 725).

Free Phase Product

Contaminated fill material from non-site related chromium ore processing activities is present on the site property, as well as on other properties in the Hackensack Meadowlands, particularly in floodplain areas adjacent to principal waterways such as the Hackensack River. Surface slag fill material was placed prior to the 1940's along areas of low lying conditions to achieve greater topographic relief (Ref. 6, pp. 1-3). The fill material consists of both coarse and fine grained materials and consists of clay, silt, sand, gravel, slag, cinders and was found to be of random thickness across the entire lagoon area, ranging from six to eleven feet thick throughout the site (Ref. 9, pp. 20). This fill is underlain by organic silt, humus and reed peat deposits (meadow mat) (Ref. 9, pp. 6, 20). These deposits are typically formed in bogs along rivers and in flood plains, and are characterized by peats and associated silt, clay and sand sediments (Ref. 9, pp. 20). The meadow mat ranges from approximately two to five feet thick (Ref. 9, pp. 20). The fill and meadow mat are underlain by a Holocene sand layer (the Lower Sand unit). This sand is present beneath the entire lagoon area and is approximately 3 to 6 feet thick (Ref. 9, pp. 20). The Lower Sand unit is primarily silty sand to sand with trace silt. Discontinuous silt lenses are present. The coarse and fine fractions grade laterally into each other indicative of stream channel sands and adjacent floodplain sediments of a fluvial depositional environment. The unit is completely saturated and the lower portion of the sand unit showed evidence of the presence of free product in several areas (Ref. 9, pp. 21). A varved clay (Pleistocene Age) unit is present beneath the sand. The thickness of the clay is approximately 25 to 35 feet thick (Ref. 9, pp. 20). The sequence of fill/peat underlain by sand, which is underlain by varved clay (glacial till) comprises the overburden stratigraphy at the Site. The bedrock beneath the overburden consists of the Triassic age Brunswick formation. (Ref. 9, pp. 4, 6) The bottom of the lagoon appears to lie within or on top of the meadow mat surface (Ref. 9, pp. 21). The high permeability of the surrounding fill material evidently disperses drainage (Ref. 8, pp. 5-3)

The southern drainage ditch receives flow from shallow groundwater. Shallow groundwater flows laterally in the sands and discharges to the southern drainage ditch and to the Hackensack River (Ref. 8, pp. 2-5). Free phase product has been observed discharging into the southern drainage ditch (Ref. 7, pp. 7-9; 14, pp. 15; 28, pp.5-8). Contaminants of concern can be found in groundwater and soils as free phase product across the site. The highest concentrations of dichlorobenzenes are found in the western portion of the site and highest concentrations of naphthalene and phenols and phenolics occur in the eastern portion of the site (Ref. 8, pp. 5-52). Free phase product was observed in sample SB-2B from the sand just above the clay and in the groundwater from MW-15L (Ref. 8, pp. 5-24). Sample analysis indicates that sample SB-2B contained toluene (960J µg/kg), benzene (48,000J µg/kg), chlorobenzene (220,000 µg/kg), 1,2-dichlorobenzene (9,200,000 µg/kg), 1,3-dichlorobenzene (1,300,000 µg/kg), 1,4-dichlorobenzene (1,300,000 µg/kg), and 1,2,4-trichlorobenzene (2,400,000J µg/kg) (Ref. 8, table 5-6). Analysis of samples taken from MW-15L indicate contamination with benzene (3010 µg/kg), chlorobenzene (1830 µg/kg), 1,4-dichlorobenzene (19,500 µg/kg), 1,2-dichlorobenzene (20,600 µg/kg), 1,3-dichlorobenzene (15,200 µg/kg), 1,2,4-trichlorobenzene (81.2 µg/kg), and naphthalene (20.4 µg/kg) (Ref. 8, table 5-11). Based on these results, it appears that soils and free phase product in the vicinity of Building 2 are a continuing source of contamination to the groundwater (Ref. 8, pp. 5-24).

Offsite Sources

Surface water drains from the site along two paths which each lead to outfalls to the Hackensack River at the northeastern and southeastern corners of the property. The northeast outfall receives drainage from the northwest corner of the property where runoff collects in a depression which drains through a culvert into a buried storm drain which runs along the entire northern border of the property. This storm drain also receives runoff from the Belleville Turnpike (Ref. 8, pp. 5-24).

Most of the site drainage reaches the southern drainage ditch which also receives runoff from the Koppers property to the south. Shallow groundwater also discharges to the ditch. The sediments in the drainage ditch have a yellow-brown color which also forms a scum on the water surface. This appears to be related to the chromium fill (Ref. 7, pp. 7-9; 8, pp. 5-25; 28, pp. 5-8). While it is possible that surface water and sediments in the southern drainage ditch may be impacted from contaminants from the Koppers property to the south of the site, the highest concentration of contaminants were detected in the center of the Standard Chlorine property where the ditch originates onsite. The contaminants detected in the surface water and sediment samples collected in the southern drainage ditch are all site attributable compounds (Ref. 8, 5-33).

4.0 SURFACE WATER MIGRATION PATHWAY

4.1 OVERLAND/FLOOD MIGRATION COMPONENT

4.1.1.1 Definition of Hazardous Substance Migration Path for Overland/flood Component

Standard Chlorine is located in flat former meadow land that has been filled in with chromium ore processing residue (COPR). The property is bounded on the east by the Hackensack River and on the south by an unnamed creek referred to as the southern drainage ditch. The southern drainage ditch is the northern border of an area of wetlands that are present in the northern portion of the Koppers property just south of the Standard Chlorine property (Ref. 8, pp. 2-1 - 2- 2, fig 2-1). The surface water and sediments in the ditch and the wetlands is discolored with oily material and a pale yellow skim which is possibly associated with the chromium waste (Ref. 7, pp. 7-9; 8, pp. 2-1 - 2-2; 14, pp.11-20, 928, 930-931, 936- 937, 940, 943-955, 957, 959-961; 28, pp.5-8). The creek and the wetland are separated from the Hackensack River by a wooden berm with an outflow culvert. The outflow culvert is equipped with a tidal gate which is supposed to prevent backflow during high tides, however, it does not prevent the discharge of the creek into the Hackensack River (Ref. 8, pp. 2-2; Ref. 14, pp. 3, 8, 28, pp. 8). Aerial photographs from April 16, 1973 show an outfall plume at the end of the southern drainage ditch into the Hackensack River (Ref. 25, pp. 51-52).

The southern drainage ditch received flow from drainage ways near buildings 2, 3, and 4 in the southwestern portion of the site. This flow included NPDES permitted wastewater effluent from active buildings (Ref. 8, pp.1-8, 2-2; Ref. 25, pp. 24, 30, 36, 42, 52, 56, 62, 72). During the EPA October 2002 sampling event, SC-SW/SED 19 was taken at a point in the drainage ditch directly at a pipe which seemed to drain from this building area (Ref. 14, pp. 19, 956-957). This sample location has been designated **Probable Point of Entry (PPE) 3** on the National Wetlands Inventory map (Ref. 5). Analysis of surface water sample SC-SW-19 indicates concentrations of 1,4-dichlorobenzene (46 µg/kg) above 3 times background (Ref. 14, pp. 694, 956). Sediment sample SC-SED-19 contained concentrations of naphthalene (23,000 µg/kg), 1,4-dichlorobenzene (6,000,000 µg/kg), 1,2,4-trichlorobenzene (2,900,000 µg/kg), chlorobenzene (250,000 µg/kg) and 2,3,7,8-TCDD (85.1 ng/kg) (Ref. 14, pp. 626, 725, 889, 956-957).

Historical area photographs and other evidence indicate the presence of former tank locations and a railroad spur entering the southeast corner of the property behind Building 2 where materials were handled and stored (Ref. 8, pp.5-8, 5-24; 25, pp-12, 36, 44-45, 52-53, 56-59). These tanks did not appear to have secondary containment in 1963 (Ref. 25, pp.36). Soil samples taken from the area surrounding Building 2 during Weston RI indicate soil contamination with dichlorobenzenes, 1,2,4-trichlorobenzene, and chlorobenzene in the percentage range (Ref. 8, table 5-6). Sample SC-SW/SED-21was taken in the southern drainage ditch south of Building 2 (Ref. 14, pp. 20, 960-961). Observed releases by chemical analysis of 1,4-dichlorobenzene (240,000 µg/kg), 1,2,4-trichlorobenzene (25,000 µg/kg), and chlorobenzene (41,000 µg/kg) to the sediment and of 1,4-dichlorobenzene (610 µg/kg), 1,2,4-trichlorobenzene (200 µg/kg), and chlorobenzene (760 µg/kg) to the surface water are representative of historical operations at this site (Ref. 14, pp. 632-633, 700-701, 728, 751). This location has been designated **PPE4** (Ref. 5).

A small drainage way south of the lagoons along the eastern side of the abandoned railroad spur in the center of the site also drains southward to the ditch (Ref. 8, pp. 2-2, fig 2-1; 14, pp. 4, 13, 932-933). Sample SC-SW/SED 07 was taken during the October 2002 sampling event at the point where a pipe enters this branch of the southern drainage ditch (Ref. 14, pp. 13, 932-933) . This point has been designated **PPE 2** (Ref. 5). There is an observed release by chemical analysis of naphthalene (270 µg/kg), 1,4-dichlorobenzene (200 µg/kg), and 1,2,4-trichlorobenzene (82 µg/kg) to the surface water at this point (Ref. 14, pp. 659, 932).

Surface water also drains from the site through a buried stormdrain under the road along the northern boundary of the site which discharges to the Hackensack River through a tidal gate near the northeast corner of the property. Runoff collects in a depression on the northwest corner of the property which then drains through a culvert into the buried stormdrain. (Ref. 8, pp. 2-2, 4-14, 5-24, fig 2-1). The outfall is totally emerged at high tide (Ref. 8, pp.5-24-25). While the tidal gate has been installed to prevent the backflow of water into the stormdrain, the tidal gate appeared to be in disrepair during a 2002 EPA site visit (Ref. 7, pp. 1-2). This northern outfall has been designated **PPE 5** (Ref. 5).

The southern drainage ditch also receives flow from shallow groundwater. Shallow groundwater flows laterally in the sands and discharges to the southern drainage ditch and to the Hackensack River (Ref. 8, pp. 2-5; 28, pp. 8). Free phase product has been observed discharging into the southern drainage ditch (Ref. 7, pp. 7,9; 14, pp. 15; 28, pp. 5). Contaminants of concern can be found in groundwater soils as free phase product across the site. The highest concentrations of dichlorobenzene are found in the western portion of the site and highest concentrations of naphthalene and phenols and phenolics occur in the eastern portion of the site (Ref. 8, pp. 5-52).

During the October 2002 EPA sampling event, a seep was observed entering the Hackensack River from the sediment 8.7 feet to the southeast of the outfall where the southern drainage ditch confluences with the Hackensack River (Ref. 14, pp. 3, 920). The seep was black in color with observed sediment (Ref. 14, pp. 3, 920). Chemical analysis of the seep indicates the presence of 1,4-dichlorobenzene (Ref. 14, pp. 542, 641). This seep has been designated as **PPE1** (Ref. 5).

The Hackensack River is part of the Newark Bay Complex and the New York Bight Watershed. The Hackensack River also runs through the Hackensack Meadowlands, the largest remaining brackish wetland complex in the New York-New Jersey Harbor Estuary (Ref. 22, pp. 26). The Hackensack Meadowlands habitat complex includes the remaining tidal wetlands and adjacent palustrine wetlands and uplands along the lower Hackensack River north of Jersey City, New Jersey. The habitat complex is generally bounded by the Conrail railroad tracks and Route 17 to the west south, the New York, Susquehanna, and Western Railroad tracks to the east, and Route 46 to the north; its northwest corner is bounded by the runways at Teterboro Airport. The complex also includes the aquatic habitat and adjacent upland habitat of Overpeck Creek which feeds into the Hackensack River at the complex's northeastern end. This 8,400 acre wetland area encompasses the remaining wetlands and open space habitats that support significant concentrations of waterfowl, wading birds, shorebirds, raptors, anadromous fish, and estuarine fish (Ref. 22, pp. 26, 37).

There is a Health Advisory issued for the Hackensack River regarding the consumption of blue crab and striped bass due to dioxin contamination and american eel, white perch, and white catfish due to PCB contamination in the river. The Hackensack River advisory is included as part of the Newark Bay complex advisory (Ref. 18; 19). Fishing for consumption regularly takes place on the Hackensack River despite the Health Advisory (Ref, 20; 21). There are two popular fishing locations on the banks of the river both up and downstream from Standard Chlorine and hook and line fishing from boats takes place on the River off the Standard Chlorine property (Ref. 20; 21;28, pp. 13-15).

The surface water migration pathway has a maximum score of 100.00 based on actually contaminated fisheries and sensitive environments, therefore potential surface water targets were not evaluated. Although not evaluated in this documentation package, it should be noted that there are numerous other surface water targets within the TDL. The Hackensack River is tidally influenced, however the extent of tidal carry at the site is unknown. Just upstream of the site lies a tidal wetlands complex that has been designated a priority habitat in the Meadowlands. This wetland complex consists of three sites: the Kingsland Impoundment, Kearny Marsh, and Sawmill Creek Wildlife Management Area. The Sawmill Creek Wildlife Management Area is a 900 acre wildlife management area managed by the state of New Jersey. The Kingsland Impoundment is 700 acres managed by the Hackensack Meadowlands Development Commission. Kearny Marsh consists of approximately 400 acres of predominantly freshwater, flooded, reed marsh (Ref. 22, pp. 28, 37-38).

4.1.2.1 Likelihood of Release

4.1.2.1.1 Observed Release

Direct Observation

- Basis for Direct Observation:

During the October 2002 EPA sampling event, a seep was observed entering the Hackensack River from the sediment 8.7 feet to the southeast of the outfall where the southern drainage ditch confluences with the Hackensack River (Ref. 14, pp. 3, 920). The seep was black in color with observed sediment (Ref. 14, pp. 3, 920). Chemical analysis of the seep documents the presence of 1,4-dichlorobenzene as well as other potentially identified substances (Ref. 14, pp. 542, 641).

Standard Chlorine has been found in violation of the Spill Compensation and Control Act, specifically N.J.S.A. 58:10-23.11c, and the Water Pollution Control Act, specifically N.J.S.A. 58:10A-6. as stated in the Administrative Consent Order issued by the NJDEP and signed by NJDEP and Standard Chlorine on October 20 and October 18, 1989, respectively (Ref. 23, pp.5,18). The violations were issued for the past and current discharges of hazardous substances and pollutants into the waters and onto the lands of the State of New Jersey (Ref. 23, pp.2-5). The hazardous substances and pollutants referenced in the violations include dioxin, naphthalene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, trichloroethylene, tetrachloroethylene, benzene, chlorobenzene, toluene, and hydrochloric acid (Ref. 23, pp. 2-5) .

Both of these incidents document that hazardous substances from the site have directly entered the surface water.

- Hazardous Substances in Release:

Hazardous Substance	Evidence	Reference
1,4-Dichlorobenzene	SC-SW-01, NJDEP signed ACO, NJDEP Selected Substances Report	Ref. 14, pp. 3, 542, 641, 920; 23 pp. 2-5; 8, pp.1-7
2,3,7,8-TCDD	NJDEP signed ACO	Ref. 23 pp. 2-5
naphthalene	NJDEP signed ACO, NJDEP Selected Substances Report	Ref. 23 pp. 2-5; 8, pp.1-7
1,2-dichlorobenzene	NJDEP signed ACO , NJDEP Selected Substances Report	Ref. 23 pp. 2-5; 8, pp.1-7
1,3-dichlorobenzene	NJDEP signed ACO , NJDEP Selected Substances Report	Ref. 23 pp. 2-5; 8, pp.1-7
1,2,3-trichlorobenzene	NJDEP signed ACO	Ref. 23 pp. 2-5
1,2,4-trichlorobenzene	NJDEP signed ACO, NJDEP Selected Substances Report	Ref. 23 pp. 2-5; 8, pp.1-7
chlorobenzene	NJDEP signed ACO	Ref. 23 pp. 2-5
trichloroethylene	NJDEP signed ACO	Ref. 23 pp. 2-5
tetrachloroethylene	NJDEP signed ACO	Ref. 23 pp. 2-5
benzene	NJDEP signed ACO	Ref. 23 pp. 2-5

Hazardous Substance	Evidence	Reference
toluene	NJDEP signed ACO	Ref. 23 pp. 2-5
hydrochloric acid	NJDEP signed ACO	Ref. 23 pp. 2-5

Chemical Analysis

On 2 and 3 October, 2002, the EPA Superfund Contract Support Team conducted a sampling event at the Standard Chlorine site to investigate the extent of VOC, BNA, PCB, pesticides, total metals and dioxin contamination in the surface water and sediments located in the southern drainage ditch onsite and on the banks of the Hackensack River (Ref. 14, pp. 2).

Samples SC-SW/SED-01 through SC-SW/SED-04 were taken in the Hackensack River during low tide. SC-SED-01 was taken downstream of the Standard Chlorine site, off shore of the Koppers property. SC-SW/SED-04 were taken upstream from the Standard Chlorine site off shore of the Diamond Shamrock property. Sample SC-SW-01 was taken from a visible seep in the river bank 8.7 feet east of the southern outfall. SC-SW-02 was collected directly from the surface water discharging from the culvert pipe into the Hackensack River. SED-02 was collected 18.5 feet east of the southern outfall and SC-SW/SED-03 were collected where the bank came in contact with the River, 72 ft east of the outfall (Ref. 14, pp. 3, 93).

Samples SC-SW/SED-05 through SC-SW/SED-08 were taken in the southern drainage ditch on the eastern portion of the site, between the right of way and the Hackensack River. SC-SW/SED-07 was taken from a branch of the drainage ditch that seems to originate south of lagoon area (Ref. 14, pp.4, 93).

Samples SC-SW/SED-09 through SC-SW/SED-12 were collected from the southern drainage ditch on the west side of the right of way. Duplicate SC-SW/SED-30 was collected with SC-SW/SED-10 (Ref. 14, pp.5, 93).

Samples SC-SW/SED-13 through SC-SW/SED-16 were taken in the open water where the drainage ditch appears to have deteriorated and opened up into the wetlands. This area was accessed by boat. SC-SW/SED-13 was located at the confluence of the wetlands and the upstream segment of the southern drainage ditch. SC-SW/SED-14, 15, and 16 were taken in the wetlands area on the Koppers property (Ref. 14, pp.5-6, 93).

Samples SC-SW/SED-17 though SC-SW/SED-20 were taken in the upstream portion of the drainage ditch that originates onsite. SC-SW/SED-19 was taken in a cove that branched off to the west. The sample was taken at a pipe which appears to empty into this cove area. SC-SW/SED-20 was taken as close to the origination point as was accessible by boat. A duplicate sample SC-SW/SED-31 was taken with SC-SW/SED-18. (Ref. 14, pp.6, 93) This portion of the stream was apparently lined by a responsible party as an interim remedial measure, but it has not been maintained, as plant growth has grown through tears and holes (Ref. 28, pp.2). It also does not appear to line the entire ditch as sediment samples were easily obtained without encountering the liner (Ref. 14, pp. 18-20). Sample SC-SW/SED-21 was from the portion of the ditch south of Building 2 (Ref. 14, pp. 6, 93).

Because the southern drainage ditch originates onsite, background sample locations were not found. However, not all contaminants were found in all sample locations, therefore, this lack of uniform distribution of these not naturally occurring man-made substances will serve to set a “background level” of non-detect.

- Background Concentrations:

Sample ID	Sample Medium	Sample Location	Depth	Date	Reference
SC-SW-04	surface water	upstream Hackensack River, 263' north of north outfall and 24' from bank	surface	10/02/02	Ref. 14, pp. 93, 926
SC-SW-05	surface water	east end of drainage ditch, 11' west of wooden berm wall.	surface	10/02/02	Ref. 14, pp. 93, 928
SC-SW-09	surface water	19'4" west of center of right of way	surface	10/03/02	Ref. 14, pp. 93, 936
SC-SW-10	surface water	94'10" west of center of right of way	surface	10/03/02	Ref. 14, pp. 93, 938
SC-SW-11	surface water	155'8" west of center of right of way	surface	10/03/02	Ref. 14, pp. 93, 940
SC-SW-13	surface water	wetland area at confluence of southern drainage ditch and wetlands, near fence	surface	10/03/02	Ref. 14, pp. 93, 944
SC-SW-14	surface water	southwest wetland area, across from drainage ditch entry	surface	10/03/02	Ref. 14, pp. 93, 946
SC-SW-15	surface water	northeast wetland area, across from SC-SW-14 and south of drainage ditch	surface	10/03/02	Ref. 14, pp. 93, 948
SC-SW-16	surface water	cove in west end of wetland, as far west as possible	surface	10/03/02	Ref. 14, pp. 93, 950
SC-SW-17	surface water	originating onsite drainage ditch, 21'2" from fence at channel confluence	surface	10/03/02	Ref. 14, pp. 93, 952
SC-SW-18	surface water	originating onsite ditch, 106'9" from fence at channel confluence, at bend in ditch	surface	10/03/02	Ref. 14, pp. 93, 954
SC-SW-21	surface water	112' west of southeast corner of existing building 2	surface	10/03/02	Ref. 14, pp. 93, 960

Sample ID	Sample Medium	Sample Location	Depth	Date	Reference
SC-SED-05	sediment	east end of drainage ditch, 11' west of wooden berm wall.	0-3.0 inches	10/02/02	Ref. 14, pp. 93, 929
SC-SED-06	sediment	east end of drainage ditch, 312' west of wooden bermed wall	0-3.0 inches	10/02/02	Ref. 14, pp. 93, 931
SC-SED-07	sediment	east end of drainage ditch, from a cove to the north, 67 ft east of right of way, directly below a pipe south of lagoons	0-3.0 inches	10/02/02	Ref. 14, pp. 93, 933
SC-SED-08	sediment	east end of drainage ditch, 21'7" feet east of right of way	0-3.0 inches	10/02/02	Ref. 14, pp. 93, 935
SC-SED-09	sediment	19'4" west of center of right of way	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 937
SC-SED-10	sediment	94'10" west of center of right of way	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 939
SC-SED-11	sediment	155'8" west of center of right of way	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 941
SC-SED-12	sediment	246'8" west of center of right of way	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 943
SC-SED-15	sediment	northeast wetland area, across from SC-SW-14 and south of drainage ditch	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 949
SC-SED-17	sediment	originating onsite ditch, 21'2" from fence at channel confluence	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 953
SC-SED-20	sediment	originating drainage ditch, as far north as accessible, 96'1" from SC-SED-19	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 959
SC-SED-21	sediment	drainage ditch, 112' west of southeast corner of existing building 2	0-3.0 inches	10/03/02	Ref. 14, pp. 93, 961

Sample ID	Hazardous Substance	Concentration (µg/kg)	Reporting Limit (µg/kg)	Reference
SC-SW-04	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND* ND ND	4.0 4.0 4.0	14, pp. 650
SC-SW-05	chlorobenzene	ND	10	14, pp. 561
SC-SW-09	1,4-dichlorobenzene	5.6	4.0	14, pp. 665
SC-SW-10	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND ND 6.0	4.0 4.0 4.0	14, pp. 668
SC-SW-11	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND ND 6.3	4.0 4.0 4.0	14, pp. 670-671
SC-SW-13	naphthalene 1,2,4-trichlorobenzene	ND ND	4.0 4.0	14, pp. 677
SC-SW-14	chlorobenzene 1,2,4-trichlorobenzene	ND ND	10 4.0	14, pp. 680, 740
SC-SW-15	chlorobenzene 1,2,4-trichlorobenzene	ND ND	10 4.0	14, pp. 683, 742
SC-SW-16	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND ND 4.2	10 4.0 4.0	14, pp. 685, 686, 743
SC-SW-17	1,2,4-trichlorobenzene	ND	4.0	14, pp. 689
SC-SW-18	naphthalene	ND	4.0	14, pp. 692
SC-SW-21	naphthalene	5.6	4.0	14, pp. 697
SC-SED-05	chlorobenzene 1,2,4-trichlorobenzene	ND ND	4,900 1,400	14, pp. 549, 584
SC-SED-06	1,2,4-trichlorobenzene	ND	860	14, pp. 587
SC-SED-07	1,4-dichlorobenzene	480 JQM***	520	14, pp. 589
SC-SED-08	chlorobenzene	ND	2,800	14, pp. 553
SC-SED-09	chlorobenzene	ND	2,900	14, pp. 711
SC-SED-10	naphthalene chlorobenzene 1,2,4-trichlorobenzene	ND ND ND	650 2,900 650	14, pp. 599, 712
SC-SED-11	chlorobenzene 1,2,4-trichlorobenzene	ND ND	2,700 780	14, pp. 603, 714
SC-SED-12	chlorobenzene	ND	3,600	14, pp. 715

Sample ID	Hazardous Substance	Concentration (µg/kg)	Reporting Limit (µg/kg)	Reference
SC-SED-15	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND ND 5,100	11,000 3,300 3,300	14, pp. 614, 720
SC-SED-17	naphthalene	ND	1,500	14, pp. 620
SC-SED-20	naphthalene	ND	1,600	14, pp. 630

Notes: * ND = non-detect. These samples have been chosen to demonstrate a background level for these contaminants. These contaminants are man-made substance which are not ubiquitous in the area.
*** JQM is the qualifier used to indicate that the results are estimated values below the established "Reporting Limit" of the method. The Laboratory generally reports results down to the reporting limit of the method. Results with a "J" have a decreased accuracy relative to results that are reported equal to or above the Reporting Limit of the method (Ref. 14, pp. 542). The Reporting limit of samples qualified JQM is being used as the value indicative of a relative background level for this contaminant. Even though the contaminant is present, it is present below a value that is still three times below the values of the release samples.

Sample ID	Hazardous Substance	Concentration nanograms/kilogram (ng/kg)	EMPC/EDL *** (ng/kg)	Reference
SC-SED-08	2,3,7,8-TCDD	ND*	4.05	14, pp. 845
SC-SED-11	2,3,7,8-TCDD	1.53	10.0	14, pp. 857
SC-SED-20	2,3,7,8-TCDD	ND	0.982	14, pp. 899
SC-SED-21	2,3,7,8-TCDD	21.7	20.0	14, pp. 903

Notes: * ND = non-detect. These samples have been chosen to demonstrate a background level for this contaminant. 2,3,7,8-TCDD is a man-made substance which is not ubiquitous in the area.
***Estimated Maximum Possible Concentrations/Estimated Detection Level is reported by laboratory for samples that are non-detect. The SOW DLM01.4 does not require the lab to report EDLs for hit samples. Therefore, the Contract Required Quantitation Limit (CRQL) of 1.0 ng/kg is being used for those samples where the sample specific EDL is not available. CRQLs of samples that have been diluted have been adjusted for the dilution factor (Ref. 26).

- Sample Concentrations Adjusted for Total Organic Carbon

In order to account for the variations in total organic carbon found in the sediment samples and its possible influence on contaminant levels, the concentration of contaminant in µg/kg was divided by the total organic carbon in µg/kg. The result was then multiplied by 10^6 in order to make the results more manageable numbers. The resultant value represents the concentration of contaminant in grams per kilogram (g/kg) per g/kg of total organic carbon. This was done to ensure that the observed releases were due to actual increases in contamination, not due to the nature of the media. All samples used in the observed release have been normalized and are three times above the normalized background concentrations.

Sample ID	Hazardous Substance	Concentration (µg/kg)	Total Organic Carbon (TOC) (µg/kg)	Normalized Concentration (concentration/ TOC)*10^6	Normalized Concentration of Reporting Limit (concentration/ TOC)*10^6	Reference
SC-SED-05	chlorobenzene 1,2,4-trichlorobenzene	ND ND	29,000,000	ND		14, pp. 549, 584, 765; 15
SC-SED-06	1,2,4-trichlorobenzene	ND	15,000,000	ND		14, pp. 587, 766; 15
SC-SED-07	1,4-dichlorobenzene	480 JQM***	25,000,000	19.2	20.8	14, pp. 589, 767; 15
SC-SED-08	chlorobenzene	ND	27,000,000	ND		14, pp. 553, 768; 15
SC-SED-09	chlorobenzene	ND	18,000,000	ND		14, pp. 711, 769; 15
SC-SED-10	naphthalene chlorobenzene 1,2,4-trichlorobenzene	ND ND ND	11,000,000	ND ND ND		14, pp. 599, 712, 770; 15
SC-SED-11	chlorobenzene 1,2,4-trichlorobenzene	ND ND	14,000,000	ND ND		14, pp. 603, 714, 771; 15
SC-SED-12	chlorobenzene	ND	12,000,000	ND		14, pp. 715, 772; 15
SC-SED-15	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	ND ND 5,100	170,000,000	ND ND 30.0		14, pp. 614, 720, 775; 15

Sample ID	Hazardous Substance	Concentration (µg/kg)	Total Organic Carbon (TOC) (µg/kg)	Normalized Concentration (concentration/ TOC)*10^6	Normalized Concentration of Reporting Limit (concentration/ TOC)*10^6	Reference
SC-SED-17	naphthalene	ND	28,000,000	ND		14, pp. 620, 777; 15
SC-SED-20	naphthalene	ND	14,000,000	ND		14, pp. 630, 780; 15

Notes:
*** JQM is the qualifier used to indicate that the results are estimated values below the established "Reporting Limit" of the method. The Laboratory generally reports results down to the reporting limit of the method. Results with a "J" have a decreased accuracy relative to results that are reported equal to or above the Reporting Limit of the method (Ref. 14, pp. 542). The Reporting limit of samples qualified JQM is being used as the value indicative of a relative background level for this contaminant. Even though the contaminant is present, it is present below a value that is still three times below the values of the release samples.

Sample ID	Hazardous Substance	Concentration nanograms/kilogram (ng/kg)	Total Organic Carbon (TOC) (µg/kg)	Normalized Concentration (concentration/ TOC)*10^6	Reference
SC-SED-08	2,3,7,8-TCDD	ND*	27,000,000	ND	14, pp. 768, 845; 15
SC-SED-11	2,3,7,8-TCDD	1.53	14,000,000	.000109	14, pp. 771, 857; 15
SC-SED-20	2,3,7,8-TCDD	ND	14,000,000	ND	14, pp. 780, 899; 15
SC-SED-21	2,3,7,8-TCDD	21.7	160,000,000	.000136	14, pp. 781, 903; 15

- Contaminated Samples:

Sample ID	Sample Medium	Sample Location	Distance from PPE	Depth	Date	Reference
SC-SW-02	surface water	directly from outfall from southern drainage ditch into Hackensack River	. 1084' 4" PPE4	surface	10/02/02	14, pp. 93, 922
SC-SW-03	surface water	Hackensack River 72' east of southern outfall	. 1156' PPE4	surface	10/02/02	14, pp. 93, 924
SC-SW-06	surface water	east end of drainage ditch 312' west of wooden berm wall	. 772' PPE4	surface	10/02/02	14, pp. 93, 930
SC-SW-07	surface water	east end of drainage ditch, from a cove to the north, 67 ft north of the edge of right of way, directly below a pipe south of lagoons	0ft - PPE2	surface	10/02/02	14, pp. 93, 932
SC-SW-08	surface water	east end of drainage ditch, 21'7" east of right of way	. 665'7" PPE4	surface	10/02/02	14, pp. 93, 934
SC-SW-09	surface water	19'4" west of center of right of way	. 561'5" PPE3	surface	10/03/02	14, pp. 93, 936
SC-SW-12	surface water	246'8" west of center of right of way	. 398' PPE4	surface	10/03/02	14, pp. 93, 942
SC-SW-19	surface water	104' from SC-SW-18; just past bend in drainage ditch there is a cove to west. Collected below a 6 inch pipe just east of building 2.	0 ft - PPE3	surface	10/03/02	14, pp. 93, 956
SC-SW-20	surface water	originating drainage ditch, as far north as accessible, 96'1" from SC-SW-19	96'1" - PPE3	surface	10/03/02	14, pp. 93, 958
SC-SW-21	surface water	drainage ditch, 112' west of the southeast corner of Building 2	0ft - PPE4	surface	10/03/02	14, pp. 93, 960
SC-SED-05	sediment	east end of drainage ditch, 11' west of wooden bermed wall	. 1073' PPE4	0-3.0 inches	10/02/02	14, pp. 93, 928

Sample ID	Sample Medium	Sample Location	Distance from PPE	Depth	Date	Reference
SC-SED-08	sediment	east end of drainage ditch, 21'7" east of right of way	.665'7" PPE4	0-3.0 inches	10/02/02	14, pp. 93, 935
SC-SED-09	sediment	19'4" west of center of right of way	.561'5" PPE3	0-3.0 inches	10/03/02	14, pp. 93, 937
SC-SED-11	sediment	155'8" west of center of right of way	.301'9" PPE3	0-3.0 inches	10/03/02	14, pp. 93, 941
SC-SED-12	sediment	246'8" west of center of right of way	.398' PPE4	0-3.0 inches	10/03/02	14, pp. 93, 943
SC-SED-13	sediment	wetland area at confluence of onsite originating ditch and wetlands, near fence	.378'4" PPE4	0-3.0 inches	10/03/02	14, pp. 93, 945
SC-SED-14	sediment	southwest wetland area, across from drainage ditch entry.	>210'9" PPE3	0-3.0 inches	10/03/02	14, pp. 93, 947
SC-SED-15	sediment	northeast wetland area, across from SC-SED-14, south of drainage ditch	>210'9" PPE3	0-3.0 inches	10/03/02	14, pp. 93, 949
SC-SED-16	sediment	cove in west end of wetland area, as far west as possible	>378'4" PPE4	0-3.0 inches	10/03/02	14, pp. 93, 951
SC-SED-18	sediment	onsite originating ditch, 106'9" from fence at channel confluence, at bend in ditch	104' from PPE3	0-3.0 inches	10/03/02	14, pp. 93, 955
SC-SED-19	sediment	104' from SC-SED-18; just past bend in drainage ditch there is a cove to west. Collected below a 6 inch pipe just east of building 2.	0ft - PPE3	0-3.0 inches	10/03/02	14, pp. 93, 957
SC-SED-20	sediment	originating drainage ditch, as far north as accessible, 96'1" from SC-SED-19	96'1" from PPE3	0-3.0 inches	10/03/02	14, pp. 93, 959
SC-SED-21	sediment	drainage ditch, 112' west of southeast corner of building 2	0ft - PPE4	0-3.0 inches	10/03/02	14, pp. 93, 961

Sample ID	Hazardous Substance	Concentration (μg/kg)	Reporting Limit (μg/kg)	Reference
SC-SW-02	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	45 12 4.0 JQM	4.0	14, pp. 644
SC-SW-03	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	42 11 4.0 JQM	4.0	14, pp. 647
SC-SW-06	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	77 16 79	5.0	14, pp. 656
SC-SW-07	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	270 82 200	5.0	14, pp. 659
SC-SW-08	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	100 33 77	4.0	14, pp. 662
SC-SW-09	naphthalene	33	4.0	14, pp. 665
SC-SW-12	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	31 6.7 15	10 4.0 4.0	14, pp. 674, 737
SC-SW-19	1,4-dichlorobenzene	46	4.0	14, pp. 694
SC-SW-20	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	600 45 420	10 4.0 4.0	14, pp. 697, 749
SC-SW-21	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	760 200 610	10 4.0 4.0	14, pp. 700, 751
SC-SED-05	naphthalene	1,900	860	14, pp. 584
SC-SED-08	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	4,500 1,400 3,000	680	14, pp. 593
SC-SED-09	naphthalene	6,300	890	14, pp. 596
SC-SED-11	naphthalene	840	780	14, pp. 603
SC-SED-12	naphthalene	3,700	1,200	14, pp. 605
SC-SED-13	naphthalene 1,4-dichlorobenzene	3,400 18,000	2,600	14, pp. 608-609

Sample ID	Hazardous Substance	Concentration (μg/kg)	Reporting Limit (μg/kg)	Reference
SC-SED-14	naphthalene	4,900	3,100	14, pp. 611
SC-SED-16	naphthalene 1,4-dichlorobenzene	5,700 13,000	25,00	14, pp. 617
SC-SED-18	naphthalene	970	960	14, pp. 624
SC-SED-19	naphthalene chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	23,000 250,000 2,900,000 6,000,000	13,000 26,000 13,000 13,000	14, pp. 626, 725
SC-SED-20	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	43,000 1,700 21,000	43,000 1,600 1,600	14, pp. 629-630, 727
SC-SED-21	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	41,000 25,000 240,000	7,400 3,900 3,900	14, pp. 632-633, 728

Notes:
*** JQM is the qualifier used to indicate that the results are estimated values below the established "Reporting Limit" of the method. The Laboratory generally reports results down to the reporting limit of the method. Results with a "J" have a decreased accuracy relative to results that are reported equal to or above the Reporting Limit of the method (Ref. 14, pp. 542).

