

***FINAL***

## **Newark Bay Study Area Problem Formulation**

Baseline Human Health and  
Ecological Risk Assessment

**Tierra Solutions, Inc.**

**East Brunswick, New Jersey**

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**Acronyms and Abbreviations**

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzofuran
AOC	Administrative Order on Consent
AE	assessment endpoint
ATSDR	Agency for Toxic Substances & Disease Registry
AVS	acid volatile sulfides
BAZ	biologically active zone
BEHP	bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
BHHERA	Baseline Human Health and Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BSAF	biota-sediment accumulation factor
CARP	Contaminant Assessment and Reduction Project
CBR	critical body residue
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cm	centimeter(s)
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
CPG	Cooperating Parties Group
CSM	conceptual site model
CSO	combined sewer overflow
DDT	dichlorodiphenyltrichloroethane
dioxin	polychlorinated dibenzo- <i>p</i> -dioxin (PCDD)
DO	dissolved oxygen
DRA	deterministic risk assessment
EFH	essential fish habitat

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ERA	ecological risk assessment
ft	foot/feet
ft/sec	feet per second
furan	polychlorinated dibenzofuran (PCDF)
g/day	gram per day
HDP	Harbor Deepening Project
HHRA	Human Health Risk Assessment
HMW	high-molecular-weight
LMW	low-molecular-weight
LPRRP	Lower Passaic River Restoration Project
m	meter(s)
m/sec	meters per second
ME	measurement endpoint
MLW	mean low water
NBSA	Newark Bay Study Area
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
NOAA	National Oceanic and Atmospheric Administration
NYAS	New York Academy of Sciences
NY/NJ	New York/New Jersey
NYSDEC	New York State Department of Environmental Conservation
OEHHA	Office of Environmental Health Hazard Agency
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PAR	Pathways Analysis Report
PBB	polybrominated biphenyl
PBDD	polybrominated dibenzo- <i>p</i> -dioxin
PBDE	polybrominated diphenyl ether

PBDF	polybrominated dibenzofuran
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo- <i>p</i> -dioxin (dioxin)
PCDF	polychlorinated dibenzofuran (furan)
PCN	polychlorinated naphthalene
PRA	probabilistic risk assessment
PSE&G	Public Service Electric and Gas Company
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
redox	reduction-oxidation potential
REMAP	Regional Environmental Monitoring and Assessment Program
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIWP	Remedial Investigation Work Plan
SAP	Sampling and Analysis Plan
SEM	simultaneously extracted metals
SI	Sediment Investigation
SLERA	Screening-Level Ecological Risk Assessment
SVOC	semivolatile organic compound
TEF	toxic equivalency factor
Tierra	Tierra Solutions, Inc.
TOC	total organic carbon
TRV	toxicity reference value
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WHO	World Health Organization
Windward	Windward Environmental, LLC

## 1. Introduction

Pursuant to the Statement of Work appended to the Administrative Order on Consent (AOC) for the Remedial Investigation and Feasibility Study (RI/FS), Newark Bay Study Area (NBSA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Index No. 02-2004-2010 (U.S. Environmental Protection Agency [USEPA] 2004), one of the goals of the RI/FS is to “Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the NBSA.” To accomplish this goal, baseline human health and ecological risk assessments will be conducted in the NBSA, which is identified as Newark Bay (the Bay) and portions of the Hackensack River, Kill van Kull, and Arthur Kill (USEPA 2004a). A regional map showing the NBSA is provided as Figure 1-1.

As part of the risk assessment process, this Problem Formulation was prepared by Tierra Solutions, Inc. (Tierra) on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]) to establish the overall goals, breadth, and focus of the baseline ecological and human health risk assessments and to define the questions that need to be addressed during these evaluations. This report documents issues that need to be addressed in the human and ecological risk assessments for the NBSA, which are based on the potentially complete exposure pathways and effects identified as part of the conceptual site model (CSM) (Tierra 2011) and decisions that were made during the Baseline Human Health and Ecological Risk Assessment (BHHERA) Workshop held in June 2011 as documented in the BHHERA Workshop Meeting Minutes dated December 1, 2011.

This Problem Formulation was prepared in accordance with guidance from the following USEPA sources, as well as the human health risk assessment (HHRA) guidance documents listed in Section 2.1:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. EPA/540/R-97/OCS. (USEPA 1997a)
- *Considerations for Developing Problem Formulations for Ecological Risk Assessments Conducted at Contaminated Sites under CERCLA: A Discussion Paper*. Prepared for M. Greenberg, Environmental Response Team, USEPA (MacDonald Environmental Sciences Ltd. and Cantox Environmental, Inc. 2004)

Although a problem formulation is not typically performed as part of the HHRA, it is included in this document to provide consistency between the human and ecological risk assessments and to define a roadmap for the implementation of the Baseline Human Health Risk Assessment (BHHRA). For the human health evaluation, the problem formulation primarily describes the CSM, including exposure pathways, potentially exposed populations, available data, and data needs. The *Newark Bay Study Area Pathways Analysis Report* (PAR, USEPA 2006a) will be updated and submitted for USEPA review and approval prior to the development of the BHHRA.

## **1.1 Summary of Risk Assessment Guidance**

### **1.1.1 Ecological Risk Assessment**

The USEPA eight-step Superfund ecological risk assessment process (ERA) (USEPA 1997a) is shown on Figure 1-2. Step 1 (Screening-Level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-Level Exposure Estimate and Risk Calculation) were completed in the NBSA PAR (USEPA 2006a) and *Screening-Level Ecological Risk Assessment* (SLERA) for the Newark Bay Study Area (USEPA 2008a), respectively. The results of the SLERA demonstrate that a Baseline Ecological Risk Assessment (BERA), encompassing Steps 3 through 8, is required for the NBSA. In addition, the SLERA contains a compilation of substantial ecological data and information to help guide the BERA process.

The ecological risk sections of this document represent Step 3 (Problem Formulation) of the eight-step ERA process. Specific objectives of Step 3 per USEPA (1997a) are to:

- Refine preliminary constituents of potential ecological concern (COPECs)
- Further characterize ecological effects of COPECs
- Review and refine information on COPEC fate and transport, complete exposure pathways, and ecosystems potentially at risk
- Select assessment endpoints (AEs)
- Develop a CSM with working hypotheses or questions that the site investigation will address

Steps 4 and 5 of the ERA process, which encompass the overall study design and field sampling, are anticipated to be driven by the information contained within this document. Finally, results from Step 6 (Analysis) and Step 7 (Ecological Characterization) will be presented in the BERA report. Results of the BERA will be used to manage ecological risks in the NBSA by informing the remedial action decision-making process (Step 8).

#### 1.1.2 Human Health Risk Assessment

A BHHRA will be conducted for the NBSA pursuant to USEPA's Risk Assessment Guidance for Superfund (RAGS) Human Health Evaluation Manual, Volume I, Parts A through F (USEPA 1989, 1991a, 1991b, 2001a, 2007a, 2009a). Other guidance documents that will be used include, but are not limited to the following (available from [www.epa.gov/risk/](http://www.epa.gov/risk/) and [www.epa.gov/oswer/riskassessment/risk\\_superfund.htm](http://www.epa.gov/oswer/riskassessment/risk_superfund.htm)):

- Guidelines for Carcinogen Risk Assessment (USEPA 2005a)
- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA 2005b)
- Recommended Toxicity Equivalence Factors for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin and Dioxin-Like Compounds (USEPA 2010a)
- Exposure Factors Handbook (USEPA 2011a)
- Child-Specific Exposure Factors Handbook. (USEPA 2008b)
- Highlights of the Child-Specific Exposure Factors Handbook (USEPA 2009b)
- A Framework for Assessing Health Risks of Environmental Exposures to Children (USEPA 2006b)
- Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants (USEPA 2005c)
- Soil Screening Guidance (USEPA 1996a, 1996b, 2002a)

- Guidance for Conducting Health Risk Assessment of Chemical Mixtures (USEPA 2000a, 1986)
- Guidelines for Exposure Assessment (USEPA 1992a)
- Guidance for Data Usability in Risk Assessment (USEPA 1992b)
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.(USEPA 2002b)
- Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA 1992c)
- Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (USEPA 2002c)
- Land Use in the CERCLA Remedy Selection Process. (USEPA 1995a)
- Role of Background in the CERCLA Cleanup Program (USEPA 2002d)
- Framework for Metals Risk Assessment (USEPA 2007b)
- Polychlorinated biphenyl (PCB) Guidance (USEPA 1996c)
- Polycyclic aromatic hydrocarbon (PAH) Guidance (USEPA 1993a)

Consistent with USEPA guidance (USEPA 1995b, USEPA 2000a), assessments will be conducted for both reasonable maximum exposure and central tendency exposure. The BHHRA will be conducted following an approach designed to support risk management decision-making by initially defining the constituents of potential concern (COPCs) for each medium, based on existing and new data collected during the Remedial Investigation (RI), and using this information to prioritize areas requiring further assessment. The Interim CSM (Tierra 2011) will be updated, as appropriate, and COPCs will be identified using the approach previously approved by USEPA for the Lower Passaic River Restoration Project (LPRRP) (Windward Environmental, LLC [Windward] 2012). Once the updated CSM is reviewed and approved by USEPA, RAGS Part D Tables 1 through 6 will be prepared for review and approval. Following

approval, risk assessment calculations will be conducted in a deterministic risk assessment (DRA).

Depending on the results of the DRA, a probabilistic risk assessment (PRA), consistent with RAGS Volume III Part A Process for Conducting Probabilistic Risk Assessment (USEPA 2001b), Policy for Use of Probabilistic Analysis in Risk Assessment (USEPA 1997b), and Guiding Principles for Monte Carlo Analysis (USEPA 1997c) may be proposed for refining human health risk and hazard estimates in the NBSA. The PRA may also be used to determine risk-based remediation goals. Use of PRA techniques will follow USEPA guidelines (USEPA 2001b, USEPA 1997b, 1997c) and will be conducted with USEPA oversight of all input parameter distributions and modeling approaches. If a PRA is conducted, it will be performed after the work plan is submitted to, and approved by, USEPA. Toxicity factors would not be varied in the PRA, but distributions of exposure point concentrations, toxic equivalency factors for dioxins and dioxin-like compounds, and selected exposure factors would be applied. The goal of the PRA would be to provide more information regarding the range and distribution of risks associated with site contaminants to inform remedial decisions.

## **1.2 Report Organization**

This Problem Formulation is organized into the following sections:

- Section 2: Environmental History and Setting of the NBSA – Provides a concise summary of the site in terms of historical, industrial, and physical setting.
- Section 3: Data Summary – Provides a description of the available qualitative and quantitative data that are currently available for the risk assessments.
- Section 4: Baseline Ecological Risk Assessment – Presents the ecological CSM, including receptors and exposure pathways; discusses assessment and candidate measurement endpoints (MEs) and data needs for the BERA.
- Section 5: Baseline Human Health Risk Assessment – Presents the human health CSM, including receptors and exposure pathways, and data needs for the BHHRA.
- Section 6: Next Steps – Outlines future steps in the risk assessment process that will be conducted following approval of the Problem Formulation.
- Section 7: References – Provides a list of cited literature.

## **2. Environmental History and Setting of the NBSA**

Newark Bay is situated between the cities of Newark and Elizabeth and is bordered by Newark Liberty International Airport to the west, Jersey City and Bayonne to the east, and Staten Island, New York to the south (Figure 2-1). The Passaic and Hackensack Rivers empty into Newark Bay in the north. Two tidal straits in the southern portion of the NBSA, Kill van Kull and Arthur Kill, connect the Bay to Upper New York Harbor and Raritan Bay, respectively. Other tributaries with their confluences in the NBSA include the Elizabeth River, Peripheral Ditch, and Piersons Creek.

### **2.1 History**

As part of the New York/New Jersey (NY/NJ) Harbor Estuary, Newark Bay has evolved into a key shipping port and ideal setting for myriad industries for over two centuries (Brydon 1974; Cunningham 1954, 1966a, 1966b; Meyers 1945). The NBSA is home to major cargo ports, an international airport, numerous industrial properties, and has several bridge crossings for automobile and rail travel between New Jersey and New York. The history of the NBSA is a key factor in understanding the current conditions of the site. As population, industry, and commerce grew during the 1800s and 1900s, significant expansion and development of the NBSA occurred. An historical timeline of major development activities in the NBSA is presented on Figure 2-2.

Situated at the center of one of the most urbanized and industrialized areas in the United States, the NBSA has been subjected to environmental degradation over the past two centuries due to a variety of factors: shoreline and land development (U.S. Army Corps of Engineers [USACE] 2006a), wetlands destruction, habitat degradation, garbage and sewage disposal, and releases of hazardous substances (Iannuzzi et al. 2002). As a result of such practices, the NBSA is known to contain a number of chemical constituents, including but not limited to, PCBs, PAHs, pesticides, herbicides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated dibenzo-*p*-dioxins (PCDDs, or dioxins), polychlorinated dibenzofurans (PCDFs, or furans), and metals (National Oceanic and Atmospheric Administration [NOAA] 1995; USEPA 1998). These constituents originate from a variety of sources throughout the Newark Bay area (Bonnievie et al. 1994; Crawford et al. 1994, 1995; Gillis et al. 1993, 1995; Gunster et al. 1993a, 1993b; Huntley et al. 1995; Iannuzzi et al. 1995). Industries such as metal refineries, dye manufacturers, tanneries, lumber processors, petroleum processors, chemical manufacturers, and ship builders have produced products using hazardous chemicals that have been discharged into Newark Bay or its tributaries (Iannuzzi et al. 2002). The following paragraphs describe some of the specific sources.

Various waterfront industries have a history of documented discharges to the Lower Passaic River, Newark Bay, and its tributaries. Along the Lower Passaic River, historical discharges of chemicals (primarily dioxins) have occurred from the Diamond Alkali Superfund Site. From 1951 to 1969 the Diamond Alkali Company manufactured chemicals, herbicides, and pesticides (including Agent Orange), of which 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is a byproduct. After hazardous substances were detected at the facility, the USEPA placed the Diamond Alkali Site on the National Priorities List in 1984 (USEPA 1984, 1993b, 2012a).

The entire waterfront area of the Lower Passaic is significantly industrialized, including several other historical operations associated with dioxins, as well as PCBs, PAHs and other chemicals. For instance, the Sherwin-Williams site, adjacent to the Diamond Alkali site, has also been characterized and shown to be similarly contaminated with significant levels of dioxins and other chemicals (Roy F. Weston 2001; Weston Solutions, Inc. 2005, 2008). Present-day and historical discharges from the Bayonne Barrel and Drum Site in Newark have also been documented. This site has been extensively characterized and shown to be contaminated with dioxins, PCBs, metals, and other chemicals (New Jersey Department of Environmental Protection [NJDEP] 1988, 2008; USEPA 2000b, 2004b; Louis Berger & Associates 1986; New York Academy of Sciences [NYAS] 2006).

Documented historical discharges from sites along the south and west lower three miles of the Passaic River, from the vicinity of the Diamond Alkali Site to the river's confluence with Newark Bay, include (but are not limited to) the following: Sherwin-Williams, Chris-Craft (Montrose Chemical site), Hilton-Davis/Thomasett, Benjamin Moore, Atlas Refining, Inc., Fairmount Chemical Company, Essex County Resource Recovery Facility (American Ref-Fuel), Public Service Electric and Gas Company (PSE&G; Essex Generating Station), Newark Boxboard Company, Chemical Leaman Tank Lines (Quala Systems), Getty Newark Terminal (Chevron), Sun Chemical Corporation (Foundry Street), Ashland Chemical, Pitt Consol (Reilly), Alliance Chemical, Elan Chemical Company, Essex Chemical Company, Celanese Chemical Company, Revere Smelting and Refining Co., Reichhold Chemicals (Spencer Kellogg), Vulcan Materials Company (Safety Kleen), and Atlantic Richfield. Documented historical discharges from sites located on the opposite side of the Passaic River have also occurred from the following facilities: Monsanto, SpectraServ, Inc., Alcan Aluminum, Lucent Technologies (Western Electric), and BASF Corp. Some of the more well-documented dischargers (based upon available public information) are documented in Table 2-1.

Along the northern and central portions of Newark Bay, historical and present-day discharges of dioxins and other chemicals have occurred from a number of sites in Newark, Kearny, Jersey City, and Bayonne, including, but not limited to, the following: Central Steel Drum, Prentiss Drug and Chemical Company, Troy Chemical Corporation, Engelhard Corporation, BP Marine Americas, Koppers Inc., Standard Chlorine, PJP Landfill, PSE&G sites, Columbia Terminals, Alpha Metals Inc., Mallinckrodt (MI Holdings), Honeywell, and Pharma Chem (Plant #1 facility). Again, based on publically available records, Table 2-1 highlights those sites that have documented discharges to Newark Bay. Along the southern portions of Newark Bay, historical and present-day discharges of dioxins and other chemicals have occurred from a number of sites in Elizabeth, Linden, Bayonne, and Staten Island, NY. For example, in Elizabeth, discharges occurred to the southern areas of Newark Bay from the Kapkowski Landfill, Allied Signal, Central Railroad/Conrail Site, Nuodex, and Singer Company. Also in Elizabeth, discharges have occurred to the Elizabeth River and Arthur Kill from Elizabethtown Gas Company, Borne Chemical Company, Phelps Dodge, Reichhold Chemicals, Iron Oxide, Apex Chemical Company, and Thomas & Betts Corp.

In Linden, discharges have occurred to the Arthur Kill from the Exxon-Mobil Bayway facility, DuPont, GAF Chemicals Corporation, and American Cyanamid/Cytec. Discharges from Bayonne occurred to the southern areas of Newark Bay from EFKA Plastics (Electric Boat), Texaco, and General Cable. Also in Bayonne, discharges occurred to the Kill van Kull from Pharma Chem (Plant # 2 facility), Dow Chemical, Standard Tank Cleaning, White Chemical, Bayonne Industries, International-Matex Tank Terminal-Bayonne, Exxon-Mobil, and Powell Duffryn. Finally, in Staten Island, discharges occurred to Newark Bay from Procter & Gamble. Table 2-1 provides additional information on those sites located in southern Newark Bay that have well documented evidence of discharge.

Additionally, garbage, sewage, and contaminants have also been released into the waters of the NBSA, adjoining tributaries, and tidal straits through dumping, storm sewers, and combined sewer overflows (CSOs) (Crawford et al. 1994; Gunster et al. 1993b). These include discharges from combined sewer districts that occurred prior to the construction of sewage treatment plants and consisted of the continuous discharge of industrial waste from these outfalls. These releases occurred in Newark, Jersey City, Bayonne, Elizabeth, and Staten Island, NY. Extensive shipping traffic in Newark Bay, as well as pipeline and facility operations, have resulted in numerous oil and chemical spills, also leading to contamination of NBSA sediments.

In addition to contamination of the NBSA, development of the shoreline has led to the destruction of wetlands and a sharp decline in habitats for plants and animals (Iannuzzi et al. 2002). Between 1891 and 1934, a series of navigation channels were constructed by the federal government. In addition, a marine terminal at Port Newark was constructed by the City of Newark and Newark Liberty International Airport opened in 1927. In 1948, the Port Authority of New York and New Jersey (PANYNJ) assumed management of the airport, and the shoreline was filled for expansion activities beginning in the late 1940s through 1970 (PANYNJ 2012a). Development of the Newark Liberty International Airport led to the construction of the Peripheral Ditch, which receives and transports stormwater runoff into the NBSA. Construction of the Port Elizabeth Marine Terminal began in 1958, which also significantly changed the shoreline (PANYNJ 2012a).

Dredging was first initiated in the Newark Bay area in 1874 to accommodate deep-draft vessels (USACE 2007a). Large quantities of dredged material removed during Newark Bay development activities were used as fill for large stretches of Newark Bay's shoreline to facilitate industrial, residential, and recreational development. Over time, several major metropolitan areas were built along the shores. With increases in technological advancements, industry, and trading, the need for transportation into and around Newark Bay grew. In-filling portions of Newark Bay for new construction was not only a necessary practice, but became commonplace. In addition to the growth of port and vessel traffic, various bridges were also built for interstate automobile and train traffic.

## **2.2 Physical Setting**

Tributaries to the NBSA are shown on Figures 1-1 and 2-1. Newark Bay is hydrodynamically influenced by three major forces: tributary flows from the Passaic and Hackensack Rivers and the Kills, astronomical tides, as well as local and regional meteorological events (Herrington et al. 2002; Wakeman 2006). Each of these forces is described in more detail in this section. In addition, Newark Bay's geographic and geomorphic areas are described in Sections 2.2.1 and 2.2.2, respectively.

### **2.2.1 Geographic Areas**

The NBSA has been subdivided by geographic area, as presented on Figure 2-3. The major geographic areas, from north to south, are:

- Passaic River

- Hackensack River
- Newark Bay North
- Newark Bay Central
- Port Channels
- Newark Bay South
- Kill van Kull
- Arthur Kill

The SLERA focused on the three major geographic areas that form Newark Bay proper – Newark Bay North, Central, and South. In addition, a full site-wide evaluation that incorporated all geographic areas was conducted in the SLERA (USEPA 2008a).

As discussed above, the Passaic River is being addressed under separate AOCs that include investigation and clean-up of the lower 17 miles of the river. Contaminated sites along the Hackensack River and the Kills are also being addressed under separate regulatory programs.

The baseline risk assessments will focus on geomorphic areas, habitat types, and area usage of selected receptors. The geomorphic area and habitat discussions are presented below in Sections 2.2.2 and 3.1.1, respectively. Geographic areas of the Bay are important in terms of nature and extent of contamination. Detailed discussions are provided in other RI documents (e.g., Tierra 2008a, 2009, 2011, 2013).

#### 2.2.2 Geomorphic Areas

The NBSA was grouped into seven distinct geomorphic areas based on comparable bathymetry and slopes, hydrodynamic conditions, and historical influences (Figure 2-4). The boundaries/shapes of these areas have evolved with the development of information presented in prior reports (Tierra 2005, 2007, 2011):

- Historically Disturbed Subtidal Flats
- Industrial Waterfront Area

- Intertidal Areas
- Navigation Channels
- Port Channels
- Subtidal Flats
- Transitional Slopes

The Newark Bay Confined Disposal Facility (CDF) is another notable area that comprises less than 1% of the NBSA, but is not considered a geomorphic area due to the use of this area for waste disposal. It was constructed in 1997 within a subtidal flat in the central portion of Newark Bay, between the Port Newark and Elizabeth Channels (Douglas et al. Undated). The CDF reached capacity in 2011 and was closed and capped with at least 3 feet (ft) of sand in June 2012 (Newark Bay Study Area Coordination Team 2012). As a result, the CDF will be excluded from analysis in the baseline risk assessments.

Five of the seven geomorphic areas have unique ecological characteristics and provide important habitat, as discussed below. Exhibit 2-1 provides a breakdown of the percent each geomorphic area contributes to the NBSA.

**Exhibit 2-1 Geomorphic Area Percent Contribution to the NBSA**

<b>Geomorphic Area</b>	<b>Percent of NBSA</b>
Subtidal Flats	43%
Historically Disturbed Subtidal Flats	6%
Transitional Slopes	10%
Navigation Channels	25%
Port Channels	6%
Intertidal Areas	1%
Industrial Waterfront Area	9%
<b>Total</b>	<b>100%</b>

#### 2.2.2.1 *Subtidal Flats*

The broad, shallow Subtidal Flats located outside of the navigation channels cover approximately 43% of the NBSA (Figure 2-4). Water depth in the Subtidal Flats averages approximately 9 ft based on the bathymetric survey conducted as part of the Phase I Sediment Investigation (Tierra 2005, 2007). Water flow in these areas is largely driven by tidal influence and local winds.

The Historically Disturbed Subtidal Flats geomorphic area was defined for sediment characterization and nature and extent investigational purposes and consists of approximately 6% of the area of the NBSA. These are specific areas located within the Subtidal Flats that were altered by anthropogenic activities, such as dredging or construction. Intermittent natural sedimentation and lack of maintenance has since filled the former depressions to a sediment bed elevation that is comparable with the surrounding Subtidal Flats. The surficial features and habitats of the Historically Disturbed Subtidal Flats are similar to the surrounding Subtidal Flats; only the depositional rates differ. However, both areas will be sampled and sediment chemistry results will be evaluated to determine if there are any differences in risk between these two areas.

USACE catch data indicate the fish community in the Subtidal Flats is dominated by small schooling fish (e.g., bay anchovy [33%] and Atlantic herring [29%]), with fewer larger fish (e.g., white perch [14%] and striped bass [8%]) (USACE 2009).

#### 2.2.2.2 *Transitional Slopes*

Transitional Slopes (Figure 2-4) are located between the deeper dredged channels and the Subtidal Flats. This geomorphic feature covers approximately 10% of the NBSA, with average water depths of approximately 25 ft. The slopes are generally 3 to 1 based on observations from available NOAA bathymetric charts and consistent with the results of the bathymetric survey conducted as part of the Phase I Sediment Investigation (Tierra 2005).

The shallow portions of the Transitional Slopes would be expected to exhibit habitat similar to that of the Subtidal Flats. The deeper portions of the transitional slopes likely lack any vegetation or habitat importance due to periodic maintenance dredging, deepening-project activities, and limited sunlight conditions at depth.

### 2.2.2.3 Channels

Navigation Channels (Figure 2-4) include the main federally-authorized channels within Newark Bay and cover approximately 25% of the NBSA. Other privately dredged channels lead from the navigation channels to various waterfront facilities, particularly along the industrial waterfront on Staten Island and along Bergen Point on the southeast side of Newark Bay. Navigation Channels south of Port Newark, with the exception of the channel south of Shooters Island, have, since 2001, been dredged to maintain water depths of 35 to 50 ft below mean low water (MLW). These areas are also currently part of the Harbor Deepening Project (HDP), which is deepening these channels to 50 ft below MLW South of (and not including) Port Newark; the federally-authorized Navigation Channel was last dredged in 1989, at which time the project depth was 35 ft MLW. Additional information regarding maintenance dredging practices in the NBSA is provided by USACE (2007a).

The Navigation Channels are unique from the rest of Newark Bay due to the depths that are maintained by dredging for vessel traffic that utilizes these areas. Based on a bathymetric survey conducted in 2005, the average depth of the Navigation Channels is approximately 45 ft (Tierra 2005). Since this survey, however, some areas of the southern channels have been deepened to approximately 50 ft as part of the HDP. Due to their deep depths, the Navigation Channels are not subject to wind-wave resuspension and have a tendency to accumulate sediments (Tierra 2005). However, preferential sediment deposition within the Navigation Channels occurs along the sides of the channels where sediments are least subject to navigation-induced resuspension (Wakeman 2006).

Port Channels are located at Port Newark, Elizabeth, and South Elizabeth. Within these ports, large marine vessels maneuver and dock for cargo exchanges, then exit from the piers. The types of forces generated by vessels in these areas create a unique hydrodynamic condition. The Port Channels account for approximately 6% of the NBSA, with average water depths of approximately 48 ft (Tierra 2005). Maintenance dredging occurs on a regular basis within the established Port and Navigation Channels and associated berths for container ships at the larger terminals. Berths associated with privately owned properties along the shoreline of the NBSA are also periodically maintained.

There is little to no difference in the ecology or the biological communities of the Port Channels versus the Navigation Channels. As such, the term Channels will be used to encompass both the Port and Navigation Channels as a whole in the baseline risk assessments. Biological communities in the deep Channels of the NBSA include

benthic invertebrates and predatory fish. Surveys have shown blue crabs and predatory fish (e.g., striped bass) to be abundant in the deeper water of the Channels in the winter months (USACE 1997). USACE community trawl data collected between 2002 and 2009 were separated based on Channel catch vs. non-Channel catch. Overall, 42% more organisms were captured in the Channels than in the non-Channel areas; large fish species, such as white perch, striped bass, and spotted hake, dominated the catch in the Channels (USACE 2009). Due to the sloughing properties of the slopes of the Channels and accumulation of sediments in the Channel bottoms, this geomorphic area will be evaluated as a separate exposure area in the BERA.

#### 2.2.2.4 Intertidal Areas

Intertidal Areas (Figure 2-4) are characterized by two main features: wetlands and mudflats (or sand/cobble flats) that are typically exposed during low tide. Figure 2-5 shows the NBSA wetland areas, which are typically characterized by the presence of emergent vegetation, such as common reeds (*Phragmites australis*) and/or saltmarsh cordgrass (*Spartina alterniflora*), as well as soft muddy or organic substrates. Wetlands may provide important foraging and nesting grounds for seasonally abundant waterfowl and other water birds. Mudflats, sand, and cobble flats are characterized by unvegetated expanses of mud, fine sand, or clay. Benthic organisms, such as infaunal invertebrates, crustaceans, bivalves, and forage fish, can be found in these areas. They are also important feeding areas for predatory fish and shorebirds, such as herons, egrets, and sandpipers.

Most of the wetlands historically present around the fringes of the NBSA have been filled, yet small Intertidal Areas remain in various locations around Newark Bay – these represent approximately 1% of the area within the NBSA.

#### 2.2.2.5 Industrial Waterfront Area

As previously described, the Newark Bay shoreline has been significantly modified by human activities over time. These modifications include construction of marine facilities, privately dredged channels, publicly owned treatment works, CSOs, stormwater outfalls, rip-rap, and other facilities. The large number of constructed pier and shipping facilities along the waterfront is evidence of extensive historical removal, reworking, and disturbance of sediments. These facilities also present numerous physical obstructions to water currents and may cause highly localized variation in sedimentation patterns.

For purposes of the RI, shoreline areas along the NBSA within 100 ft of the entire shoreline of the NBSA, excluding Intertidal Areas, are considered part of the Industrial Waterfront Area (Figure 2-4). This area covers approximately 9% of the NBSA with average water depths of 17 ft, not including upland areas. While much of the Bay's shoreline is industrial, other non-industrial land uses such as public walkways, piers, and docks are also included in this geomorphic area.

Aquatic and wetland habitat is limited within the Industrial Waterfront Area. Though dilapidated pier structures and submerged wrecks, notably along the southern portion of Newark Bay, Kill van Kull, and Arthur Kill, may provide limited structural habitat for some juvenile and other small pelagic fish species, overall species abundance and diversity is reduced in these areas (Duffy-Anderson et al. 2003). In addition, these areas provide adequate substrate for spawning, egg development, foraging, and sheltering habitat for juvenile/larvae of winter flounder and other essential fish habitat species.

#### 2.2.3 Tributaries

Major freshwater inputs to the NBSA are from the Passaic and Hackensack Rivers. The combined watershed for these two tributaries is approximately 726,700 acres in New Jersey and New York (USEPA 2012b). The Passaic River is roughly 80 miles long with its origin in the center of Mendham, in southern Morris County, New Jersey. It meanders through the swamp lowlands between the ridge hills of rural and suburban northern New Jersey, called the Great Swamp. In the upper reaches of the Passaic River, its tributaries drain much of the northern portion of the state. Upriver of the Dundee Dam in Little Falls, the mean daily flow is approximately 1,200 cubic feet per second (cfs; U.S. Geological Survey [USGS] 2012). In its lower reaches, the Passaic River flows through the most urbanized and industrialized areas of the state, including downtown Newark, and then it enters the upper northwestern corner of Newark Bay. Due to the severe pollution and industrialization in these parts of the river, the lower 17 miles of the Passaic River are identified as the LPRRP, with a separate AOC under the auspices of the CERCLA program.

The Hackensack River originates in Rockland County, New York, just west of the Hudson River and flows for approximately 50 miles into Newark Bay's upper northeast portion. Tributaries of the Hackensack include Sawmill Creek, Berrys Creek, and Overpeck Creek. Just south of the Oradell Dam in New Milford, New Jersey, the Hackensack River has a mean daily flow of approximately 90 cfs. To the south of this dam, an approximately 34 square-mile area known as the Hackensack Meadowlands includes approximately 8,400 acres of wetlands that provide habitat to migratory birds,

serve as a spawning area for fish, filter surface water runoff, and protect the uplands from storm surges. Historically, these barren areas were once considered wastelands and, as a result, were subjected to pollution, alteration, in-filling, and illegal dumping.

The Elizabeth River originates in Hillside, New Jersey, and is approximately 6 miles long. It drains a small, highly urbanized basin and flows into the Arthur Kill. This river has small discharges, typically less than 100 cfs, which are affected by inputs from sewers and other outfalls, several small dams, and wetland areas, all of which affect the hydrologic response (USGS 2010).

Piersons Creek, Peripheral Ditch, and Plum Creek are three small tributaries that flow into central Newark Bay. There are limited data for these tributaries. Piersons Creek and Plum Creek are associated with the area north and east of the Newark Liberty International Airport and are located in a highly industrialized area. The Peripheral Ditch is approximately 4 miles long and varies in width from 100 to 200 ft. It serves as the drainage trench for the airport, commencing along the west side of the facility, wrapping around the southern perimeter, and flowing into the NBSA on the east side of the airport.

The tidally influenced straits of the Kill van Kull and Arthur Kill serve as the main connectors between the NBSA and the Upper Bay of New York Harbor and Raritan Bay, respectively. The Kill van Kull is approximately 3 miles long and 1,000 ft wide. The Arthur Kill is approximately 10 miles long and 600 ft wide. Both are maintained by regular dredging to accommodate cargo vessels travelling to ports and/or various private facilities along the NBSA and Arthur Kill.

Two small tributaries in Staten Island, New Creek, and Old Place Creek flow into the southern NBSA. These small tributaries also have extremely limited data. They are responsible for draining the northwest portion of Staten Island. New Creek is located along the eastern side of the Howland Hook Marine Terminal and is likely associated with the drainage of this facility. It originates just south of General Douglas MacArthur Park and is approximately 1 mile long. Old Place Creek is larger than New Creek and drains the marsh area south of Interstate 278, flowing into the NBSA just north of Goethals Bridge. It originates in the Graniteville Swamp Woods and is just over 1 mile long.

#### 2.2.4 Tides

Newark Bay has a semi-diurnal tide with a tidal period of 12.42 hours (Chant 2006; Pence 2004). The tidal amplitude is similar throughout Newark Bay, with only slight

variations in mean tide levels between the north and south ends of Newark Bay, with the mean tide level at the northern end (Kearny Point) equal to 2.85 ft (0.87 meters [m]) and equal to 2.77 ft (0.84 m) in the southwestern portion of Newark Bay (Pence 2004; Wakeman 2006). Although the tidal amplitude is similar throughout Newark Bay, tidal current velocities vary by location (Pence 2004). According to published tidal charts (NOAA 1998), the maximum ebb tidal current velocity is 2.7 ft per second (ft/sec; 0.8 m per second [m/sec]) towards the southwest near the Elizabeth Channel, and the maximum flood tidal current velocity is 3.0 ft/sec (0.9 m/sec) toward the northeast near the mouth of the Hackensack River. The weakest tidal currents are found south of the South Elizabeth Channel (west side) and in the cove south of Droyers Point (east side) (USACE 1997).

#### 2.2.5 Storm Events

Due to its location along the northeastern coastline of the United States, the NBSA is vulnerable to hurricanes, tropical storms, blizzards, Nor'easters, and other strong storms. Major flooding events have occurred in the region resulting from the combination of significant storm events, as well as the tidal dynamics. Limited information is available on specific events that have caused flooding in Newark Bay; however, there is some information on flooding events caused by storms in the Passaic River. USACE (2006a, 2012a) and NOAA (2011) report a history of significant events that caused "major" flood conditions in the Passaic River, some as recently as 2012. NOAA (2011) also indicates that many of the flooding events (categorized as "minor," "moderate," or "major") along the Passaic River are associated with channelization and regulation/diversion conditions in the river. This implies that not all major floods along the Passaic River resulted in flooding conditions in Newark Bay. Figure 2-2 highlights periods of time when large, flooding storms occurred in the region, including major floods along the Passaic River. It should be noted that these conditions indicate potential flooding in the NBSA, but are not definitive as to whether flooding occurred in the NBSA.

### 3. Data Summary

To gain a thorough understanding of the ecosystem and current environmental conditions in Newark Bay, various historical and current literature and data/information sources were reviewed. These sources included, but were not limited to, regulatory agency-sponsored reports (e.g., the PAR [USEPA 2006a] and the SLERA [USEPA 2008a]), documents written by Windward (Windward 2011) and Windward/AECOM (2009) on behalf of the Cooperating Parties Group (CPG) for the LPRRP, and Tierra-sponsored reports, including studies summarized in the Inventory and Overview Report of Historical Data (herein referred to as the Inventory Report) in Volume 1 of the NBSA Phase I Remedial Investigation Work Plan (RIWP) (Tierra 2004).

The available data are divided into qualitative and quantitative data. Qualitative data provide an understanding of the physiography and land use, available ecological habitats and species present, as well as the recreational areas along Newark Bay. Quantitative data provide specific concentrations of constituents in biotic and abiotic media and will be used to calculate potential risks in the baseline risk assessments. Depending on the quality of secondary data, these data may supplement data anticipated to be collected under Phase III of the RI for the NBSA. For example these data could be used to support the updated COPEC screen, aid in the development of sampling designs and plans, and/or evaluate potential risk to ecological and human receptors.

The qualitative and quantitative datasets available for the Bay are described below. A full reference list is provided in Section 7.

#### 3.1 Qualitative Data

Iannuzzi et al. (2002) and Crawford et al. (1994) present summaries of the environmental history of Newark Bay and the surrounding lands. Iannuzzi et al. (2002) review the historical ecology of the Passaic River and part of the Newark Bay estuary, showing how anthropogenic activities from the past 150 years have progressively degraded the natural ecology of the region. Crawford et al. (1994) demonstrate how both the abundance and diversity of aquatic species in the Newark Bay estuary have been substantially reduced since the late 1800s due to the intense industrialization and urbanization that occurred throughout the region. This section discusses the land use of the NBSA and describes the various ecological and biological communities that reside within each habitat in Newark Bay.

### 3.1.1 Land Use and Important Ecological Habitats

As depicted on Figure 3-1, which is based on the Anderson et al. (1976) land-use classification scheme, major land uses in the NBSA are barren land, forest, water, wetlands, and urban. Barren land occupies just over 1%; wetlands and forests each comprise around 2% of the land use in the NBSA. Water encompasses 22%, and the majority of land use (73%) in the NBSA today is classified as urban.

Despite the changing habitat conditions and urbanization of the NBSA during the 20<sup>th</sup> century, Newark Bay continues to serve as a spawning ground, migratory pathway, and a nursery/foraging area for a variety of aquatic organisms. The following sections describe each land-use category and the predominant organisms residing within these habitats.

#### 3.1.1.1 Water

Water depth in Newark Bay ranges from approximately 9 ft in the shallow Subtidal Flats (Tierra 2007) to up to around 50 ft in the dredged channels (USACE 2012b). Salinity in Newark Bay ranges from approximately 14 to 24 parts per thousand, with an average annual salinity of approximately 20 parts per thousand (USACE 2004a). The temperature of Newark Bay is typical of mid-Atlantic waters, ranging from near freezing during the winter months to around 25 degrees Celsius in the summer months. The variable conditions of Newark Bay support a wide range of species that inhabit several of the geomorphic regions: Subtidal Flats, navigation and port channels, and transitional slopes. Newark Bay provides habitat for invertebrates, marine mammals and fish freely swimming within the water column, as well as those residing on or within the sediment, as discussed in this section.

#### Aquatic Invertebrates

The zooplankton community can be divided into two major categories: permanent holoplankton (which include various forms of small, sometimes microscopic organisms, such as protozoans and copepods) and temporary meroplankton (which include larval stages of shallow-water invertebrates and fish). Among the meroplankton are the ichthyoplankton, consisting of egg, larval, and juvenile stages of fish. A major ichthyoplankton survey conducted in Newark Bay between 1993 and 1994 by the National Marine Fisheries Service collected larvae of 20 different species of fish. Only two species, bay anchovy (*Anchoa mitchilli*) and one unidentified goby (*Gobiosoma* sp.), were collected in substantial numbers at any time during the study year. Both species were present from June through September.

More thorough ichthyoplankton surveys were also conducted by USACE from seven stations within Newark Bay during sampling events for the HDP (USACE 2011). Data collected between 1999 and 2006 (USACE 2003a, 2004b, 2005, 2006b) are presented in Table 3-1. Forty-two species of ichthyoplankton were identified at various life stages (i.e., egg, larvae, or juvenile), including eggs and larvae from one unidentified species. It is unclear why the counts of juveniles are much lower than the other life stages for most species, but could be due to factors such as seasonality, method of capture, or identification procedures. Bay anchovy dominated the catch across all 8 years. All life stages were captured for bay anchovy, winter flounder (*Pleuronectes americanus*), weakfish (*Cynoscion regalis*), and windowpane flounder (*Scophthalmus aquosus*), indicating that these species are spawning and have early life stages in Newark Bay.

### **Benthic Invertebrates**

Fourteen studies have been conducted on the benthic invertebrate communities of Newark Bay and its tributaries; six of which focused solely on Newark Bay (Tierra 2004). These studies consistently indicate that the benthic invertebrate communities throughout Newark Bay are characterized by low abundance and diversity, and that the benthic environment is stressed from various pollutants and anoxic conditions. Species lists in all existing studies are dominated by polychaete worms, oligochaete worms, and small bivalves (clams/mussels). These organisms serve as a forage base for a variety of crustaceans, fish, and wading birds.

A survey of benthic habitats in the NY/NJ Harbor Estuary conducted in June and October 1995 (Iocco et al. 2000) indicates that Newark Bay bottom sediments are predominantly characterized as silt with occasional sand. Grab samples from approximately one-half the stations contained benthic infauna, consisting of predominantly polychaetes (e.g., *Streblospio benedicti*) and bivalves (e.g., *Mulinia lateralis* and *Mya arenaria*). Benthic habitats, such as large clam beds and mats of *Ampelisca abdita* that were seen elsewhere in the NY/NJ Harbor Estuary, were not observed in Newark Bay. At several stations in Newark Bay, the sediment gas content indicated high pollutant or organic content. In 1993-1994 and 1998-1999, USEPA (under the Regional Environmental Monitoring and Assessment Program [REMAP]) collected 56 randomly located benthic invertebrate samples in the area referred to as the Newark Bay sub-basin, which, in addition to Newark Bay, included stations in the Arthur Kill, Lower Passaic River, and Hackensack River (USEPA 2003a). The study concluded that the overall benthic invertebrate community is characterized by low abundance and diversity and is dominated by pollution-indicative species. The Benthic Index of Biotic Integrity, an index calculated based on various structure and abundance metrics, indicated that as much as 90% of the Newark Bay benthos can be classified as moderately to highly impacted (Figure 3-2). All but one station within the NBSA boundaries was considered highly impacted (USEPA 2003a).

Surveys conducted by NOAA in 1993-1994 and USACE in 1995-1996 also found Newark Bay to be dominated by polychaetes and small clams, with a low diversity and abundance of pollution-indicative species (NOAA 1994; USACE 1997). Benthic infaunal abundance and species composition increase in the late winter and early spring months and decline in the summer (USACE 1997). The most abundant species observed in six benthic invertebrate surveys are identified in Table 3-2.

Communities of large invertebrates in the channels and shoals are mainly dominated by blue crabs (*Callinectes sapidus*), which are present year-round in Newark Bay. Blue crabs at shallow water stations (Subtidal Flats) appear to be more abundant in the summer and fall (May to November) and are nearly absent during the other months when they migrate to the deeper channels or offshore (USACE 1997). Bivalve mollusks in Newark Bay were dominated by the dwarf surfclam (*M. lateralis*) and the softshell clam (*M. arenaria*).

Various physical parameters can affect chemical constituents in sediments in the NBSA, making them more or less bioavailable to benthic invertebrates and other organisms. Such factors include, but are not limited to, total organic carbon (TOC), pH, sulfide content, reduction-oxidation potential (redox), and grain size. In addition, various hydrodynamic transport factors, both spatially and temporally, can also influence bioavailability. These include processes such as sedimentation, scouring events, resuspension, and deposition of suspended solids.

A study conducted in October 2005 at 14 stations in Newark Bay utilized sediment profile imagery and supplemental grab samples to determine the biologically active zone (BAZ; Tierra 2008b). Results of the study indicate that the surface sediment is structured by physical (e.g., currents and sediment movement) and biological processes (e.g., movement of infaunal organisms), both of which can affect the bioavailability of chemical constituents. The fauna and biogenic structures observed were sufficient to bioturbate sediment to the estimated total BAZ depths of 13.7 to 16.4 centimeters (cm; average of approximately 6 inches or 0.5 ft). The deepest vertically burrowing species observed were large individuals of *Macoma balthica* and *M. arenaria* clams. The species with the potential to create the deepest convoluted burrow galleries were *Glycera* spp. and *Nereis* spp. Other species found in the grab samples were the burrowing isopod *Cyathura polita* and large-bodied, tube-building polychaetes (*Diopatra cuprea*), maldanids (*Pectinaria gouldii*), and the amphipod *Ampelisca* spp. Most of the stations sampled in this investigation were composed of benthic assemblages in a Stage III (relatively well-developed) successional stage that suggests stability in the sediment structure (Tierra 2008b).

### Fish

The finfish assemblage that resides in or is transient to Newark Bay is typical of large coastal estuaries and inshore waterways located along the Mid-Atlantic Bight. Situated in the transition zone between northern coldwater (boreal) and temperate (warm) water with low to moderate salinity, Newark Bay acts as a spawning ground, migratory pathway, and a nursery/foraging area for a variety of estuarine, marine, and anadromous fish species.

Essential fish habitat (EFH) exists for several finfish species, as documented in Environmental Impact Statements required for federal maintenance dredging (USACE 2004a, Undated). The EFH was extracted from NOAA's online EFH data mapper for the Hudson River/Raritan/Sandy Hook Bays area (<http://www.nero.noaa.gov/hcd/est.htm>). The entire bay is identified as EFH for one or more important life stages (i.e., eggs, larvae, juveniles, adults, and spawning adults) of 21 fish species (Table 3-3).

Many of the seasonally abundant fish species in Newark Bay are transient or migratory, passing through Newark Bay to upstream spawning grounds or entering the area seasonally from nearby ocean waters. These include estuarine migratory species, such as striped bass (*Morone saxatilis*), that depend on the estuary as a nursery and a forage area for juveniles and adults. Species that frequent Newark Bay during similar life history stages include both marine and estuarine predators, such as winter flounder, bluefish (*Pomatomus saltatrix*), and summer flounder (*Paralichthys dentatus*). These fish migrate in and out of Newark Bay seasonally depending on spawning area (estuarine vs. marine) and period (winter vs. summer) (U.S. Fish and Wildlife Service [USFWS] 1997; Woodhead 1991).

A few fish species are year-round residents in Newark Bay; these species generally begin spawning in late spring and continue throughout most of the summer following general onshore and offshore seasonal movement patterns (onshore in spring and summer, offshore to deeper waters in fall and winter). Most life stages of these species may be found in the estuary throughout the year. These species, such as the mummichog (*Fundulus heteroclitus*) and striped killifish (*Fundulus majalis*), provide an important forage base for larger predatory species.

Previous biological investigations have characterized the seasonal distribution and composition of the fish community in various habitats and areas of Newark Bay. The National Marine Fisheries Service conducted a major fish sampling program in Newark Bay as part of an evaluation of a flood control project for the Passaic River Basin (NOAA 1994). This study provides additional information on habitat preference of species (e.g., channel vs. shoal [subtidal] areas). Monthly fish sampling was conducted

from May 1993 through April 1994. Juvenile and adult fish were sampled with bottom trawls and gill nets. A total of 56 species of fish and invertebrates were identified from 299 otter trawl tows, 105 shrimp trawl tows, and 92 gill net sets. The dominant species caught in the channels were striped bass and Atlantic tomcod (*Microgadus tomcod*). The dominant species caught in the shrimp trawl were bay anchovy, Atlantic herring (*Clupea harengus*), and Atlantic tomcod. The dominant species caught in the gill nets were Atlantic menhaden (*Brevoortia tyrannus*) and striped bass. From the seven shoal stations on the east side of Newark Bay (relative to the main channel), 28 species of fish were collected with a bottom trawl. Six species – striped bass, winter flounder, bay anchovy, Atlantic herring, Atlantic tomcod, and Atlantic silverside (*Menidia menidia*) – dominated the catch from all shoal stations combined (USACE 2004a). Most species, whether resident or transient, were found throughout the extant range of habitat conditions. The notable exception is white perch (*Morone americana*), which was not collected in waters that had less than 6.23 milligrams per liter of dissolved oxygen (DO) (NOAA 1994).

In order to describe the species composition and relative abundance of fish in shoal areas of Newark Bay, Lawler, Matusky and Skelly Engineers, Inc. conducted sampling trawls from April 1995 to March 1996 (Lawler, Matusky and Skelly Engineers, Inc. 1996). Four shoal areas in Newark Bay were sampled to provide information on the fish community. Species collected from the shoal stations were dominated by relatively few species. Eight species – bay anchovy, striped bass, winter flounder, windowpane flounder, Atlantic silverside, summer flounder, northern pipefish (*Syngnathus fuscus*), and white perch – dominated the catch. Most species occurred infrequently and in very low numbers during the 12-month study. However, there was a consistent seasonal pattern for fish among the shoal stations. Fish were relatively abundant from April through October, but much less abundant from November through March. During the period when fish were most abundant, only four species – striped bass, winter flounder, summer flounder, and bay anchovy – occurred during each month.

Since 1998, USACE has collected fish community data from various stations in Newark Bay with a 30-ft otter trawl as part of the NY/NJ HDP. USACE notes that multi-year sampling programs are essential to establishing the use of channel and non-channel areas within the harbor from year to year. Sampling data can be used to describe annual variability in seasonal movement patterns, in usage and relative abundance, and to expand the temporal coverage of the program database. This sampling has provided a valuable long-term dataset to assess the response of fish communities to changing conditions and anthropogenic alterations in the harbor. In Newark Bay, species abundance has varied from year to year, but is generally dominated by a few species (e.g., white perch, striped bass, and bay anchovy). Data from 5 years of sampling (2005 through 2009) are presented on Figure 3-3.

The available fish community data collected in Newark Bay between 1993 and 2011 are summarized in Table 3-4. Data are presented as catch per unit effort and rounded to the nearest whole number. Direct comparisons of the studies are not possible because different gear types were used (gill nets vs. trawls) in different areas of Newark Bay (shoal vs. channel stations), the sampling efforts were substantially different, and some studies did not provide station information. However, the studies are useful for the identification of species, relative abundance, and seasonal occurrence of fish. Species composition among studies appears to be similar despite gear-type differences. Numbers of some species, such as American eel (*Anquilla rostrata*) and mummichog, may be under-represented in these studies due to the types of fishing methods used. Success rates for capturing such species may be higher with appropriate minnow or eel traps, rather than tow/otter trawls or gill nets.

As shown on Figure 3-4, during 17 years of sampling, the following 12 species dominated the overall composition of Newark Bay finfish community: bay anchovy (31%); white perch (17%); striped bass (16%); Atlantic tomcod (6%); Atlantic herring (5%); alewife (*Alosa pseudoharengus*), winter flounder, and weakfish (4% each); spotted hake (*Urophycis regius*) and blueback herring (*Alosa aestivalis*) (3% each); Atlantic menhaden (2%); and gizzard shad (*Dorosoma cepedianum*) (1%). The remaining species each represented less than 1% of the catch (Figure 3-4). The shortnose sturgeon (*Acipenser brevirostrum*), although federally listed as a protected species in Newark Bay, has not been documented in any of the studies in Newark Bay or adjacent waters (USACE 1997).

The seasonality of the finfish community is plotted on Figure 3-5, which shows the seasonal abundance for several species. For instance, striped bass appears to peak in the late fall (i.e., November). Both weakfish and bay anchovy peak in the late summer/early fall (i.e., September); Atlantic herring peaks around May. White perch is one of the few species that peaks in the winter. Although it appears that Atlantic tomcod peak in the summer, only five fish have been captured since 2005. The cause for the population decline is largely unknown, although investigators have speculated that the cause could be chemical contaminant concentrations (Fernandez et al. 2004; Wirgin 2004; Wirgin and Chambers 2006) and/or rising water temperatures (Daniels et al. 2005).

### **Marine Mammals**

There is limited available aquatic habitat for marine mammals, such as cetaceans, in the NBSA. In addition, the noise and traffic of cargo ships entering and leaving Newark Bay would likely deter these animals from intentionally entering it. As discussed by USEPA (1997a) and in the SLERA (USEPA 2008a), the possibility of cetaceans entering Newark Bay is remote.

There have been recent sightings, however, of harbor seals (*Phoca vitulina*) and harp seals (*Pagophilus groenlandicus*) in the Hackensack River (New Jersey Meadowlands Commission 2010, 2011; Frazier 2011). These seals would have had to traverse Newark Bay to get to foraging grounds in the Meadowlands. Although they are not common in the NBSA, they are a potential visitor.

#### 3.1.1.2 Wetlands

The NBSA wetlands shown on Figure 2-5 were classified based on their salinity (e.g., marine, estuarine, and freshwater) according to the USFWS National Wetlands Inventory Program. The dominant wetland type of the NBSA is estuarine/marine. Intertidal wetlands are sporadically observed on the west side of Newark Bay near the Newark Bay Bridge, along Kearny Point, on the southeastern side of Newark Bay just south of the Elizabeth Channel, and near the confluence with the Arthur Kill. A large, contiguous wetland habitat also exists along the eastern side of the Arthur Kill (Figure 2-5). Wetlands dominate the intertidal geomorphic region and provide refuge for a variety of organisms, including aquatic vegetation, which is discussed below.

#### Aquatic Vegetation

The intertidal wetlands (Intertidal Areas) of the NBSA primarily consist of emergent common reeds and saltmarsh cordgrass, with the cordgrass occupying lower portions of the shoreline, while common reeds are generally located further upland. A vegetation survey along the Lower Passaic River by the USACE in 2008 noted only 20 to 29% of herbaceous plant species and 60 to 80% of shrubs were native (USACE 2004b, 2005, 2006b, 2007b, 2008a, 2009); the remaining were non-native (Windward/AECOM 2009). Similar to the Lower Passaic River, there are likely both native and non-native species along the shoreline of the NBSA, but a vegetation survey has not been performed. In addition to vegetation, the NBSA supports a variety of phytoplankton and algal communities that are periodically surveyed, sampled, and characterized by NJDEP (2009a). In 2005 as in previous years, the Hudson/Raritan estuary was dominated by a diverse assemblage of diatoms in mild to full bloom proportions. Dinoflagellates detected during this season were *Gyrodinium undulans*, *Olisthodiscus luteus*, and *Prorocentrum micans*. In addition, *Pseudonitzschia spp.* and *Dinophysis spp.*, both potentially toxic species, were detected below bloom or toxic concentrations (NJDEP 2008b).

#### Reptiles and Amphibians

In freshwater wetlands, reptiles and amphibians are typically abundant. However, given the estuarine nature of the water of Newark Bay, amphibians, such as salamanders and frogs, are unlikely to be present (USFWS 1997). However, USACE

(1997) notes the possibility that the diamondback terrapin (*Malaclemys terrapin*) could occur as a transient visitor to the NBSA as it moves between the Hackensack Meadowlands Complex and marshes and tidal creeks along the Arthur Kill. The diamondback terrapin is the only species of turtle in North America that spends its life in brackish water (National Aquarium 2010). No terrapins have been collected to date in bottom trawls, but they appear to be a pollution-tolerant species (Wood 1995, as cited in USACE 1997). USACE (1997) also notes the possibility for three species of marine turtles – loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempi*), and the green sea turtle (*Chelonia mydas*) – to utilize the shoal areas (i.e., Subtidal Flats) of Newark Bay. However, there is no documented evidence of these species in the NBSA (Table 3-5).

#### 3.1.1.3 Forested Areas

Shooters Island, located in the southern portion of Newark Bay, is one of the major forested areas of Newark Bay. It is partially wooded with species such as black locust (*Robinia pseudoacacia*), tree-of-heaven (*Ailanthus altissima*), and Japanese honeysuckle (*Lonicera japonica*). Small patches of saltmarsh containing common reeds and cordgrass occur around the island's shoreline, including scattered debris, rotting docks, abandoned buildings, shipwrecks, and barges (USFWS 1997). Despite its impacted condition, Shooters Island continues to serve as a bird sanctuary and refuge for migratory birds such as gulls, cormorants, and osprey, which have recently been observed on the island (Bernick and Craig 2008).

Additional forested areas occur along the eastern tip of Kearny Point, just south of the Elizabeth Marine Terminal, along the eastern side of Bayonne Park, and in Richard A. Rutkowski Park. Sporadic forested areas also occur between Veterans and City Parks, in Mariners Marsh, and around the Newark Bay Bridge (Figure 3-1).

### **Birds**

Populations of birds that inhabit or utilize the forested (and other) areas of Newark Bay are mainly water birds, including waterfowl such as ducks and geese; wading birds such as herons and egrets; shorebirds such as sandpipers (*Scolopacidae*), plovers (*Charadrius melodus*), and oystercatchers (*Haematopus*); seabirds such as gulls, terns, and cormorants (*Phalacrocoracidae*); and birds of prey such as osprey (*Pandion haliaetus*). Many of the water bird species found in the Newark Bay region (and NY/NJ Harbor Estuary as a whole) are migratory. The area is part of the Atlantic Flyway, a major north-south migration route that is used by migrant species as a seasonal stopover (Elphick et al. 2001). The birds utilize open waters of Newark Bay and the Intertidal Areas, feeding and resting for a few days to a few weeks en route to northern

breeding grounds or southern wintering areas. Sandpipers, plovers, and their relatives are abundant migrants, and some are winter residents (Walsh et al. 1999).

For those water birds that breed in the NBSA, adequate nesting grounds are limited due to the highly urbanized shoreline of Newark Bay and its tributaries (i.e., the Passaic River, Hackensack River, Arthur Kill, and Kill van Kull). Therefore, most water birds primarily build their nests for breeding offshore on the 17 islands located within the NY/NJ Harbor Estuary. Two of the islands are located in the Arthur Kill/Kill van Kull complex (Prall's Island, and Isle of Meadows), while Shooters Island is located in the southern portion of Newark Bay. These islands and, to a lesser extent, mainland areas of the NY/NJ Harbor Estuary, have been surveyed for decades to quantify and characterize the nesting and trends in water bird populations.

In general, it appears that flight lines occur from colonies on various islands to the Hackensack Meadowlands Complex, which likely provides a variety of foraging habitats (marshes, mudflats, and tidal creeks) (Gelb 2004; USACE 1997). Overall, the breeding populations of water birds in the NY/NJ Harbor Estuary vary in abundance over time (Harbor Herons Subcommittee 2010). The top portion of Figure 3-6 shows the total number of nests for 10 species of water birds documented between 2001 and 2009. Because all 17 islands were not surveyed each year, the bottom portion of Figure 3-6 shows the number of nests normalized to the number of islands surveyed each year, better reflecting the annual variability.

Wading birds can be found foraging in mudflats along the Lower Passaic and Hackensack Rivers and in tidal marshes within the region (Iannuzzi and Ludwig 2004; Ludwig et al. 2010; Windward 2011). They are not expected to be a major component of the bird fauna of the relatively restricted confines of Newark Bay, but they do likely forage on the few intertidal mudflats of Newark Bay. On the other hand, seabirds and birds of prey are able to utilize the entire NY/NJ Harbor Estuary, including Newark Bay, for foraging (USFWS 1997). Several waterfowl species are known or suspected of breeding in the NBSA, including mallard (*Anas platyrhynchos*), American black duck (*Anas rubripes*), and gadwall (*Anas strepera*) (New York State Department of State 1992; Walsh et al. 1999).

Bird species observed in the NBSA from several bird surveys that have been conducted since 1990 are identified in Table 3-6. The list, originally provided in the Inventory Report (Tierra 2004) and further documented by Ludwig et al. (2010), has been updated to include more recent bird surveys that have been conducted in the region; notably, the Harbor Herons Project survey data collected in 2004, 2007, and 2008, as well as the Hackensack Meadowlands District data collected from 2004 through 2005 (Bernick 2007; Bernick and Craig 2008; Kerlinger 2004; Mizrahi et al. 2007). The majority of bird species were observed in the Hackensack River (248),

including the Meadowlands District; followed by the Arthur Kill (213), including Prall's Island and Isle of Meadows; Newark Bay (81), including Shooters Island; Kill van Kull (59); and the lower 6 miles of the Passaic River (49).

Results of the 2010 summer bird survey of the Lower Passaic River performed by the CPG indicate more aquatic and semi-aquatic bird species observed than during the summer 2000 survey (Ludwig et al. 2010): 21 species were observed in summer 2000, whereas 28 species were observed in summer 2011 (Windward 2011). Similar numbers of species were observed in fall 1999 and fall 2010: 22 species in fall 1999 and 23 species in fall 2010. Gulls were the most commonly observed birds in the fall (1999) and summer (2000), followed by swans, geese, ducks, wading birds, and shorebirds (Ludwig et al. 2010; Windward 2011).

The Natural Heritage Programs of NJDEP and the New York State Department of Environmental Conservation (NYSDEC) have identified and observed 12 rare and protected bird species in the NBSA (refer to Section 3.1.2).

### **Mammals**

Mammals most likely to inhabit the NBSA are human-tolerant species that are commonly found in urban environments, such as squirrels, raccoons, rabbits, bats, and opossum (USACE 1997; USEPA 2008c). The likelihood of any of these animals foraging directly from NBSA waters or the minimal available shoreline is limited, as they would likely remain in the terrestrial habitat.

USACE (1997) identified nine species of bats, a muskrat (*Ondatra zibethica*), and a harbor seal as "possible" mammalian species utilizing the Subtidal Flats of Newark Bay (Table 3-5). In addition, the river otter (*Lontra canadensis*) is a common inhabitant of the Hudson River and the NY/NJ Harbor Estuary. Although commonly called a "river" otter, the name can be misleading, as the animal inhabits marine, as well as freshwater environments, and some populations permanently reside in marine shoreline habitats. The North American river otter is found in a wide variety of aquatic habitats, both freshwater and coastal marine, including lakes, rivers, inland wetlands, coastal shorelines and marshes, and estuaries. The river otter's main requirements are a steady food supply and easy access to a body of water. The North American river otter has been extirpated from much of its historical range due to a number of factors including habitat loss and pollution (Dewey and Ellis 2003).

#### **3.1.1.4 Urban Landscape**

Urban areas of the NBSA are covered by bulkheads, rip-rap, buildings, and pavement and are shaded gray on Figure 3-1. These areas limit the available wildlife habitat,

such as nesting and foraging areas for birds. The vast extent of impervious surface (i.e., pavement and concrete) decreases stormwater infiltration and shunts stormwater runoff directly into Newark Bay and its tributaries.

Within the urban areas, there are several parklands and public recreational areas for active or passive use (Figure 3-1). The active facilities are designed for activities such as field sports, jogging, and children's play, whereas the passive facilities are intended for activities such as strolling, reading, sunbathing, sitting, bird watching, or dog walking. In many cases, the parklands and public recreation areas can be used for either active or passive recreation.

#### 3.1.1.5 *Barren Land*

Barren land (Figure 3-1) consists of recently cleared or disturbed areas where soils have been disturbed (coal cinders are often a major soil constituent). Vegetation consists of tolerant, often introduced, species. Vegetation is present in scattered patches, offering little cover for wildlife, particularly in winter. Garbage and debris items are present in the vacant lots/fields. Typical plant species include goldenrod (*Solidago canadensis* or *Solidago virgaurea*), mugwort (*Artemisia vulgaris*), raspberry (*Rubus*), Asian bittersweet (*Celastrus orbiculatus*), pokeweed (*Phytolacca americana*), and saplings of royal paulownia (*Paulownia tomentosa*), mulberry (*Morus* spp.), tree-of-heaven, and black locust. Typical wildlife observed includes terrestrial, urban-tolerant species (United States Coast Guard 2010).

#### 3.1.2 Population Data

##### 3.1.2.1 *Threatened and Endangered Species*

The state and federally listed threatened and endangered species for the NBSA are documented in Appendix A. To identify these species, a request was submitted to the National Heritage Program for the State of New Jersey, and an online search using NYSDEC's Nature Explorer was conducted with a user-defined subject area for the State of New York. The online search area consisted of the southern portion of Newark Bay and portions of the Kills, which are the areas of Newark Bay that fall under New York state jurisdiction. The listed species consist mainly of birds, but also includes three insects, one plant, and one fish species. The State of New York also lists two habitats. The only federally endangered species are the Atlantic and shortnose sturgeon. The species and habitats are identified below.

**Exhibit 3-1 Threatened and Endangered Species in the NBSA**

Species	Common Name	Federally Listed	State Listed
<b>Birds</b>			
<i>Nycticorax nycticorax</i>	Black-crowned night heron		NJ
<i>Bubulcus ibis</i>	Cattle egret		NJ, NY
<i>Plegadis falcinellus</i>	Glossy ibis		NJ, NY
<i>Sterna antillarum</i>	Least tern		NJ
<i>Egretta caerulea</i>	Little blue heron		NJ, NY
<i>Pandion haliaetus</i>	Osprey		NJ
<i>Falco peregrinus</i>	Peregrine falcon		NJ
<i>Egretta thula</i>	Snowy egret		NJ, NY
<i>Egretta tricolor</i>	Tricolored heron		NJ
<i>Nyctanassa violacea</i>	Yellow-crowned night heron		NJ, NY
<i>Ardea alba</i>	Great egret		NY
<i>Tyto alba</i>	Barn owl		NY
<b>Insects</b>			
<i>Pontia protodice</i>	Checkered white butterfly		NJ
<i>Somatochlora linearis</i>	Mocha emerald dragonfly		NY
<i>Ischnura ramburii</i>	Rambur's forktail damselfly		NY
<b>Plants</b>			
<i>Elocharis quadrangulata</i>	Angled spikerush		NY
<b>Fish</b>			
<i>Acipenser brevirostrum</i>	Shortnose sturgeon	X	NJ
<i>Acipenser oxyrinchus</i> *	Atlantic sturgeon	X	
<b>Habitats</b>			
Colonial Waterbird Nesting Area			NY
Gull Colony			NY

**Note:** Refer to Appendix A.

\*Species added based on USEPA comments

### 3.1.2.2 Humans

Human use activities in the NBSA are dictated by a variety of factors, including shoreline type (e.g., bulkhead, bridges, and sheet piling), land use (e.g., industrial, manufacturing, commercial, and residential), public access areas (defined as areas where the public can reasonably reach the edge of the Bay for recreational purposes),

and waterway use (e.g., shipping and fishing). The primary human uses of the NBSA include commercial activities (e.g., shipping, commerce, and industrial and municipal infrastructure and use) and recreational activities (e.g., fishing and shoreline use). Recreational fishing and shellfish collecting are recognized activities that are expected to result in the highest potential for exposure to chemicals in the NBSA (Burger 2002, 2003). Current and future land-use evaluations were performed for the NBSA. A summary of results is presented below. Additional descriptions of the evaluations are provided in Appendix B. Appendix C contains photographs and descriptions that depict additional site reconnaissance in the residential areas near Newark Bay. The photographs in Appendix C show the lack of Newark Bay access at various points near residential areas.

#### **Current Land Use Evaluation**

The NBSA is a very large site with mixed human uses. Thus, the entirety of the NBSA shoreline was evaluated for the potential for humans to contact environmental media (i.e., sediment and surface water) under current use conditions. Categories of shoreline accessibility were generally based on current zoning, development plans and physical conditions (i.e., steep elevation changes) and were classified by the type of access as follows:

- Industrial/Manufacturing/Commercial Zoning – No Access – An area of shoreline that is zoned for industrial, manufacturing, or commercial purposes and has no readily available access to sediment and/or surface water by humans.
- Industrial/Manufacturing/Commercial Zoning – With Access – An area of shoreline that is zoned for industrial, manufacturing, or commercial purposes that provides the potential for access to the sediment and/or surface water by humans.
- Residential Zoning – No Access – A residentially zoned area of shoreline that does not provide residential or recreational access to sediment and/or water due to physical conditions/barriers such as steep rocky slopes.
- Residential Zoning -- With Recreational Access – A residentially zoned area of shoreline that provides the possibility of recreational access to sediment and/or surface water by humans. The public could access NBSA sediment and/or surface water during activities such as wading, swimming, boating, canoeing, and fishing or crabbing.
- Residential Zoning – With Residential Access – A residentially zoned area of shoreline that provides the possibility for residential access to sediment and/or

surface water, with residential access defined as exposure 350 days per year for 30 years.

Appendix B contains a detailed description of the current land use and site access evaluation process, and Appendix C provides details regarding on-site reconnaissance activities. Exhibits 3-2a and 3-2b below summarize the results of this evaluation. Exhibit 3-2a contains a summary of the general exposure characterization categories for the NBSA shoreline, and Exhibit 3-2b shows additional detail, including zoning designations. Further site reconnaissance will be conducted to assess areas with potential human access and will be discussed in future documents.

**Exhibit 3-2a Summary of Exposure Characterizations – Current Land Use**

Characterization	Total Length (miles)	Percentage of Total Perimeter (%)
Industrial/Manufacturing/Commercial Zoning – No Access	15.1	55.3
Industrial/Manufacturing/Commercial – With Access	5.6	20.5
Residential Zoning – No Access	2.9	10.6
Residential Zoning – With Recreational Access	3.7	13.6
Residential Zoning – With Residential Access	0	0
All characterizations	27.3	100

**Note:** Refer to Appendix B for details.

**Exhibit 3-2b Detailed Exposure Characterizations Using Zoning Categories Utilized by Municipalities – Current Land Use**

Zoning Category as Listed by Municipalities	Total Length (miles)	Percentage of Total Perimeter (%)
Industrial/Manufacturing Zoning – No Access	13.0	47.6
Industrial/Manufacturing/ Zoning – With Access	4.8	17.6
Bayfront I Redevelopment Area – No Access*	0.2	0.7
Droyers Point Redevelopment Area – No Access*	0.9	3.3
Droyers Point Redevelopment Area – With Recreational Access*	0.1	0.4
Kapkowski Road Redevelopment Area – With Access*	1.1	4.0
Residential Zoning – No Access*	1.8	6.6

<b>Zoning Category as Listed by Municipalities</b>	<b>Total Length (miles)</b>	<b>Percentage of Total Perimeter (%)</b>
Residential Zoning – With Recreational Access*	2.5	9.2
Residential Zoning – With Residential Access	0	0
Commercial Zoning – No Access*	1.1	4.0
Commercial Zoning – With Access*	0.4	1.5
Manufacturing, Research & Commercial Zoning – No Access*	1.0	3.7
Manufacturing, Research & Commercial Zoning – With Access*	0.4	1.5
All characterizations	27.3	100

\*Non-industrial area

### **Future Land Use Evaluation**

Four areas along the perimeter of the NBSA have the potential to undergo future residential development. These areas were identified on regional zoning maps and further investigated by reviewing development plans from the respective cities or counties surrounding the NBSA (City of Bayonne 2000, 2001, 2003; City of Elizabeth 2012; City of Kearny 2009; City of Newark 2004; Hudson County 2010; Jersey City 2001, 2008; New York City 2011a, 2011b; Schoor DePalma, Inc. 2005). The objective of this review was to determine if there are any differences between current and future land use with respect to potential exposure to surface water and sediments. A more detailed description of the future residential developments can be found in Appendix B. Figure B8 depicts the locations of these four areas. Exhibit 3-3 below summarizes the areas identified for potential future residential development and shoreline access.

### **Exhibit 3-3 Areas Slated for Alternative Future Development (Including Residential)**

<b>Zone</b>	<b>Length (miles)</b>	<b>Current Shoreline Access Characterization</b>	<b>Potential Future Use (and Shoreline Access Characterization)</b>
Bayfront I Redevelopment Zone	0.2	Industrial/Manufacturing – No Access	Mixed-use residential, retail, parks or recreation, and commercial area which will be bulk-headed, limiting access
Waterfront Development District	0.8	Industrial/Manufacturing – With Access	Mixed-use residential, parks, and commercial area with recreational access
Kapkowski Road Redevelopment Area	1.0	Industrial/Manufacturing – With Access	Mixed-use residential and commercial area with recreational access

Zone	Length (miles)	Current Shoreline Access Characterization	Potential Future Use (and Shoreline Access Characterization)
Staten Island – North Shore	NA	Industrial/Manufacturing – With Access	Mixed-use recreational and commercial with recreational access

**Note:** NA = not available

In summary, although land uses may change in the future, there appears to be no difference between current and future shoreline access. Some industrial properties and some recreational areas are situated such that humans could have direct access to NBSA environmental media. However, no residential properties were identified under current land use or appear likely in the future that will provide access 350 days per year to environmental media such as sediments. Further site reconnaissance will be conducted to assess areas with potential human access and discussed in future documents.

### 3.2 Quantitative Data

Apart from sediment data, few other quantitative analytical chemistry data have been collected from the NBSA. Table 3-7 presents a preliminary summary of available data from third-party sources that have been reviewed and are considered relevant and acceptable for quantitative or semi-quantitative use in the risk assessments, as discussed below. Per the June 2011 BHHERA workshop (ARCADIS and ToxStrategies 2011), for the HHRA the Bay will be evaluated as a single exposure unit and the data will be analyzed for the presence of hotspots. For the BERA, exposure areas will be evaluated based on geomorphic area (e.g., Channels, Intertidal Areas, Subtidal Flats), as well as habitat preferences and home ranges of ecological receptors.

#### 3.2.1 Secondary Data Evaluation

An evaluation of all secondary data sources is being conducted to evaluate the quality and usability of data collected by third parties. USEPA identified numerous secondary data sources considered potentially relevant to the NBSA data assessment process (USEPA 2008d, USEPA 2012c). These data sources, and any additionally identified data, are being reviewed as part of the secondary data evaluation. The overall objective of this evaluation is to identify how the data provided in individual source documents can be used to fulfill each of the three RI goals: nature and extent of contamination, risk assessment, and/or source identification.

Data sources being reviewed include government studies, academic theses, peer-reviewed journal articles, and independent studies. Risk assessment-related data generally include biological tissue concentration data and/or bioaccumulation data for

metals, PAHs, PCBs, pesticides, PCDDs, and PCDFs and surficial sediment chemistry, population metrics (e.g., richness and abundance), and toxicity data. The review of each data source involves a step-wise process that ultimately leads to a usability classification:

1. Level 1 (Qualitative) – Data have limitations and should only be used for qualitative purposes in the risk assessments.
2. Level 2 (Semi-Quantitative) – Data have some limitations, but could be used on a semi-quantitative basis in the risk assessments, as appropriate.
3. Level 3 (Quantitative) – Data are considered appropriate for quantitative use in the risk assessments.

Descriptions of major datasets preliminarily deemed reliable for semi-quantitative and quantitative use (i.e., considered Levels 2 or 3) in the baseline risk assessments are provided in the following sections.

### 3.2.2 Sediment Data

The USEPA (2004a) AOC identified various hazardous substances in NBSA sediments that may pose a risk to human and ecosystem health. These chemicals of interest include, but are not limited to, cadmium, copper, lead, mercury, nickel, zinc, PAHs, PCBs, dichlorodiphenyltrichloroethane (DDT), 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), 2,4-dichlorophenoxy acetic acid, 2,4,5-trichlorophenoxy acetic acid, and 2,4,5-trichlorophenol. As part of the sediment investigations (Phase I and Phase II Sediment Investigations [SIs]) conducted under this AOC and associated RI program, sediment core locations across the NBSA were sampled for various analytes, including pesticides, PCBs (as Aroclors, congeners, and homologues), SVOCs, metals, cyanide, chlorinated herbicides, dioxins/furans, and total petroleum hydrocarbons (Tierra 2005, 2007, 2008a). A limited number of VOCs were also analyzed, including chlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, and 1,2,3-trichlorobenzene (Tierra 2005, 2007, 2008a). Collectively, chemical analyses were performed for 366 individual chemicals or chemical groups in the Phase I and Phase II SIs, providing an abundance of data for these chemicals of interest (Tierra 2008a, 2013).

In addition to the chemicals recognized in the AOC, there are a substantial number of additional chemicals that may be present in the NBSA, including but not limited to, emerging contaminants associated with pharmaceuticals, personal care products, and flame retardants. For example, USEPA has identified the following chemicals as potential emerging chemicals of concern in the environment: bisphenol A; phthalates;

perfluorinated chemicals; penta-, octa-, and decabromodiphenyl ethers; short-chain chlorinated paraffins; benzidine dyes; diisocyanates; nonylphenol and nonylphenol ethoxylates; and siloxanes (USEPA 2010b). Furthermore, van den Berg et al. (2013) has recently proposed toxic equivalency factor (TEF) values for a number of polybrominated dibenzo-*p*-dioxins (PBDDs), polybrominated dibenzofurans (PBDFs) and polybrominated biphenyls (PBBs) but EPA will need to evaluate this report to determine how it will be addressed in the assessment. This is important given the presence of a former PBB manufacturing facility (one of only three facilities in the United States as reported by ATSDR [2004a]) adjacent to the Kill van Kull. Some of these emerging chemicals have already been identified in the NBSA. For example, an SI conducted by the NYSDEC for the Contaminant Assessment and Reduction Project (CARP) detected polybrominated diphenyl ethers (PBDEs; flame retardants) in Newark Bay sediments (NYSDEC 2003). In conjunction with Phase II activities, polychlorinated naphthalenes (PCNs) and PBDEs were also found to be present in sediment throughout the NBSA (Tierra 2013). In an effort to be consistent with USEPA guidance (USEPA 2001a), the RI will include an evaluation of PBDEs and PCNs; those that are identified will be addressed in the BERA and BHHRA either quantitatively or qualitatively based on the available information. It may be necessary to add other chemicals to the RI analyte list in the future (such as PBBs) in order to properly assess human health risks at the site either quantitatively or qualitatively. However, any such addition to the RI analyte list will be done in coordination with USEPA and consideration of available toxicity values to assess the cancer risk or noncancer health hazards.

#### 3.2.2.1 *Sediment Chemistry Data*

Sediment samples have been collected in Newark Bay since 1990 and analyzed for various parameters, including metals, PAHs, PCBs, pesticides, herbicides, VOCs, SVOCs, PCDDs, PCDFs, TOC, grain size, radiochemistry, and acid volatile sulfides/simultaneously extracted metals (AVS/SEM). Sediment core data are available across the NBSA for sediment depths ranging from 0 to 29.5 ft below sediment surface and from surficial sediment grab samples.

The most recent and comprehensive large-scale sediment sampling in the NBSA was conducted by Tierra in 2005 and 2007 under the RI program (the Phase I and Phase II SIs, respectively). Collectively, these sediment sampling events collected and analyzed over 640 surface and subsurface sediment samples from 119 locations in the NBSA, providing data for 366 individual chemicals or chemical groups. These data provide important insight on the horizontal and vertical distribution of COPECs and COPCs throughout the NBSA sediment. These data are available in Tierra 2008a, 2009, and 2013.

The risk assessments will focus on the BAZ, which has been established as the top 15 cm (approximately 6 inches or 0.5 ft) of surface sediment (Tierra 2008b). In order to utilize data that may best represent the current/recent BAZ (i.e., chemistry within the top 6 inches of the sediment bed) and to maintain consistency with other ongoing programs in Newark Bay, only analytical chemistry data collected since 2000 will be quantitatively utilized for risk assessment purposes.

#### 3.2.2.2 Sediment Toxicity Data

Fourteen laboratory studies have documented sediment toxicity within Newark Bay and its tributaries (Tierra 2004). Various organisms were used to measure survival and growth, including amphipods (*Ampelisca abdita* and *Rhepoxynius abronius*), polychaetes (*Armandia brevis*), mysids (*Mysidopsis bahia*), bivalves (*Mulina lateralis*), and sand dollars (*Dendraster excentricus*). In general, the studies showed that, with the exception of *A. abdita*, the organisms were not sufficiently sensitive, from either a growth or survival aspect, to evaluate differences in toxicity of various sediments.

The amphipod *A. abdita* is the most widely used organism in sediment toxicity studies in the NY/NJ Harbor Estuary; the NBSA results are shown in Table 3-8 and on Figure 3-7. Eighty-five individual survival toxicity tests have been conducted using *A. abdita* (Figure 3-7), 55 of which (65%) exhibited toxicity (defined as percent survival significantly less than control). Results from one of the largest programs, USEPA's REMAP, indicated that an estimated 50% of Newark Bay is toxic to amphipods (samples from the Arthur Kill were also included in this estimate) (USEPA 1998, 2003b). NOAA (1995) estimated 85% of the Newark Bay region is toxic (area included the Lower Passaic River, Hackensack River, and Kills). Both the REMAP and NOAA studies used a stratified random design to estimate the areal extent of toxicity.

#### 3.2.3 Tissue Data

##### 3.2.3.1 Tissue Chemistry Data

Fish and other biota tissue sampling for contaminant characterization is limited for the NBSA. During the 1980s, NJDEP captured and analyzed fish for PCBs and pesticides from edible fillets (NJDEP 1982, 1983, 1985). Also during the 1980s, Brown et al. (1994) and Rappe et al. (1991) collected dioxin/furan data from various fish and shellfish tissue in Newark Bay. Most recently, CARP captured and analyzed tissue data from one location in the center of Newark Bay (NYSDEC 2004a, 2004b, 2004c, 2005, 2006). Tissue data from CARP are available for the following seven fish species and associated matrices:

- American eel: whole body minus head and viscera

- Blue crab: all edible tissue, hepatopancreas, and muscle tissue
- Mummichog: whole body
- Ribbed mussel (*Geukensia demissa*): all soft parts
- Sevenspine bay shrimp (*Crangon septemspinosa*): whole organism
- Striped bass: liver tissue and standard fillets
- White perch: standard fillets, whole body minus head and viscera, and whole body.

Additional data are available for polychaetes and zooplankton greater than 64 microns. All tissue data were analyzed for metals, PAHs, PCBs, pesticides, PCDDs, and PCDFs (Table 3-7). Length, weight, and percent lipid data were also collected for four fish species, bivalves, and blue crabs (Exhibit 3-4).

**Exhibit 3-4 Length, Weight, and Percent Lipid Data for Species Captured Under CARP**

Species	Average Length (mm)	Average Weight (g)	Average Percent Lipid (%)
Mummichog	64	64	2
White perch	218	167	5
American eel	544	420	17*
Striped bass	562	2160	3
Bivalves	59	20	1
Blue crab muscle	140	152	5
Blue crab hepatopancreas	140	152	9
Blue crab – all edible	142	149	2

**Notes:**

mm = millimeter

g = gram

\*based on only two samples; additional characterization needed

Tissue data were also collected from Newark Bay for the New Jersey Routine Monitoring Program for Toxics in Fish (Horwitz et al. 2006). Under this program, three samples of blue crab muscle and hepatopancreas tissue were collected from crabs at two stations located in Newark Bay, one at Shooters Island and one at Turnpike Bridge (Table 3-7).

A study by Parsons (2003), also conducted under the CARP program, analyzed samples of double-crested cormorant eggs, blood, and feathers for various chemical parameters (e.g., metals, PAHs, pesticides, PCBs, dioxins/furans) from three islands throughout the NY/NJ Harbor Estuary. The objectives of the study were to determine if concentrations of chemicals were present in the birds at levels of concern, and to determine if there was any correlation between the concentrations of the chemicals and reproductive success in the population. Results indicate that tissue samples collected from birds on Shooters Island, in general, had higher concentrations of chemicals than tissues collected from birds on the other two islands (Swinburne and Gardiners; Parsons 2003). However, no correlation could be made between reproductive success (e.g., egg production, hatching success, and chick survival) and chemical concentrations among the three islands (Parsons 2003).

Additional studies (e.g., Cooper and Buchanan 2007; Bugel 2009, 2011; Gale et al. 2000) have collected biomarker data such as external examinations, blood smears, hematocrit, total and organ weights, histopathology, biochemical endpoints, including endocrine disruption (e.g., ethoxyresorufin-O-deethylase induction), and fluorescent activity. These data attempt to document potential changes in fish at the molecular level; however, it is difficult to scientifically link alterations in biomarkers to particular constituents.

#### 3.2.3.2 Bioaccumulation Studies

Four studies documented bioaccumulation in benthic invertebrates within Newark Bay and its tributaries (Tierra 2004). Some studies calculated accumulation factors but did not present the raw data. In addition, two other benthic bioaccumulation studies have been reviewed: one for the CARP program (Hydroqual 2007) and one by USACE (2010a).

As part of the CARP program, co-located sediment and polychaete samples were collected and analyzed from seven locations in the NY/NJ Harbor Estuary, and biota-sediment accumulation factors (BSAFs) were calculated for two subgroups (inner and outer harbor) (Hydroqual 2007). BSAFs for the inner harbor (Upper Bay, Newark Bay, and Arthur Kill) were calculated and range as follows:

- Congener PCBs: 0.16 to 1.38
- PCDD/Fs: 0.05 to 0.27
- Pesticides: 0.15 to 2.82
- PAHs: 0.01 to 0.24.

The dataset used to calculate BSAFs from CARP is small (7 samples) and the limited paired sediment-tissue data do not appear to demonstrate a statistical relationship, based on the large range of BSAFs. According to equilibrium partitioning theory, organic carbon and lipid should account for the variability in the concentrations of COPCs in the tissues. As such, the BSAF values should be similar or at least within the same order of magnitude for each constituent. Because the BSAFs calculated from the CARP differ by an order of magnitude or more, a valid statistical relationship does not appear to exist.

The USACE conducted laboratory bioaccumulation tests and kinetic modeling using Newark Bay and Arthur Kill sediment with the polychaete, *Nereis virens*, and the clam, *Macoma nasuta* (USACE 2010a). The study found that the standard 28-day exposure duration was generally adequate for *N. virens* but not for *M. nasuta*, indicating that clams may require a longer time to reach steady-state conditions with sediment-borne contaminants. As this example suggests, it is important to evaluate and, wherever possible, control the different sources of variability when developing uptake factors.

Bivalves such as the softshell clam (*Mya arenaria*), blue mussel (*Mytilus edulis*), and eastern oyster (*Crassostrea virginica*) have been used to study levels and physiological effects of bioaccumulative constituents (Pruell et al. 1993, Rappe et al. 1991, others, as cited in Wintermyer et al. 2005). The accumulation of constituents in bivalves is influenced by filter feeding while the concentration is influenced by seasonal effects. Bivalves undergo a seasonal increase of percent lipids during gametogenesis and gonadal development, which affects the concentration of constituents in their tissues. For instance, oysters have been shown to accumulate dioxin in gonadal tissue, causing adverse effects on egg and sperm development and fertilization (Wintermyer and Cooper 2003, Wintermyer et al. 2005). While past studies have used eastern oysters as a sentinel species for constituent uptake, the species has not been prevalent in the NBSA for decades (Kurlansky 2006).

#### 3.2.3.3 Tissue Ingestion Data

It is expected that the consumption of fish and/or shellfish from the NBSA poses the most significant potential for exposure by humans to chemicals in NBSA environmental media (USEPA 2000c, 2005d); thus accurate characterization of this pathway is important for reducing uncertainty in the BHHRA. A review of existing pertinent information related to human use activities and creel/angler surveys in and around the NBSA is provided below.

**Human Activities Related to Crab and Tissue Ingestion**

A human use survey of the NBSA was conducted by Burger (2003) as part of a study that documented the public's perception of the most significant environmental concerns in the area and the most important environmental improvements. Different forms of recreational use of Newark Bay were ranked from 1 to 5 (1 being the least important and 5 being the most important). Results indicated that swimming is least important (average ranking of 1.3), fishing/crabbing are moderately important (2.6 to 2.9), and "commune with nature/enjoyment of a place without people" was ranked highest (3.5 to 3.6). With regard to potential restoration opportunities in Newark Bay, the public showed the greatest desire (3.8) for creating more breeding fish habitat.

Additionally, there have been observations of people fishing and crabbing along the Bayonne waterfront, on the eastern side of the NBSA, from piers, exposed rocky shorelines, docks, and pilings, including the pilings of the Central Railroad of New Jersey Newark Bay Bridge that was demolished in the 1980s (Anglerweb.com, accessed August 3, 2010 [Exhibit 3-5]). It is important to note that these activities have been observed despite fishing advisories. Because of the presence of chemicals in NBSA biota, the State of New Jersey advises high risk individuals not to consume blue crab, striped bass, American eel, white perch or white catfish (NJDEP and New Jersey Department of Health and Senior Services [NJDHSS] 2012) while New York advises high risk individuals (women under 50 years of age and children under 15 years of age) not to consume any fish from the NBSA (New York State Department of Health 2013). The general public is currently advised not to eat any blue crab, American eel (*Anguilla rostrata*), or white perch from the NBSA (NJDEP and NJDHSS 2012). Harvest and sale of blue crab and the sale of striped bass and American eel is banned. Current federal regulation requires all anglers to register with their state or the federal government to fish in marine waters. The free saltwater registry for NJ can be found at [www.nj.gov/dep/fgw/marinelicenses.htm](http://www.nj.gov/dep/fgw/marinelicenses.htm).

**Exhibit 3-5 Observations of Recreational Fishing, Boating, and Crabbing in Newark Bay****Creel/Angler Surveys**

There have been four major creel/angler surveys for the area in and around the NBSA: May and Burger (1996), Pflugh et al. (1999), Burger et al. (1999), and Burger (2002). Pflugh et al. (1999) and Burger et al. (1999) are evaluations of the same 1995 survey of the Newark Bay complex. NJDEP also conducted more recent crab/angler surveys in 2002 and 2005, and these data are analyzed in Pflugh et al. (2011). Brief summaries of these studies are provided below, and these data will be considered in the development of site-specific exposure factors for the human health risk assessment. Note that exposure parameters, including fish/crab ingestion rates, will be presented and discussed in the PAR.

May and Burger (1996) interviewed 318 people from May to September 1994 along the shore and on party boats in the Arthur Kill, Raritan Bay, and at two unspecified locations along the New Jersey shore. The survey examined the consumption habits of anglers at these sites, whether the anglers were aware of the fish consumption advisories, how the anglers perceived the risk of eating fish caught from the sites, whether the anglers were exposed to toxic substances in fish, and whether their risk perceptions matched the severity of the hazard. Results showed that the frequency of fishing was highest in the Arthur Kill, averaging over eight times per month. Although 60% of anglers and crabbers in the Arthur Kill reported hearing warnings about consuming fish from these waters, 70% of anglers and 76% of crabbers said that they consumed their catch.

Pflugh et al. (1999) conducted interviews between July and October 1995 with 300 anglers at 26 unspecified fishing and crabbing sites around the NBSA. Data were collected on the six species under a state fish consumption advisory for recreational fishing: blue crab, striped bass, American eel, white catfish (*Ameiurus catus*), white perch, and bluefish. Results provided information regarding anglers' knowledge and belief in fish advisories, perceptions on the safety of consumption, and sources of information about fish and fish consumption advisories. Burger et al. (1999) also published a paper that evaluated the effect of ethnicity on the results of the Pflugh et al. (1999) study. They found that there were ethnic differences in consumption rates and knowledge regarding the safety of ingesting the fish tissue and awareness of fish advisories.

Burger (2002) reported the results from interviews with 267 people observed angling at several locations within the Newark Bay Complex between May and September 1999. Survey locations included Newark Bay, Hackensack and Passaic Rivers, Kill van Kull, and Arthur Kill. The primary objective of the study was to relate the sociological reasons that people fish to their consumption patterns. The survey addressed demographics, consumption behavior (including information regarding serving size), knowledge of advisories, and reasons for angling. Of those interviewed, 111 people reported consuming only fish (44%), 110 people reported consuming only crab (44%), and 33 people (12%) reported consuming both fish and crab. No information was asked regarding species, parts consumed, preparation or cooking practices, or sharing. Based on the meal size and frequency data, Burger (2002) estimated mean consumption rates for fish-only consumers (22 grams per day [g/day]), crab-only consumers (15.6 g/day), and both fish and crab consumers (37 g/day of fish and 17 g/day of crab). More than 30% of anglers interviewed did not eat their catch and were not included in the calculation of consumption rates. There was wide variation in consumption patterns within each ethnic group (White, Black, Hispanic, Asian), but the study found no ethnic differences in reasons for fishing. Most people fished and/or crabbed for recreation; people rated "angling to obtain food" relatively low as a reason

for fishing. Examples of species of finfish commonly caught for human consumption from the NBSA included white perch, striped bass, bay anchovy, Atlantic herring, bluefish, American eel, and various species of flounder.

Pflugh et al. (2011) reviewed and summarized crabbing surveys conducted by the NJDEP in 1995, 2002, and 2005 for the Newark Bay Complex, using the collective data to conclude that crabbing for recreational purposes and for dietary supplementation was occurring despite fishing and crabbing bans. The surveys provided data on the duration, frequency, and amount of crab consumed.

#### 3.2.4 Surface Water Data

Outfalls serve as a continuing source of contaminants into the NBSA surface water and sediments. Chemical contributions from outfalls will be characterized during the RI/FS to understand their impact on the NBSA and their contribution to human health risks.

##### 3.2.4.1 *Surface Water Chemistry Data*

Only a limited amount of chemical contaminant data has been collected for surface water from Newark Bay. For example, analytical chemistry data collected during the 1999-2006 Honeywell International Sampling Program are limited to metals, including hexavalent chromium (Table 3-7). A key difficulty in contaminant characterization sampling for surface water is the ability to achieve detection limits low enough to support risk assessments. Furthermore, because the surface water ingestion pathway is generally considered minor in terms of contaminant uptake, most sampling programs concentrate their efforts on collecting sediment.

Water column samples were collected under the CARP program and analyzed for various analytes, including metals (cadmium, lead, mercury, methylmercury, and silver), at five locations in Newark Bay between 1998 and 2000 (NYSDEC 2003).

Surface water sampling is currently being conducted in Newark Bay and the Lower Passaic River. AECOM's (2011) Small Volume Chemical Water Column Monitoring data were collected in 2011 and 2012 from eight stations within Newark Bay and analyzed for over 200 chemical and physical parameters. In addition, data for the High Volume Chemical Water Column Monitoring program are also anticipated. These data are being collected under a variety of flow conditions and tidal phases to aid in characterizing the variability in fluxes and mixing processes in the NBSA. The data will be evaluated for risk assessment purposes and additional data will be collected, as appropriate, to fulfill risk assessment needs.

#### 3.2.4.2 *Surface Water Quality Data*

Various programs (e.g., NOAA 1994) have collected non-chemistry surface water quality data from the NBSA, including DO, pH, salinity, temperature, conductivity, turbidity, and pathogens. The 2006 Regional Summary of Water Quality in the Newark Bay Area indicated high levels of fecal coliform and low levels of DO in bottom waters of Newark Bay (New Jersey Harbor Dischargers Group 2008). These parameters are also being collected in Newark Bay as part of the surface water monitoring program for the Lower Passaic River.

### **3.3 NBSA Modeling**

Numerical modeling of the Lower Passaic River-Newark Bay system is being performed by the CPG pursuant to the Settlement Agreement and Order on Consent (AOC) effective May 8, 2007 (USEPA 2007d). The work is being conducted according to the Lower Passaic River Restoration Project Modeling Work Plan (Hydroqual 2006a) and the Newark Bay Study Modeling Work Plan Addendum (Hydroqual 2006b). The modeling consists of four sub-models: hydrodynamic, sediment transport, contaminant fate and transport, and bioaccumulation.

The suite of models will be used to inform management decisions, including the development of the baseline risk assessments, which will utilize the results of the physio-chemical models (hydrodynamic, sediment transport, and chemical fate and transport) to estimate the potential for sediment movement and future sediment conditions. The bioaccumulation model will be used to estimate the resulting constituent concentrations in tissue. In addition, the updated CSM will inform the development and/or refinement of the model for Newark Bay.

### **3.4 Hydrodynamic Model**

The Lower Passaic River Study Area hydrodynamic model, based on the ECOM modeling code, was developed by HydroQual, Inc. under contract to Malcolm Pirnie, Inc. for USEPA Region 2 (Hydroqual 2008). The modeling and model performance are documented in the referenced report. As required by the AOC (2007), the CPG has been using this sub-model to develop the sediment transport and contaminant fate and transport models. In addition, the CPG will use the hydrodynamic model to support modeling needs associated with the remedial investigations and feasibility studies for the Lower Passaic River and Newark Bay, inclusive of the associated risk assessments, the latter of which (Newark Bay) is the subject of this Problem Formulation. The model still needs to be calibrated and validated for the NBSA.

**3.5 Sediment Transport Model**

The sediment transport model, using the code from SEDZLJ, is under development by the CPG, under the oversight of USEPA. Modifications to the model code and the results of model calibration and verification are reviewed by USEPA during regular modeling collaboration meetings. Modeling efforts on the current version of the model, SEDZLJS, have largely focused on the LPR. Work on the model in the NBSA is in the early stages.

**3.6 Contaminant Fate and Transport Model**

The contaminant fate and transport model, using the code from RCATOX, is under development by the CPG, in coordination with USEPA. Modifications to the model code and the results of model calibration and verification are reviewed by USEPA during regular modeling collaboration meetings. Work on the contaminant fate and transport model was recently initiated for the Lower Passaic River; work on the model in Newark Bay has not yet begun.

**3.7 Bioaccumulation Model**

The site-specific ecological and chemical characterization data for the NBSA will be used to develop a steady-state bioaccumulation model to help evaluate current and future exposures in the baseline risk assessments. Consideration will be given to the modeling framework currently being developed and tested for the Lower Passaic River by the CPG.

#### **4. Baseline Ecological Risk Assessment**

The BERA, consisting of Steps 3 through 7 of USEPA's Eight-Step ERA process (USEPA 1997a), builds on the results of the SLERA to provide a more accurate and realistic estimate of potential ecological risk in the NBSA. To do this, various site-specific data are collected, toxicity tests are conducted, and potential risks to wildlife are estimated using refined food web exposure models. Results of the BERA are then used to manage ecological risks by informing the remedial action decision-making process in Step 8 of the ERA process.

The following activities are conducted as part of the Problem Formulation for the BERA:

- Refine the preliminary list of COPECs
- Characterize the potential ecological effects of COPECs
- Review and refine information on the fate and transport of COPECs, potential exposure pathways, and receptors potentially at risk
- Select assessment and measurement endpoints
- Refine the CSM with testable hypotheses (i.e., risk questions) that the investigation will address

As shown on Figure 1-2, the Problem Formulation concludes with a scientific/management decision point (SMDP) that consists of agreement on the following:

- Assessment endpoints
- Exposure pathways
- Risk questions
- A CSM that integrates the above components

#### 4.1 Refinement of COPECs

The first step in the BERA process is to refine the COPECs that were originally identified in the SLERA based on any new data and any recently updated toxicologically based screening benchmarks.

##### 4.1.1 Summary of COPECs from SLERA

The SLERA utilized data collected between 1990 and 2005 to compare maximum concentrations of constituents in sediment and tissue (i.e., fish, benthic invertebrates, crabs, mollusks, and avian embryos) to conservative ecological screening benchmarks to obtain a hazard quotient. Ecological screening benchmarks were identified for each distinct environmental media (sediment and biological tissue) and for each relevant exposure pathway. The screening benchmarks for sediment were based on the lowest of various published benchmarks (e.g., NYSDEC, NJDEP, and USEPA).

For those constituents considered bioaccumulative (USEPA 2000d), wildlife protective concentration levels were back-calculated for sediment and tissue using conservative exposure assumptions to be protective of bioaccumulative hazards to upper trophic-level receptors. In addition, a tissue screen was performed by comparing tissue concentrations to available literature-based critical body residue (CBR) values. As a result of the screening process, many constituents were identified as COPECs in sediment, fish tissue, mollusk tissue, crab tissue, benthic invertebrates, and avian embryos. Constituents with hazard quotients greater than 1 were retained as COPECs to be further evaluated in the BERA. A summary table of COPECs in each exposure medium is presented in Table 4-1.

##### 4.1.2 Updated COPEC Screen

Additional sediment data have been collected in Newark Bay since the SLERA was conducted in 2008 during the Phase I and II SIs (Tierra 2013). The COPEC screen for surficial sediment (0 to 0.5 ft) has been updated to incorporate these new data (Table 4-2).

Datasets for the updated COPEC screen are limited to the last 12 years (2000 to present) because it is likely that chemical concentrations in surface sediments of older datasets are no longer considered representative of surficial concentrations. Furthermore, only data preliminarily classified as Level 3 by the secondary data evaluation review are incorporated into the COPEC screen. These data are applicable to the study area because they are located within 2 miles of the study area boundaries; were collected under an approved work plan, Quality Assurance Project Plan (QAPP), or were peer-reviewed; have undergone quality assurance/quality control methods;

and have been validated according to USEPA Region 2 standards. As such, they can be utilized quantitatively in the baseline risk assessments.

The complete dataset for the updated surficial sediment COPEC screen consists of data collected from the Honeywell International Sampling Program (1999-2006) and the Newark Bay Phase I and Phase II SIs (Tierra 2013). The dataset consists of over 200 constituents, plus individual congeners of PCBs, PCNs, and PBDEs. The sample size varies for each constituent, from three samples (for pyridine) to 258 samples (for chromium). Additional datasets from CARP (NYSDEC 2003) and USACE (2010a) were identified as Level 2 and were, therefore, not incorporated into the screen.

Ecological screening values for sediment were selected preferentially from values recommended by the Partner Agencies<sup>1</sup>, which include those developed for the LPRRP. These values were supplemented with the following, in order of preference: 1) current NJDEP Ecological Screening Criteria for marine sediment (NJDEP 2009b), 2) current NJDEP Ecological Screening Criteria for freshwater sediment (NJDEP 2009b), 3) Region 3 benchmarks for marine sediment (USEPA 2006c), 4) Region 3 benchmarks for freshwater sediment (USEPA 2006d), and 5) Region 5 Ecological Screening Levels for sediment (USEPA 2003c). Constituents without screening values were conservatively retained as COPECs.

The COPEC screen also considered frequency of detection of each constituent. If less than 10% of samples had detected values for a particular constituent, the constituent was eliminated as a COPEC. Non-detect data were incorporated into the dataset at one-half the detection limit. Essential nutrients (calcium, magnesium, potassium, and sodium) were also eliminated as COPECs. Results of the COPEC screen for surficial sediment are discussed in the following section.

A surface water COPEC screen has not been conducted because the most recent surface water datasets are not yet available from the study area. A surface water COPEC screen will be conducted once final validated data from all ongoing surface water sampling events are available. The table below summarizes the availability of the current datasets for the NBSA:

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<sup>1</sup> The Partner Agencies include USACE, NJDEP, New Jersey Department of Transportation, NOAA, and USFWS.

**Exhibit 4-1 Available Surface Water Datasets for Newark Bay**

Date	Sampling Event	Number of Stations	Number of Samples	Number of Analytes	Notes
1999-2006	Honeywell International Sampling Programs	56	92	2 - 8	Number of analytes varies by sample; only analyzed for metals and hexavalent chromium; results for total and filtered samples.
2000-2004	CARP NJ Surface Water Program	4	165	1 - 192	Number of analytes varies by sample.
2000-2004	CARP NY Surface Water Program	1	48	1 - 561	Number of analytes varies by sample.
August 2011	CPG Small Volume Chemical Water Column Monitoring – Routine Event 1	7	106	550	Number of analytes varies by sample.
February 2012	CPG Small Volume Chemical Water Column Monitoring – Routine Event 2	8	101	224	Number of analytes varies by sample.
March 2012	CPG Small Volume Chemical Water Column Monitoring – Routine Event 3	8	64	473	Number of analytes varies by sample.
June 2012	CPG Small Volume Chemical Water Column Monitoring – Routine Event 4	8	~100	~220	Number of analytes varies by sample.
December 2012	CPG Small Volume Chemical Water Column Monitoring – Routine Event 5	8	64	~470	Final validated results not available.
January 2013	CPG High Volume Chemical Water Column Monitoring – Event 1	3	15	~230	Final validated results not available.
February/ March 2013	CPG Small Volume Chemical Water Column Monitoring – High Flow Event 1	8	56	~470	Final validated results not available.

**4.1.3 Revised Sediment COPEC Screen Results**

Table 4-2 presents the results of the updated surficial sediment COPEC screen. Of the 391 constituents screened, a total of 100 COPECs were identified<sup>2</sup>. These include detected constituents that have maximum concentrations that exceed their respective

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<sup>2</sup> Note that individual dioxins/furan and PCB congeners presented, but only included in COPEC count as totals (e.g., Total PCB congeners).

sediment screening values (70 COPECs) and those that lack a screening value (30 COPECs). Of those 70 COPECs with maximum concentrations exceeding their screening values, 60 constituents have mean concentrations that also exceed their screening values. Only five constituents were eliminated because maximum concentrations are lower than screening values.

Thirty-seven constituents were eliminated because they were detected in less than 10% of the samples. Seventy constituents were eliminated because they were not detected in surface sediments; 39 of these have detection limits that exceed their respective screening value. This represents some uncertainty in the COPEC screen.