Sample ID	Hazardous Substance	Concentration (ng/kg)	EMPC/EDL *** (ng/kg)	Reference
SC-SED-13	2,3,7,8-TCDD	96.4	30.0	14, pp. 865
SC-SED-14	2,3,7,8-TCDD	81.0	30.0	14, pp. 869
SC-SED-15	2,3,7,8-TCDD	91.7	20.0	14, pp. 873
SC-SED-16	2,3,7,8-TCDD	50.0	10.0	14, pp. 877
SC-SED-19	2,3,7,8-TCDD	85.1	20.0	14, pp. 889

Notes:
***Estimated Maximum Possible Concentrations/Estimated Detection Level is reported by laboratory for samples that are non-detect. The SOW DLM01.4 does not require the lab to report EDLs for hit samples. Therefore, the Contract Required Quantitation Limit (CRQL) of 1.0 ng/kg is being used for those samples where the sample specific EDL is not available. CRQLs of samples that have been diluted have been adjusted for the dilution factor (Ref. 26).

- Sample Concentrations Adjusted for Total Organic Carbon

In order to account for the variations in total organic carbon found in the sediment samples and its possible influence on contaminant levels, the concentration of contaminant in µg/kg was divided by the total organic carbon in µg/kg. The result was then multiplied by 10^6 in order to make the results more manageable numbers. The resultant value represents the concentration of contaminant in grams per kilogram (g/kg) per g/kg of total organic carbon. This was done to ensure that the observed releases were due to actual increases in contamination, not due to the nature of the media. All samples used in the observed release have been normalized and are three times above the normalized background concentrations.

Sample ID	Hazardous Substance	Concentration (µg/kg)	Total Organic Carbon (TOC) (µg/kg)	**Normalized Concentration (concentration/ TOC)*10^6	Reference
SC-SED-05	naphthalene	1,900	29,000,000	65.517	14, pp. 584, 765; 15
SC-SED-08	naphthalene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	4,500 1,400 3,000	27,000,000	166.667 51.852 111.111	14, pp. 593, 768; 15
SC-SED-09	naphthalene	6,300	18,000,000	350.000	14, pp. 596, 769; 15
SC-SED-11	naphthalene	840	14,000,000	60.000	14, pp. 603, 771; 15
SC-SED-12	naphthalene	3,700	12,000,000	308.333	14, pp. 605, 772; 15
SC-SED-13	naphthalene 1,4-dichlorobenzene	3,400 18,000	130,000,000	26.154 138.462	14, pp. 608-609, 773; 15
SC-SED-14	naphthalene	4,900	120,000,000	40.833	14, pp. 611, 774; 15
SC-SED-16	naphthalene 1,4-dichlorobenzene	5,700 13,000	120,000,000	47.500 108.333	14, pp. 617, 776; 15
SC-SED-18	naphthalene	970	16,000,000	60.625	14, pp. 624, 778; 15
SC-SED-19	naphthalene chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	23,000 250,000 2,900,000 6,000,000	100,000,000	230.000 2,500 29,000 60,000	14, pp. 626, 725, 779; 15
SC-SED-20	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	43,000 1,700 21,000	14,000,000	3071.429 121.429 1,500	14, pp. 629-630, 727, 780; 15
SC-SED-21	chlorobenzene 1,2,4-trichlorobenzene 1,4-dichlorobenzene	41,000 25,000 240,000	160,000,000	256.25 156.25 1,500	14, pp. 632-633, 728, 781; 15

Sample ID	Hazardous Substance	Concentration (ng/kg)	Total Organic Carbon (TOC) (µg/kg)	**Normalized Concentration (concentration/ TOC)*10^6	Reference
SC-SED-13	2,3,7,8-TCDD	96.4	130,000,000	.000742	14, pp. 773, 865; 15
SC-SED-14	2,3,7,8-TCDD	81.0	120,000,000	.000675	14, pp. 774, 869; 15
SC-SED-15	2,3,7,8-TCDD	91.7	170,000,000	.000539	14, pp. 775, 873; 15
SC-SED-16	2,3,7,8-TCDD	50.0	120,000,000	.000417	14, pp. 776, 877; 15
SC-SED-19	2,3,7,8-TCDD	85.1	100,000,000	.000851	14, pp. 779, 889; 15

Attribution

Standard Chlorine operations at the site included manufacturing of moth crystals and flakes from dichlorobenzene. Standard Chlorine separated dichlorobenzenes at the site from 1963 to 1982. Standard Chlorine also separated and stored 1,2,4-trichlorobenzene at the site from 1970 to 1980. SNP processed liquid petroleum naphthalene at the site from 1963 until 1982. Raw materials were transported to the site by rail and tank truck for processing. Chloroben Chemical Corporation (Chloroben), a subsidiary of Standard Chlorine, operated a batch formulation and blending operation at the site for various drain cleaners known as "Chloroben". From 1963 until 1981, chloroben products were made from 1,2-dichlorobenzene, after which they were produced from hydrochloric acid, sulfuric acid, and methyl benzoate (Ref. 23, pp.2).

A NJDEP Selected Substances Report dated August 1980 indicates that Standard Chlorine disposed of an estimated 12,000 lb/yr of waste from the processing of 1,2,4-trichlorobenzene into the lagoon system between 1975 and 1979 (Ref. 23, pp.2; 6, pp.1-7). Also listed as substances present at the site include 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, and naphthalene (Ref. 23, pp.2).

Standard Chlorine has been found in violation of the Spill Compensation and Control Act, specifically N.J.S.A. 58:10-23.11c, and the Water Pollution Control Act, specifically N.J.S.A. 58:10A-6. as stated in the ACO issued by the NJDEP and signed by NJDEP and Standard Chlorine on October 20 and October 18, 1989, respectively (Ref. 23, pp.5, 18). The violations were issued for the past and current discharges of hazardous substances and pollutants into the waters and onto the lands of the State of New Jersey (Ref. 23, pp.5). The hazardous substances and pollutants referenced in the violations include dioxin, naphthalene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, trichloroethylene, tetrachloroethylene, benzene, chlorobenzene, toluene, and hydrochloric acid (Ref. 23, pp. 2-5) .

In 1985, NJDEP conducted the Phase II Dioxin Investigation, which identified 23 sites in New Jersey suspected of contamination with halogenated dibenzo-p-dioxins, specifically 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, or dioxin). The Standard Chlorine site was included in the investigation because Standard Chlorine once produced and stored two dioxin related compounds at the site, 1,2,4-trichlorobenzene and 1,2-dichlorobenzene (Ref. 11, pp. 7). Results from this sampling event prompted a more in-depth dioxin investigation by Standard Chlorine (Ref. 23, pp.3). In February and March 1987, a "Stage I" dioxin sampling event was conducted (Ref. 6, pp.2-2; 12; 23, pp.4). Samples were collected at four depths at a total of 20 locations. The first two shallow samples were analyzed and the two deeper core samples were archived to be analyzed for dioxin if the shallow samples revealed contamination (Ref. 12, pp. 19; 23, pp.4). The results of the re-analyzed samples are referred to as Stages II and III (Ref. 6, pp. 2-2; 12, pp. 19; 13, pp. 11-12). These samples were taken in the lagoon area and show contamination of 2,3,7,8-TCDD (Ref. 6, pp. 2-3, fig. 116-2.8; 12, pp. 8-9, 21, 24; 13, pp. 13,14-15, 24, 25).

Most of the site drainage reaches the southern drainage ditch which also receives runoff from the Koppers property to the south. Shallow groundwater also discharges to the ditch. The sediments in the drainage ditch have a yellow-brown color which also forms a scum on the water surface (Ref. 7, pp. 7-9; 28, pp.5-8). This appears to be related to the chromium fill (Ref. 8, pp. 5-25). While it is possible that surface water and sediments in the southern drainage ditch may be impacted from contaminants from the Koppers property to the south of the site, the highest concentration of contaminants were detected in the center of the property where the ditch originates onsite. The contaminants detected in the surface water and sediment samples collected in the southern drainage ditch are all site attributable compounds (Ref. 8, 5-33).

Furthermore, the observed release by direct observation demonstrates that at least part of the significant increase in contaminant concentrations is due to releases from the site (Ref. 14, pp. 3, 542, 641, 920;23, pp. 2-5).

Hazardous Substances Released

naphthalene
1,4-dichlorobenzene
1,2,4-trichlorobenzene
chlorobenzene
2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, or dioxin)
1,2-dichlorobenzene
1,3-dichlorobenzene
1,2,3-trichlorobenzene
trichloroethylene
tetrachloroethylene
benzene
toluene
hydrochloric acid

Surface Water Observed Release Factor Value: 550

4.1.3.2 Human Food Chain Threat Waste Characteristics

4.1.3.2.1 Toxicity/Persistence/Bioaccumulation

Hazardous Substance	Source No.	Toxicity Factor Value	Persistence Factor Value*	Bioaccu-mulation Value**	Toxicity/ Persistence/ Bioaccumulation Factor Value (Table 4-16)	Ref.
1,4-dichlorobenzene	1,2, OR	10	.4000	50	200	2, pp. B-7
2,3,7,8-TCDD	1, OR	10000	1	5000	50,000,000	2, pp. B-17
naphthalene	1,2, OR	100	.4000	500**	20,000	2, pp. B-13
1,2,4-trichlorobenzene	1,2, OR	100	.4000	500	20,000	2, pp. B-18
chlorobenzene	1,2, OR	100	.0007	50	3.5	2, pp. B-4
1,2 dichlorobenzene	1,2, OR	10	.4000	50	200	2, pp. B-7
1,3 dichlorobenzene	1,2, OR	0	.4000	50	0	2, pp. B-7
1,2,3 trichlorobenzene	2, OR	0	0	0	0	2, pp. B-18
trichloroethylene	2, OR	10	.4000	50	200	2, pp. B-18
tetrachloroethylene	2, OR	100	.4000	50	2000	2, pp. B-16
benzene	1,2, OR	100	.4000	5000	200,000	2, pp. B-2
toluene	1,2, OR	10	.4000	50	200	2, pp. B-17
hydrochloric acid	OR	1000	.4000	0.5	200	2, pp. B-11
methylene chloride	1,2	10	.4000	5.0	20	2, pp. B-13
ethylbenzene	1	10	.4000	50	200	2, pp. B-9

Notes:

C Persistence value for Rivers

** Bioaccumulation factor value for higher of freshwater or saltwater - Bioaccumulation factor for naphthalene is the saltwater value. HRS states that if any fisheries are in brackish water [Hackensack River has a salinity ranging from 0-16 parts per thousand (Ref. 22, pp. 27)], use the BCF data that yield the higher factor value to assign the bioaccumulation potential factor value to the hazardous substance (HRS 4.1.3.2.1.3, pp.51617)

Toxicity/Persistence/Bioaccumulation Factor Value: $5x10^7$

4.1.3.2.2 Hazardous Waste Quantity

Source No.	Source Type	Source Hazardous Waste Quantity
1	surface impoundment	2033.33
2	contaminated soil	>0

Sum of Values: 2933

Hazardous Waste Quantity Factor Value: 100
(Table 2-6)

4.1.3.2.3 Waste Characteristics Factor Category Value

Toxicity/Persistence Factor Value: 10,000
Hazardous Waste Quantity Factor Value: 100
Bioaccumulation value: 5,000

Toxicity/Persistence Factor Value x Hazardous Waste Quantity Factor Value: $1x10^6$
(10,000 x 100 = $1x10^6$)
(Max $1x10^8$)

Bioaccumulation potential factor value x
(Toxicity/Persistence Factor Value x Hazardous Waste Quantity Factor Value): $5x10^9$
(5,000 x $1x10^6$ = $5x10^9$)
(Max $1x10^{12}$)

Waste Characteristics Factor Category Value: 180
(Ref. 1, Table 2-7)

4.1.3.3 Human Food Chain Threat Targets

Actual Human Food Chain Contamination

Sample ID	Sample Medium	Distance from PPE	Hazardous Substance	Bioaccumulation Factor Value	Refs.
SC-SW-02, SC-SW-03	surface water	SW-03 is .1073'5" ft from PPE3	naphthalene	20000	14, pp. 93, 644, 647, 922, 924; 2, pp. B-13, B-18
SC-SW-02, SC-SW-03	surface water	SW-03 is .1137' from PPE4	1,2,4-trichlorobenzene	20000	14, pp. 93, 644, 647, 922 924; 2, pp. B-13, B-18

- Closed Fisheries: While no fisheries are designated as closed, there is a Health Advisory issued for the Hackensack River regarding the consumption of blue crab and striped bass due to dioxin contamination and american eel, white perch, and white catfish due to PCB contamination in the river. The Hackensack River advisory is included as part of the Newark Bay complex advisory (Ref. 18; 19).

Identity of Fishery	Sample ID	Distance from PPE	Hazardous Substance	Refs.
Hackensack River	SC-SW-02	.1084'4" from PPE4	naphthalene 1,2,4-trichlorobenzene	14, pp. 93, 644, 922
Hackensack River	SC-SW-03	.1156' from PPE4	naphthalene 1,2,4-trichlorobenzene	14, pp. 93, 647, 924

Level I Concentrations

No Level I fisheries were identified in the TDL.

Most Distant Level II Sample

Sample ID: SC-SW-03
Distance from the probable point of entry: .1156 ft from PPE4
Reference: 14, pp. 93, 647, 924

Fishing for consumption regularly takes place on the Hackensack River despite the Health Advisory (Ref, 20; 21). There are two popular fishing locations on the banks of the river both up and downstream from Standard Chlorine and hook and line fishing from boats takes place on the River off the Standard Chlorine property (Ref. 20; 21;28, pp. 13-15).

Level II Fisheries

Identity of Fishery	Extent of Level II Fishery (Relative to PPE or Level I Fishery)	Refs.
Hackensack River	There is a Level II Fishery in the Hackensack River at SC-SW-03. SC- SW-03 is located approximately 1156 ft from PPE4.	14, pp. 93, 647, 924; 18; 19; 20; 21

4.1.3.3.1 Food Chain Individual

Sample ID: SC-SW-03
Level I/Level II/or Potential: Level II
Hazardous Substance: naphthalene, 1,2,4-trichlorobenzene
Bioaccumulation Potential: 20,000

Identity of Fishery	Type of Surface Water Body	Dilution Weight (Table 4-13)	Refs.
Hackensack River	moderate to large stream	0.01	24

Food Chain Individual Factor Value: 45

4.1.3.3.2 Population

4.1.3.3.2.1 Level I Concentrations

No Level I fisheries were identified within the TDL.

4.1.3.3.2.2 Level II Concentrations

Identity of Fishery	Annual Production (pounds)	References	Human Food Chain Population Value (Table 4-18)
Hackensack River	>0	20; 21	.03

Sum of Level II Human Food Chain Population Values: 0.03

Level II Concentrations Factor Value: 0.03

4.1.3.3.2.3 Potential Contamination

The surface water migration pathway has a maximum score of 100.00 based on actual contamination, therefore potential surface water targets were not evaluated.

Potential Contamination Factor Value: 0

4.1.4.2 Environmental Threat Waste Characteristics

4.1.4.2.1 Ecosystem Toxicity/Persistence/Bioaccumulation

Hazardous Substance	Source No.	Ecosystem Toxicity Factor Value[a]	Persistence Factor Value*	Environmental Bioaccu-mulation Value**	Ecosystem Toxicity/ Persistence/ Bioaccumulation Factor Value (Table 4-21)	Ref.
1,4-dichlorobenzene	1,2, OR	100	.4000	50	2000	2, pp. B-7
2,3,7,8-TCDD***	1, OR	10000	1	5000	$5x10^7$	2, pp. B-17
naphthalene	1,2, OR	1000	.4000	5000**s	$2x10^6$	2, pp. B-13
1,2,4-trichlorobenzene	1,2, OR	1000	.4000	500	$2x10^5$	2, pp. B-18
chlorobenzene	1,2, OR	1000	.0007	50	35	2, pp. B-4
1,2 dichlorobenzene	1,2, OR	100	.4000	50	2000	2, pp. B-7
1,3 dichlorobenzene	1,2, OR	100	.4000	50	2000	2, pp. B-7
1,2,3 trichlorobenzene	2, OR	0	0	0	0	2, pp. B-18
trichloroethylene	2, OR	100*f	.4000	50	2000	2, pp. B-18
tetrachloroethylene	2, OR	100*f	.4000	50	2000	2, pp. B-16
benzene	1,2, OR	1000*s	.4000	50000**s	$2x10^7$	2, pp. B-2
toluene	1,2, OR	100	.4000	50	2000	2, pp. B-17
hydrochloric acid	OR	1	.4000	0.5	0.2	2, pp. B-11
methylene chloride	1,2	10*s	.4000	5.0	20	2, pp. B-13
ethylbenzene	1	100*f	.4000	50	2000	2, pp. B-9

Notes:

* Persistence value for Rivers

** Bioaccumulation factor value for Salt water - Bioaccumulation factors for naphthalene and benzene are the Saltwater values. HRS states that if any sensitive environments are in brackish water [Hackensack River has a salinity ranging from 0-16 parts per thousand (Ref. 22, pp. 27)], use the BCF data that yield the higher factor value to assign the bioaccumulation potential factor value to the hazardous substance (HRS 4.1.4.2.1.3, pp.51617)

*** Data for TCDD

[a] Ecosystem Toxicity factor value for saltwater (*s) or freshwater (*f). HRS states that if some of the sensitive environments being evaluated are in freshwater and some are in saltwater, or if any are in brackish water [Hackensack River has a salinity ranging from 0-16 parts per thousand (Ref. 22, pp. 27)], use the value (freshwater or marine) that yields the higher factor value to assign the ecosystem toxicity factor value to the hazardous substance (HRS 4.1.4.2.1.1, pp.51621)

Ecosystem Toxicity/Persistence/Bioaccumulation Factor Value: $5x10^7$

4.1.4.2.2. Hazardous Waste Quantity

Source No.	Source Type	Source Hazardous Waste Quantity
1	surface impoundment	2933.33
2	contaminated soil	>0

Sum of Values: 2933

Hazardous Waste Quantity Factor Value: 100
(Table 2-6)

4.1.4.2.3. Waste Characteristics Factor Category Value

Ecosystem Toxicity/Persistence Factor Value: 10,000
Hazardous Waste Quantity Factor Value: 100
Bioaccumulation value: 5,000

Ecosystem Toxicity/Persistence Factor Value x Hazardous Waste Quantity Factor Value: $1x10^6$
($10,000 \times 100 = 1x10^6$)
(max $1x10^8$)

Bioaccumulation potential factor value x
(Ecosystem Toxicity/Persistence Factor Value x Hazardous Waste Quantity Factor Value): $5x10^9$
($5,000 \times 1x10^6 = 5x10^9$)
(Max $1x10^{12}$)

Waste Characteristics Factor Category Value:180
(Ref.1, Table 2-7)

4.1.4.3 Environmental Threat Targets

Level I Concentrations

Because none of the contaminants found in the observed release have applicable benchmark values, all actually contaminated targets are subject to Level II contamination. Therefore there are no Level I targets in the TDL.

Most Distant Level II Sample

Sample ID: SC-SW-03
Distance from the probable point of entry: . 1156 ft from PPE4
Reference: 14, pp. 93, 647, 924

4.1.4.3.1 Sensitive Environments

4.1.4.3.1.1. Level I Concentrations

Because none of the contaminants found in the observed release have applicable ecological benchmark values, all targets are subject to Level II contamination. Therefore there are no Level I targets in the TDL.

Level I Concentrations Factor Value: 0

4.1.4.3.1.2. Level II Concentrations

Because none of the contaminants found in the observed release have applicable benchmark values, all actually contaminated targets are subject to Level II contamination.

Sensitive Environments

The Hackensack Meadowlands Habitat Complex has been identified by the US Fish and Wildlife Service as a Significant Habitat Complex of the New York Bight Watershed at the request of the US EPA's New York - New Jersey Harbor Estuary Program (Ref. 22, pp. 6). The Hackensack Meadowlands habitat complex includes the remaining tidal wetlands and adjacent palustrine wetlands and uplands along the lower Hackensack River north of Jersey City, New Jersey. The habitat complex is generally bounded by the Conrail railroad tracks and Route 17 to the west south, the New York, Susquehanna, and Western Railroad tracks to the east, and Route 46 to the north; its northwest corner is bounded by the runways at Teterboro Airport. The complex also includes the aquatic habitat and adjacent upland habitat of Overpeck Creek which feeds into the Hackensack River at the complex's northeastern end. This 8,400 acre wetland area encompasses the remaining wetlands and open space habitats that support significant concentrations of waterfowl, wading birds, shorebirds, raptors, anadromous fish, and estuarine fish (Ref. 22, pp. 26, 37).

Sensitive Environment	Distance from PPE to Nearest Sensitive Environment	References	Sensitive Environment Value (Table 4-23)
Hackensack Meadowlands	PPE1 is in Sensitive Environment. SC-SW-03 is located approximately 1156 ft from PPE4.	14, pp. 93, 542, 641, 647, 920, 924; 22 pp.26	Sensitive Area identified under National Estuary Program - 100

Sum of Level II Sensitive Environments Value: 100

Wetlands

The southern drainage ditch forms the northern frontage of 2 wetland areas designated on National Wetland Inventory maps as PEM1R (palustrine, emergent, persistent, seasonal-tidal), PEM5R (palustrine, emergent,) and E2EM5P (estuarine, Intertidal, emergent, mesohaline, irregularly flooded). The National Wetland Inventory Geographic Information Systems (GIS) data layer was overlain on a New Jersey Digital Orthophoto Quadrangle (DOQ). Wetland frontage was measured using the GIS scale in feet. Ref. 5 shows this overlay. It can be observed on the map that the NWI wetlands polygons do not properly line up with the known boundaries of the wetlands (the southern drainage ditch). This is believed to be an issue of the overlay. Photo-documentation and field observations indicate that wetlands extend to the southern drainage ditch and that this ditch does form the northern boundary of the wetlands (Ref. 14, pp. 11-17, 20, 944-951; 28, pp. 4-8). Wetland frontage was measured from the boundary of the NWI polygons, recognizing that this would be a conservative measurement.

Wetland	Wetland Frontage (miles)	References
PEM5R, PEM1R	905.81 ft = 0.17 miles	5
E2EM5P	444.54 ft = 0.08 miles	5

Sum of Level II Wetland Frontages: 0.25 miles
Wetlands Value (Table 4-24): 25

Sum of Level II Sensitive Environments Value + Wetlands Value: 125

Level II Concentrations Factor Value: 125

4.1.4.3.1.3 Potential Contamination

The surface water migration pathway has a maximum HRS score of 100.00 based on actual contamination, therefore potential surface water targets were not evaluated.

Potential Contamination Factor Value: 0

Ventron/Velsicol

New Jersey

EPA ID#: NJD980529879

EPA REGION 2

Congressional District(s): 09

Bergen

Wood-Ridge Borough

NPL LISTING HISTORY

Proposed Date: 9/1/1983

Final Date: 9/1/1984

Site Description

A mercury processing plant operated at the Ventron/Velsicol site from 1929 until 1974. Approximately 160 tons of process waste may have been buried on the 40-acre property. The Ventron facilities were abandoned and demolished in 1974. Two buildings have been erected on-site where the old mercury processing plant stood; presently, one of these buildings is used as a frozen food distribution center and the other for warehousing activities (mercury levels in indoor air are well below action levels). Contaminants still remain on-site and potential pathways for migration are groundwater and air. The Ventron/Velsicol site is located in a densely populated and industrialized area; however, access to the site is restricted. There are approximately 11,600 people living within a 1-mile radius of the site.

The investigation of the Berry’s Creek Study Area is considered a portion of the Ventron/Velsicol site. Discharges from the Ventron/Velsicol facility are known to have contaminated Berry's Creek with mercury and other chemicals. Mercury levels in the sediment adjacent to the former facility are very high. Other facilities in the Berry’s Creek Study Area may have contributed to the contamination of the creek and surrounding wetlands.

Site Responsibility: This site is being addressed through Federal, State, and potentially responsible party actions.

Threat and Contaminants

Soils, sediments, surface water, and groundwater are contaminated with mercury. Off-site sediments and surface water are contaminated with mercury and PCBs, as well certain metals.. Exposure to site-related contaminants could occur by ingestion of or direct contact with the water or sediments in the creek. In addition, on-site workers may also be exposed to contaminants located in the soils and sediments. Site-related contaminants are found in the wetlands adjacent to the creek. Exposure to mercury and PCBs via consumption of organisms in Berry’s Creek may impact people and wildlife. The Berry's Creek study will consider a wide range of contaminants besides mercury, as there are numerous potential sources of contamination to the creek within the Berry's Creek watershed.

Cleanup Approach

This site is being addressed in two phases. The first phase will address the contamination of soils and groundwater on the 40-acre property. The second phase will address contamination of marsh, wetland areas and all waterways.

Upland portion of the Site: A potentially responsible party, in cooperation with the State of New Jersey, conducted investigations into site contamination and the most effective methods to clean up the upland portion of the property. A remedy was selected in October 2006.

EPA is the lead agency for the second phase of investigations addressing contamination in Berry’s Creek and its adjacent wetlands and water bodies. A group of potentially responsible parties (PRPs) has agreed to conduct the studies necessary to evaluate the full extent of the problems in Berry's Creek and develop alternatives to address the contamination.

Cleanup Progress

Sampling of surrounding areas led to the discovery of elevated mercury levels in soil at nine residential properties and one publicly owned tract. In the fall of 1990, contaminated soils were removed from these properties and replaced with clean fill.

After completing the Remedial Investigation and Feasibility Study (evaluating alternatives to address contamination on the plant property) a Proposed Plan was released for public comment in August 2006. The remedy for the upland portion of the site was selected in October 2006, calling for; excavation and off-site disposal of soil with greater than 620 parts per million of mercury, capping of mercury contaminated soil above NJDEP non-residential direct contact soil cleanup criteria (270 ppm), deed restrictions on properties with contamination greater than the NJDEP residential soil cleanup criteria (14 ppm), and establishment of a clean buffer zone between capped areas and creeks or wetlands. A vertical hydraulic barrier system will be installed to serve as a physical barrier to ground water flow and to encapuslate the areas of highest mercury concentrations under one of the warehouses. Ground water use restrictions would be put in place, including a Classification Exception Area and a Well Restriction Area. The potentially responsible parties completed the design of the remedy and began soil remediation in Spring 2009. Construction was completed in December 2010.

In May 2008, approximately 100 parties agreed to conduct a remedial investigation for the Berry's Creek Study Area. Field work began in May 2009. Data collection to characterize the site is planned through 2013. The evaluation of alternatives and the remedy selection process will take approximately two years after data collection is complete.

In 2009, the New Jersey Meadowlands Commission planned to replace the tide gate adjacent to the property. It was determined that prior to replacing the tide gate it would be advantageous to remove the contaminated soil in that area to alleviate potential exposure to tide gate contractors and redistribution of contamination during construction. The potentially responsible party conducting the upland soil remediation at that time volunteered to conduct the work under an EPA Removal order and during Fall 2009 excavated approximately 4000 cubic yards of soil from around the tide gate. Replacement is the tide gate is still pending.

Site Repositories

Wood-Ridge Memorial Library 231 Hackensack Street Wood-Ridge, NJ 07075

USEPA Records Center 290 Broadway, 18th floor New York, NY 1007 (212) 637-4308

Third Five-Year Review Report

Universal Oil Products Superfund Site
East Rutherford
Bergen County, New Jersey

Prepared by:

United States Environmental Protection Agency
Region 2
Emergency & Remedial Response Division
New York, New York

September 2011

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EXECUTIVE SUMMARY

This is the third five-year review of the Universal Oil Products Superfund site, located in East Rutherford in Bergen County, New Jersey. This review covers the Operable Unit 1 (OU1) site remedy for soils and shallow groundwater (the shallow groundwater is referred to as "leachate" in the OU1 Record of Decision (ROD)). The OU1 remedy is considered an interim remedy as it pertains to the site acting as a continuing source of groundwater or surface water contamination. Groundwater under the site is non-potable (NJDEP Class III-B) so there is not a threat to human health from contaminants remaining in the groundwater at the site that would result from exposure to a source of potable water. The implemented remedy for OU1 protects human health and the environment in the short-term by controlling the exposure pathways that could result in unacceptable risks; however, in order for OU1 to be protective in the long-term, final institutional controls (deed notices) need to be implemented.

The OU1 remedy is fully implemented and the site is being returned to productive use; a portion of the site was redeveloped for commercial use prior to the last five-year review, and within the last five years, additional improvements to the site have taken place. These improvements have led to further response actions beyond that which was contemplated by the OU1 ROD, performed with oversight from the New Jersey Department of Environmental Protection (NJDEP) or EPA. Thus, this five-year review also documents these changes to the site and affirms that the remedy continues to be protective in light of these changes. OU1 is not the final action planned for the site; additional actions are contemplated including a non-time critical removal action (NTCRA) and an OU2 RI/FS.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name ***(from WasteLAN)*****: Universal Oil Products Site**		
EPA ID ***(from WasteLAN)*****: NJD 002005106**		
Region: 2	**State: NJ**	**City/County: East Rutherford/Bergen County**
SITE STATUS		
NPL status: X Final ☐ Deleted ☐ Other (specify)		
Remediation status (choose all that apply): ☐ Under Construction ☐ Operating X Complete		
Multiple OUs?* X YES ☐ NO	**Construction completion date:**	
Are site related properties currently in use? ☐ YES ALL X YES SOME ☐ NO NONE ☐ N/A GW		
REVIEW STATUS		
Lead agency: X EPA ☐ State ☐ Tribe ☐ Other Federal Agency ___________		
Author name: Doug Tomchuk		
Author title: Remedial Project Manager	**Author affiliation: EPA**	
Review period:** **09 / 29 /2006 to 09 / 29 / 2011**		
Date(s) of site inspection: 06 / 21 / 2011		
Type of review: X Post-SARA **Statutory** ☐ Pre-SARA or post-SARA **Policy** ☐ NPL-Removal only ☐ Non-NPL Remedial Action Site ☐ Regional Discretion		
Review number: ☐ 1 (first) ☐ 2 (second) X 3 (third) ☐ Other (specify) _______		
Triggering action: X Previous Five-Year Review Report ☐ Other (specify) ☐ Actual RA On-site Construction or RA Start at OU #____ ☐ Construction Completion		
Triggering action date ***(from WasteLAN)*****: 09 / 29 / 2006**		
Does the report include recommendation(s) and follow-up action(s)? X yes ☐ no		
Does the remedy protect the environment? X yes ☐ no		

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Five-Year Review Summary Form, cont'd.

Issues, Recommendations and Follow-up Actions:

Other than the two recommendations below, this report does not identify any issue or recommend any action at this site needed to protect public health and/or the environment that is not addressed by the remedy selected in the site decision documents as routinely operated, modified, maintained and adjusted over time.

1. Implement the institutional controls (deed restrictions) that were called for in the ROD.
2. Provide additional lines of evidence to support the finding that vapor intrusion does not cause unacceptable risk for the commercial buildings in Area 2 of the site.

Protectiveness Statement:

The implemented remedy for OU1 protects human health and the environment in the short-term by controlling the exposure pathways that could result in unacceptable risks. In addition, changes in site use since the last five-year review have been performed in such a manner that affected areas of the OU1 remedy continue to be protective.

In order for OU1 to be protective in the long-term, final institutional controls (deed notices) need to be implemented.

Other Comments:

None.

I. Introduction

The purpose of the five-year review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify issues found during the review, if any, along with recommendations to address them. This review was conducted pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. §9601 et seq. and 40 C.F.R. 300.430(f)(4)(ii) and with the *(Comprehensive Five-Year Review Guidance), OSWER Directive 9355.7-03B-P* (June 2001).

This is the third five-year review for the Universal Oil Products Superfund site, which is located in East Rutherford in Bergen County, New Jersey. The triggering action for this statutory review is the second five-year review for the site, which was approved on September 29, 2006. The five-year review is required due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

This review was conducted by U.S. Environmental Protection Agency (EPA) Remedial Project Manager (RPM) Douglas Tomchuk. This document will become part of the site file. Reports pertinent to this five-year review are listed in Table 2 of the report.

The site has been divided into six separate areas (Areas 1, 1A, 2, 3, 4, and 5) to be addressed in two operable units. OU1 consists of the upland portions of the site, the Areas 1, 1A, 2, and 5 (see Figure 1), and the shallow groundwater. OU2 consists of the area of the former waste lagoon, designated as Area 3, and the on-site stream channels (including Ackerman's Creek) and wetlands, designated as Area 4.

The remedial action for OU1 was addressed in a 1993 Record of Decision (ROD), and 1998 ROD Amendment. Construction of the remedial action began in March 1996 and most of the physical construction work was completed by 1999. There are two Remedial Action Reports for OU1; one for Areas 1, 1A and 5, and the groundwater remedial action, and another for Area 2. The Area 2 Remedial Action Report - Addendum was submitted in July 2006 to describe remedial activities associated with the redevelopment that occurred in Area 2. A Supplemental-Addendum to the Remedial Action Report for Area 2 was submitted in August 2008.

In 2007, an interim remedial measure (IRM) was conducted in accordance with New Jersey site remediation guidelines along the proposed path of a commuter rail right-of-way through the site because, after completion of the rail line, soils and sediments in that right-of-way would no longer be accessible. The rail line has now been installed across the site.

New Jersey Department of Environmental Protection (NJDEP) was the lead agency for the site from 1982 to 2008. In July 2008, EPA assumed the role of lead agency. In September 2010, EPA and Honeywell, a potentially responsible party (PRP) for the site, entered into a Settlement Agreement to complete the Remedial Investigation/Feasibility Study (RI/FS) activities for OU2 and to perform a NTCRA for the berms of the lagoon and the surrounding area. A draft RI

Report has been submitted for OU2; however, additional work is required to complete the OU2 RI/FS. That work is ongoing.

II. Site Chronology

Table 1 summarizes the relevant site-related events from discovery of contamination to the writing of this third five-year review.

III. Background

Site Location and Description

The UOP Superfund Site consists of an approximately 75-acre site located in the Borough of East Rutherford, Bergen County, New Jersey (Figure 1). The site, once a chemical facility, is in an urban/industrial area, and a portion of the site is within the Hackensack Meadowlands District, which is administered in part by the New Jersey Meadowlands Commission. The site is divided into 6 areas (Areas 1, 1A, 2, 3, 4 and 5). Area 2 has been redeveloped, including a home center (Lowes), a restaurant and a strip mall.

The nearby Berry's Creek has received contamination from the UOP site as well as from other hazardous waste sites in the vicinity. Creek sediments are contaminated with mercury, polychlorinated biphenyls (PCBs) and other chemicals. Fish and crabs in Berry's Creek and adjacent water bodies have been found to be contaminated with chemicals at levels that exceed U.S. Food and Drug Administration guidelines for human consumption, and NJDEP consumption advisories are in place for several species of fish and for crabs. An RI/FS for the Berry's Creek Study Area (BCSA) is ongoing.

Topography

Conditions at the site are complex, particularly the tidal interactions among the site operable units and nearby Berry's Creek. The site is mostly flat with elevations of four to nine feet above mean sea level for the upland areas of the site, Areas 1, 1A, 2, and 5. The 75-acre site is bounded on the east by State Route 17 and on the west by Berry’s Creek, and it is divided roughly into thirds by the New Jersey Transit Pascack Valley commuter rail line and by Murray Hill Parkway (see Figure 1). The site is regularly subjected to tidal flooding and is partly covered by a tidal salt marsh and a system of natural and artificial surface water channels. The tidal influence is lessened west of Murray Hill Parkway, and lessened again west of the New Jersey Transit right-of-way. The main channel on the site is referred to as Ackerman's Creek, which drains into Berry's Creek, a tidal tributary of the Hackensack River. Many flora and fauna are found in the vicinity of the site. Upland portions have been built up to current grade with miscellaneous fill material.

Geology/Hydrogeology

Groundwater at the site exists in two units. The upper unit consists of a layer of fill on top of an organic layer called meadow mat. This unit is isolated horizontally by the on-site surface waters and is generally brackish. In 1996, in response to a petition by the PRP, New Jersey designated this shallow aquifer at the site as Class III-B, non-potable and hydraulically connected to a saline water body. A deeper aquifer is separated from the shallow aquifer by approximately 100 feet of varved clay. The vertical hydraulic gradient in the area tends to be upward, and the site has not affected the deeper aquifer.

Because the groundwater is not considered potable, this review does not need to assess the protectiveness of the remedy with respect to groundwater consumption. As part of OU2, an evaluation of surface groundwater was conducted to determine whether groundwater contamination is contributing to contamination of the wetlands and creeks in Area 4 of the site. The study did not identify exceedances of New Jersey surface water quality standards for volatile organic compounds (VOCs). Exceedances of New Jersey surface water quality standards for PCBs were found, but they are likely from sediment resuspension. A comprehensive summary of these findings and a determination of the impact of remaining upper aquifer contamination will be included in the OU2 ROD.

Land and Resource Use

The UOP property is surrounded by undeveloped tidal marshes, highways, and commercial and light industrial properties. The closest residential area is approximately one-half mile to the west. The site is zoned for commercial and industrial development. Other former facilities in the immediate area, such as Becton Dickinson and Matheson Gas, had drainage systems that ultimately discharged to Ackerman's Creek, (i.e., these facilities may be upgradient sources of contamination to the site).

Area 2 has been redeveloped, including a home center (Lowes), a restaurant and a strip mall. Areas 1, 1A and 5 are fenced to restrict public access. The on-site landfill in Area 5 that was constructed as part of the remediation has an additional fence. Other areas on site with lower levels of contamination were capped with clean soil to prevent direct contact threats.