COPECs are similar to those identified in the SLERA (USEPA 2008a) and include individual constituents from various classes of chemicals (e.g., dioxins/furans, metals, pesticides, PCBs, SVOCs, PAHs, and a few VOCs). For the BERA, all identified COPECs will be evaluated in sediment, benthic invertebrate tissue, and fish tissue. Following analysis, the COPEC list will be refined to evaluate exposure to birds and mammals. Summaries of COPEC fate and transport and ecotoxicity are provided in Sections 4.1.4 and 4.1.5, respectively. Due to the large number of COPECs, the discussions are based on COPEC groups, as opposed to individual COPECs.

#### 4.1.4 Constituent Fate and Transport

The following sections describe general fate and transport processes for the major constituent classes. More specific and detailed discussions of the nature and extent of 18 select COPECs in the NBSA (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, 2,3,7,8-TCDD, bis(2-ethylhexyl)phthalate (BEHP), Total petroleum hydrocarbons, Total DDT, Total Aroclor PCBs, Total Congener PCBs, Total PAHs, Total Chlordane) are provided in the Interim Conceptual Site Model (Tierra 2011), which is anticipated to be updated in 2013, and the Data Evaluation and Analysis Report (Tierra 2013).

##### 4.1.4.1 Metals

Metals may be encountered in their singular elemental states but are more commonly found as complexes. Arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc all exist in a variety of oxidative states depending on element loading, microbial activity, nutrient content, pH, redox potential, suspended sediment load, sedimentation rate, salinity, and other variables (Eisler 1987a). When found as compounds, metals are typically bound to other elements, including carbon, oxygen, chlorine, and sulfur atoms. In estuarine environments, metal compounds that include chlorine are regularly encountered. In water, some metals form soluble compounds, while others will precipitate out of solution as insoluble salts; these reactions are largely

dependent on water chemistry. Barium and lead are typically insoluble in water, while silver and zinc are usually found in soluble forms. Metals are also often bound to sediments due to bonding with suspended solids or organic matter in water or due to reactions on the surface of clay minerals.

Some metals are considered essential nutrients in plants and animals and net uptake may be regulated as such over a limited range of concentrations (Agency for Toxic Substances and Disease Registry [ATSDR] 2004b). Plants' tolerance to, and ability to accumulate metals, varies widely by chemical, species, and environmental conditions. Similarly for non-plant aquatic species, the uptake of metals into tissues is highly variable. Some metals are lipophilic (mercury and lead), and concentrations tend to accumulate in fat, liver, brain, egg, and other tissues. Other metals, such as zinc, behave differently with concentrations in organisms not directly related to the concentration in the environment (McGeer et al. 2003). The evidence suggests that fish placed in environments with lower zinc concentrations can sequester zinc in their bodies. The fact that many organisms are capable of regulating internal metals concentrations within certain limits means that, in some instances, organisms can stabilize internal concentrations against perturbations or high concentrations in the external environment (World Health Organization [WHO] 2001). However, this ability is likely to be exceeded at excessively high concentrations.

Consideration of AVS and SEM provides a way to screen out situations where toxicity due to sediment SEMs (copper, cadmium, nickel, lead, silver, zinc) is not expected (USEPA 2005e, 2007c). The difference between the sum of the molar concentrations of SEM (the metal extracted in the AVS extraction procedure) minus the molar concentration of AVS is normalized to the organic carbon fraction in the sediment and can accurately predict which sediments are not toxic because of these metals (USEPA 2005e).

#### 4.1.4.2 PAHs

PAHs are a large group of organic chemicals composed of two or more fused benzene rings (USEPA 2003b). PAHs in the environment originate primarily from two sources: petrogenic (i.e., petroleum sources, including different types of oils, coal, and organic shales) and pyrogenic (i.e., combustion), with the majority associated with pyrogenic sources. Petrogenic PAHs are usually associated with local or point sources such as refineries and other petroleum industries, while pyrogenic PAHs tend to occur on a broader scale.

PAHs are considered persistent organic pollutants, but may undergo a variety of degradation processes in abiotic environmental media, including, photolysis, oxidation, biodegradation, binding to solid media, and volatilization. Photolysis of PAHs has been

shown to be dependent on the physical and chemical structure of the substrate the PAH is sorbed to as opposed to the structure of the PAH itself (ATSDR 1995). Similarly, the rate of oxidation is influenced by the nature of the media, as well as PAH structure. Biodegradation of PAHs is influenced by concentration, DO, water temperature, and microorganisms present (ATSDR 1995). Binding of PAHs to organic carbon is controlled by the organic carbon-water partitioning coefficient ( $K_{oc}$ ). Degradation of PAHs in water depends in part on the temperature and oxygen content of the water (ATSDR 1995). Degradation in soils and sediments depends in part on soil organic content, soil structure, physical factors, the presence of microbes, and the characteristics of the microbes and PAHs (ATSDR 1995).

Physio-chemical properties that affect the fate of individual PAH compounds depend in part on the molecular weight and ring structure of the individual PAH. The rate by which PAHs volatilize from the water column to the atmosphere is dependent on Henry's law constant for the particular PAHs present. Low-molecular-weight (LMW) PAHs volatilize more readily than high-molecular-weight (HMW) PAHs. In general, PAHs have low water solubility and a high  $K_{oc}$  value that indicate moderate to high affinity for organic carbon (ATSDR 1995). Thus, in aquatic systems, most of the total amount of PAHs is typically sorbed to suspended particulate matter or sediments rather than being found in the dissolved phase (ATSDR 1995). The presence of dissolved organic carbon has been shown to reduce PAH bioavailability (McCarty and Jimenez 1985; Landrum et al. 1987, as cited in USEPA 2009c).

Photo-oxidation and chemical oxidation are important degradation processes for PAHs in water (ATSDR 1995). PAHs can also be chemically oxidized by chlorination and ozonation. Photolysis, hydrolysis, and chemical oxidation are generally not considered important degradation processes for PAHs in soils and sediments, especially for HMW PAHs (ATSDR 1995). Data suggest that naphthalene and phenanthrene may biodegrade most readily in water; anthracene, benzo(a)anthracene, chrysene, and fluorene may biodegrade in sediment water/slurries; and benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, and other PAHs with five or more rings may not biodegrade readily at all (ATSDR 1995).

PAHs are lipophilic and can rapidly bioaccumulate from water, sediments, soil, and food. Less soluble PAHs are typically taken up more readily in the gastrointestinal tracts of animals (USEPA 2007c). In general, bioconcentration is higher for HMW than LMW PAHs, but can vary by taxa based on the ability of organisms to metabolize parent PAHs to other compounds (ATSDR 1995). Fish can metabolize PAHs in the liver and excrete the metabolites in feces and urine. Most crustaceans also possess the required enzymes for metabolism. Organisms tend to take up PAHs easily from food, although dietary exposure sometimes contributes a limited amount to body burdens compared to water exposure. Due to metabolic ability, PAH concentrations in

fish are typically low. Some data suggest that skin, as well as lipids, may be a temporary site of accumulation and may pose a barrier to the migration of PAHs in tissues. Mollusks and some other invertebrates may be unable to metabolize PAHs efficiently, although they can eliminate them. Studies of marine mollusks have found that while LMW PAHs were bioconcentrated more or less than HMW PAHs, the LMW PAHs were more readily eliminated. Sediment can also be a significant source of body burdens of PAHs for benthic invertebrates and fish. Biomagnification through aquatic food chains has not been observed, likely due to rapid biotransformation and elimination (ATSDR 1995; Eisler 1987b).

#### 4.1.4.3 PCBs

PCBs are a group of chemicals that were produced between 1929 and 1978 in the United States for use as industrial coolants, insulators, and lubricants. The term PCBs encompasses 209 individual congeners with one to 10 chlorine atoms attached to a biphenyl molecule. PCBs may be grouped by homologues (defined by the number of chlorines), Aroclors (trade names), coplanar/non-coplanar (positions of chlorines), and as total PCBs (i.e., sum of homologues, sum of Aroclors, or sum of congeners). PCBs are highly lipophilic, semivolatile compounds that bioaccumulate and biomagnify in ecological receptors (USEPA 1999).

Release of PCBs to the environment occurred as the result of industrial discharges, leaks, disposal, landfills, and atmospheric transport of incompletely incinerated PCBs (Eisler 1986). The same chemical properties that made PCBs useful to industry are now responsible for persistent levels of PCBs remaining in the environment. Although the manufacture and use of PCBs was banned in the United States in 1979, they are a ubiquitous contaminant worldwide. This is because PCBs are extremely stable and slow to degrade (Eisler 1986). PCBs are generally ubiquitous in the aquatic environment, particularly in sediments. They may enter aquatic systems from wet and dry deposition, river inflows, groundwater flow, and direct and indirect discharge from industrial facilities. Once in aquatic systems, PCBs quickly partition into the more nonpolar compartments of the ecosystem or are physically adsorbed on particulate matter (Eisler 1986). PCBs are relatively insoluble in water, but are freely soluble in nonpolar organic solvents and in biological lipids (Eisler 1986).

Physical properties of each PCB molecule affect what happens to it over time in the environment. Increasing chlorination causes the solubility of PCBs to decrease and also affects the degree to which a PCB sorbs to organic matter and the ability of biota to excrete the PCB rather than retain it in body tissues. As a result, individual congener PCBs have the potential to bioaccumulate to different extents.

PCB mixtures in environmental media degrade over time, either by processes of weathering or by microbial degradation. These processes can cause dechlorination of PCB molecules, thus affecting the overall bioavailability of individual PCBs. The degree of dechlorination depends on the number and position of chlorine atoms, with lower chlorinated compounds more readily degraded. The degree of chlorination also leads to a wide range of volatility among congeners (Wenning et al. 2011).

PCB molecules are hydrophobic (have low solubility in water), adhere readily to organic matter in soil or sediment, and may bioaccumulate in adipose tissue in fish or other animals. Thus, the highest levels of exposure to PCBs in the environment typically occur through the food chain via ingestion of food items, rather than by direct contact with soil, sediment, air, or water. Many physical, chemical, and biological processes can affect the bioavailability and subsequent uptake of PCBs in the environment, including organic carbon content in sediment or soil and the lipid content in the receptor species. Accumulations are highest in adipose tissue and skin. Accumulation and metabolism are a function of chlorination, with higher chlorinated compounds more difficult to metabolize and more likely to accumulate (Eisler 1986).

#### 4.1.4.4 *Organochlorine Pesticides*

The organochlorine compounds chlordane and DDT are persistent hydrocarbon compounds that were widely used as pesticides in the recent past. Both chlordane and DDT are synthesized chemicals, and their presence in the environment is associated with their production and use as pesticides. These compounds became widely used in agriculture beginning in the 1940s and 1950s. DDT usage in the United States was banned in 1972, while chlordane was banned in 1988 due to increasing evidence regarding their environmental persistence and potential adverse effects on wildlife and human health. Organochlorine pesticides can enter the environment after pesticide applications, disposal of contaminated wastes into landfills, and releases from manufacturing plants.

In general, the organochlorine pesticides have low aqueous solubility and tend to bind strongly to particulates and organic matter in soils and sediments. Chlordane and DDT are very persistent with half lives up to 30 years depending on environmental conditions. It is not known whether much breakdown of chlordane occurs in water or in sediment. Chlordane breaks down in the atmosphere by reacting with light and with some chemicals in the atmosphere; however, it is sufficiently long lived that it can travel long distances and be deposited on land or in water far from its source. Similarly, DDT is highly persistent, but does break down slowly via photolysis and both aerobic and anaerobic degradation. Both chlordane and DDT, and their metabolites, are lipophilic and readily taken up into the aquatic food chain. These chemicals are also known to biomagnify in higher trophic level organisms.

Organochlorine pesticides are highly bioaccumulative, a primary reason they were effective as pesticides. DDT and chlordane bioconcentrate in organisms making up the lower trophic levels of the food chain and accumulate moving up the food chain. Following introduction via the gills or through ingestion of prey items, organochlorines travel through the blood and are then distributed to soft organs and ultimately lipids (USEPA 1999). The individual forms of chlordane vary in their uptake and bioaccumulation (Eisler 1990). After accumulation in tissues, organochlorines may be eliminated over time if exposure is terminated. Little is known about the uptake of DDT and chlordane into aquatic plants.

#### 4.1.4.5 *Dioxins and Furans*

Dioxins and furans are aromatic heterocyclic compounds in the organochlorine group. Dioxins and furans are similar in structure to PCBs with the main difference being the addition of one oxygen atom between rings in furans and two oxygen atoms between rings of the dioxin molecules. Dioxins and furans have no commercial uses and have been introduced to the environment as byproducts of industrial processes including production of Agent Orange and as a byproduct of both natural and anthropogenic combustion. The number of chlorine atoms included in the molecular structure is variable between one and eight resulting in 75 possible dioxin isomers and 135 possible furan isomers. Toxicity of these chemicals is variable based on the position of the chlorine atoms, especially in the “lateral positions” (2,3,7, and 8) with 2,3,7,8-TCDD and 2,3,7,8- tetrachlorodibenzofuran (2,3,7,8-TCDF) having chlorine in all four positions and, as a result, are the most toxic isomers (Hoffman et al. 1995). A group of 12 PCBs are referred to as “dioxin-like compounds” as they behave similarly to dioxin (USEPA 2006e).

Dioxins and furans are commonly detected in air, soil, and sediment around the world. Dioxins and furans are widely distributed at low concentrations with higher concentrations noted in heavily industrialized areas. These compounds enter aquatic environments via soil erosion and stormwater runoff in urban areas and break down very slowly. Like other chlorinated chemicals, dioxins and furans are persistent environmental pollutants ending up in sediments in the aquatic environment due to poor solubility. Increased chlorination of isomers leads to an increase in overall stability and lipophilicity, as well as the slowing of elimination in organisms (USEPA 2008c). Photolysis and volatilization may remove some dioxins and furans from the aquatic environment, but these effects decrease with depth leaving sediments generally unaffected depending on water clarity.

Dioxins and furans are readily taken up into the aquatic food chain; depending on the chemical structure these constituents are known to biomagnify in higher trophic-level organisms in aquatic ecosystems (Hoffman et al. 1995). They are readily biomagnified

in the aquatic food chain, moving from sediments to higher trophic-level organisms. The individual molecular structure of the isomer determines the exact uptake and bioaccumulation due to chemical properties and individual  $K_{ow}$  values. After accumulation in tissues, dioxins and furans are not readily eliminated by the organism.

#### 4.1.4.6 *Bis(2-ethylhexyl)phthalate*

Bis(2-ethylhexyl)phthalate (also commonly known as BEHP, di[2-ethylhexyl]phthalate, and DEHP) is the most common phthalate compound and is widely used as a softener in the manufacturing of products made of polyvinyl chloride. Products include packaging film and sheets, wall coverings, floor tiles, upholstery, shower curtains, garden hoses, swimming pool liners, rainwear, shoes, medical tubing, and sheathing for wire and cable (Office of Environmental Health Hazard Agency [OEHHA] 2009). BEHP is ubiquitous in the environment due to the high usage levels in modern society. BEHP can leach out of common products and enter the environment.

In landfills, BEHP has been shown to leach out of products and may enter runoff surface water or groundwater. Once in the water, BEHP has low solubility and tends to disperse slowly. In aquatic systems, BEHP is generally found attached to suspended particles or in the sediment. BEHP is readily degraded with exposure to light. The dominant mechanism for degradation in surface water and sediment is via exposure to bacteria and actinomycetes (OEHHA 2009). Half-lives in surface and marine waters range from under 1 day to more than 2 weeks (OEHHA 2009). BEHP is not considered a persistent pollutant.

BEHP has been shown to bioaccumulate in aquatic plants and invertebrates (OEHHA 2009). Although BEHP is often found in lipid tissues, fish do not readily bioaccumulate BEHP (OEHHA 2009). Specific enzymes in the gills of freshwater fish are thought to be able to break down BEHP, limiting entry into the organism, and thus, limiting bioaccumulation (OEHHA 2009).

#### 4.1.5 Ecotoxicity of COPECs

##### 4.1.5.1 *Metals*

The toxicity of metals in the aquatic environment is dependent on the partitioning and speciation of the given contaminant in the environment, which affect the overall bioavailability of the metal. Examining the total concentration of metal in a medium is not always predictive of the bioavailability of the metal in that environment. In general, metal bioavailability is dependent on redox, pH, hardness, organic carbon, percent fines, AVS, and other factors (ATSDR 2004b; Eisler 1998; Hoffman et al. 1995; USEPA 2007c). For several divalent metals, a key partitioning phase that controls

cationic metal activity and toxicity in sediments appears to be AVS, which is a measure of the amount of sulfides in sediment capable of binding to metals (DiToro et al. 1990, 1991; Ankley et al. 1996). Examining SEM and AVS can successfully estimate the bioavailability of some metals in aquatic environments. It is particularly useful for identifying samples in which toxicity due to SEM metals (i.e., cadmium, copper, nickel, silver, zinc) is not likely to occur (USEPA 2005e).

Some metals can act as essential nutrients to plants (e.g., copper, nickel, zinc, and others) at low to moderate concentrations but can be toxic at higher concentrations. Other metals can adversely affect growth and photosynthesis and may cause lethality depending on the chemical and species present (ATSDR 2004b). In invertebrates, exposure to metals can cause variable effects based on the taxa. Effects due to metals exposure to invertebrates may include decreased survival, growth, reproduction, immobility, gill damage, reduced filtration and feeding rates, and valve closure. In fish, effects from exposure to metals can include alterations to respiration and osmoregulation, gill damage, changes in olfactory and lateral line function, and changes to survival, growth, reproductive and developmental success, and behavior (ATSDR 2004b, 2005; Eisler 1987a, 1998). Some species may be able to develop tolerance to limited concentrations of certain metals, including but not limited to, cadmium and copper, via binding metals to metallothioneins and other proteins as a protective mechanism (Hoffman et al. 1995; International Program on Chemical Safety 1992).

#### 4.1.5.2 PAHs

The aquatic toxicity of PAHs may be mitigated by several factors: PAH concentrations in even heavily polluted water are usually far below levels required for acute toxic effects, and PAHs in sediment may be less bioavailable and less toxic than PAHs in solution (Eisler 1987b). The molecular weight of PAHs is also an important factor in aquatic toxicity because toxicity generally increases as molecular weight increases; however, HMW PAHs tend to have low acute toxicity, possibly due to low water solubility (Eisler 1987b). Among aquatic organisms, crustaceans are most sensitive and teleost fish are least sensitive (Eisler 1987b). Toxic effects of PAH exposure in various taxa may include effects on photosynthesis, mobility, blood chemistry, skin, hematopoietic system, organs, immune system, respiratory and cardiovascular systems, reproduction, growth, and survival (Eisler 1987b; USEPA 2007c).

Unsubstituted LMW PAHs are not generally carcinogenic, while many HMW PAHs are known or suspected carcinogens, genotoxins, and mutagens (Eisler 1987b). Neoplasms or related disorders have been observed in connection with high exposure to HMW PAHs in terrestrial and aquatic organisms, including invertebrates and fish. Intraspecies and interspecies differences in response, as well as significant

interactions between HMW PAHs of differing potential carcinogenicity, make characterization of the specific carcinogenic contribution of individual HMW PAHs in the field difficult (Eisler 1987b). HMW PAHs in sediment have been associated with effects on benthic invertebrates, including reproductive effects, delayed emergence, sediment avoidance, and mortality. A variety of carcinogenic (especially in the liver), teratogenic, and other developmental effects have been observed in fish in connection with HMW PAH exposure in water and sediment (Hoffman et al. 1995, USEPA 2009c).

Toxic responses to PAHs have been shown to be induced by ultraviolet radiation. Photo-induced PAH toxicity has been shown to occur in aquatic organisms in petroleum-contaminated habitats (Ireland et al. 1996, Barron et al. 2000) and with specific PAHs such as anthracene (Oris and Giesy 1986) and fluoranthene (Boese et al. 1997).

Although individual PAHs may be toxic to an organism by a compound-specific mode of action, the prevalent mechanism of toxicity in invertebrates is narcosis, which can result in the alteration of cell membrane function (USEPA 2009c). Because narcosis is a non-specific mode of action and the effects are additive, it requires that the toxicity of PAH mixtures be considered (Swartz et al. 1997; DiToro and McGrath 2000; USEPA 2008c). The target lipid model (DiToro et al. 2000, Di Toro and McGrath 2000, McGrath et al. 2009) provides a way to quantify the narcotic effect of PAH mixtures while considering PAH bioavailability as well (USEPA 2003b, 2009c).

#### 4.1.5.3 PCBs

Coplanar PCBs have chlorine atoms in non-ortho positions that allow the two benzene rings to lie in the same plane; non-coplanar PCBs have chlorine atoms in the ortho position causing the molecule to twist and the rings are on different planes. The relative toxicities of coplanar PCBs are calculated by expressing their toxicity in relation to 2,3,7,8-TCDD, which also shares the coplanar structure and is the most toxic dioxin (Eisler and Belisle 1996). These fractional potencies are known as toxic equivalency factors (TEFs) and are useful in estimating toxicity in PCBs and PCB mixtures. Toxicity of PCBs is a factor of both the number of chlorine atoms in the molecule and how close the benzene rings are to being coplanar (Loseto and Ross 2011).

PCB toxicity varies among different species of animals, but in general, reproductive effects tend to be the most sensitive endpoint. PCBs may also act as endocrine disruptors. Toxicity is believed to be related to the ability of the congeners to induce cytochrome P450-dependent activity. There are limited data regarding toxicity of PCBs to plant species. PCBs incorporated into phytoplankton exert inhibitory effects on photosynthesis and cell motility (Eisler 1986). PCB toxicity to invertebrates is generally less than that observed in vertebrate species due to limited detoxification systems.

Crustaceans and younger developmental stages appear to be the most sensitive groups, and lower chlorinated compounds appeared to be more toxic. The ability of invertebrates to accumulate PCBs from sediment or the water column makes them good indicator species.

PCB effects may be associated with the survival, growth, and reproduction of individuals within the local populations of fish and wildlife species, with reproduction broadly defined to include egg maturation, spawning, egg hatchability, and survival of fish larvae. The most sensitive endpoint for effects of PCB on fish is found during early life stage survival and recruitment as a result of PCB transfer from maternal tissue to eggs (Berlin et al. 1981). As a group, birds are more resistant to acutely toxic effects of PCBs than mammals, based on literature values (Eisler 1986). Signs of PCB poisoning among birds included morbidity, tremors, beak pointed upwards, and muscular incoordination (Eisler 1986). In mammals, long-term neurobehavioral changes were reported in children, monkeys, and rodents exposed to commercial PCB mixtures during fetal and neonatal development (Eisler 1986). Mink (*Mustela vison*) is among the most sensitive mammals to PCB toxicity, with documented reproductive failure, fetal death, altered blood chemistry, abnormal liver metabolism and histology, raised cortisol excretion, and altered metabolism of Vitamin A (Eisler 1986).

#### 4.1.5.4 Organochlorine Pesticides

Organochlorine pesticides are made up of four groups based on chemical structure; these groups include the cyclodienes (e.g., chlordane, endosulfan, and endrin), diphenyl aliphatics (e.g., DDT and its metabolites), hexachlorocyclohexanes (e.g., lindane), and polychloroterpenes (e.g., toxaphene) (Becvar and Lotufo 2011). As a group, the cyclodienes are characterized as the most acutely toxic of the organochlorine pesticides (Elliott and Bishop 2011). There is variation in toxicity between the compounds, likely because of their varying ability to be metabolized. For example, chlordane can be metabolized to form a number of different metabolic products, including heptachlor and heptachlor epoxide, which may be more toxic than chlordane itself. However, all cyclodienes act through a central nervous system mechanism, with dietary exposure considered the most important route (Elliott and Bishop 2011). Acute toxicity of organochlorine pesticides to aquatic organisms has long been studied, oftentimes with rapid death of sensitive organisms at relatively low tissue concentrations and the accumulation of higher residues in the remaining resistant organisms (Becvar and Lotufo 2011). At low concentrations, pink shrimp are similarly susceptible to chlordane as grass shrimp. In contrast, similarly exposed Eastern oysters only showed decreased growth, with no apparent effects on mortality. Signs of chlordane poisoning in fish included hyper excitability, increased respiration rate, erratic swimming, loss of equilibrium, and convulsions; death frequently occurred within 12 hours of exposure (National Research Council Canada 1975).

The diphenyl aliphatics, such as DDT, are highly toxic to aquatic invertebrates with early developmental stages, which make them more susceptible to acute effects of DDT than adults (WHO 1989). Some effects may be reversible prior to lethality setting in, and some invertebrates have also shown resistance to DDT (WHO 1989). DDT is highly toxic to fish, causing effects to behavior, biochemistry, development, growth, histology, reproduction, and mortality (WHO 1989). The bioavailability and effects on benthic organisms of DDT (and other non-ionic chemicals acting by a specific mode of action) may be evaluated using equilibrium partitioning methods (DiToro et al. 1991, 2000).

#### 4.1.5.5 *Dioxins and Furans*

While over 200 dioxin and furan isomers exist, seven dioxins and 10 furans are known by the WHO to be highly toxic (USEPA 2008c), with the most toxic isomers being 2,3,7,8-TCDD and 2,3,7,8-TCDF. In order to more readily assess the toxicity of dioxins and furans as a mixture, the system of TEFs was developed based on the toxicity of 2,3,7,8-TCDD. In this system, each isomer on the WHO list is assigned a factor (i.e., TEF) based on its potency relative to 2,3,7,8-TCDD; the estimated toxicity of all isomers present is summed to come up with an overall estimate of toxicity. Toxicity for these compounds is thought to be broken into three modes of action: 1) irreversible chemical binding to macromolecules inhibiting their function, 2) accumulation to high concentrations in lipids resulting in stress-induced dosing, and 3) irreversible binding to cellular receptors and enzymes inhibiting biochemical communications between cells (McKinney and Walker 1994). In most cases, the toxicity of dioxins and furans is linked to the interruption of function of a specific intracellular protein (AhR).

Invertebrate and vertebrate organisms respond differently to elevated concentrations of dioxins and furans, with invertebrates being relatively tolerant of exposure compared to vertebrate species. This difference may be due to the absence of some receptors in invertebrates that are adversely affected in vertebrate species (Hoffman et al. 1995). Due to their tolerance to exposure, invertebrates may accumulate dioxins and furans into their tissues from sediments, making them more biologically available to vertebrate species in the aquatic environment (Hoffman et al. 1995).

Laboratory toxicity data show that fish are generally more sensitive to 2,3,7,8-TCDD than plants, aquatic invertebrates, and other aquatic vertebrates (e.g., amphibians) (USEPA 2008c). The high lipid content in fish makes them highly susceptible to bioaccumulation of 2,3,7,8-TCDD in their tissues, which can essentially be transferred up the food chain to higher-trophic-level organisms, such as birds and mammals (including humans). Effects of 2,3,7,8-TCDD exposure to mammals and birds are similar to fish and include delayed mortality, a “wasting” syndrome characterized by

reduced food intake and reduced body weight, reproductive toxicity, histopathological alterations, developmental abnormalities, and immunosuppression (USEPA 2008c).

#### 4.1.5.6 BEHP

Toxicity to aquatic organisms is variable with arthropods being the most sensitive group that have been studied. Some fish, including the medaka, were sensitive to exposure with sublethal effects noted at low exposure concentrations (OEHHA 2009). However, in most studies toxic effects did not occur until reaching an exposure level above the water solubility of BEHP (OEHHA 2009). Sublethal effects include increased hatching time, reductions in body weight, reduced gonado-somatic index, changes in blood chemistry, developmental difficulty, and changes in sex ratio. Lethality is also possible depending on the concentration and organism (OEHHA 2009).

## 4.2 Ecological Conceptual Site Model

A preliminary ecological CSM was presented in the Phase I RIWP (Tierra 2005), in the SLERA (USEPA 2008a), and was recently updated in the Draft Interim Conceptual Site Model Report (Tierra 2011). Based on the review of additional data and reports (i.e., the data and information summarized in this document) and decisions from the BHERA Workshop (ARCADIS and ToxStrategies 2011), the ecological/food web components of the CSM have been updated as displayed on Figure 4-1; the specific ecological exposure pathways are depicted on Figure 4-2. A summary of the key, risk-based components of the CSM is provided below.

## 4.3 Ecological Exposure Pathways and Receptors

Representative receptor species for evaluation in the BERA were selected based on the available reports, biological surveys, habitat data, and other information from the NBSA, as discussed above. The following factors that were considered for the selection of proposed ecological receptors are the same as those considered in the Problem Formulation Document for the LPRRP (Windward/AECOM 2009):

- **Potential for exposure to sediment-associated chemicals** – Ecological receptors exposed to sediments through direct and incidental ingestion of sediment, ingestion of sediment-exposed prey, or direct contact with sediments have the greatest potential for exposure to sediment-associated chemicals, as opposed to species with less direct sediment contact. In addition, ecological species with small home ranges and whose site use is limited to the NBSA (e.g., mummichog) have a greater potential for exposure to site-related chemicals in sediment than do migratory species (e.g., bluefish), species with large home ranges, or species that do not exclusively use aquatic habitats (e.g., raccoon).

- **Relative ability to bioaccumulate/biomagnify site-related chemicals** – Species from upper-trophic levels (e.g., piscivores) have a greater potential for long-term exposure to bioaccumulative chemicals and a greater potential for the biomagnification of those chemicals.
- **Societal and cultural significance (including species that are highly valued by society)** – Federally and state-listed threatened and endangered species have special consideration in the selection of receptors. Appendix A provides the animal and plant species listed by the states of New Jersey and New York. In addition, the Atlantic sturgeon has a distinct population segment in the New York Bight that is federally-listed as endangered and has been captured once in Newark Bay in 1993 (Table 3-4). Also, those species that are commercially and recreationally important receive greater consideration in the selection of receptors.
- **Ecological significance (including species that serve a unique ecological function)** – Species with unique foraging preferences, such as those that primarily feed in shallow mudflat areas or are bottom-dwellers, receive special consideration.
- **Sensitivity to site-related chemicals** – Species with known sensitivities to particular chemicals (e.g., piscivorous birds sensitive to DDT, mink sensitive to PCBs) receive special consideration in the selection of receptors.

Ecological receptors may be directly exposed to chemicals through contact (e.g., direct contact to sediment and/or surface water), through ingestion of chemicals in water or sediments, or indirectly through the ingestion of contaminated food items. For an exposure pathway to be complete, a chemical must be able to travel from the source to receptors that utilize or inhabit the site and be taken up by the receptors via one or more exposure routes.

The representative receptors that may be exposed to chemical constituents in sediment, surface water, and/or tissue from the NBSA are listed below. Most of these organisms are subject to being exposed to multiple habitats and areas within the NBSA. Aside from plants and infaunal benthic invertebrates, most species are not sessile and will actively move in and out of different habitats/geomorphic areas; thus exposing them to a wide range of chemical constituents within Newark Bay sediments and surface water. For instance, blue crabs inhabit the subtidal flats and intertidal areas in the summer but will overwinter deep in the Channels. Species with known locational (i.e., site) fidelity for all or part of their life history were considered in the selection of receptors. Species were also selected based on feeding guild (e.g., benthic-feeders vs. piscivorous) which reflects differences in exposure.

- Aquatic plants
- Invertebrates
  - Benthic invertebrate community (e.g., amphipods [*Ampelisca abdita* and *Leptocheirus plumulosus*], polychaetes [*Neanthes virens*])
  - Crustaceans (e.g., blue crab, shrimp)
  - Mollusks (e.g., eastern oyster, softshell clam, blue mussel, *Macoma* sp.)
  - Plankton (e.g., zooplankton, ichthyoplankton)
- Reptiles (e.g., diamondback terrapin and sea turtles)
- Fish
  - Forage (e.g., mummichog, bay anchovy, alewife, and herring)
  - Benthic (e.g., Atlantic tomcod, winter/summer flounder, and Atlantic sturgeon)
  - Pelagic (e.g., white perch, striped bass, American eel, weakfish, and bluefish)
- Birds
  - Benthic-feeding (e.g., spotted sandpiper)
  - Insectivorous (e.g., tree swallow, marsh wren, and red-winged blackbird)
  - Omnivorous (e.g., lesser scaup)
  - Piscivorous (e.g., double-crested cormorant, osprey, common tern, and belted kingfisher)
- Mammals
  - Insectivorous (e.g., little brown bat)
  - Omnivorous (e.g., raccoon, muskrat)
  - Piscivorous (e.g., river otter, harbor seal, mink)

#### **4.4 Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints**

AEs are defined as “an explicit expression of the environmental value that is to be protected” (USEPA 1997a). Because it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem, AEs focus the risk assessment on particular components of the ecosystem that could be adversely affected by site-related constituents. The AEs were selected based on the June 2011 BHHERA workshop (ARCADIS and ToxStrategies 2011) and are as follows:

- Survival and/or growth of aquatic plants and maintenance of plants as a food resource and habitat for fish and wildlife
- Survival, growth, and/or reproduction of invertebrates
- Survival, growth, and/or reproduction of reptiles
- Survival, growth, and/or reproduction of fish
- Survival, growth, and/or reproduction of birds
- Survival, growth, and/or reproduction of mammals

Following the selection of AEs, testable hypotheses are developed to determine whether or not a potential risk to the AE exists (USEPA 1997a). A testable hypothesis is an operational statement of an investigator’s research assumption made to evaluate logical or empirical consequences (USEPA 1997a, 1998). Similar to the LPRRP, the testable hypotheses for the NBSA are presented as a series of risk questions about the relationship between each of the AEs and the responses of the receptors when exposed to chemicals within Newark Bay.

Hypotheses usually postulate that there is no effect or no difference (among groups or measurements), and data are collected to confirm or refute that hypothesis. This document provides a series of risk questions developed based on the June 2011 BHHERA workshop (ARCADIS and ToxStrategies 2011). Table 4-3 presents an overview of the candidate AEs, testable risk hypotheses (phrased as risk questions), representative receptors, MEs, data use objectives, and biological data to be collected based on discussions at the BHHERA Workshop. Also included in Table 4-3 is a general discussion of the data that may be collected and/or compiled based on existing data, as appropriate, from background reference areas to help address the risk questions and MEs. According to USEPA (2002d), the background reference area is an area where background samples are collected for comparison with samples

collected on site. The reference area should have the same physical, chemical, geological, and biological characteristics as the site being investigated, but has not been affected by activities on the site. A regional background approach and stressor evaluation will be developed for use in the risk characterization of the risk assessments, subject to USEPA approval (USEPA 2002d).

An ME is defined as the “measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint” (USEPA 1997a). Final MEs have been selected based on various discussions and document exchanges among Tierra, USEPA, and the Partner Agencies:

- A conference call among all parties on January 22, 2013
- A meeting between Tierra and USEPA on February 22, 2013
- Meeting Minutes from the February 22, 2013 Meeting
- Responses to USEPA Comments on the Draft Problem Formulation document (February 28, 2013)
- EPA Resolution on Comments and Responses to Comments NBSA Problem Formulation Document (provided in an email from E. Naranjo dated March 22, 2013)
- Email from E. Naranjo dated April 4, 2013 (USEPA 2013)

Table 4-4 presents the final selected AEs, MEs, and data to be collected to support the BERA. It also provides the anticipated timeframe for data collection over the next year. Additional dialogue with USEPA and its Partner Agencies as well as future planning documents (i.e., work plans, field sampling plans, QAPPs) will establish final sampling efforts.

#### 4.4.1 Plants

Assessment Endpoint 1: Survival and/or growth of aquatic plants and maintenance of plants as a food resource and habitat for fish and wildlife.

Plants comprise the base of the food web, serving as food for herbivorous and omnivorous organisms, and create refuge habitat for small, juvenile, and sessile organisms.

Risk Question: *Are COPEC concentrations in surface water and sediments from the NBSA greater than benchmarks for the survival and/or growth of aquatic plants?*

The risk question for plants will be addressed by comparing concentrations of COPECs in surface water (including associated physical parameters) and surficial sediment from intertidal areas to available and relevant toxicological benchmarks. The data use objective for this ME is to estimate the exposure of plants via direct contact and uptake of chemicals in surface water and sediment.

#### 4.4.2 Invertebrates

Assessment Endpoint 2: Survival, growth, and/or reproduction of invertebrates.

Invertebrates form the base of the food web for fish and other upper-trophic level organisms. There are a variety of taxonomic feeding guilds for aquatic and benthic invertebrates including filter-feeders, deposit-feeders, detritivores, and omnivores. Each taxonomic feeding guild has a unique exposure potential to constituents in NBSA media which will be evaluated in the BERA.

Risk Question: *Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?*

This question will be addressed by comparing community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) from Newark Bay to appropriate reference populations using diversity indices, multivariate, and spatial statistical techniques. The data (chemicals and conventional parameters, such as grain size) and results of the benthic community analysis will be used to develop benthic community metrics to be used as an additional line of evidence. This line of evidence will be part of the sediment quality triad approach, which is a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics. Additional information will be collected on ecosystem characteristics, such as grain size, TOC, and other attributes, to assist in the evaluation of the data in the context of the overall health of the benthic community. The details of the approach for the sediment quality triad and risk characterization using the benthic community data will be presented in the upcoming field sampling plans/work plans.

Risk Question: *Are COPEC residues in invertebrate tissues from the NBSA greater than tissue benchmarks (e.g., critical body residues [CBRs]) for the survival, growth, and/or reproduction of invertebrates?*

This question will be addressed by comparing chemical concentrations in laboratory-exposed and/or site-collected invertebrate tissues to literature-based CBR values. The data use objective for this ME is to assess the adverse effects of chemicals on the invertebrate community. Field-collected tissue data from clams (e.g., *Mya arenaria* or *Macoma* sp.), and/or blue crabs from the NBSA will be analyzed and compared to literature-based CBRs. If sufficient tissue cannot be collected for analysis, a caged bivalve study will be conducted to evaluate COPEC residues in bivalves. In addition, a polychaete worm (e.g., *Nereis virens*) and/or the eastern oyster (*Crassostrea virginica*) may be used to conduct the laboratory and/or field bioaccumulation tests. Whole-body benthic infaunal invertebrate tissue from the tests will be chemically analyzed and then compared to literature-based CBRs.

Risk Question: *Are the COPEC concentrations in sediments from the BAZ greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?*

Chemical concentrations in sediment will be compared to toxicological sediment benchmarks from the literature. The data use objective for this ME is to evaluate the effects of chemical concentrations in sediment on the benthic invertebrate community of the NBSA. Surficial sediment will be collected from the BAZ, which is estimated to be the top 6 inches, and chemically analyzed.

Risk Question: *Is the survival, growth, and/or reproduction of invertebrates exposed to sediments from the BAZ of the NBSA significantly lower than that in reference sediments?*

Laboratory toxicity tests using NBSA surface sediment will be conducted. Proposed tests include a 10-day survival and growth study with *Ampelisca abdita*, a subset of stations are proposed for a 28-day study with *Leptocheirus plumulosus* for survival, growth, and reproduction; and a caged *in-situ* study with eastern oyster for reproduction. The data use objective for this ME is to assess the adverse effects of chemicals (and evaluation of conventional parameters, such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community.

Surface sediment for the bioassays will be collected throughout the NBSA from the BAZ, which is estimated to be the top 6 inches. The results of the bioassays will be statistically compared to bioassays conducted with control sediment for quality assurance/quality control purposes.

The results will also be evaluated using existing regional background comparisons to support risk management decisions, subject to USEPA approval. Amphipods

are considered to be a sensitive biological organism for representing potential risk to the benthic community. Caged bivalve study results will be compared to results obtained at relatively un-impacted reference stations, if practicable.

Risk Question: *Are COPEC concentrations in porewater and surface water from the NBSA greater than toxicological benchmarks for the survival, growth, and/or reproduction of invertebrates?*

This question will be addressed by comparing dissolved chemical concentrations in pore and surface water collected from benthic invertebrate exposure areas to toxicological benchmarks. The data use objective for this ME is to estimate the exposure of the benthic invertebrate community to dissolved COPECs in surface water and in sediment porewater. Surface water will be collected from two depth intervals (one sample from near the sediment-water interface and one sample from 2 ft below the water's surface). This will provide a range of concentrations for different habitats/exposure areas. The water column sample will be representative of pelagic habitat and the sample closer to the sediment-water interface will be representative of epi-benthic habitat.

#### 4.4.3 Reptiles

Assessment Endpoint 3: Survival, growth, and/or reproduction of reptiles.

Risk Question: *Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival, growth, and/or reproduction of reptiles?*

This question will primarily be addressed qualitatively by discussing the possibility of reptiles inhabiting the NBSA. Information pertaining to any reptiles noted during reconnaissance surveys and/or field work will be recorded. In addition, concentrations of COPECs in surface water and surficial sediment from subtidal and intertidal areas will be compared to available, relevant toxicity-based benchmarks. The data use objective for this ME is to estimate the exposure of reptiles via direct contact and uptake of chemicals in surface water and sediment.

#### 4.4.4 Fish

Assessment Endpoint 4: Survival, growth, and/or reproduction of fish.

Fish in the NBSA serve the middle portions of the food web. They consume invertebrates and other lower-trophic level organisms but, in turn, are fed upon by upper-trophic level birds and mammals. Similar to invertebrates, there are

various taxonomic feeding guilds for fish including benthic-feeding (i.e., benthivores), omnivorous forage fish, and pelagic predatory fish. Each feeding guild has a unique exposure potential to constituents in NBSA media which will be evaluated in the BERA.

Risk Question: *Are COPEC concentrations in fish tissues from the NBSA greater than critical body residue values (i.e., CBRs) for the survival, growth, and/or reproduction of fish?*

Identified fish receptors will be collected throughout the NBSA for whole-body chemical analyses. These data will be compared to literature-based CBRs and/or to whole-body fish tissue chemical concentrations of selected receptors from background reference locations. Specific species of fish will be targeted so that representative species from each of three trophic levels are captured: forage fish, benthic/demersal, and pelagic predatory. Additional physical and biological information will be collected (details to be provided in the upcoming field sampling plans, work plans, and QAPPs) to assist in the interpretation of results in terms of fish population health and include, but are not limited to the following: COPEC concentrations in the tissues (whole body, liver, bile) of fish from the NBSA and reference areas, and associated variables (e.g., percent lipids, fish species, length, weight, age, sex). Species with relatively small home ranges will be targeted. Tissue samples for the BERA should be at sizes relevant to predator preferences and should be whole body composites (e.g., 10 to 20 fish ranging in size from 5 to 20 cm long). Chemical concentrations in a subset of liver and gut tissues will also be collected and compared to relevant CBRs.

External health observations (gross histological analysis) will be made on all fish to provide information on fish population health. The qualitative fish health observation data (e.g., gross histology) will be used to provide general information about the health of NBSA fish populations. Internal histopathology (e.g., of existing tumors, liver, and gonad tissues) of a subset (e.g., 5 to 10 select fish) will also be conducted.

Risk Question: *Are COPEC concentrations in porewater, surface water, and sediment from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of fish?*

Chemical concentrations in dissolved pore water and surface water collected from the NBSA will be compared to toxicological benchmarks. The data use objective for this ME is to estimate the exposure of fish via the surface water exposure pathway to chemicals in surface water. Surface water data, including chemical and physical parameters, such as DO, salinity, pH, and hardness, will be used to

address this risk question. Chemical concentrations in sediment will be compared to toxicological sediment benchmarks from the literature. The data use objective for this ME is to evaluate the effects of chemical concentrations in sediment on fish populations in the NBSA. Surface sediment will be collected from the BAZ, which is estimated to be the top 6 inches, chemically analyzed, and compared to appropriate benchmarks.

To evaluate the potential effects of chemical constituents on reproduction of NBSA fish, a study may be conducted to assess the reproduction of fish species common in the NBSA, such as white perch or mummichog, similar to studies conducted by Cooper and Buchanan (2007). Fish would be collected from both the NBSA and a reference location. Reproductive health will be assessed on individual fish collected via morphology and/or biomarkers (e.g., gonado-somatic index, gonad condition and fecundity estimates, and vitellogenin) (Cooper and Buchanan 2007; Hsiao et al. 1994). Laboratory reproductive bioassays may also be conducted on the mummichog using sediment and/or water collected from various locations in the NBSA, as well as a reference area. Methods for a short-term reproductive bioassay with mummichog have been presented by Peters et al. (2007). In addition, an *in-situ* caged reproduction study may be considered. This would consist of enclosing fish from an appropriate background/reference location in cages in Newark Bay. This may be considered as an additional line of evidence if the primary lines of evidence are insufficient.

Assessing reproductive health of fish species in a large area can be difficult as effects seen in an individual fish may not always correspond to population-level effects. Some species have also been shown to develop adaptive resistance to environmental contamination over time (Cooper and Buchanan 2007; Nacci et al. 1999). It is recommended to use multiple lines of evidence (e.g., community studies, reproductive health of individuals, and bioassays) to estimate overall reproductive health in fish populations in the NBSA. To this effect, ichthyoplankton sampling will also be conducted during the fish trawls to aid in the evaluation of the reproductive health of the fish community and to supplement the existing ichthyoplankton community data.

#### 4.4.5 Birds

Assessment Endpoint 5: Survival, growth, and/or reproduction of birds.

Birds comprise part of the upper trophic levels of the food web. There are four major feeding guilds of birds that will be evaluated in the BERA: benthivores (consume benthic invertebrates), insectivores (consume flying insects), omnivores (consume plant and animal matter), and piscivores (consume fish).

Each feeding guild has a unique exposure potential to constituents in NBSA media which will be evaluated in the BERA.

Risk Question: Does the daily dose of COPECs received by birds (including piscivorous, benthivorous/sediment probing, omnivorous, and insectivorous) from consumption of tissues of prey species and other media in the NBSA exceed the toxicity reference values (TRVs) for survival, growth, and/or reproduction of birds? If yes, what are the probabilities of effects of differing magnitude for survival, growth and/or reproduction of birds?

This ME will be evaluated by comparing receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary dose TRVs. The data use objective for this ME is to estimate exposure of bird receptors via various exposure pathways to chemicals in surface water, sediment, and prey tissue. Four different feeding guilds will be evaluated: piscivorous, benthivorous/sediment-probing, omnivorous, and insectivorous. Surface sediment chemical data (from the BAZ), surface water chemical data (whole water concentrations), and benthic invertebrate and/or fish prey tissue chemical data, depending on receptor-specific diet, will be used to develop the dietary model for each bird receptor. Exposure data used in this ME will be used in the development of a food web model. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainty in the food web modeling.

Risks to birds may also be assessed by evaluating field-collected tissue residues of birds (specifically egg tissue) that will be compared to literature-based CBRs for avian eggs. Egg tissue could be collected from the islands within the NBSA (e.g., Shooters Island, Pralls Island) that have historically provided adequate nesting habitat. Final selection of species and specific nesting locations will be determined prior to egg collection during a nest survey. Double-crested cormorant eggs would be the primary target because of their piscivorous diet and their abundance. Caveats to egg tissue collection and analysis include the limited available toxicity thresholds and permitting limitations associated with collecting the eggs. Any egg tissue sampling would likely be an opportunistic event and the targeted number of samples would be dependent upon species, number of nests available, permit requirements, and sample design.

#### 4.4.6 Mammals

Assessment Endpoint 6: Survival, growth, and/or reproduction of mammals.

Mammals comprise another portion of the upper trophic levels of the food web. There are four major feeding guilds of mammals that will be evaluated in the BERA: insectivores (consume flying insects), omnivores (consume plant and animal matter), and piscivores (consume fish). Each feeding guild has a unique exposure potential to constituents in NBSA media which will be evaluated in the BERA.

Risk Question: Does the daily dose of COPECs received by mammals (including omnivorous, piscivorous, and insectivorous mammals) from consumption of the tissues of prey species and from other media at the NBSA exceed the TRVs for survival, growth, and/or reproduction of mammals? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of mammals?

This ME will be evaluated by comparing receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary dose TRVs. The data use objective for this ME is to estimate exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue. Three different feeding guilds will be evaluated: omnivorous, piscivorous, and insectivorous. Surface sediment chemical data (from the BAZ), surface water chemical data (whole water concentrations), and benthic invertebrate and/or fish prey tissue chemical data, depending on receptor-specific diet, will be used to develop the dietary model for each mammal receptor. Exposure data used in this ME will be used in the development of a food web model. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainty in the food web modeling.

#### 4.5 Ecological Risk Assessment Data Needs

Sampling/data needs for the BERA are identified in Table 4-4, as well as with their associated data use objective and include the following general needs:

- Co-located surficial sediment chemistry data collected from the top 6 inches (possibly to 12 inches in areas that are likely to experience surface sediment erosion) and porewater analytical data from throughout Newark Bay, including the Intertidal Areas, Subtidal Flats, and Channels
- Surface water analytical data from two distinct depths, one close to the sediment-water interface and one from 2 ft below the water's surface
- Toxicity data (i.e., from laboratory and *in situ* studies)

- Benthic invertebrate community structure data
- Forage fish, benthic fish, and pelagic predatory fish tissue data (including gut contents and bile analysis)
- Ichthyoplankton community data
- Whole body invertebrate chemistry data (e.g., blue crab and softshell clam)
- Blue crab hepatopancreas chemistry data
- Bird (egg) tissue chemistry data
- Mammal population survey
- Regional background reference locations will need to be established for sediment and fish tissue collection

## 5. Baseline Human Health Risk Assessment

This section discusses the BHHRA framework for the NBSA. The human health CSM includes potential exposure scenarios, populations exposed, and potential exposure pathways. In addition, exposure factors are discussed, and a preliminary summary of environmental data needs for the BHHRA is provided. As discussed in Section 1, although the problem formulation step is formally part of USEPA's Eight-Step ERA process (USEPA 1997a), and as such, is not typically addressed as part of the HHRA, it is included in the BHHRA portion of this document to provide a roadmap for implementing the fieldwork to support the BHHRA for the NBSA.

### 5.1 Human Health Conceptual Site Model

An interim human health CSM has been developed and is presented in the *Interim Conceptual Site Model* (Tierra 2011). Based on the review of additional data and reports (i.e., the data and information summarized in this document) and decisions from the BHHRA Workshop (ARCADIS and ToxStrategies 2011), the current human health CSM has been revised and updated and is depicted on Figure 5-1. As more information is collected throughout the RI/FS process, the CSM will be further refined as appropriate. For example, soil may be added as a secondary source as more information about historical floodplains is acquired.

As shown in Figure 5-1, primary sources of contamination include industrial point sources, non-point source runoff, sanitary sewer overflows, CSOs, tributaries, and atmospheric deposition. Secondary contamination sources include sediment and surface water. Potential exposure routes resulting from sediment and surface water include ingestion of fish and shellfish, ingestion of waterfowl, dermal contact, incidental ingestion and inhalation (via ambient air). The following pathways will be quantitatively evaluated for the recreational user: dermal contact, incidental ingestion, and inhalation from sediment and surface water. For the angler/sportsman, waterfowl ingestion will be qualitatively evaluated; the remaining pathways will be quantitatively evaluated (fish and shellfish ingestion, dermal contact, incidental ingestion, and inhalation from sediment and surface water). The applicable residential exposure pathways (fish and shellfish ingestion, dermal contact, incidental ingestion, and inhalation from sediment and surface water) will be further considered after additional reconnaissance determines whether a standard residential scenario is applicable for the NBSA. All applicable exposure pathways will be qualitatively evaluated for the transient (fish and shellfish ingestion, dermal contact, incidental ingestion, and inhalation from sediment and surface water). For the port/dock worker, the following pathways will be

quantitatively evaluated: dermal contact, incidental ingestion, and inhalation from sediment and surface water. The need to evaluate a diver for this scenario is currently under review. Additional detail regarding the CSM, associated sources and migration pathways will be documented in the 2013 revision to the *Interim Conceptual Site Model* (Tierra 2011).

## 5.2 Human Exposure Scenarios – Current and Future Land Use

As discussed above in Section 3.1.2.2, future land use is not expected to differ significantly from current use; as such, the BHHRA will apply a “combined current and future land use” scenario. It is important to note, however, that the concentrations of COPCs in NBSA environmental media are expected to decrease over time. This will need to be accounted for in the Feasibility Study and will be discussed in the revised CSM.