Area 3 is a lagoon, which is only accessible through Area 4 or along the train tracks. Area 4 is a wetland that is relatively inaccessible due to the soft muddy ground surface and phragmites, a common wetland plant. Area 4 is on both sides of the Murray Hill Parkway and borders Berry's Creek.

The New Jersey Transit Pascack Valley Line crosses the site between Area 2 and the rest of the site. An extension of the Pascack Valley Line to the Meadowlands Sports Complex, in planning during the last five-year review, has now been constructed and is operational. The Meadowlands rail spur extends across part of Area 4 (wetlands and waterways) crosses through the middle of the lagoon (Area 3) then crosses Areas 1A and 5 on its way to the Meadowlands Sports Complex. The other branch of the "Y" for return trains crosses Area 1. (See Figure 1)

Groundwater is not used at the site, and the groundwater has been classified as Class III-B, non-potable because of its hydraulic connection to a saline water body. As part of OU2, an evaluation of shallow groundwater was conducted to determine whether groundwater is contributing to contamination of the wetlands and creeks in Area 4 of the site. The only site-related contaminants detected above SWQS were PCBs. It is likely that the surface water exceedances were a result of sediment resuspension. Further review of surface water contamination will be included in the OU2 ROD.

There were no federally listed or proposed threatened or endangered species found at the site.

History of Contamination

The site was developed in 1932 and was originally used as an aroma chemical laboratory. Facilities were later expanded to handle chemical wastes and solvent recovery operations. Two waste water lagoons were used as holding areas for the facility wastewater. UOP acquired the property and facilities in 1960. Use of the waste treatment plant and waste water lagoons ceased in 1971. All operations at the facility ceased in 1979. In 1980, all site structures were demolished except for concrete slabs and a pipe bridge over the railroad tracks. During the years of operation, both the wastewater lagoons and the routine handling of raw materials and wastes resulted in the release of various hazardous substances to the soils and shallow groundwater.

Initial Response

The Universal Oil Products site was placed on the National Priorities List (NPL) on September 8, 1983.

Investigations conducted by the PRP with State oversight, completed in May 1985, provided sufficient information for NJDEP to direct the PRP to perform a removal action for contamination at the waste lagoons (Area 3). Contaminated media in the lagoons included water, waste sludges, and sediments. The removal action was conducted in 1990 by the PRP with state oversight pursuant to a May 23, 1986 Administrative Consent Order (ACO) with New Jersey. The ACO required excavation of all contaminated materials comprising the two waste lagoons, and disposal of the materials off site. The lagoons were dredged or excavated to the underlying clay and the berm between the two lagoons removed, resulting in one larger lagoon. No backfill was placed. This action was completed in August 1990.

Basis for Taking Action

The site was included on the NPL in 1983. In addition to the removal action described above, an RI/FS conducted in the early 1990s found that soils at the site were contaminated with polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), VOCs and lead, and that the groundwater at the site was contaminated with VOCs. Exposure scenarios included: young people trespassing on the property, future adult workers that would be present if the site was developed, and a construction worker population that would be present for a short period of time during any construction project.

Contaminants

The groundwater on the site was found to be contaminated with various VOCs, including benzene, chlorobenzene, 1,2-dichloroethene, trichlorethene, 1,1,2,2-tetrachloroethane and toluene. The maximum concentration of total VOCs in groundwater identified during the RI/FS was 210 parts per million (210 ppm). The soil was contaminated primarily with PCBs, PAHs, VOCs and lead. Maximum concentrations found on site were: greater than 2,000 ppm PCBs, 1,474 ppm PAHs, 2,108 ppm total VOCs, and 14,100 ppm lead. Chromium and mercury have also been identified in the sediment on site, to be assessed as part of the OU2 RI/FS.

IV. Remedial Actions

OU1 Remedy Selection - Upland soils and leachate

OU1 includes the upland areas of the UOP site (i.e. Areas 1, 1A, 2, and 5; see Figure 1). OU1 addresses contaminated soils and groundwater in upland areas. OU1 was addressed in a September 1993 ROD, a 1998 ROD Amendment and a 1999 Explanation of Significant Differences (ESD), each of which is described below. The 1993 ROD addresses all known soil contamination and contaminated groundwater (termed "leachate" in the ROD) in the upland areas of the UOP site. However, because part of the OU1 soil remedy calls for on-site containment, upon completion of the remedy, the ROD requires a determination of whether the remedy is protective of surface water and sediment quality in waterbodies adjacent to OU1 (i.e., Ackerman's Creek), and groundwater. Therefore, the remedy is considered an interim remedy.

The remedy selected for OU1 and documented in the September 1993 ROD consisted of the following:

For PCB/PAH-contaminated soils:

- The ROD requires the excavation and on-site treatment by thermal desorption of approximately 6,800 cubic yards of highly contaminated soil. Contaminated soils with PCB concentrations greater than 25 ppm or PAH concentrations greater than 29 ppm must be treated to below 10 ppm PCB and below 20 ppm PAH, placed on site, and covered. Soil cover must be at least 2 feet in depth.
- The ROD requires soil cover for contaminated soils with PCB concentrations less than 25 ppm (4.9 acres). All soils above remediation goals established in the ROD must be covered. Soil cover must be at least 2 feet in depth.
- The ROD requires institutional controls (deed restrictions) to prevent direct contact with remaining contamination.

For VOC-contaminated soils:

- The ROD requires excavation and on-site treatment by thermal desorption of approximately 7,000 cubic yards of soil with VOC concentrations above the remediation goal of 1,000 ppm total VOCs, and placement of treated soils on site.
- On-site thermal desorption will also be used to treat contaminated soils associated with

storm sewers on site.

For lead-contaminated soils:

- The ROD requires soil cover/impermeable cap (3.7 acres) for all soil above the remediation goal of 600 ppm of lead.
- The ROD requires institutional controls (deed restrictions) to prevent direct contact with remaining contamination.

For VOC-contaminated leachate (shallow groundwater):

- The ROD requires leachate collection from trenches and pits; on-site treatment of an estimated 5.6 million gallons of leachate exceeding remediation goals identified in the ROD; and discharge of treated effluent to groundwater. The areas delineated for leachate treatment are based on delineation criteria of 10 milligrams per liter (10 mg/l) of total VOCs or 1 mg/l of individual VOCs.

The remedial action described in the ROD addressed known soil contamination, and "leachate" that serves as a source of groundwater contamination in the OU1 upland areas. As discussed above, the selected remedial alternative for OU1 was identified as an interim remedy, specifically with regard to whether the VOC-contaminated soil treatment and leachate removal were sufficient to protect the surface water quality of Ackerman's Creek and groundwater. An evaluation of potential degradation of surface water from groundwater has been performed. Preliminary findings showed no exceedances of New Jersey surface water quality standards for VOCs. A final decision for groundwater will be documented in the OU2 ROD.

The 1993 remedy was amended in 1998 due to inefficiencies in the operation of the thermal desorption unit. This unit was also the source of odor complaints from workers at an adjoining property. In December 1998, a ROD Amendment was issued. The major components of the modified remedy are as follows:

- Approximately 6,200 tons of remaining sols with concentrations greater than the remedial action goals will be excavated;
- Soils with carcinogenic PAHs above the remediation goals will be disposed off-site;
- Soils with PCB concentrations at or above 50 ppm will be disposed of in a TSCA permitted landfill;
- Soils with PCB concentrations above 2 ppm but below 50 ppm will be disposed of in a RCRA Subtitle D permitted landfill.

In addition, an ESD in April 1999 changed the remedy technology for VOC-contaminated soils from thermal desorption to Thermally Enhanced Vapor Extraction (TEVE).

The PRP proposed several adjustments to the remedy, including lowering the thermal treatment goal for PCBs to less than 2 ppm, and placement of all treated materials beneath a multimedia cap. As these would provide additional protection, they were accepted by NJDEP and EPA.

A seep/sewer investigation determined that relatively high levels of VOCs were present in the on-site sewer system and were discharging to Ackerman's Creek. Therefore, NJDEP required, in addition to the remedial action specified in the ROD, that all sewers be cleaned of sediment or removed.

OU1 Remedy Implementation

Remedial construction under the 1993 ROD began in 1996. As of the date of the December 1998 ROD amendment, approximately 8,200 tons of the 14,400 tons of PCB/PAH contaminated soil on the site had been treated by thermal desorption. The soil that was treated, as well as less contaminated PCB/PAH soil, was placed on site in a containment area along with lead-contaminated soil. The on-site containment area is located primarily in Area 5 of the site.

Because of the problems with the thermal desorption system, the PRP chose to investigate other treatment options for the VOC-contaminated soils. In June 1998, a pilot test was conducted on the remaining 2,000 cubic yards of VOC-contaminated soil using a TEVE system Final soil sample results demonstrated that TEVE successfully treated the VOC-contaminated soils to the remediation goals.

A collection system for shallow groundwater was installed in Areas 1, 1A, 2 and 5. Over 2,800 linear feet of collection trenches, along with sumps and underground piping were installed. Once extracted, the water was conveyed to the water treatment plant, where it was treated with granular activated carbon. Treated water was discharged on site. A total of approximately 7 million gallons of shallow groundwater was extracted and treated. Groundwater collection and treatment started in 1996 and was completed in December 1998.

Remedial Action Reports addressing OU1 were submitted by the PRP in November 1997 for Area 2, and in August 2000 for Areas 1, 1A and 5.

The Remedial Action Report for Area 2 documented work completed including excavation of approximately 9,300 cubic yards of PCB/PAH contaminated soil and approximately 300 cubic yards of VOC-contaminated soil; thermal treatment of approximately 4,000 cubic yards of excavated soils; placement of excavated soils above remediation goals but below thermal treatment goals within the on-site containment area covered by a multi-media cap; installation of groundwater collection trenches and collection and treatment of approximately 2 million gallons of groundwater. NJDEP and EPA found several deficiencies in the implementation of the remedial action, which the PRP was required to address. Among these were findings of high PCB levels in post-excavation soil samples along the railroad right-of-way, requiring further delineation, excavation, and off-site disposal. In September 2001, the PRP submitted a revised Remedial Action Report for Area 2 which addressed the actions it took in response to the NJDEP and EPA concerns. In November 2004, NJDEP informed the PRP that NJDEP and EPA considered the remedial activities in Area 2 to have been conducted and completed in accordance with the 1993 ROD.

According to the Remedial Action Report for Areas 1, 1A and 5, work completed includes: excavation of approximately 27,000 cubic yards of soils primarily contaminated with PCBs and PAHs, approximately 13,000 cubic yards of VOC-contaminated soil, and 15,000 cubic yards of lead-contaminated soil; thermal treatment of approximately 10,500 cubic yards of excavated soil; installation of groundwater collection trenches and collection and treatment of approximately 4.8 million gallons of groundwater; placement of excavated soils above remediation goals but below thermal treatment goals within the on-site multi-media containment area; and construction of a multi-media cap over excavated soils. The Remedial Action Report for Areas 1, 1A, and 5 has not been approved, pending resolution of questions with respect to the interim groundwater remedy.

As a result of the requirements resulting from the seep/sewer investigation, all process, sanitary and storm sewers on site were cleaned or excavated. All manholes were sealed. Sediments removed from all sewers, as well as all excavated materials, were placed within the on-site containment area. As necessary to meet remediation goals, sediments were thermally treated along with the excavated upland soils prior to placement in the containment area.

Under the remedy, the site will be kept secure and hazardous substances at the site will be contained and prevented from leaving the properties via engineering controls, including the cap. According to the Remedial Action Reports, all upland site perimeters are enclosed by a security fence. Access to the site via the unfenced portion of the site perimeter is limited by the marshes and tidal channels. In addition, the containment area is enclosed by a fence to prevent unauthorized access. A monitoring program was implemented to determine the effectiveness of the remedy. Information pertaining to the monitoring is included in the Remedial Action Reports. Further investigation will be necessary to determine remedial actions necessary for the remaining portions of the UOP site (see below). The aquifer is designated as Class III-B, and is unsuitable for drinking. The NJDEP requires approval of water supply wells and will not allow groundwater on the site to be used as a drinking water supply. NJDEP has required the establishment of deed notices for areas of the site where contamination remains, however these deed notices are still pending.

OU1 Operation and Maintenance

The PRP conducts routine maintenance of the site including mowing and grubbing the capped area, and filling any areas that may show signs or erosion or damage from burrowing animals. Inspections are conducted semi-annually and include the capped area, drainage structures, security fences and locks, monitoring wells, and concrete foundation caps. There are no process operations currently ongoing.

V. Progress since the Last Review

A major portion of the work on the UOP site occurred prior to the first five-year review. Subsequent to the completion of the OU1 remedy, additional soils from OU1 were removed and disposed of off site during the development of Area 2. The additional soil removal that took place during the redevelopment of Area 2, and the Area 2 changes in use (from fenced open space to a developed commercial property) was discussed in the last five-year review, with the conclusion that the remedy at Area 2 is still protective.

New Jersey Transit Right-of-Way PCB Soils Removal

Additional contamination was also removed during the IRM along the New Jersey Transit rail line right-of-way. Between 2003 and 2005, New Jersey Transit conducted soil sampling and removal activities in the right-of-way in areas in and adjacent to the UOP site. Although the removal of PCB-contaminated soils along the rail line occurred prior to the second five-year review (September 2006), it was not reported in that document. Additional information on this action, (*e.g.*, sampling results) still needs to be supplied to EPA. The Pascack Valley line passes through the UOP site, between Area 2 and the rest of the site. The work was performed by New Jersey Transit. New Jersey Transit has stated that a total of 3,250 tons of soil containing PCBs between 2 and 5 ppm, and 678 tons of soils containing PCBs greater than 50 ppm were removed from the right-of-way and taken off site for disposal.

Meadowlands Rail Line Right-of-Way IRM

In 2006, recognizing that the alignment of the proposed rail link between the Pascack Valley Line and the Meadowlands Sports Complex would cross directly over unremediated portions of the UOP site, the New Jersey Sports and Exhibition Authority (NJSEA) conducted sampling along the proposed footprint of the rail line. In 2007, an IRM was conducted within portions of Areas 3 and 4, because they were heavily contaminated and would no longer be accessible for remediation after completion of rail line. NJDEP, EPA, and the PRP concluded that a preemptory action of removing all potentially contaminated sediments/soils to the native clay in the footprint of the right-of-way was the only available course of action. Sediment contamination was addressed typically by removing 4 feet of sediments from the existing grade within the proposed railroad footprint. The 4-foot depth was chosen to accommodate construction activities, and was associated with the beginning of native clay material; it was not based on risk calculations. Portions of the lagoon and tidal ditches along the rail right-of-way were excavated to a depth of 2 feet below the proposed final grade. In some areas, surcharge material was added to establish the rail bed above the existing grade. Because contaminated sediments/soils under the right-of-way for Areas 3 and 4 were removed to the native clay, confirmation sampling was not conducted as part of the IRM.

The UOP property on the east side of the Pascack Valley line was transferred from the PRP to NJSEA, which sponsored the rail line. In turn, the right-of-way for the rail line was transferred to New Jersey Transit. As part of these land transactions, responsibility for site cleanup remains with the PRP.

OU2 Remedial Investigation and EE/CA

Work on the OU2 portion of the site, which includes Areas 3 and 4, has moved forward substantially since the last five-year review. Although the IRM and construction work associated with the rail link delayed some of the RI data collections, the sampling and analysis have now been completed and a draft RI Report for OU2 was submitted in April 2011. Included in the RI effort has been hydrodynamic modeling to help evaluate the mobility of contaminants in the sediments on the UOP site. In addition, as part of the EPA Settlement Agreement (September 2010), the PRP agreed to conduct an Engineering Evaluation/Cost Analysis (EE/CA) for a NTCRA for the berms of the former lagoon and the surrounding area. A draft EE/CA was submitted in April 2011. The NTCRA is expected to be conducted during the 2012 construction season, and is expected to include removal, for off-site disposal, of the berms and sediment in the vicinity of the lagoon, which are contaminated with PCBs.

Berry's Creek Study Area RI/FS

The UOP site is contained within the Berry's Creek Study Area (BCSA), which is a separate but related CERCLA study. Over 100 parties, including Honeywell, are participating in the multi-year investigation on the BCSA. Data from both investigations has been shared to the extent possible. Additional coordination between the projects is expected as the field investigations near completion and the RI/FS process moves toward evaluation of alternatives.

VI. Five-Year Review Process

Administrative Components

The five-year review team consisted of Douglas Tomchuk (EPA-RPM), Lora Smith (EPA-Risk Assessor), Michael Scorca (EPA-Hydrogeologist) and Mindy Pensak (EPA-Ecological Risk Assessor). Dave Kluesner (EPA-Community Involvement Coordinator), Gwen Zervas (NJDEP Project Manager), and Steve MacGregor (NJDEP-Technical Support) were contacted to provide input.

Community Notification and Involvement

EPA notified the community of its initiation of the five-year review process by publishing a notice in the South Bergenite (East Rutherford section) on June 2, 2011. The notice indicated that EPA would be conducting a five-year review of the remedy at the Universal Oil Products Site to ensure that the remedy remains protective of public health and is functioning as designed. The notice included the RPM's address and telephone number for questions related to the five-year review process. In addition, the notice indicated that once the five-year review was completed, the results would be made available to the public at the following locations:

East Rutherford Municipal Building
1 Everett Place
East Rutherford, New Jersey 07073

East Rutherford Memorial Library
143 Boiling Springs Avenue
East Rutherford, New Jersey 07073

The RPM did not receive comments in response to the notice.

Document Review

A list of the documents that were reviewed in the preparation of this review can be found in Table 2.

Data Review

The draft RI Report for OU2 provides a substantial data set, which mostly applies to Areas 3 and 4, a portion of the site that has not been remediated yet. However, there were data collections in the OU1 portions of the site to determine whether contaminants remaining in the Class III-B aquifer may be impacting surface water or wetlands.

Groundwater in the Uplands area was collected and analyzed from 17 temporary well points in 2010. The screened intervals for these shallow points ranged from 1 to 11 feet to 5 to15 feet below ground surface. The northern part of the OU1 uplands still contains significant concentrations of several VOCs, including benzene, toluene, chlorobenzene, TCE, cis-1,2-DCE, ethylbenzene, etc.; however, the Class III-B State groundwater designation for this area recognizes that the aquifer could not be used as a potable water resource, and drinking water standards are not ARARs for the groundwater.

Analysis of three surface water samples that are near some of the temporary groundwater wells showed very low concentrations of a few VOCs. Although it is possible that some groundwater contaminants could be discharging to surface water, significant effects of groundwater on surface contamination are not apparent in the data at this time.

Site Inspection

A site inspection related to the five-year review was conducted on June 21, 2011. Those in attendance included: Douglas Tomchuk (EPA-RPM); Lora Smith (EPA-Risk Assessor); and Michael Scorca (EPA- Hydrogeologist). Also in attendance were Honeywell project manager Rich Galloway, Andy Hopton of CH2MHILL (Honeywell consultant) and Dave Forti of NJSEA.

The inspection included a walk-through of Areas 1 and 1A. NJSEA arranged for NJ Transit personel to be on site to assist in the rail crossings, and allowed observation of the proposed EE/CA area from the rail line over the lagoon. The landfill in Area 5 appeared maintained and secure - although it is suggested that mowing only be conducted outside of avian nesting season to ensure that ground nesting birds are not disrupted. The developed Area 2 seemed well maintained and there was nothing to note related to site remedy effectiveness.

Interviews

EPA Region 2 staff met on-site with the Honeywell project manager Rich Galloway, Andy Hopton of CH2MHILL (Honeywell consultant), and Dave Forti of NJSEA during the site visit. EPA also interviewed Gwen Zervas and Steve MacGregor of NJDEP. No other formal interviews were conducted for this review.

VII. Remedy Assessment

Question A: Is the remedy functioning as intended by the decision document?

The 1993 OU1 remedy for upland soils and leachate called for the following:

- Soils contaminated with PCBs and carcinogenic PAHs (cPAHs) - on-site thermal desorption of highly contaminated soils and placement of treated soils on site, soil cover for less contaminated soils and institutional controls;
- VOC-contaminated soils - on-site thermal desorption and placement of treated soils on site;
- Lead-contaminated soils - soil cover and institutional controls; and
- VOC-contaminated leachate (groundwater contaminated by the leaching of surface water through VOC-contaminated soils) - on-site treatment of leachate and discharge of treated effluent to groundwater.

A 1998 ROD Amendment for the OU1 remedy addressed the PCB- and cPAH-contaminated soils. Thermal desorption proved to be an inefficient remedy and caused odor complaints from the neighboring property. Elements of the amended remedy included: excavation of soils greater than the remedial action goals; off-site disposal of soils contaminated with cPAHs above site remediation goals; disposal of soils with PCB contamination above 50 ppm to a TSCA permitted landfill, and disposal of soils with PCB contamination above 2 ppm but less than 50 ppm to a RCRA Subtitle D landfill. Soil already capped as part of the original ROD was to remain in place.

In 1999, NJDEP issued an ESD to modify the VOC-contaminated soil remedy selected in the 1993 ROD. Thermal desorption was initially selected to remediate soils contaminated with PCBs, cPAHs, and VOCs but the thermal desorption unit ceased operation in 1998, as described in the ROD Amendment. As a result of the problems associated with running the thermal desorption unit, the PRP chose to investigate other treatment options. After a successful pilot study, the ESD remedy called for treatment of VOC-contaminated soils by way of a Thermally Enhanced Soil Vapor Extraction (TEVE) system.

As a result of the 1998 ROD Amendment and 1999 ESD, the 1993 ROD for upland soils and leachate is now functioning as intended as site soils have been remediated. Highly contaminated soils were treated and/or placed into an on-site landfill, and less contaminated soils were covered with clean soil, thereby protecting potential human and ecological receptors. Institutional controls pertaining to contaminated soils that remain on site under the soil cover have yet to be implemented. This remains the only outstanding action of the OU1 ROD.

The IRM and construction of the railroad right-of-way has been performed in a manner consistent with the implemented remedy. For areas of OU1, the rail line has been placed over areas previously capped as required by the ROD, further enhancing the protectiveness of the remedy.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?

The physical changes to the site following the remedy decision, redevelopment of Area 2 and construction of the rail link to the Meadowlands Sports Complex were both accompanied by additional investigations and contaminant removal and therefore have not adversely affected the protectiveness of the remedy.

Land use assumptions, exposure assumptions and pathways, and cleanup levels considered in the decision documents remain valid. No remedial action objectives (RAOs) were identified in the OU1 ROD; however, based on the remedy, it is assumed that the purpose was to minimize or eliminate dermal contact with contaminated soils and minimize or eliminate leaching of contaminants through the soil and into underlying groundwater. Although specific parameters have changed since the 1989 baseline risk assessment was completed, the process that was used remains valid.

Since the time of the ROD and since the last five-year review, New Jersey has promulgated new non-residential soil remediation standards. While some ROD cleanup goals are less conservative than current standards, they are within an order of magnitude and in most cases only a factor of two greater than current standards. Since EPA remediates carcinogens to a 10^{-6} risk level and our acceptable risk range is 10^{-6} to 10^{-4}, the updated standards remain within EPA's acceptable risk range. As a result, the remedy that was selected remains protective of human health and the environment.

Some treated and less contaminated soils remain on site under a soil cap. A majority of contaminated soils were disposed of off site as a result of the ROD Amendment. Removing contamination from the site resulted in a higher degree of protection of human health and the environment. Additionally, soils contaminated with VOCs were treated using a TEVE system rather than the originally proposed thermal desorption, which resulted in an expedited remediation process for VOCs. While ICs to protect the on-site soil cap have yet to be implemented, the cap is functioning as intended; therefore, no current exposure pathway exists and the remedy remains protective in the short term.

Groundwater beneath the site has been reclassified as non-potable (Class III-B) due to saltwater intrusion. As a result, no human health threats have been identified currently or in the future due to exposure to groundwater as a drinking water source.

An investigation of contamination that remains in the shallow aquifer was conducted during 2010. While no groundwater standards exist for Class III-B waters and no site-specific criteria have been developed, the NJDEP stated that its goal was to confirm that no remaining sources exist in the uplands (OU1) that are adversely affecting surface water quality. Only shallow temporary well points were used to monitor groundwater at the site during the most recent data collection (2010). A determination regarding whether shallow groundwater contamination impacts surface water will be included in the OU2 ROD.

In terms of surface water impacts, some site-related groundwater contaminants have been detected in the surface water, but most at concentrations below their respective saline surface water quality standards. The only site-related contaminants detected above SWQS were PCBs. Based on this information, it is difficult to ascertain whether the observed surface water contamination is a result of groundwater interaction or sediment resuspension. Continued surface water and groundwater monitoring will aid in determining the source of surface water contamination. Continued monitoring will also aid in trend analysis to determine whether the current and future remedies are functioning as intended.

Soil vapor intrusion (SVI) is evaluated when soils and/or groundwater are known or suspected to contain VOCs. The only recommendation from the 2006 five-year review was for new buildings in Area 2 to be evaluated for soil vapor intrusion to ensure that the cleanup goals remain protective for this pathway. This evaluation was submitted in the Supplement-Addendum to the Remedial Action Report for Area 2 in August 2008. The report also provided the design plans for the Lowes home center store, which includes a vapor barrier. Similar information (design documents including a vapor barrier) was not provided for the strip mall north of the Lowes store. As such, it has been assumed that such a barrier was not installed. The analysis included modeling of potential risk, based on several post remediation soil samples. While this analysis found that vapor intrusion should not cause unacceptable risks for the commercial buildings in Area 2, better methods for evaluating the potential of risk from vapor intrusion have been developed since that report was prepared. Additional investigations and analyses are recommended to provide additional lines of evidence to support the finding that vapor intrusion is not a concern for Area 2, and to put this issue to rest.

While much of the area east of the New Jersey Transit line is designated as wetlands or waterways, there are still upland portions of the site on which buildings could potentially be constructed. Some of these areas were recently found to still have fairly high levels of VOCs in the shallow groundwater. Therefore, soil vapor intrusion must be considered as part of any site reuse plans that include construction of buildings. For example, such consideration could include installation of a vapor mitigation system during construction, or the design of a sub-slab monitoring program (with installation of a mitigation system if vapors are detected above levels of concern).

An ecological risk assessment was not conducted for OU1. A preliminary survey of terrestrial plants and wildlife on the site was conducted in October 1988. The survey of terrestrial animals and both woody and herbaceous vegetation indicated no differences between study and reference areas that might be associated with environmental impact. Based on the results of the preliminary survey, it was determined that no further studies were warranted. The remediation goals for surface soil (Table 3) were compared to the Wildlife Preliminary Remedial Goals for Flora and Fauna (New Jersey Department of Environmental Protection, 2009, Ecological Screening Criteria, http://www.nj.gov/dep/srp/guidance/ecoscreening/). Several of the remedial goals were greater than the NJDEP's screening values (chrysene, PCB, lead and 1,1,2,2,-tetracholoethane).

While the methodology used to assess ecological risk does not follow our current Ecological Risk Assessment Guidance (EPA, 1997, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, EPA 540-R-97-006), it appears that the remedy in place is protective to ecological receptors as all surface soil contamination has been addressed via capping and soil cover. Therefore, there is no potential ecological risk associated with this pathway of exposure.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No.

Technical Assessment Summary

For the uplands (OU1) portion of the site, the remedy treated contaminated soil, removed contaminants off site or contained contaminants that remained on site. This review finds that the contaminants that remain on site are covered, surface soils are suitable for reuse for the anticipated human and environmental exposures, and areas with subsurface soil contamination are fenced. Therefore, the implemented remedy is functioning as intended by the decision documents.

VIII. Recommendations and Follow-Up Actions

Other than the two recommendations below, this report does not identify any issue or recommend any action at this site needed to protect public health and/or the environment that is not addressed by the remedy selected in the site decision documents as routinely operated, modified, maintained and adjusted over time.

Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Follow-up Actions: Affects Protectiveness (Y/N)	
				Current	Future
Implement the institutional controls (deed restrictions) that were called for in the ROD	PRP	NJDEP	June 2013	N	Y
Provide additional lines of evidence to support the finding that vapor intrusion does not cause unacceptable risk for the commercial buildings in Area 2 of the site	PRP	EPA	June 2014	N	N

IX. Protectiveness Statement

The implemented remedy for OU1 protects human health and the environment in the short term by controlling the exposure pathways that could result in unacceptable risks; however, in order for OU1 to be protective in the long-term, final institutional controls (deed notices) need to be implemented.

X. Next Review

The next (fourth) five-year review for the UOP site should be completed before September 2016, which is five years from this report's approval date.

Walter E. Mugdan, Director
Emergency and Remedial Response Division
EPA – Region 2

Sept. 26, 2011
Date

Table 1
Chronology of Site Events

Event	Date
Trubeck Laboratories developed the uplands portion of the site and operated an aroma and fragrance laboratory there.	1932 to 1979
Trubeck began operating a solvent recovery facility	1955
Trubeck constructed a wastewater treatment plant	1956
Started to utilize two on-site wastewater lagoons	1959
Universal Oil Products (a division of Signal Companies) acquired the property and facilities	1963
The wastewater treatment plant and wastewater lagoons ceased operations	1971
All remaining operations at the facility were closed	1979
UOP became a division of the Signal Companies	1979
All structures, except for the concrete building slabs and the pedestrian bridge across the NJ Transit tracks, were demolished	1980
The UOP site was added to the National Priorities List (NPL)	1983
An Administrative Consent Order (ACO) was issued by NJDEP for conducting investigations at the UOP site	1983
Allied Corporation merged with Signal Companies to form AlliedSignal	1984
A second ACO was issued for completing investigations and to conduct a feasibility study	1986
EPA released the Record of Decision of OU1 which addressed uplands soils and leachate. Called for thermal desorption for highly contaminated soils and placement of those treated soils into an on-site cap. Soil cover for less contaminated soils, collection and treatment of leachate (groundwater).	1993
ROD Amendment released by EPA. Treatment option for PCB/PAH contaminated soils was changed from vapor extraction to off-site disposal	1998
Pilot studies were conducted on treating VOC-contaminated soils with thermally enhanced vapor extraction	1998
EPA issued an Explanation of Significant Differences which changed the treatment for VOC-contaminated soils from thermal desorption to thermally enhanced soil vapor extraction.	1999

Event	Date
AlliedSignal became Honeywell International, Inc.	1999
First five-year review issued.	Sept. 28, 2001
NJDEP approved completion of remedial activities for Area 2.	2004
Development of Area 2 initiated. Construction of home center, restaurant and strip mall. During construction, approximately 50,000 cubic yards of contaminated material were excavated and disposed of off-site or stockpiled predominantly on Area 5.	2005
Characterization of contamination under proposed Meadowlands rail alignment	Nov 2005 to Jan 2006
Soil originally from Area 2, removed for off-site disposal	2006
Second five-year review issued	Sept. 29, 2006
IRM for material underlying Meadowlands rail alignment	2007
Administrative Settlement Agreement and Order on Consent for completing RI/FS for OU2 and to perform NTCRA	Sept. 27, 2010

Table 2

Documents Reviewed:

Record of Decision, September 1993
ROD Amendment, December 1998
Explanation of Significant Differences, April 1999
Addendum to the Remedial Action Report for Area 2, July 2006
Amended Remedial Action Report for Area 2, July 2001
Remedial Action Report for Areas 1, 1A and 5, August 2001
Final Interim Remedial Measure Action Report, June 2008
Quarterly Reports/Semi Annual Reports
Second Five-Year Review Report, September 2006
draft Supplement-Addendum to the Remedial Action Report for Area 2, August 2008
draft Uplands Groundwater Report, March 2011
draft Remedial Investigation Report for Operable Unit 2, April 2011
draft Engineering Evaluation/Cost Assessment, April 2011

Table 3: Cleanup Goals: OU1 ROD

Contaminant	Cleanup Goal
Soil	(mg/kg)
Benzo(b)fluoranthene	4
Benz(a)anthracene	4
Benzo(a)pyrene	0.66
Benzo(k)fluoranthene	4
Chrysene	40
Dibenz(ah)anthracene	0.66
Indeno(1,2,3-cd)pyrene	4
PCBs	2
Lead	600
VOCs	1000
1,1,2,2-Tetrachloroethane	21*
Groundwater	(mg/l)
Total VOCs	10
Individual VOCs	1

*The current New Jersey Soil Cleanup Criteria for 1,1,2,2-TCA include 70 mg/kg for nonresidential direct contact and 1 mg/kg for impact to groundwater. Please see the response to Question B for additional information.

Legend
- Becton Dickinson outfalls
- OU1-OU2 Boundary
- Historical Surface Drainage
- Storm Drain
- Areas of Concern
- Multi-media Cap
- UOP Site Boundary

Note:
- Functional Areas 1, 1A, 2, and 5 are considered the Uplands and comprise OU1. Functional Areas 3 and 4, the former wastewater lagoon and Streamlands, respectively, comprise OU2.
- MHP - Murray Hill Parkway

Figure 1-2
UOP Site Features and Functional Areas
OU2 Remedial Investigation Report
Universal Oil Products (UOP)
East Rutherford, NJ

CH2MHILL

Originator: M. Rissing/VBO   Checked by: T.Himmer/BOS

FIGURE 1

PJP Landfill
New Jersey
EPA ID#: NJD980505648

EPA REGION 2
Congressional District(s): 13
Hudson
Jersey City

NPL LISTING HISTORY
Proposed Date: 12/30/1982
Final Date: 9/8/1983

Site Description

The PJP Landfill covers 87 acres in Jersey City. The site may have been used as early as 1968 to dispose of an unknown quantity of chemical and industrial wastes. The New Jersey Department of Environmental Protection (NJDEP) certified the landfill to receive solid wastes in 1971. The landfill has a history of underground fires.

Presently, the site is closed, fenced and the landfill is partially capped. In March 2008, a portion of the site was purchased by AMB Corporation. They have begun construction of a warehouse and transfer station. It is expected that AMB will finished construction in 2014.

In June 2010, Jersey City signed an agreement with Waste Managment ,who was resposible for the remainder of the Landfill, to take over their portion of the property after Waste Management constructed a landfill cap. The cap was completed in early 2012. Jersey City took over all responsibility for the property in May 2012 and is working on construction of a park.

Approximately 11,900 people reside within a 1-mile radius of the site. The closest residence is within 1,000 feet of the site. A high-rise apartment complex and a park are within 1/2 mile. The site is bordered by the Hackensack River on the west. The river is used for boating and for commercial shipping.

Site Responsibility: This site is being addressed through a combination of State, Federal, and Potentially Responsible Party (PRP) actions. NJDEP is the lead agency

Threat and Contaminants

The shallow ground water in the vicinity of the site is contaminated with the heavy metal chromium, phenols, various pesticides, and volatile organic chemicals (VOCs). The leachate from the landfill is contaminated with VOCs, including benzene and chlorobenzene, and the heavy metal lead. The deeper aquifer has not been significantly impacted by the landfill. Potential health risks are possible from the accidental ingestion of contaminated ground water and leachate, or from direct contact with the contaminants. The Landfill is fenced and the drinking water is supplied through a municipal system.

Cleanup Approach

The site is being addressed in two stages: immediate actions and a long-term remedial phase directed at cleanup of the entire site.

Response Action Status

Initial Actions: In 1985, the New Jersey Department of Environmental Protection (NJDEP) extinguished the landfill fires through major excavation work and capping of the landfill. In addition, a gas venting system was installed to prevent the buildup of gases within the landfill.

Long-term Remedial Phase of the Entire Site: NJDEP began an investigation to determine the nature and extent of contamination, and to identify remediation options. All phases of the site investigation, which included field sampling of ground water, sediment, soil and surface water from the Hackensack River were completed in 1995. A Record of Decision (ROD), signed in September 1995, documented the remedy which includes: removing all buried drum materials; capping of the remaining landfill area; replacing of the Sip Avenue ditch with an alternative form of drainage; monitoring and modeling of groundwater/leachate; conducting quarterly site inspections; and creating institutional controls (e.g., deed restriction).

Site Facts: NJDEP entered into an Administrative Consent Order (ACO) with the PRPs for the Remedial Design/Remedial Action (RD/RA) for the Site on June 2, 1997. In 2007, Waste Management submitted a 100% Design Report which has been approved.

In early 2008, AMB submitted an amended design plan for the landfill cap for their portion of the site. The AMB design was approved in July 2008 and construction began in August 2008. As of May 2012, construction was on hold while PSE&G (local gas utility) relocates a gas line. Construction is expected to resume in the summer of 2012.

In April 2010, NJDEP approved Waste Management's revised design plan for construction of landfill cap on their portion of the Site. In June 2010, Jersey City signed an agreement with Waste Managment ,who was resposible for the remainder of the Landfill, to take over their portion of the property after Waste Management constructed a landfill cap. The cap was completed in early 2012. Jersey City took over all responsibility for the property in May 2012 and is working on construction of a park.

Cleanup Progress

Initial actions to extinguish underground fires at the site and the installation of a gas venting system have reduced the potential for exposure to hazardous contaminants at the site. NJDEP, with EPA concurrence, has issued a ROD for the site. The drum removal phase of the Remedial Design has been completed and activities associated with capping of the remaining landfill area have been initiated. About half of the landfill has been capped under these actions.

The amended 100% remedial design submitted by AMB in early 2008 was approved in July 2008. Construcion began in the fall of 2008. As of May 2012, construction is on hold while PSE&G (local gas utility) relocates a gas line. Construction is expected to resume in August 2012. A Classification Exception Area (CEA) was approved in July 2008 and the Deed Notice will be filed upon completion of construction.