Additionally, USEPA’s comments on the Interim Conceptual Site Model (USEPA 2011b) regarding NBSA future use state the following:

*It is our goal to restore full use of the NBSA as a valuable natural resource for native species and to restore full recreational and commercial use. This would involve improvements in surface water and sediment quality to reduce or remove current fishing and crabbing bans and allow safe wading and swimming. Therefore, future use should be characterized as higher frequency and duration of use.*

Meeting Minutes from the June 2011 BHHRA Workshop (ARCADIS and ToxStrategies 2011) state that future land use will be documented and considered consistent with USEPA’s land use and land reuse guidance (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.7-19) entitled *Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites* (USEPA 2010c), which says:

*Information on surrounding land use may suggest how the site could reasonably be used in the future. Sources and types of information that may aid EPA in determining the reasonably anticipated future land use include: current land use; zoning maps; comprehensive community master plans; accessibility of site to existing infrastructure; recent development patterns; cultural factors; and environmental justice issues. (OSWER Directive No. 9355.7-04, p.5). Discussions with the public, local land use authorities and other appropriate officials should be*

*conducted. "By developing realistic assumptions based on information gathered from these sources early in the RI/FS process, EPA may develop remedial alternatives that are consistent with the anticipated future use" (OSWER Directive No. 9355.7-04, pp. 4-5).*

### 5.3 Human Health Exposure Factors

Where appropriate, exposure factors used for the LPRRP HHRA will be used for the NBSA BHHRA. Where alternative values are proposed for the NBSA, these values will be fully documented. Exposure parameters will rely on site-specific data to the extent feasible, USEPA guidance documents, including the Exposure Factors Handbook (USEPA 2011a), and information in published literature. Exposure factors will be documented and discussed in the PAR; the factors will be presented in USEPA RAGS Part D format.

### 5.4 Potentially Exposed Human Populations

Human use of the NBSA includes commercial (e.g., shipping, commerce, industrial, and municipal infrastructure and use) and recreational (e.g., fishing, boating, swimming, and shoreline use) activities. Characterization of these activities is discussed in this section.

Based on currently available information, a residential scenario will not be evaluated because no properties or shoreline land segments were identified that would be characteristic of a standard residential exposure scenario. While residential properties do border the NBSA, significant obstructions or land-water elevation differences significantly limit human access. These characteristics, as a practical matter, exclude the typical residential exposure scenario for direct contact with NBSA surface water and sediment. As further discussed in Appendix B, to determine that a standard residential scenario was not applicable to the NBSA, Google Earth (imagery date: June 17, 2010) was previously used to determine whether the shoreline and sediments could be easily accessed. Ground-truthing of the Google Earth images, by taking additional photos and documenting the shoreline type, will be conducted during sediment and/or biota sampling. These assessments and findings will be included in later documents.

In addition to ground-truthing the Google Earth images for assessing potential residential land use, a reconnaissance survey will be performed to identify potentially accessible areas for the BHHRA (Section 6). This will also be conducted during

sediment and/or biota sampling activities. Current and future land use scenarios for consideration in the BHHRA will be revisited pending the outcome of these evaluations. Although the currently available information indicates a residential scenario is not applicable, local residents, including those whose properties border the NBSA will be evaluated using the parameters that are applied for the recreational user exposure scenario. The potentially exposed populations and associated site-specific exposure scenarios that will be evaluated are described further below.

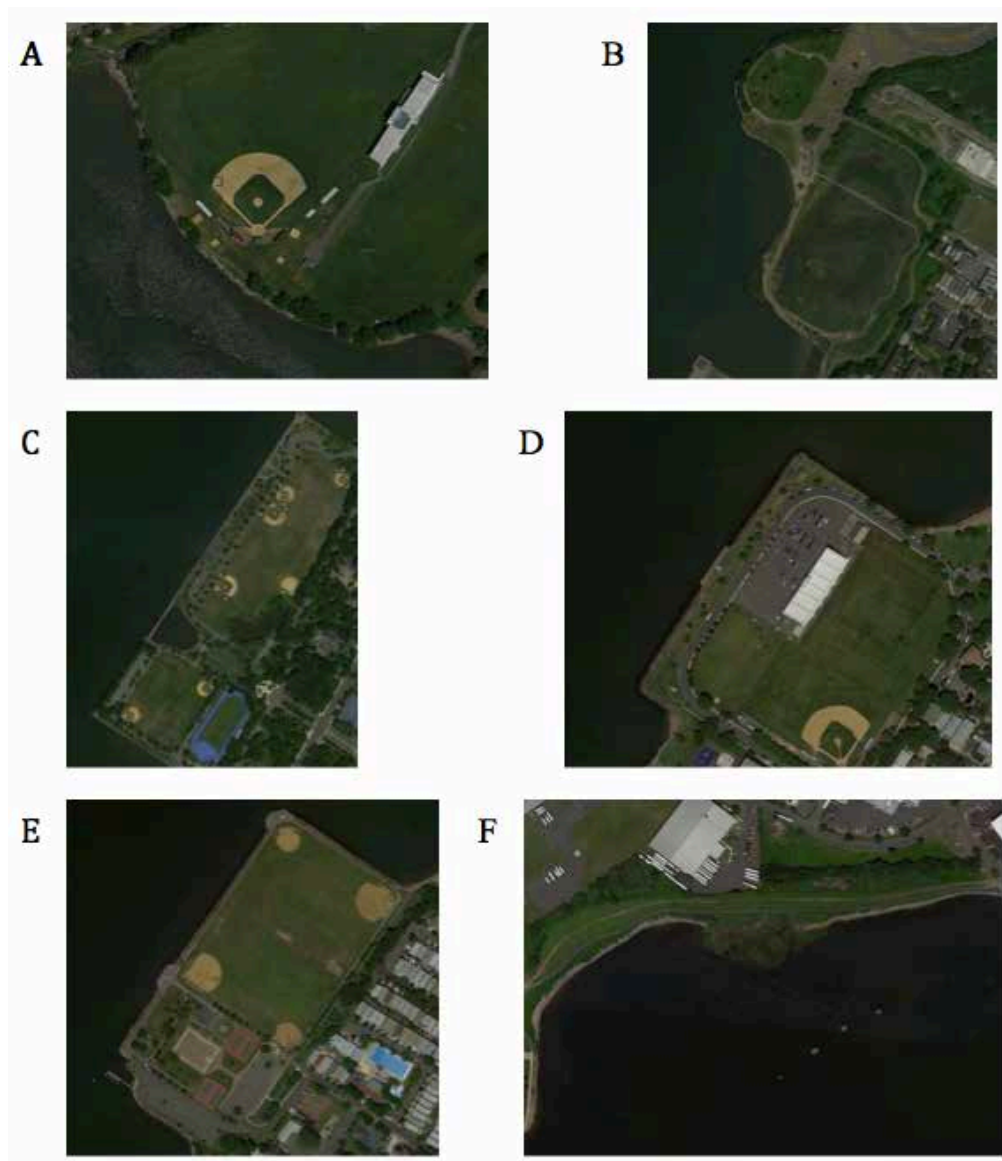
#### 5.4.1 Recreational Users

Five recreational areas exist along the eastern shore and one park area borders the western NBSA in the southern portion of the site. Although these parks are along the shore, they primarily offer land-based recreational opportunities, such as baseball diamonds, swing sets, and walking paths (City of Bayonne 2000, 2003) with limited opportunities for direct contact with sediments (Exhibit 5-1). Five recreational areas were identified in the Hackensack River south of Route 7. The Passaic River Yacht Club offers boating. Similar to recreational areas along the NBSA, the other four recreational areas primarily provide land-based recreational opportunities, including baseball diamonds, walking paths, swimming pools and tennis courts (Exhibit 5-2).

A desktop evaluation of potential recreational use of the NBSA was conducted by contacting numerous city and county parks and recreation departments, boating companies, and government agencies to characterize recreational activities, such as boating, sail boating, jet skiing, canoeing, and kayaking activities. Appendix D provides a list of entities contacted. The information collected from these entities indicates that there are occasional recreational activities that occur in the NBSA. For example, recreational boats travel through the NBSA to get to other areas (e.g., Raritan Bay and the Atlantic Ocean). Information also indicates that fishing is much more common in the NBSA than any other recreational activity. Separate from this assessment, a City of Bayonne document indicates that recreational boating in the NBSA appears to be limited due to commercial traffic and industry (City of Bayonne 2000). Marinas and boat ramps in the NBSA were identified using Google Earth imagery of the shoreline and internet searches (Appendix B). The National Park Service is developing a canoe and kayak trail in the Passaic River that will continue into northern Newark Bay, concluding on Kearny Point with a boat ramp and possible picnic area.

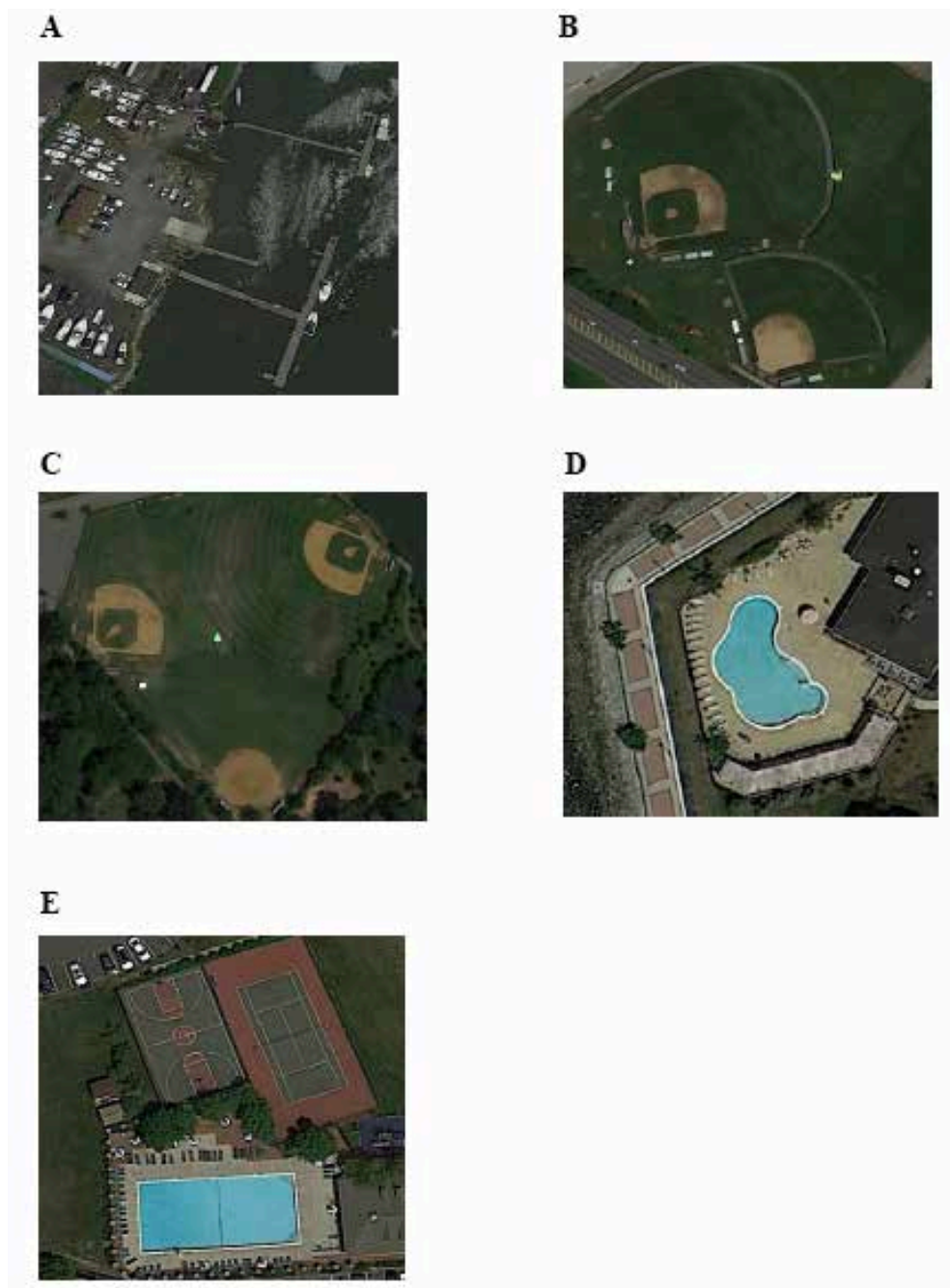
**Newark Bay Study  
Area Problem  
Formulation**

Baseline Human Health and  
Ecological Risk Assessment



**Exhibit 5-1 NBSA Recreational Areas**

A) Thomas M. Gerrity Athletic Complex, B) Rutkowski Park, C) Bayonne Park,  
D) Veterans Park, E) 16<sup>th</sup> Street Park, F) Arthur Kill Park



**Exhibit 5-2 Hackensack River Recreational Areas**

A) Passaic River Yacht Club, B) Joseph J. Jaroschak Field, C) Lincoln Park, D) Society Hill at Droyers Point, E) Society Hill in Jersey City

The possibility of a hunting scenario was also evaluated for the NBSA. Existing hunting regulations were reviewed, and the New Jersey Division of Fish and Wildlife, Bureau of Law Enforcement and the New Jersey State Police were contacted. Research confirmed that hunting is permitted in the NBSA, and there are no Federal Aviation Administration regulations that prevent shooting in the vicinity of Newark Liberty International Airport. State laws govern hunting in the area, including hunting for waterfowl. New Jersey Division of Fish and Wildlife, Bureau of Law Enforcement indicated that they have not observed anyone hunting in the NBSA. Waterfowl hunting is popular in the Hackensack River, and to a lesser extent, in the Passaic River. These data collectively indicate that hunting in the area is not likely to occur, and hunters do not frequent the area. Since hunting is legal in the NBSA, waterfowl hunting will be qualitatively evaluated for the angler/sportsman scenario.

As previously discussed, there are indications that people actively fish and/or crab along several locations of the NBSA shoreline.

#### 5.4.2 Port/Dock Workers

There are several bridges and other structures located in the NBSA. For instance, the piers/foundations that support the Bayonne and Goethals Bridges are located close to or within the water. As such, port/dock workers and commercial divers perform bridge, construction, and repair work in various areas of the NBSA. A number of commercial diving companies, including the U.S. Coast Guard and other entities, were contacted to develop information to characterize potential exposures to industrial workers (Appendix D). Based on the information received to date, commercial divers work on a project-specific basis, with no limit on the number of consecutive days they may dive. Some work 8- to 10-hour days and over 200 days per year. Additional information regarding commercial diving in the area is being collected and will be presented in future documents.

#### 5.4.3 Transient Users

In order to characterize a potential transient population living along the perimeter of the NBSA, a desktop review was conducted using various internet websites, peer-reviewed literature, publicly available documents describing transient activity in the area, and newspaper archives for the cities and counties surrounding the NBSA. Peer-reviewed literature on the transient population of the NBSA was limited to papers and abstracts that characterized the populations along the Lower Passaic River (e.g., Donovan et al. 2008, Proctor et al. 2002) and not the shoreline of the NBSA.

Publicly available documents describing long-term plans to address transient individuals and other community involvement plans were reviewed for details or characterizations of potential transient populations associated with the NBSA. These documents included the following:

- The Hudson County 2010-2014 Five Year Consolidated Plan (Hudson County 2010)
- The Road Home: A Ten Year Plan to End Homelessness in Newark and Essex County (2010-2020) (Essex-Newark Task Force to End Homelessness 2010)
- Lower Passaic River Restoration Project and Newark Bay Study – Community Involvement Plan (Malcolm Pirnie, Inc. 2006)

Malcolm Pirnie, Inc. (2006) indicates that homeless populations are living in several places along the Passaic River and around Newark Bay, but does not identify any specific locations along the actual perimeter of Newark Bay. The report notes that areas where transient populations congregate include “Container City” near Port Newark, an area near Minish Park in Newark, and wooded areas near the Dundee Island in the northern portion of the LPRRP area. The other two documents provide city and county homeless population statistics, but no quantitative or qualitative assessments of individuals along the NBSA.

General internet searches for blogs, community websites, and other information on the transient population in the area did not produce any results.

A search of newspaper archives going back to January 2004 yielded two results related to transient individuals in the NBSA. *The Jersey Journal* reported on March 19, 2012, that a man, presumed to be transient, had been found deceased on the shore of Newark Bay in Bayonne (Conte 2012). The article does not describe any other known transient activity in the area and treats the death as an isolated incident. On September 7, 2010, *The Jersey Journal* reported the homicide of a man on a cove near the Tidelands Athletics Complex (Conte 2010). According to the article, investigators determined that the man had been staying with relatives but had been camping on the shore for a couple of days before the murder. Only a single tent was identified on the shore, and the article did not include any additional details about transient persons frequenting that area.

In summary, internet searches, peer-reviewed literature, public studies, and long-term community plans do not describe transient populations living along the NBSA itself. Newspaper archives provide only two individual instances of transient persons along the banks of the NBSA. Therefore, while there are occasional descriptions of transient individuals in the area, the information sources reviewed do not indicate that a significant transient population inhabits the NBSA shoreline. Given the lack of information, the transient population will be evaluated qualitatively in the BHHRA.

### 5.5 Human Health Exposure Pathways

Based on the human use activities discussed above, it is likely that the current and future human users (i.e., the potentially exposed populations) of the NBSA include anglers/sportsmen, port/dock workers, recreational users, and potential transients (Figure 5-1). The human use activity data also indicate that the media of interest relevant to evaluating potential human health exposures for the NBSA include the following:

- Surface water
- Sediment
- Fish tissue
- Shellfish tissue
- Ambient air

Human exposure pathways were identified based on consideration of the source, release, type, and location of chemicals at the site; the likely environmental fate (including persistence, partitioning, transport, and intermedia transfer) of these chemicals; and the location and activities of the potentially exposed populations. Exposure points (points of potential contact with chemicals) and routes of exposure (e.g., ingestion and inhalation) were identified for each exposure pathway consistent with USEPA guidance (USEPA 1989). The most significant pathway by which people may be exposed to chemical constituents in the NBSA is expected to be from consuming fish and/or shellfish (USEPA 2000c, 2005d). These populations may also be exposed to chemicals through direct contact with sediment and/or surface water during recreational activities, such as fishing, boating, or wading. They may also incidentally ingest chemical constituents from sediment and/or surface water during

these activities. Impacts to sediments will be evaluated for fish and shellfish ingestion, dermal contact, incidental ingestion, and inhalation exposures (Figure 5-1).

Each of the above-listed routes of exposures will be evaluated quantitatively using algorithms presented in USEPA guidance (e.g., USEPA 1989, 1991a, 1991b, 2001a, 2007a, 2009a). All pathways of exposure to a transient population that potentially resides or spends considerable time along the shore will be assessed qualitatively.

- Inhalation of chemicals that may volatilize from the exposed sediment or surface water and pose a threat to humans
- Exposures to a transient population that potentially reside or spend considerable time along the shore

#### 5.5.1 Angler/Sportsman

The angler/sportsman exposure scenario considers adults, adolescents, and children catching and consuming a variety of fish (e.g., striped bass, bluefish, and flounder) and shellfish (e.g., blue crab and softshell clams) from the banks of the NBSA and from a boat on the NBSA. The angler/sportsman scenario for the NBSA includes both a reasonable maximum exposure angler/sportsman scenario and a central tendency exposure angler/sportsman scenario. As previously discussed, the collection and consumption of fish and shellfish (e.g., blue crab, softshell clams) from the NBSA has been documented or is expected, and thus, this exposure pathway is considered to be complete. Other potential exposure pathways relevant to the angler/sportsman include direct exposure (i.e., dermal contact and incidental ingestion) of sediment and surface water contacted during these activities. Inhalation of airborne chemicals may also occur if activities occur in intertidal areas, and if VOCs are present in sediments or surface waters. The sediment exposure scenario of an angler/sportsman catching fish from the shoreline will be quantitatively evaluated. The sediment exposure scenario of a person fishing from a boat, who is unlikely to be exposed to sediments, will be described qualitatively. Decreased concentrations of some COPCs in fish/shellfish through cooking loss will be considered and will be discussed in the PAR.

Since hunting is legal in the NBSA, waterfowl hunting will be qualitatively evaluated for the angler/sportsman scenario. Considerations for the decision to evaluate waterfowl on a qualitative instead of quantitative basis include the lack of observed hunting in the area and the type of food waterfowl consume (grass, not fish), which results in lower tissue concentrations. New Jersey state and federal migratory bird regulations discuss

hunting restrictions, permits, and bag limits. Relevant information from these documents, as well as ingestion rates based on bag limits and hunting seasons, will be discussed qualitatively in the BHHRA.

#### 5.5.2 Recreational Users – Boaters, Swimmers, and Waders

In the BHHRA, three primary recreational uses associated with the NBSA will be quantitatively evaluated: boating, wading, and swimming. For these scenarios, exposure is primarily via direct contact (i.e., ingestion and dermal contact) with sediment and surface water. Inhalation exposure to VOCs may also occur if activities occur in intertidal areas or near surface water and/or sediments. Ingestion of fish will not be included as a potential exposure pathway for this scenario. Child, adolescent, and adult recreational exposure age categories will be evaluated for each of these recreational scenarios.

#### 5.5.3 Port/Dock Worker – Including Commercial Diver

Port/dock workers have been identified as potentially exposed populations for activities involving repair of piers and pilings or surveying for subsurface (i.e., underwater) construction projects. These workers could potentially be exposed to sediment and surface waters of the NBSA via ingestion, inhalation, and dermal contact. These workers are governed by Occupational Safety and Health Administration (OSHA) in general and, for divers, the OSHA commercial diving regulations (29 Code of Federal Regulations Part 1910, Subpart T – Commercial Diving Operations). However, a review of applicable OSHA documents did not yield information useful for risk assessment purposes. Additional research regarding exposure to port/dock workers during diving activities will be conducted and discussed in a future document.

#### 5.5.4 Transient

Although transients have been observed in temporary makeshift shelters near the Passaic River (Proctor et al. 2002), it does not appear that transient populations use the NBSA shore in a similar manner. Access to the shore in the industrialized areas of the port is restricted. Other areas, where recreational users have access to the shore, do not appear to support a transient population living along the shore. In addition, the industrialized shoreline of the NBSA limits potential areas for shelter, compared to the Passaic River. Thus, the potential for exposures to transient populations will be evaluated qualitatively, and publically available information will be used to characterize any such population.

## 5.6 Preliminary Human Health Risk Assessment Data Needs

Currently identified data needs for the HHRA are listed below. As various assessments are ongoing, which may influence the types of data available, the list may be revised over time.

### 5.6.1 Land Use, Zoning, Future Development Plans, and Hunting

As described above, research regarding current and future zoning, the potential for future development and use of the NBSA for hunting is considered complete. Land-use data indicate that future land use and zoning will not be significantly different from current land use and zoning. Any new residential developments will not likely provide significant access to the NBSA or warrant the need for a residential exposure scenario in any area. Based on this research, exposure by hunting will be qualitatively discussed but not included in the quantitative risk assessment. Additional research regarding access in non-industrial areas will be conducted as part of initial sampling efforts and discussed in future documents.

### 5.6.2 Environmental Media

Environmental media that need to be collected from the NBSA for the HHRA are: 1) fish and shellfish biological tissue data, and 2) sediment and surface water data from accessible areas. Each is discussed in detail below.

#### 5.6.2.1 *Fish and Shellfish Biological Tissue Data*

Additional measurements of chemical concentrations in fish and shellfish from the NBSA are needed to better characterize the exposures from ingestion from fishing and crabbing. For some species of fish and for some types of chemicals, the data are limited or non-existent. For example, no tissue data are currently available for PCNs or PBDEs, and no data are available for dioxin-like congener PCBs in fish (NJDEP dataset only includes data for these contaminants in crabs). For several chemicals, including dioxins and furans, the data are limited to one white perch fillet, two American eel, and seven striped bass fillet samples. Therefore, future sampling efforts, particularly for fish tissue in the NBSA, representative of multiple edible species and analyzing for all COPCs, including but not limited to, PCNs, PDBEs, dioxins/furans, and dioxin-like PCBs, are necessary. The data needs for specific fish/crab tissue types (e.g., fish fillets, crab muscle/hepatopancreas) and a list of target species will be provided in the sampling work plan.

#### 5.6.2.2 *Sediment Concentrations in Accessible Areas*

In areas where the public may access NBSA sediment, samples of shoreline sediments will be collected to characterize COPC concentrations. Specific sediment sampling areas will be discussed in the sampling work plan after identification during a reconnaissance survey. All areas of accessible sediment will be considered, including areas beyond CSOs and stormwater outfalls.

#### 5.6.2.3 *Surface Water Concentrations in Accessible Areas*

In areas where the public may access NBSA surface water, additional surface water samples will be collected to characterize COPC concentrations in these areas. In addition, COPC concentrations will be evaluated in surface water, sediment, and biological tissue collected from regional “background” locations. However, at this time, an appropriate “background” location has not been identified.

#### 5.6.3 Exposure Factors

Several exposure factors could potentially be refined upon additional data gathering, including exposure frequency, exposure duration, exposure time, and skin surface area for port/dock workers. While some site-specific information has been collected regarding current port/dock workers (specifically commercial divers) and current recreational exposures, additional information may be collected from more commercial diving, recreational boating companies, and government entities. For example, for estimating current exposures for the port/dock worker and the recreational user, additional data to estimate exposure frequency and duration would help delineate these scenarios more accurately. Additional information regarding commercial diving in the area is being collected and will be presented in future documents to assist in evaluating whether a diver will be assessed quantitatively or qualitatively. Lastly, for further assessing potential residential land use and exposures (e.g., exposure frequency), ground-truthing of Google Earth images and a reconnaissance survey will be performed to identify potentially accessible areas.

## 6. Next Steps

This document presents Step 3 of the eight-step ERA process (Problem Formulation), which includes a CSM with identified exposure pathways and receptors, AEs, as well as the pertinent risk questions to be answered via data collection and analysis. Next, Step 4 will include the development of work plans, field sampling plans, and QAPPs, followed by data collection (Step 5), analysis (Step 6), risk characterization (Step 7), and risk-based decision making (Step 8).

The following work plans are examples of those anticipated to be developed during the next step of the process. However, it should be noted that these are preliminary examples, pending the outcome of the secondary data evaluation:

- **Field Survey/Reconnaissance Work Plan** will discuss how to physically document and characterize the possible ecological habitats in the NBSA, including the shoreline and intertidal areas. In addition, the reconnaissance survey will identify potentially accessible areas for the BHHRA. During this reconnaissance, mammal and bird nest surveys will also be performed.
- **Surface Water, Porewater, and Sediment Sampling and Analysis Plan (SAP)/QAPP** will describe, in detail, the proposed stations and methodology for collecting and analyzing surface water, porewater, and surficial sediment in the NBSA. Information will be provided regarding the collection of sediment and surface water for laboratory analysis.
- **Toxicity/Bioaccumulation Studies Work Plan** will describe, in detail, the proposed toxicity and bioaccumulation studies to evaluate potential adverse effects to fish and invertebrates exposed to media from the NBSA. The methodology for the collection and analysis of benthic invertebrate community metrics will also be provided.
- **Fish and Blue Crab SAP/QAPP** will describe, in detail, the proposed sampling methodology for collecting and analyzing fish and blue crabs from the NBSA.
- **PAR (Updated)** will be prepared. The updated PAR will include the COPC identification for the BHHRA, which was previously approved by the USEPA for the LPRRP HHRA (Windward 2012). Surface water will be screened against both aquatic criteria and human health criteria. The updated PAR will also include methods for calculating exposure point concentrations; an updated CSM; and

**Newark Bay Study  
Area Problem  
Formulation**

Baseline Human Health and  
Ecological Risk Assessment

detailed discussions of the exposure scenarios, exposure parameters, and assumptions proposed to be used in the baseline risk assessments. Proposed toxicity reference values (TRVs) for the BERA will also be included. Results of the site reconnaissance to “ground-truth” shoreline access assumptions, habitats, and additional research regarding exposure to divers will also be included. The BHHERA will be prepared following USEPA approval of the PAR.

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## Tables

**Table 2-1**  
**Industrial Sources to Newark Bay and its Tributaries**

Site Name	Select On-Site COPCs <sup>1</sup>	Discharges Occurring From Site	References
<b>Lower Passaic River</b>			
Sherwin Williams	1,2,4-Trichlorobenzene	Historic combined sewer overflows (CSOs) and stormwater outfalls (SWOs) allowed for the discharge of process wastes to the Passaic River. Intentional dumping of product occurred to the Passaic River directly or via pipelines. Product spills led to piping network and then to the river.	U.S. Department of the Interior. 1969. Federal Water Pollution Control Administration: <i>Report on the Quality of the Interstate Waters of the Lower Passaic River and Upper and Lower Bays of the New York Harbor</i> , November, 1969.  PVSC Annual Reports, 1975 - 1976; excerpts concerning Brown Street Storm Sewer.  PVSC. 1986. Memo from Lawrence to D'Ascensio, January 30, 1986.  Letter from NJDEP to Various Parties, enclosing <i>Directive No. 1 for Natural Resource Injury Assessment and Interim Compensatory Restoration of Natural Resource Injuries</i> ; September 19, 2003.
	1,2-Dichlorobenzene		
	1,3-Dichlorobenzene		
	1,4-Dichlorobenzene		
	2,3,7,8-TCDD		
	2,4,5-Trichlorophenol		
	2,4,6-Trichlorophenol		
	2,4-Dichlorophenol		
	2-Chlorophenol		
	Aroclor PCBs		
	Arsenic		
	BEHP		
	Chlorobenzene		
	Chromium		
	DDT		
	Hexachlorobenzene		
	Mercury		
	PAHs		
	PCDD/Fs (in addition to 2,3,7,8-TCDD)		
	Pentachlorophenol		
Diamond Alkali Superfund Site	2,3,7,8-TCDD	Direct discharges from the site occurred to the Passaic River via pipe.	Diamond Shamrock Chemicals Company; IT Corporation; Woodward- Clyde Consultants; Enviro-Measure, Inc. 1985. Site Evaluation 80 Lister Avenue; February.  Letter from NJDEP to Various Parties, enclosing Directive No.1 for Natural Resource Injury Assessment and Interim Compensatory Restoration of Natural Resource Injuries; September 19, 2003.  USEPA 1984 Fact Sheet Diamond Alkali Co. EPA ID # NJD980528996, Region 2, Congressional District 13, NPL Listing History, Proposed Date 9/8/1983, Final Date September 21, 1984.  PVSC 1956. Weekly Summary of Inspections by Inspectors, Week of July 16 to July 20, 1956.
	1,2-Dichlorobenzene		
	1,4-Dichlorobenzene		
	2,4,6-Trichlorophenol		
	2,4-Dichlorophenol		
	2,4-Dimethylphenol		
	Hexachlorobenzene		
	Chlorobenzene		
	Methylene Chloride		
	BEHP		
	DDT		
	DDE		
	PAHs		
	Acetone		
	Arsenic		
	Chromium		
	Cyanide		
	Copper		
	Lead		
	Mercury		
	Phenol		
Bayonne Barrel & Drum	2,3,7,8-TCDD	Contaminated stormwater runoff from historic operations drained directly to the Passaic River via drainage ditches and storm drains to Harrison Creek. Process wastes discharged directly to the Passaic River via Harrison Creek.	USEPA. 1988. Site Inspection Review Report for Bayonne Barrel & Drum, December 7, 1988.
	2,3,7,8-TCDF		
	PCDD/Fs (in addition to above)		
	2,4-Dimethylphenol		
	Phenol		
	Benzenes		
	Chlorobenzene		
	Aroclor PCBs		
	Arsenic		
	Chromium		
	Mercury		
	Xylenes		
	4,4'-DDD		
	4,4'-DDE		
Chris-Craft (Montrose Chemical Site)	2,4-Dichlorophenol	Former employee stated in signed affidavit that wastes were piped directly to the Passaic River until the mid-1970s.	State of New Jersey, County of Essex 1993. <i>Affidavit of Oscar Randall</i> , notarized by Eileen M. Stephens, dated July 21, 1993.
	2,4,5-Trichlorophenol		
	Lindane		
	1,2-Dichlorobenzene		
	1,4-Dichlorobenzene		
	1,2,4-Trichlorobenzene		
	2,4-Dinitrophenol		

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**Industrial Sources to Newark Bay and its Tributaries**

Site Name	Select On-Site COPCs <sup>1</sup>	Discharges Occurring From Site	References
<b>Lower Passaic River</b>			
Chris-Craft (Montrose Chemical Site) (cont.)	Pentachlorophenol		
	Hexachlorobenzene		
	Chlorobenzene		
	DDT		
	BEHP		
	Aroclor PCB 1248		
	PAHs		
	Arsenic		
	Chromium		
	Copper		
	Mercury		
Hilton-Davis/ Thomasett	1,2-Dichlorobenzene	Site sewers were historically piped directly to the Passaic River.	Letter from NJDEP to Various Parties, enclosing <i>Directive No. 1 for Natural Resource Injury Assessment and Interim Compensatory Restoration of Natural Resource Injuries</i> , September 19, 2003.  PVSC. 1956. <i>Weekly Summary of Inspections by Inspectors</i> , re: Hilton Davis site; August.  360 North Pastoria Environmental Corporation 1996. 104(e) Response provided to USEPA by 360 North Pastoria Environmental Corporation on behalf of Thomasset Colors Inc./Hilton Davis Chemical Company – A Division of Sterling Drug Inc.; January.
	1,2,4-Trichlorobenzene		
	Hexachlorobenzene		
	Chlorobenzene		
	1,4-Dichlorobenzene		
	1,3-Dichlorobenzene		
	Aroclor PCB 1260		
	PAHs		
	BEHP		
	Arsenic		
Alliance Chemical	1,2-Dichlorobenzene	Site contained a landfill and a lagoon. The discharge pathway was from Plum Creek to the Passaic River from the onsite wastewater lagoon; another pathway was through the Roanoke Ave CSO to the river.	NUS Corporation. 1989. <i>Final Draft Preliminary Assessment Report for Alliance Inc.</i> prepared for USEPA. June.
	1,3-Dichlorobenzene		
	1,4-Dichlorobenzene		
	1,2,4-Trichlorobenzene		
	Chlorobenzene		
	2,4-Dichlorophenol		
	2,4-Dinitrophenol		
	Pentachlorophenol		
	2-Chlorophenol		
	Aroclor PCBs		
Pitt Consol (Reilly)	BEHP	Direct discharges occurred to the Passaic River via Roanoke Avenue CSO. Other discharges that occurred were from illegal process discharges, spills, and leaks to ground and surface water.	U.S. Department of the Interior. 1969. Federal Water Pollution Control Administration: <i>Report on the Quality of the Interstate Waters of the Lower Passaic River and Upper and Lower Bays of the New York Harbor</i> , November, 1969.  PVSC. 1973. Annual Report by S. A. Lubetkin, for the Year 1973, excerpts re: Roanoke Avenue Storm Sewer.  Clinton Bogert Associates 1979. <i>City of Newark Feasibility Study Pollution Abatement Program</i> ; January  Letter from NJDEP to Various Parties, enclosing <i>Directive No. 1 for Natural Resource Injury Assessment and Interim Compensatory Restoration of Natural Resource Injuries</i> ; September 19, 2003.
	PAHs		
	Chlorobenzene		
	Benzene		
Lucent Technologies (Western Electric)	Aroclor PCBs	Drains were located in the drum storage area with unknown discharge points. Historic untreated discharges occurred to the municipal sanitary system. Process wastes discharged to the Passaic River via storm sewer system.	U.S. Department of the Interior. 1969. Federal Water Pollution Control Administration: <i>Report on the Quality of the Interstate Waters of the Lower Passaic River and Upper and Lower Bays of the New York Harbor</i> , November, 1969.  Letter from NJDEP to Various Parties, enclosing <i>Directive No. 1 for Natural Resource Injury Assessment and Interim Compensatory Restoration of Natural Resource Injuries</i> ; September 19, 2003.
	BEHP		
	PAHs		
	Arsenic		
	Benzene		
	Chromium		
	Copper		
	Mercury		

**Table 2-1**  
**Industrial Sources to Newark Bay and its Tributaries**

Site Name	Select On-Site COPCs <sup>1</sup>	Discharges Occurring From Site	References
Lower Passaic River			
Vulcan Materials Co. (Safety Kleen)	Aroclor PCBs	Historic direct discharges occurred to the Passaic River/Newark Bay via the on-site 36" outfall. Indirect discharges occurred from this facility due to explosions/fires.	U.S. Department of the Interior. 1969.Federal Water Pollution Control Administration: <i>Report on the Quality of the Interstate Waters of the Lower Passaic River and Upper and Lower Bays of the New York Harbor</i> ; November, 1969.
	Chlorobenzene		NJDEP. 1993. <i>Administrative Consent Order</i> re: Vulcan Materials Site, June.
	Benzenes		RCRA Facility Assessment Narrative. 1987. Prepared for Vulcan Materials; May.
	Xylenes		Vulcan Materials Company. 1969. Report to: EPA Region II New York re: Newark, NJ Plant; November.
	PAHs		U.S. Department of the Interior, Federal Water Pollution Control Administration. 1969. Proceedings, Conference, In the matter of pollution of the Interstate Waters of the Hudson River and its Tributaries - New York and New Jersey, November.
	Lead		Inland Chemical. 1975. Letter to PVSC, August.
	Mercury		
BASF Corp.	Aroclor PCBs	Stormwater and process water discharges to the Passaic River; spills, leaks and migration to the Passaic River of waste formerly stored on ground surface.	Memorandum For Record re: RCRA and PCB Inspections at the Kearny Works, circa October 27, 1981.
	BEHP		BASF. 1994. 104 (e) Response provided to USEPA, January.
	PAHs		BASF. 1995. Additional 104 (e) Response provided to USEPA, November.
	Arsenic		NJDEP. 1990. <i>Compliance Evaluation Inspection for BASF Kearny Site</i> , November.
	Benzene		NJDEP. 1990. <i>Inspection Results for BASF Kearny Site</i> , ECRA case #90537, December.
	Chromium		
	Copper		
	Mercury		
Hackensack River			
Standard Chlorine	2,3,7,8-TCDD	Overflows from on-site lagoons entered the Hackensack River, a tributary of Newark Bay, during times of heavy water usage or during flooding events. Chlorobenzene distilling operations wastewaters were discharged via a 4-6 inch line to the Hackensack River.	E.C. Jordan. 1985. <i>Phase II Dioxin Site Investigation Final Report – Standard Chlorine</i> , prepared for NJDEP, December.
	1,2,4-Trichlorobenzene		
	1,2-Dichlorobenzene		
	1,3-Dichlorobenzene		
	1,4-Dichlorobenzene		New Jersey State Department of Health - FWPCA Hudson Delaware Basins Office. 1969. Industrial Waste Survey for Standard Chlorine, July.
	2,4-Dimethylphenol		
	2,4-Dichlorophenol		
	Aroclor PCBs		
	PAHs		
	DDT		
	Arsenic		
	Chromium		
	Copper		
	Mercury		
Northern & Central Newark Bay			
Prentiss Drug & Chemical	2,3,7,8- TCDD	Stormwater and runoff discharges to Piersons Creek which eventually discharges to Port Newark Channel.	NJDEP, Prentiss Drug and Chemical Company, <i>General Information and Site History</i> , undated.
	Aroclor PCBs		
	Chlordane		
	DDT		
	Alpha BHC		
	Beta BHC		
	BEHP		
	PAHs		
	Benzene		
	Arsenic		
	Barium		
	Cadmium		
	Copper		
	Lead		
	Mercury		
	Zinc		

**Table 2-1**  
**Industrial Sources to Newark Bay and its Tributaries**

Site Name	Select On-Site COPCs <sup>1</sup>	Discharges Occurring From Site	References
Northern & Central Newark Bay			
Central Steel Drum	2,3,7,8-TCDD	Drainage ditches exist to the east and south. These ditches received wastes from site runoff. Catch basins on the eastern portion of the site reportedly discharged to the drainage ditch along the east side of the site. These drainage ditches discharged into Newark Bay east of the site.	NJ Division of Law, Hazardous Site Litigation Section, SOL Referral, Site Summary report for Central Steel Drum, undated.
	2,3,7,8-TCDF		
	PCDD/Fs (in addition to above)		NJDEP Memorandum 1999. From A. Motter to J. DeNoble re: Central Steel Drum/Newark MOA, <i>Remedial Investigation Workplan</i> , September.
	Aroclor PCBs		
	2,4,5-TP		
	2,4,5-Trichlorophenoxyacetic acid		
	2,4-D		
	p,p'-DDT		
	Benzenes		
	PAHs		
	Arsenic		
	Chromium		
	Copper		
	Lead		
	Mercury		
BEHP			
VOCs			
Xylenes			
Troy Chemical Corp.	1,2,4-Trichlorobenzene	Direct discharges have occurred from the site via 15 discharge pipes to Piersons Creek which discharges to Port Newark Channel.	S. McCone. 1977. Inspector Field Notes re: Albert Steel Drum and Related Properties in Newark, June.
	1,2-Dichlorobenzene		
	2,4-Dimethylphenol		
	Benzene		
	Chlorobenzene		
	PAHs		
	Aroclor PCBs		
	BEHP		
	Arsenic		
	Barium		
	Cadmium		
	Lead		
	Mercury		
	Silver		
	Zinc		
4,4'-DDT			
Honeywell	Chromium	Surface drainage collected in ditches and storm sewer catch basins. Two ditches discharge directly to the Hackensack River/Newark Bay confluence.	United States District Court for the District of New Jersey. 2000. Civil Action – (Docket # 95-2097) <i>Declaration of William F. Hughes</i> , February.
	Mercury		United States District Court for the District of New Jersey. 2003. <i>Civil Action (Docket # 95-2097) - Third Progress Report of Special Master Robert G. Torricelli</i> , December.
	Cyanide		
	Lead		
	Zinc		
	Phenols		
Southern Newark Bay			
Singer Co.	Aroclor PCBs	Direct discharges occurred to Newark Bay/Arthur Kill via 6 on-site outfalls. Industrial wastes were directed to a wastewater sand pit which discharged to Newark Bay via a 36" line. Spill events occurred, affecting Newark Bay.	NJ State Commissioner of Health 1965. Letter to Singer Co.; March
	Cadmium		<i>New Jersey State Health Department and The Interstate Sanitation Commission 1962</i> . Industrial Waste Preliminary Report
	Chromium		
	Copper		
	Lead		
	Mercury		
	Nickel		
	Zinc		
	PHCs		
Arthur Kill			
Exxon-Mobil Bayway	PAHs	Numerous documented direct discharges occurred on-site to the ground, as well as to Morses Creek leading to the Arthur Kill.	Arthur D. Little. 2000. Bayway Phase 1B Remedial Investigation, Draft Report Volume V, of VI, October.
	Aroclor PCBs		TRC Ravix Associates. 2004. <i>Bayway Refinery Phase 2 Remedial Investigation Report</i> , April.
	4,4'-DDD		
	4,4'-DDE		
	BEHP		
	Chlorobenzene		
Arsenic			

**Table 2-1**  
**Industrial Sources to Newark Bay and its Tributaries**

Site Name	Select On-Site COPCs <sup>1</sup>	Discharges Occurring From Site	References
Exxon-Mobil Bayway (cont.)	Copper		
	Lead		
	Nickel		
	Zinc		
	PHCs		
	Dieldrin		
	Endrin aldehyde		
	Gamma Chlordane		
Kill Van Kull			
White Chemical Co.	2,4-Dichlorophenol	Documented direct discharges to Platty Kill Canal via onsite pond have been noted.	NJDEP. 1988. <i>CERCLA Site Investigation Report for White Chemical Corporation</i> , Volume 1 of 2, October.
	2-Chlorophenol		
	2,4-Dinitrophenol		
	2-Nitrophenol		
	Phenol		
	Pentachlorophenol		
	Monochlorobenzene		
	4, 4'-DDD		

**Notes:**

1. Not likely a complete list of all COPCs found on-site. The COPCs listed here are for those found on-site and which also match COPCs found in Newark Bay and/or its tributaries in their respective geographic areas.

**Table 3-1**  
**Annual Ichthyoplankton Catch in Newark Bay (1999-2006)**

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Acipenser sp. Larvae	—	—	—	—	—	—	—	1	1
Alosa sp. Egg	—	—	1	—	—	—	—	—	1
Larvae	—	—	2	—	—	—	—	—	2
American sand lance Larvae	—	—	9	1	2	1	1	—	14
American shad Larvae	—	—	—	—	—	—	39	—	39
Atlantic cod Larvae	—	—	—	—	—	1	—	—	1
Atlantic croaker Juvenile	—	—	—	—	1	—	1	18	20
Larvae	—	—	—	—	5	1	13	13	32
Atlantic herring Juvenile	—	—	—	—	—	1	—	—	1
Larvae	6	—	5	—	9	8	—	2	30
Atlantic mackerel Larvae	—	—	—	—	1	—	—	—	1
Atlantic menhaden UID	—	—	—	—	—	—	59	2	61
Egg	39	—	9	85	105	469	1311	44	2062
Larvae	257	1	2	7	61	100	172	9	609
Atlantic silverside Larvae	—	—	—	2	3	1	1	—	7
Atlantic tomcod Juvenile	—	—	5	—	1	3	4	—	13
Larvae	—	—	11	—	1	20	31	—	63
Bay anchovy Egg	705	—	144	2431	66	19068	30112	849	53375
Juvenile	—	1	—	—	1	—	1	—	3
Larvae	37	1	2	721	589	1929	525	110	3914
Blennidae Larvae	—	—	1	2	—	—	—	—	3
Butterfish Larvae	—	—	—	1	—	—	—	—	1
Clupeid unidentified Larvae	—	—	16	362	10	—	—	—	388
Conger eel (unidentified)	—	—	1	—	—	—	—	—	1
Cunner Larvae	—	—	—	2	—	—	5	—	7
Fourbeard rockling Egg	28	—	9	1	1	—	19	5	63

**Table 3-1**  
**Annual Ichthyoplankton Catch in Newark Bay (1999-2006)**

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Fourspot flounder									
Egg	73	—	—	—	—	—	—	—	73
Larvae	—	—	—	—	1	—	—	—	1
Gadid unidentified									
Egg	—	—	—	—	—	1	39	3	43
Larvae	—	—	—	—	—	—	2	—	2
Gobiid unidentified									
Larvae	6	—	—	1208	44	29	158	496	1941
Goosefish									
Larvae	—	—	—	1	—	—	—	—	1
Grubby									
UID	—	—	—	—	—	4	3	—	7
Juvenile	—	—	—	—	—	2	—	—	2
Larvae	—	—	478	244	35	430	358	81	1626
Hogchocker									
Larvae	—	—	—	—	—	—	1	—	1
Egg	55	—	2	25	—	—	—	—	82
Labridae									
Egg	350	—	680	391	24	886	1640	90	4061
Longhorn sculpin									
Larvae	—	—	—	—	—	3	—	—	3
Myoxocephalus sp.									
Larvae	68	—	—	—	—	—	—	—	68
Northern pipefish									
Juvenile	2	—	—	6	1	—	—	—	9
Larvae	8	—	8	92	10	13	62	20	213
Northern puffer									
Larvae	—	—	—	—	—	—	1	—	1
Prionotus sp.									
Larvae	—	—	—	—	—	—	1	—	1
Egg	—	—	—	—	6	—	132	10	148
Rock gunnel									
Larvae	—	—	4	11	1	4	5	1	26
Spot									
Larvae	—	—	—	2	—	—	—	—	2
Striped bass									
Larvae	—	—	1	—	1	—	—	—	2
Striped cuskeel									
Larvae	—	—	1	—	—	—	—	—	1
Summer flounder									
Larvae	—	6	6	1	—	—	—	—	13
Tautog									
Larvae	—	—	—	2	—	3	29	0	34

**Table 3-1**  
**Annual Ichthyoplankton Catch in Newark Bay (1999-2006)**

Species	Annual Ichthyoplankton Catch								Total Number Caught
	1999	2000	2001	2002	2003	2004	2005	2006	
Unidentified									
UID	–	–	–	–	–	1	1	–	2
Egg	–	–	–	1	–	–	–	–	1
Larvae	6	–	–	34	16	350	–	–	406
Walleye									
Larvae	–	–	–	–	–	–	–	2	2
Weakfish									
Egg	870	–	52	108	4	25	5884	2	6945
Juvenile	–	–	1	–	–	–	1	–	2
Larvae	9	9	–	72	7	28	114	–	239
White perch									
Larvae	–	–	–	–	13	–	–	–	13
Windowpane									
Egg	–	–	396	551	77	256	13	–	1293
Juvenile	–	–	1	1	3	–	–	–	5
Larvae	35	–	21	10	6	4	37	5	118
Winter flounder									
UID	–	–	–	–	–	4	13	–	17
Egg	15	–	–	6	1	1	4	–	27
Juvenile	–	–	–	–	2	–	1	–	3
Larvae	34	–	230	537	626	721	198	97	2443

**Notes:**

2007, 2008, and 2009 data are given in density only and are, therefore, not included.

**Acronyms and Abbreviations:**

UID = unidentified

USACE = U.S. Army Corps of Engineers

**Source:**

USACE. 2003. *Aquatic Biological Sampling Program 1998–2003*. Raw data in Access database. New York and New Jersey Harbor Navigation Project. U.S. Army Corps of Engineers, New York District, New York, New York. August.

USACE. 2004, 2005, and 2006. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project*. U.S. Army Corps of Engineers, New York District, New York, New York.

**Table 3-2**  
**Dominant Benthic Invertebrate Species in Newark Bay**

	NOAA May 1993 to April 1994 <sup>a</sup>	REMAP Summer 1993/94 <sup>b</sup>	USACE June 1995 <sup>c</sup>	USACE October 1995 <sup>c</sup>	USACE Monthly 1995/96 <sup>d</sup>	REMAP Summer 1998/99 <sup>b</sup>
Sampling Program						
Number of Stations	25	28	10	10	5	29
Taxa - Scientific Name	Dominant Species	Species Count				
Polychaeta						
Cirratulidae	—	—	2	—	—	—
<i>Glycera americana</i>	—	—	—	9	—	—
<i>Glycera</i> spp.	—	—	—	—	9	—
<i>Heteromastus filiformis</i>	—	9	6	—	—	—
<i>Leitoscoloplos fragilis</i>	—	—	8	—	—	—
<i>Leitoscoloplos robustus</i>	Ü	4	—	7	—	8
<i>Leitoscoloplos</i> sp.	—	5	3	—	—	—
<i>Marenzelleria viridis</i>	—	—	5	—	—	—
<i>Mediomastus</i> sp.	—	—	—	—	—	2
<i>Mediomastus ambiseta</i>	Ü	6	4	2	—	—
Paraonidae	—	—	—	—	4	—
<i>Pectinaria gouldii</i>	—	—	—	5	—	—
Phyllodoceidae	—	—	10	—	8	—
<i>Polydora cornuta</i> *	Ü	—	—	10	—	3
<i>Polydora ligni</i>	—	—	—		10	—
<i>Sabellaria vulgaris</i>	Ü	—	—	6	—	—
<i>Scoloplos</i> sp.	—	—	—	—	1	—
<i>Streblospio benedicti</i> *	Ü	1	1	3	2	1
<i>Tharyx</i> sp. A	Ü	7	9	—	—	—
Oligochaeta						
<i>Oligochaeta</i> *	Ü	2	7	8	—	4
Mollusca						
Bivalvia	—	—	—	4	—	—
<i>Odostomia</i> sp.	Ü	—	—	—	—	—
<i>Mulinia lateralis</i> *		10	—	1	3	9
<i>Mya arenaria</i>	Ü	—		—	6	—
<i>Mytilus edulis</i>	—	—	—	—	—	6
<i>Rictaxis punctostriatus</i>	—	—	—	—	—	10

**Table 3-2**  
**Dominant Benthic Invertebrate Species in Newark Bay**

Sampling Program	NOAA May 1993 to April 1994 <sup>a</sup>	REMAP Summer 1993/94 <sup>b</sup>	USACE June 1995 <sup>c</sup>	USACE October 1995 <sup>c</sup>	USACE Monthly 1995/96 <sup>d</sup>	REMAP Summer 1998/99 <sup>b</sup>
Number of Stations	25	28	10	10	5	29
Taxa - Scientific Name	Dominant Species	Species Count				
Crustacea						
<i>Ampelisca abdita</i>	—	—	—	—	—	7
<i>Corophium tuberculatum</i>	—	—	—	—	—	5
<i>Cyathura polita</i>	—	—	—	—	5	—
<i>Gammarus daiberi</i>	—	3	—	—	—	—
<i>Leucon americanus</i>	Ü	8	—	—	—	—
<i>Oxyurostylis smithi</i>	—	—	—	—	7	—

**Notes:**

\* Indicates pollution indicative species (USEPA 2003b).

ü indicates dominant species (NOAA 1994).

**Acronyms and Abbreviations:**

NOAA = National Oceanic and Atmospheric Administration

REMAP = Regional Environmental Monitoring and Assessment Program

USACE = U.S. Army Corps of Engineers

USEPA = U.S. Environmental Protection Agency

Species count indicates number of organisms of each species found in the study.