In April 2010, NJDEP approved Waste Management's revised design plan for construction of landfill cap on their portion of the Site. In June 2010, Jersey City signed an agreement with Waste Managment ,who was resposible for the remainder of the Landfill, to take over their portion of the property after Waste Management constructed a landfill cap. The cap was completed in early 2012. Jersey City took over all responsibility for the property in May 2012 and is working on construction of a park.

A small section of the PJP Landfill is owned by Jay Dee Tucking and is an active industial company. The CEA was approved in November 2010 and a Deed Notice was filed in January 2011.

Site Repositories

Jersey City Public Library 472 Jersey Avenue Jersey City, NJ 07302 201-547-4516

US EPA Region 2 290 Broadway, 18th Floor NY, NY 10007 212-637-3261

Scientific Chemical Processing

New Jersey

EPA ID#: NJD070565403

EPA REGION 2

Congressional District(s): 09

Bergen

Carlstadt

NPL LISTING HISTORY

Proposed Date: 12/30/1982

Final Date: 9/8/1983

Site Description

The Scientific Chemical Processing site includes the 6-acre former Scientific Chemcial Processing Company property plus contaminated groundwater in the vicinity of this property. It is located in a light industrial area of Carlstadt. The property was used as a waste processing facility that accepted various wastes for recovery and disposal. About 375,000 gallons of hazardous substances were stored on site in tanks, drums, and tank trailers. The facility shut down operations in 1980 in response to a court order. Some company officials received fines and jail terms for illegally dumping hazardous waste. From 1979 to 1980, drums and contaminated soil were removed. The property is now vacant. A final remedy for the on-property soil and shallow groundwater, which prevents direct contact with contaminated soil and controls off-property migration of contamination from on-site soils and shallow groundwater, is in place. A proposed plan to address contaminated deep and off-property groundwater was issued in August 2012. The site is located within a coastal wetlands management area, bordered on the northeast by Peach Island Creek, a tidal waterway. Local surface water is used for recreation and industrial water supplies. There is a residential area located approximately 1.2 miles northwest of the site. All nearby businesses and residences are believed to be on public water supplies.

Site Responsibility: This site is being addressed through a combination of Federal, State, and potentially responsible parties' actions.

Threat and Contaminants

On-site groundwater and soil contamination includes volatile organic compounds (VOCs), including benzene, chloroform, and trichloroethylene (TCE); PCBs; polycyclic aromatic hydrocarbons (PAHs), including naphthalene; and heavy metals. The property is entirely fenced and bordered by Peach Island Creek on the northeast side, thereby reducing public access. The potential health risks to individuals who may come in contact with site pollutants through contact with contaminated soil and groundwater have been mitigated through the implementation of the final on-property remedy and the establishment of instituational controls to prevent the installation of groundwater wells within the contaminated area. The potential threat to coastal wetlands by site contaminants has also been reduced by the remedy. Contamination in the adjacent creek is being addressed as part of another superfund site, Berry's Creek.

Cleanup Approach

The site is being addressed in three stages: immediate actions and two long-term remedial phases. The first long-term remedial phase focused on cleanup of the on-property soil and shallow groundwater, while the second focuses on cleanup of the deeper aquifer and off-property groundwater contamination.

Response Action Status

Immediate Actions: To address the immediate threats posed by the contaminants, Inmar Associates, the property owner, removed 55 tanks and one tank trailer under New Jersey Department of Environmental Protection supervision between 1985 and 1986.

On-Property Soil and Shallow Groundwater: Under EPA oversight, the potentially responsible parties began conducting an investigation in 1985 to determine the type and extent of soil and groundwater contamination. In 1990, the EPA selected an interim remedy to address the contaminated soil and shallow groundwater on the former Scientific Chemical Processing Company property itself, which included construction of a slurry wall, infiltration barrier, and ground water collection system to retrieve groundwater for treatment off-site. This interim remedy, which was completed in June 1992, was intended to contain the contamination until a permanent remedy could be implemented. After further investigation and monitoring of the effectiveness of the interim remedy, in August 2002 EPA selected a final remedy for the on-property soil and shallow groundwater which essentially upgraded and made permament the interim remedy. The final remedy also included air stripping followed by solidification of a hot spot of soil contamination, with excavation of the hot spot if treatment was not successful, and the implementation of institutional controls to prevent the installation of groundwater wells in the contaminated area.

In July 2004 EPA reached a settlement with the responsible parties to undertake the on-property soil and shallow groundwater remedy, and the remedial design prepared by the responsible parties was approved by EPA in June 2007. Field work for the remedial action was initiated in April 2008 and was completed in October 2011. Treatment of the hot spot did not prove successful, so the area was excavated and the material was disposed of at an approved off-site facility.

Deep and Off-Property Groundwater: The parties potentially responsible for the contamination, under EPA oversight, also performed investigations of the deep and off-property groundwater to determine the type and extent of contamination present, and to identify cleanup alternatives. Groundwater was monitored over several years, and interim results reports were reviewed to refine the sampling program. The investigation was completed in 2009 and a feasibility study, describing cleanup alternatives, was completed in July 2012. EPA's proposed plan for cleanup of the deep and off-property groundwater was issued in August 2012 for public comment.

Site Facts: A Federal District Court trial resulted in the conviction of three corporate officials of Scientific Chemical Processing on charges arising from the disposal of bulk solvents into the Newark, New Jersey sewer systems and drummed wastes into Lone Pine Landfill. In September 1985, the EPA issued an Administrative Order on Consent to 108 respondents for the performance of an investigation to determine the type and extent of contamination at the site and to identify alternative technologies for the cleanup. In October 1985, the EPA issued a Unilateral Administrative Order to an additional 31 respondents, requiring them to cooperate with the 108 parties and to participate in the investigation. A civil complaint against Inmar was filed by the United States in January 1987. The complaint sought reimbursement for EPA's oversight costs as well as penalties for violation of the EPA's Administrative Order. A settlement was reached in 1988. In September 1990, EPA issued a Unilateral Administrative Order requiring 43 respondents to implement the interim remedy. The interim remedy was completed in June 1992. The final on-property soil and shallow groundwater remedy was implemented under a September 2004 Consent Decree, and was completed in October 2011.

Cleanup Progress

The owner of the property addressed immediate threats posed by the Scientific Chemical Processing site by removing 55 contaminated tanks and a tank trailer under EPA oversight. An interim remedy, which was intended to reduce migration of the contamination from on-property soil and shallow groundwater until a final remedy was selected and implemented, was put in place in 1992. In August 2002, a final remedy was selected for the on-property soil and shallow groundwater, and in 2004 an agreement was reached with the potentially responsible parties to design and implement the remedy. The design was completed in June 2007, implementation of the final remedy began in April 2008, and the remedy was completed in October 2011.

Extensive investigations of the deep and off-property groundwater have been conducted by the potentially responsible parties. Bench- and pilot-scale studies of potential remedies have been conducted and a feasibility study outlining potential cleanup approaches for the groundwater was finalized in July 2012. EPA's proposed plan to address the deep and off-property groundwater was issued in August 2012.

Site Repositories

EPA Records Center, Region II 290 Broadway, 18th Floor New York, New York, 10007-1866 (212) 637-3261 Hours: Monday to Friday, 9:00 am to 5:00 pm

William E. Demody Free Public Library, 420 Hackensack Street, Carlstadt, New Jersey

Superfund Program
Proposed Plan

U.S. Environmental Protection Agency
Region II

Scientific Chemical Processing Site
August 2012

EPA ANNOUNCES PROPOSED PLAN

This Proposed Plan identifies the U.S. Environmental Protection Agency's (EPA's) Preferred Alternative for addressing off-property and deep groundwater contamination at the Scientific Chemical Processing (SCP) Superfund Site (Site) in the Borough of Carlstadt, New Jersey. The Preferred Alternative for the contaminated groundwater is in-situ treatment, monitored natural attenuation and institutional controls. This Proposed Plan includes summaries of the cleanup alternatives that were evaluated for use at the Site. This document is issued by EPA, the lead agency for the Site, in conjunction with the New Jersey Department of Environmental Protection (NJDEP), the support agency.

EPA is issuing this document as part of its public participation responsibilities under Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), and Section 300.435 (c)(2)(ii) of the NCP. This document summarizes information that can be found in detail in the Administrative Record file for the Site. This Proposed Plan is being provided to inform the public of EPA's preferred remedy, and to solicit public comments pertaining to the preferred alternative. The remedy described in this Proposed Plan is the preferred remedy for the Site. Changes to the preferred remedy, or a change from the preferred remedy to another remedy, may be made if public comments or additional data indicate that such a change will result in a more appropriate remedial action. The final decision regarding the selected remedy will be made after EPA has taken all public comments into consideration. Therefore, the public is encouraged to review and comment on the preferred alternative considered by EPA in this Proposed Plan.

MARK YOUR CALENDAR

PUBLIC COMMENT PERIOD:

August 3, 2012 – September 4, 2012

EPA will accept written comments on the Proposed Plan during the public comment period.

PUBLIC MEETING:
August 9, 2012

EPA will hold a public meeting to explain the preferred remedy presented in the Proposed Plan. Oral and written comments will also be accepted at the meeting. The meeting will be held at the Carlstadt Borough Hall, located at 500 Madison Street, Carlstadt, New Jersey at 7:00 p.m.

For more information, see the Administrative Record at the following locations:

EPA Records Center, Region II
290 Broadway, 18th Floor
New York, New York 10007-1866
(212) 637-3261
Hours: Monday - Friday 9:00 am to 5:00 pm

The William E. Dermody Public Library
420 Hackensack Street
Carlstadt, NJ 07072
(201) 438-8866
Hours: Monday - Thursday 10:00 am to 9:00 pm, Friday 10:00 am to 5:00 pm, Saturday 10:00 am to 2:00 pm (closed Saturdays in July and August)

SITE HISTORY

The former SCP property lies at the corner of Paterson Plank Road (Route 120) and Gotham Parkway in Carlstadt, New Jersey. Peach Island Creek, a tributary to Berry's Creek, forms the northeastern border of the property and a trucking company forms the southeastern border (see Figure 1).

The land use in the vicinity of the Site is classified as light industrial by the Borough of Carlstadt. The establishments in the immediate vicinity of the Site include a bank, horse stables, warehouses, freight carriers, and service sector industries. There is a residential area located approximately 1.2 miles northwest of the Site.

The land on which the former SCP property is located was purchased in 1941 by Patrick Marrone, who used the land for solvent refining and solvent recovery. Mr. Marrone eventually sold the land to a predecessor of Inmar Associates, Inc. Aerial photographs from the 1950s, 1960s and 1970s indicate that drummed materials were stored on the property. On October 31, 1970, the Scientific Chemical Processing Company leased the property from Inmar Associates. SCP used the property for processing industrial wastes from 1971 until the company was shut down by court order in 1980.

While in operation, SCP received liquid byproduct streams from chemical and industrial manufacturing firms, and then processed the materials to reclaim marketable products which were sold to the originating companies. In addition, liquid hydrocarbons were processed to some extent, and then blended with fuel oil. The mixtures were typically sold back to the originating companies or to cement and aggregate kilns as fuel. SCP also received other wastes, including paint sludges, acids and other unknown chemical wastes.

In 1983, the Site was placed on the National Priorities List. Between 1983 and 1985, NJDEP required the property owner to remove approximately 250,000 gallons of wastes stored in tanks which had been abandoned at the Site.

In May 1985, EPA assumed the lead role in the response actions, and issued notice letters to more than 140 Potentially Responsible Parties (PRPs). EPA offered the PRPs an opportunity to perform a Remedial Investigation and Feasibility Study (RI/FS) for the Site, and in September 1985, EPA issued an Administrative Order on Consent to the 108 PRPs who had agreed to conduct the RI/FS. Subsequently, in October 1985, EPA issued a Unilateral Order to 31 PRPs who failed to sign the Consent Order. The Unilateral Order required the 31 PRPs to cooperate with the 108 consenting PRPs on the RI/FS. In the fall of 1985, EPA also issued an Administrative Order to Inmar Associates, requiring the company to remove and properly dispose of the contents of five tanks containing wastes contaminated with Polychlorinated Biphenyls (PCBs) and numerous other hazardous substances.

Inmar removed four of the five tanks remaining on the property in 1986. The fifth tank was not removed at the time because it contained high levels of PCBs and other contaminants, and disposal facilities capable of handling those wastes were not available at that time. The fifth tank and its contents were subsequently removed by the PRPs in February 1998 and disposed of at an EPA-approved off-site facility.

The PRPs initiated the RI/FS in April 1987, and it was completed in March 1990. The RI focused on the most heavily contaminated zone at the Site, which included the contaminated soil, sludge, and shallow groundwater within the SCP property, down to the clay layer (hereinafter, this zone will be referred to as the “Fill Area”). The RI also included data from the deeper groundwater areas, both on and off the SCP property. The deeper areas consist of the till aquifer, which lies just under the Fill Area’s clay layer, and the bedrock aquifer, which underlies the till aquifer. Groundwater within both the till and bedrock aquifer was found to be contaminated with site-related compounds. The RI also found that the adjacent Peach Island Creek’s surface water and sediments were impacted by contaminants similar to those found in the Fill Area.

The FS indicated that, although there seemed to be several potential methods or combinations of methods to remedy the Fill Area, there were uncertainties regarding the relative effectiveness of the various technologies. Consequently, EPA made a decision that treatment alternatives needed further assessment. In the meantime, however, measures were needed to contain and prevent exposure to the Fill Area contaminants. As such, an interim remedy for the on-property soil and shallow groundwater was selected in a September 1990 Record of Decision (ROD).

EPA typically addresses sites in separate phases and/or operable units. In developing an overall strategy for the Site, EPA has identified the interim Fill Area remedy as Operable Unit 1 (OU1), the final Fill Area remedy as OU2, and the off-property and deep groundwater remedy, which is the subject of this Proposed Plan, as OU3. Contamination in the adjacent Peach Island Creek will be addressed as part of another superfund site, Berry’s Creek. Peach Island Creek is a tributary to Berry’s Creek.

Interim Remedy: Soil and Shallow Groundwater on Property (OU1)

The goals of the interim remedy selected for OU1 were to prevent exposure to contaminated soil and sludge in the Fill Area and to prevent the contaminated groundwater within the Fill Area from migrating off-property. The interim remedy was constructed from August 1991 through June 1992 by the PRPs for the Site, with EPA oversight, pursuant to a Unilateral

Administrative Order dated September 28, 1990, and consisted of the following:

- A lateral containment wall comprised of a soil-bentonite slurry with an integral high density polyethylene (HDPE) vertical membrane surrounds the Fill Area and is keyed into the clay layer;
- A sheet pile retaining wall along Peach Island Creek;
- An HDPE horizontal infiltration barrier covering the property;
- An extraction system for shallow groundwater within the containment area with discharge to an above-ground storage tank for off-site disposal;
- A chain link fence around the property to restrict access; and
- Regular groundwater sampling, plus monitoring of the interim remedy to assure it remained effective until a final remedy was selected.

Final Remedy: Soil and Shallow Groundwater on Property (OU2)

While implementing the OU1 remedy, EPA continued to oversee additional RI/FS work which would provide information to select a final remedy for the Fill Area, as well as a remedy for the deep and off-property groundwater. A ROD selecting the Final Remedy for the Fill Area (OU2) was signed in August 2002. The major elements of the selected remedy included:

- Treatment of a Hot Spot area of contamination to reduce concentrations of volatile organic compounds, followed by soil stabilization of the area using cement and lime. If the treatment did not prove effective, the ROD specified that excavation of the Hot Spot area, with off-site disposal, would occur;
- Installation of a 2-foot thick “double containment” cover system over the entire Fill Area;
- Improvement of the existing, interim groundwater recovery system; and
- Improvement of the existing sheet pile wall along Peach Island Creek.

The OU2 remedy was implemented by the PRPs, with EPA oversight, pursuant to a Consent Decree entered in September 2004. Design of the remedy was completed in June 2007 and construction of the remedy was initiated in April 2008. Performance standards for the treatment and stabilization of the Hot Spot area of contamination were not met. As such, sludge and soil from the area was excavated and disposed of at an EPA-approved off-site disposal facility.

Implementation of the OU2 remedy was completed in October 2011. The groundwater recovery system is operating and regular maintenance is being conducted.

Off-Property and Deep Groundwater (OU3)

OU3 includes groundwater located outside of the boundaries of the former SCP property, as well as groundwater beneath the property, but deeper than the limits of the OU2 remedy (i.e., below the clay layer, in the till and bedrock aquifers). Investigation of OU3 groundwater has been ongoing since the initiation the RI for the Site in 1987. An Interim Data Report was submitted by the PRPs in 1997, and an Off-Property Groundwater Investigation Report was submitted in May 2003.

After reviewing the May 2003 report, EPA determined that additional investigation was needed to further define the nature and extent of groundwater contamination in the till and bedrock aquifers. The scope of the additional investigation was agreed to at a meeting with EPA in November 2006, and the associated fieldwork was conducted between March and July 2007. The Final Off-Property Groundwater Investigation Report for Operable Unit 3 (the Final RI for OU3) was submitted by the PRPs in July 2009.

A remedial action objectives and remedial alternatives (RAO/RA) report, identifying a preliminary list of remedial technologies for OU3, was submitted to EPA by the PRPs in June 2008. The RAO/RA report also proposed that bench and, possibly, pilot-scale studies be conducted to test the efficacy of certain remedial technologies for use at this Site.

Additional groundwater investigations were performed in advance of the bench and pilot-scale treatability studies that were conducted to support the OU3 FS. This additional investigation work was conducted in December 2009 and January 2010 in accordance with a work plan for additional groundwater delineation submitted by the PRPs in April 2009. The results were reported in an OU3 FS Phase 1 Treatability Studies report dated September 2010, which proposed further delineation activities and provided a work plan for an enhanced anaerobic bioremediation pilot test that is ongoing at the Site.

The OU3 RI/FS was completed in July 2012. The results of the OU3 RI are summarized below, and form the basis for the development of the FS report. Both documents, as well as the OU3 Human Health Risk Assessment, can be found in the Administrative Record for the Site.

SITE CHARACTERISTICS

The stratigraphy at the Site consists of the following layers:

- Man made fill (3 to 10 feet thick)
- Marine and marsh "meadow mat" (0 to 4 feet thick)
- Glaciolacustrine varved clay unit, including an upper stiff bedded unit and a lower soft plastic unit (0 to 20 feet thick)
- Glacial till, including a soft upper unit (0 to 17 feet thick) and an over-consolidated lower lodgement till (0 to 30 feet thick)
- Passaic Formation bedrock consisting of siltstones and mudstones with occasional interbeds of sandstones.

The geologic layers that are most relevant to OU3 include the glaciolacustrine varved material, which serves as a confining layer, and the underlying glacial till and bedrock aquifers, which are designated as Class IIA groundwater by the State of New Jersey, which means they are potential sources of drinking water. However, no wells in the affected area are used for potable water purposes.

Groundwater generally flows to the north from the property. However, the flow direction and water levels are significantly influenced by the presence of several extraction wells in the vicinity, used for non-residential, non-potable water purposes, which operate during the week and then sit idle during the weekend. During the weekend, flows can actually reverse direction and head south, away from the property, or more generally can flow towards the northwest.

Sampling Results

The results of the RI are summarized in the final report dated July 2009. Additional sampling conducted since that time has been incorporated into the FS for OU3.

The primary contaminants of concern in groundwater at the Site include Volatile Organic Compounds (VOCs), predominantly tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE), and vinyl chloride, localized areas of aromatic hydrocarbons, including benzene, toluene, ethylbenzene, and xylenes, and 1,4-dioxane.

There are two distinct areas of contamination in the OU3 groundwater. They are described separately below.

Northern Area Contamination

The primary contaminants of concern in the northern area are the VOCs mentioned above. Concentrations decrease substantially with increasing horizontal and vertical distance from the former SCP property. For example, the highest concentrations of total VOCs in the bedrock, approximately 3,000 parts per billion (ppb), were found in Monitoring Well -13R (MW-13R), which is located adjacent to the northwest corner of the former SCP property. Total VOC concentrations decrease to trace levels in the bedrock just 600 to 1,000 feet away horizontally. Concentrations also decline vertically, with only trace VOC concentrations detected in MW-23R, located adjacent to but deeper than MW-13R.

Similarly, the highest concentration of total VOCs detected in the till wells was approximately 5,500 ppb in MW-5D, which is located in the northwest corner of the property, and draws water from beneath the OU2 containment remedy. Concentrations in the till aquifer decline to 718 ppb in MW-20D, located approximately 500 feet north of the property, to 5 ppb in MW-26D, located approximately 950 feet north of the property. Total VOC concentrations also decline to 51 ppb in MW-25D, approximately 1,000 feet northwest of the property.

Southern Area Contamination

The primary contaminant of concern that defines the contamination to the south of the property is 1,4-dioxane, though other contaminants, including benzene and 1,1-dichloroethane, are also present at elevated concentrations. 1,4-dioxane has been detected in groundwater in the southern area at concentrations ranging from 5 ppb to 6,300 ppb. The highest concentrations were observed in the soft till, and were an order of magnitude higher than in groundwater samples collected in the deeper, lodgement till.

1,4-dioxane does not appear to be present above concentrations of concern in the bedrock aquifer.

SCOPE AND ROLE OF THIS ACTION

As stated previously, EPA is addressing this Site in three operable units, two of which have already been implemented. OU1 provided an interim infiltration barrier, slurry wall, groundwater collection system, and off-site disposal of contaminated groundwater. OU2 improved upon and made permanent the OU1 remedy. It constituted the final remedy for the Fill Area of the Site. OU3, the final operable unit and the subject of this Proposed Plan, addresses contaminated groundwater in the deeper aquifers where contamination extends off-property and under the OU2 containment area. The Remedial Action Objectives for OU3 are to prevent unacceptable exposures to impacted groundwater, control future migration of contaminants of concern in the groundwater, and restore groundwater quality to regulatory or risk-based concentrations.

SUMMARY OF OPERABLE UNIT 3 RISKS

The purpose of a human health risk assessment is to identify potential cancer risks and non-cancer health hazards at a site assuming that no further remedial action is taken. A baseline human health risk assessment (BHHRA) was performed to evaluate current and future cancer risks and non-cancer health hazards based on the results of the RI.

An ecological risk assessment was determined to be unnecessary for OU3. The OU2 remedy specified that ecological risks would be addressed as part of the OU3 remedy. However, at that time, Peach Island Creek was to be addressed as part of the Site. However, contamination in the creek, and any associated ecological risks, will now be addressed as part of the Berry's Creek site.

Human Health Risk Assessment

As part of the RI, a BHHRA was conducted to estimate the risks and hazards associated with the current and future effects of contaminants on human health. A BHHRA is an analysis of the potential adverse human health effects caused by hazardous substance exposure in the absence of any actions to control or mitigate exposure under current and future land uses. The BHHRA for OU3 considered exposure to Chemicals of Potential Concern (COPCs) in the bedrock and till groundwater aquifers assuming no remediation and no institutional controls.

WHAT IS RISK AND HOW IS IT CALCULATED?

A Superfund baseline human health risk assessment is an analysis of the potential adverse health effects caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these under current and future land uses. A four-step process is utilized for assessing site-related human health risks for reasonable maximum exposure scenarios.

Hazard Identification: In this step, the contaminants of concern at the site in various media (i.e., soil, groundwater, surface water, and air) are identified based on such factors as toxicity, frequency of occurrence, fate and transport of the contaminants in the environment, concentrations of the contaminants in specific media, mobility, persistence, and bioaccumulation.

Exposure Assessment: In this step, the different exposure pathways through which people might be exposed to the contaminants identified in the previous step are evaluated. Examples of exposure pathways for a groundwater site include ingestion of groundwater and inhalation of volatiles while showering. Factors relating to the exposure assessment include, but are not limited to, the concentrations that people might be exposed to and the potential frequency and duration of exposure. Using these factors, a "reasonable maximum exposure" scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, is calculated.

Toxicity Assessment: In this step, the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response) are determined. Potential health effects are chemical- specific and may include the risk of developing cancer over a lifetime or other non-cancer health effects, such as changes in the normal functions of organs within the body (e.g., changes in the effectiveness of the immune system). Some chemicals are capable of causing both cancer and non-cancer health effects.

Risk Characterization: This step summarizes and combines exposure information and toxicity assessments to provide a quantitative assessment of site risks. Exposures are evaluated based on the potential risk for developing cancer and the potential for non-cancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a "one in ten thousand excess cancer risk"; or one additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions explained in the exposure assessment. Current federal Superfund guidelines for acceptable exposures are an individual lifetime excess cancer risk in the range of 10^{-4} to 10^{-6} (corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk). For non-cancer health effects, a "hazard index" (HI) is calculated. An HI represents the sum of the individual exposure levels compared to their corresponding Reference Doses. The key concept for a non-cancer HI is that a "threshold level" (measured as an HI of 1) exists below which non-cancer health effects are not expected to occur.

A four-step human health risk assessment process was used for assessing site-related cancer risks and non-cancer health hazards. The four-step process is comprised of: Hazard Identification of COPCs, Exposure Assessment, Toxicity Assessment, and Risk Characterization (see "What Is Risk and How Is It Calculated" box on previous page).

The current/future land use scenarios evaluated in the BHHRA included the following exposure pathways and receptors:

- Adult/Child Residents: ingestion of, dermal contact with, and inhalation of vapors from OU3 groundwater.

- Industrial Workers: ingestion of and dermal contact with OU3 groundwater.

There are currently no known exposures to OU3 groundwater, and it is not used a potable source, so the BHHRA focused on future risk conditions.

Exposure point concentrations in groundwater were estimated using either the maximum detected concentration of a contaminant or the 95%, 97.5% or 99% upper-confidence limit (UCL) of the average concentration. Chronic daily intakes were calculated based on the reasonable maximum exposure (RME), which is the highest exposure reasonably anticipated to occur at the Site. The RME is intended to represent a conservative exposure scenario that is still within the range of possible exposures. Central tendency exposure (CTE) assumptions, which represent typical, average exposures, were also developed. A complete summary of all exposure scenarios can be found in the BHHRA.

Summary of Risks to Future Residents
The carcinogenic risk calculated for future adult residents under RME conditions was $3x10^{-3}$ (three in 1,000), which exceeds the acceptable risk range of 10^{-4} (one in 10,000) to 10^{-6} (one in 1,000,000). The risk is due primarily to ingestion of 1,4-dioxane (77%) and TCE (13%) in the groundwater. The total estimated adult cancer risk calculated using CTE assumptions was $4x10^{-4}$ (4 in 10,000), which is within the upper bounds of the acceptable risk range.

The carcinogenic risk calculated for future child residents under RME conditions was $2x10^{-3}$ (2 in 1,000), which is due primarily to the ingestion of 1,4-dioxane (45%) and TCE (41%) in the groundwater. The total estimated future child cancer risk under CTE conditions was calculated to be $1x10^{-3}$ (one in 1,000), which still exceeds the risk range.

The non-cancer Hazard Index (HI) calculated for future adult residents was 54 under RME conditions and 25 under CTE conditions. Both of these exceed the goal of protection of an HI of less than 1. The primary COPCs in groundwater contributing to the total HI are 1,4-dioxane, TCE and cis-1,2-dichloroethene.

For future child residents, the total HI was calculated to be 125 under RME conditions and 63 under CTE conditions, due primarily to ingestion of 1,4-dioxane,cis-1,2-dichloroethene, TCE and PCE in groundwater. Again, the overall HI is greater than the goal of protection of an HI of less than 1 for both the RME and CTE exposures.

An evaluation of cancer risks and non-cancer hazards associated with showering were found to be below the cancer risk range and an HI of 1 for potential future residents.

Summary of Risks to Industrial Workers
Under future exposure conditions, the sum of all RME cancer risks for the adult industrial/commercial worker was calculated to be $9x10^{-4}$ (9 in 10,000), which exceeds the acceptable risk range. Estimated risks are primarily driven by ingestion of 1,4-dioxane (78%) and TCE (13%) in groundwater. The total estimated cancer risk under CTE conditions was calculated to be $4x10^{-4}$ (4 in 10,000), which is within the upper bounds of the acceptable risk range.

The total estimated non-cancer HI for future industrial/ commercial workers was calculated to be 19 under RME conditions and 10 under CTE conditions, due primarily by the ingestion of TCE in groundwater. The overall HI is greater than the goal of protection of an HI of less than 1 under both RME and CTE exposure conditions.

Summary
The results of the BHHRA indicate that action is necessary to reduce the risks associated with contamination in the OU3 groundwater. In addition, it is EPA's judgment that the Preferred Alternative identified in this Proposed Plan is necessary to protect public health or welfare from actual or threatened releases of hazardous substances into the environment.

REMEDIAL ACTION OBJECTIVES

Based on the human health risk assessment, the primary contaminants of concern in the deep and off-property groundwater are VOCs, aromatic hydrocarbons, and 1,4-dioxane. There are no current completed exposure pathways to OU3 groundwater, but future exposure pathways are associated with potential groundwater extraction and use via ingestion, inhalation and dermal contact routes. The vapor intrusion pathway is not a concern due to the depth of the OU3 groundwater. The relatively clean shallow groundwater (5 to 10 feet below ground surface) would effectively block the potential migration of volatile contaminants from the deeper groundwater (more than 30 feet below ground surface) to the surface.

The following remedial action objectives address the human health risks and environmental concerns posed at the Site:

- Prevent unacceptable exposures to impacted groundwater;
- Control future migration of contaminants of concern in the groundwater; and
- Restore groundwater quality to the lower of the federal drinking water standards or the New Jersey Groundwater Quality Standards (NJGWQSs).

The cleanup of the Site is based on remediating the contaminated groundwater to within EPA's acceptable cancer risk range for a reasonable maximum exposure if the groundwater were utilized in the future for residential purposes. The cleanup goals also have to be consistent with federal drinking water standards and NJGWQSs. The Preliminary Remediation Goals proposed by EPA for the contaminants of potential concern for OU3 are based on the NJGWQSs, and are consistent with federal and state guidance.

SUMMARY OF REMEDIAL ALTERNATIVES

Remedial alternatives for the off-property groundwater are presented below. Potential applicable technologies were initially identified and screened using effectiveness, implementability, and cost as criteria, with an emphasis on the effectiveness of the alternative. Those technologies that passed the initial screening were then assembled into three remedial alternatives which were fully evaluated in the FS.

The time frames below for construction do not include the time to design the remedy or to procure necessary contracts. Because each of the action alternatives are expected to take longer than five years, a Site review will be conducted every five years (Five-Year Review) until remedial goals are achieved.

Alternative 1 – No Action

Regulations governing the Superfund program require that the "no action" alternative be evaluated generally to establish a baseline for comparison. Under this alternative, EPA would take no action at the Site to prevent exposure to the groundwater contamination.

Total Capital Cost	$0
Total Operation and Maintenance	$0
Total Present Worth Cost	$0
Estimated Timeframe	None

Alternative 2 – In-Situ Treatment, Monitored Natural Attenuation, and Institutional Controls

Total Capital Cost	$1,772,439
Total Operation and Maintenance	$9,410,460
Total Present Worth Cost	$7,830,000
Estimated Timeframe	30 years

This alternative would treat the contamination in the groundwater directly, through the injection of a substance, or substances, designed to cause or enhance the breakdown of the contaminants of concern to less toxic forms.

As described above, there are two distinct areas of contamination for OU3. A bench-scale test was conducted on the southern portion of the plume and a long-term, pilot-scale test is nearing completion in the northern portion of the plume. Both tests indicate that in-situ treatment technologies can effectively remediate the contamination that is present in the OU3 groundwater.

Based on the test results, it is anticipated at this time that enhanced anaerobic bioremediation (EAB) would be utilized to treat the contaminants in the northern portion of the plume and that in-situ chemical oxidation (ISCO) would be used on the southern portion. To arrive at the cost estimates provided above, the following assumptions were made in the FS:

Northern Area

- Treatment using EAB through the injection of lactate into the till aquifer;
- 51 injection wells were assumed, with 9 to be located on-property and the rest located off of the former SCP property; and

- Off-property injections of lactate were assumed to occur quarterly for 5 years, while on-property injections were assumed to continue for up to 30 years.

Southern Area

- Based on the bench-scale tests that were conducted, treatment using ISCO through the injection of a combination of sodium persulfate and sodium hydroxide into the aquifer;
- 20 injection wells were assumed, with 7 to be located on-property and the rest off of the property; and
- A total of 3 injections were assumed, over a period of 3 to 5 years.

The details of the in-situ treatment technology to be used in each area, including the substances to be injected, the number of injection points, the extent of the treatment zone, and the timeframes for treatment, would be refined during the remedial design, and may change significantly based on the final results of the pilot study and results from the pre-design investigation. However, the use of an in-situ treatment technology or technologies is expected to remain an appropriate remedy for OU3.

After the initial treatment period, monitored natural attenuation (MNA) would be used to complete the remediation of OU3 groundwater. MNA addresses contaminated groundwater through ongoing natural attenuation processes accompanied by verification monitoring. By EPA's definition, MNA utilizes natural in-situ processes to reduce the mass, toxicity, mobility, volume, and/or concentration of chemicals through biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical or biological stabilization, transformation, or destruction of contaminants. The primary in-situ process contributing to the ongoing natural attenuation that has been documented for the contaminants present in OU3 is biodegradation (i.e., the natural breakdown of chemicals through biological processes). Multiple lines of evidence exist which show that natural attenuation processes are occurring.

Institutional controls would also be part of this alternative. A deed notice is already in place which restricts the placement of groundwater wells on the former SCP property itself. In addition, a Classification Exception Area/Well Restriction Area (CEA/WRA) would be established to prevent the installation of wells within the affected area until the remediation is complete.

Alternative 3 – Groundwater Extraction and Treatment, Monitored Natural Attenuation, and Institutional Controls

Total Capital Cost	$1,972,573
Total Operation and Maintenance	$15,747,600
Total Present Worth Cost	$11,140,000
Estimated Timeframe	30 years

In this alternative, contaminated groundwater from OU3 would be extracted, treated on-site, and then disposed of off-site. Detailed modeling would need to be conducted during the design to determine, for example, where to place the extraction wells, how many to place, and how to treat the contaminated water. However, to arrive at the cost estimates above, it was assumed that five extraction wells screened in the till unit to just above bedrock would be needed. Three would be located in the northern area and two would be placed in the southern area. All wells were assumed to pump at a rate of two gallons per minute.

Separate processes would be needed to treat the water contaminated with 1,4-dioxane from the water contaminated with other VOCs only, since 1,4-dioxane is both much more soluble in water and does not adsorb as readily to carbon as the other VOCs present in the groundwater. Disposal of the water would be either directly to a surface water body or to a publicly operated treatment facility.

As with Alternative 2, MNA would be used to address contamination outside of the extraction zone, which would be refined during the remedial design, and institutional controls would be used to assure that the alternative remains protective while the remediation is being completed.

EVALUATION OF ALTERNATIVES

EPA uses nine evaluation criteria to assess remedial alternatives individually and against each other in order to select a remedy. The criteria are described in the box on the next page. This section of the Proposed Plan profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. A detailed analysis of each of the alternatives is in the FS report. A summary of those analyses follows.

Overall Protectiveness of Human Health and the Environment

Alternative 1 (no action) would not provide protection of human health and the environment in the long term, since contamination would persist in the groundwater. Alternative 2 (in-situ treatment) and Alternative 3 (ex-situ treatment) would eliminate risk through treatment or removal of the contaminated groundwater in the long term, and would be protective in the short term through the placement of institutional controls. Both would comply with the RAOs.

Since Alternative 1 is not protective of human health and the environment, it is eliminated from consideration under the remaining eight criteria.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Alternatives 2 and 3 will comply with ARARs over time. Both would comply with chemical-specific ARARs through either treatment or removal of contaminated groundwater, though Alternative 2 would likely achieve chemical-specific ARARs faster than Alternative 3. Similarly, both alternatives would meet action-specific ARARs, though due to the need for disposal of treated groundwater, it would be much more difficult for Alternative 3 to meet them.

Long-Term Effectiveness and Permanence

Both alternatives would provide long-term effectiveness and permanence, since under both alternatives the impacted groundwater would either be treated or removed. Both would require long-term monitoring until ARARs are achieved, though Alternative 3 would likely require a longer active treatment time.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would reduce the toxicity, mobility, and volume of contaminants in the groundwater through treatment. The treatment would degrade contaminants to less-toxic forms, thereby reducing both toxicity and volume, and would reduce mobility through direct source control. Alternative 3 would reduce both the mobility and volume of contaminants in the groundwater, but would not enhance the reduction of toxicity in-situ that is already occurring through natural attenuation processes.

THE NINE SUPERFUND EVALUATION CRITERIA

Overall Protectiveness of Human Health and the Environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.

Compliance with ARARs evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

Long-term Effectiveness and Permanence considers the ability of an alternative to maintain protection of human health and the environment over time.

Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

Short-term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.

Implementability considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.

Cost includes estimated capital and annual operations and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

State/Support Agency Acceptance considers whether the State agrees with the EPA's analyses and recommendations, as described in the RI/FS and Proposed Plan.