**Sources:**

- a. NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994*. Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: <http://sh.nefsc.noaa.gov>.
- b. USEPA. 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures*. EPA-600-R-02-013. Office of Research and Development. November.
- c. Iocco, L.E., P. Wilber, R.J. Diaz, D.G. Clarke, and R.J. Will. 2000. *Final Report. Benthic Habitats of New York/New Jersey Harbor: 1995 Survey of Jamaica, Upper, Newark, Bowery, and Flushing Bays*. National Oceanic and Atmospheric Administration, Virginia Institute of Marine Sciences, and U.S. Army Corps of Engineers.
- d. USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility*. U.S. Army Corps of Engineers, New York District, New York, New York. April.  
USACE. 1999. *Draft Feasibility Report for New York and New Jersey Harbor Investigation Study. Draft Environmental Impact Statement (DEIS)*. U.S. Army Corps of Engineers, New York District, New York, New York.

**Table 3-3**  
**Essential Fish Habitat Designations by Life Stage for Newark Bay**

Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Red hake ( <i>Urophycis chuss</i> )	Ü	Ü	Ü	Ü	–
Winter flounder ( <i>Pseudopleuronectes americanus</i> )	Ü	Ü	Ü	Ü	Ü
Windowpane flounder ( <i>Scopthalmus aquosus</i> )	Ü	Ü	Ü	Ü	Ü
American plaice ( <i>Hippoglossoides platessoides</i> )	–	Ü	Ü	Ü	–
Atlantic sea herring ( <i>Clupea harengus</i> )	–	Ü	Ü	Ü	–
Bluefish ( <i>Pomatomus saltatrix</i> )	Ü	Ü	Ü	Ü	–
Atlantic butterfish ( <i>Peprilus triacanthus</i> )	–	Ü	Ü	Ü	–
Atlantic mackerel ( <i>Scomber scombrus</i> )	–	–	Ü	Ü	–
Summer flounder ( <i>Paralichthys dentatus</i> )	–	Ü	Ü	Ü	–
Scup ( <i>Stenotomus chrysops</i> )	Ü	Ü	Ü	Ü	–
Black sea bass ( <i>Centropristus striata</i> )	–	–	Ü	Ü	–
King mackerel ( <i>Scomberomorus cavalla</i> )	Ü	Ü	Ü	Ü	–
Spanish mackerel ( <i>Scomberomorus maculatus</i> )	Ü	Ü	Ü	Ü	–
Atlantic mackerel ( <i>Scomber scombrus</i> )	–	–	Ü	Ü	–
Cobia ( <i>Rachycentron canadum</i> )	Ü	Ü	Ü	Ü	–
Dusky shark ( <i>Carcharhinus obscurus</i> )	–	Ü	Ü	–	–
Sand tiger shark ( <i>Carcharias taurus</i> )	–	Ü	Ü	–	–
Sandbar shark ( <i>Carcharhinus plumbeus</i> )	–	Ü	Ü		–
Clearence skate ( <i>Raja eglanteria</i> )	–	–	Ü	Ü	–
Little skate ( <i>Raja erinacea</i> )	–	–	Ü	Ü	–
Winter skate ( <i>Leucoraja ocellata</i> )	–	–	Ü	Ü	–

**Notes:**

- Ü indicates habitat is suitable for lifestage.  
– indicates habitat is not suitable for lifestage.

**Acronyms and Abbreviations:**

USACE = U.S. Army Corps of Engineers

**Sources:**

- USACE. 2004. Essential Fish Habitat Assessment. New York and New Jersey Harbor Deepening Project.  
U.S. Army Corps of Engineers, New York District, New York, New York.
- USACE. Undated. Essential Fish Habitat Assessment for Newark Bay Maintenance Dredging:  
Newark Bay – Port Newark Channel, Port Newark Pierhead Channel, and Port Elizabeth Channel  
of Newark Bay, Hackensack and Passaic Rivers Federal Navigation Project.  
Prepared by USACE, New York, New York. 26 pp.

Table 3-4  
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2013)

Common Name	Scientific Name	January											February												
		Jan-94	Jan-96	Jan-02	Jan-03	Jan-04	Jan-05	Jan-06	Jan-07	Jan-09	Average	Average % Comp	Feb-94	Feb-96	Feb-99	Feb-02	Feb-03	Feb-04	Feb-05	Feb-06	Feb-07	Feb-08	Feb-09	Average	Average % Comp
Bay anchovy	Anchoa mitchilli	0	0	2	5	0	31	0	5	2	5	0.8	0	0	0	0	0	0	0	2	0	1	0	0	0.0
White perch	Morone americana	244	0	591	613	119	121	889	743	189	390	61.5	738	0	131	634	55	219	8	648	985	0	6	311	54.7
Striped bass	Morone saxatilis	215	0	355	147	69	28	179	35	10	115	18.2	1021	2	24	362	12	281	2	289	169	0	117	207	36.4
Atlantic herring	Clupea harengus	0	0	0	0	0	1	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic tomcod	Microgadus tomcod	9	0	0	0	1	0	0	0	0	1	0.2	8	0	0	0	0	2	0	0	0	0	0	1	0.2
Alewife	Alosa pseudoharengus	9	0	22	6	1	0	0	1	1	4	0.7	0	0	0	22	0	1	0	7	0	0	1	3	0.5
Winter flounder	Pleuronectes americanus	52	0	45	37	14	3	11	14	5	20	3.2	33	2	0	38	6	48	1	15	0	0	20	15	2.6
Weakfish	Cynoscion regalis	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spotted hake	Urophycis regia	0	0	10	2	0	2	1	96	0	12	1.9	0	0	0	33	1	0	0	1	0	0	0	3	0.6
Blueback herring	Alosa aestivalls	0	0	13	2	0	0	6	10	5	4	0.6	0	0	0	44	0	5	0	27	0	0	0	7	1.2
Atlantic menhaden	Brevoortia tyrannus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Gizzard shad	Dorosoma cepedianum	47	1	6	2	8.1	4	7	18	1	10	1.7	1	0	0	1	0	1	0	1	4	0	0	1	0.1
Rainbow smelt	Osmerus mordax	313	0		0	0	0	0	0	1	39	6.2	25	0	0	0	0	0	0	0	0	0	0	2	0.4
Atlantic silverside	Menidia menidia	1	0		21	1	7	0	45	4	9	1.4	0	0	0	12	0	3	2	25	2	18	7	6	1.1
Grubby	Myoxocephalus aeneus	66	0	2	0	1	0	0	0	0	8	1.2	44	0	0	0	0	4	0	0	0	0	17	6	1.0
Summer flounder	Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Bluefish	Pomatomus saltatrix	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Butterfish	Peprillus tracanthus	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Red hake	Urophycis chuss	3	0	0		4	0	4	25	2	5	0.7	0	0	0	0	1	0	0	3	7	0	0	1	0.2
Windowpane	Scophthalmus aquosus	1	0	14	0	2	2	0	2	0	2	0.4	2	0	0	18	1	0	0	0	1	0	0	2	0.4
American shad	Alosa sapidissima	0	0	5	0	0	0	0	0	0	1	0.1	0	0	0	6	0	0	0	0	1	0	2	1	0.1
Silver hake	Merluccius bilinearis	0	0	0	1	2	0	0	1	0	0	0.1	0	0	0	0	0	2	0	0	1	0	0	0	0.0
Striped searobin	Prionotus evolans	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic croaker	Micropogonia undulatus	0	0	0	1	0	39	1	0	0	5	0.7	0	0	0	0	0	0	0	7	0	0	0	1	0.1
Smallmouth flounder	Etropus microstomus	0	0	4	0	0	0	0	1	0	1	0.1	0	0	0	1	0	0	0	0	0	0	0	0	0.0
Northern pipefish	Syngnathus fuscus	0	0	1	1	0	0	0	0	1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silver perch	Bairdiella chrysura	0	0	0	0	0	0	19	0	0	2	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern searobin	Prionotus carolinus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Hogchoker	Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Silverside	Atherinidae (unidentified)	0	0	24	0	0	0	0	0	0	3	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic moonfish	Selene setapinnis	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Threespine stickleback	Gasterosteus aculeatus	1	0	0	0	0	1	0	0	0	0	0.0	6	0	0	0	0	0	0	0	0	0	0	1	0.1
American eel	Anguilla rostrata	2	0	1	0	0	0	0	1	0	0	0.1	1	0	0	0	0	0	0	0	0	0	0	0	0.0
Scup	Stenotomus chrysops	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Cunner	Tautoglabrus adspersus	1	0	1	1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Tautog	Tautoga onitis	0	0	0	0	0	0	1	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Black sea bass	Centropristis striata	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern kingfish	Menticirrhus saxatilis	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Spot	Leiostomus xanthurus	0	0	0	0	0	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0		0	0	0	0.0
Striped anchovy	Anchoa hepsetus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Crevalle Jack	Caranx hippos	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rock gunnel	Pholis gunnellus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Naked goby	Gobiosoma bosc	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Little skate	Raja erinacea	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Oyster toadfish	Opsanus tau	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Herring	Clupeidae (unidentified)	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Striped killifish	Fundulus majalis	1	0	0	0	0	0	0	0	0	0	0.0	1	0	0	0	1	1	0	0	0	0	0	0	0.0
Lookdown	Selene vomer	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern puffer	Sphaeroides maculatus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Fourspot flounder	Paralichthys oblongus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
American sandlance	Ammodytes americanus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Seaboard Goby	Gobiosoma ginsburgi	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Mummichog	Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	1.7	0	0	0	0	0	0	0.0
Lined seahorse	Hippocampus erectus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Atlantic sturgeon	Acipenser oxyrinchus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Chub mackerel	Scomber japonicus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Clearnose skate	Raja eglanteria	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
Conger eel	Conger oceanicus	1	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Goby	Gobiidae sp.	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Northern stargazer	Astroscopus guttatus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Planehead filefish	Monacanthus hispidus	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Pollock	Pollachius sp.	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Striped cuskeel	Ophidion marginatum	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0	0	0	0	0.0
	TOTALS	966	1	1096	839	223	239	1118	1000	221			1880	4	155	1174	77	569	13	1025	1170	19	170		
	Monthly Average									634													569		

		March													April															
		Mar-94	Mar-96	Mar-99	Mar-02	Mar-03	Mar-04	Mar-05	Mar-06	Mar-07	Mar-08	Mar-09	Average	Average % Comp	Apr-94	Apr-95	Apr-99	Apr-02	Apr-03	Apr-04	Apr-05	Apr-06	Apr-07	Apr-08	Apr-09	Apr-11	Average	Average % Comp		
Common Name	Scientific Name	Mar-94	Mar-96	Mar-99	Mar-02	Mar-03	Mar-04	Mar-05	Mar-06	Mar-07	Mar-08	Mar-09	Average	Average % Comp	Apr-94	Apr-95	Apr-99	Apr-02	Apr-03	Apr-04	Apr-05	Apr-06	Apr-07	Apr-08	Apr-09	Apr-11	Average	Average % Comp		
Bay anchovy	Anchoa mitchilli	0	0	0	1	0	0	0	1	0	0	0	0.0	0.0	1	0	0	1	0	0	1	0	0	0	0	2	0	0.1		
White perch	Morone americana	669	0	326	24	6	726	80	172	269	0	248	229	39.1	355	1	0	0	49	191	1	0	1	0	2	0	50	12.5		
Striped bass	Morone saxatilis	1844	0	234	27	21	866	1	63	18	0	16	281	47.9	1009	17	38	63	57	110	24	1	1	31	2	113	28.2			
Atlantic herring	Clupea harengus	1	0	0	1	0	0	1	0	0	0	0	0	0.0	7	0	0	19	33	12	4	175	0	72	0	1	27	6.7		
Atlantic tomcod	Microgadus tomcod	7	0	0	0	0	35	0	0	0	0	0	4	0.7	102	0	0	0	0	19	0	0	0	0	0	0	10	2.5		
Alewife	Alosa pseudoharengus	0	0	0	6	0	17	1	10	6	1	27	6	1.1	9	0	1	3	2	129	10	10	1	0	116	62	29	7.1		
Winter flounder	Pleuronectes americanus	57	3	242	22	8	20	11	6	5	0	3	34	5.8	72	8	100	27	11	29	5	0	0	1	5	0	22	5.4		
Weakfish	Cynoscion regalis	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		
Spotted hake	Urophycis regia	0	0	14	34	0	5	0	15	0	0	0	6	1.1	26	0	300	211	95	103	1	7	8	0	11	9	64	16.0		
Blueback herring	Alosa aestivalis	0	0	0	31	0	45	2	0	2	0	1	7	1.3	1	0	0	3	1	62	0	105	1	0	1	660	70	17.4		
Atlantic menhaden	Brevoortia tyrannus	0	0	0	1	0	0	0	0	0	0	0	0	0.0	2	0	0	0	0	0	0	0	0	1	0	0	0	0.1		
Gizzard shad	Dorosoma cepedianum	0	0	1	1	0	0	0	2	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		
Rainbow smelt	Osmerus mordax	28	0	0	0	0	0	0	0	0	0	0	3	0.4	2	0	0	0	0	0	0	0	0	0	0	0	0	0.0		
Atlantic silverside	Menidia menidia	2	0	0	0	0	9	2	13	2	0	0	3	0.4	0	0	0	0	0	2	0	0	0	0	2	2	1	0.1		
Grubby	Myoxocephalus aeneus	54	0	7	0	0	1	0	0	0	0	0	6	1.0	13	0	1	2	0	2	0	0	0	0	0	0	2	0.4		
Summer flounder	Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0	0	0.0	8	0	0	1	2	1	0	0	0	0	0	0	1	0.2		
Bluefish	Pomatomus saltatrix	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		
Butterfish	Peprillus tracanthus	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		
Red hake	Urophycis chuss	1	0	0	1																									

### Table 3-4

[illegible]

Table 3-4  
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2013)

		July					August							September							October						
Common Name	Scientific Name	Jul-93	Jul-95	Jul-11	Average	Average %	Aug-93	Aug-95	Aug-99	Aug-06	Aug-11	Average	Average %	Sep-93	Sep-95	Sep-06	Sep-11	Average	Average %	Oct-93	Oct-95	Oct-98	Oct-06	Oct-11	Average	Average %	
Bay anchovy	Anchoa mitchilli	453	147	1782	794.0	52.7	Aug-93	785	1	12636	886	2943.4	83.8	758	1700	1994	830	1320.5	75.1	2	9	100	338	1773	444.4	36.5	
White perch	Morone americana	0	1	0	0.3	0.0	0	0	0	0	0	0.0	0.0	0	4	0	0	1.0	0.1	1	0	0	0	1	0.4	0.0	
Striped bass	Morone saxatilis	348	42	0	130.0	8.6	47	0	0	1	0	9.6	0.3	36	1	3	0	10.0	0.6	80	9	0	5	0	18.8	1.5	
Atlantic herring	Clupea harengus	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	1	0	0	0	0	0.2	0.0	
Atlantic tomcod	Microgadus tomcod	1226	1	0	409.0	27.2	684	0	0	0	0	136.8	3.9	15	0	0	0	3.8	0.2	91	0	0	0	0	18.2	1.5	
Alewife	Alosa pseudoharengus	31	0	1	10.7	0.7	4	0	0	0	0	0.8	0.0	3	0	0	71	18.5	1.1	31	1	1	0	757	158.0	13.0	
Winter flounder	Pleuronectes americanus	182	7	0	63.0	4.2	285	1	5	2	0	58.6	1.7	54	9	2	0	16.3	0.9	116	5	1	4	0	25.2	2.1	
Weakfish	Cynoscion regalis	9	4	0	4.3	0.3	808	0	603	2	0	282.6	8.0	1128	1	22	2	288.3	16.4	740	0	173	35	8	191.2	15.7	
Spotted hake	Urophycis regia	31	4	0	11.7	0.8	0	0	0	1	0	0.2	0.0	0	0	0	0	0.0	0.0	17	0	0	2	0	3.8	0.3	
Blueback herring	Alosa aestivalis	0	0	6	2.0	0.1	0	0	0	0	0	0.0	0.0	0	0	1	3	1.0	0.1	2	0	0	4	498	100.8	8.3	
Atlantic menhaden	Brevoortia tyrannus	83	0	1	28.0	1.9	22	0	1	80	0	20.6	0.6	2	0	10	3	3.8	0.2	30	0	1	724	7	152.4	12.5	
Gizzard shad	Dorosoma cepedianum	0	0	0	0.0	0.0	2	0	0	0	0	0.4	0.0	0	0	0	1	0.3	0.0	13	0	0	0	170	36.6	3.0	
Rainbow smelt	Osmerus mordax	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Atlantic silverside	Menidia menidia	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	78	0	1	19.8	1.1	30	44	0	10	0	16.8	1.4	
Grubby	Myoxocephalus aeneus	13	0	0	4.3	0.3	8	0	0	0	0	1.6	0.0	0	0	0	0	0.0	0.0	4	0	0	0	0	0.8	0.1	
Summer flounder	Paralichthys dentatus	89	3	0	30.7	2.0	46	8	5	0	0	11.8	0.3	10	1	0	0	2.8	0.2	1	6	1	0	0	1.6	0.1	
Bluefish	Pomatomus saltatrix	3	0	2	1.7	0.1	7	5	0	17	1	6.0	0.2	18	32	61	9	30.0	1.7	3	6	3	22	24	11.6	1.0	
Butterfish	Peprillus tracanthus	0	0	14	4.7	0.3	42	0	1	55	2	20.0	0.6	18	0	37	3	14.5	0.8	23	0	20	15	5	12.6	1.0	
Red hake	Urophycis chuss	1	0	0	0.3	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Windowpane	Scophthalmus aquosus	13	1	0	4.7	0.3	4	0	0	0	0	0.8	0.0	2	0	0	0	0.5	0.0	19	0	2	0	0	4.2	0.3	
American shad	Alosa sapidissima	0	0	0	0.0	0.0	3	1	0	0	0	0.8	0.0	2	9	0	1	3.0	0.2	0	3	1	0	9	2.6	0.2	
Silver hake	Merluccius bilinearis	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	3	0.6	0.0	
Striped searobin	Prionotus evolans	3	0	0	1.0	0.1	9	0	1	2	0	2.4	0.1	45	0	8	0	13.3	0.8	25	0	3	5	0	6.6	0.5	
Atlantic croaker	Micropogonia undulatus	0	0	0	0.0	0.0	7	0	0	2	0	1.8	0.1	3	0	0	0	0.8	0.0	4	0	0	0	1	1.0	0.1	
Smallmouth flounder	Etropus microstomus	0	0	0	0.0	0.0	0	0	0	1	0	0.2	0.0	2	0	0	0	0.5	0.0	0	0	0	0	0	0.0	0.0	
Northern pipefish	Syngnathus fuscus	4	6	0	3.3	0.2	1	0	0	1	0	0.4	0.0	2	0	2	0	1.0	0.1	0	0	0	0	0	0.0	0.0	
Silver perch	Bairdiella chrysura	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	8	0	0	0	5	2.6	0.2	
Northern searobin	Prionotus carolinus	7	0	0	2.3	0.2	10	0	1	0	0	2.2	0.1	0	0	0	0	0.0	0.0	2	0	0	0	0	0.4	0.0	
Hogchoker	Trinectes maculatus	1	0	0	0.3	0.0	2	0	0	0	0	0.4	0.0	7	0	0	0	1.8	0.1	0	0	0	1	0	0.2	0.0	
Silverside	Atherinidae (unidentified)	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Atlantic moonfish	Selene setapinnis	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	5	1.3	0.1	0	0	0	0	15	3.0	0.2	
Threespine stickleback	Gasterosteus aculeatus	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
American eel	Anguilla rostrata	0	0	0	0.0	0.0	1	0	0	0	0	0.2	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Scup	Stenotomus chrysops	0	0	0	0.0	0.0	0	0	31	1	0	6.4	0.2	0	0	1	0	0.3	0.0	1	0	0	2	0	0.6	0.0	
Cunner	Tautoglabrus adspersus	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Tautog	Tautoga onitis	0	0	0	0.0	0.0	1	0	0	0	0	0.2	0.0	0	0	0	0	0.0	0.0	0	0	1	0	0	0.2	0.0	
Black sea bass	Centropristis striata	0	0	0	0.0	0.0	0	0	0	8	0	1.6	0.0	0	0	0	0	0.0	0.0	0	0	0	4	0	0.8	0.1	
Northern kingfish	Menticirrhus saxatilis	0	0	0	0.0	0.0	3	0	0	0	0	0.6	0.0	0	6	2	0	2.0	0.1	0	0	1	2	0	0.6	0.0	
Spot	Leiostomus xanthurus	0	0	0	0.0	0.0	3	0	0	0	0	0.6	0.0	2	0	1	0	0.8	0.0	1	0	0	0	0	0.2	0.0	
Striped anchovy	Anchoa hepsetus	0	0	0	0.0	0.0	0	0	0	0	10	2.0	0.1	0	0	0	1	0.3	0.0	0	0	0	0	4	0.8	0.1	
Crevalle Jack	Caranx hippos	0	0	0	0.0	0.0	0	0	0	1	0	0.2	0.0	2	3	0	0	1.3	0.1	1	0	0	0	0	0.2	0.0	
Rock gunnel	Pholis gunnellus	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Naked goby	Gobiosoma bosc	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	1	0.2	0.0	
Little skate	Raja erinacea	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Oyster toadfish	Opsanus tau	0	0	0	0.0	0.0	0	0	0	2	0	0.4	0.0	0	0	0	0	0.0	0.0	0	0	0	1	0	0.2	0.0	
Herring	Clupeidae (unidentified)	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0	0	0	0	0	0	0.0	0.0	
Striped killifish</																											

Table 3-4  
Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2013)

		November						December									Overall	
Common Name	Scientific Name	Nov-93	Nov-95	Nov-06	Nov-11	Average	Average %	Dec-93	Dec-95	Dec-98	Dec-01	Dec-02	Dec-09	Dec-11	Average	Average %	Species Avg	Avg Percent Comp (%)
Bay anchovy	<i>Anchoa mitchilli</i>	5	0	195	839	259.8	19.5	9	0	7	0	1	71	637	103.6	26.8	541.10	31.436
White perch	<i>Morone americana</i>	507	1	23	8	134.8	10.1	272	0	77	0	459	15	0	117.5	30.4	103.16	17.404
Striped bass	<i>Morone saxatilis</i>	1748	0	41	0	447.3	33.6	205	0	70	0	135	1	0	58.8	15.2	118.60	16.246
Atlantic herring	<i>Clupea harengus</i>	17	0	0	0	4.3	0.3	0	0	0	0	0	0	2	0.3	0.1	40.10	4.752
Atlantic tomcod	<i>Microgadus tomcod</i>	277	0	0	0	69.3	5.2	110	0	0	0	0	0	0	15.7	4.1	67.64	5.627
Alewife	<i>Alosa pseudoharengus</i>	161	0	18	318	124.3	9.3	4	0	15	0	42	4	102	23.9	6.2	35.62	3.723
Winter flounder	<i>Pleuronectes americanus</i>	371	1	5	0	94.3	7.1	169	3	8	0	16	4	0	28.5	7.4	33.74	3.710
Weakfish	<i>Cynoscion regalis</i>	104	0	12	1	29.3	2.2	4	1	9	0	0	0	0	2.0	0.5	66.77	3.637
Spotted hake	<i>Urophycis regia</i>	20	0	9	0	7.3	0.5	15	0	2	0	3	0	0	2.9	0.7	21.23	3.389
Blueback herring	<i>Alosa aestivalis</i>	2	0	157	44	50.8	3.8	8	0	0	3	5	46	29	13.0	3.4	23.95	3.286
Atlantic menhaden	<i>Brevoortia tyrannus</i>	4	0	6	2	3.0	0.2	0	0	0	0	7	0	0	1.0	0.3	19.64	1.554
Gizzard shad	<i>Dorosoma cepedianum</i>	196	0	4	40	60.0	4.5	18	0	3	0	7	3	8	5.6	1.4	9.54	0.902
Rainbow smelt	<i>Osmerus mordax</i>	0	0	0	0	0.0	0.0	5	0	0	0	0	0	0	0.7	0.2	3.76	0.606
Atlantic silverside	<i>Menidia menidia</i>	3	4	22	1	7.5	0.6	8	0	1	0	0	2	0	1.6	0.4	5.32	0.545
Grubby	<i>Myoxocephalus aeneus</i>	6	0	0	0	1.5	0.1	23	0	0	0	0	0	0	3.3	0.9	3.04	0.465
Summer flounder	<i>Paralichthys dentatus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	5.20	0.418
Bluefish	<i>Pomatomus saltatrix</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	4.39	0.289
Butterfish	<i>Peprillus tracanthus</i>	1	0	3	3	1.8	0.1	0	0	1	0	0	0	0	0.1	0.0	4.60	0.260
Red hake	<i>Urophycis chuss</i>	0	0	0	0	0.0	0.0	13	0	0	0	0	0	0	1.9	0.5	1.52	0.248
Windowpane	<i>Scophthalmus aquosus</i>	19	0	0	0	4.8	0.4	5	0	1	0	0	1	0	1.0	0.3	2.09	0.248
American shad	<i>Alosa sapidissima</i>	5	0	7	18	7.5	0.6	2	0	10	0	0	0	0	1.7	0.4	1.94	0.231
Silver hake	<i>Merluccius bilinearis</i>	0	0	2	55	14.3	1.1	0	0	0	0	1	0	2	0.4	0.1	1.56	0.155
Striped searobin	<i>Prionotus evolans</i>	7	0	1	0	2.0	0.2	0	0	1	0	0	0	0	0.1	0.0	2.23	0.152
Atlantic croaker	<i>Micropogonia undulatus</i>	5	0	1	0	1.5	0.1	3	0	0	0	0	0	4	1.0	0.3	0.94	0.116
Smallmouth flounder	<i>Etropus microstomus</i>	3	0	3	0	1.5	0.1	2	0	2	0	0	1	0	0.8	0.2	0.64	0.116
Northern pipefish	<i>Syngnathus fuscus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	1	0	0.1	0.0	0.63	0.068
Silver perch	<i>Bairdiella chrysura</i>	13	0	0	0	3.3	0.2	0	0	0	0	0	0	0	0.0	0.0	0.66	0.066
Northern searobin	<i>Prionotus carolinus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.66	0.058
Hogchoker	<i>Trinectes maculatus</i>	0	0	0	0	0.0	0.0	2	0	0	0	0	0	0	0.3	0.1	0.35	0.035
Silverside	Atherinidae (unidentified)	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.22	0.035
Atlantic moonfish	<i>Selene setapinnis</i>	0	0	0	3	0.8	0.1	0	0	0	0	0	0	0	0.0	0.0	0.42	0.031
Threespine stickleback	<i>Gasterosteus aculeatus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.18	0.030
American eel	<i>Anguilla rostrata</i>	2	0	1	0	0.8	0.1	1	0	0	0	0	0	0	0.1	0.0	0.22	0.030
Scup	<i>Stenotomus chrysops</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.63	0.024
Cunner	<i>Tautoglabrus adspersus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	1	0	0.2	0.0	0.13	0.024
Tautog	<i>Tautoga onitis</i>	3	0	0	0	0.8	0.1	1	0	0	0	0	0	0	0.1	0.0	0.15	0.017
Black sea bass	<i>Centropristis striata</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.24	0.016
Northern kingfish	<i>Menticirrhus saxatilis</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.27	0.015
Spot	<i>Leiostomus xanthurus</i>	0	0	2	0	0.5	0.0	0	0	0	0	0	0	0	0.0	0.0	0.18	0.011
Striped anchovy	<i>Anchoa hepsetus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.25	0.011
Creville Jack	<i>Caranx hippos</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.14	0.008
Rock gunnel	<i>Pholis gunnellus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.03	0.007
Naked goby	<i>Gobiosoma bosc</i>	0	0	0	0	0.0	0.0	0	0	0	0	1	0	0	0.1	0.0	0.04	0.007
Little skate	<i>Raja erinacea</i>	1	0	1	0	0.5	0.0	0	0	0	0	0	0	0	0.0	0.0	0.06	0.007
Oyster toadfish	<i>Opsanus tau</i>	0	0	1	0	0.3	0.0	0	0	0	0	0	0	0	0.0	0.0	0.09	0.006
Herring	Clupeidae (unidentified)	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.03	0.006
Striped killifish	<i>Fundulus majalis</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.03	0.005
Lookdown	<i>Selene vomer</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.05	0.004
Northern puffer	<i>Sphaeroides maculatus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.06	0.004
Fourspot flounder	<i>Paralichthys oblongus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.02	0.003
American sandlance	<i>Ammodytes americanus</i>	0	0	0	0	0.0	0.0	0	0	0	0	1	0	0	0.1	0.0	0.01	0.003
Seaboard Goby	<i>Gobiosoma ginsburgi</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.02	0.003
Mummichog	<i>Fundulus heteroclitus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.002
Lined seahorse	<i>Hippocampus erectus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.02	0.002
Atlantic sturgeon	<i>Acipenser oxyrinchus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Chub mackerel	<i>Scomber japonicus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Clearnose skate	<i>Raja eglanteria</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Conger eel	<i>Conger oceanicus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Goby	Gobiidae sp.	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Northern stargazer	<i>Astroscopus guttatus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Planehead filefish	<i>Monacanthus hispidus</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.02	0.001
Pollock	<i>Pollachius sp.</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
Striped cuskeel	<i>Ophidion marginatum</i>	0	0	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.01	0.001
	TOTALS	3480	6	514	1332			879	4	207	3	678	150	784				
	Monthly Average				1333									386				905

**Table 3-4**  
**Monthly Finfish Catch Data from Newark Bay Fish Community Studies (1993-2013)**

**Table 3-4 Notes:**

Based on catch per unit effort (CPUE).

**Acronyms and Abbreviations:**

LMS = Lawler, Matusky and Skelly Engineers, Inc.

NOAA = National Oceanic and Atmospheric Administration

USACE = U.S. Army Corps of Engineers

**Sources:**

LMS. 1996. *Biological Survey of Newark Bay Shoal Areas and Adjacent Kill Van Kull and Arthur Kill Channels*. Lawler, Matusky and Skelly Engineers, Inc. Prepared for the Port Authority of New York and New Jersey.

NOAA. 1994. *Results of a Biological and Hydrographical Characterization of Newark Bay, New Jersey, May 1993–April 1994*. Report prepared by U.S. Department of Commerce, National Marine Fisheries, and Northeast Fisheries Service Center, National Oceanic and Atmospheric Administration. Also available online at: <http://sh.nefsc.noaa.gov>.

USACE. 2004, 2005, 2006, 2007, 2008, and 2009. *Aquatic Biological Survey Report. New York and New Jersey Harbor Deepening Project*. U.S. Army Corps of Engineers, New York District, New York, New York.

USACE 2013. *Migratory Finfish Report 2011*. New York and New Jersey Harbor Deepening Project. USACE New York District. Final Report. January.

**Table 3-5**  
**Mammal and Reptile Species that could Possibly Use the NBSA**

Common Name	Scientific Name	Season	Habitat
<b>Mammals</b>			
Eastern pipistrelle	<i>Pipistrellus subflavus</i>	Spring to fall	Aerial – over land and water
Big brown bat	<i>Eptesicus fuscus</i>	Spring to fall	Aerial – over land and water
Red bat	<i>Lasiurus borealis</i>	Spring to fall	Aerial – over land and water
Hoary bat	<i>Lasiurus cinereus</i>	Spring to fall	Aerial – over land and water
Evening bat	<i>Nycticeius humeralis</i>	Spring to fall	Aerial – over land and water
Silver-haired bat	<i>Lasionycteris noctivagans</i>	Spring to fall	Aerial – over land and water
Small-footed bat	<i>Myotis leibii</i>	Spring to fall	Aerial – over land and water
Little brown bat	<i>Myotis lucifugus</i>	Spring to fall	Aerial – over land and water
Northern long-eared bat	<i>Myotis septentrionalis</i>	Spring to fall	Aerial – over land and water
Muskrat	<i>Ondatra zibethica</i>	Spring to fall	Marsh – wetland, riverine, small bays, and creeks
River otter	<i>Lutra canadensis</i>	Spring to fall	Marsh – wetland, riverine, small bays, and creeks
Harbor seal	<i>Phoca vitulina</i>	All year	Marine bays, channels, and coastal waters
<b>Reptiles</b>			
Loggerhead	<i>Caretta caretta</i>	Summer	Coastal waters
Kemp's ridley	<i>Lepidochelys kempii</i>	Summer	Coastal waters
Green sea turtle	<i>Chelonia mydas</i>	Summer	Coastal waters
Diamondback terrapin	<i>Malaclemys terrapin</i>	Spring to summer	Marsh – wetland, riverine, small bays, and creeks

**Acronyms and Abbreviations:**

NBSA = Newark Bay Study Area

USACE = U.S. Army Corps of Engineers

**Source:**

Adapted from USACE. 1997. *Final Environmental Impact Statement on the Newark Bay Confined Disposal Facility*. U.S. Army Corps of Engineers, New York District, New York, New York. April.

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
<b>Loons</b>						
Loon, common	–	P	P	P	–	W
Loon, red-throated	–	P	–	P	–	W
<b>Grebes</b>						
Grebe, eared	–	–	–	P	–	T
Grebe, horned	–	P	–	P	–	W
Grebe, pied-billed	–	P	–	P	–	R
<b>Pelicaniformes</b>						
Cormorant, double-crested	P	P	P	P	P	<b>R</b>
Cormorant, great	–	–	–	P	–	W
Pelican, brown	–	–	–	P	–	T
<b>Wading Birds</b>						
Bittern, American	–	P	–	P	–	S
Bittern, least	–	P	–	P	–	S
Egret, cattle	–	P	P	P	P	<b>R</b>
Egret, great	P	P	P	P	P	<b>S</b>
Egret, snowy	P	P	P	P	P	<b>S</b>
Heron, black-crowned night	P	P	P		P	<b>R</b>
Heron, great blue	P	P	–	P	–	R
Heron, green	P	P	P	P	P	<b>S</b>
Heron, little blue	P	P	P	P	P	<b>S</b>
Heron, tricolored	–	P	P	P	P	<b>S</b>
Heron, yellow-crowned night	–	P	P	P		<b>S</b>
Ibis, glossy	–	P	P	P	P	<b>S</b>
<b>Swans, Geese and Ducks</b>						
Brant	–	P	P	P	–	W
Bufflehead	–	P	–	P	–	W
Canvasback		P	P	P	–	W
Duck, American black	P	P		P	P	<b>R</b>
Duck, fulvous whistling	–	P	–	–	–	T
Duck, long-tailed	–	P	–	P	–	W
Duck, ring-necked	–	P	–	–	–	W
Duck, ruddy	–	P	–	P	–	W
Duck, wood	P	P	–	P	–	R
Gadwall	–	P	P	P	P	<b>R</b>
Goldeneye, common	–	P	–	P	–	W
Goose, Canada	P	P	P	P	P	<b>R</b>
Goose, snow	–	P	–	–	–	W
Mallard	P	P	P	P	P	<b>R</b>
Merganser, common	P	–	–	P	–	W
Merganser, hooded	–	P	–	P	–	R
Merganser, red-breasted	–	P	–	P	–	W
Northern pintail	–	P	–	P	–	W
Northern shoveler	–	P	–	P	–	W
Redhead	–	P	–	–	–	W
Scaup, greater	–	P	P	P	–	W
Scaup, lesser	–	P	–	P	–	W
Scoter, black	P	–	–	P	–	W
Scoter, surf	–	P	–	P	–	W
Scoter, white-winged	P	P	–	P	–	W

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
Swan, mute	–	P	–	P	–	R
Swan, tundra	–	P	–	–	–	M
Teal, blue-winged	–	P	–	P	–	S
Teal, green-winged	–	P	–	P	–	R
Wigeon, American	–	–	–	P	–	W
<b>Diurnal Raptors</b>						
American kestrel	P	P	P	P	–	R
Bald eagle	–	P	P	–	–	W
Falcon, peregrine	P	P	P	P	–	R
Hawk, broad-winged	–	P	P	P	–	S
Hawk, Cooper's	–	P	P	P	–	R
Hawk, red-shouldered	–	P	P	P	–	R
Hawk, red-tailed	P	P	P	P	–	R
Hawk, rough-legged	–	P	–	P	–	W
Hawk, sharp-shinned	–	P	P	P	–	S
Merlin	–	P	P	P	–	W
Northern goshawk	–	P	–	–	–	R
Northern harrier	–	P	P	P	P	W
Osprey	P	P	P	P	–	<b>S</b>
Vulture, turkey	–	P	P	P	–	R
<b>Upland Game Birds</b>						
Pheasant, ring-necked	–	P	–	P	P	R
<b>Gruiformes</b>						
American coot	–	P	–	P	–	W
Common moorhen	–	P	–	P	P	S
Rail, clapper	–	P	–	P	–	S
Rail, king	–	P	–	–	–	S
Rail, Virginia	–	P	–	P	P	S
Rail, yellow	–	P	–	–	–	T
Sora	–	P	–	P	–	S
<b>Shorebirds</b>						
American avocet	–	P	–	–	–	T
American oystercatcher	–	–	P	–	–	S
American woodcock	–	P	P	P	–	R
Common snipe	–	P	–	P	–	W
Dunlin	–	P	–	P	–	W
Dowitcher, long-billed	–	P	–	P	–	M
Dowitcher, short-billed	–	P	–	–	–	M
Godwit, Hudsonian	–	P	–	–	–	M
Godwit, marbled	–	P	–	–	–	T
Killdeer	P	P	–	P	–	R
Phalarope, red	–	P	–	–	–	M
Phalarope, Wilson's	–	P	–	–	–	T
Plover, American golden	–	P	P	–	–	M
Plover, black-bellied	–	P	–	P	–	W
Plover, semipalmated	–	P	–	P	–	M
Red knot	–	P	–	P	–	W
Ruff	–	P	–	–	–	T
Sanderling	–	P	–	P	–	W
Sandpiper, Baird's	–	P	–	–	–	T

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
Sandpiper, buff-breasted	–	P	–	–	–	T
Sandpiper, curlew	–	P	–	–	–	T
Sandpiper, least	P	P	–	P	–	M
Sandpiper, pectoral	–	P	–	P	–	M
Sandpiper, purple	–	–	–	P	–	W
Sandpiper, semipalmated	–	P	–	P	–	M
Sandpiper, solitary	–	P	–	P	–	M
Sandpiper, spotted	P	P	P	P	P	S
Sandpiper, stilt	–	P	–	–	–	M
Sandpiper, upland	–	P	P	–	–	M
Sandpiper, western	–	P	–	–	–	T
Sandpiper, white-rumped	–	P	–	–	–	M
Stilt, black-necked	–	P	–	–	–	T
Turnstone, ruddy	–	P	–	P	–	W
Whimbrel	–	P	–	P	–	M
Willet	–	P	–	P	–	S
Yellowlegs, greater	P	P	–	P	–	W
Yellowlegs, lesser	P	P	–	–	–	M
<b>Gulls, Terns and Skimmers</b>						
Gull, great black-backed	P	P	P	P	P	<b>R</b>
Gull, Bonaparte's	–	P	–	P	–	W
Gull, common black-headed	P	P	–	P	–	T
Gull, glaucus	–	P	–	P	–	W
Gull, herring	P	P	P	P	P	<b>R</b>
Gull, Iceland	–	P	–	–	–	T
Gull, laughing	P	P	P	P	–	S
Gull, little	–	–	–	P	–	W
Gull, ring-billed	P	P	P	P	–	W
Skimmer, black	–	P	–	–	–	S
Tern, black	–	P	–	P	–	M
Tern, Caspian	–	P	–	P	–	M
Tern, common	–	P	P	P	–	<b>S</b>
Tern, Forster's	–	P	–	P	–	M
Tern, gull-billed	–	P	–	P	–	S
Tern, least	–	P	P	P	–	S
Tern, roseate	–	P	–	P	–	S
Tern, royal	–	P	–	–	–	S
<b>Pigeons and Doves</b>						
Dove, mourning	P	P	P	P	–	R
Dove, rock	P	P	P	P	P	<b>R</b>
<b>Cuckoos and their Allies</b>						
Cuckoo, black-billed	–	P	–	P	–	S
Cuckoo, yellow-billed	–	P	P	P	–	S

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
<b>Owls</b>						
Owl, barn	–	P	–	P	–	R
Owl, barred	–	–	–	P	–	R
Owl, eastern-screech	–	P	–	–	–	R
Owl, great horned	–	P	–	P	–	R
Owl, long-eared	–	P	–	–	–	W
Owl, short-eared	–	P	–	P	–	W
Owl, snowy	–	P	–	–	–	W
<b>Goatsuckers and Swifts</b>						
Chimney swift	–	P	–	P	–	S
Nighthawk, common	–	P	–	P	–	S
<b>Hummingbirds</b>						
Hummingbird, ruby-throated	–	P	–	P	–	S
<b>Kingfishers</b>						
Kingfisher, belted	P	P	P	P	P	R
<b>Woodpeckers</b>						
Flicker, northern	–	P	–	P	P	R
Sapsucker, yellow-bellied	–	P	–	P	P	W
Woodpecker, hairy	–	P	–	–	–	R
Woodpecker, red-bellied	–	–	–	P	–	R
Woodpecker, downy	–	P	P	P	P	R
Woodpecker, red-headed	–	P	–	–	–	T
<b>Tyrant Flycatchers</b>						
Eastern wood-pewee	–	P	–	P	–	S
Flycatcher, great-crested	–	P	–	P	–	S
Flycatcher, least	–	P	–	P	–	S
Flycatcher, olive-sided	–	–	–	P	–	M
Flycatcher, willow	–	–	–	P	–	S
Flycatcher, yellow-bellied	–	P	–	P	–	M
Kingbird, eastern	P	P	–	P	–	S
Kingbird, western	–	P	P	–	–	T
Phoebe, eastern	–	P	–	P	P	S
<b>Shrikes and Vireos</b>						
Shrike, northern	–	P	–	–	–	T
Vireo, red-eyed	–	P	–	P	P	S
Vireo, solitary	–	P	–	P	–	S
Vireo, warbling	–	P	P	P	–	S
Vireo, white-eyed	–	P	–	–	–	S
Vireo, yellow-throated	–	P	–	–	–	S
<b>Jays, Crows and their Allies</b>						
Crow, American	P	P	P	P	–	R
Crow, fish	P	P	P	P	–	R
Jay, blue	P	P	–	P	–	R
<b>Larks</b>						
Lark, horned	–	P	–	–	–	R

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
<b>Swallows</b>						
Purple martin	–	P	P	–	–	S
Swallow, bank	–	P	–	P	–	S
Swallow, barn	P	P	P	P	–	S
Swallow, cliff	–	P	–	–	–	M
Swallow, northern rough-winged	P	P	–	P	–	S
Swallow, tree	–	P	P	P	–	S
<b>Chickadees and their Allies</b>						
Chickadee, black-capped	–	P	–	P	–	R
Titmouse, tufted	–	P	–	P	–	R
<b>Nuthatches and Creepers</b>						
Brown creeper	–	P	–	P	–	R
Nuthatch, red-breasted	–	P	–	P	–	W
Nuthatch, white-breasted	–	P	–	P	–	R
<b>Wrens</b>						
Wren, Carolina	–	P	P	P	–	R
Wren, house	–	P	P	P	P	S
Wren, marsh	–	P	–	P	–	S
Wren, sedge	–	P	–	–	–	T
Wren, winter	–	P	–	P	–	W
<b>Old World Warblers, Thrushes and their Allies</b>						
Robin, American	–	P	–	P	P	R
Gnatcatcher, blue-gray	–	P	–	P	–	S
Kinglet, golden-crowned	–	P	–	P	P	W
Kinglet, ruby-crowned	–	P	–	P	P	W
Thrush, gray-cheeked	–	P	P	P	–	M
Thrush, hermit	–	P	–	P	P	R
Thrush, Swainson's	–	P	P	P	P	M
Thrush, wood	–	P	–	P	–	S
Veery	–	P	–	P	–	S
<b>Mimids</b>						
Brown thrasher	–	P	–	P	P	R
Catbird, gray	P	P	P	P	P	R
Mockingbird, northern	P	P	–	P	–	R
<b>Starlings and Minas</b>						
Starling, European	P	P	P	P	–	<b>R</b>
<b>Wagtails and Pipits</b>						
American pipit	–	P	–	–	–	M
<b>Waxwings</b>						
Waxwing, cedar	–	P	–	P	P	R
<b>Wood-Warblers</b>						
American redstart	–	P	P	P	P	S
Chat, yellow-breasted	–	–	P	–	–	S
Northern parula	–	P	–	P	–	M
Ovenbird	–	P	–	P	P	S
Warbler, bay-breasted	–	P	–	P	–	M
Warbler, black-and-white	–	P	P	P	P	S
Warbler, blackburnian	–	P	–	P	–	M
Warbler, blackpoll	–	P	–	P	P	M
Warbler, black-throated blue	–	P	P	P	P	M
Warbler, black-throated green	–	P	–	P	–	S

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
Warbler, blue-winged	–	P	–	P	P	S
Warbler, Canada	–	P	–	P	–	M
Warbler, Cape May	–	P	–	P	–	M
Warbler, cerulean	–	–	P	P	–	M
Warbler, chestnut-sided	–	P	–	P	P	S
Warbler, Connecticut	–	P	P	P	P	M
Warbler, golden-winged	–	–	P	–	–	M
Warbler, hooded	–	–	P	P	–	S
Warbler, Kentucky	–	–	–	P	–	S
Warbler, magnolia	–	P	P	P	P	M
Warbler, mourning	–	–	P	P	–	M
Warbler, Nashville	–	P	–	P	P	S
Warbler, orange-crowned	–	P	–	–	–	T
Warbler, palm	–	P	–	P	P	M
Warbler, pine	–	–	P	–	–	S
Warbler, prairie	–	P	–	P	–	S
Warbler, prothonotary	–	–	–	P	–	S
Warbler, Tennessee	–	P	–	P	–	M
Warbler, Wilson's	–	P	–	–	P	M
Warbler, worm-eating	–	–	P	P	–	S
Warbler, yellow	–	P	P	P	–	S
Warbler, yellow-rumped	–	P	–	P	P	W
Warbler, yellow-throated	–	–	P	P	–	S
Waterthrush, Louisiana	–	P	–	P	–	S
Waterthrush, northern	–	P	P	P	P	M
Yellowthroat, common	–	P	–	P	P	S
<b><i>Tanagers, Cardinals and their Allies</i></b>						
Bunting, indigo	–	P	–	P	–	S
Dickcissel	–	P	–	–	–	T
Grosbeak, blue	–	P	–	–	–	T
Grosbeak, rose-breasted	–	P	–	P	–	S
Northern cardinal	P	P	–	P	–	R
Tanager, scarlet	–	P	–	P	–	S
<b><i>Emberizine Sparrows and their Allies</i></b>						
Bunting, snow	–	P	–	–	–	W
Junco, dark-eyed	–	P	–	P	P	W
Longspur, lapland	–	P	–	–	–	W
Sparrow, American tree	P	P	–	P	–	W
Sparrow, chipping	–	P	–	P	–	S
Sparrow, field	–	P	–	P	P	R
Sparrow, fox	–	P	P	–	–	W
Sparrow, Lincoln's	–	P	P	–	–	M
Sparrow, Savannah	–	P	–	P	–	S
Sparrow, seaside	–	P	–	P	–	R
Sparrow, sharp-tailed	–	P	–	P	–	S
Sparrow, song	P	P	P	P	P	R
Sparrow, swamp	–	P	–	P	P	R
Sparrow, vesper	–	P	–	–	–	S
Sparrow, white-crowned	–	P	–	P	–	W
Sparrow, white-throated	P	P	–	P	P	W
Towhee, eastern	–	P	–	P	P	S

**Table 3-6**  
**Inventory of Bird Observations in the Newark Bay Study Area**

Species	Observed Locations					Residency
	Passaic River	Hackensack River	Newark Bay	Arthur Kill	Kill van Kull	
<i>Icterids</i>						
Blackbird, red-winged	P	P	–	P	–	R
Blackbird, rusty	–	P	–	–	–	W
Blackbird, yellow-headed	–	P	–	–	–	T
Bobolink	–	P	–	–	–	S
Cowbird, brown-headed	–	P	–	P	–	R
Eastern meadowlark	–	P	–	P	–	R
Grackle, common	P	P	P	P	–	R
Grackle, boat-tailed	–		–	P	–	R
Oriole, Baltimore	–	P	P	P	–	S
Oriole, orchard	–	–	P	–	–	S
<i>Finches and Old World Sparrows</i>						
Common redpoll	–	P	–	–	–	W
Finch, house	P	P	–	P	–	R
Finch, purple	–	P	–	P	–	R
Goldfinch, American	P	P	P	P	P	R
Siskin, pine	–	P	–	P	–	W
Sparrow, house	P	P	–	P	–	<i><b>R</b></i>
Total Number of Species	49	248	81	213	59	

**Notes:**

1. P indicates species was observed during any of the following surveys: Tierra (2004), Ludwig et al. (2010), Kerlinger (2004), Bernick (2007), Bernick and Craig (2008), Mizrahi et al. (2006).
2. The Passaic River Bird Survey was conducted on the lower six miles of the river.
3. The residency column differentiates between year-round residents (R), summer residents (S), winter residents (W), migratory species (M) who may stop-over during migration, or transient/vagrant species (T) that normally do not occur in the NBSA based on the *Birds of North America Online*. Species known, or suspected to breed in the NBSA are in bold italics.

**Sources:**

- Bernick, A.J. 2007. *NYC Audubon's Harbor Herons Project: 2007 Nesting Survey*. NYC Audubon, New York. 48 pp.
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**Table 3-7**  
**Sediment and Tissue Datasets for Use in Risk Assessments**

Date	Author	Title	Media
1980	Ellis et al.	A Comprehensive Monitoring and Assessment Program for Selected Heavy Metals in New Jersey Aquatic Fauna	Tissue
1982	NJDEP	PCBs in Fish: 1975-1980. A Comprehensive Survey	Tissue
1983	NJDEP	PCBs in Selected Finfish Caught Within New Jersey Waters 1981-1982 (With Limited Chlordane Data)	Tissue
1985	NJDEP	A Study of Dioxin (2,3,7,8-Tetrachlorodibenzo-p-Dioxin) Contamination in Select Finfish, Crustaceans and Sediments of New Jersey Waterways	Tissue
1991	Rappe et al.	Levels and Patterns of PCDD and PCDF Contamination in Fish, Crabs, and Lobsters from Newark Bay and the Newark Bight	Tissue
1991	Woodhead, P.M.J.	Module 5.3 Inventory and Characterization of Habitat and Fish Resources and Assessment of Information on Toxic Effects of the New York-New Jersey Harbor Estuary	Tissue
1994	Brown et al.	Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Mya arenaria in the Newark/Raritan Bay Estuary	Tissue
1997	NOAA	Fish, Megainvertebrates, and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, during May 1993 – April 1994	Tissue
1999	USACE	New York and New Jersey Harbor Navigation Study. Biological Monitoring Program 1998-1999, Volume I of II	Tissue
1999-2006	Honeywell	Offshore Investigation Results Summary Report	Sediment
2000	Gale et al.	Evaluation of Planar Halogenated and Polycyclic Aromatic Hydrocarbons in Estuarine Sediments using Ethoxyresorufin-O-Deethylase Induction of H4IIE Cells	Tissue
2000	USFWS	Impacts of Dioxins, Furans, and Polychlorinated Biphenyls on Anadromous Fish and Piscivorous Birds in Newark Bay. Pre Assessment Study for the Diamond Alkali Superfund Site, Newark, Essex County, New Jersey	Tissue
2001	Yuan et al.	Is Hepatic Cytochrome P4501A1 Expression Predictive of Hepatic Burdens of Dioxins, Furans, and PCBs in Atlantic Tomcod from the Hudson River Estuary?	Tissue
2002	Horwitz et al.	Environmental Assessment and Risk Analysis Element Research Project Summary: Assessment of Total Mercury Concentrations in Fish from Rivers, Lakes and Reservoirs in New Jersey	Tissue
2003	NYSDEC	Contaminant Assessment and Reduction Project: NY/NJ Harbor Sediment Report, 1998-2001	Sediment
2003	USACE	New York and New Jersey Harbor Navigation Project. Aquatic Biological Sampling Program Survey Report, 2001-2002.	Tissue
2003	USACE	New York/ New Jersey Harbor Navigation Project. Aquatic Biological Survey Report, 2002-2003	Tissue
2003	Wintermyer, M.L. and K.R. Cooper	Dioxin/Furan and Polychlorinated Biphenyl Concentrations in Eastern Oyster (Crassostrea virginica, Gmelin) Tissues and the Effects on Egg Fertilization and Development	Tissue
2004	Fernandez et al.	Spatial Variation in Hepatic Levels and Patterns of PCBs and PCDD/Fs among Young-of-the-Year and Adult Atlantic Tomcod ( <i>Microgadus tomcod</i> ) in the NY/NJ Harbor Estuary	Tissue
2004	NYSDEC	Polychlorinated Biphenyls (PCBs) in Five Fish Species from the New York-New Jersey Harbor Estuary	Tissue
2004	NYSDEC	Dioxins and Furans in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2004	NYSDEC	Mercury, Methyl Mercury, Cadmium and Lead in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2004	USACE	New York/New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2004	Tissue
2005	NOAA	Benthic Macrofauna and Associated Hydrographic Observations Collected in Newark Bay, New Jersey, between June 1993 and March 1994	Tissue
2005	NYSDEC	Organochlorine Pesticides in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary.	Tissue
2005	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2005	Tissue
2006	Academy of Natural Sciences	Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey. Second Year of Routine Monitoring Program. Final Report. Report No. 06-04F	Tissue
2006	NYSDEC	Polynuclear Aromatic Hydrocarbons (PAHs) in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary	Tissue
2007	Cooper, K.R. and G.A. Buchanan	Integrated Biomarkers for Assessing the Exposure and Effects of Endocrine Disruptors and Other Contaminants on Marine/Estuarine Fish	Tissue
2007	USACE	New York/New Jersey Harbor Deepening Project. Migratory Finfish Report, 2006	Tissue
2007	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2007	Tissue

**Table 3-7**  
**Sediment and Tissue Datasets for Use in Risk Assessments**

Date	Author	Title	Media
2008	Bernick, A.J. and E. Craig.	NYC Audubon's Harbor Herons Project: 2008 Interim Nesting Survey	Tissue
2008	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2008	Tissue
2008	USACE	Dredging Operations Environmental Research Program. Dredged Material Analysis Tools. Performance of Acute and Chronic Sediment Toxicity Methods	Tissue
2009	Bugel, S.M.	An Integrated Biomarker Approach for Assessing Exposure and Effects of Endocrine Disruptors and other Contaminants in Killifish ( <i>Fundulus heteroclitus</i> ) from the New York-New Jersey Harbor Estuary	Tissue
2009	USACE	New York and New Jersey Harbor Deepening Project. Aquatic Biological Survey Report, 2009	Tissue
2010	USACE	Dredging Operations and Environmental Research Program. Determining Steady-state Tissue Residues for Invertebrates in Contaminated Sediment.	Tissue
2010	USACE	Stratified Sampling Project Summary Report and Evaluation of Data. New York District. New York, NY	Sediment
2010	Tierra	Phase I and Phase II Data Evaluation and Analysis Report. Newark Bay Study Area Remedial Investigation. Revision 0. Tierra Solutions, Inc., East Brunswick, NJ. April	Sediment
2011	Bugel, S.M.	Decreased Vitellogenin Inducibility and 17 $\beta$ -estradiol Levels Correlated with Reduced Egg Production in Killifish ( <i>Fundulus heteroclitus</i> ) from Newark Bay, NJ	Tissue
2011	Pflugh et al.	Consumption Patterns and Risk Assessment of Crab Consumers from the Newark Bay Complex, New Jersey, USA	Tissue
2013	USACE	New York/New Jersey Harbor Deepening Project. Migratory Finfish Report, 2011	Tissue

**Notes:**

Datasets are preliminarily deemed Level 2 or 3 from the ongoing secondary data evaluation.