Community Acceptance considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

Short-Term Effectiveness

Both alternatives would have some impact to the community during pre-design investigations. The impacts to the community posed by Alternative 2 would be low. Periodic access to some properties would be needed to complete injections during the active treatment period and during the long-term monitoring of wells. Alternative 3 would have a much greater impact on the community due to the need to construct a treatment plant and a groundwater extraction and discharge system. Since a conveyance system to carry the water from the extraction wells to the treatment system would need to be installed, including along roadways and utility corridors, construction of the system would impact both public and private properties

Implementability

Alternative 2 is readily implementable. The materials needed are generally available and only limited access will be needed to properties near the Site. Alternative 3 is also implementable, but it would pose a greater challenge to implement than Alternative 2. While the materials needed should be readily available, more invasive access will be needed to properties to install pipelines and extraction wells.

Cost

Alternative 3 has a slightly higher capital cost than Alternative 2 due to the need to construct a groundwater extraction and treatment facility. Alternative 3 also has a significantly higher operations and maintenance cost than Alternative 2.

State/Support Agency Acceptance

The State of New Jersey agrees with the preferred alternative in this Proposed Plan.

Community Acceptance

Community acceptance of the preferred alternative will be evaluated after the public comment period ends and will be described in the ROD for the Site.

SUMMARY OF THE PREFERRED ALTERNATIVE

The Preferred Alternative for cleanup of the OU3 groundwater at the SCP Site in Carlstadt, New Jersey is Alternative 2, In-Situ Treatment, Monitored Natural Attenuation, and Institutional Controls.

In-situ treatment of various contaminants has worked successfully at other sites, and results of bench-scale and pilot-scale tests conducted at this Site indicate that in-situ treatment options should be available to effectively treat the contamination present at this Site. As part of the remedy, monitored natural attenuation will be conducted during and after treatment and institutional controls will be maintained to assure the remedy remains protective until cleanup goals are met.

EPA believes the Preferred Alternative will be protective of human health and the environment, will comply with ARARs, will be cost effective, and will utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. Through the use of an in-situ treatment technology to treat the groundwater, the Selected Remedy meets the statutory preference for the use of remedies that employ treatment that reduces toxicity, mobility or volume as a principal element to address the principal threats at the Site. The Preferred Alternative can change in response to public comment or new information.

Consistent with EPA Region 2's *Clean and Green* policy, EPA will evaluate the use of sustainable technologies and practices with respect to any remedial alternative selected for the Site.

As is EPA's policy, Five-Year Reviews will be conducted until remediation goals are achieved and the Site is available for unrestricted use and unlimited exposure.

COMMUNITY PARTICIPATION

EPA provides information regarding the cleanup of the SCP Superfund Site to the public through public meetings, the Administrative Record file for the Site, and announcements published in the South Bergenite newspaper. EPA and NJDEP encourage the public to gain a more comprehensive understanding of the Site and the Superfund activities that have been conducted there.

The dates for the public comment period, the date, location and time of the public meeting, and the locations of the Administrative Record files, are provided on the front page of this Proposed Plan.

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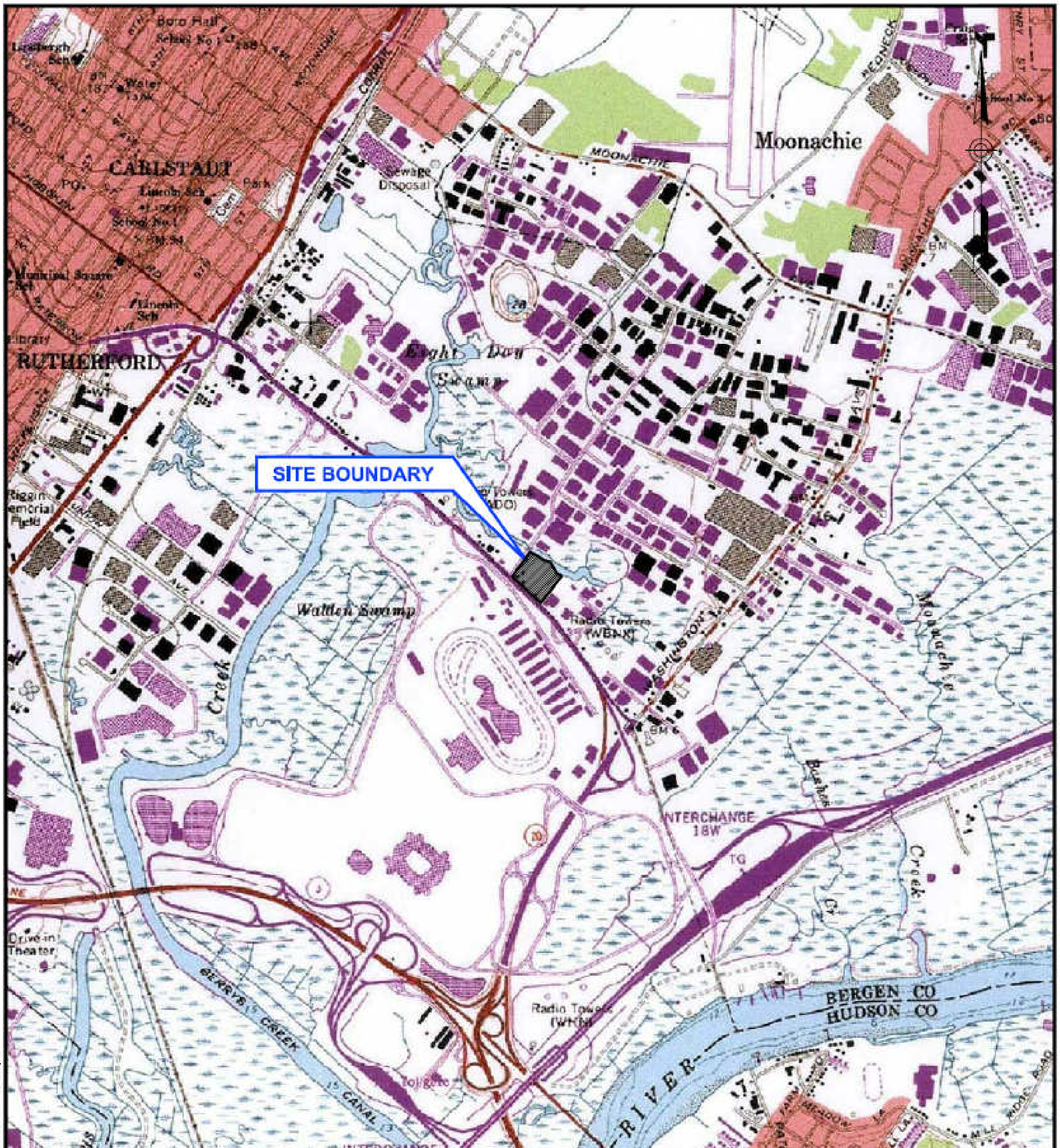

REFERENCES

1.) BASE MAP TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLE OF WEEHAWKEN, NEW JERSEY, DATED 1967 AND PHOTOREVISED 1981.

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APPROXIMATE SCALE FEET

Golder Associates, Mt. Laurel, New Jersey	SCALE: AS SHOWN	TITLE	
	DATE: 05/04/12	SITE LOCATION MAP	
	DESIGN: HAL		
	CADD: AM		
FILE No. 9436222V018	CHECK: HAL		
PROJECT No. 943-6222 REV. 0	REVIEW: PSF	216 PATERSON PLANK ROAD SITE	FIGURE 1

Drawing file: 9436222V018.dwg May 04, 2012 - 12:04pm

FIVE-YEAR REVIEW REPORT
PJP LANDFILL SUPERFUND SITE
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

Prepared by

U.S. Environmental Protection Agency
Region II
New York City, New York

Approved:

Walter E. Mugdan, Director
Emergency and Remedial Response Division

Sept. 30, 2013
Date

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EXECUTIVE SUMMARY

This is the first five-year review for the PJP Landfill Superfund Site located in Jersey City, New Jersey. This site has one operable unit (OU1).

The Record of Decision (ROD) called for removal of contaminated material, construction of a cap with a gas venting system, monitoring of groundwater at the Site and surface water in the Hackensack River, assessment of the wetlands and replacement of the Sip Avenue Ditch to provide drainage in the area. NJDEP is the lead agency for this Site.

Since the issuance of the ROD on September 28, 1995, portions of the property have been bought by two separate entities. The western portion of the site was purchased in March 2008 by AMB Property, L.P. and AMB Pulaski Distribution Center, LLC together known as AMB. AMB is now owned by Prologis, which is constructing a warehouse and transfer station on their portion of the Site. The remedy on the northern portion of the Site was completed by Waste Management of New Jersey, Inc. and CWM Chemical Services, LLC (together known as CCS) in May 2012, and was subsequently purchased by Jersey City. Jersey City plans to develop their portion of the Site into a public park.

The remedy at the PJP Landfill is expected to be protective of human health and the environment upon completion. In the interim, response activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: PJP Landfill		
EPA ID: NJD 980 505 648		
Region: 2	**State:** NJ	**City/County:** Jersey City/Hudson County
SITE STATUS		
NPL Status: Final		
Multiple OUs? No	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: NJDEP		
Author name (Federal or State Project Manager): Renee Gelblat		
Author affiliation: EPA		
Review period: 7/24/2008 - 6/30/2013		
Date of site inspection: May 16, 2013		
Type of review: Statutory		
Review number: 1		
Triggering action date: 7/24/2008		
Due date *(five years after triggering action date)*: 7/24/2013		

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU1 – removal of contaminated material, construction of a cap with a venting system, monitoring of groundwater at the Site, monitoring of surface water in the Hackensack River, assessment of the wetlands and replacement of the Sip Avenue Ditch to provide drainage in the area.

Five-Year Review Summary Form (continued)

Issues and Recommendations Identified in the Five-Year Review:				
OU(s):	**Issue Category: No Issue**			
	Issue: N/A			
	Recommendation: N/A			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
N/A	N/A	N/A	N/A	N/A

Protectiveness Statement(s)
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit: OU1 – Entire Site	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy is expected to be protective of human health and the environment upon completion. In the interim, response activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.		

I. Introduction

This first five-year review for the PJP Landfill site (Site), located in Jersey City, Hudson County, New Jersey, was conducted by Renee Gelblat, the U.S. Environmental Protection Agency (EPA) remedial project manager (RPM) for the Site. It was conducted pursuant to Section 121 (c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. §9601 et seq. and 40 CFR §300.430(f)(4)(ii), and in accordance with the Comprehensive Five-Year Review Guidance, OSWER Directive 9355.7-03B-P (June 2001). A five-year review is required by statute at this Site because hazardous substances, pollutants or contaminants remain at the Site above levels that do not allow for unlimited use and unrestricted exposure. The purpose of a five-year review is to ensure that the remedial actions remain protective of public health and the environment and are functioning as intended by the decision documents. This document will become part of the site file.

The PJP Landfill Site is being addressed as one operable unit which addresses contamination of the surface and subsurface soils, groundwater, and surface water. The trigger date for this statutory five-year review is the initiation of remedial activities.

II. Site Chronology

Table 1 (attached) summarizes site-related events from discovery to present activities.

III. Background

Physical Characteristics

The PJP Landfill Superfund Site is an inactive landfill located at 400 Sip Avenue, Jersey City, Hudson County, New Jersey. The Site occupies approximately 87 acres and is bordered on the north and west by the Hackensack River and on the southeast by Truck Routes 1 and 9. There are various light industries along the other borders and multiple-dwelling housing units located northeast and southeast of the Site. The Site is bisected by the Sip Avenue Ditch which runs roughly east-west and conveys run-off from the PJP landfill and the Jersey City stormwater/sewer system into the Hackensack River. The Pulaski Skyway, an elevated highway, passes over a portion of the Site. (Figure 1)

Land and Resource Use

The Site was originally a salt marsh, part of which was condemned in 1932 for construction of an elevated portion of the Pulaski Skyway. In the early 1970s, the PJP Landfill Company operated a commercial landfill which accepted chemical and industrial wastes.

Since closure of the landfill, operations on the Site were industrial and commercial. Most were located on the northern portion of the Site (north of the Sip Avenue Ditch). A material staging area (referred to during the remedial investigation (RI) as the RV Salvage Yard) is located adjacent to the Hackensack River on the northwest corner of the Site. A truck stop (Truck Stop) and several other commercial establishments are located along Truck Route 1 and 9 on the northeastern corner of the Site. The Truck Stop and RV Salvage Area were owned by Edwin Siegel and are referred to in documents as the "Siegel property" A former automotive salvage area (Junkyard) was located southeast of the truck stop until the drum removal component of the remedy was implemented during 2001. Property owned by the Archdiocese of Newark (Archdiocese Property) was located in the southeast corner of the Site. The elevated Pulaski Skyway passes over the Site in a west-east direction, toward the truck stop on the northeast corner of the Site.

At the time the Record of Decision (ROD) was issued in 1995, the Site had a variety of owners including the Archdiocese of Newark, Edwin Siegel and Jay Dee Trucking. A large portion (45 acres) of the Site consisted of the Interim Remedial Measure (IRM) cap which covers a heavily contaminated section of the Site (shown on figure 1) and is more fully described in section "*Initial Response*" below. The IRM area was surrounded by a stone lined perimeter ditch which conveyed storm water runoff from the cap to the Hackensack River. The Site had various areas of wetlands, including along the Hackensack River, the Sip Avenue Ditch, and a portion of the IRM perimeter ditch. There was also a separate small freshwater wetland in the southeast corner of the Site. The Site was fenced along the southeast, south, and southwest with a vehicle entrance along Route 1 and 9.

On March 7, 2008, AMB Property, L.P. and AMB Pulaski Distribution Center, LLC together known as AMB purchased about 52 acres of the Site (including most of the IRM cap and the area formerly owned by the Archdiocese of Newark) for construction of a warehouse and transfer station and agreed to construct the remedy on their portion of the Site. A portion of the AMB property along the Hackensack River will become green space which, eventually, will be accessible from the Jersey City portion of the Site by a pedestrian bridge. Construction began in July 2008 and is expected to be completed in 2014. In June 2011, AMB merged with Prologis (AMB/Prologis).

At the time of the AMB/Prologis purchase, Jersey City showed interest in the remainder of the Site for construction of a park. Under an agreement between Jersey City and Waste Management of New Jersey, Inc. and CWM Chemical Services, LLC (together known as CCS), Jersey City agreed to take over the rest of the Site after construction of the landfill cap was completed by CCS. Construction of the cap by CCS began in August 2010 and was completed in January 2012. Jersey City took control of the property in June 2012. At that time, Jersey City became responsible for all activities required by the ROD, including operation and maintenance of the remedy. (Figure 2)

The current land use for the area surrounding the Site is light industrial, parks and residences, and is expected to remain so in the future. Today, a small truck stop and a recycling operation are located adjacent to the landfill along Route 1 and 9 north of the Sip Avenue Ditch. Hartz Mountain, adjacent to the Site on the northeast side, also remains in operation. In addition Jay Dee Trucking borders the Site on the south side and a portion of their operation (about three acres) is located on the IRM cap portion the Site.

History of Contamination

From about 1970 to 1974, the PJP Landfill Company operated a commercial landfill which accepted chemical and industrial wastes. Although the landfill was closed in 1974, allegations of illegal dumping continued until 1984. As a result of the material in and dumped on top of the landfill, there were frequent fires which produced a lot of smoke.

Geology/Hydrogeology

The PJP Landfill Site is located in the Hackensack Meadowlands which is in the Piedmont Lowland section of the Piedmont physiographic province of northeastern New Jersey. The Site is located on man-made fill deposits which are approximately 10 to 30 feet thick. The fill material is underlain by a discontinuous layer of peat called "meadow mat" that was the original land surface. Below the peat is a layer of unconsolidated glaciolacustrine silts and sand. These are underlain by bedrock which begins approximately 60 to 90 feet below the ground surface.

The bedrock of the Piedmont Lowlands consists of igneous and sedimentary rocks of the Triassic-Jurassic age Newark Supergroup. The bedrock underlying the Site is the Passaic Formation (also called the Brunswick Formation) which consists of fluvial and lacustrine reddish brown shales and some fine grained sandstones.

There are two aquifers in the vicinity of the PJP Landfill. They are the unconsolidated glaciolacustrine silts and sand deposits and the underlying Passaic Formation bedrock aquifer.

Groundwater in the unconsolidated materials is divided into the shallow water-bearing zone (in the man-made fill above the meadow mat) and the deep water-bearing zone (below the meadow mat). Groundwater flow in the shallow zone is controlled by precipitation, topography, tides and manmade structures. The shallow zone has a very high permeability and transmissivity. The groundwater flows toward the Sip Avenue Ditch and the Hackensack River. Groundwater in the deep zone is semi-confined and less likely to be influenced by precipitation. Data from the deep wells shows that some of them are interconnected with the Hackensack River. North of the Sip Avenue Ditch, the water flows west to the Hackensack River. In areas, south of the Sip Avenue Ditch, the deep groundwater aquifer flows south-southwest, also toward the Hackensack River.

Water in the shale and sandstone of the bedrock Passaic Formation occurs under confined and unconfined conditions. In the Piedmont Lowlands of the Hackensack Meadowlands, the bedrock aquifer is generally confined or semi-confined by glaciolacustrine clays and silts.

The principle source of groundwater in the area is from rock units in the Passaic Formation. This groundwater is not used for potable water in the lower Hackensack River Basin but might be used for commercial and industrial purposes. The area near the PJP landfill is served by the Jersey City municipal water supply system, whose water comes from the Boonton Reservoir.

Initial Response

In July 1973, the New Jersey Department of Transportation uncovered steel and plastic drums containing chemicals under the Pulaski Skyway. In 1977, NJDEP issued an order to the PJP Landfill Company to properly cover and grade the landfill and to remove wastes which were in contact with the Hackensack River and the Sip Avenue Ditch. The PJP Landfill Company did not comply with that order.

From 1970 to 1985, there were frequent subsurface fires in a 45-acre portion of the area near the Hackensack River and under the Pulaski Skyway. The fires were attributed to spontaneous combustion of subsurface drums and decomposition of landfill materials. The fires also produced a lot of smoke which resulted in periodic closure of the Pulaski Skyway.

Throughout the early 1980s, NJDEP and the Hudson Regional Health Commission inspected the Site, took samples, and conducted air monitoring. The Site was put on the National Priorities List (NPL) in December 1982. NJDEP was and remains the lead agency for remedial investigations and remedial activities at the Site.

During 1985 and 1986, NJDEP conducted an IRM to deal with immediate threats. Under these activities the landfill fires were extinguished, over one million cubic yards of material were recompacted; grossly contaminated soils were removed as were cylinders and drums containing hazardous materials. These hazardous materials were properly disposed of off-site at secure landfills or destroyed in hazardous waste incinerators. A fire break trench was installed and the 45 acres were regraded, capped, and reseeded. This is referred to as the IRM cap. The IRM cap is comprised of one foot of clay soil compacted over the 45 acres of the landfill and covered by one foot of vegetated topsoil (see Figure 11 of the ROD). A gas venting system consisting of 49 vents was also installed. The IRM was completed in May 1986 and no fires have occurred since then.

In 1988, NJDEP contracted with ICF Technology, Inc. to perform a remedial investigation/feasibility study (RI/FS) on the entire 87-acre Site. The RI was designed to: determine the nature and extent of contamination resulting from historic Site activities, identify potential contamination migration routes, identify potential receptors of Site contaminants, characterize potential human health risks and related environmental impacts, and evaluate any impacts the Site may have on the adjacent Hackensack River. The RI was completed in 1990.

Summary of Results of the Phase I RI and the NJDEP 1993 Sampling Event

During the RI, surface and subsurface soil samples were taken from throughout the Site, except from the capped area. The results of the RI identified contaminants above the existing New Jersey soil cleanup criteria in surface soils, subsurface soils (excluding the test pits) and test pits in the subsurface soils, sediments from the Sip Avenue Ditch. The air samples for the landfill gas vents were also evaluated.

Surface Soil

Surface soil samples were taken from six locations where drums were staged during NJDEP's IRM activities. Volatile organic compounds (VOCs), semi-organic compounds (SVOCs), petroleum hydrocarbons, pesticides and inorganic constituents were detected. Only arsenic was detected in the surface soils above the existing NJDEP Soil Cleanup Criteria of 20 parts per million (ppm).

Subsurface Soil

RI subsurface soil samples were collected from 17 locations above the meadow mat and six locations from below the peat layer during installation of the Site monitoring wells. Composite subsurface samples were collected from twenty test pits completed as part of the buried drum investigation.

In the subsurface soils (outside of the test pits) the following contaminants were detected at levels above the NJDEP cleanup criteria: benzene (maximum concentration of 1.6 ppm), bis (2-ethylhexyl) phthalate (maximum concentration of 180 ppm) and chlorobenzene (maximum concentration of 2.92 ppm).

In the test pits, contaminants were detected more frequently and at higher concentration than in the subsurface soil outside of the test pits. Bis (2-ethylhexyl) phthalate (maximum concentration of 33,100 ppm) and petroleum hydrocarbons were the predominant organic compounds that exceeded the NJDEP subsurface soil standards. Other organic compounds that exceeded the NJDEP impact to groundwater soil cleanup criteria include: benzene (maximum concentration of 250 ppm), dieldrin (maximum concentration of 200 ppm), tetrachloroethene (maximum concentration of 41 ppm) and total xylenes (maximum concentration of 3,900 ppm). Polycyclic aromatic hydrocarbons (PAHs) and inorganics were also frequently detected in the test pit subsurface soils.

Air Samples from the Landfill Gas Vents

During the RI, a preliminary gas screening survey took place using the 49 vents installed in the IRM cap. The maximum flow rate from the 49 vents was used to calculate the potential discharges (8.73 cubic feet per minute). The maximum contaminant concentrations (from three rounds of sampling) were used for each contaminant.

Based on the results of the screening, eight "high emission level" vents were selected for sampling and VOC analyses. All eight vents contained benzene, chlorobenzene, toluene, vinyl chloride, xylenes, and a hydrocarbon pattern similar to gasoline.

Based on the flow rates for the 49 vents along with the average and maximum contaminant concentrations measured in the eight high emission vents, total emissions and total toxic emissions were calculated. The total emissions average was 0.43 pounds/hour (lbs/hr) and the total emissions maximum was1.5 lbs/hr. These values are within the acceptable/allowable limit of 1.5 lbs/hr. The toxic emissions average was 0 .07 lbs/hr which is within the acceptable/allowable limit of 0.1

lbs/hr. However the toxic emissions maximum was 0.27 lbs/hr. which is above the acceptable/allowable limit of 0 .1 lbs/hr.

Sediments

Fourteen sediment samples were collected from the Sip Avenue Ditch, Hackensack River, and a leachate seep area. VOCs, SVOCs and inorganic constituents were found in the Sip Avenue Ditch and the Hackensack River.

Sediment samples from the Sip Avenue Ditch were compared to the National Oceanographic and Atmospheric Administration (NOAA) sediment screening guidelines. These guidelines set criteria for contaminants which are potentially harmful to aquatic life. The contaminants in the Sip Avenue Ditch which exceeded the NOAA guidelines included: total PAHs (maximum 14.8 ppm for carcinogenic PAHs and maximum 30.1 ppm for noncarcinogenic PAHs), antimony (93.8 ppm), cadmium (maximum 6.3 ppm), chromium (maximum 771.0 ppm), copper (maximum 34,000 ppm), lead (maximum 406 ppm), mercury (maximum 5.1 ppm), nickel (maximum 1,260 ppm) and zinc (maximum 9,830 ppm).

Surface Water

Ten surface water samples were collected from the Sip Avenue Ditch and the Hackensack River. The results were compared to the Federal Ambient Water Quality Criteria (AWQC.)

Analyses of the surface water from the Sip Avenue Ditch showed that a number of contaminants exceeded their AWQC. The criteria was exceeded by the following VOCs: benzene, 1,1,1-trichloroethane, chlorobenzene and chloroform, and the following SVOCs: bis (2-chloroethyl) ether and bis (2-chloroisopropyl) ether. Inorganics detected above the criteria include: arsenic, copper, iron, manganese and zinc. Some of these constituents were also found in background monitoring wells at the eastern end of the Site.

Hackensack River samples contained levels of benzene, arsenic, copper, iron, manganese, zinc, mercury, and beryllium above their respective AWQC.

1993 Sampling Event by NJDEP

In the summer of 1993, NJDEP implemented a plan to evaluate existing impact of the Site on the Hackensack River, the deep aquifer beneath the fill material, and the Sip Avenue Ditch. They took samples from three shallow wells and three deep wells as well six surface water and sediment locations. Hackensack River samples were taken both upstream and downstream of the Site. Water and sediment samples were taken from the Sip Avenue Ditch at locations adjacent to Routes 1 and 9 as well as at its confluence with the Hackensack River. The samples were analyzed for organic and inorganic chemical parameters. Also, a series of bioassays (mysid shrimp chronic toxicity tests) were performed at the sediment sample locations and in the waters of the two wells with the highest contamination levels. The results of the 1993 sampling event showed the following:

Surface water

Contamination was found in the Sip Avenue Ditch near Route 1 and 9 and at the confluence with the Hackensack River, with the highest levels found adjacent to Route 1 and 9. Chemicals detected in the water samples include VOCs, such as tetrachloroethene at 44 parts per billion (ppb), and inorganics such as lead and zinc.

Hackensack River water samples both upstream and downstream of the Site contained inorganics such as iron, aluminum, copper and zinc. The fact that contamination was detected both upstream and downstream in the Hackensack River suggests that there may be off-site sources of contamination.

Sediments

Sediment samples from the Hackensack River indicated the presence of VOCs, SVOCs, pesticide, PCBs, and inorganics both upstream and downstream of the Site. The predominant chemicals detected in the sediments include PAHs (maximum about 25 ppm), PCBs (maximum 360 ppb), lead (maximum about 222 ppm) and mercury (maximum about 2.7 ppm).

In the Sip Avenue Ditch, tetrachloroethane, toluene, numerous PAHs, copper, lead and zinc were detected.

Bioassays

A series of bioassay (mysid shrimp chronic toxicity tests) were performed using water collected from the Hackensack River, Sip Avenue Ditch, at the sediment sampling locations and in the water from the two wells with the highest contamination. All four of the bioassay sampling locations in the Hackensack River (including the upstream location), and the Sip Avenue Ditch location from the confluence of the ditch and the river showed significant mortality. These data indicate that potential adverse impacts on biota by these contaminated waters were likely occurring.

Bedrock Wells

The results of the bedrock aquifer well sampling indicated that contaminant levels in all three wells are below the New Jersey Ground Water Quality Standard (NJGWQS) for VOCs, SVOCs, and pesticides.

Groundwater

Groundwater monitoring was conducted at the Site during the RI and by NJDEP in 1993 in order to evaluate impact to the Hackensack River and the deeper aquifer beneath the fill (bedrock aquifer). Results from the three monitoring wells showed that eleven compounds were detected at levels slightly above the NJGWQs.

VOCs tended to increase toward the Hackensack River with the highest levels of VOCs located in both the shallow and deep water-bearing zones of the unconsolidated materials under the IRM cap area and in the former RV salvage yard. The most common VOCs in the shallow zone were total xylenes, benzene, and chlorobenzene found in the shallow water-bearing zone north of the Pulaski Skyway. In the deep water-bearing zone the most prevalent VOCs were methylene chloride and chloroform. VOCs were not detected in the bedrock wells and the deep water-bearing zone had lower concentrations of VOCs than the shallow water-bearing zone.

For SVOCs, the highest concentrations are also located in both the shallow and deep water-bearing zones of the unconsolidated materials under the IRM cap area and in the former RV salvage yard. The most common SVOCs detected in the shallow zone were naphthalene, phenanthrene, and 2-methyl naphthalene and 4-methylphenol (highest concentration). In the deep water-bearing zone, di-n-butyl phthalate, benzoic acid, acenaphthene, benzyl alcohol, dibenzofuran, phenol, bis (2-chloroethyl) ether and bis (2-chloroisopropyl) ether were detected. Only bis (2-chloroethyl) ether in monitoring well MW-1D (a deep well at the upgradient end of the Site) exceeded the NJ GWQS for a drinking water aquifer.

There were no pesticides, polychlorinated biphenols (PCBs) or dioxins detected in the shallow or deep water bearing zones. Total petroleum hydrocarbons were detected in the shallow water-bearing zone with the highest concentrations found under the IRM cap and in the RV salvage yard. Total petroleum hydrocarbons were not found in the deep water-bearing zone.

Also, during the RI, groundwater from both water-bearing zones was analyzed for total (unfiltered) metals. Inorganics in the shallow water-bearing zone were found under the IRM cap, the RV salvage yard, the Pulaski Skyway and the southern area of the Site. The metals that were detected above the NJGWQS were aluminum, antimony, arsenic, cadmium, mercury, thallium, lead, chromium, manganese, nickel, iron and sodium. In the deep water-bearing aquifer, the metals detected above the NJGWQS include aluminum, arsenic, iron, lead, manganese, silver, and sodium. Since unfiltered metal samples were not taken, NJDEP was not able to determine if the concentration of metals were from suspended particulates or dissolved in the groundwater.

Basis for Taking Action

The RI and 1993 sampling event identified contaminants above the existing NJDEP cleanup criteria in surface soils, subsurface soils, sediments from the Sip Avenue Ditch, and air. In addition, the portion of the Site where the fires occurred are now covered by an interim action and a final remedy is necessary.

Human Health Risk

Various exposure scenarios were evaluated based on current and potential future land use. Based on the baseline risk assessment, the greatest risk associated with the Site was the incidental ingestion and dermal absorption of chemicals in sediment by trespassing children wading in the Sip Avenue Ditch. The carcinogenic risk for children was estimated to be 4×10^{-5}.

If the Site was developed, on-site construction workers could be exposed via direct contact with contaminated sediments, subsurface soil, materials in test pits or air from gas vents. Generally, the concentrations of chemicals detected in test pits and subsurface soils are substantially higher than in sediments which could result in unacceptable risks to on-site workers.

Ecological Risk

The environmental assessment provided a qualitative evaluation of the actual or potential impacts from the Site on plants and animals. The environmental assessment identified several endangered species and sensitive habitats in the vicinity of the Site. It concluded that chemical contamination detected during the RI is not expected to have significant impacts on plants or terrestrial wildlife, but may be impacting aquatic life.

For plants, the chemical-related impacts were not expected to be significant and were likely to be limited to contamination source areas (e.g., the drum disposal area) since surface soil contamination is not widespread.

Potential impacts were evaluated for terrestrial wildlife. Some species could use the Sip Avenue Ditch or Hackensack River. However, exposure was not expected to be significant since there are other water sources nearby and these species have a large foraging area. None of the chemicals of potential concern detected in the surface water are expected to be acutely or chronically toxic at the levels of exposure at the Site.

Aquatic life was exposed to contaminated surface water and sediments and potential impacts were evaluated. There was a potential for food chain effects to occur due to predation on aquatic species since several of the contaminants, such as cadmium and mercury, bioconcentrate. Several contaminants in surface water and sediments in the Sip Avenue Ditch and Hackensack River exceed their respective toxicity vales, suggesting that aquatic life may be impacted.

IV. Remedial Actions

Based on the results of the pre-RI investigation, the RI, 1993 monitoring event and the risk assessment, feasibility studies (FS) were prepared by the contractor for NJDEP. The Phase I FS report was completed in November 1989, the Phase II FS report was prepared in May 1993 and the Phase III report was prepared in July 1993. NJDEP, with EPA's concurrence, issued a ROD on September 28, 1995.

Remedy Selection

The Remedial Action Objectives (RAOs) for the remedy are:

- Eliminate exposure to contaminated sediments in the Sip Avenue Ditch;
- Prevent additional contaminant influx into the groundwater via infiltration of rain water;
- Removal of contaminant sources that may impact groundwater; and

- Evaluate if future actions are necessary to mitigate the leaching of Site contaminants into the Hackensack River through monitoring and modeling to check the effectiveness of the remedy. If significant adverse impact is found, NJDEP and EPA will evaluate remedial alternatives and select an appropriate remedy in accordance with CERCLA and the NCP.

The major components of the 1995 ROD included:

- Removal of all known and suspected buried drum materials and associated visibly contaminated soil;

- Capping of the remaining landfill area of the site with a multi-layer modified solid waste cap in accordance with the NJDEP Bureau of Landfill Engineering Guidance with gas venting;

- Extension of the existing gravel lined ditch around the perimeter of the site to collect the surface water runoff;

- A passive or active gas venting system installed in the new portion of the cap (If an active system is deemed necessary, however, both areas will be included);

- Site fencing and institutional controls (e.g., declaration of environmental restriction and public information program);

- Quarterly inspection and maintenance, and a re-evaluation of the previously capped area;

- Replacement of the Sip Avenue ditch with an alternate form of drainage;

- Quarterly ground water monitoring to evaluate the reduction of contaminant concentrations over time;

- Modeling to demonstrate the effectiveness of the cap by predicting the impact of ground water leachate migrating to the Hackensack River from the landfill;

- Because contamination levels in the ground water are above the Class IIA Ground Water Quality Criteria (GWQC), a Classification Exemption Area(CEA)/Well Restriction Area (WRA) will be established; and

- Implementation of a wetlands assessment and restoration plan. (The wetlands assessment will be performed prior to implementation of any of the remedial actions).

Remedy Implementation

After the ROD was issued, NJDEP and two potentially responsible parties (PRPs), CWM Chemical Services, L.L.C. (CCSL) and Waste Management of New Jersey (WMNJ) collectively referred to as "CCS", entered into an administrative consent order (ACO) in June 1997 and amended the agreement in September 1997 (together referred to as the original ACO) for remedial design and remedial action (RD/RA).

The original ACO was amended in June 2000 (First Amendment) to implement the remedy selected in the ROD, as more specifically defined in the statement of work. The ACO was further amended in March 2008 (Second Amendment) to reflect the purchase of a portion of the Site by AMB, and again in June 2011 (Third Amendment), to reflect the purchase of another portion of the Site by Jersey City.

EPA entered into a Consent Decree with numerous parties for past costs which was entered on January 17, 2002, and has since been closed.

Pre-Design Investigation

As part of the remedy, the PRP's contractor (Golder Associates) conducted a pre-design investigation (PDI). The PDI included the following activities: preparation of an updated topographic base map (including cross-sections of the Sip Avenue Ditch); wetlands delineation and assessment; landfill gas evaluation; IRM cap inspection; storm water evaluation; conceptual design for the Sip Avenue Ditch; preparation of a drum removal work plan; pre-remedial baseline groundwater and surface water quality monitoring and preparation of a Classification Exception Area/Well Restriction Area (CEA/WRA) application.

Fence Evaluation and Boundary Assessment

As part of the PDI, the fence surrounding Site was inspected. Portions of the fence to the south of the Site were covered with overgrown vegetation and other sections were damaged by trespassers. The fence line along Route 1 and 9 was in poor condition, with portions cut and damaged. The fence line that enclosed the Junkyard restricted vehicles but not foot traffic. The Truck Stop is still active and the property owner provides security. Access to the RV Salvage is only available through the Hartz Mountain entrance, which is guarded. The 2007 Final Remedial Design Report recommended that the areas to be capped be enclosed by combination of fence and natural barriers such as the Hackensack River. .

The boundary assessment was undertaken to determine the appropriate boundaries of the planned landfill cap. A series of historical aerial photos were analyzed and based on this assessment, the cap boundaries were determined. The assessment showed that Truck Route 1 and 9, trucking operations along Duncan Avenue (south of the Site) and the Truck Stop/Hartz Mountain warehouse to the north of the Site existed before landfill operations began at the Site in 1968. Therefore it is unlikely that landfill material extends onto these adjacent areas. Also, the Truck Stop and Recycling Facility located along Route 1 and 9 and northeast of the Sip Avenue Ditch is not part of the Site, even though it was formerly included in the Site during the RI. These areas will not be included in the landfill cap.

Drum Removal

During the PDI, drums and related materials such as soils visually stained by drum contents were removed. Most of this took place in two areas of the Site: the Auto Junkyard Area to the south of the Sip Avenue Ditch, and a smaller area to the north of the Auto Junkyard Area and beneath the Pulaski Skyway.

The excavation activities began in February 2001 and were completed in April 2001. A total of 10,776 drums, including 17 intact drums with contents, and drum remnants were recovered. This material was transported off-site and disposed of properly. Soil which was excavated as part of the removal was analyzed and, if hazardous, was disposed of off-site. Wastewater and decontamination water from these activities were analyzed, found to be non-hazardous and disposed of off-site.

About one foot of clean fill was placed in the excavated areas to protect the groundwater. The areas were then covered with excavated soils that were determined to be non-hazardous. The area was graded to facilitate drainage and erosion control.

Topographic Base Map

A topographic base map was generated from an aerial fly over on November 2, 1998. Horizontal and vertical control points were used to tie the base map into the New Jersey Coordinate Grid System.

Wetlands Delineation and Assessment

The wetlands delineation was completed in April 2001. It showed the existence of wetlands in the IRM perimeter ditch of approximately 0.15 acres and in the entire Sip Avenue Ditch which covered 2.03 acres. There also was a fringe of wetlands along the Hackensack River of approximately 0.04 acres. A 0.8 acre freshwater wetland was found in the southeastern corner of the Site. During implementation of the remedy, the 0.8 acre freshwater wetland will be removed from its current location and recreated at the junction of the redesigned Sip Avenue Ditch and the Hackensack River.