**Table 3-8**  
**Summary of Amphipod Survival Studies in Newark Bay**

Reference	Data Collection Date(s)	Data Collection Season(s)	Average or Range of Survival as % of Control
Battelle (1992)	1992	Not provided	37
Battelle (1997a)	1995	Summer	19 - 62
Battelle (1997b)	1995	Summer	67
NOAA (1995)	1991, 1993	Not provided	0 - 87
Rice et al. (1995)	1991	Spring	NA
Tierra (2004)	2000	Summer	35
USACE (1997)	1996	Spring	81 - 97
USEPA (1990)	not provided	Not provided	0 - 89
USEPA (1998)	1990 - 1994	Summer	8 - 94
USEPA (2003)	1998	Summer	0 - 99

**Notes:**

NA = not available

**Sources:**

- Battelle. 1992. *Sediment Toxicity and Concentrations of Trace Metals in Sediment and Porewater in New York/New Jersey Harbor*. Ocean Sciences, Duxbury, MA. Submitted to New York City Department of Environmental Protection.
- Battelle. 1997a. *Evaluation of Dredged Material Proposed for Ocean Disposal from Arthur Kill Project Area, New York*. Battelle, Sequim, WA.
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- NOAA. 1995. *Magnitude and Extent of Sediment Toxicity in the Hudson Raritan Estuary*. NOAA Technical Memorandum NOS ORCA 88. National Oceanic and Atmospheric Administration Silver Spring, MD.
- Rice, C.A., P.D. Plesha, E. Casillas, D.A. Misitano, and J.P. Meador. 1995. Growth and survival of three marine invertebrate species in sediments from the Hudson-Raritan Estuary, New York. *Environ. Toxicol. Chem.* 14(11): 1931-1940.
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- USEPA. 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures*. EPA-600-R-02-013. Office of Research and Development. November.

Table 4-1  
Summary of COPECs from the SLERA

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
<b>Metals</b>						
Antimony	Ü					
Arsenic	Ü	Ü		Ü		
Cadmium	Ü	Ü		Ü		Ü
Chromium	Ü	Ü		Ü		
Copper	Ü	Ü		Ü		
Iron	Ü					
Lead	Ü	Ü	Ü	Ü		
Manganese	Ü					
Mercury	Ü					
Mercury (Elemental)		Ü	Ü	Ü	Ü	Ü
Mercury (Total)			Ü	Ü	Ü	Ü
Methyl mercury			Ü		Ü	Ü
Nickel	Ü	Ü		Ü		
Selenium	Ü					
Silver	Ü	Ü		Ü		
Zinc	Ü	Ü		Ü		
<b>VOCs</b>						
Ethylbenzene	Ü					
<b>SVOCs (Non-PAHs)</b>						
1,2,4-Trichlorobenzene	Ü					
1,3-Dichlorobenzene	Ü					
1,4-Dichlorobenzene	Ü					
Bis(2-ethylhexyl)phthalate	Ü					
<b>SVOCs (PAHs)</b>						
1-Methylnaphthalene						Ü
1-Methylphenanthrene						Ü
2,3,5-Trimethylnaphthalene						Ü
2,6-Dimethylnaphthalene						Ü
2-Methylnaphthalene	Ü					Ü
Acenaphthene	Ü					Ü
Acenaphthylene	Ü					Ü
Anthracene	Ü					Ü
Benzo(a)anthracene	Ü	Ü	Ü	Ü	Ü	Ü
Benzo(a)pyrene	Ü	Ü		Ü		Ü
Benzo(b)fluoranthene	Ü	Ü		Ü	Ü	
Benzo(g,h,i)perylene	Ü					Ü
Benzo(k)fluoranthene	Ü	Ü		Ü	Ü	
Benzo[e]pyrene						Ü
Benzofluoranthenes (total)	Ü					
Biphenyl						Ü
Chrysene	Ü	Ü	Ü	Ü	Ü	Ü
Dibenzo(a,h)anthracene	Ü	Ü	Ü	Ü		Ü
Fluoranthene	Ü					Ü
Fluorene	Ü					Ü
Indeno[1,2,3-cd]-pyrene	Ü	Ü	Ü	Ü	Ü	Ü
Naphthalene	Ü					Ü
Perylene						Ü
Phenanthrene	Ü					Ü
Pyrene	Ü					Ü
Total PAHs	Ü	Ü	Ü	Ü	Ü	Ü
HMW PAHs	Ü	Ü	Ü	Ü	Ü	Ü
LMW PAHs	Ü	Ü	Ü	Ü	Ü	Ü

Table 4-1  
Summary of COPECs from the SLERA

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
<b>PCBs</b>						
Aroclor 1016			Ü			
Aroclor 1242	Ü		Ü			Ü
Aroclor 1248	Ü		Ü			Ü
Aroclor 1254	Ü		Ü	Ü	Ü	Ü
Aroclor 1260	Ü					Ü
PCB 18CONGX2	Ü					Ü
Total Aroclor	Ü		Ü	Ü	Ü	Ü
Total PCBs	Ü	Ü	Ü	Ü	Ü	Ü
<b>Pesticides/Herbicides</b>						
2,4'-DDD	Ü	Ü				Ü
2,4'-DDE	Ü			Ü		Ü
2,4'-DDT	Ü					Ü
4,4'-DDD	Ü	Ü	Ü	Ü		Ü
4,4'-DDE	Ü	Ü	Ü	Ü		Ü
4,4'-DDT	Ü	Ü				Ü
Total DDx	Ü	Ü	Ü	Ü	Ü	Ü
Aldrin	Ü	Ü		Ü		Ü
alpha-BHC	Ü					Ü
beta-BHC	Ü					Ü
delta-BHC	Ü					Ü
gamma-BHC (Lindane)	Ü					Ü
Total BHC	Ü					Ü
Chlordane	Ü					Ü
Chlordane alpha (cis)	Ü					Ü
Chlordane gamma (trans)	Ü					Ü
Chlordane oxy	Ü					Ü
Total chlordane	Ü	Ü	Ü	Ü	Ü	Ü
Dieldrin	Ü	Ü	Ü	Ü		Ü
Endrin	Ü					Ü
Endrin aldehyde						Ü
Endrin ketone						Ü
Total endrin	Ü		Ü			Ü
Endosulfan sulfate						Ü
Endosulfan alpha						Ü
Endosulfan beta						Ü
Total endosulfan	Ü	Ü		Ü		Ü
Heptachlor	Ü					Ü
Heptachlor epoxide	Ü					Ü
Total heptachlor	Ü					Ü
Hexachlorobenzene	Ü					Ü
Methoxychlor	Ü					Ü
Mirex						Ü
Nonachlor cis-						Ü
Nonachlor trans-						Ü
Total Nonachlor			Ü			Ü

**Table 4-1**  
**Summary of COPECs from the SLERA**

Chemical	Sediment	Benthic Invertebrates	Fish	Mollusk	Crab	Avian Embryo
<b>Dioxins/Furans</b>						
2,3,7,8-TCDD	Ü					Ü
DIOX_TEQ_BIRD		Ü	Ü		Ü	Ü
DIOX_TEQ_FISH			Ü	Ü	Ü	Ü
DIOX_TEQ_MAMMAL		Ü	Ü		Ü	Ü
PCB_TEQ_BIRD			Ü	Ü	Ü	Ü
PCB_TEQ_FISH			Ü	Ü	Ü	Ü
PCB_TEQ_MAMMAL			Ü	Ü	Ü	Ü
TOTAL_TEQ_BIRD		Ü	Ü	Ü	Ü	Ü
TOTAL_TEQ_FISH			Ü	Ü	Ü	Ü
TOTAL_TEQ_MAMMAL	Ü	Ü	Ü	Ü	Ü	Ü

**Acronyms and Abbreviations:**

BHC = benzene hexachloride  
 COPEC = constituent of potential ecological concern  
 DDD = dichlorodiphenyldichloroethane  
 DDE = dichlorodiphenyldichloroethylene  
 DDT = dichlorodiphenyltrichloroethane  
 HMW = high molecular weight  
 LMW = low molecular weight  
 PAH = polycyclic aromatic hydrocarbons  
 PCB = polychlorinated biphenyls  
 SLERA = screening level ecological risk assessment  
 SVOC = semi-volatile organic compound  
 TCDD = tetrachlorodibenzo-p-dioxin  
 TEQ = toxic equivalent  
 VOC = volatile organic compound  
 DIOX\_TEQ = dioxin TEQ  
 PCB\_TEQ = dioxin-like PCBs TEQ  
 Total\_TEQ = sum of dioxin and dioxin-like PCB TEQ

**Notes:**

PCB congener data will be collected to obtain data for Total PCBs and to verify Aroclor totals.

The form of mercury specified in the various studies/toxicological sources used to obtain screening benchmarks for the different environmental media (e.g., sediment, tissue types) evaluated in the SLERA differed, leading to the identification of different types of mercury as COPECs for different media.

**Source:**

USEPA. 2008. *Screening-Level Ecological Risk Assessment for Newark Bay Study Area*. Submitted to USEPA Region 2 and USACE Kansas City District. Prepared by Battelle under contract to Malcolm Pirnie, Inc. December 15.

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
Dioxins/Furans (µg/kg)													
35822-46-9	1,2,3,4,6,7,8-HpCDD		NA	168/169	99%	0.267	0.00254	2.26	0.288	0.155	0.216	YES*	Included in total
67562-39-4	1,2,3,4,6,7,8-HpCDF		NA	169/169	100%	0.458	0.012941	7.82	0.882	0.218	0.242	YES*	Included in total
55673-89-7	1,2,3,4,7,8,9-HpCDF		NA	157/169	93%	0.0153	0.000452	0.165	0.0202	0.00866	0.0102	YES*	Included in total
39227-28-6	1,2,3,4,7,8-HxCDD		NA	142/169	84%	0.00379	0.0001	0.0231	0.00343	0.00264	0.00319	YES*	Included in total
70648-26-9	1,2,3,4,7,8-HxCDF		NA	167/169	99%	0.114	0.00273	2.21	0.247	0.0519	0.058752	YES*	Included in total
57653-85-7	1,2,3,6,7,8-HxCDD		NA	156/169	92%	0.0156	0.000544	0.0983	0.0156	0.00968	0.012991	YES*	Included in total
57117-44-9	1,2,3,6,7,8-HxCDF		NA	163/169	96%	0.0312	0.00075	0.401	0.0456	0.0159	0.0173	YES*	Included in total
19408-74-3	1,2,3,7,8,9-HxCDD		NA	151/169	89%	0.00875	0.000419	0.0505	0.00759	0.00596	0.00783	YES*	Included in total
72918-21-9	1,2,3,7,8,9-HxCDF		NA	116/169	69%	0.00409	0.000213	0.0502	0.00572	0.00226	0.00236	YES*	Included in total
40321-76-4	1,2,3,7,8-PeCDD		NA	144/169	85%	0.00378	0.000116	0.0471	0.00465	0.00249	0.00298	YES*	Included in total
57117-41-6	1,2,3,7,8-PeCDF		NA	161/169	95%	0.0127	0.000443	0.152	0.0181	0.0077	0.00909	YES*	Included in total
60851-34-5	2,3,4,6,7,8-HxCDF		NA	160/169	95%	0.0128	0.000498	0.135	0.0161	0.00775	0.0095	YES*	Included in total
57117-31-4	2,3,4,7,8-PeCDF		NA	161/169	95%	0.0216	0.000827	0.243	0.0285	0.0129	0.016	YES*	Included in total
1746-01-6	2,3,7,8-TCDD	0.0025	Recommended by Partner Agencies	167/169	99%	0.0752	0.00091	1.35	0.132	0.0371	0.0486	YES	AboveScreenValue
51207-31-9	2,3,7,8-TCDF		NA	160/169	95%	0.017	0.000738	0.16	0.0174	0.0111	0.0141	YES*	Included in total
3268-87-9	OCDD		NA	169/169	100%	2.65	0.079604	28.1	3.01	1.64	2.02	YES*	Included in total
39001-02-0	OCDF		NA	169/169	100%	0.744	0.01765	13.1	1.38	0.362	0.402	YES*	Included in total
WHODIOXTEQ(B)	Total WHO Dioxin TEQ(Bird)		NA	169/169	100%	0.142	0.0067	1.59	0.189	0.0836	0.108	YES	NSV
WHODIOXTEQ(F)	Total WHO Dioxin TEQ(Fish)		NA	169/169	100%	0.115	0.00528	1.5	0.169	0.0646	0.0818	YES	NSV
WHODIOXTEQ(H)	Total WHO Dioxin TEQ(Human/Mammal)		NA	169/169	100%	0.115	0.0053	1.5	0.167	0.0647	0.0822	YES	NSV
Inorganics (mg/kg)													
7429-90-5	Aluminum	18000	NJDEP ESC Table - Marine	177/178	99%	12500	0.55	31500	5110	10600	13050	YES	AboveScreenValue
7440-36-0	Antimony	9.3	NJDEP ESC Table - Marine	21/174	12%	2.56	0.235	35.8	4.3	1.37	1.25	YES	AboveScreenValue
7440-38-2	Arsenic	8.2	NJDEP ESC Table - Marine	181/181	100%	14.4	1.4	113	12.9	11.5	11.4	YES	AboveScreenValue
7440-39-3	Barium	48	NJDEP ESC Table - Marine	181/181	100%	146	9.1	871	110	117	123	YES	AboveScreenValue
7440-41-7	Beryllium		NA	147/178	83%	0.675	0.036	1.6	0.277	0.603	0.69	YES	NSV
7440-43-9	Cadmium	1.2	NJDEP ESC Table - Marine	149/181	82%	1.84	0.02	21.5	2.54	1.02	1.1	YES	AboveScreenValue
7440-70-2	Calcium		NA	173/173	100%	7480	345	37800	5100	6300	6940	NO	Nutrient
7440-47-3	Chromium	81	Recommended by Partner Agencies	258/258	100%	433	7	7430	877	170	136.5	YES	AboveScreenValue
7440-48-4	Cobalt	10	NJDEP ESC Table - Marine	165/178	93%	9.31	2.4	21.8	3.42	8.59	9.5	YES	AboveScreenValue
7440-50-8	Copper	13.318	Recommended by Partner Agencies	176/176	100%	145	6.8	781	122	108	118	YES	AboveScreenValue
7439-96-5-DIV	Divalent Manganese		NA	20/21	95%	116	12.1	304	72.3	92.6	95.8	YES	NSV
18540-29-9	Hexavalent Chromium		NA	50/84	60%	18	0.2415	951	106	1.91	1.275	YES	NSV
7439-89-6	Iron	20000	USEPA Reg 3 - Freshwater	178/178	100%	26600	5310	57800	9480	24300	27950	YES	AboveScreenValue
7439-92-1	Lead	10.606	Recommended by Partner Agencies	207/207	100%	153	7	882	122	115	120	YES	AboveScreenValue
7439-95-4	Magnesium		NA	178/178	100%	6800	1250	15400	2610	6130	7230	NO	Nutrient
7439-96-5	Manganese	260	NJDEP ESC Table - Marine	178/178	100%	364	51.6	790	149	324	369	YES	AboveScreenValue
7439-97-6	Mercury	0.037	Recommended by Partner Agencies	203/204	100%	4.52	0.04	77	9.13	2.18	2.3	YES	AboveScreenValue
7440-02-0	Nickel	21	NJDEP ESC Table - Marine	178/178	100%	35.2	5.7	179	18.8	31	34.825	YES	AboveScreenValue
7440-09-7	Potassium		NA	169/169	100%	2890	298	8440	1500	2390	2960	NO	Nutrient
7782-49-2	Selenium	1	NJDEP ESC Table - Marine	83/177	47%	1.16	0.14	4.6	0.952	0.884	0.81	YES	AboveScreenValue
7440-22-4	Silver	1	NJDEP ESC Table - Marine	142/172	83%	2.22	0.08	15.85	2.01	1.59	1.7	YES	AboveScreenValue
7440-23-5	Sodium		NA	178/178	100%	7200	551	25200	4020	5980	6915	NO	Nutrient
7440-28-0	Thallium		NA	48/174	28%	0.988	0.071	9.60	0.987	0.71	0.75	YES	NSV
7440-32-6	Titanium		NA	106/106	100%	444	116	896	130	423	454	YES	NSV
7440-62-2	Vanadium	57	NJDEP ESC Table - Marine	178/178	100%	35.1	5.8	98.5	14.5	31.6	35.975	YES	AboveScreenValue
7440-66-6	Zinc	6.62	Recommended by Partner Agencies	178/178	100%	271	19.2	1460	192	218	222.25	YES	AboveScreenValue
1191-48-6	Dibutyltin		NA	64/97	66%	5.19	0.47	46.5	6.62	3.13	3.2	YES	NSV
78763-54-9	Monobutyltin		NA	0/95	0%	1.53	0.55	3.55	0.617	1.4	1.55	NO	ND
1461-25-2	Tetrabutyltin		NA	5/97	5%	2.03	0.95	24	2.35	1.76	1.75	NO	Low FOD
688-73-3	Tributyltin		NA	63/97	65%	5.96	0.85	74	9.85	3.42	3.7	YES	NSV
REAC-CN	Reactive Cyanide		NA	0/9	0%	14100	10000	20300	3900	13700	14050	NO	ND
57-12-5	Total Cyanide	100	NJDEP ESC Table - Freshwater	25/103	24%	285	50	4150	447	200	180	YES	AboveScreenValue
Pesticides/Herbicides (µg/kg)													
93-76-5	2,4,5-T	12300	USEPA Reg 3 - Freshwater	26/104	25%	273	3.6	3783	449	102	232.5	NO	BelowScreenValue
93-72-1	2,4,5-TP (Silvex)	675	USEPA Reg 3 - Freshwater	24/94	26%	318	1.6	3783	462	146	260	YES	AboveScreenValue
94-75-7	2,4-D	1273	USEPA Reg 5	18/107	17%	690	5	9328	1090	270	600	YES	AboveScreenValue
94-82-6	2,4-DB		NA	14/86	16%	639	16	7060	872	378	500	YES	NSV
53-19-0	2,4'-DDD		NA	9/37	24%	6.82	2.2	47	9.9	4.75	3.8	YES	NSV
3424-82-6	2,4'-DDE		NA	12/36	33%	8.65	2.2	33	8.76	5.93	3.875	YES	NSV
789-02-6	2,4'-DDT		NA	9/39	23%	4.77	1.3	56	8.48	3.48	3.6	YES	NSV
72-54-8	4,4'-DDD	2	NJDEP ESC Table - Marine	79/196	40%	23	1.9	320	40	12.8	10.5	YES	AboveScreenValue
72-55-9	4,4'-DDE	2.2	NJDEP ESC Table - Marine	127/196	65%	39	1.9	1000	80.5	20.7	22	YES	AboveScreenValue
50-29-3	4,4'-DDT	1	NJDEP ESC Table - Marine	36/193	19%	23.4	1.4	560	56.1	9.92	8	YES	AboveScreenValue
309-00-2	Aldrin	2	Recommended by Partner Agencies	9/195	5%	7.08	0.63	115	10.4	4.49	4.65	NO	Low FOD
319-84-6	Alpha-BHC	6	NJDEP ESC Table - Freshwater	16/196	8%	7.49	0.59	115	10.9	4.46	4.525	NO	Low FOD
5103-71-9	Alpha-Chlordane	3.24	Recommended by Partner Agencies	37/152	24%	7.68	0.39	115	11.7	4.39	4.4	YES	AboveScreenValue
319-85-7	Beta-BHC	5	NJDEP ESC Table - Freshwater	13/192	7%	7.51	1	115	11.6	4.52	4.6	NO	Low FOD
5013-74-2	Beta-Chlordane	3.24	Recommended by Partner Agencies	11/26	42%	3.33	1	12	2.69	2.55	1.725	YES	AboveScreenValue
57-74-9	Chlordane	3.24	Recommended by Partner Agencies	0/47	0%	55.1	4.15	100	20.8	47.7	55	NO	ND
319-86-8	Delta-BHC	3	NJDEP ESC Table - Freshwater	20/195	10%	7.13	1	115	10.4	4.58	4.6	YES	AboveScreenValue
60-57-1	Dieldrin	271	Recommended by Partner Agencies	27/195	14%	12.9	0.67	230	20.7	7.68	6.75	NO	BelowScreenValue
959-98-8	Endosulfan I	2.9	USEPA Reg 3 - Freshwater	9/196	5%	7.57	1	115	10.7	4.8	4.725	NO	Low FOD
33213-65-9	Endosulfan II	14	USEPA Reg 3 - Freshwater	1/196	1%	12.4	1.9	230	20.7	7.41	6.5	NO	Low FOD

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
1031-07-8	Endosulfan sulfate	34.6	NJDEP ESC Table - Freshwater	14/195	7%	12.5	1.3	230	20.8	7.42	6.5	NO	Low FOD
72-20-8	Endrin	3	Recommended by Partner Agencies	9/199	5%	12.5	1	230	20.6	7.4	6.5	NO	Low FOD
7421-93-4	Endrin Aldehyde	480	NJDEP ESC Table - Freshwater	17/196	9%	13.5	1.2	230	22.6	7.83	6.6	NO	Low FOD
53494-70-5	Endrin Ketone		NA	17/196	9%	14.2	1.4	230	21.7	8.2	7	NO	Low FOD
58-89-9	Gamma-BHC (Lindane)	3	NJDEP ESC Table - Freshwater	5/198	3%	6.97	0.41	115	10.3	4.33	4.525	NO	Low FOD
5566-34-7	Gamma-Chlordane	3.24	Recommended by Partner Agencies	21/122	17%	9.58	1.1	115	12.5	6.28	5.5	YES	AboveScreenValue
76-44-8	Heptachlor	0.68	Recommended by Partner Agencies	12/197	6%	7.37	0.85	115	11.1	4.52	4.65	NO	Low FOD
1024-57-3	Heptachlor epoxide	5	NJDEP ESC Table - Freshwater	26/195	13%	8.25	0.85	140	14.1	4.96	4.75	YES	AboveScreenValue
72-43-5	Methoxychlor	13.6	Recommended by Partner Agencies	10/199	5%	58.3	3.8	1150	107	26.9	20.5	NO	Low FOD
TBHC	Total BHC	3	Recommended by Partner Agencies	48/199	24%	7.99	0.61	115	12	4.64	4.5	YES	AboveScreenValue
TDDT-24-44	Total DDT (2,4 & 4,4)		NA	39/39	100%	72.7	8.5	520	103	40.6	30	YES	NSV
TDDT-24	Total DDT (2,4)		NA	17/39	44%	13.6	1.3	78	20.5	6.58	4	YES	NSV
TDDT-44	Total DDT (4,4)	1.58	Recommended by Partner Agencies	129/196	66%	64.9	1.9	1100	134	27.8	28.25	YES	AboveScreenValue
8001-35-2	Toxaphene	0.077	NJDEP ESC Table - Freshwater	0/199	0%	443	8.5	11500	1000	212	195	NO	ND
TOT_AGChlor	Total Alpha + Gamma Chlordane	3.24	Recommended by Partner Agencies	37/126	29%	10	0.39	115	12.6	6.39	5.5	YES	AboveScreenValue
PCBs (µg/kg)													
2051-60-7	PCB-1		NA	105/105	100%	1.16	0.0252	6.43	1.06	0.744	0.946	YES*	Included in total
39485-83-1	PCB-100		NA	105/106	99%	0.309	0.0188	1.72	0.264	0.218	0.2585	YES*	Included in total
60145-21-3	PCB-103		NA	104/106	98%	0.333	0.0172	1.89	0.325	0.221	0.258	YES*	Included in total
56558-16-8	PCB-104		NA	71/106	67%	0.0288	0.003	0.258	0.0298	0.0215	0.0213	YES*	Included in total
32598-14-4	PCB-105		NA	168/169	99%	7.52	0.0244	66.9	9.57	4.1	5.32	YES*	Included in total
PCB-106/118	PCB-106/118		NA	169/169	100%	20.1	0.0629	160	24.1	11.1	14.4	YES*	Included in total
70424-68-9/7447	PCB-107/109		NA	106/106	100%	1.65	0.017	11.9	1.87	1.05	1.1575	YES*	Included in total
70362-41-3/7447	PCB-108/112		NA	105/106	99%	1.31	0.0211	12.1	1.72	0.789	0.8465	YES*	Included in total
2050-67-1	PCB-11		NA	106/106	100%	6.64	0.135	59.1	8.82	3.92	4.1875	YES*	Included in total
38380-03-9	PCB-110		NA	106/106	100%	27.6	0.161	210	33.8	16.7	18.05	YES*	Included in total
PCB-111/115	PCB-111/115		NA	105/106	99%	0.495	0.0201	4.97	0.704	0.286	0.3035	YES*	Included in total
68194-10-5	PCB-113		NA	79/106	75%	0.106	0.003	1.91	0.245	0.0481	0.0508	YES*	Included in total
74472-37-0	PCB-114		NA	161/169	95%	0.474	0.00669	5.71	0.682	0.26	0.317	YES*	Included in total
56558-17-9	PCB-119		NA	105/106	99%	0.696	0.0211	4.44	0.703	0.462	0.5315	YES*	Included in total
PCB-12/13	PCB-12/13		NA	105/106	99%	2.66	0.04225	16.7	2.73	1.73	2.095	YES*	Included in total
68194-12-7	PCB-120		NA	87/106	82%	0.401	0.003	33.2	3.22	0.0495	0.0523	YES*	Included in total
56558-18-0	PCB-121		NA	2/106	2%	0.0216	0.003	0.155	0.0213	0.016	0.020575	NO	Low FOD
76842-07-4	PCB-122		NA	105/106	99%	0.306	0.0139	2.91	0.406	0.187	0.208	YES*	Included in total
65510-44-3	PCB-123		NA	161/169	95%	0.392	0.00728	3.15	0.481	0.228	0.284	YES*	Included in total
70424-70-3	PCB-124		NA	105/106	99%	0.859	0.0211	6.36	1.07	0.521	0.55475	YES*	Included in total
57465-28-8	PCB-126		NA	153/169	91%	0.117	0.002465	0.9	0.125	0.0776	0.0953	YES*	Included in total
39635-33-1	PCB-127		NA	2/106	2%	0.0204	0.003	0.1065	0.0168	0.0158	0.02055	NO	Low FOD
PCB-128/162	PCB-128/162		NA	106/106	100%	3.02	0.018	19.5	3.55	1.83	2.05	YES*	Included in total
55215-18-4	PCB-129		NA	105/106	99%	0.807	0.0211	5.4	1.01	0.482	0.509	YES*	Included in total
52663-66-8	PCB-130		NA	106/106	100%	1.24	0.011	6.72	1.28	0.804	0.89925	YES*	Included in total
61798-70-7	PCB-131		NA	10/106	9%	0.0195	0.003	0.1045	0.0147	0.0155	0.0205	NO	Low FOD
38380-05-1/7447	PCB-132/161		NA	106/106	100%	5.52	0.0306	36.1	6.53	3.34	3.595	YES*	Included in total
PCB-133/142	PCB-133/142		NA	105/106	99%	0.604	0.02015	3.51	0.653	0.385	0.4195	YES*	Included in total
PCB-134/143	PCB-134/143		NA	105/106	99%	1.06	0.0211	6.79	1.22	0.659	0.716	YES*	Included in total
52744-13-5	PCB-135		NA	106/106	100%	2.73	0.0206	17	3.01	1.72	1.875	YES*	Included in total
38411-22-2	PCB-136		NA	106/106	100%	2.72	0.0151	17.6	3.08	1.69	1.93	YES*	Included in total
35694-06-5	PCB-137		NA	105/106	99%	0.917	0.0211	6.57	1.15	0.553	0.583	YES*	Included in total
35065-28-2/7447	PCB-138/163/164		NA	106/106	100%	19.8	0.119	118	21.6	12.5	13.825	YES*	Included in total
PCB-139/149	PCB-139/149		NA	106/106	100%	17.1	0.103	107	18.7	10.8	12.15	YES*	Included in total
34883-41-5	PCB-14		NA	2/106	2%	0.0353	0.00393	0.2135	0.0351	0.0248	0.03675	NO	Low FOD
59291-64-4	PCB-140		NA	101/106	95%	0.129	0.006275	0.594	0.123	0.0878	0.0989	YES*	Included in total
52712-04-6	PCB-141		NA	106/106	100%	3.45	0.0241	24.7	4.31	2.04	2.1675	YES*	Included in total
68194-14-9	PCB-144		NA	105/106	99%	0.941	0.0211	6.76	1.1	0.581	0.63	YES*	Included in total
74472-40-5	PCB-145		NA	27/106	25%	0.0183	0.003	0.071	0.0115	0.0147	0.0201	YES*	Included in total
51908-16-8/7447	PCB-146/165		NA	106/106	100%	2.98	0.0237	17	3.06	1.92	2.15	YES*	Included in total
68194-13-8	PCB-147		NA	105/106	99%	0.615	0.0211	2.41	0.534	0.427	0.496	YES*	Included in total
74472-41-6	PCB-148		NA	91/106	86%	0.054	0.003	0.36	0.0513	0.039	0.0429	YES*	Included in total
2050-68-2	PCB-15		NA	106/106	100%	15.1	0.319	74.8	13.3	10.4	13.05	YES*	Included in total
68194-08-1	PCB-150		NA	98/106	92%	0.0845	0.006275	0.459	0.0761	0.0599	0.0652	YES*	Included in total
52663-63-5	PCB-151		NA	105/106	99%	4.78	0.0211	31.8	5.4	2.97	3.26	YES*	Included in total
68194-09-2	PCB-152		NA	81/106	76%	0.0331	0.003	0.249	0.0334	0.0243	0.022825	YES*	Included in total
35065-27-1	PCB-153		NA	106/106	100%	19.6	0.113	124	21.2	12.4	13.65	YES*	Included in total
60145-22-4	PCB-154		NA	105/106	99%	0.484	0.0211	2.405	0.413	0.338	0.3865	YES*	Included in total
33979-03-2	PCB-155		NA	101/106	95%	0.156	0.006275	2.71	0.352	0.0748	0.074475	YES*	Included in total
38380-08-4	PCB-156		NA	165/169	98%	1.78	0.0211	12.3	2.1	0.999	1.22	YES*	Included in total
69782-90-7	PCB-157		NA	160/169	95%	0.4	0.00924	2.48	0.446	0.239	0.2915	YES*	Included in total
74472-42-7/4141	PCB-158/160		NA	106/106	100%	2.15	0.0145	13.2	2.44	1.32	1.455	YES*	Included in total
39635-35-3	PCB-159		NA	76/106	72%	0.154	0.00393	1.54	0.225	0.0678	0.102125	YES*	Included in total
PCB-16/32	PCB-16/32		NA	106/106	100%	12.5	0.0502	200	22.9	6.2	6.115	YES*	Included in total
41411-63-6	PCB-166		NA	98/106	92%	0.0783	0.003	0.485	0.0875	0.0515	0.054225	YES*	Included in total
52663-72-6	PCB-167		NA	165/169	98%	0.754	0.0078	5.23	0.831	0.443	0.53	YES*	Included in total
59291-65-5	PCB-168		NA	83/106	78%	0.0419	0.003	0.181	0.033	0.0313	0.03015	YES*	Included in total
32774-16-6	PCB-169		NA	28/169	17%	0.0234	0.000745	0.131	0.031	0.0125	0.0142	YES*	Included in total
37680-66-3	PCB-17		NA	106/106	100%	8.93	0.0407	136	16.1	4.41	4.45	YES*	Included in total

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
35065-30-6	PCB-170		NA	144/146	99%	4.71	0.0244	38.1	5.76	2.53	3.215	YES*	Included in total
52663-71-5	PCB-171		NA	106/106	100%	1.39	0.0113	10.8	1.62	0.863	0.96	YES*	Included in total
52663-74-8	PCB-172		NA	105/106	99%	0.854	0.0211	6.86	1	0.534	0.5915	YES*	Included in total
68194-16-1	PCB-173		NA	99/106	93%	0.114	0.0041	0.788	0.13	0.0729	0.08115	YES*	Included in total
38411-25-5	PCB-174		NA	106/106	100%	5.39	0.0343	51.5	7.08	3.19	3.64	YES*	Included in total
40186-70-7	PCB-175		NA	105/106	99%	0.286	0.0138	1.83	0.315	0.184	0.198	YES*	Included in total
52663-65-7	PCB-176		NA	105/106	99%	0.783	0.0211	5.18	0.875	0.494	0.535	YES*	Included in total
52663-70-4	PCB-177		NA	106/106	100%	3.44	0.021	26.7	3.94	2.16	2.4275	YES*	Included in total
52663-67-9	PCB-178		NA	105/106	99%	1.33	0.0211	7.9	1.37	0.865	0.962	YES*	Included in total
52663-64-6	PCB-179		NA	106/106	100%	2.9	0.0185	18.5	3.18	1.84	2.0675	YES*	Included in total
37680-65-2	PCB-18		NA	106/106	100%	18.1	0.0858	342	37.7	8.39	7.82	YES*	Included in total
35065-29-3	PCB-180		NA	145/146	99%	12.7	0.0244	105	15.6	6.8	8.82	YES*	Included in total
74472-47-2	PCB-181		NA	92/106	87%	0.056	0.003	0.488	0.0731	0.0338	0.0353	YES*	Included in total
PCB-182/187	PCB-182/187		NA	105/106	99%	8.6	0.0242	51.8	9.04	5.52	6.365	YES*	Included in total
52663-69-1	PCB-183		NA	106/106	100%	3.47	0.0251	21.9	3.79	2.19	2.4825	YES*	Included in total
74472-48-3	PCB-184		NA	82/106	77%	0.0292	0.003	0.22	0.0257	0.023	0.022975	YES*	Included in total
52712-05-7	PCB-185		NA	105/106	99%	0.629	0.0205	6.1	0.839	0.377	0.4135	YES*	Included in total
74472-49-4	PCB-186		NA	2/106	2%	0.0202	0.003	0.1065	0.0168	0.0156	0.020525	NO	Low FOD
74487-85-7	PCB-188		NA	86/106	81%	0.0342	0.003	0.436	0.0451	0.0248	0.024775	YES*	Included in total
39635-31-9	PCB-189		NA	157/169	93%	0.18	0.002465	1.22	0.191	0.114	0.134	YES*	Included in total
38444-73-4	PCB-19		NA	105/106	99%	1.73	0.0211	31.8	3.53	0.813	0.8155	YES*	Included in total
41411-64-7	PCB-190		NA	105/106	99%	1.01	0.0211	7.24	1.14	0.634	0.6995	YES*	Included in total
74472-50-7	PCB-191		NA	105/106	99%	0.204	0.0106	1.33	0.222	0.132	0.14475	YES*	Included in total
74472-51-8	PCB-192		NA	3/106	3%	0.0201	0.003	0.1065	0.0168	0.0156	0.020525	NO	Low FOD
69782-91-8	PCB-193		NA	105/106	99%	0.619	0.0211	4.18	0.671	0.4	0.4525	YES*	Included in total
35694-08-7	PCB-194		NA	106/106	100%	3.45	0.0269	26.5	4.06	2.16	2.395	YES*	Included in total
52663-78-2	PCB-195		NA	105/106	99%	1.3	0.0211	10.8	1.56	0.809	0.9205	YES*	Included in total
PCB-196/203	PCB-196/203		NA	106/106	100%	4.57	0.0323	30.1	4.79	2.97	3.46	YES*	Included in total
33091-17-7	PCB-197		NA	101/106	95%	0.145	0.00585	1.01	0.159	0.0948	0.101	YES*	Included in total
68194-17-2	PCB-198		NA	104/106	98%	0.249	0.0112	2.14	0.309	0.157	0.16775	YES*	Included in total
52663-75-9	PCB-199		NA	106/106	100%	4.63	0.0276	33.6	5.04	3	3.4725	YES*	Included in total
2051-61-8	PCB-2		NA	105/105	100%	0.328	0.0144	1.3	0.238	0.246	0.29	YES*	Included in total
38444-84-7/5570	PCB-20/21/33		NA	106/106	100%	11.5	0.0361	243	26.1	5.07	4.875	YES*	Included in total
52663-73-7	PCB-200		NA	105/106	99%	0.466	0.0177	3.81	0.574	0.291	0.314	YES*	Included in total
40186-71-8	PCB-201		NA	105/106	99%	0.615	0.0211	4.08	0.659	0.405	0.4675	YES*	Included in total
2136-99-4	PCB-202		NA	106/106	100%	1.32	0.0117	6.95	1.2	0.916	1.07	YES*	Included in total
74472-52-9	PCB-204		NA	12/105	11%	0.0192	0.003	0.1065	0.0153	0.0153	0.0205	YES*	Included in total
74472-53-0	PCB-205		NA	105/106	99%	0.146	0.00633	1.03	0.157	0.0987	0.1065	YES*	Included in total
40186-72-9	PCB-206		NA	106/106	100%	3.94	0.0491	46.7	5.45	2.52	2.87	YES*	Included in total
52663-79-3	PCB-207		NA	105/106	99%	0.346	0.0149	2.51	0.364	0.237	0.2655	YES*	Included in total
52663-77-1	PCB-208		NA	106/106	100%	1.25	0.0198	9.86	1.34	0.853	0.9585	YES*	Included in total
2051-24-3	PCB-209		NA	154/155	99%	4.03	0.0366	93.9	9.87	1.9	2.44	YES*	Included in total
38444-85-8	PCB-22		NA	105/106	99%	9.46	0.0421	158	18.2	4.6	4.51	YES*	Included in total
55720-44-0	PCB-23		NA	55/106	52%	0.0318	0.003	0.42	0.0516	0.0205	0.020475	YES*	Included in total
PCB-24/27	PCB-24/27		NA	105/106	99%	1.97	0.0211	22.6	2.94	1.09	1.19	YES*	Included in total
55712-37-3	PCB-25		NA	106/106	100%	4.33	0.028	37	5.62	2.55	3.11	YES*	Included in total
38444-81-4	PCB-26		NA	106/106	100%	6.47	0.0388	73.4	9.34	3.69	4.3975	YES*	Included in total
7012-37-5	PCB-28		NA	106/106	100%	36.4	0.128	415	53.3	20.6	22.8	YES*	Included in total
15862-07-4	PCB-29		NA	93/106	88%	0.107	0.003	2.09	0.228	0.0542	0.05085	YES*	Included in total
2051-62-9	PCB-3		NA	106/106	100%	0.877	0.0273	4.67	0.777	0.612	0.7755	YES*	Included in total
35693-92-6	PCB-30		NA	17/106	16%	0.0251	0.003	0.205	0.0299	0.0172	0.0207	YES*	Included in total
16606-02-3	PCB-31		NA	106/106	100%	29	0.136	458	52.6	15.1	15.55	YES*	Included in total
37680-68-5	PCB-34		NA	101/106	95%	0.2	0.006275	2.88	0.34	0.112	0.12	YES*	Included in total
37680-69-6	PCB-35		NA	104/106	98%	1.04	0.02055	8.51	1.22	0.626	0.7175	YES*	Included in total
38444-87-0	PCB-36		NA	77/106	73%	0.0381	0.003	0.197	0.028	0.03	0.03335	YES*	Included in total
38444-90-5	PCB-37		NA	106/106	100%	10.4	0.08	94	12.2	6.58	8.005	YES*	Included in total
53555-66-1	PCB-38		NA	98/106	92%	0.191	0.003	1.96	0.238	0.119	0.1315	YES*	Included in total
38444-88-1	PCB-39		NA	93/106	88%	0.0896	0.003	0.456	0.0824	0.0632	0.07345	YES*	Included in total
PCB-4/10	PCB-4/10		NA	104/106	98%	4.02	0.04225	60.1	6.82	2.13	2.595	YES*	Included in total
38444-93-8	PCB-40		NA	100/100	100%	4.5	0.0231	73	8.44	2.17	2.2325	YES*	Included in total
52663-59-9/5266	PCB-41/64/71/72		NA	91/92	99%	23.9	0.02055	318	39.4	12	11.95	YES*	Included in total
36559-22-5/7447	PCB-42/59		NA	106/106	100%	9.71	0.0387	134	16.1	5.12	5.055	YES*	Included in total
PCB-43/49	PCB-43/49		NA	106/106	100%	24.5	0.118	311	38.4	13.4	13.525	YES*	Included in total
41464-39-5	PCB-44		NA	106/106	100%	27.1	0.102	429	49.4	13.4	12.8	YES*	Included in total
70362-45-7	PCB-45		NA	105/106	99%	3.89	0.0211	70.2	7.83	1.78	1.645	YES*	Included in total
41464-47-5	PCB-46		NA	105/106	99%	1.66	0.0211	29.9	3.33	0.778	0.7345	YES*	Included in total
2437-79-8	PCB-47		NA	106/106	100%	10.7	0.0626	144	16.9	6.1	6.655	YES*	Included in total
70362-47-9/3259	PCB-48/75		NA	106/106	100%	5.03	0.019	57.6	7.55	2.64	2.42	YES*	Included in total
PCB-5/8	PCB-5/8		NA	105/106	99%	8.7	0.04225	135	14.7	4.87	5.735	YES*	Included in total
62796-65-0	PCB-50		NA	96/106	91%	0.0941	0.003	1.31	0.161	0.0499	0.0436	YES*	Included in total
68194-04-7	PCB-51		NA	105/106	99%	1.68	0.0211	19.1	2.4	0.953	1.03	YES*	Included in total
35693-99-3/6023	PCB-52/69		NA	106/106	100%	29.5	0.141	386	47.7	15.6	15.4	YES*	Included in total
41464-41-9	PCB-53		NA	106/106	100%	4.15	0.0147	62.1	7.32	2.06	2.0275	YES*	Included in total
15968-05-5	PCB-54		NA	99/106	93%	0.1	0.00448	0.858	0.13	0.0608	0.066	YES*	Included in total
74338-24-2	PCB-55		NA	105/106	99%	0.349	0.0153	3.63	0.488	0.206	0.216	YES*	Included in total

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
PCB-56/60	PCB-56/60		NA	106/106	100%	16.4	0.0751	208	26.6	8.82	8.8775	YES*	Included in total
70424-67-8	PCB-57		NA	103/106	97%	0.183	0.006275	1.59	0.231	0.114	0.125	YES*	Included in total
41464-49-7	PCB-58		NA	100/106	94%	0.0923	0.003	0.49	0.0955	0.0624	0.06945	YES*	Included in total
25569-80-6	PCB-6		NA	104/106	98%	2.26	0.04225	24.2	2.94	1.36	1.7	YES*	Included in total
PCB-61/70	PCB-61/70		NA	106/106	100%	28.9	0.117	383	45.7	15.6	15.95	YES*	Included in total
54230-22-7	PCB-62		NA	0/106	0%	0.0201	0.003	0.1065	0.0166	0.0156	0.02055	NO	ND
74472-34-7	PCB-63		NA	105/106	99%	1.12	0.0169	13.3	1.75	0.609	0.66025	YES*	Included in total
33284-54-7	PCB-65		NA	11/106	10%	0.026	0.003	0.177	0.0289	0.0179	0.020675	YES*	Included in total
73575-53-8	PCB-67		NA	105/106	99%	0.927	0.0141	10.3	1.33	0.525	0.5655	YES*	Included in total
73575-52-7	PCB-68		NA	94/95	99%	0.222	0.00894	3.2	0.354	0.138	0.139	YES*	Included in total
PCB-7/9	PCB-7/9		NA	98/106	92%	0.694	0.01205	11.6	1.33	0.351	0.356	YES*	Included in total
74338-23-1	PCB-73		NA	9/106	8%	0.197	0.003	16.3	1.58	0.0202	0.020725	NO	Low FOD
32690-93-0	PCB-74		NA	106/106	100%	13	0.0556	168	20.3	7.12	7.45	YES*	Included in total
PCB-76/66	PCB-76/66		NA	106/106	100%	27.1	0.126	314	41.1	15.1	16.2	YES*	Included in total
32598-13-3	PCB-77		NA	167/169	99%	3.31	0.0244	28.9	4.14	1.84	2.55	YES*	Included in total
70362-49-1	PCB-78		NA	22/106	21%	0.0367	0.003	0.539	0.0718	0.0191	0.0207	YES*	Included in total
41464-48-6	PCB-79		NA	88/106	83%	0.262	0.0142	2.01	0.307	0.163	0.1735	YES*	Included in total
33284-52-5	PCB-80		NA	0/106	0%	0.0201	0.003	0.1065	0.0166	0.0156	0.02055	NO	Included in total
70362-50-4	PCB-81		NA	158/169	93%	0.193	0.00522	3.42	0.388	0.0861	0.0735	YES*	Included in total
52663-62-4	PCB-82		NA	106/106	100%	3.19	0.0244	28.1	4.43	1.83	1.985	YES*	Included in total
60145-20-2	PCB-83		NA	52/106	49%	0.0257	0.003	0.2	0.0284	0.0181	0.020475	YES*	Included in total
52663-60-2/5266	PCB-84/92		NA	106/106	100%	10.6	0.0651	93.6	14	6.2	6.59	YES*	Included in total
PCB-85/116	PCB-85/116		NA	106/106	100%	4.48	0.0317	41	6.06	2.64	2.965	YES*	Included in total
55312-69-1	PCB-86		NA	101/106	95%	0.195	0.003	2.53	0.334	0.102	0.1065	YES*	Included in total
38380-02-8/6819	PCB-87/117/125		NA	106/106	100%	8.56	0.0561	73.2	11.5	4.97	5.365	YES*	Included in total
PCB-88/91	PCB-88/91		NA	106/106	100%	4.54	0.0274	40.3	5.8	2.73	2.985	YES*	Included in total
73575-57-2	PCB-89		NA	104/106	98%	0.425	0.00765	5.68	0.736	0.225	0.228	YES*	Included in total
PCB-90/101	PCB-90/101		NA	106/106	100%	24.8	0.156	183	30.3	14.9	16.15	YES*	Included in total
73575-56-1	PCB-93		NA	3/106	3%	0.532	0.003	38.9	4.05	0.0178	0.020575	NO	Low FOD
73575-55-0	PCB-94		NA	104/106	98%	0.225	0.006275	1.74	0.26	0.143	0.162	YES*	Included in total
38379-99-6/6023	PCB-95/98/102		NA	106/106	100%	19.2	0.109	154	24.7	11.2	11.95	YES*	Included in total
73575-54-9	PCB-96		NA	103/106	97%	0.243	0.004175	2.93	0.364	0.136	0.1405	YES*	Included in total
41464-51-1	PCB-97		NA	106/106	100%	8.08	0.0513	72.4	10.6	4.75	5.11	YES*	Included in total
38380-01-7	PCB-99		NA	105/106	99%	12.5	0.02055	96.8	14.9	7.41	8.505	YES*	Included in total
12674-11-2	Aroclor-1016	7	NJDEP ESC Table - Freshwater	0/132	0%	76.4	19	750	87.2	57.2	45.25	NO	ND
11104-28-2	Aroclor-1221		NA	0/132	0%	82.5	21.5	750	84.8	65.8	65	NO	ND
11141-16-5	Aroclor-1232		NA	0/132	0%	76.4	19	750	87.2	57.2	45.25	NO	ND
53469-21-9	Aroclor-1242		NA	39/132	30%	123	19	1000	147	84.9	90	YES	NSV
12672-29-6	Aroclor-1248	30	NJDEP ESC Table - Freshwater	74/132	56%	298	18	9100	899	102	100	YES	AboveScreenValue
11097-69-1	Aroclor-1254	60	NJDEP ESC Table - Freshwater	101/132	77%	272	19	4100	464	139	150	YES	AboveScreenValue
11096-82-5	Aroclor-1260	5	NJDEP ESC Table - Freshwater	108/132	82%	127	14	980	158	83.4	80.5	YES	AboveScreenValue
37324-23-5	Aroclor-1262		NA	0/106	0%	87.9	21.5	750	93.9	67.4	72.5	NO	ND
11100-14-4	Aroclor-1268		NA	2/106	2%	87.4	9.8	750	94.2	66.1	72.5	NO	Low FOD
TOT_PCB_ARO(7)	Total Aroclor PCBs (Sum of 7 Aroclors)	22.7	Recommended by Partner Agencies	116/132	88%	729	37	14000	1450	358	370	YES	AboveScreenValue
TOT_PCB_ARO(9)	Total Aroclor PCBs (Sum of 9 Aroclors)	22.7	Recommended by Partner Agencies	104/106	98%	862	37	14000	1590	472	440	YES	AboveScreenValue
TPCB Cong-209	Total PCB Congeners (209)	22.7	Recommended by Partner Agencies	106/106	100%	762	4.53	7700	1020	446	478.25	YES	AboveScreenValue
TPCB CongNOAA89	Total PCB Congeners (NOAA 1989)		NA	106/106	100%	566	3.05	5520	746	332	353	YES	NSV
WHOPCBTEQ(B)	Total PCB TEQ (Bird)		NA	169/169	100%	0.198	0.004	1.87	0.254	0.114	0.141	YES	NSV
WHOPCBTEQ(F)	Total PCB TEQ (Fish)		NA	169/169	100%	0.00116	0	0.01	0.00141	0.00121	0.001	YES	NSV
WHOPCBTEQ(H)	Total PCB TEQ (Human/Mammal)		NA	169/169	100%	0.0137	0	0.096	0.0143	0.00941	0.011	YES	NSV
Semivolatile Organic Compounds (µg/kg)													
95-94-3	1,2,4,5-Tetrachlorobenzene	1252	NJDEP ESC Table - Freshwater	0/38	0%	215	115	850	122	199	190	NO	ND
120-82-1	1,2,4-Trichlorobenzene	4.8	NJDEP ESC Table - Marine	20/111	18%	524	13	4450	824	84.7	54	YES	AboveScreenValue
95-50-1	1,2-Dichlorobenzene	13	NJDEP ESC Table - Marine	11/111	10%	627	17	4450	790	139	250	NO	Low FOD
541-73-1	1,3-Dichlorobenzene	1315	NJDEP ESC Table - Freshwater	14/111	13%	619	19	4450	794	133	230	YES	AboveScreenValue
106-46-7	1,4-Dichlorobenzene	110	NJDEP ESC Table - Marine	46/114	40%	504	8.8	4450	789	102	125	YES	AboveScreenValue
90-12-0	1-Methylnaphthalene		NA	13/14	93%	46.9	2.5	130	33.6	34.3	42	YES	NSV
540-54-5	2,2-oxybis(1-Chloropropane)		NA	0/149	0%	547	110	4450	696	371	325	NO	ND
58-90-2	2,3,4,6-Tetrachlorophenol	284	USEPA Reg 3 - Freshwater	0/38	0%	215	115	850	122	199	190	NO	ND
95-95-4	2,4,5-Trichlorophenol	3	NJDEP ESC Table - Marine	0/152	0%	540	110	4450	691	365	325	NO	ND
88-06-2	2,4,6-Trichlorophenol	6	NJDEP ESC Table - Marine	0/152	0%	540	110	4450	691	365	325	NO	ND
120-83-2	2,4-Dichlorophenol	5	NJDEP ESC Table - Marine	0/149	0%	547	110	4450	696	371	325	NO	ND
105-67-9	2,4-Dimethylphenol	304	NJDEP ESC Table - Freshwater	1/149	1%	545	100	4450	697	367	325	NO	Low FOD
51-28-5	2,4-Dinitrophenol	6.21	NJDEP ESC Table - Freshwater	0/149	0%	2490	220	22500	3660	1360	1350	NO	ND
121-14-2	2,4-Dinitrotoluene	14.4	NJDEP ESC Table - Freshwater	0/152	0%	459	38	4450	714	229	195	NO	ND
606-20-2	2,6-Dinitrotoluene	39.8	USEPA Reg 5	0/149	0%	465	38	4450	720	230	200	NO	ND
91-58-7	2-Chloronaphthalene	417	NJDEP ESC Table - Freshwater	0/149	0%	547	110	4450	696	371	325	NO	ND
95-57-8	2-Chlorophenol	8	NJDEP ESC Table - Marine	0/149	0%	547	110	4450	696	371	325	NO	ND
91-57-6	2-Methylnaphthalene	70	NJDEP ESC Table - Marine	111/164	68%	366	6.6	4450	679	148	105	YES	AboveScreenValue
95-48-7	2-Methylphenol	55.4	USEPA Reg 5	0/152	0%	540	110	4450	691	365	325	NO	ND
88-74-4	2-Nitroaniline		NA	0/149	0%	701	110	4450	700	538	485	NO	ND
88-75-5	2-Nitrophenol		NA	0/149	0%	547	110	4450	696	371	325	NO	ND
108-39-4/106-44	3&4-Methylphenol	670	USEPA Reg 3 - Freshwater	0/3	0%	165	165	165	0	165	165	NO	ND
91-94-1	3,3'-Dichlorobenzidine	127	NJDEP ESC Table - Freshwater	0/149	0%	1040	115	9000	1430	621	650	NO	ND
99-09-2	3-Nitroaniline		NA	0/149	0%	1090	215	9000	1400	735	650	NO	ND

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
534-52-1	4,6-Dinitro-2-methylphenol	104	USEPA Reg 5	0/149	0%	1690	220	14000	2140	1080	1150	NO	ND
101-55-3	4-Bromophenyl phenyl ether	1230	USEPA Reg 3 - Freshwater	0/109	0%	616	110	4450	790	392	395	NO	ND
59-50-7	4-Chloro-3-Methylphenol	388	USEPA Reg 5	0/149	0%	547	110	4450	696	371	325	NO	ND
106-47-8	4-Chloroaniline	146	USEPA Reg 5	45/149	30%	436	12	4450	640	248	225	YES	AboveScreenValue
7005-72-3	4-Chlorophenyl phenyl ether		NA	0/149	0%	547	110	4450	696	371	325	NO	ND
106-44-5	4-Methylphenol	670	USEPA Reg 3 - Freshwater	37/149	25%	474	8.8	4450	716	235	210	YES	AboveScreenValue
100-01-6	4-Nitroaniline		NA	0/149	0%	1090	215	9000	1400	735	650	NO	ND
100-02-7	4-Nitrophenol	13.3	NJDEP ESC Table - Freshwater	0/149	0%	1690	220	14000	2140	1080	1150	NO	ND
83-32-9	Acenaphthene	16	NJDEP ESC Table - Marine	120/180	67%	614	7.9	11000	1210	210	180	YES	AboveScreenValue
208-96-8	Acenaphthylene	44	NJDEP ESC Table - Marine	164/180	91%	454	8.6	4950	741	235	230	YES	AboveScreenValue
98-86-2	Acetophenone		NA	6/38	16%	211	56	850	138	183	190	YES	NSV
120-12-7	Anthracene	85	NJDEP ESC Table - Marine	171/179	96%	737	18	7400	1130	408	380	YES	AboveScreenValue
1912-24-9	Atrazine	6.62	USEPA Reg 3 - Freshwater	0/38	0%	215	115	850	122	199	190	NO	ND
100-52-7	Benzaldehyde		NA	14/38	37%	166	34	850	133	133	172.5	YES	NSV
56-55-3	Benzo(a)anthracene	261	NJDEP ESC Table - Marine	179/179	100%	1590	34	20000	2320	966	910	YES	AboveScreenValue
50-32-8	Benzo(a)pyrene	430	NJDEP ESC Table - Marine	179/179	100%	1560	29	15000	1820	1060	1000	YES	AboveScreenValue
205-99-2	Benzo(b)fluoranthene	1800	NJDEP ESC Table - Marine	179/179	100%	1630	19	23000	2320	1050	1000	YES	AboveScreenValue
192-97-2	Benzo(e)pyrene		NA	14/14	100%	812	53	1400	393	651	820	YES	NSV
191-24-2	Benzo(g,h,i)perylene	170	NJDEP ESC Table - Freshwater	178/179	99%	754	16	7400	830	519	510	YES	AboveScreenValue
207-08-9	Benzo(k)fluoranthene	240	NJDEP ESC Table - Freshwater	176/179	98%	1230	27	16000	1580	802	770	YES	AboveScreenValue
92-52-4	Biphenyl	1220	USEPA Reg 3 - Freshwater	16/52	31%	155	1.7	850	141	86.5	172.5	NO	BelowScreenValue
111-91-1	bis(2-Chloroethoxy)methane		NA	0/149	0%	547	110	4450	696	371	325	NO	ND
111-44-4	bis(2-Chloroethyl)ether	3520	NJDEP ESC Table - Freshwater	1/149	1%	455	19	4450	725	190	195	NO	Low FOD
117-81-7	bis(2-ethylhexyl phthalate)	182.16	Recommended by Partner Agencies	144/149	97%	5830	80	71000	10600	2540	2700	YES	AboveScreenValue
85-68-7	Butyl benzyl phthalate	63	NJDEP ESC Table - Marine	38/149	26%	511	38	4450	697	302	325	YES	AboveScreenValue
105-60-2	Caprolactam		NA	1/38	3%	213	115	850	123	197	190	NO	Low FOD
86-74-8	Carbazole		NA	82/149	55%	430	8.7	4450	761	172	170	YES	NSV
218-01-9	Chrysene	384	NJDEP ESC Table - Marine	179/179	100%	1970	29	45000	3930	1130	1035	YES	AboveScreenValue
53-70-3	Dibenzo(a,h)anthracene	63	NJDEP ESC Table - Marine	143/179	80%	389	9.6	4950	706	198	180	YES	AboveScreenValue
132-64-9	Dibenzofuran	7300	USEPA Reg 3 - Marine	84/163	52%	426	2.5	4450	719	173	150	NO	BelowScreenValue
132-65-0	Dibenzothiophene		NA	13/14	93%	76.8	2.5	210	67.3	49.3	56	YES	NSV
84-66-2	Diethyl phthalate	6	NJDEP ESC Table - Marine	1/149	1%	547	110	4450	696	371	325	NO	Low FOD
131-11-3	Dimethylphthalate		NA	0/149	0%	547	110	4450	696	371	325	NO	ND
84-74-2	Di-n-Butylphthalate	58	NJDEP ESC Table - Marine	17/149	11%	634	37	5100	892	379	335	YES	AboveScreenValue
117-84-0	Di-n-Octylphthalate	40600	USEPA Reg 5	16/141	11%	580	47	4450	742	376	380	NO	BelowScreenValue
206-44-0	Fluoranthene	600	NJDEP ESC Table - Marine	179/179	100%	3840	34	210000	16000	1550	1400	YES	AboveScreenValue
86-73-7	Fluorene	19	NJDEP ESC Table - Marine	123/180	68%	453	5.6	4950	813	181	155	YES	AboveScreenValue
118-74-1	Hexachlorobenzene	20	Recommended by Partner Agencies	7/153	5%	396	1.6	4450	736	76.9	55	NO	Low FOD
87-68-3	Hexachlorobutadiene	1.3	NJDEP ESC Table - Marine	0/152	0%	459	38	4450	714	229	195	NO	ND
77-47-4	Hexachlorocyclopentadiene	901	NJDEP ESC Table - Freshwater	0/118	0%	1620	135	14000	2390	810	850	NO	ND
67-72-1	Hexachloroethane	73	NJDEP ESC Table - Marine	0/152	0%	449	19	4450	719	187	192.5	NO	ND
193-39-5	Indeno(1,2,3-cd)pyrene	200	NJDEP ESC Table - Freshwater	174/179	97%	718	13	6300	787	486	490	YES	AboveScreenValue
78-59-1	Isophorone	432	NJDEP ESC Table - Freshwater	0/149	0%	547	110	4450	696	371	325	NO	ND
91-20-3	Naphthalene	160	NJDEP ESC Table - Marine	141/180	78%	600	18	6400	1010	272	230	YES	AboveScreenValue
98-95-3	Nitrobenzene	145	NJDEP ESC Table - Freshwater	3/152	2%	451	19	4450	718	191	195	NO	Low FOD
621-64-7	N-Nitroso-di-n-propylamine		NA	0/149	0%	455	19	4450	725	188	195	NO	ND
86-30-6	N-Nitrosodiphenylamine	422000	USEPA Reg 3 - Marine	6/149	4%	519	73	4450	668	355	325	NO	Low FOD
87-86-5	Pentachlorophenol	17	NJDEP ESC Table - Marine	0/153	0%	1580	4.7	14000	2180	455	1100	NO	ND
198-55-0	Perylene		NA	14/14	100%	322	23	600	149	262	325	YES	NSV
85-01-8	Phenanthrene	240	NJDEP ESC Table - Marine	173/179	97%	1080	25	31000	3090	499	440	YES	AboveScreenValue
108-95-2	Phenol	130	NJDEP ESC Table - Marine	5/149	3%	533	110	4450	694	359	325	NO	Low FOD
129-00-0	Pyrene	665	NJDEP ESC Table - Marine	179/179	100%	3770	65	150000	11500	1930	1800	YES	AboveScreenValue
110-86-1	Pyridine	106	USEPA Reg 5	0/3	0%	850	850	850	0	850	850	NO	ND
THMW PAHs-SVOC	Total HMW PAHs-SVOC	1700	Recommended by Partner Agencies	179/180	99%	17100	0	470000	38100	9930	9500	YES	AboveScreenValue
TLMW PAHs-SVOC	Total LMW PAHs-SVOC	552	Recommended by Partner Agencies	160/164	98%	2700	8.6	44000	5460	1380	1325	YES	AboveScreenValue
TOT_PAH_SVOC	TOTAL PAHs - SVOC	4000	Recommended by Partner Agencies	164/164	100%	19300	290	520000	44500	10800	11000	YES	AboveScreenValue
TEPH	TEPH		NA	67/67	100%	1340000	67000	9700000	1610000	843000	930000	YES	NSV
TPH	Total Petroleum Hydrocarbons		NA	39/39	100%	1220000	280000	5400000	1020000	982000	900000	YES	NSV
Volatile Organic Compounds (µg/kg)													
71-55-6	1,1,1-Trichloroethane	213	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
79-34-5	1,1,2,2-Tetrachloroethane	850	NJDEP ESC Table - Freshwater	0/66	0%	14.1	3	450	54.6	7.13	7	NO	ND
79-00-5	1,1,2-Trichloroethane	518	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
75-34-3	1,1-Dichloroethane	0.575	USEPA Reg 5	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
75-35-4	1,1-Dichloroethene	19.4	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
87-61-6	1,2,3-Trichlorobenzene	858	USEPA Reg 3 - Freshwater	0/38	0%	9.43	4.85	14.5	2.34	9.14	9.5	NO	ND
120-82-1	1,2,4-Trichlorobenzene	4.8	NJDEP ESC Table - Marine	0/38	0%	9.43	4.85	14.5	2.34	84.7	54	NO	ND
95-50-1	1,2-Dichlorobenzene	13	NJDEP ESC Table - Marine	0/38	0%	9.43	4.85	14.5	2.34	139	250	NO	ND
107-06-2	1,2-Dichloroethane	260	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
540-59-0	1,2-Dichloroethene (total)	654	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
78-87-5	1,2-Dichloropropane	333	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
541-73-1	1,3-Dichlorobenzene	1315	NJDEP ESC Table - Freshwater	0/38	0%	9.43	4.85	14.5	2.34	133	230	NO	ND
106-46-7	1,4-Dichlorobenzene	110	NJDEP ESC Table - Marine	2/38	5%	9.32	4.85	14.5	2.24	102	125	NO	Low FOD

Table 4-2  
Surficial Sediment COPEC Screen

CAS Number	Analyte	Screening Value	Basis	Detects/Total Samples	Frequency of Detects	Mean Concentration	Minimum Concentration	Maximum Concentration	Standard Deviation	Geometric Mean	Median	COPEC?	Rationale
78-93-3	2-Butanone	42.4	USEPA Reg 5	19/35	54%	51.6	7	900	150	21.9	16	YES	AboveScreenValue
591-78-6	2-Hexanone	58.2	USEPA Reg 5	0/67	0%	27.9	5.5	900	108	14.2	13.5	NO	ND
108-10-1	4-Methyl-2-pentanone	25.1	USEPA Reg 5	0/67	0%	27.9	5.5	900	108	14.2	13.5	NO	ND
67-64-1	Acetone	9.9	USEPA Reg 5	66/66	100%	85.4	8	580	101	54.6	51.5	YES	AboveScreenValue
71-43-2	Benzene	340	NJDEP ESC Table - Marine	7/70	10%	13.1	0.67	450	53.1	6.32	6.25	NO	Low FOD
75-27-4	Bromodichloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
75-25-2	Bromoform	492	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
74-83-9	Bromomethane	1.37	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
75-15-0	Carbon disulfide	0.851	USEPA Reg 3 - Freshwater	44/67	66%	19.1	2	450	57.1	8.2	7	YES	AboveScreenValue
56-23-5	Carbon tetrachloride	1450	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
108-90-7	Chlorobenzene	291	NJDEP ESC Table - Freshwater	24/108	22%	13.5	2.5	450	43.2	7.82	7	YES	AboveScreenValue
75-00-3	Chloroethane		NA	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
67-66-3	Chloroform	121	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
74-87-3	Chloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
10061-01-5	cis-1,3-Dichloropropene		NA	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
124-48-1	Dibromochloromethane		NA	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
100-41-4	Ethylbenzene	1400	NJDEP ESC Table - Marine	2/67	3%	14.3	2	450	54.3	7.14	7	NO	Low FOD
75-09-2	Methylene chloride	159	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
100-42-5	Styrene	254	NJDEP ESC Table - Freshwater	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
127-18-4	Tetrachloroethene	450	NJDEP ESC Table - Marine	1/70	1%	13.4	2.5	450	53.1	6.75	6.625	NO	Low FOD
108-88-3	Toluene	2500	NJDEP ESC Table - Marine	5/67	7%	14.7	3	450	54.6	7.13	6.75	NO	Low FOD
10061-02-6	trans-1,3-Dichloropropene	7.31	USEPA Reg 3 - Marine	0/67	0%	14	3	450	54.2	7.12	7	NO	ND
79-01-6	Trichloroethene	1600	NJDEP ESC Table - Marine	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
75-01-4	Vinyl chloride	202	NJDEP ESC Table - Freshwater	0/70	0%	13.5	2.5	450	53.1	6.8	6.625	NO	ND
1330-20-7	Xylene (Total)	120	NJDEP ESC Table - Marine	3/67	4%	14.7	3	450	54.4	7.4	7	NO	Low FOD

Notes:

Data from Phase I and Phase II Sediment Investigations (Tierra 2010) and Honeywell International Sampling Investigation (2006).

Surficial sediment is top 0-0.5 feet.

A value of one-half the detection limit is used for non-detects in the dataset and in the summary statistics above.

Bold and shaded cells indicate detected concentrations exceed screening values.

Bold values indicate non-detected concentrations exceed screening values.

Calcium, magnesium, potassium, and sodium, considered essential nutrients and eliminated as COPECs.

Database totals calculated as follows:

Total WHO Dioxin TEQ (Bird): Sum of WHO Dioxin TEQ (bird)

Total WHO Dioxin TEQ (Fish): Sum of WHO Dioxin TEQ (fish)

Total WHO Dioxin TEQ (Human/Mammal): Sum of WHO Dioxin TEQ (human/mammal)

Total DDT (2,4 & 4,4): Sum of 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

Total DDT (2,4): Sum of 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT.

Total DDT (4,4): Sum of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

Total Alpha + Gamma Chlordane: Sum of Alpha-Chlordane and Gamma-Chlordane.

Total Aroclor PCBs (Sum of 7 Aroclors): Sum of Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260.

Total Aroclor PCBs (Sum of 9 Aroclors): Sum of Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260, Aroclor-1262, and Aroclor-1268.

Total PCB Congeners (209): Sum of 209 individual congener PCBs. Co-elutions included at full value.

Total PCB Congeners (NOAA 1989): Two times the sum of congener PCB numbers 8, 18, 28, 44, 52, 66, 101, 105, 77, 118, 126, 128, 138, 153, 170, 180, 187, 195, 206, and 209 coelutions included at full value.

Total PCB TEQ (Bird): Sum of WHO PCB TEQ (bird)

Total PCB TEQ (Fish): Sum of WHO PCB TEQ (fish)

Total PCB TEQ (Human/Mammal): Sum of WHO PCB TEQ (human/mammal)

Total HMW PAHs-SVOC: Sum of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Total LMW PAHs-SVOC: Sum of naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

TOTAL PAHs-SVOC: Sum of LMW PAHs and Total HMW PAHs.

Acronyms and Abbreviations:

COPEC = constituent of potential ecological concern

NJDEP ESC = New Jersey Department of Environmental Protection Ecological Screening Criteria

NA = not available

USEPA = United States Environmental Protection Agency

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

ND = non-detect, eliminated as COPEC

Low FOD = low frequency of detection (<10%), eliminated as COPEC

NSV = no screening value, retained as COPEC

YES = retained as COPEC

YES\* = individual congeners retained as COPEC in sum (i.e., total PCBs)

NO = eliminated as COPEC

Screening values selected, based on the following hierarchy:

1. Recommended by Partner Agencies: Ecological sediment screening levels for saline waters —as recommended by the Partner Agencies for the Lower Passaic River in email correspondence to Scott Kirchner of CDM dated May 26, 2011.

2. NJDEP ESC Table - Marine: NJDEP Ecological Screening Criteria (ESC) for Marine Sediment. March 2009.

3. NJDEP ESC Table - Freshwater: NJDEP Ecological Screening Criteria (ESC) for Freshwater Sediment. March 2009.

4. USEPA Reg 3 - Marine: USEPA Region 3 Marine Sediment Screening Benchmarks. July 2006.

5. USEPA Reg 3 - Freshwater: USEPA Region 3 Freshwater Sediment Screening Benchmarks. August 2006.

6. USEPA Reg 5: USEPA Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels. August 2003.

Sources:

Honeywell. 1999-2006 . *Offshore Investigation Results Summary Report*.

Tierra. 2013. *Phase I and Phase II Data Evaluation and Analysis Report. Newark Bay Study Area Remedial Investigation*. Revision 1. Tierra Solutions, Inc., East Brunswick, New Jersey. April.

**Table 4-3**  
**Candidate Assessment Endpoints, Measurement Endpoints, and Data Needs Based on BHHRA Workshop Discussions**

Receptor Group and Assessment Endpoint	Risk Question	Candidate Measurement Endpoint	Data Use Objective	Proposed Biological Data/Media to be Sampled	Background Evaluation?
<b>Assessment Endpoint No. 1 -</b> Survival and/or growth of aquatic plants and maintenance of plants as a food resource and habitat for fish and wildlife	Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival and growth of aquatic plants?	COPEC concentrations in sediment and surface water collected from the NBSA as compared with available and relevant toxicological benchmarks	Estimating the exposure of plants via direct contact and uptake of COPECs in surface water and sediment	Surface water and surficial sediment chemistry and conventional parameters from the NBSA	None
<b>Assessment Endpoint No. 2 -</b> Survival, growth, and/or reproduction of invertebrates	Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?	Community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) and ecosystem characteristics data (e.g., grain size, TOC, and other attributes) from Newark Bay as compared with appropriate regional reference area background datasets using diversity indices, multivariate, and spatial statistical techniques	Evaluating the data in the context of the overall health of the benthic community using the sediment quality triad (SQT) approach, a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics	Benthic invertebrate taxonomic survey and identification data	Regional background datasets
	Are COPECs in invertebrate tissues from the NBSA greater than tissue benchmarks (i.e., critical body residues [CBRs]) for the survival, growth, and/or reproduction of invertebrates?	Chemical concentrations in laboratory-exposed and/or site-collected invertebrate tissues (e.g., <i>Nereis virens</i> , <i>Crassostrea virginica</i> ) as compared with literature-based CBRs	Assessing adverse effects of chemicals on the invertebrate community	Whole-body benthic infaunal invertebrate tissue from 28-day laboratory and/or field bioaccumulation tests using NBSA surface sediment	None
	Are COPEC concentrations in sediments from the BAZ greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	Chemical concentrations in sediment as compared with toxicological sediment benchmarks from the literature	Evaluating the effects of chemical concentrations in sediment on the benthic invertebrate community of the NBSA	Surficial sediment (from the biologically active zone [BAZ]) chemistry and conventional parameters	None
	Is the survival, growth, and/or reproduction of invertebrates exposed to whole sediments from the BAZ of the NBSA significantly lower than that in reference sediments?	Laboratory toxicity tests (e.g., a 10-day survival and growth study with <i>Ampelisca abdita</i> , a 28-day study with <i>Leptocheirus plumulosus</i> for survival, growth, and reproduction; and/or a caged <i>in situ</i> study with eastern oyster for reproduction) using NBSA surface sediment statistically compared to bioassays conducted with control sediment	Assessing the adverse effects of chemicals (and evaluation of conventional parameters such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community	Surficial sediment (from the BAZ) chemistry and conventional parameters	Regional background datasets
	Are COPEC concentrations in pore water and surface water from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	Dissolved chemical concentrations in pore and surface water collected from benthic invertebrate exposure areas as compared with toxicological benchmarks	Estimating the exposure of the benthic invertebrate community to COPECs the surface and pore water exposure pathways	Surface water collected from two depth intervals (one sample from near the sediment-water interface and one sample from 2 feet below the water's surface) and pore water samples	None

**Table 4-3**  
**Candidate Assessment Endpoints, Measurement Endpoints, and Data Needs Based on BHHERA Workshop Discussions**

Receptor Group and Assessment Endpoint	Risk Question	Candidate Measurement Endpoint	Data Use Objective	Proposed Biological Data/Media to be Sampled	Background Evaluation?
<b>Assessment Endpoint No. 3 -</b> Survival, growth, and/or reproduction of reptiles	Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival, growth, and/or reproduction of reptiles?	COPEC concentrations in sediment and surface water collected from the NBSA as compared with available and relevant toxicological benchmarks	Estimating the exposure of reptiles via direct contact and uptake of COPECs in surface water and sediment	Surface water and surficial sediment chemistry and conventional parameters from the NBSA	None
<b>Assessment Endpoint No. 4 -</b> Survival, growth, and/or reproduction of fish	Are COPEC concentrations in fish tissues from the NBSA greater than critical tissue values (i.e., CBRs) for the survival, growth, and/or reproduction of fish?	Whole-body chemical analyses, liver and other tissue (including bile, gut contents) chemical analyses, and external health observations of identified fish receptors as compared with literature-based critical body residues and/or with whole-body fish tissue chemical concentrations of selected receptors from background locations	Estimating the exposure of fish to COPECs in the NBSA	Whole-body fish tissue chemical concentrations, liver chemical concentrations, gross histological analysis, and gross histology of representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory)	Representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory) from background locations
	Are COPEC concentrations in pore water, surface water, and sediment from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of fish?	Chemical concentrations in dissolved pore water and surface water collected from the NBSA as compared with toxicological benchmarks	Estimating the exposure of fish via the surface water exposure pathway to chemicals in surface water	Data (chemical and conventional parameters such as DO, salinity, pH, hardness) collected as part of the surface water monitoring program	None
		Chemical concentrations in sediment as compared with toxicological sediment benchmarks from the literature	Evaluating the effects of chemical concentrations in sediment on fish populations in the NBSA	Surface sediment collected from the BAZ	None
		Reproductive health of fish collected from both the NBSA and a reference location assessed via morphology and/or biomarkers (e.g., GSI, gonad condition and fecundity estimates, and vitellogenin) and/or laboratory reproductive bioassays using mummichog or white perch	Evaluating the potential effects of chemical constituents on reproduction of NBSA fish	Fish collected from the NBSA	Fish collected from a background location

**Table 4-3**  
**Candidate Assessment Endpoints, Measurement Endpoints, and Data Needs Based on BHHRA Workshop Discussions**

Receptor Group and Assessment Endpoint	Risk Question	Candidate Measurement Endpoint	Data Use Objective	Proposed Biological Data/Media to be Sampled	Background Evaluation?
<b>Assessment Endpoint No. 5 -</b> Survival, growth, and/or reproduction of birds	Does the daily dose of COPECs received by birds (including piscivorous, benthivorous/sediment-probing, omnivorous, insectivorous birds) from consumption of the tissues of prey species and from other media in the NBSA exceed the toxicity reference values (TRVs) for survival, growth, and/or reproduction of birds? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of birds?	Receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue as compared with literature-based dietary dose toxicity reference values (TRVs). COPEC concentrations in bird egg tissues may also be collected and compared to CBRs for bird eggs.	Estimating exposure of bird receptors via various exposure pathways to chemicals in surface water, sediment, and prey tissue. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet. Bird egg tissue from the NBSA.	None
<b>Assessment Endpoint No. 6 -</b> Survival, growth, and/or reproduction of mammals	Does the daily dose of COPECs received by mammals (including piscivorous, omnivorous, and insectivorous) from consumption of the tissues of prey species and from other media in the NBSA exceed the TRVs for survival, growth, and/or reproduction of mammals? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of mammals?	Receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue as compared with literature-based dietary dose TRVs	Estimating exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet	None

**Acronyms and Abbreviations:**

BAZ = biologically active zone  
COPEC = constituent of potential ecological concern  
DO = dissolved oxygen  
GSI = gonadosomatic index  
NBSA = Newark Bay Study Area  
SQT = sediment quality triad  
TOC = total organic carbon  
TRV = toxicity reference value  
USEPA = US Environmental Protection Agency

**Table 4-4<sup>a</sup>**  
**Final Selected Assessment Endpoints, Measurement Endpoints, and Data Needs to Support the BERA**

Receptor Group and Assessment Endpoint	Risk Question	Final Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled	Background Evaluation?	Representative Species	Anticipated Data Collection Timeframe
<b>Assessment Endpoint No. 1 -</b> Survival and/or growth of aquatic plants and maintenance of plants as a food resource and habitat for fish and wildlife	Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival and growth of aquatic plants?	COPEC concentrations in sediment and surface water collected from the NBSA as compared with available and relevant toxicological benchmarks	Estimating the exposure of plants via direct contact and uptake of COPECs in surface water and sediment	Surface water and surficial sediment chemistry and conventional parameters from the NBSA	None	NA	Spring/Summer 2014
<b>Assessment Endpoint No. 2 -</b> Survival, growth, and/or reproduction of invertebrates	Are invertebrate communities in the NBSA different from those found in similar nearby water bodies with chemical concentrations at regional background levels?	Community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) and ecosystem characteristics data (e.g., grain size, TOC, and other attributes) from Newark Bay as compared with appropriate regional reference area background datasets using diversity indices, multivariate, and spatial statistical techniques	Evaluating the data in the context of the overall health of the benthic community using the sediment quality triad (SQT) approach, a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics	Benthic invertebrate taxonomic survey and identification data	Regional background datasets	NA	Spring through Fall 2014
	Are COPECs in invertebrate tissues from the NBSA greater than tissue benchmarks (e.g., critical body residues [CBRs]) for the survival, growth, and/or reproduction of invertebrates?	COPEC concentrations in laboratory-exposed and/or site-collected invertebrate tissues (e.g., <i>Nereis virens</i> , <i>Mya arenaria</i> ) as compared with literature-based CBRs	Assessing adverse effects of COPECs on the invertebrate community	Site-collected invertebrate tissue from softshell clams ( <i>M. arenaria</i> ) and/or blue crabs; whole-body benthic infaunal invertebrate tissue from 28-day laboratory and/or field bioaccumulation tests using NBSA surface sediment	None	Polychaetes - <i>Nereis virens</i> Softshell clam - <i>Mya arenaria</i> Hard clam - <i>Macoma</i> sp.	Spring through Fall 2014
	Are COPEC concentrations in sediments from the BAZ greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	COPEC concentrations in sediment as compared with toxicological sediment benchmarks from the literature	Evaluating the effects of COPEC concentrations in sediment on the benthic invertebrate community of the NBSA	Surficial sediment (from the biologically active zone [BAZ]) chemistry and conventional parameters	None	NA	Spring through Fall 2014
	Is the survival, growth, and/or reproduction of invertebrates exposed to whole sediments from the BAZ of the NBSA significantly lower than that in reference sediments?	Laboratory toxicity tests (a 10-day survival and growth study with <i>Ampelisca abdita</i> and a 28-day study with <i>Leptocheirus plumulosus</i> for survival, growth, and reproduction) using NBSA surface sediment statistically compared to bioassays conducted with control sediment	Assessing the adverse effects of chemicals (and evaluation of conventional parameters such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community	Surficial sediment (from the BAZ) chemistry and conventional parameters	Regional background datasets	<i>Ampelisca abdita</i> <i>Leptocheirus plumulosus</i>	Spring through Fall 2014
	Are COPEC concentrations in pore water and surface water from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of invertebrates?	Dissolved COPEC concentrations in pore and surface water collected from benthic invertebrate exposure areas as compared with toxicological benchmarks	Estimating the exposure of the benthic invertebrate community to COPECs the surface and pore water exposure pathways	Surface water collected from two depth intervals (one sample from near the sediment water interface and one sample from 2 feet below the water's surface) and pore water samples	None	NA	Spring through Fall 2014

**Table 4-4<sup>a</sup>**  
**Final Selected Assessment Endpoints, Measurement Endpoints, and Data Needs to Support the BERA**

Receptor Group and Assessment Endpoint	Risk Question	Final Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled	Background Evaluation?	Representative Species	Anticipated Data Collection Timeframe
<b>Assessment Endpoint No. 3 -</b> Survival, growth, and/or reproduction of reptiles	Are COPEC concentrations in site surface water and sediment at levels that might adversely affect survival, growth, and/or reproduction of reptiles?	COPEC concentrations in sediment and surface water collected from the NBSA as compared with available and relevant toxicological benchmarks	Estimating the exposure of reptiles via direct contact and uptake of COPECs in surface water and sediment	Surface water and surficial sediment chemistry and conventional parameters from the NBSA	None	NA	Spring 2014
<b>Assessment Endpoint No. 4 -</b> Survival, growth, and/or reproduction of fish	Are COPEC concentrations in fish tissues from the NBSA greater than CBRs for the survival, growth, and/or reproduction of fish?	Whole-body chemical analyses, liver and other tissue (including bile, gut contents) chemical analyses, and external health observations of identified fish receptors as compared with literature-based critical body residues and/or with whole-body fish tissue chemical concentrations of selected receptors from background locations	Estimating the exposure of fish to COPECs in the NBSA	Whole-body fish tissue chemical concentrations, liver chemical concentrations, gross histological analysis, and gross histology of representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory)	Representative species from each of three trophic levels (forage fish, benthic/demersal, and pelagic predatory) from background locations	TBD (Examples include mummichog, flounder, white perch)	One event each season for 1 calendar year: Fall 2013, Winter 2013, Spring 2014, Summer 2014
	Are COPEC concentrations in pore water, surface water, and sediment from the NBSA greater than benchmarks for the survival, growth, and/or reproduction of fish?	COPEC concentrations in dissolved pore water and surface water collected from the NBSA as compared with toxicological benchmarks	Estimating the exposure of fish via the surface water exposure pathway to COPECs in surface water	Data (chemical and conventional parameters such as DO, salinity, pH, hardness) collected as part of the surface water monitoring program	None	NA	Spring through Fall 2014
		COPEC concentrations in sediment as compared with toxicological sediment benchmarks from the literature	Evaluating the effects of COPEC concentrations in sediment on fish populations in the NBSA	Surface sediment collected from the BAZ	None	NA	Spring through Fall 2014
		Reproductive health of fish collected from both the NBSA and a reference location assessed via morphology (e.g., GSI, gonad condition), ichthyoplankton trawls	Evaluating the potential effects of COPECs on reproduction of NBSA fish	Fish and ichthyoplankton collected from the NBSA	Fish collected from background reference locations	NA	Spring through Fall 2014

**Table 4-4<sup>a</sup>**  
**Final Selected Assessment Endpoints, Measurement Endpoints, and Data Needs to Support the BERA**

Receptor Group and Assessment Endpoint	Risk Question	Final Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled	Background Evaluation?	Representative Species	Anticipated Data Collection Timeframe
<b>Assessment Endpoint No. 5 -</b> Survival, growth, and/or reproduction of birds	Does the daily dose of COPECs received by birds (including piscivorous, benthivorous/sediment-probing, omnivorous, insectivorous birds) from consumption of the tissues of prey species and from other media in the NBSA exceed the toxicity reference values (TRVs) for survival, growth, and/or reproduction of birds? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of birds?	Receptor-specific modeled daily doses associated with the ingestion of COPECs in surface water, sediment, and prey tissue as compared with literature-based dietary dose toxicity reference values (TRVs). COPEC concentrations in bird egg tissues may also be collected and compared to CBRs for bird eggs.	Estimating exposure of bird receptors via various exposure pathways to COPECs in surface water, sediment, and prey tissue. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet. Bird egg tissue from the NBSA.	None	TBD (Examples include spotted sandpiper, marsh wren, lesser scaup, osprey)	Bird egg collection - early Spring 2014; nesting survey could be done Fall 2013
<b>Assessment Endpoint No. 6 -</b> Survival, growth, and/or reproduction of mammals	Does the daily dose of COPECs received by mammals (including piscivorous, omnivorous, and insectivorous) from consumption of the tissues of prey species and from other media in the NBSA exceed the TRVs for survival, growth, and/or reproduction of mammals? If yes, what are the probabilities of effects of differing magnitude for survival, growth, and/or reproduction of mammals?	Receptor-specific modeled daily doses associated with the ingestion of COPECs in surface water, sediment, and prey tissue as compared with literature-based dietary dose TRVs	Estimating exposure of aquatic and semi-aquatic mammals to chemicals in NBSA surface water, sediment, and prey tissue. If potential risks are evident, a Probabilistic Risk Assessment may be conducted to quantify the uncertainties in the food web models.	Surface sediment chemistry (from the BAZ) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet	None	Mink, harbor seal, river otter, little brown bat, raccoon	Mammal survey - Summer 2014

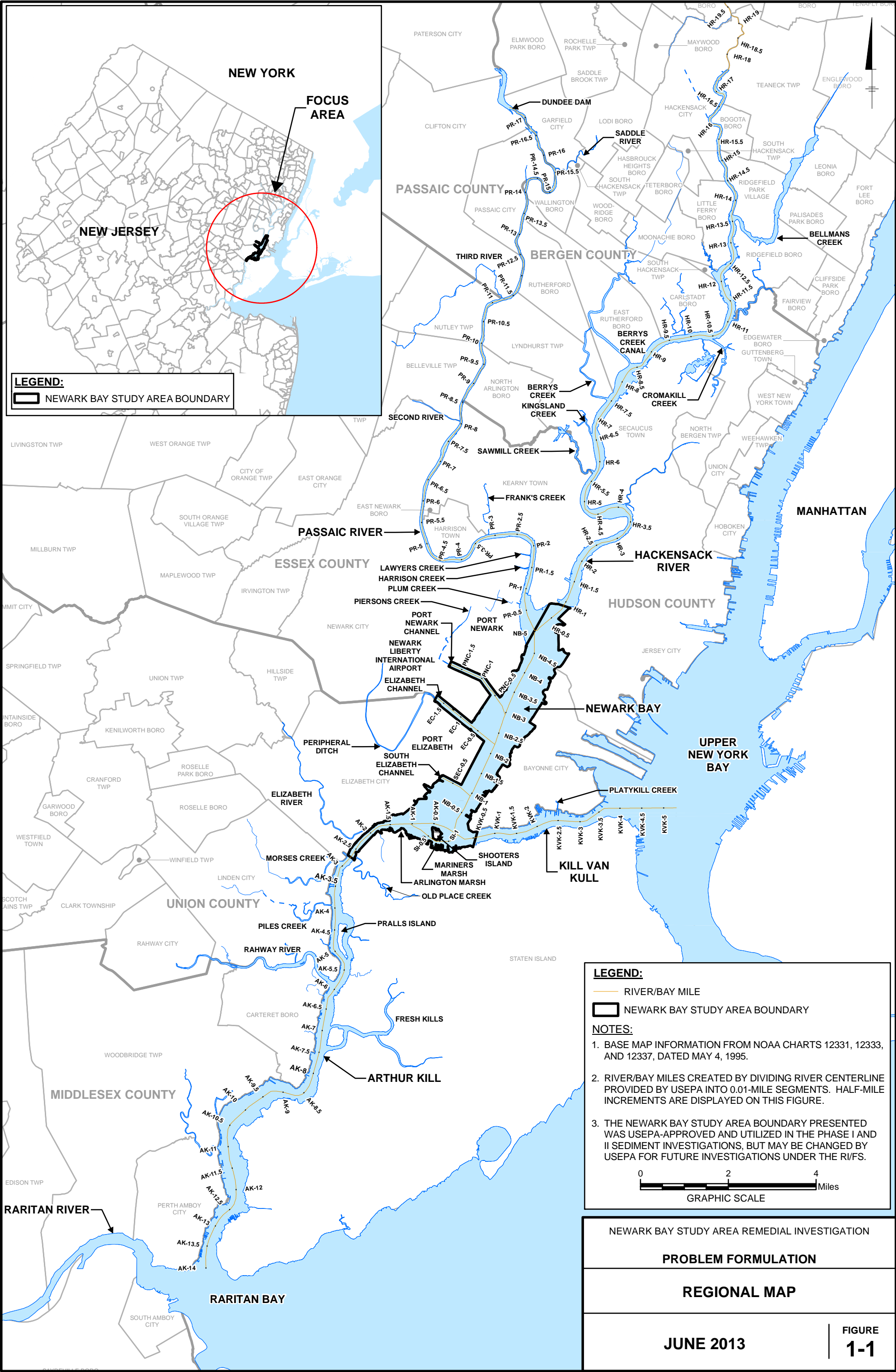
**Acronyms and Abbreviations:**

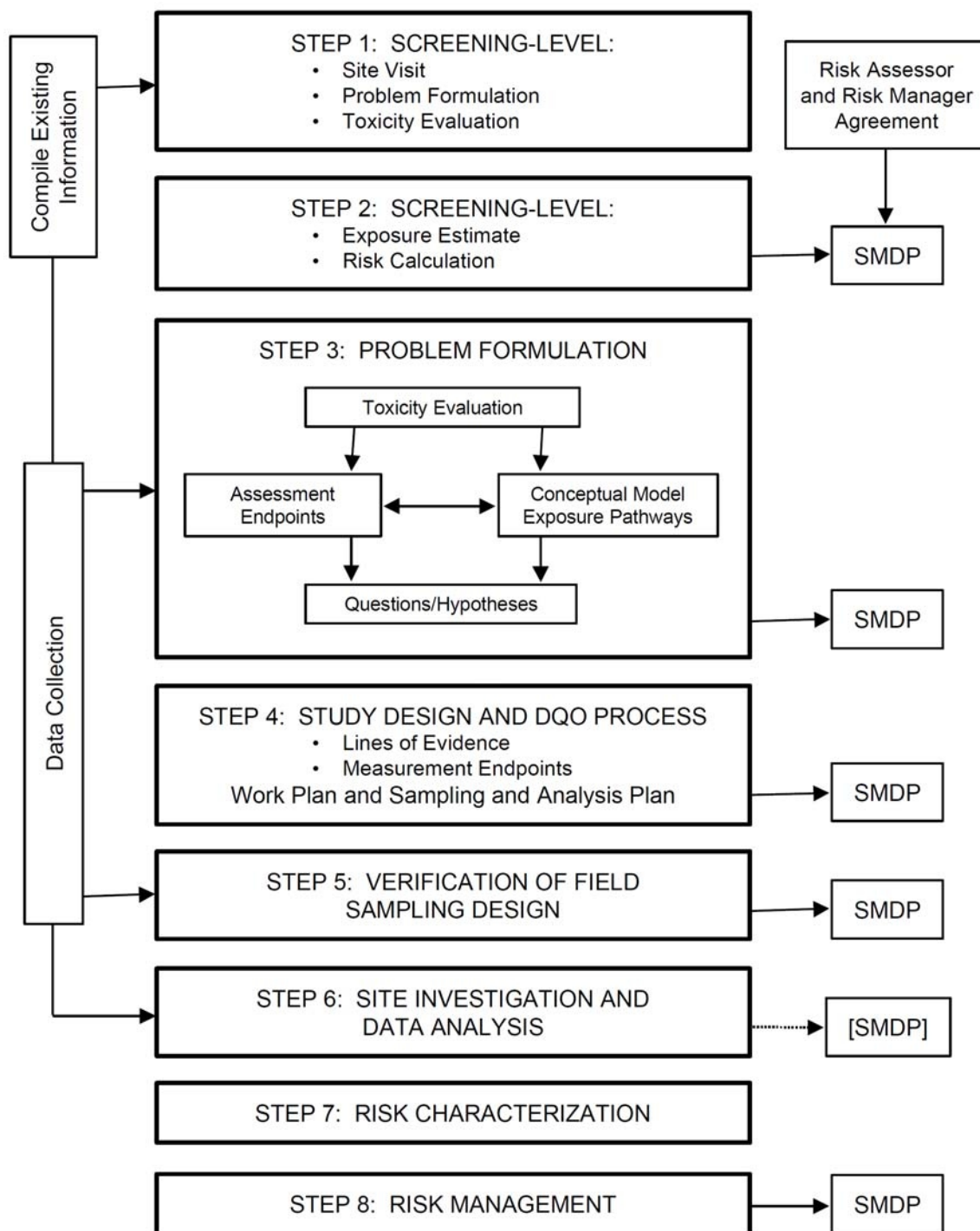
BAZ = biologically active zone  
COPEC = constituent of potential ecological concern  
DO = dissolved oxygen  
GSI = gonadosomatic index  
NBSA = Newark Bay Study Area  
SQT = sediment quality triad  
TOC = total organic carbon  
TRV = toxicity reference value  
USEPA = US Environmental Protection Agency

**Notes:**

- a. Table based on discussions/documentation among Tierra, USEPA, and Partner Agencies, including the following:  
A conference call among all parties on January 22, 2013  
A meeting between Tierra and USEPA on February 22, 2013  
Meeting Minutes from the February 22, 2013 Meeting  
Responses to USEPA Comments on the Draft Problem Formulation document (February 28, 2013)  
USEPA's Resolution on Comments and Responses to Comments (March 22, 2013)  
Email from E. Naranjo dated April 4, 2013 (USEPA 2013)

## Figures





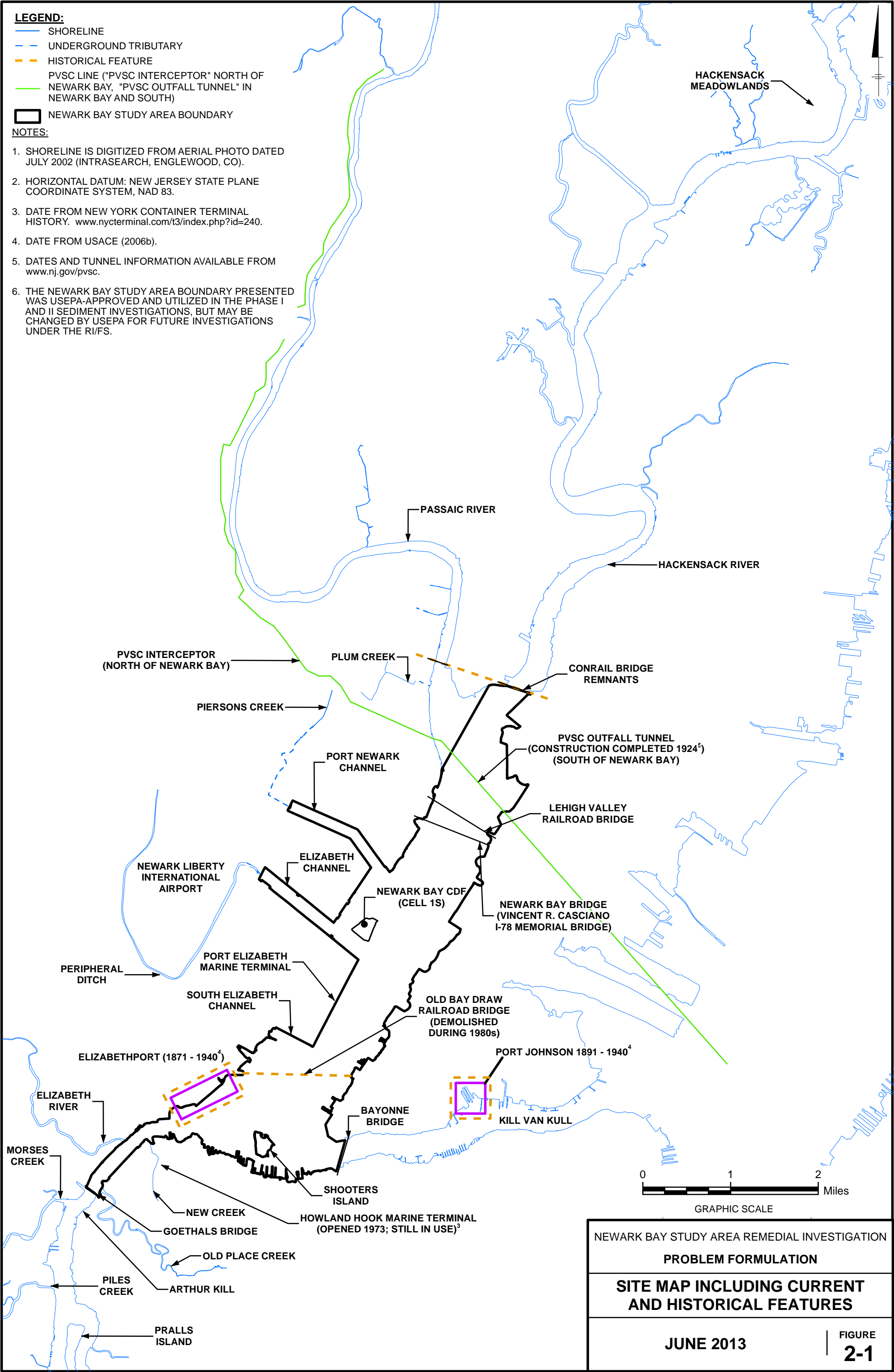
SMDP = Scientific Management Decision Point  
 [SMDP] = only if change to the sampling and analysis plan is necessary  
 DQO = Data Quality Objective

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
**PROBLEM FORMULATION**

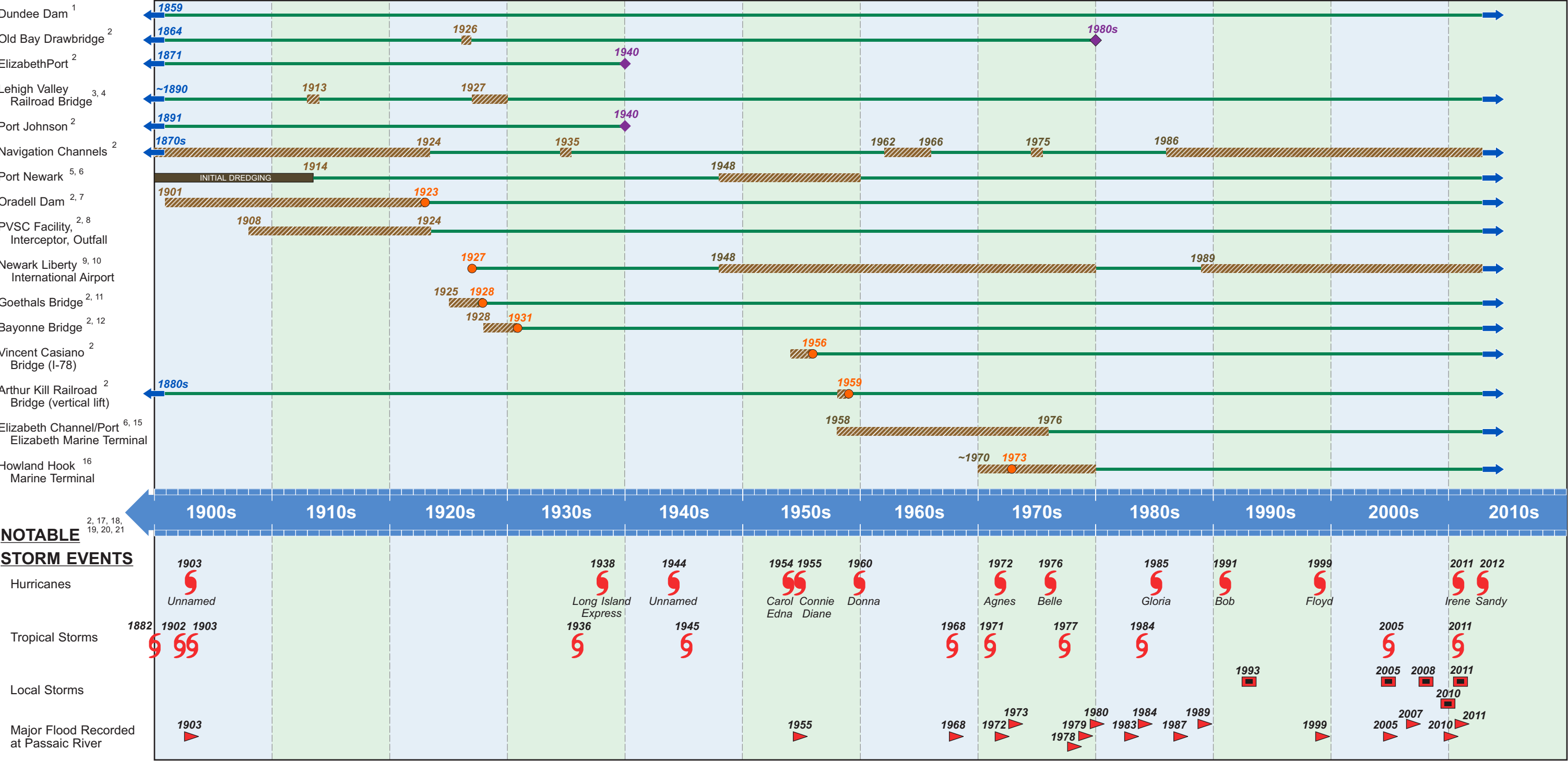
**EIGHT-STEP ECOLOGICAL  
 RISK ASSESSMENT PROCESS FOR  
 SUPERFUND (USEPA 1997)**