For the wetlands assessment: surface water, sediment and biota samples were taken from the Site and compared to three background samples taken from the New Jersey Natural Lands Trust area approximately 2.6 miles upriver from the Site. The sampling data was screened using eco-toxicological benchmarks and showed the presence of eleven PAH compounds and ten inorganics at levels of concern at the Site. Most of these contaminants were also found above the levels of concern in the background samples. These constituents may not be Site-related

However, some contaminants were found in sediment samples in the Sip Avenue Ditch. These samples showed the presence of chromium, lead, nickel and zinc at levels that have the potential to cause adverse effects to the aquatic life. Contaminants from samples in the Sip Avenue Ditch are likely to be Site-related. Those constituents will be remediated as part of the remedy for the Sip

Avenue Ditch.

Landfill Gas

The need for an active or passive gas management system for the landfill remedy was evaluated using the following criteria: field measurements of gas quality and quantity; possibility of off-site migration of gasses to potential receptors; theoretical life cycle gases calculations; and potential end use of the Site. The results of this evaluation were compared to data collected during the RI to determine how to manage gas generated by the content of the landfill after the full cap is installed.

Four sampling events were conducted in the spring and summer of 2001 and average concentrations of VOCs were calculated. Only benzene and chloroform were detected at some of the sampling locations. All VOCs detected during the PDI were below the concentrations measured during the RI.

Since the VOC levels measured during the PDI were below the RI levels, and the calculated emission rates were below the NJDEP limit of 0.1 lb/hr, and other calculated values are low, it was concluded that an active landfill gas extraction system is not needed. The landfill cap, which is part of the remedy, requires only a passive system to be sampled periodically.

IRM Cap Evaluation

The IRM Cap was visually evaluated in September 1998 and June 2011 to identify areas of cover soil erosion, exposed waste or poor vegetation cover. In general, the landfill cover was in good condition. There were areas of poor vegetation beneath the Pulaski Skyway, possibly due to the lack of sunlight. These areas were reseeded in 2002.

Stormwater Evaluation

The storm water evaluation was completed in June 2001. It was conducted in order to understand drainage at the Site and design a storm water management system for the remedy. Drainage at the Site consists of IRM perimeter ditch which collects runoff from the IRM cap, the Hackensack River and the Sip Avenue Ditch.

At the time of the evaluation, the IRM perimeter ditch was functioning as designed although there was vegetation, sediment buildup and debris in the ditch. The Sip Avenue Ditch conveyed runoff to the Hackensack River from portions of the IRM cap, the Archdiocese and Junkyard Area, the Truck Stop and the RV Salvage Area as well as for discharge from the Jersey City Storm Sewer at the intersection of Sip Avenue and Truck Route 1 and 9.

Groundwater and Surface Water Samples

All groundwater samples were compared to the NJGWQC for Class II-A aquifers. There was a concern that the detection of metals was due to suspended particles. Therefore, in 2001, all monitoring wells were redeveloped and sampled using low flow sampling methods.

The surface water samples from the Sip Avenue Ditch and Hackensack River were compared to the NJSWQS. Only ethers were found above its NJSWQS and those exceedances were found in the Sip Avenue Ditch.

Most of the exceedances in shallow groundwater were from samples under the IRM cap or in the eastern portion of the Site. Constituents which exceeded the NJGWQC included benzene, chlorobenzene, ethers, iron, manganese, barium, and lead.

In samples from wells in the deep water-bearing zone in 2001, inorganics were detected either below the NJGWQC or below background levels for the first two rounds of sampling. Concentrations of some inorganic constituents (ex. calcium and sodium) were greater at the down gradient end of the landfill. This was attributed to interaction with the Hackensack River because Hackensack River samples contained higher concentrations of those elements.

Next Steps

The above data was used to design the landfill cap over the entire Site. The Final Design Report for the cap and other elements of the remedy was submitted by CCS on April 4, 2007 and approved by NJDEP and EPA on July 26, 2007. Some elements, such as the drum removal, were implemented during the PDI.

Construction of the cap and other elements of the remedy in the approved Design Report were delayed because outside parties began to show interest in purchasing and redeveloping the Site.

Changes in Ownership of the Site and Revision of Elements of the Remedy

AMB/Prologis

On March 7, 2008, AMB Property, L.P. and AMB Pulaski Distribution Center, LLC together known as AMB, bought approximately 51.76 acres of the Site (formerly owned by the Archdiocese of Newark) (Figure 2). At that time, AMB assumed remedial obligations by entering into an ACO with NJDEP. On March 7, 2008, NJDEP modified their existing ACO with CCS to reflect the change in ownership for portion of the Site. CCS was now responsible for the remedy on the remaining portion of the Site.

This majority of the AMB property will be capped through the construction of a warehouse and transfer station and associated impervious cover. A portion of their property, which borders the Hackensack River, will be given to Jersey City as green space. AMB submitted a revised design for the cap which was approved by EPA and NJDEP on July 24, 2008. AMB first mobilized in July 2008. In June 2011, AMB was purchased by Prologis, who assumed full responsibility their portion of the Site. The construction of the warehouse and transfer station is ongoing and is expected to be completed in 2014.

Jersey City

Shortly after AMB purchased a portion of the Site, Jersey City, where the Site is located, expressed interest in obtaining the remaining 32 acres of the Site then owned by Edwin Siegel (Figure 2). In order to do so, NJDEP, Jersey City and CCS agreed that CCS would construct the landfill cap on the 32 acres. Upon completion of the cap, Jersey City would take posession of the area and become responsible for all operation and maintenance activities.

In November 2009, Malcolm Pirnie, the contractor for Jersey City, submitted a plan to modify the landfill cap plan previously submitted by CCS and approved by NJDEP and EPA. This modification changed the slopes of the landfill cap in order to maximize the amount of the level surface at the top of the landfill for the proposed beneficial reuse of the Jersey City property as a public park. This new plan was called the "Closure Equivalency Engineering Report" and was approved by NJDEP and EPA on February 5, 2010.

CCS began construction of this portion of the cap on August 18, 2010 and was completed on January 5, 2012. The construction completion report (titled "Construction Quality Assurance Final Report") was submitted February 14, 2012 and was approved by NJDEP and EPA on May 18, 2012. The final Operation and Maintenance Plan was submitted on August 22, 2012 and approved on September 11, 2012.

Under the Third Amendment to the ACO with CCS and the City of Jersey City's Memorandum of Understanding with NJDEP, both dated June 21, 2011, Jersey City assumed environmental obligations associated with this portion of the Site upon CCS's completion of the final capping activities.

Jay Dee Trucking

The Jay Dee Trucking operation is located adjacent to the southeast corner of the Site. They began storing empty trailers on an area of approximately three acres on the IRM cap. In addition, NJDEP found that during an inspection conducted on May 6, 2008 Jay Dee Trucking had installed light poles, installed a fence, installed additional capping material, destroyed groundwater monitoring wells and removed gas vents. Therefore, they became PRPs for the three acres and are responsible for a portion of the Site remedy.

Based on the June 2010 Gas Vent Sampling and Analysis Report, NJDEP and EPA agreed that no further monitoring of the gas vents (from the IRM cap) on the Jay Dee Trucking property is necessary. However, they remain responsible for soil and groundwater under the IRM cap. They will obtain Remedial Action Permits for the soil and groundwater as described below.

Summary of Changes

Although the design elements of the cap selected in the ROD was modified by the new owners of portions of the Site, the elements of the remedy were not changed. The entire PJP Landfill will be capped. AMB/Prologis will construct one portion of the cap, which has been modified to accommodate their reuse of the property and CCS has done the same to accommodate reuse of the property by Jersey City. The AMB/Prologis portion of the cap is currently under construction. CCS has completed their portion of the cap and has left the area of their cap which borders the AMB/Prologis property, ready to seal with the AMB/Prologis cap.

Wetlands Mitigation

The entire Sip Avenue Ditch is located on the Jersey City portion of the Site. During construction, the ditch was lined with the same material as the landfill. The ditch was also widened and native vegetation was planted along its slopes. Wetlands were also restored along the Hackensack River after that portion of the landfill was completed. As noted during the wetlands mitigation and assessment portion of the PDI, the 0.8 acre freshwater wetland was removed from its near Route 1 and 9 on what is now the AMB/Prologis portion of the Site. The 0.8 acres of wetland were added to the junction of the redesigned Sip Avenue Ditch and the Hackensack River which is now also on the Jersey City portion of the Site.

Wetlands restoration along the Hackensack River on the AMB/Prologis portion of the Site will take place after construction activities are complete.

Institutional Controls

Since waste is left in place throughout the PJP Landfill Site, each owner of a portion of the Site (AMB/Prologis, Jersey City and Jay Dee Trucking) is required to file a deed notice along with paperwork to define a CEA and a WRA. Each owner must also obtain Remedial Action Permits for soil and for groundwater, as well as file any necessary future reports.

The CEA/WRA for the PJP landfill Site as a whole was established on April 26, 2001 and modified by CCS on July 29, 2008, after AMB/Prologis purchased a portion of the Site. It has since been revised to reflect the changes in ownership.

Jersey City filed a Deed Notice on May 29, 2013. In a May 30, 2013 letter from NJDEP to Jersey City's contractor (Dresdner Robin), NJDEP determined that although Jersey City will eventually need to file the paperwork to establish a CEA/WRA, there is not yet enough groundwater data to do so. Jersey City was directed to conduct an additional six rounds of quarterly sampling (for a total of eight) before submitting a revised CEA/WRA.

The CEA/WRA for the AMB/Prologis portion of the Site was approved on July 18, 2008. A Deed Notice will be filed after the final construction completion report is approved. The current construction schedule estimates this will occur in 2014.

The CEA/WRA for Jay Dee Trucking was approved on August 18, 2010 and the Deed Notice was filed on January 20, 2011.

V. Progress Since the Last Five-Year Review

This is the first five-year review.

VI. Five-Year Review Process

Administrative Components

The five-year review team consists of Renee Gelblat (EPA, RPM), Kate Mishkin (EPA, hydrogeologist), Rebecca Ofrane and Chloe Metz (EPA, risk assessors for human health), and Mindy Pensak (EPA, ecological risk assessor).

Community Involvement

EPA published a notice on the Jersey City website, on May 6, 2013 notifying the community of the initiation of the five-year review process.

Document Review

The documents, data, and information which were reviewed in completing this five-year review are summarized in Table 2.

Data Review (Post-PDI sampling)

In March 2008, AMB/Prologis purchased a portion of the PJP landfill site and since that time the Site has been divided into two main parts with separate owners. Each owner has full responsibility for implementation of the selected remedy on their property.

Groundwater

The ROD requires that monitoring wells are sampled on a quarterly basis. Such sampling has taken place, except during construction activities. Figure 3 shows the location of the monitoring wells.

The contaminants found in the groundwater, surface water, and sediments have been found throughout the Site. The COCs in groundwater include: benzene, chlorobenzene, PCE, iron and manganese and 1,4-dioxane. The COCs found in surface water and sediments include PAHs and inorganics, principally benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluorine, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, manganese and copper. The details of sampling on each portion of the Site are described below.

Groundwater Sampling on the Jersey City Property

Prior to construction of the remedy on the Jersey City portion of the Site, CCS sampled the seven groundwater monitoring wells quarterly in 2008, 2009, 2010 and 2011. Sampling was suspended during construction of the remedy. After the remedy was completed in January 2012, quarterly sampling resumed in December 2012. That sampling event showed exceedances of benzene, chlorobenzene, manganese and iron. A groundwater sampling event also took place in March 2013 but the results were not available for this five-year review.

Groundwater samples could not be collected from MW-12S because a dense non-aqueous phase liquid (DNAPL) was discovered in the well during the December 2012 sampling event. As a result, NJDEP required the PRPs to inspect seeps along the riverbank since MW-12S is situated in close proximity to the Hackensack River. In addition the DNAPL in the well was evacuated four times, and samples were sent to a lab. The DNAPL was analyzed and contained quinolines and other polar oxygen containing compounds. These constituents are indicative of a dye and are likely a combination of industrial and medical waste. This well will be monitored in subsequent quarterly sampling events.

Groundwater Sampling on the AMB/Prologis Property

Quarterly sampling of monitoring wells on the AMB/Prologis portion of the PJP Landfill took place in April, July, Oct of 2008 and some wells were also sampled in 2010. Upon initiation of construction activities, AMB/Prologis and NJDEP agreed to the temporary abandonment of five on-site monitoring wells and the permanent abandonment of four on-site monitoring wells.

Prior to construction, there were exceedances of benzene and chlorobenzene in some of the wells. The chemical 1,4-dioxane was added to the sampling list in April 2010 has only been sampled once, in July 2010. 1,4-dioxane was found in concentration up to 6,600 µg/L in the shallow water-bearing zone. It was also present but found in lower concentrations in the deep water-bearing zone. Construction is scheduled to be completed in 2014 at which time quarterly sampling will resume.

Surface water

Surface water samples are collected quarterly from three co-located surface water and sediment locations along the remediated Sip Avenue Ditch and two in the Hackensack River adjacent to the Site. Sampling locations in the Hackensack River include one that is upgradient of the Site, to the north of the Jersey City property and downgradient of the Site, to the southwest of the AMB/Prologis property. The Sip Avenue Ditch conveys run-off from the Site as well as from the Jersey City storm water/sewer system and is tidal for the full length of the ditch.

The principal contaminants of concern that have been detected in surface water include PAHs and inorganics. PAHs most commonly detected include: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluorine, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene. Common metal exceedances of arsenic, manganese, and copper have been found.

PAHs exceeded surface water standards at all sampling locations, including upgradient of the Site. This suggests some contribution from non-site sources. Manganese concentrations exceeded surface water criteria in both the Hackensack River and the Sip Avenue while arsenic and copper concentrations exceeded surface water criteria only in samples collected in the Hackensack River.

Sample data were also screened against NJDEP ecological screening criteria for saline surface water and exceedances of copper, lead and zinc (January 2012) and arsenic, lead, mercury, and zinc (December 2012) were noted. However, at this time, there is no clear pattern of inorganic exceedances as the ditch is tidal. Exceedances were seen throughout the Sip Avenue Ditch as well as the two locations within the Hackensack River.

Surface water sampling will continue after all construction at the Site has been completed.

Vapor Intrusion Investigation

Currently, there are no buildings on the Site. A large warehouse and transfer station is under construction on the AMB/Prologis portion of the property. Although groundwater concentrations on the AMB/Prologis portion remain above levels that could potentially cause vapor intrusion to occur, the building design includes a low permeability cap and venting system in its base. This is designed to act as a vapor barrier.

Recently, Jersey City submitted a vapor intrusion evaluation of the Hartz building (a large warehouse and trucking facility located adjacent to the Jersey City portion of the Site). This is the only building in close proximity to the site that may be impacted by Site related vapor intrusion. Jersey City concluded that the well closest to this building (MW-18S, which is 94 feet from the edge of the Hartz foundation) had concentrations of benzene and vinyl chloride slightly above New Jersey Groundwater Screening Levels. Given the distance of this well from the building, Jersey City proposed evaluating two additional rounds of groundwater data before making the determination to do any further vapor evaluation. NJDEP and EPA agreed with this proposal.

Site Inspection

An inspection of the Site was conducted on May 16, 2013 by the EPA RPM, human health and ecological risk assessors and hydrogeologist. Officials from Jersey City and AMB/Prologis, along with their respective contractors also attended.

The purpose of the inspection was to assess whether the remedies are functioning as designed, and to determine whether current conditions at the Site are protective of human health and the environment.

Construction on the Jersey City portion of the Site has been completed and access is controlled with a locked fence which is in good condition. Current plans for this portion of the Site include a nature center and a park. In the future, a pedestrian bridge will be constructed over the Sip Avenue Ditch at its confluence with the Hackensack River to connect the park to the portion of the AMB/Prologis property along the Hackensack River which was donated to Jersey City.

New plant growth is evident along the banks of the Sip Avenue Ditch. At the time of the Site visit, the vegetation, including plantings in the reconstructed wetlands, were less than a year old and had not yet been subjected to winter weather. The vegetation will be monitored over the winter and its condition evaluated in the spring. Vegetation will be replaced as necessary.

There are long pipes hang from the Pulaski Skyway which are used to drain rainwater from the Skyway. These pipes drop water onto squares of gravel on the Site. The gravel was placed there to prevent erosion of the vegetation overlying the cap under the Skyway. The rainwater then infiltrates the Site and moves to the Sip Avenue Ditch and, eventually to the Hackensack River.

The AMB/Prologis portion of the Site is an active construction area. The area is fully fenced and there is security at all times.

Interviews

Renee Gelblat of EPA has discussed ongoing activities at the site with the five-year review team, the owners of the Site and officials from Jersey City. EPA also placed a notice on the Jersey City web site on May 6, 2013. The city officials had no comments and EPA did not receive comments from the public. There were no issues or concerns raised about the protectiveness of the remedies in place or under construction at the Site.

Other Comments on Operation, Maintenance, Monitoring and Institutional Controls

Table 3 presents several comments and offers suggestions for their resolution.

VII. Technical Assessment Summary

Question A: Is the remedy functioning as intended by the decision documents?

The remedy called for eliminating exposure to contaminated sediments in the Sip Avenue Ditch and preventing additional contaminant influx into the groundwater via infiltration. The installation of the cap on the Jersey City portion of the Site, which includes the Sip Avenue ditch, effectively does this. The cap on the AMB portion of the property is currently being constructed. Once construction in complete, the entire site will be covered by a low permeability cap that will eliminate all current and future direct contact exposure pathways. Air emissions from the IRM portion of the site have decreased significantly since the RI, such that the PRPs have asked for the venting system to be decommissioned. This will eliminate the air exposure route as well.

As discussed in the 2007 *Final Design Report*, drums were discovered and removed from beneath the Pulaski Skyway in 2001, north of the Sip Avenue ditch (Jersey City portion). Along with the drums, soil was removed and soil classified as hazardous under RCRA was disposed of offsite. The area was backfilled with a foot of clean fill above the shallow water-bearing unit and then the soil which was removed during the drum removal event and not determined to be hazardous was placed above the clean fill. No post-removal samples were collected. However, the *Construction Quality Assurance Final Report* shows that this area was capped as part of the remedy.

Although the remedy is not fully implemented, the NJGWQS are used to evaluate the effectiveness of the cap at preventing groundwater infiltration. Concentrations are currently in exceedance of these standards across the site; however, a CEA for the shallow groundwater is in place, ensuring that groundwater will not be available for consumption. The need for a CEA for the deeper groundwater should be explored once the remedy is complete based on the preliminary 1,4-dioxane results discussed above. Surface water and sediment samples will be collected quarterly upon remedy completion. These sample locations will serve as compliance monitoring points to ensure that contaminated groundwater is not impacting the Hackensack River and the Sip Avenue ditch. An evaluation of existing surface water data indicates that although site-related compounds (primarily PAHs) are present in surface water, there does not appear to be widespread impacts from the Site.

The landfill cap is expected to eliminate any potential ecological risks from surface soil contaminants to terrestrial receptors. The Sip Avenue Ditch, which is also included within the landfill cap, is similarly expected to eliminate risk to aquatic receptors (from sediment and surface water) as identified during the remedial investigation process. Surface water data from the December 2012 and January 2013 events show exceedances of inorganics. However the ditch carries storm water drainage and is tidal and therefore there is no pattern of site-related exceedances established throughout the ditch or the Hackensack River.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

The cleanup levels and remedial action objectives used at the time of the remedial action remain valid. 1,4-dioxane was included in the original contaminant list and was added to the sampling list in 2010. It has been included in recent sampling events for groundwater and surface water and will continue to be evaluated.

The baseline risk assessment evaluated the health effects that could potentially result from ingestion of and dermal contact with soils, sediment, and surface water by site trespassers and workers, as well as inhalation of landfill gases by these receptors. Ingestion of groundwater by hypothetical future residents was also evaluated. The exposure assumptions and toxicity values that were used to estimate potential cancer risks and noncancer hazards for these pathways in the 1995 ROD followed the Superfund risk assessment process at the time and remain valid.

The vapor intrusion pathway was not evaluated during this five-year review. Currently, there are no buildings on the Site and a large warehouse and transfer station is under construction on the AMB/Prologis portion of the property. Although groundwater concentrations on the AMB/Prologis portion remain above levels that could potentially cause vapor intrusion to occur, the building design includes a low permeability cap and venting system in its base which is designed to act as a vapor barrier.

Recently, Jersey City submitted a vapor intrusion evaluation of the Hartz building (a large warehouse and trucking facility located adjacent to the Jersey City portion of the Site). This is the only building in close proximity to the site that may be impacted by Site related vapor intrusion. Jersey City concluded that the well closest to this building (MW-18S, which is 94 feet from the edge of the Hartz foundation) had concentrations of benzene and vinyl chloride slightly above New Jersey Groundwater Screening Levels. Given the distance of this well from the building, Jersey City proposed evaluating two additional rounds of groundwater data before making the determination to do any further vapor evaluation. NJDEP and EPA agreed with this proposal.

An ecological risk assessment was conducted to support the 1995 ROD and its assumptions remain valid. The assessment concluded that there was a potential for food chain effects to occur due to predation on aquatic species since several of the contaminants, such as cadmium and mercury, bioconcentrate. Several contaminants in surface water and in sediments in the Sip Avenue Ditch and Hackensack River exceed their respective toxicity vales, suggesting that aquatic life may be impacted. The Sip Avenue Ditch as been lined with the landfill material cap and its surface water continues to be monitored to evaluate leachate impacts.

Question C: Has any other information come to light that could call into question the protectiveness of the remedies?

The remedy has not been fully implemented. At this time there is no information that could call into question the protectiveness of the remedy.

At the time of the Site visit, the vegetation, including plantings in the reconstructed wetlands had only recently been planted (less than a year). Spartina and other plants should be monitored at a minimum frequency of semi-annually and quantitative success criteria should be included in a wetlands monitoring plan. Towards the mouth of the Sip Avenue Ditch (where it meets the Hackensack River), some of the Spartina plantings appeared to be sparse. Adaptive management will be considered in the event that this area fails to thrive.

VIII. Recommendations and Follow-up Actions

The remedy has not been fully implemented. There are no comments, issues, suggestions or recommendations concerning the remedy.

IX. Protectiveness Statement

The remedy is expected to be protective of human health and the environment upon completion. In the interim, response activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.

X. Next Review

The next five-year review for the PJP Landfill should be completed by September 2018.

Table 1: Chronology of Site Events	Date
Landfill activities conducted at the Site	1970 - 1974
NJDEP issued an order to PJP Landfill Company to properly cover and grade the landfill	1977
Periodic surface fires occur in 45 acre area under the Pulaski Skyway and near the Hackensack River	1970-1985
Final listing on EPA's National Priorities List	12/1982
NJDEP conducts Interim Remedial Measures to extinguish fires and remove immediate hazards	1985-1986
NJDEP begins Remedial Investigation/Feasibility Study	1988
Remedial Investigation completed	1990
Phase III Feasibility Study completed	7/22/1993
1993 Sampling event for groundwater and surface water	1993
Record of Decision for Operable Unit One issued	9/28/1995
Administrative Consent Order with CCS (Original ACO)	6/2/1997, amended on 9/29/1997
ACO amendment modified for Remedial Design and Remedial Action with more specific Statement of Work	6/15/2000
EPA Consent Decree for Past Costs Entered	1/17/2002
Pre-Design Investigation	2001-2004
Drum Removal	2/2001-4/2001
Approval of Final Design Report by EPA and NJDEP	7/26/2007
AMB purchases about 51 acres south of Sip Avenue Ditch and signs ACO with NJDEP to assume remedial obligations.	3/7/2008
NJDEP issues ACO with CCS modified to state that AMB has assumed all environmental responsibilities for the portion they have purchased.	3/7/2008
AMB revised remediation action plan approved	7/24/2008
AMB mobilizes	7/24/2008

Table 1: Chronology of Site Events (cont'd)	Date
Closure Equivalency Engineer Report to modify the remedial action on the CCS portion of the Site approved	2/5/10
ACO with CCS modified to state that Jersey City will assume all environmental obligations not on-AMB's portion of the Site upon CCS's completion of final capping activities	6/21/2010
Jersey City signs Memorandum of Understanding with NJDEP to assume all environmental obligations on the non-AMB portion of the Site upon CCS's completion of final capping activities	6/21/2010
Construction of CCS portion of the cap	8/18/2010-1/5/2012
Prologis purchases AMB	6/3/2011
NJDEP approves modification to the remedial design to give permanent easement to Hartz Mountain for their trucking operations	6/2011
Construction Completion Report Approved ("Construction Quality Assurance Final Report") for CCS portion of the Site	5/18/2012
Operation and Maintenance Plan for Jersey City approved	9/11/2012

Table 2: Documents, Data, and Information Used in Completing Five-Year Review
• Phase I Remedial Investigation Report, ICF Technology, April 1990
• Phase III Focused Feasibility Study Report, ICF Technology, July 1993
• Proposed Plan, NJDEP, August 1994
• Operable Unit One Record of Decision, NJDEP, September 1995
• Final (100%) Design Report, Golder Associates, April 2007
• Amended Remedial Design Report (for AMB Pulaski Distribution Center, LLC), Sadat Associates, June 2008
• Annual Groundwater Monitoring Report for the PJP Landfill for CCS for 2008, 2009, 2010, and 2011, Golder Associates, 2008, 2009, 2010, and 2011
• Closure Equivalency Engineer Report (to modify the remedial action on the CCS portion of the Site for Jersey City), Malcolm Pirnie, Inc., November 2009
• Annual Groundwater Monitoring Reports for the AMB Pulaski Distribution Center, LLC, for 2009 and 2010, Sadat Associates, June 2010 and March 2011
• Construction Quality Assurance Final Report (construction completion of the Jersey City portion), Geosyntec Consultants, February 2012
• Final O&M Plan for Jersey City, ARCADIS, August 2012.
• Quarterly Groundwater Sampling Report for the Marion Greenway, ARCADIS (formerly Malcolm Pirnie), December 2012
• Comments from Kate Mishkin, EPA Hydrogeologist, May 2013
• Comments from Mindy Pensak, EPA Eco Risk Assessor, June 2013
• Comments from Chloe Metz, EPA Risk Assessor, August 2013
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Table 3: Other Comments on Operation, Maintenance, Monitoring and Institutional Controls	
Comment	**Suggestion**
On the Jersey City portion of the Site, MW-18S has benzene and vinyl chloride levels above the NJ Groundwater Screening Levels. This could result in a vapor intrusion problem in the nearby and off-Site Hartz Mountain Facility.	Jersey City proposed evaluating two additional rounds of groundwater sampling before making a determination to conduct any further vapor intrusion evaluation. NJDEP and EPA agreed with this proposal.

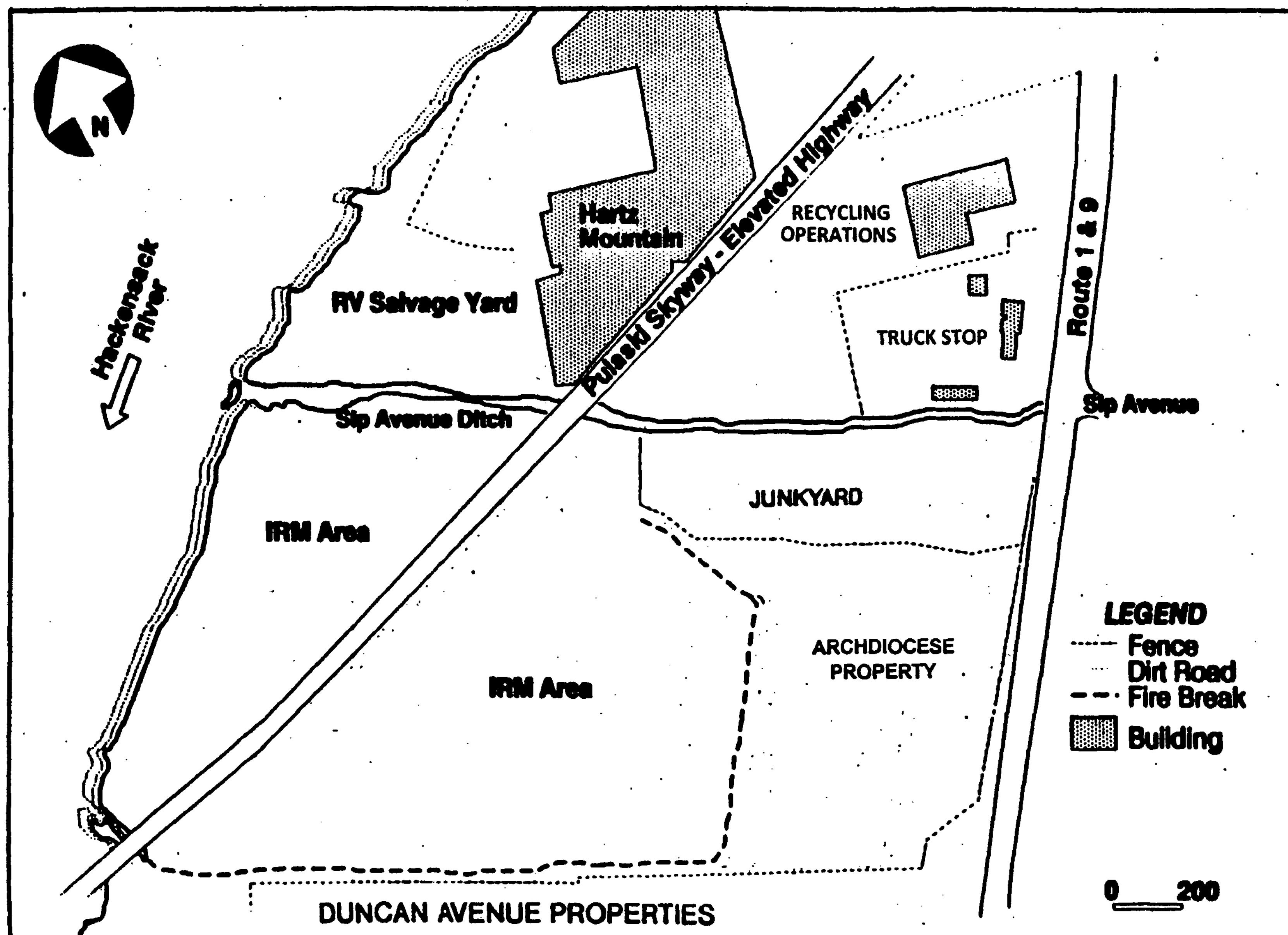
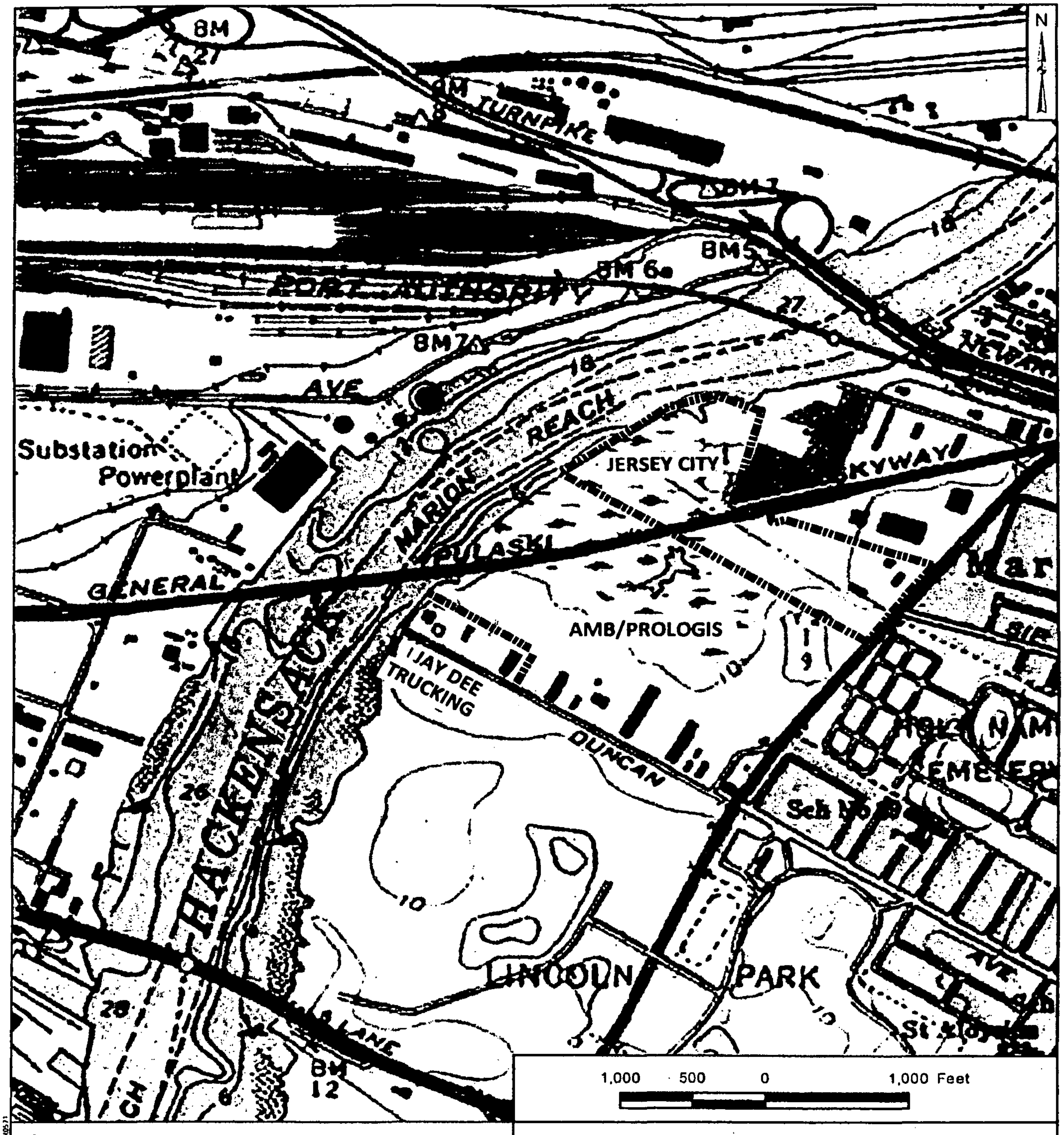


Figure 1 SITE MAP (1995)

PJP LANDFILL, JERSEY CITY, NEW JERSEY



Legend

Approximate Property Boundaries

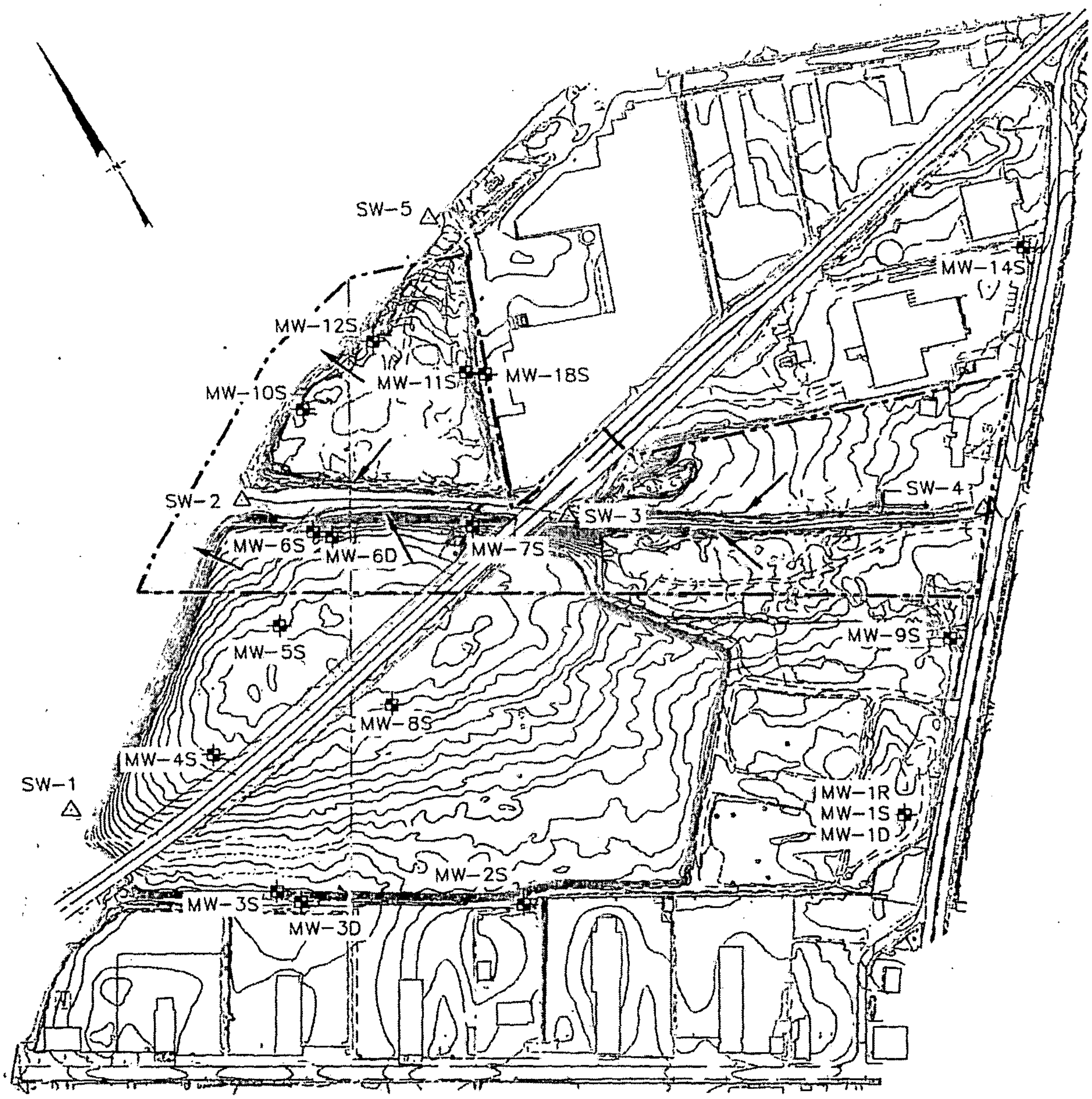
USGS Quadrangle Map
PJP Landfill
Jersey City, New Jersey

Notes
USGS Quadrangle Jersey City, published 1982. Copyright:© 2011 National Geographic Society, i-cubed.

Geosyntec
consultants

Figure 2

Columbia, Maryland | April 2012



LEGEND

- CEA BOUNDARY **FOR JERSEY CITY**
- MW-11S — MONITORING WELL LOCATION
- SW-5 — SURFACE WATER SAMPLE LOCATION
- GROUNDWATER FLOW DIRECTION

500 250 0 500

SCALE: 1" = 500'

NOTE: HORIZONTAL DATUM IS NEW JERSEY STATE PLAN, NAD 1983.

SITE MAP

Geosyntec consultants

COLUMBIA, MARYLAND

DATE:	APRIL 2012
PROJECT NO.	MR0571B
DOCUMENT NO.	
FILE NO.	0571f304

Figure 3

Community Update on the Berry's Creek Study Area

Berry's Creek, Bergen County, New Jersey **September 2014**

Where to Get Information:

SITE REPOSITORY
Wood-Ridge Memorial Library
231 Hackensack Street
Wood-Ridge, NJ 07075
201-438-2455

US ENVIRONMENTAL PROTECTION AGENCY

- **Doug Tomchuk,** ***Project Manager***
  212-637-3956
  tomchuk.doug@epa.gov

- **Sophia Kelley,**
  Community Involvement Coordinator
  212-637-3670
  kelley.jessicasophia@epa.gov

Progress Made on Investigation of Berry's Creek Contamination

Field studies (collection of samples and monitoring of sediment, fish and water) to investigate contamination in Berry's Creek and its surrounding waterways and wetlands are continuing in 2014. The U.S Environmental Protection Agency (EPA) is overseeing the work that is being paid for and performed by potentially responsible parties. Ongoing work includes sample collection and analysis to fill in data gaps (including numerous sediment cores), collection of high frequency water samples to support sediment transport modeling, sediment surface elevation measurements, annual fish and water samples, and monitoring of field pilot studies that will test potential cleanup technologies. These field studies are part of the Remedial Investigation/ Feasibility Study (RI/FS) for the site, which has been ongoing since 2009.

The RI/FS for the Berry's Creek Study Area is a comprehensive assessment of multiple contaminants in the water, sediment and biota in the creek, as well as the surrounding wetlands and waterways (collectively referred to as the "Study Area"). Interim reports have been prepared to help understand the information assembled to date and to focus the future data collection efforts. Substantial data collections are ongoing in 2014 to help answer questions raised by the interim reports and other data analysis from previous sample collections. In addition, certain data collections will help evaluate whether the study area has undergone changes resulting from the large storms that occurred during the study (e.g., Superstorm Sandy, Hurricane Irene, Tropical Storm Lee). Aside from the annual baseline biota monitoring program, and pilot study work, it is anticipated that the 2014 field studies will be the last major data collections. The results of the data collections are being used to assess potential risks to human health and to wildlife posed by site contaminants. A study of potential cleanup alternatives (Feasibility Study) is also being performed in conjunction with the field investigations and assessment of potential risks.

The information from the interim studies, will be updated with the recent data and be incorporated into the Remedial Investigation Report. The Remedial Investigation Report will include the risk assessments as well. Preparation of these substantial documents has been initiated and will continue through 2015.

Background

Berry's Creek is an approximately 6.5 mile-long tributary of the Hackensack River. Most of the creek is tidal, and tide gates regulate the extent of tidal influence in many of the upland tributaries. The creek originates in the West Riser Ditch near Teterboro Airport, meanders through the reed marshes, and then discharges into the Hackensack River, primarily via the Berry's Creek Canal and also via the lower portion of Berry's Creek. Portions of the creek are located in the Boroughs of Teterboro, Moonachie, Wood-Ridge, Carlstadt, Rutherford, and East Rutherford.

The BCSA has historically been associated with mercury contamination originating from the Ventron/Velsicol Superfund site; however the RI/FS is investigating numerous contaminants within the creek from multiple sources. Two other federal Superfund sites, the Universal Oil Products site and the Scientific Chemical Processing site, as well as several NJ State listed hazardous waste sites are located in the Berry's Creek watershed. Contaminants are known to be elevated throughout the BCSA surface water and sediment and the levels warrant detailed evaluation of nature, extent and potential risks.

EPA Oversight and Decision-Making

EPA is overseeing the work being conducted by the parties that signed on to conduct the RI/FS. Oversight consists of, among other things, field observation, split sampling, and document review and approval. The New Jersey Department of Environmental Protection (NJDEP) and other agencies, such as the National Oceanic and Atmospheric Administration and the US Fish and Wildlife Service also review and comment on documents developed for the project. The study is also being conducted in coordination with the New Jersey Meadowlands Commission. Following the completion of data collection and analysis and the evaluation of alternatives in the Feasibility Study, EPA will develop a Proposed Plan for the Berry's Creek Study Area that will be provided to the public for comment prior to the selection of a remedy. The selected remedy, or cleanup plan, will be outlined in a decision document called a Record of Decision. The evaluation of alternatives and the remedy selection process will take approximately two years following completion of data analysis. A cleanup proposal for the site would likely be put forth by EPA in 2018.

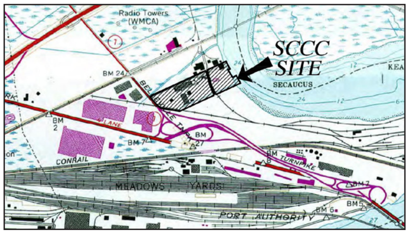
You can find more information on the Berry's Creek Study on EPA's Project Web site @ http://www.epa.gov/region02/superfund/npl/berryscreek

EPA Region 2 has designated a Superfund Regional Public Liaison Manager as a point-of-contact f or community concerns and questions about the federal Superfund program in New York, New Jersey, Puerto Rico and the US Virgin Islands. To support this effort, the Agency has established a 24-hour, toll-free number that the public can call to request information, express their concerns or register complaints about Superfund. The Superfund Regional Public Liaison Manager for EPA's Region 2 office is George H. Zachos, US EPA, Region 2, 2890 Woodbridge Avenue, MS-211, Edison, New Jersey, (732) 321-6621 or toll free at (888) 283-7626.

Update on Cleanup Activities at the Standard Chlorine Chemical Company Superfund Site

Kearny, New Jersey

Community Update **AUGUST 2015**



Site Location: 1025-1035 Belleville Turnpike, Kearny, Hudson County, New Jersey, 07032

If you have any questions or would like additional information, please contact:

Sophia Kelley
Community Involvement Coordinator
212.637-3670
kelley.jessicasophia@epa.gov

Alison Hess
Remedial Project Manager
212.637.3959
hess.alison@epa.gov

If you would like information on general environmental concerns or the federal Superfund hazardous waste program, have concerns or complaints about the Superfund program, or if you seek assistance in resolving site-specific issues that were not fully addressed by the EPA, please contact:

George Zachos
EPA Regional Public Liaison
(732) 321-6621
zachos.george@epa.gov

Or toll free at (888) 283-7626

The U.S. Environmental Protection Agency (EPA) is conducting an environmental cleanup at the Standard Chlorine Chemical Company Superfund Site in Kearny, NJ. This update has been prepared to inform the community, local officials and other interested parties of the status of activities at the Standard Chlorine site.

Site Overview:

The 25-acre site is located in a heavily industrialized area along the Hackensack River. From the early 1900s to the 1990s, several chemical manufacturing and processing activities took place on the site. These activities included the manufacture of products from naphthalene, moth balls, drain cleaner, deodorizers, and lead-acid batteries, among other things. In the past, contamination came from several sources, including two lagoons located on the eastern portion of the site as well as damaged tanks and containers containing pollutants. Several abandoned buildings in various states of disrepair were also located on the property.

Cleanup Progress:

The EPA and the potentially responsible parties entered into an agreement in May 2013 that defined the scope of work for a Remedial Investigation and Focused Feasibility Study (RI/FFS) of the site. The purpose of the RI/FFS is to investigate the nature and extent of contamination at the site in order to develop and evaluate potential cleanup options.

Since issuance of the previous Community Update in July 2014, significant progress has been made on completing the tasks outlined in the agreement, including submittal of two major reports, a Remedial Investigation Report and a Focused Feasibility Study. The following provides more detail on the RI/FFS being conducted:

- Site Characterization Summary Report (March 2013). This report includes a compilation of all previous investigation data acquired at the site.
- RI/FFS Work Plan (September 2013). The work plan serves as a project planning document outlining and describing activities to be conducted under the requirements of the agreement. The implementation of the work plan began in October 2013.
- Community Involvement Plan (February 2014). This plan outlines how the community can be actively involved in the cleanup process and is intended to support two-way communication between the EPA and the community.

- Potential cleanup technologies identified and contamination treatability studies have been performed.
- Baseline Risk Assessment and Screening Level Ecological Risk Assessment (April – May 2014). The goal of these assessments is to identify potential risks to human health and ecological receptors.
- Remedial Investigation Report (July 2015) has been submitted to the EPA for review. This report summarizes current soil and groundwater conditions in terms of the nature and extent of impacts to each medium.
- A draft Focused Feasibility Study (July 2015) has been submitted to the EPA for review. The draft Focused Feasibility Study (FFS) includes a comparative analysis of remedial alternatives for the area within the barrier wall containment system. A final FFS Report will be submitted following receipt of EPA comments on the draft FFS Report and the completion of additional investigation.
- A draft Cultural Resources Survey of the former Thomas A. Edison Inc. buildings on the site has been completed.

Site Background:

Prior to placement on the Superfund National Priorities List of hazardous waste sites in 2007, the site was sampled and studied by the New Jersey Department of Environmental Protection and a group of parties potentially responsible for the contamination. Previous work also included extensive interim cleanup measures as outlined later in this update. The EPA continues to work with the state and the potentially responsible parties to investigate the nature and extent of contamination at the site while developing and evaluating potential cleanup options.

The Standard Chlorine site is being addressed in two stages: interim actions designed to stop contaminated ground water and surface water from moving to the Hackensack River, and a long-term cleanup based on a comprehensive approach to the entire site.

Current Site Conditions

Information Repositories

Kearny Public Library

318 Kearny Avenue

Kearny, NJ 07032

201.998.2666

admin@kearnylibrary.org

U.S. EPA Region 2

Superfund Records Center

290 Broadway, 18th Floor

New York, NY 10007-1866

212.637.4308

Or visit the EPA's website:

http://www.epa.gov/region2/superfund/npl/standardchlorinechemical

Site Investigation: Drilling

Geotextile Fabric

Sealing Buildings

Assessment and Cleanup Milestones

1984-1989

Initial site investigations completed. In October 1989, the New Jersey Department of Environmental Protection and Standard Chlorine Chemical Co. Inc. (SCCC) entered into an Administrative Consent Order requiring SCCC to plan and implement the following:

- Interim Remedial Measures to prevent potential contact with materials in the lagoon area and to secure damaged tanks and containers
- A Remedial Investigation and Feasibility Study
- Selected remedial alternative(s)

1991-1993

Remedial Investigation and Interim Remedial Measures were completed, including:

- Installation of security fencing
- Addition of soil to the lagoon berm
- Placement of stabilizing geotextile and rip rap along the Hackensack River shoreline
- Removal of the contents of five above-ground storage tanks
- Repackaging of asbestos-containing material
- Installation of surface covers (geotextile fabric/aggregate or asphalt)

1994-2002

Supplemental Remedial Investigations and Site Characterization Activities completed

2003-2009

Interim Response Action planning, design and permitting completed

2007

Standard Chlorine Site added to the Superfund National Priorities List

2008-2009

Phase II Supplemental Remedial Investigation and Pre-Design Investigations completed

2010

Removal Action (consisting of the sealing of openings in former process buildings to mitigate the potential transport of wind-borne particulates)

Assessment and Cleanup Milestones

2010-2011

Interim Response Action was implemented, including:

- Physical Barrier Wall System
- Hydraulic Control System (consisting of ground water extraction wells and treatment system)
- Dense Non-Aqueous Phase Liquid (DNAPL) Recovery System
- Lagoon Dewatering, Backfilling, and Surface Cover
- Near Shore Sediment Management
- South Ditch Sediment Management and Stormwater Management System Construction
- Consolidation Area Construction
- Wetland and Shoreline Mitigation
- Septic Tank Closure
- Transformer Pad Removal and Remediation
- Site Restoration
- Air Monitoring Activities

2010-2012

Building Demolition

2012-2015

Interim Response Action Operations, Maintenance and Monitoring. RI/FFS Activities conducted under Administrative Settlement Agreement and Order on Consent (Agreement). RI/FFS activities completed to date:

- Site Characterization Summary Report
- RI/FFS Work Plan
- Site Characterization Summary Report Addendum
- Pathway Analysis Report/Memorandum on Exposure Scenarios and Assumptions
- Identification of Candidate Technologies Memorandum
- Screening Level Ecological Risk Assessment
- Baseline Human Health Risk Assessment
- Remedial Investigation Report
- Development and Screening of Remedial Alternatives
- Draft Focused Feasibility Study Report

Ongoing and Future Activities

- Cultural Resources Survey
- Completion of Additional Investigation
- Finalize Focused Feasibility Study
- Prepare Proposed Plan for final remediation
- Continue Interim Response Action maintenance and monitoring

Barrier Wall

DNAPL Recovery Wells

Slurry Wall Installation

Treatment Plant

Berry's Creek Study Area

Bergen County, NJ

The Berry's Creek Study Area (BCSA), located in Bergen County, New Jersey encompasses the 6.5-mile-long Berry's Creek, its tributaries, the Berry's Creek canal, and adjacent wetlands. Mercury concentrations in Berry's Creek sediments are greater than what is considered to be protective of wildlife. The area is highly industrialized and has a low population density, but zoning is a mix of industrial, commercial, residential, recreational, redevelopment, and marshland preservation. The creek meanders through the New Jersey Meadowlands and the municipalities of Teterboro, Moonachie, Wood-Ridge, Carlstadt, Rutherford, Lyndhurst, and East Rutherford before discharging into the Hackensack River.

Evaluation of the BCSA is highly complex, with several potential sources of contamination and numerous contaminants that may interrelate and contribute to the overall risk from exposure. Industrial development in the area began as early as the late nineteenth century and included the manufacture of disposable medical supplies, pharmaceutical products, and organic chemicals. Historically, the area has been associated with mercury contamination from the 40-acre Ventron/Velsicol Superfund site, which has migrated to Berry's Creek. Two other Superfund sites are located in the BCSA: the Universal Oil Products site and the Scientific Chemical Processing site. Currently, over 14,000 businesses operate within the area and manufacturing is still the dominant industry.

Beyond industry, the BCSA has several chemical and nonchemical sources of impairment; they include untreated sewage, urban runoff, sewer discharges, tide gates that alter the creek's flow, and extensive infrastructure (including several large roads, rail lines and the Meadowlands Sports Complex). Over time, six sewage treatment plants and at least three municipal landfills containing industrial and municipal waste have discharged pollutants into Berry's Creek. Other agencies and organizations, such as the New Jersey Department of Environmental Protection, also are addressing contamination within the study area, including cleanup of several state-listed hazardous waste sites. Portions of Berry's Creek have been used for fishing and crabbing, but advisories for blue crab and several fish species on the waterways within the Newark Bay Complex, including Berry's Creek, currently limit those activities.

More Information

- Home
- Additional Documents
- News

Related Web Sites

EXIT Disclaimer

- Ventron/Velsicol Superfund Site
- Universal Oil Products
- Scientific Chemical Processing

Public Meeting

No meetings scheduled

Your Community Involvement Coordinator

Sophia Kelley – (212) 637-3670
Kelley.jessicasophia@epa.gov

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Given the area's complexity, assessment of contamination requires intensive sampling and analysis of several pollutants. Ninety-eight parties potentially responsible for contamination in Berry's Creek (the Cooperating PRP Group) have agreed to conduct an investigation of contamination in Berry's Creek and its surrounding waterways and wetlands. EPA is closely overseeing the work. The New Jersey Department of Environmental Protection and other agencies (NJDEP), such as the National Oceanographic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS), also will review and comment on project documents. Following assessment, EPA will determine risks to human health and wildlife, examine potential cleanup alternatives, and present a proposed plan for the area.

Scientific Chemical Processing

Carlstadt, NJ

EPA added the Scientific Chemical Processing site in Carlstadt, New Jersey to the Superfund National Priorities List on September 1, 1983 because hazardous chemicals were found in the soil and ground water. The six acre superfund site was used as a processing facility for the recovery and disposal of various wastes. Hazardous substances were stored improperly on-site and contaminated the soil and groundwater. On-site ground water and soil contamination include PCBs, heavy metals and volatile organic compounds (VOCs), which are potentially harmful contaminants that can easily evaporate into the air. Off-property ground water and the adjacent Peach Island Green are also contaminated. Approximately 14,500 residents live within a two-mile radius of the site, and several private residences are within one mile of the site. The site is now vacant. A group of more than 100 potentially responsible parties is conducting the cleanup work at the site.

EPA removed contaminated tanks and fenced off the entire site, reducing public access. In 1992, to prevent the contamination from spreading further, and to prevent exposure to the contaminated soil while the site was still being studied, EPA implemented a cap over the site, constructed slurry walls, which are underground walls that contain the ground water from migrating further from the contamination source, and removed ground water within the slurry wall using pumps. The contaminated ground water was then disposed of at an approved off-site facility.

In 2002, EPA selected a final remedy for the site soil and on-property ground water. The final remedy includes solidification of the most contaminated parts of the site, the installation of a new cap over the soil, and upgrading of the ground water recovery system and the underground barriers.

More Information

- Home
- Fact Sheet [PDF 6 KB, 2 pp]
- Additional Documents
- Photos
- News

Public Meeting

No meetings scheduled.

Your Community Involvement Coordinator

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Universal Oil Products

New Jersey

EPA ID#: NJD002005106

EPA REGION 2

Congressional District(s): 09

Bergen

East Rutherford

NPL LISTING HISTORY

Proposed Date: 12/30/1982

Final Date: 9/8/1983

Site Description

The Universal Oil Products site is located on 73 acres adjacent to Route 17 in East Rutherford. Various chemicals for the fragrance industry were manufactured there since 1932. Beginning in 1960, the company also recovered solvents and waste chemicals at the site. In 1979, the company ceased operations and the plant was dismantled. Operations of the plant and two unlined waste water lagoons resulted in contamination of the soil, surface water, sediment and groundwater. Although there is groundwater usage in the nearby area, it is has not been shown to be impacted by the site. The shallow surface aquifer at the site is perched on a thick clay layer and has been determined to be unsuitable for consumption due to its connection with a saline water body (NJ Class III-B). The site is in the coastal wetland management area of the Hackensack River Basin, and much of the site is within the Meadowlands District. Berry's Creek (which is also under investigation by the Superfund program) borders the southeastern part of the site, and Ackerman's Creek, which is a tributary to Berry's Creek, passes through the site. Berry's Creek joins the Hackensack River about 3 miles downstream from the site. Local residents may use the area's surface water for recreation.

Site Responsibility:

This site is being addressed through a combination of Federal, State and Potentially Responsible Party actions.

Threat and Contaminants

The primary threats remaining at the site are exposure to contaminants in the sediment, surface water and biota on site due to PCBs, mercury and chromium. People who come into direct contact with or accidentally ingest contaminated soil, sediments, groundwater, surface water or biota may suffer adverse health effects. Ecological effects are also of concern.

Other contaminants associated with the site include volatile organic compounds (VOCs) including chlorinated benzenes, trichloroethylene (TCE), vinyl chloride, toluene, polychlorinated biphenyls (PCBs), and lead in the groundwater. Soils were found to contain VOCs, PCBs, Polycyclic Aromatic Hydrocarbons (PAHs) and lead. Previous site actions have been implemented to reduce exposure to these contaminants at the upland portions of the site.

Cleanup Approach

Contamination at the site is being addressed in phases. There have been several interim actions to address immediate concerns. The first major cleanup phase addressed contaminated soils in the upland portions of the site. The second phase of the cleanup was to address contaminated groundwater. The next phase will address contaminants in the adjoining wetland/creek areas.

Response Action Status

Immediate Actions: Several immediate actions have been implemented at the UOP site. The lagoons were addressed on an expedited basis by the potentially responsible party (PRP) in 1990. Liquids, sludges, and sediments were removed from these surface impoundments by the PRP under New Jersey Department of Environmental Protection (NJDEP) oversight. Between 2003 and 2005, PCB contaminated soils under the active Pascack Valley Railway line were removed by New Jersey Transit. In 2007, areas that would no longer be accessible to future remediation, underlying the new rail link to the Meadowlands Sports Complex, were removed. Most recently, in 2012, an additional area of the the lagoons and adjacent contaminated sediment were removed (see more below).

Entire Site: The PRP, under NJDEP and EPA monitoring, completed a study of the nature and extent of contamination of site soils and groundwater for the uplands portion of the site. A Record of Decision detailing the response actions for the uplands was signed in September 1993 and amended in December 1998. Remedial actions that addressed the contaminated soils and a portion of the groundwater have been completed. PCB/PAH-contaminated soil has been addressed through a combination of thermal desorption and offsite disposal. A portion of the VOC-contaminated soils has been treated using soil vapor extraction. Lead-contaminated soils have been excavated and placed under the on-site cap. Groundwater was remediated by an on-site treatment system which operated from October 1997 through November 1998.

Field studies to evaluate the wetland/creek areas were initiated in 2005, but were interrupted by the construction of the rail link to the Meadowlands. The findings of this study were the basis for the removal action to excavate and dispose materials off site from the lagoons and the adjacent soils and sediments. Coordination of this study with the Berry's Creek Study Area investigation has been important to the management of this project.

Site Facts: Under an Administrative Order on Consent with EPA, the PRP (Honeywell International, Inc.) has taken the lead in studying the nature and extent of contamination at the site. The 2010 Administrative Order on Consent also included a removal action for some of the most highly contaminated materials in the wetland/waterway portion of the site, from in the vicinity of the lagoon.

Cleanup Progress

Under the immediate response actions, the PRP removed 950,000 gallons of contaminated water from the lagoon areas. Of the 950,000 gallons of water removed from the lagoon areas, 271,589 gallons were treated and discharged on-site and 678,411 gallons were transported to a treatment facility in Newark, New Jersey. Approximately, 8,600 tons of contaminated soils/sediments were removed from the lagoon area and transported to a hazardous waste landfill.

As specified in the Record of Decision for the uplands area, 8,200 tons of PCB/PAH-contaminated soils were treated by soil vapor extraction and 6,600 cubic yards of PCB/PAH-contaminated soils were disposed off-site. Additionally, 45,000 cubic yards of lead and PCB/PAH-contaminated soils were placed beneath a multi-media cap. A Vapor Extraction system treated 3,200 tons of VOC contaminated soils. Approximately six million gallons of contaminated water from the shallow groundwater collection system were pumped and treated. Later, prior to the construction of a home center and restaurant on a portion of the site, additional excavations of approximately 50,000 cubic yards of soil occurred. The excavated soils were sent off site for disposal.

Additional immediate response actions occurred along the rail lines. Approximately 4000 cubic yards of PCB-contaminated soils were removed and sent for off-site disposal from within the right-of-way of the active Pascack Valley rail line. Later, prior to construction of the rail link to the Meadowlands Sports Complex, the area within the foot print of the planned rail line was excavated to a depth of approximately four feet below the current grade. Approximately 9,600 cubic yards of soil and sediment was excavated and sent off site for disposal. In some areas, marginally contaminated soils were covered by surcharge soils.

The remaining areas to be addressed are the wetland and creek areas. Studies are nearing completion for this portion of the investigation. Evaluation of potential remediation alternatives will be conducted after the study. The wetland and creek area investigations indicated there was highly contaminated material remaining on site near the previous waste water lagoons. Therefore, the PRP removed the berms of the lagoons, as well as adjacent sediment and soils that had the potential to migrate. This action was completed in early 2013, and included the excavation and off-site disposal of approximately 36,000 tons of soil and sediment.

Site Repositories

USEPA Records Center 290 Broadway, 18th floor New York, NY 10007 (212) 637-4308

East Rutherford Memorial Library 143 Boiling Springs Avenue East Rutherford, NJ 07073

Arch. Environ. Contam. Toxicol. 52, 80–89 (2007)
DOI: 10.1007/s00244-006-0093-4

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Contaminants in Fish of the Hackensack Meadowlands, New Jersey: Size, Sex, and Seasonal Relationships as Related to Health Risks

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Received: 9 May 2006/Accepted: 5 July 2006

Abstract. The trace metal content and related safety (health risk) of Hackensack River fish were assessed within the Hackensack Meadowlands of New Jersey, USA. Eight elements were analyzed in the edible portion (*i.e.*, muscle) of species commonly taken by anglers in the area. The white perch collection (*Morone americana*) was large enough ($n = 168$) to enable statistically significant inferences, but there were too few brown bullheads and carp to reach definite conclusions. Of the eight elements analyzed, the one that accumulates to the point of being a health risk in white perch is mercury (Hg). Relationships between mercury concentrations and size and with collection season were observed; correlation with lipid content, total polychlorinated biphenyl (PCB) content, or collection site were very weak. Only 18% of the Hg was methylated in October ($n = 8$), whereas June and July fish ($n = 12$) had 100% methylation of Hg. White perch should not be considered edible because the Hg level exceeded the ‘‘one meal per month’’ action level of 0.47 μg/g wet weight (ppm) in 32% of our catch and 2.5% exceeded the ‘‘no consumption at all’’ level of 1 μg/g. The larger fish represent greater risk for Hg. Furthermore, the warmer months, when more recreational fishing takes place, might present greater risk. A more significant reason for avoiding white perch is the PCB contamination because 40% of these fish exceeded the US Food and Drug Administration (FDA) action level of 2000 ng/g for PCBs and all white perch exceeded the US Environmental Protection Agency cancer/health guideline (49 ng/g) of no more than one meal/month. In fact, nearly all were 10 times that advisory level. There were differences between male and female white perch PCB levels, with nearly all of those above the US FDA action level being male. Forage fish (mummichogs and Atlantic silversides) were similarly analyzed, but no correlations were found with any other parameters. The relationship of collection site to contaminants cannot be demonstrated because sufficient numbers of game fish could not be collected at many sites at all seasons.

Correspondence to: Peddrick Weis; *email:* weis@umdnj.edu

The Hackensack Meadowlands (HM) is an ~3000-ha estuary 5–12 km west of New York City and draining into Newark Bay. It includes salt marsh, open water (the Hackensack River and its tributaries), and open and closed landfills, as well as a four-century history of residential and commercial development in northeastern New Jersey. It might be the oldest industrial area in North America. Approximately 1200 ha are now protected from further development. Substantial hunting and fishing activity takes place in the HM, although the state of New Jersey has issued advisories related to fish consumption based on data collected in 1986–1987 (Hauge *et al.* 1990) and commercial fishing and crabbing are prohibited in the HM.

The water quality of the Hackensack River has been improving since the 1970s, due to the US Clean Water Act. This has resulted in an increase in recreational fishing and crabbing within the HM. Although the water quality has improved, river sediments can be a persistent reservoir of particle-bound contaminants and might act as a source of contaminants that, in turn, can cycle through the food web. Recently, an inventory of fish species in the HM was completed (http://meri.njmeadowlands.gov/scientific/fisheries/). The sampling allowed not only a species census but also assessment of the state of health of the fish, ecological parameters, and chemical analysis of tissues from selected fish species. Thus, baseline data were provided on the extent to which the fish living in the river are accumulating contaminants. These data could be used to determine whether the level of contamination poses concern for human health and/or ecological risk.

Methods

Tissue Analysis

Selection of contaminants of concern. Given the historical anthropogenic impacts to which the Meadowlands has been subjected over the past four centuries and the many studies that have analyzed sediments

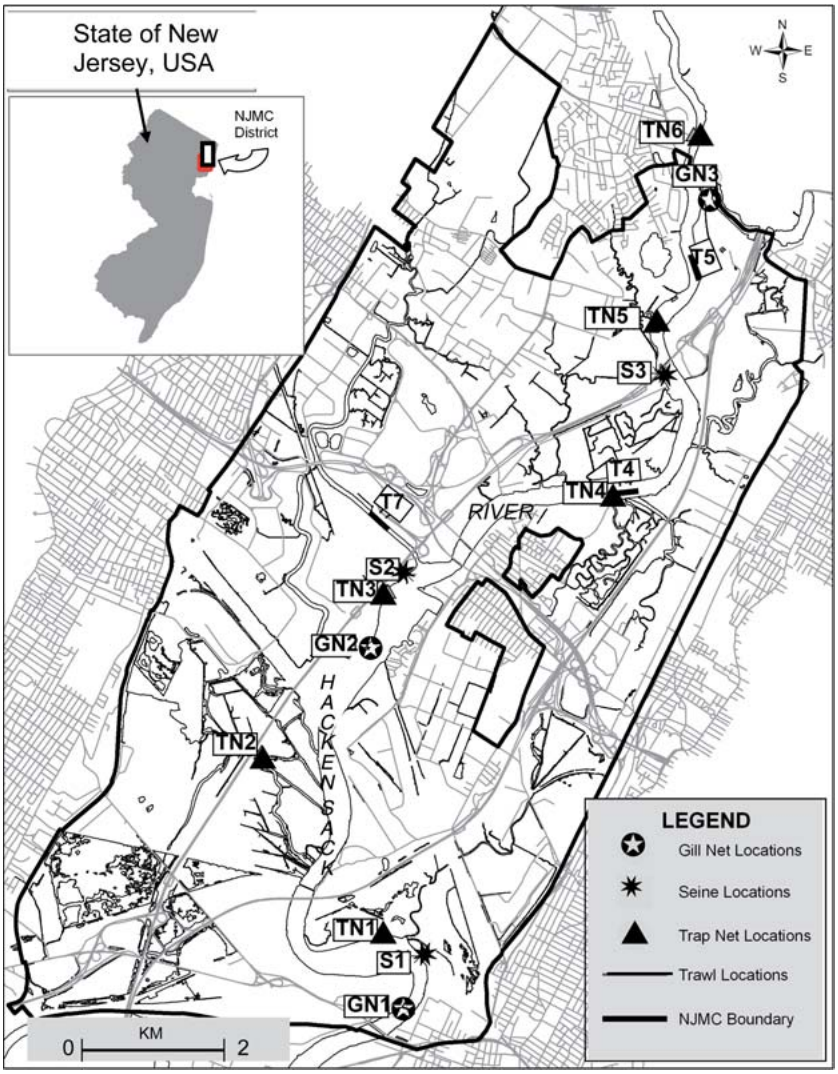

Fig. 1. Collecting sites within the New Jersey Meadowlands Commission's Hackensack Meadowlands District

and surface waters within the HM in the past 20 years, the contaminants of concern (COCs) in the Meadowlands are well known. COCs analyzed in tissue samples include metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) and organic chemicals that are known to bioaccumulate (*e.g.*, chlorinated pesticides and polychlorinated biphenyls [PCBs]). Of those COCs that *bioaccumulate*, only the organics and mercury (Hg) *bioconcentrate* (*i.e.*, accumulate to higher levels [typically, an order of magnitude] with each trophic level), making them of special concern.

Selection of target species. Species targeted for tissue analysis included common resident species that are consumed by humans (*i.e.*, ''game'' fish) and smaller resident species with small home ranges that are consumed by fishes, birds, mammals, and so forth (*i.e.*, ''forage'' fish). Thus, the target game fish included white perch (*Morone americana*), carp (*Cyprinus carpio*), pumpkinseed (*Lepomis gibbosus*), and brown bullhead (*Ictalurus nebulosus*). The target forage fish included the mummichog (*Fundulus heteroclitus*), Atlantic silverside (*Menidia menidia*), and the inland silverside (*Menidia beryllina*). Of these species, the only game fish collected in sufficient numbers allowing both seasonal and site comparisons was the white perch, and the only forage fish commonly found were the mummichog and the Atlantic silverside. Other game fish collected and analyzed were the carp and bullhead.

The collection sites, along or near the Hackensack River, are shown in Fig. 1. The collecting methods included gill nets, seining, trawling, and trap nets. These are identified at the sites in Fig. 1 as GN, S, T, and TN, respectively, and they extend from 40°44′35″N × 74°04′41″W (at GN 1) to 40°51′04″N × 74°01′47″W (at TN 6). The gill and trap nets were left in place for ~24 h. Trawling was done from the shore toward the river channel. A 16-ft otter trawl (constructed using 3/4-in. square body mesh, 5/8-in. square cod-end mesh, with a 1/4-in. mesh cod-end liner) was towed for 3 min. Two duplicate tows were made each time that we sampled a trawl location. Only those trawl sites that were productive are shown in Fig. 1. Collecting was performed at least monthly throughout the year. Data presented here are from specimens collected October 2001 through May 2003.

Processing and analysis of tissue samples. The New Jersey Meadowland Commission (NJMC) fishery team provided the specimens for analysis. For each collection, they filled out a chain-of-custody form listing the species, collection location, gear type, date, time, length, weight, and any abnormalities observed for each specimen. Specimens (in labeled Ziploc® bags) were placed in ice and brought to the NJMC lab at the end of each collection day. The specimens were kept on ice and dissected at the NJMC lab, providing the tissue necessary for analysis. Standard edible fillets (''skin off'') were cut from the game fish specimens and the remainder of the carcasses were archived at −80°C. The fillets, individually identified, were double-bagged and transferred to the University of Medicine and Dentistry of NJ (UMDNJ) for further processing. These species included the white perch, brown bullhead, and common carp. For purposes of analysis, individual fish were used; it was not necessary to combine or pool specimens. A total of 168 white perch were analyzed for metals. Other parts of some of the fish were used for other studies: edible fillets for organic chemical uptake ($n = 30$), stomach contents for diet analysis (Weis 2005), and the remainder for histopathology, reproductive status, growth rate, and parasite burdens (Czerwinski *et al.*, companion study, unpublished data). In addition, 29 brown bullheads, and 9 carp were analyzed for metals.

Forage fish were analyzed whole (including stomach contents). In the lab, composite samples were sliced vertically and 7–10 pieces (utilizing sections that included all body parts and organs) from 3–4 fish were combined for analysis. The number of specimens per composite, but not the lengths and weights of the individual fish used to make up each composite sample, were recorded. A total of 30 mummichog and 8 silverside composites were analyzed for metals, and 9 mummichog and 6 silverside composites were analyzed for organics.

Metals analysis. For metals analysis, a sufficient amount of tissue (2.0 ± 0.2 g wet weight, yielding ~0.4–0.5 g dry weight) was excised (or in the case of homogenized forage fish, combined as described earlier), oven-dried to constant weight (60°C, 48 h), weighed on a calibrated analytical balance to the nearest milligram, and mineralized in 10 mL Trace Metal Grade HNO_3 (Fisher Scientific) in Teflon bombs in a MARS-5 programmed microwave digester (CEM Corp., Mathews, NC) at 115 lb/in.^{2} and 178°C for 30 min. The resultant mineralized solution was boiled off to near dryness, restored to 10 mL volume with 1% HNO_3, and divided in half. One half was used by the NJMC laboratory for analysis of Cd, Cr, Cu, Ni, Pb, and Zn by graphite furnace–atomic absorption spectrophotometry (GF-AAS). The other half was used by UMDNJ for total Hg analysis by cold-vapor AAS in a Bacharach MAS-50D mercury analyzer and for As analysis in a Perkin-Elmer 3100Z spectrophotometer by GF-AAS with Zeeman effect. Wet weight metal levels (from which government agencies derive their risk analyses) were back calculated by dividing our dry weight values by the individual moisture contents of 74–78%.

Organic analysis. In this study, 110 individual PCB congeners, DDXs, and chlordanes were quantified in 9 mummichog, 6 silverside, and 30 white perch samples at the Academy of Natural Sciences' Patrick Center for Environmental Research. DDXs are comprised of the two isomers (p,p and o,p) of DDT [1,1,1-trichloro-2,2-bis-(*p*-chlorophenyl)ethane], the parent compound widely used to control insect pests on agricultural crops and those carrying infectious diseases, and the two isomers (p,p and o,p) of each of its metabolites, DDE [1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene] and DDD [1,1-dichloro-2, 2-bis(*p*-chlorophenyl) ethane]. Like DDXs, values for "chlordanes" were calculated as the summation of the concentrations of heptachlor, heptachlor expoxide, oxychlordane, gamma chlordane, alpha chlordane, *cis*-nonachlor, and *trans*-nonachlor.

Preparation of fish subsamples followed previously published methods (*e.g.*,Ashley *et al.* 2000). Briefly, ~2 g of each fish homogenate was used. Sodium sulfate (Na_2SO_4) was added to eliminate water. Each dried sample was extracted using a Soxhlet apparatus with dichloromethane for a minimum of 16 h. Lipids were removed from fish extracts by gel permeation chromatography (GPC) using dichloromethane as the mobile phase. The collected fraction containing the organic analytes was concentrated by roto-evaporation and an N_2 stream. Solid–liquid chromatography using Florisil® was performed as an additional cleanup. Using this technique, PCBs and DDEs were eluted from the Florosil column using petroleum ether (F1 fraction). The remaining analytes were eluted using 50:50 petroleum ether and dichloromethane (F2 fraction).

Congener-specific PCBs, DDXs, and chlordanes were analyzed using a Hewlett-Packard 5890 gas chromatograph equipped with a ^{63}Ni electron capture detector and a 5% phenylmethyl silicon capillary column. The identification and quantification of PCB congeners followed the "610 Method" (Swackhamer 1987), in which the identities and concentrations of each congener in a mixed Aroclor standard (25:18:18 mixture of Aroclors 1232, 1248, and 1262) were determined by calibration with individual PCB congener standards. Congener identities in the sample extracts were based on their chromatographic retention times relative to the internal standards added. In cases in which two or more congeners could not be chromatographically resolved, the combined concentrations were reported. DDXs and chlordanes were identified and quantified based on comparisons (retention times and peak areas) with a known calibration standard prepared from individual compounds.

Lipid analysis. Lipid normalization for organic contaminants was calculated on a gravimetric basis at the Academy of Natural Sciences using aliquots of the dichloromethane/Soxhlet elutriates produced for organic analyses.

Methylmercury analysis. In addition to the above analytical activities, eight subsamples of white perch muscle tissue for methylmercury (meHg) were analyzed at the University of Georgia's Skidaway Institute (second year only) by cold vapor atomic fluorescence detection (Bloom 1992). An additional 12 white perch muscle samples were sent to Flett Research Ltd., Winnipeg for similar meHg analysis (when the Skidaway Institute was no longer performing meHg analysis).

Quality assurance/quality control. Quality control for the analysis of fish included the following: chain-of-custody documentation of all materials selected for analysis and archiving; the use of carbon-steel dissection instruments to avoid chromium contamination from stainless steel; the use of deionized/distilled water; acid-washing and triple rinsing of glassware; use of an analytical balance calibrated with both internal and external standards; for metal analysis, inclusion of the NRC-Canada certified reference material (CRM) dogfish liver tissue (DOLT-2) and method blanks (1 CRM and 1 blank with each 12 unknowns). An acceptable run was one in which the CRM data were within the published 95% confidence interval (CI). (An exception to this was arsenic analysis, for which we were consistently at 75% of the published value) Minimum detection levels were defined as three times the standard deviation of the blanks. For the meHg analysis, both contractors used DORM-2 (dogfish muscle tissue) for a CRM as part of their quality assurance/quality control.

For organic contaminant analyses, analyte loss through analytical manipulations was assessed by the addition of surrogate PCB congeners 14, 65, and 166 prior to extraction by Soxhlet apparatus. These surrogates were not industrially prepared and, therefore, are not present in the environment. Average recoveries of congeners 14, 65, and 166 were 105 ± 12%, 89 ± 7%, and 97 ± 9%. Due to the relatively high surrogate recoveries and the low standard deviations, all reported values for organic analytes were not corrected for analyte loss. Matrix blanks (six) were generated to monitor possible laboratory contamination and to calculate the detection limits for organic analytes. Chromatograms of most blanks were void of significant peaks, suggesting that little contamination through laboratory expo-

Table 1. Metal burdens in fish (μg/g dry weight, means and standard deviaton

Species	*n*	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
White perch	168	0.19 (0.24)	0.13 (0.15)	0.24 (0.19)	2.49 (1.58)	1.80 (0.99)	1.94 (1.60)	0.70 (0.98)	9.95 (11.31)
Brown bullhead	29	0.50 (1.27)	0.11 (0.08)	0.24 (0.17)	2.42 (0.70)	0.67 (0.59)	0.94 (0.74)	0.69 (0.62)	24.7 (3.36)
Carp	9	0.06 (0.07)	0.08 (0.07)	0.22 (0.08)	2.57 (1.38)	1.20 (0.71)	1.40 (1.05)	0.24 (0.44)	n.a.[b]
Mummichog	30[a]	0.14 (0.17)	0.07 (0.05)	1.12 (1.24)	11.76 (7.49)	0.25 (0.16)	4.94 (6.28)	0.93 (1.21)	11.99 (6.23)
Atlantic silversides	8[a]	0.53 (0.36)	0.09 (0.07)	0.83 (1.05)	3.79 (1.45)	0.48 (0.21)	2.13 (2.05)	0.77 (0.74)	3.73 (2.51)

[a] Composites of two to five fish each.
[b] Data not available.

sure occurred. The detection limits were calculated as the average (or mean) mass plus three times the standard deviation of the mass. The matrix-blank-based detection limits for individual organic analytes ranged from 0.01 to 1.0 ng/g wet weight. Based on six matrix blanks, the detection limit for total PCBs (t-PCBs, the sum of all quantified PCB congeners) was 11 ng/g wet weight. National Institute for Standards and Technology (NIST) standard reference material (SRM 1974B-Organics in Mussel Tissue was used to evaluate extraction efficiency and analytical accuracy. The average percent recovery for NIST-reported analytes was 88 ± 36%. To assess precision of the organic contaminant analyses, sample duplicates of randomly selected samples were performed at a frequency of 10%. The mean relative percent difference (RPD) for t-PCBs in duplicates was 4 ± 4. The mean RPD for t-DDXs and chlordanes in duplicates were 7 ± 8 and 9 ± 6. Duplicate analyses revealed exceptional precision.

Statistical Procedures

Regression analyses, *t*-tests, one-way analysis of variance (ANOVA), Bartlett's *F*-test for homogeneity, Kruskall–Wallace test, and Dunnett's multiple comparison test were calculated within the graphics program GraphPad Prism® 4.0.

Results

Metals

A total of 168 white perch were caught, representing virtually all locations and all seasons. This is significant because this species is the one most often sought and caught by recreational anglers. However, many season/site combinations lacked sufficient numbers of specimens for individual statistical validity. In addition, 30 pooled mummichog samples were found year-round at 5 locations, and 8 pooled Atlantic silverside samples were found at several seasons at the three seining locations. Although not relevant to human health, these two species are important in the ecology of the HM, as they represent the most abundant forage fish in this system.

The results for overall metal burdens are summarized in Table 1. As stated earlier, the white perch are of special interest because of their frequency and desirability on the part of fishers. The amounts of metals in the white perch fillets were as follows:

1. Arsenic: ranged from <MDL (minimum detection level) (0.09 μg/g) to 1.01 μg/g dry weight, equivalent to 0.02–0.25 μg/g wet weight.
2. Cadmium: ranged from <MDL (0.09 μg/g) to 0.94 μg/g dry weight, equivalent to 0.02–0.23 μg/g wet weight.
3. Chromium: ranged from 0.03 to 1.28 μg/g dry weight, equivalent to 0.01–0.32 μg/g wet weight.
4. Copper: ranged from 0.86 to 6.48 μg/g dry weight, equivalent to 0.22–1.62 μg/g wet weight. (Two outliers were omitted because they were one and two orders of magnitude higher than the other 166 data points; white perch are notorious for accumulating Cu in liver [mg/g, rather than μg/g; Bunton *et al.* 1987], and liver tissue might have contaminated these two muscle samples.)
5. Mercury: ranged from 0.07 to 5.47 μg/g dry weight, equivalent to 0.02–1.17 μg/g wet weight.
6. Nickel: ranged from 0.24 to 7.27 μg/g dry weight, equivalent to 0.06–1.82 μg/g wet weight.
7. Lead: - ranged from <MDL (0.21 μg/g) to 4.25 μg/g dry weight, equivalent to 0.05–1.06 μg/g wet weight.
8. Zinc: ranged from <MDL (0.05 μg/g) to 23.1 μg/g dry weight, equivalent to 0.13–5.75 μg/g wet weight.

Mercury. Of the metals that we analyzed, the one that is of greatest concern is Hg. It is the only metal known with certainty to biomagnify, becoming an order of magnitude higher with each trophic level. The reason for this is that the most likely form to be found in fish, monomethylmercury, an especially toxic organic form, is taken up by organisms in a manner similar to organic compounds. The traditional action level for Hg in fish is 1 ppm (μg/g) wet weight (US FDA 1993). This was exceeded by 4 of the 168 white perch, and these were all larger specimens. However, there is an Environmental Protection Agency (EPA) guideline for fish consumption vis-á-vis Hg. This agency has recommended no more than one meal per month of 0.47–0.94 ppm Hg in fish (US EPA 1999c, 2000, 2001). Thus, there is a moderately high probability of catching a ''risky'' white perch, as 53 of 168 (32%) exceeded the 0.47-ppm level.

Of the other game species, only 1 of 29 brown bullheads and none of 9 carp exceeded that 0.47-ppm one-meal-per-month risk level.

Mercury versus fish size. The Hg/size correlation that typically exists in fish is demonstrated in our white perch data (Fig. 2). Although strong correlations for both length and weight were not observed, they were significant. We can conclude from Fig. 2A that a white perch longer than ~230 mm will have a 50% probability of being a risky meal and this length typifies the minimum-sized ''keeper'' for a recreational angler.

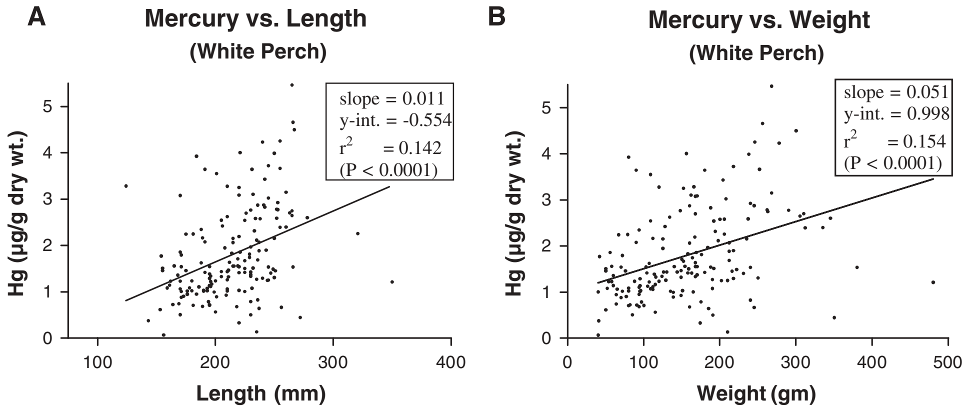

Fig. 2. Size relationships for mercury uptake in white perch, by both length **(A)** and weight **(B)**. Slight but significant relationships are demonstrated, using data from all sites and all seasons

Mercury–seasonal relationships. The white perch data were analyzed for seasonal trends. The higher Hg levels tended to occur in warmer weather, when more people are fishing. Thus, the probability of catching the more contaminated white perch would be increased in the summer (Fig. 3). (To aid in interpreting these Hg uptake graphs, recall that these are data for dry weight. Because the tissues were 74–78% moisture, the 0.47-µg/g consumption advisory level, which is based on wet weight, would be about 2 µg/g on these graphs.)

Mercury–site relationships. Collection sites were correlated with white perch Hg concentrations, after averaging all sizes and seasons for each site (Fig. 4). The geographic distribution of Hg shows that the highest levels were in TN3. However, there were no significant correlations between fish Hg and the sites' sediment contaminant levels. (Among all the metals analyzed, there was a significant correlation with collection site sediment only for Pb [E. Konsevick, personal communication].)

Methylmercury. Eight samples of white perch from a mid-October collection were sent to the University of Georgia's Skidaway Institute for analysis. Only small fractions of Hg in the tissues were found to be methylated. The meHg levels were 0.048 ± 0.027 µg/g. These were 16% of the total Hg encountered in this species. Typically, meHg as a percentage of total Hg is close to 100% in fish (Bloom 1992), including HM mummichogs (Weis *et al.* 1986), so this was surprising. Therefore, this issue was revisited. Twelve additional white perch muscle samples from June and July collections were sent to Flett Research, Inc., Winnepeg, which found that 110 ± 13.2% of the Hg was meHg. Both contract laboratories used atomic fluorescence spectrophotometry (Bloom 1992) and both, using the same CRM, demonstrated acceptable accuracy. What differed was the season during which the fish were collected.

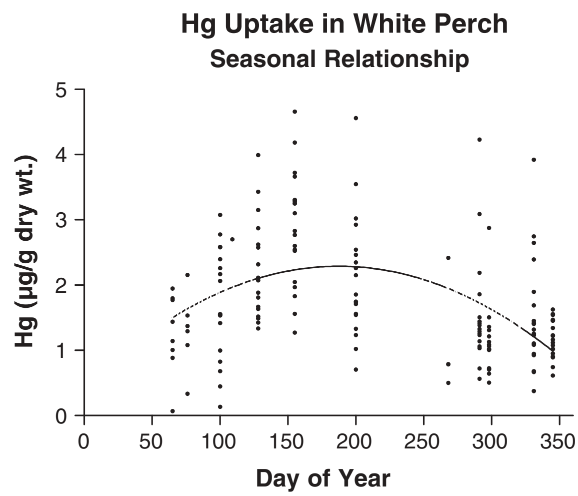

Fig. 3. The relationship of season to mercury uptake; it is seen to be higher in the summer than in the cooler months (days 130–240 are mid-May–September). The curve represents the predictable level and was calculated as $y = a + bx + cx^2$. For this curve, $r^2 = 0.211$, $p < 0.01$

Organic Contaminants

Comparisons by wet weight. The concentrations of t-PCBs, t-DDXs, and t-chlordanes is illustrated in Figure 5. t-PCB uptake was substantially greater than the other two classes of compounds. There were no significant differences among the three fish species for any of the three classes of compounds. The size and seasonal relationships for t-PCB levels and the relationship to Hg levels in the same fish are illustrated in Figure 6. There were no significant correlations between PCB concentrations and length, weight, or Hg burden. The seasonal relationship, although qualitatively similar to that for Hg, was not significant, likely due to the limited number of samples analyzed.

Concentrations of t-PCBs for white perch were higher than for silverside and mummichog, which had similar body burdens, expressed on either a wet tissue weight basis or by lipid normalization, but the interspecies differences were not significant by wet weight comparisons. This might relate to the small differences in trophic status and feeding among these species. This trend was also observed for DDXs, but it was not as strong for chlordanes, in which body burdens among the three organic contaminant classes was similar.

The Food and Drug Administration (FDA) action level for t-PCBs in food is 2000 ng/g wet weight (US FDA 1993). This

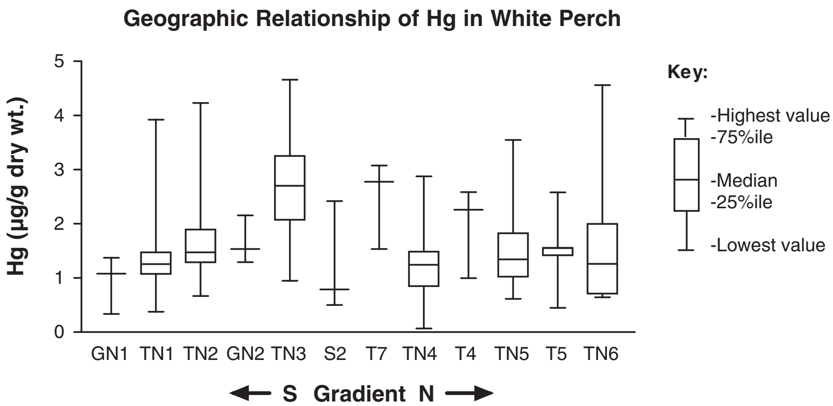

Fig. 4. The north–south distribution of Hg burdens is demonstrated in this box and whiskers plot. The total area covered by this graph is from Gill Net 1 at River Mile (RM) 2.7 to Trap Net 6 at RM 12.5. Data without boxes are those for which only a few fish were found at each of those sites (thus, not enough data were available to generate all of the predictions available in this type of graph)

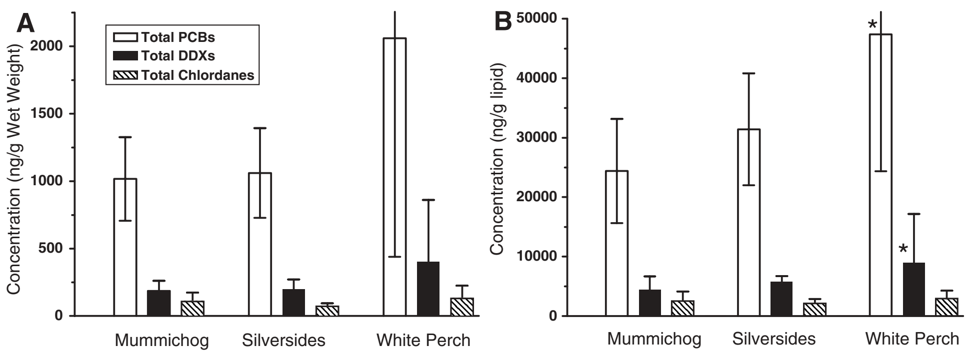

Fig. 5. Organic contaminants in fish by species: **A** concentrations by wet weight; **B** concentrations by lipid weight. *Statistically significantly different from mummichog

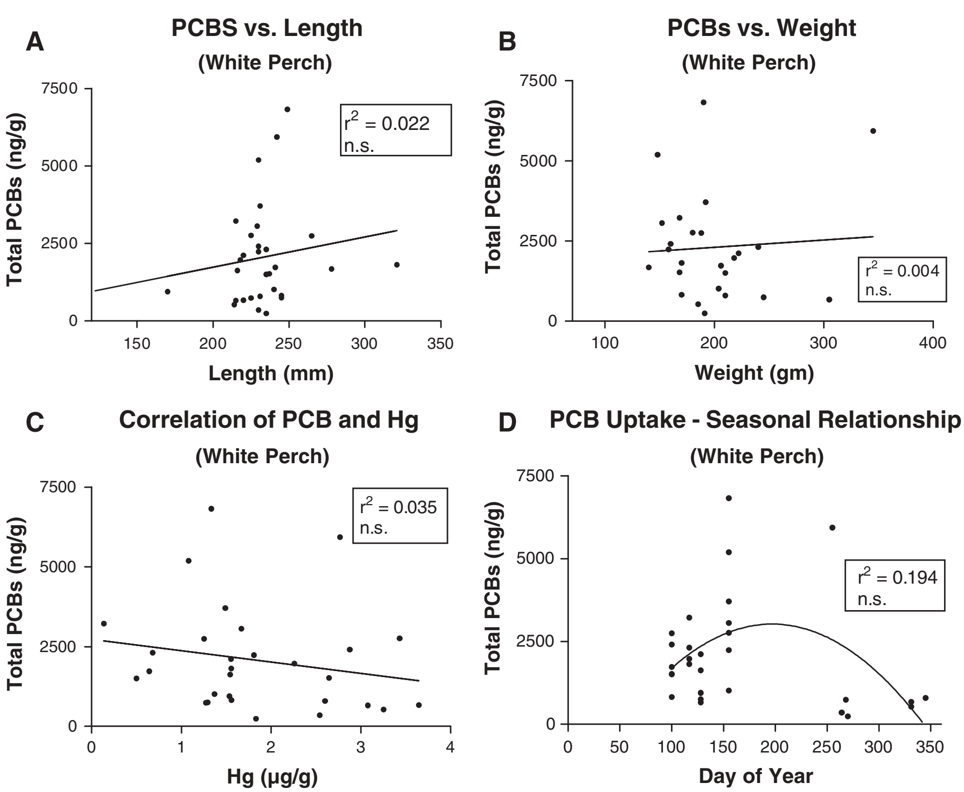

Fig. 6. The correlations of total PCBs to length (**A**), weight (**B**), mercury burdens (**C**), and season (**D**) are shown here. None of the correlations are significant

was met or exceeded in 12 of the 30 white perch (40%). The distribution of these 12 white perch covers the entire length of that part of the Hackensack River that was surveyed. None of the forage fish exceeded the action level for PCBs. The US EPA one-meal-per-month (cancer health) guideline for PCBs is 23–47 ng/g (US EPA 1999b, 2000), and this was exceeded by all fish species. The lowest measured t-PCB value was a white perch at 243 ng/g wet weight.

The action level for DDXs is 5000 ng/g wet weight. None of the white perch met or even approached that level. The highest was 2159 ng/g, and most were less than one-tenth of the action level. None of the forage fish exceeded that level. The US EPA one-meal-per-month (cancer health) guideline for DDXs is 140–280 ng/g (US EPA 2000), and this was met or exceeded by 20 of the 30 white perch. (Although this guideline is irrelevant for forage fish, it was noted that seven of the nine mummichog composites and all of the silversides composites exceeded this level as well.)

The action level for total chlordanes is 300 ng/g wet weight. One of the white perch exceeded that with 304 ng/g. Most were substantially lower, even into the single digits. None of the forage fish exceeded that level. The US EPA one-meal-per-month (cancer health) guideline for chlordanes is 130–270 ng/g (US EPA 2000), and this was met or exceeded by 13 of 30 white perch (as well as 3 of 9 mummichog and none of the silversides.)

Lipid Relationship

When analyzing organic contaminants in tissues, it can be useful to correlate the chemical burdens with the total lipid in the tissues. Variability in hydrophobic organic contaminant concentrations like PCBs and DDXs, as well as organic Hg, might often be a result of variations in lipid content (*e.g.*, Hebert and Keenleyside 1995; Stow *et al.* 1997). This normalization procedure serves as a standardization. There is a strong correlation with lipids for t-PCBs but none for Hg (Fig. 7).

Upon normalization to lipid of the wet weight concentrations of the three classes of organic contaminants, variability among species was dampened, but not eliminated, suggesting that lipid content, in part, was one determinant of contaminant levels (Fig. 5B). White perch t-PCB and t-DDX levels remained higher than those found for mummichog or silversides upon lipid normalization. These differences are significant between white perch and mummichogs (the Kruskall–Wallace statistic for t-PCBs was 10.79, $p = 0.0045$, and for t-DDXs, it was 8.441, $p = 0.0147$; for the differences between white perch and mummichogs, $p < 0.01$ for t-PCBs and $p < 0.05$ for t-DDXs by Dunnett's multiple comparison test. No other comparisons were significant. These nonparametric tests were used because Bartlett's test for homogeneity of variances showed all the organic uptakes to have unequal variances, precluding the use of ANOVA.)

Sex Differences

Because female fish lay a large amount of eggs, a lipid-rich tissue, it is generally considered that fat-soluble contaminants are depurated as a result of spawning. We separated the data by sex and found that PCBs, but not Hg, are higher in males than in females (Fig. 8). Because only 12 females and 18 males were analyzed, the interesting different trends that appear here are not statistically significant (other than the overall PCB difference in Fig. 8A). Because the males had much higher PCB levels than the females, the relationship to size was recalculated with separation of the sexes. As seen in Fig. 8B, there were very different trends between the sexes, with the males continuing to bioaccumulate over time (as shown with increasing fish length) and the females maintaining a steady state, owing probably to the depuration with the eggs. This can be contrasted with Fig. 6A. (Note also that the shortest fish in Fig. 8B is a female outlier. Because this individual was too small to be sexually mature, it has not yet ovulated. This might be why it was the highest in PCBs of all the females; when removed from the equation, the regression line for females is nearly flat, suggesting a "steady state" in PCBs for the female white perch.) Unlike PCBs, Hg does not differ between the sexes (Fig. 8C), nor does it correlate with PCBs in male white perch (Fig. 8D).

Discussion

The levels of arsenic reported here are typical of seafood in general and are not considered of significance. Most arsenic in seafood is in the form of organoarsenicals, most of which are poorly absorbed and metabolized by consumers. Thus, they are not considered to be toxic (Irgolic 1992). The EPA guidelines for arsenic in seafood of 2.8–5.6 μg/g wet weight was not exceeded by any of our fish. The FDA criterion for arsenic is even higher: 76 μg/g (US FDA 1993).

The cadmium, chromium, copper, lead, and zinc levels in the fish were not particularly high either. They do not bioconcentrate (Rhinefelder *et al.* 1998; Suedel *et al.* 1994). The chromium level of concern for consumption of crustacean shellfish is 22 μg/g (US FDA 1993), two orders of magnitude higher than the means found in our Hackensack game fish species. The US FDA criteria for cadmium (3 μg/g) and for lead (1.5 μg/g) were not exceeded either. There are not, to our knowledge, US agency criteria for copper or zinc. There are European guidelines for maximum permissible levels of several trace metals, including Cd (0.06 mg/day/person), Cu (2–3 mg/day/person), and Zn (15 mg/day/person) (European Communities 2001). These translate to 0.3 μg/g Cd, 10–15 μg/g Cu; and 75 μg/g Zn, all for a 200-g meal, *if eaten daily*. By these European guidelines, the HM white perch do not pose a risk for these metals.

Of the other metals, only Hg was found to be of concern, and that was only in white perch. The Hg in carp, although not of concern, was about three times higher than the average of 0.11 μg/g wet weight for this species in the northeast part of North America (US EPA 1999b).

Mercury

Mercury versus fish size. Of the several metals measured in this study, only Hg biomagnifies, thus increasing with size and with trophic level (Rhinefelder *et al.* 1998; Suedel *et al.* 1994). Considering the amount of Hg circulating in the HM, the amount in white perch was unexpectedly low. The answer can be found in the white perch's dietary habits. The stomach content analysis done for a companion study shows that they rarely eat fish; they eat mostly small crustaceans. This low trophic level was verified by $\delta^{15}N$ stable isotope analysis (Weis 2005).

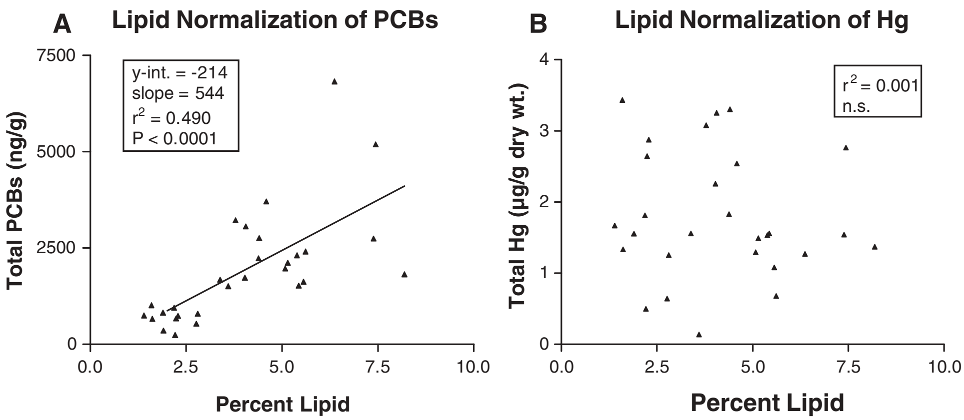

Fig. 7. Correlation of PCB (left) and Hg (right) burdens in white perch with the total lipid content of the muscle tissue

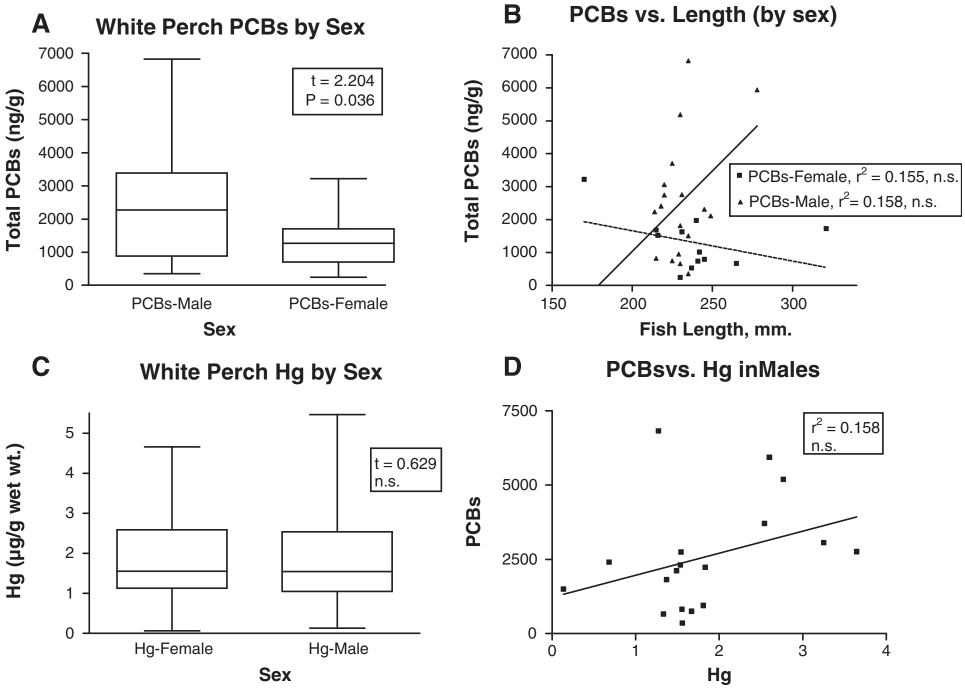

Fig. 8. Sex differences and relationships in white perch for PCB **(A, B)** and Hg **(C, D)** uptake. For regression lines, solid lines are males and dashed lines are females

Mercury–seasonal relationships. The reason for higher mercury in fish during the warmer months might be the higher food intake at this time. Depuration occurs at a rate that, like any physiological activity or chemical reaction, is temperature dependent. Nevertheless, it still continues during the winter, a time when food is scarce to nonexistent, so that a fish will show a net loss of Hg during that time. Changes in Hg burden in relation to season were previously reported in HM mummichogs (Weis *et al.* 1986).

Mercury–site relationships. The geographic distribution of Hg shows that the highest amounts were from TN3, but this interpretation might be spurious because most of these fish were caught in June, near the height of the curve shown in Figure 3. The site expected to be highest was the Berry's Creek Canal (T7), because this drains an area with three Superfund sites, one of which is infamous for Hg contamination. Unfortunately, only three fish were caught there, so that result is inconclusive. Conversely, the relatively low levels at TN4 might be similarly biased because these were all caught in the colder part of the year (October 25, December 11, and March 6). It would have been appropriate to have fish from each sampling site year-round, but the fish were not always trapped at each site. It is not known how much "site fidelity" (*i.e.*, staying in one area) white perch have or to what extent they migrate up or down river other than their spawning runs into fresher water in the spring, although it was determined in a Chesapeake study with 15 tagged fish that they tend to remain in a 0.0128-km^2 area (McGrath 2005). It might be that the inability to have a more representative collection is because our sampling methods were less than 100% successful. What *is* conclusive from our data is that a fish with an unacceptable Hg level can be caught anywhere on the river.

Methylmercury. Kannan *et al.* (1998) studied total mercury and meHg in water, sediment, and fish from South Florida estuaries and found that, among the many fish species studied, the percentage of methylated Hg varied from 20% to 100%. Mason (2004) analyzed several game fish species from numerous sites within the Chesapeake Bay system and found that white perch ($n = 6$) averaged 28% methylated form of Hg; no reporting of collection dates was made, however.

Methylmercury is bioaccumulated mostly (>85%) from the diet (Hall *et al.* 1997). Furthermore, meHg is associated more with the hypoxic interface of estuarine systems (Mason *et al.* 1993). Hypoxia is typically a warm-weather event. These two relationships (diet and hypoxia, both of which are greater in the warmer months) would explain the greater uptake of Hg in the summer and why white perch Hg is much more in methylated form at this time.

Organics

King *et al.* (2004) measured PCB levels in fish from 14 tributaries in the Chesapeake Bay watershed and correlated their findings with the amount, type, and distribution of developed land in each location. White perch t-PCBs were greatest in relation to the most intense development. In more highly developed areas, these researchers found that the farther the development was from the water, the lower the contaminant levels were in the sampled fish. An index of development inversely proportional to distance from the shoreline gave the highest correlation to t-PCBs in white perch ($r^2 = 0.99$). King *et al.* concluded that >4% total residential/commercial development in the watershed predicts exceeding the US EPA (1999b, 2000) guideline for more than one meal per month (47 ng/g t-PCBs). New Jersey has the highest population density in the United States, and this is in large part due to the northeast part of the state, the location of the HM. Thus, high PCBs are to be expected in the HM, considering the high proportion and long history of development in the area. *All* of our white perch exceeded the US EPA consumption guideline for fish (>47 ng/g t-PCBs), the lowest being 242 ng/g.

Lipid Relationship

Variability in hydrophobic organic contaminant concentrations like PCBs and DDXs, as well as organic Hg, migh often be a result of variations in lipid content (*e.g.*, Hebert and Keenleyside 1995; Stow *et al.* 1997). Upon normalization to lipid of PCB wet weight concentrations, variability between species was dampened, but not eliminated, suggesting that lipid content, in part, was one determinant of contaminant levels. Although lipid content might determine contaminant accumulation to a degree in fish, other factors such as trophic position and resident versus migratory behavior are also important. For example, Rasmussen *et al.* (1990) found food chain structure to be a prime determinant of PCB levels in lake trout and other pelagic fish. Ashley *et al*. (2000, 2003) found that resident fish with limited home ranges were more reflective of their habitats, whereas those with wider home ranges or those undergoing annual migrations were not. For chlordanes, all fishes had similar lipid-normalized concentrations, suggesting that lipid content might be a larger determinant for bioaccumulation of these contaminants or that chlordane contamination is equally dispersed over the study area. White perch t-PCB levels remained higher than those found for mummichog or silversides upon lipid normalization, suggesting biomagnification of contaminants from prey items to predator (white perch). The species' differences were significant only between mummichog and white perch for t-PCBs and t-DDXs. However, as noted earlier, white perch probably does not occupy a higher trophic level than mummichog (Weis 2005).

Unlike PCBs, Hg did not correlate with lipid content. This suggests that the small proportion found to be methylated during the colder seasons might obfuscate the potential relationship, because meHg is lipid soluble, whereas inorganic Hg is not. However, the 12 data points that we have for the summer do not show a lipid relationship (data not shown). Also, meHg is not nearly as hydrophobic as the organic contaminants studied here; the octanol-water partition coefficients (log K_{ow}) for various meHg species predicted for the pH and salinity conditions of the Hackensack River are <2 (Faust 1992), whereas those for PCBs are >6 (Linkov *et al.* 2005). For mummichog and silverside, the low number of samples analyzed and the narrower range of lipid values spanned by these fish likely explains the relatively low degrees of correlation found for organic contaminants. However, weak but positive correlations do suggest that lipid content is at least one driving factor in the accumulation of these lipophilic contaminants.

Sex Differences

Because female fish lay a large amount of eggs, a lipid-rich tissue, it is generally considered that fat-soluble contaminants are depurated as a result of spawning. This is probably responsible for the sex differences in PCB uptake shown in Fig. 8B. That there is near-identity in the Hg burdens of males and females (Fig. 8C) also reinforces the finding of relatively little meHg, at least for part of the year, and there is no sex difference as found for the PCBs. This does not explain, however, what processes are occurring in warmer weather when methylation is high. Separation of sexes allows demonstrating a possible relationship between PCBs and Hg, not evident in Fig. 6C, in males only. However, more analyses would have to be performed before more definitive conclusions can be drawn, as with the data in Fig. 8B.

Conclusions

1. The trace metal and chlorinated hydrocarbon content and safety (health risk) of HM fish has been assessed. There were too few carp to reach logical conclusions. The white perch collection, on the other hand, was large enough to enable valid conclusions.
2. It is suggested that HM white perch should be considered not edible. The Hg level exceeded the "one meal

per month'' action level of 0.47 μg/g wet weight (ppm) in 32% of our catch and 2.5% exceeded the ''no consumption at all'' level of 1 μg/g. The larger fish represent greater risk Furthermore, the warmer months, when more recreational fishing takes place, might present the greater risk for Hg, as well, because there is more Hg in the muscle tissue, and it is all methylated at this time. A greater reason for not consuming white perch is the PCB contamination, as 40% of these fish exceeded the FDA action level for this class of compound and *all exceeded the US EPA guideline* of no more than one meal/month (US EPA 1999b, 2000). In fact, nearly all were 10 times that advisory level.

3. The relationship of sampling site to mercury cannot be demonstrated because of the inability to obtain sufficient numbers of game fish at many sites at all seasons.
4. Brown bullheads and, possibly carp, might be safe to eat in relation to metals.

Acknowledgments. The assistance of many people is gratefully acknowledged: at the NJMC, Brett Bragin, who led the collection team, Yefim Lewinsky, who performed much of the atomic absorption spectrophotometry, and Edward Konsevick, who performed data management; at UMDNJ, Theodore Proctor, who has been an invaluable lab assistant for many years, for tissue processing and atomic absorption spectrophotometry; at the Academy of Natural Sciences, Ms. Linda Zaoudeh for organic contaminant analyses. This project was part of a multifaceted, multi-institutional study funded by the Meadowlands Environmental Research Institute.

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