**JUNE 2013**

FIGURE  
**1-2**



FACILITIES, STRUCTURES,  
AND DEVELOPMENT SUMMARY

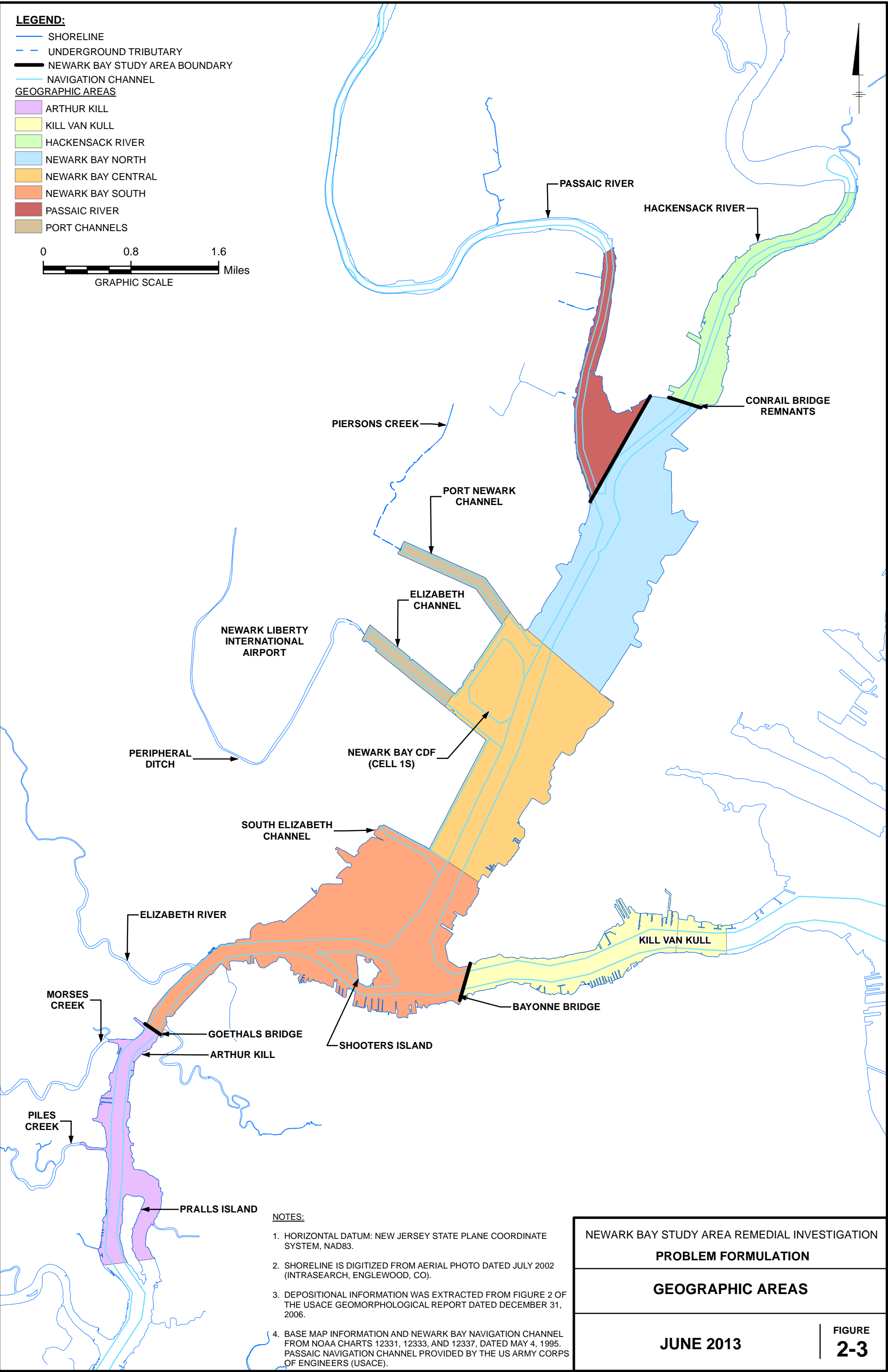


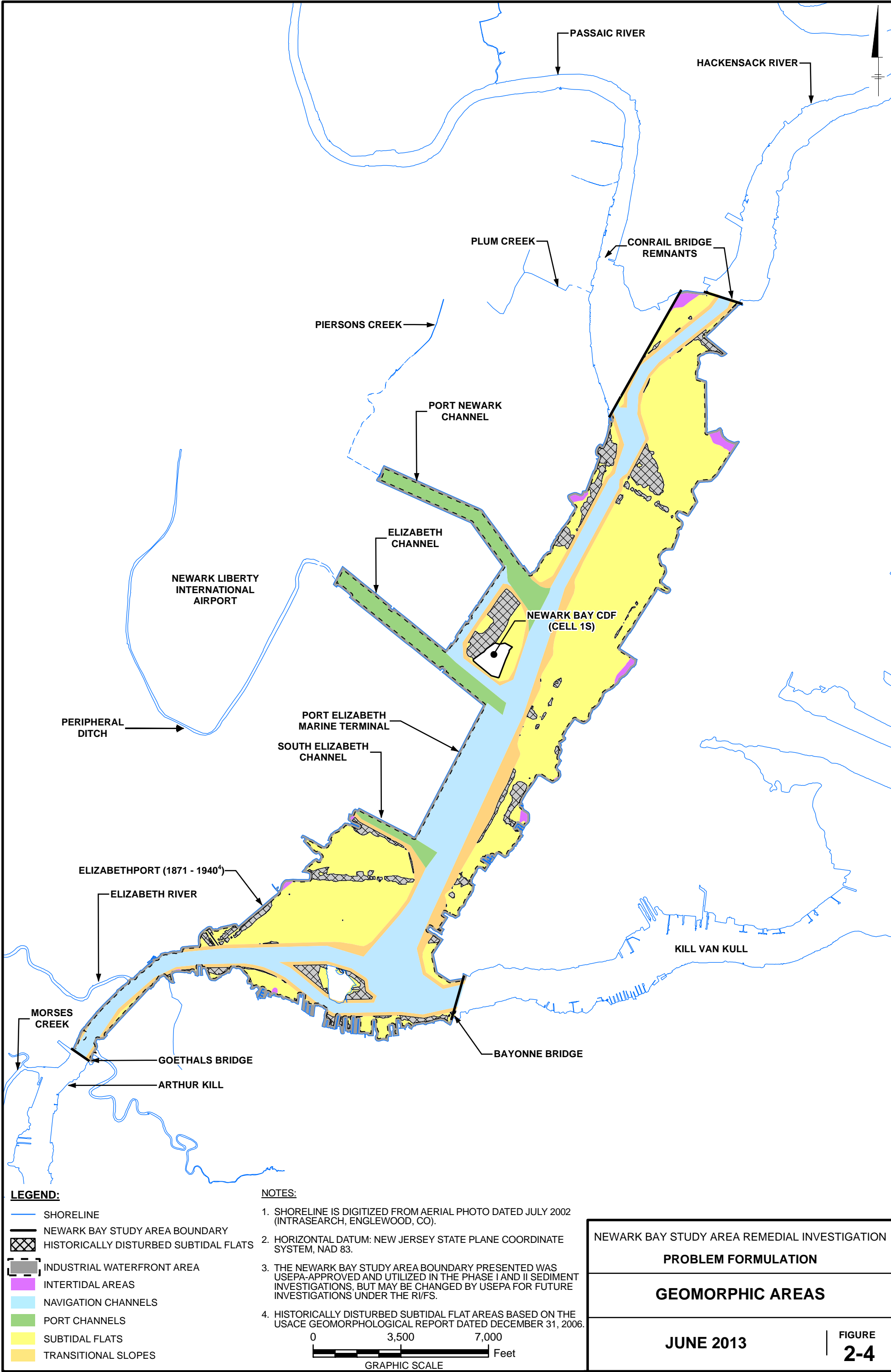
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

TIMELINE SUMMARY OF  
NBSA ACTIVITIES

JUNE 2013

FIGURE  
2-2







LEGEND:

NEWARK BAY STUDY AREA BOUNDARY

ESTUARINE & MARINE DEEPWATER

FRESHWATER FORESTED/SHRUB

FRESHWATER EMERGENT

ESTUARINE & MARINE

FRESHWATER POND

OTHER

RIVERINE

NOTES:

1. WETLANDS DATA DOWNLOADED FROM THE U.S. FISH & WILDLIFE SERVICE NATIONAL WETLANDS INVENTORY WEBSITE AT [www.fws.gov/wetlands/Data/DataDownload.html](http://www.fws.gov/wetlands/Data/DataDownload.html).

2. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

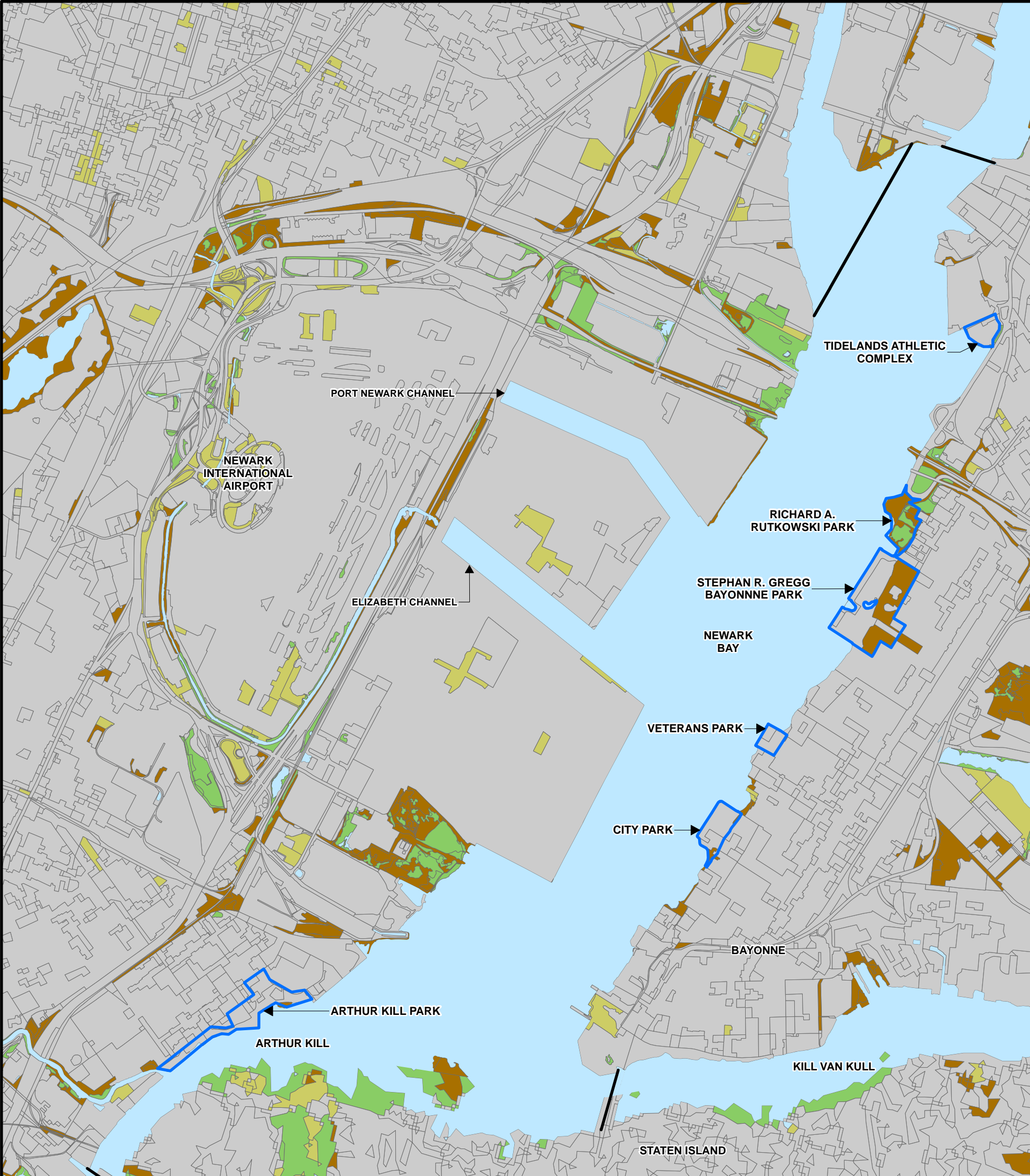
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

PROBLEM FORMULATION








NATIONAL WETLANDS INVENTORY MAP

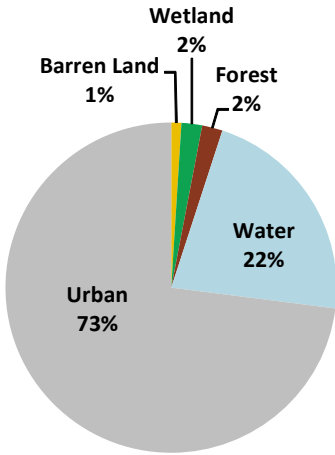
JUNE 2013

FIGURE 2-5



**LEGEND:**

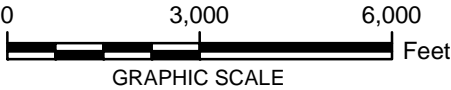
- |  |  |
|--|--|
|  BARREN LAND |  PARKS AND RECREATIONAL AREAS   |
|  FOREST      |  NEWARK BAY STUDY AREA BOUNDARY |
|  URBAN       |  |
|  WATER       |  |
|  WETLANDS    |  |



Percentage of Land Cover

**NOTES:**

1. 2007 NEW JERSEY LAND USE DATA DOWNLOADED FROM THE NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION GEOGRAPHIC INFORMATION SYSTEM WEBSITE AT [www.state.nj.us/dep/gis](http://www.state.nj.us/dep/gis).
2. 2006 NEW YORK NATIONAL LAND COVER DATA DOWNLOADED FROM THE NEW YORK STATE GEOGRAPHIC INFORMATION SYSTEMS CLEARINGHOUSE AT [www.nysgis.state.ny.us](http://www.nysgis.state.ny.us).
3. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

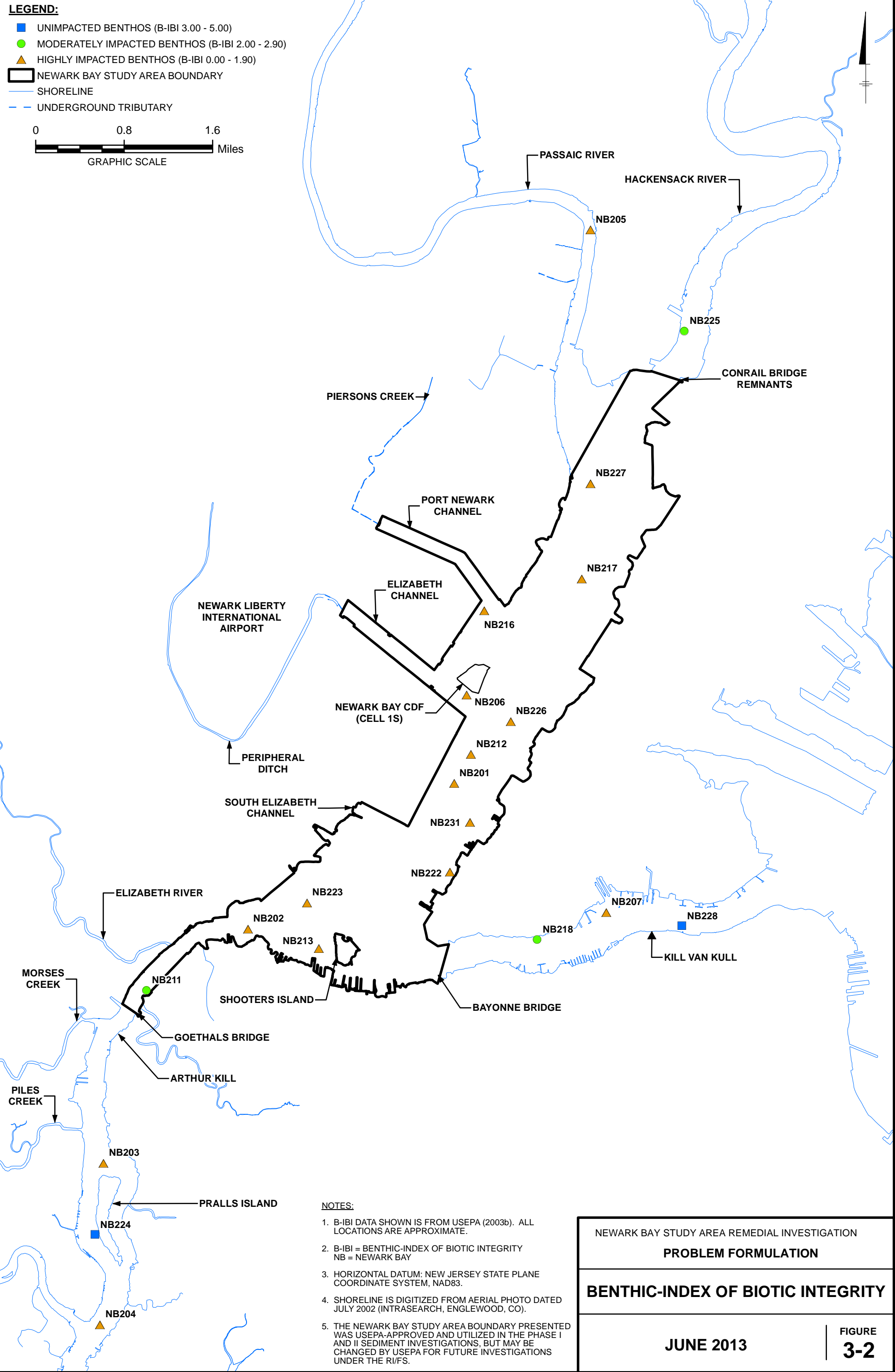


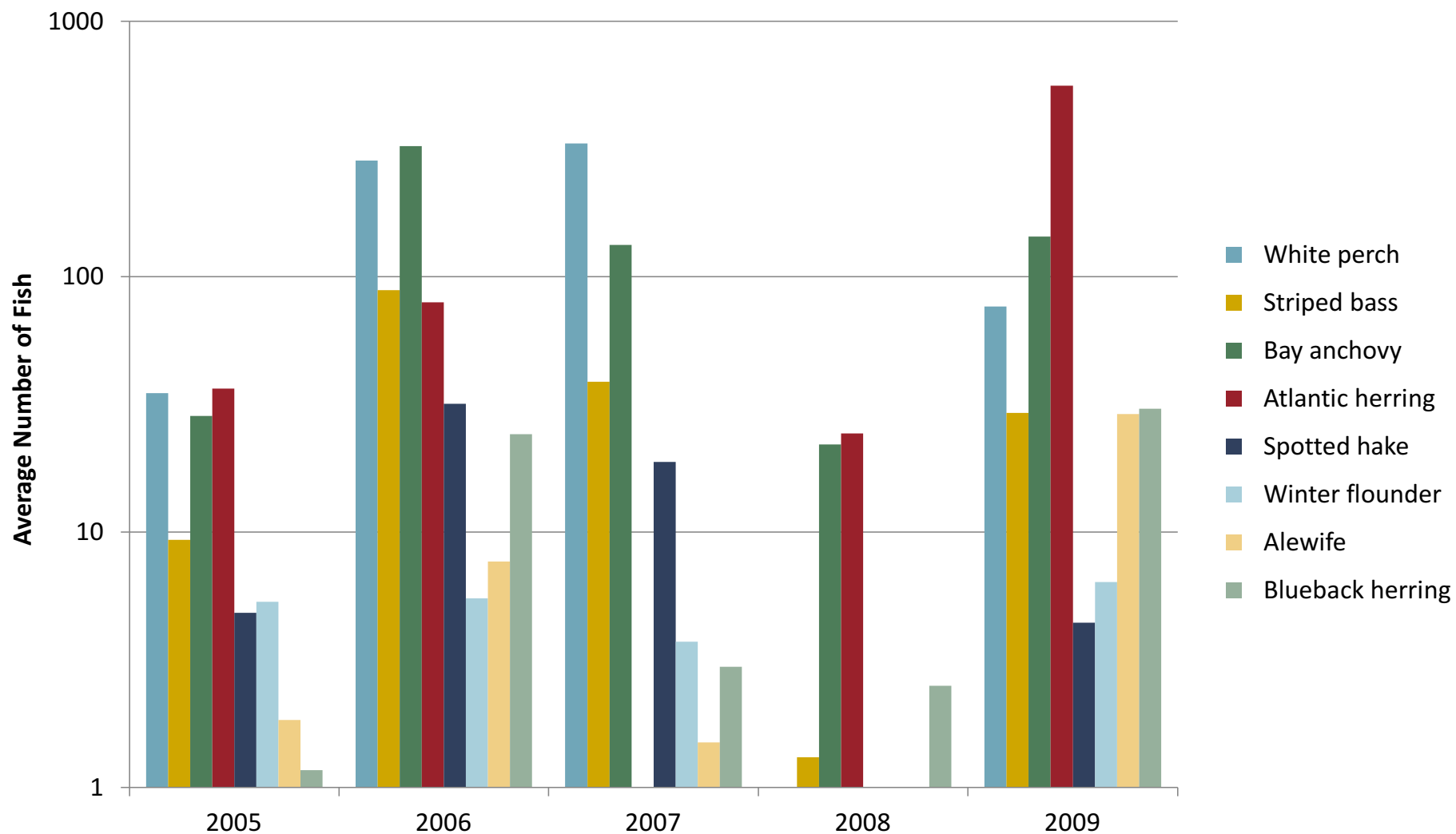
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

LAND USE/ECOLOGICAL HABITATS

JUNE 2013

FIGURE  
3-1





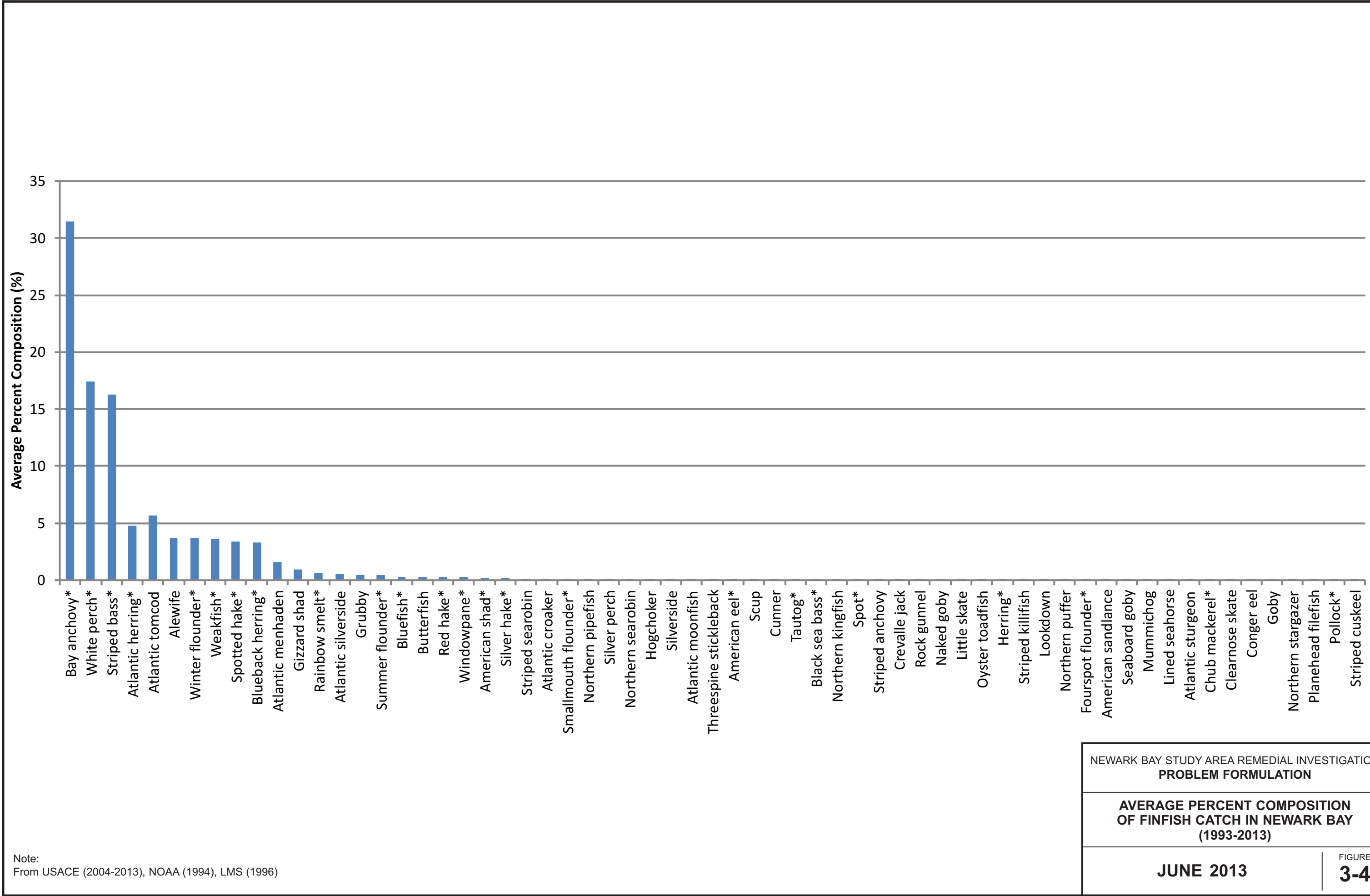
Notes:  
From USACE (2005-2009).  
Data are log-transformed.

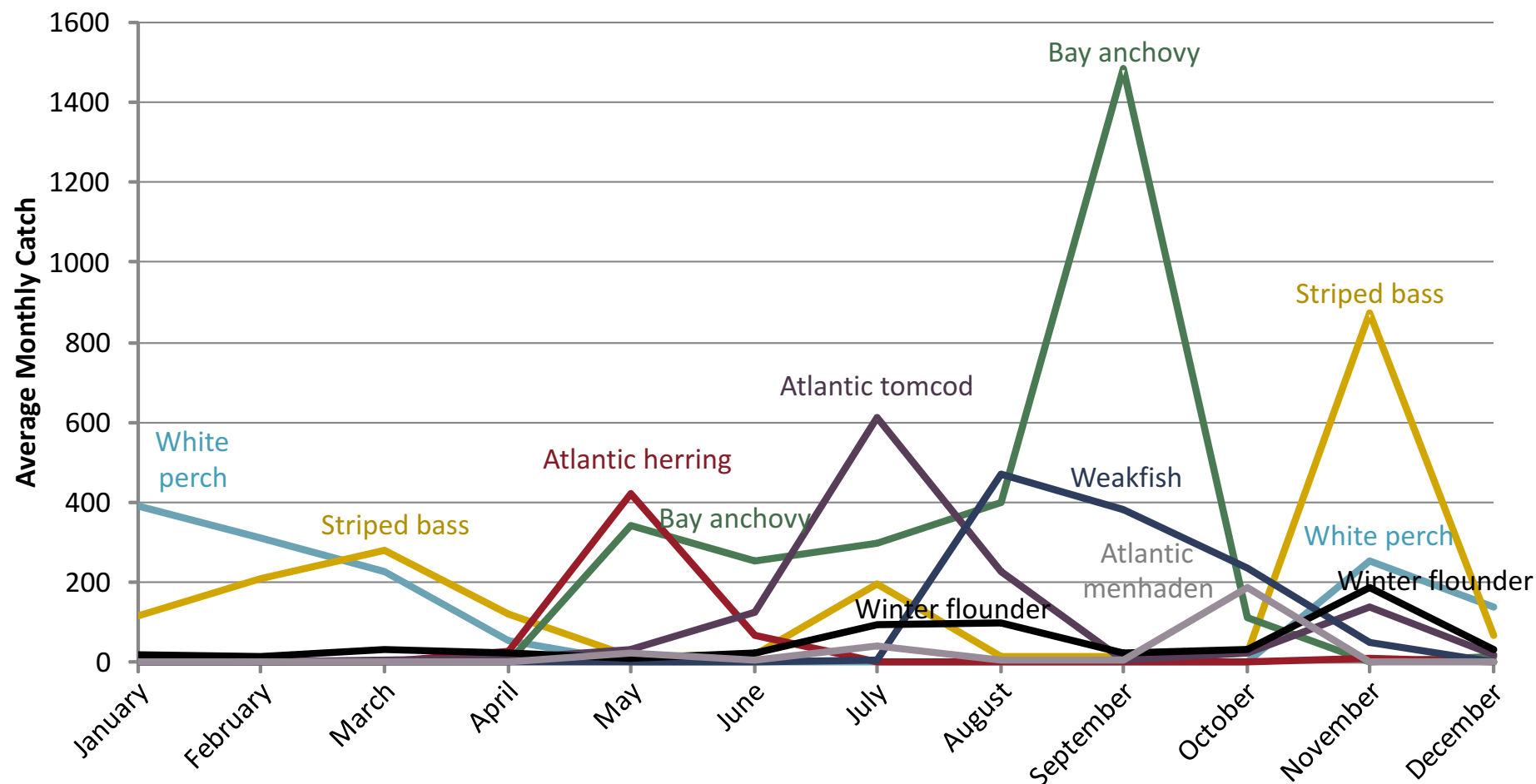
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
**PROBLEM FORMULATION**

**AVERAGE ANNUAL FINFISH  
CATCH IN NEWARK BAY  
(USACE 2005-2009)**

**JUNE 2013**

FIGURE  
**3-3**





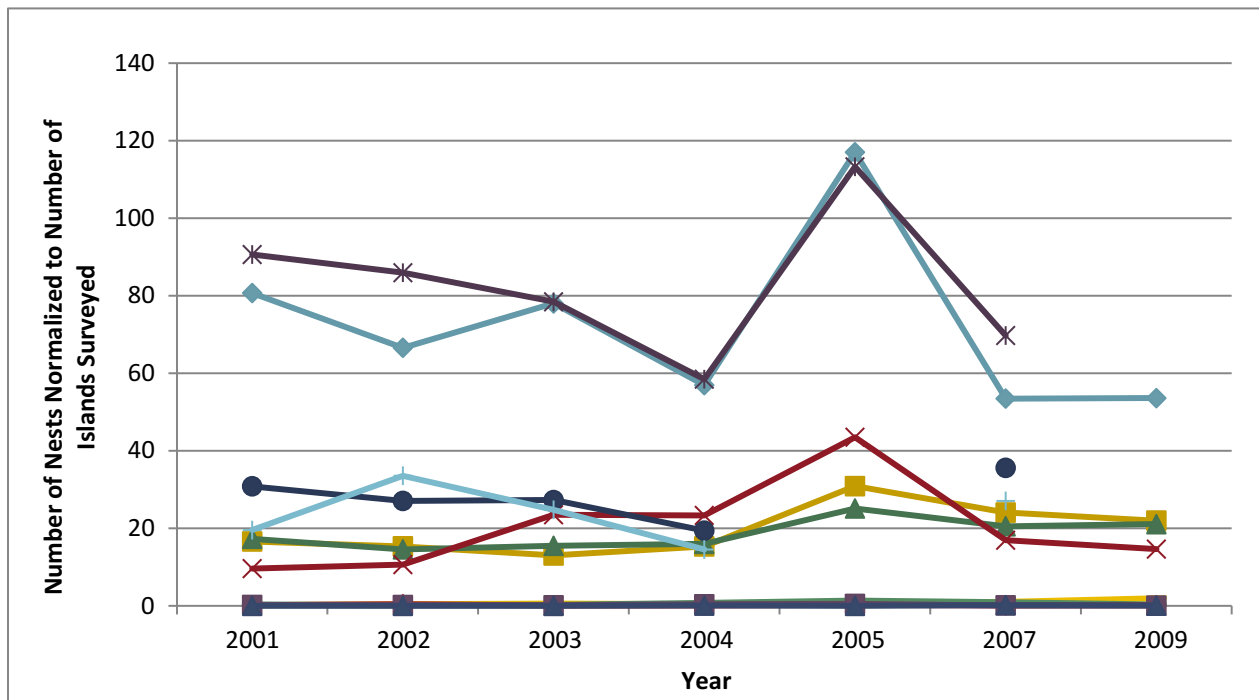
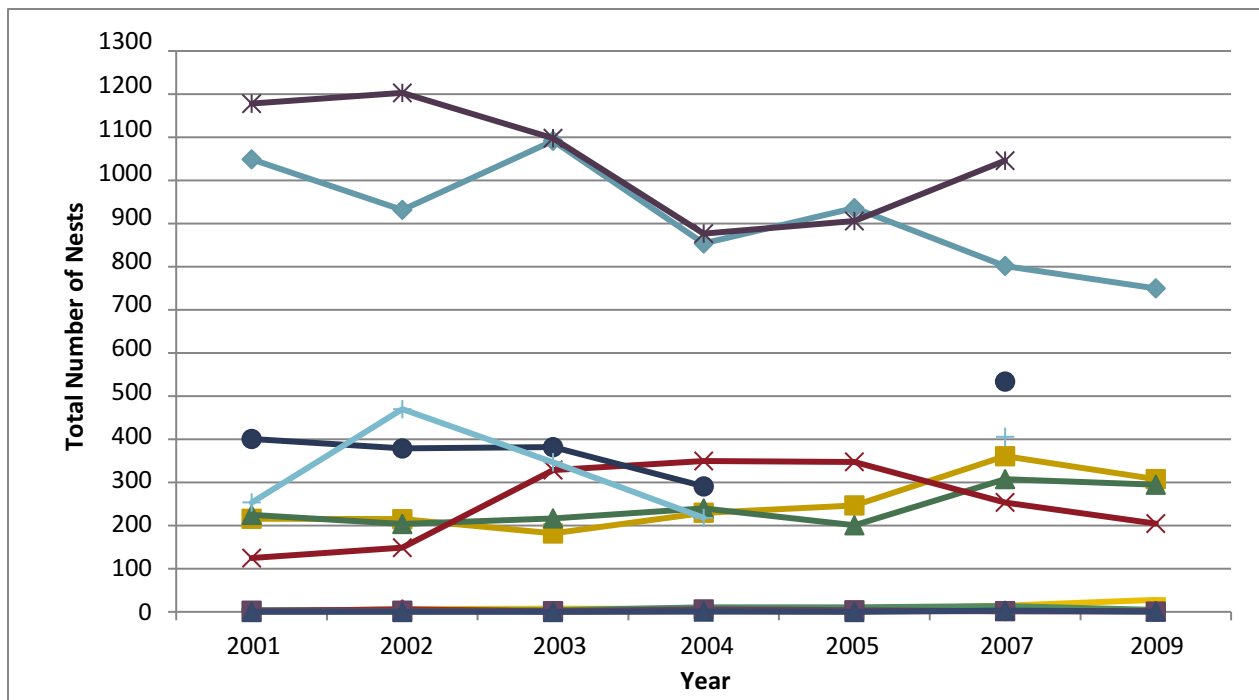
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

AVERAGE MONTHLY COMPOSITION  
OF FINFISH CATCH IN NEWARK BAY  
(1993-2009)

JUNE 2013

FIGURE  
3-5

Note:  
From USACE (2004-2009), NOAA (1994), LMS (1996).



- ◆— Black-crowned night heron
- Herring gull
- Great egret
- +— Great black-backed gull
- ▲— Snowy egret
- Yellow-crowned night heron
- ×— Glossy ibis
- Little blue heron
- \*— Double-crested cormorant
- ◆— Tricolored heron

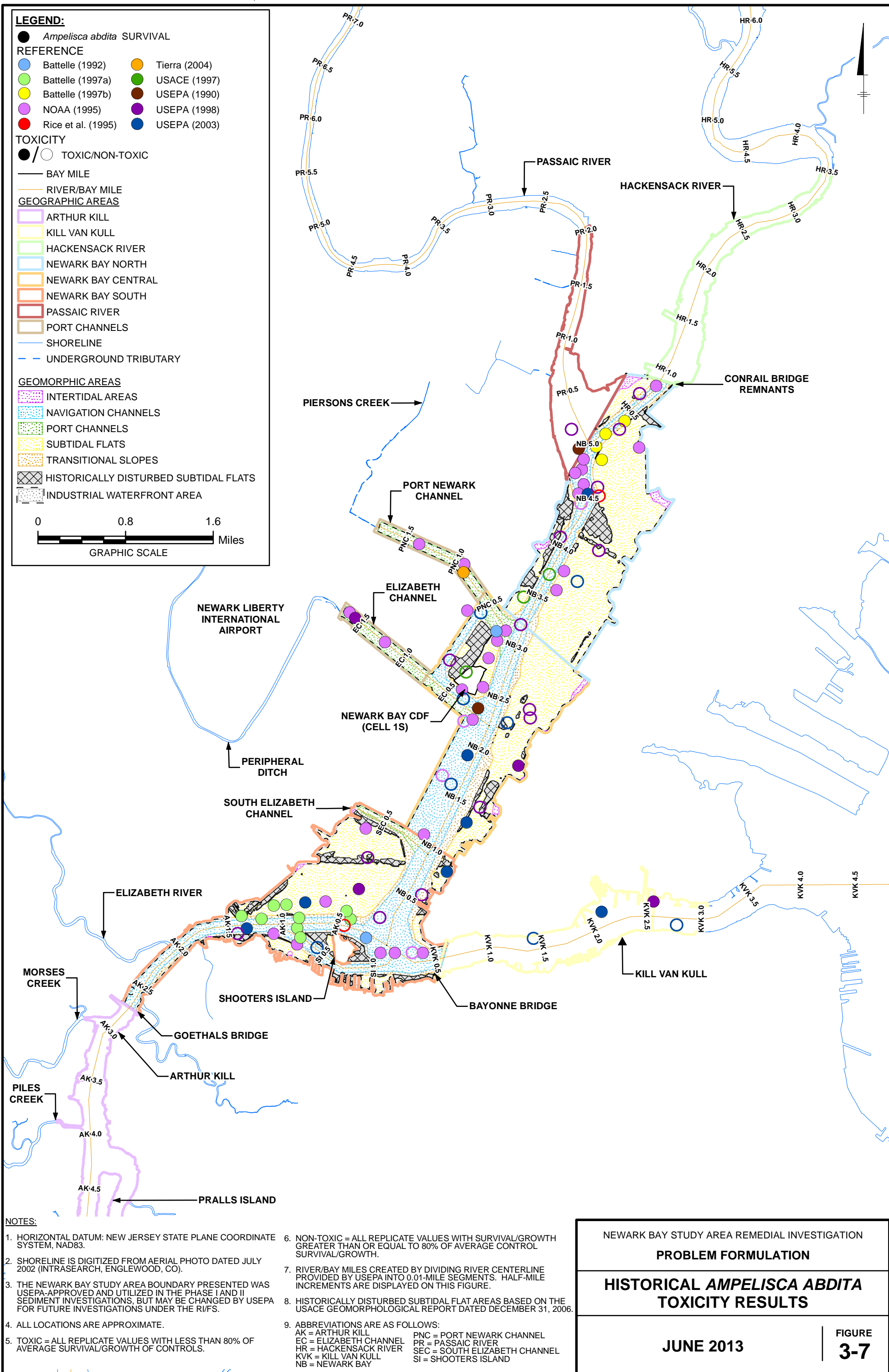
**Note:**  
From Harbor Herons Survey Data:  
Bernick (2007), Bernick and Craig (2008),  
Gelb (2004), and Harbor Herons Subcommittee (2010).

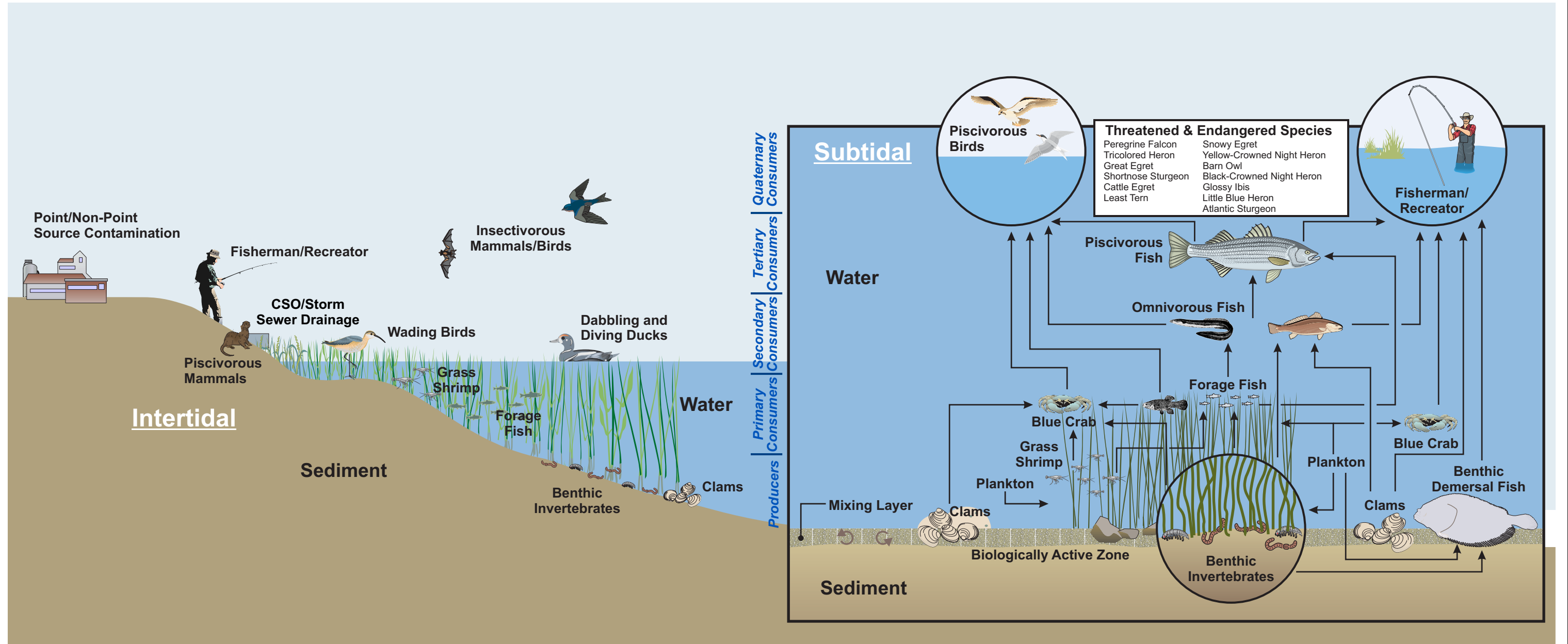
# NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION PROBLEM FORMULATION

## HARBOR HERONS PROJECT DATA (2001-2009)

JUNE 2013

FIGURE  
3-6



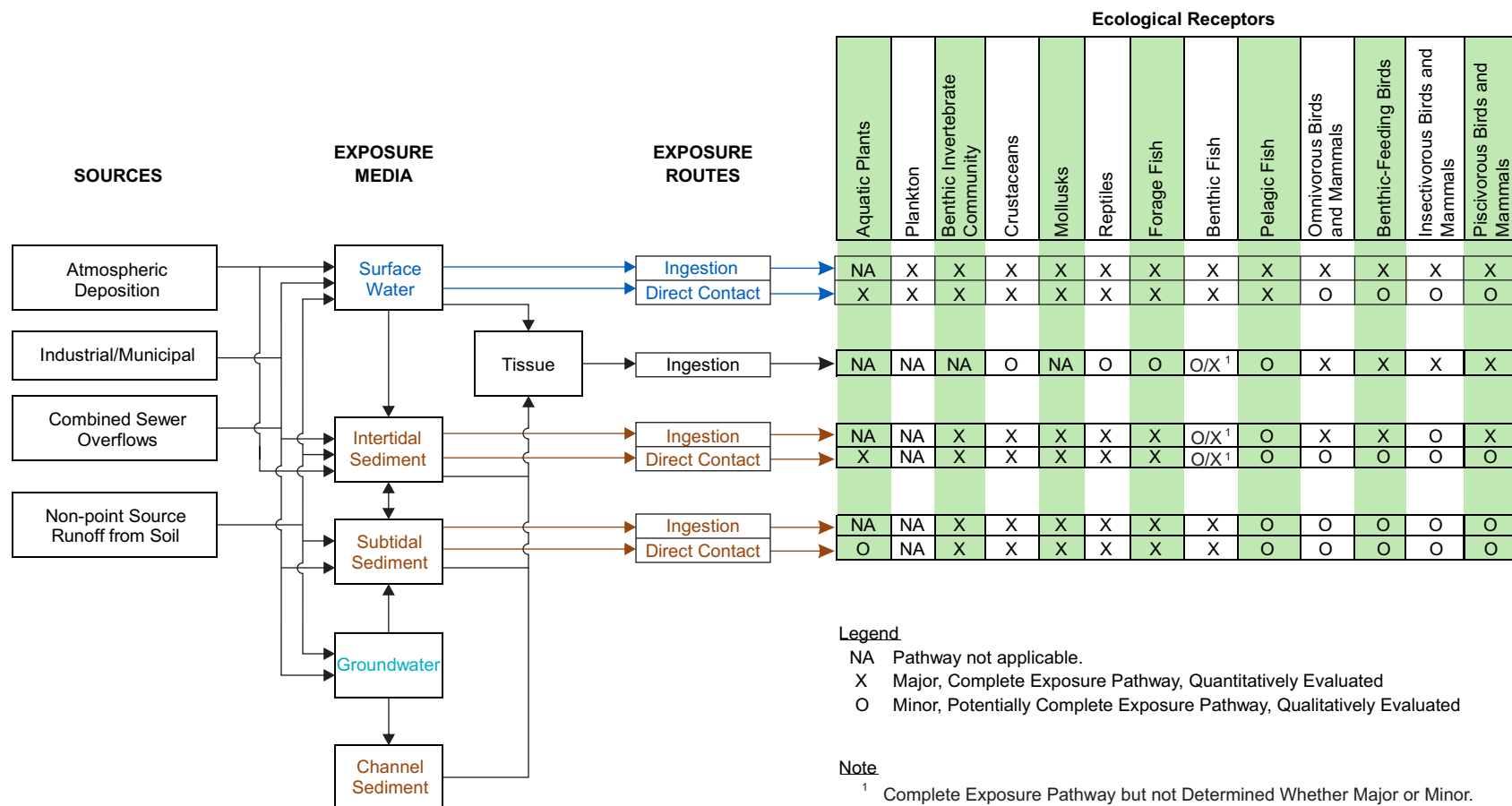


NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

FOOD WEB DIAGRAM

JUNE 2013

FIGURE  
4-1

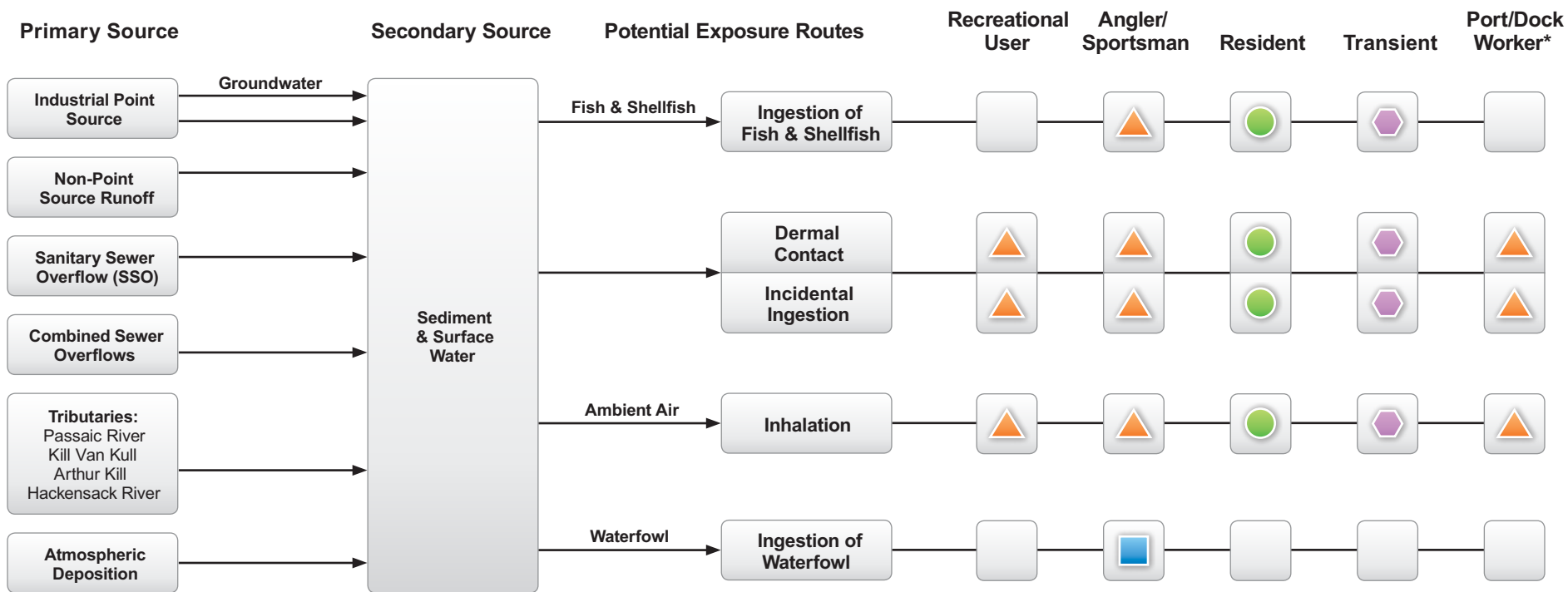


NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
**PROBLEM FORMULATION**

**ECOLOGICAL EXPOSURE PATHWAYS**

**JUNE 2013**

FIGURE  
**4-2**



\* The need to evaluate a diver for this scenario is currently under review.



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
**PROBLEM FORMULATION**

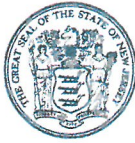
**CONCEPTUAL SITE MODEL:  
HUMAN HEALTH**

**JUNE 2013**

FIGURE  
**5-1**

## **Appendix A**

Natural Heritage Database Request  
Results



## State of New Jersey

### DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Parks and Forestry

Mail Code 501-04

ONLM - Natural Heritage Program

P.O. Box 420

Trenton, NJ 08625-0420

Tel. #609-984-1339

Fax. #609-984-1427

CHRIS CHRISTIE

*Governor*

KIM GUADAGNO

*Lt. Governor*

BOB MARTIN

*Commissioner*

April 18, 2012

Melissa Beauchemin  
ARCADIS  
194 Forbes Road  
Braintree, MA 02184

Re: Newark Bay Ecological Risk Assessment

Dear Ms. Beauchemin:

Thank you for your data request regarding rare species information for the above referenced project site in Newark, Elizabeth and Bayonne Cities, Essex, Union and Hudson County.

Searches of the Natural Heritage Database and the Landscape Project (Version 3.1) are based on a representation of the boundaries of your project site in our Geographic Information System (GIS). We make every effort to accurately transfer your project bounds from the topographic map(s) submitted with the Request for Data into our Geographic Information System. We do not typically verify that your project bounds are accurate, or check them against other sources.

We have checked the Landscape Project habitat mapping and the Biotics Database for occurrences of any rare wildlife species or wildlife habitat on the referenced site. The Natural Heritage Database was searched for occurrences of rare plant species or ecological communities that may be on the project site. Please refer to Table 1 (attached) to determine if any rare plant species, ecological communities, or rare wildlife species or wildlife habitat are documented on site. A detailed report is provided for each category coded as 'Yes' in Table 1.

We have also checked the Landscape Project habitat mapping and Biotics Database for occurrences of rare wildlife species or wildlife habitat in the immediate vicinity (within ¼ mile) of the referenced site. Additionally, the Natural Heritage Database was checked for occurrences of rare plant species or ecological communities within ¼ mile of the site. Please refer to Table 2 (attached) to determine if any rare plant species, ecological communities, or rare wildlife species or wildlife habitat are documented within the immediate vicinity of the site. Detailed reports are provided for all categories coded as 'Yes' in Table 2. These reports may include species that have also been documented on the project site.

The Natural Heritage Program reviews its data periodically to identify priority sites for natural diversity in the State. Included as priority sites are some of the State's best habitats for rare and endangered species and ecological communities. Please refer to Tables 1 and 2 (attached) to determine if any priority sites are located on or in the vicinity of the site.

A list of rare plant species and ecological communities that have been documented from Essex, Union and Hudson County can be downloaded from <http://www.state.nj.us/dep/parksandforests/natural/heritage/countylist.html>. If suitable habitat is present at the project site, the species in that list have potential to be present.

Status and rank codes used in the tables and lists are defined in EXPLANATION OF CODES USED IN NATURAL HERITAGE REPORTS, which can be downloaded from [http://www.state.nj.us/dep/parksandforests/natural/heritage/nhpcodes\\_2010.pdf](http://www.state.nj.us/dep/parksandforests/natural/heritage/nhpcodes_2010.pdf).

If you have questions concerning the wildlife records or wildlife species mentioned in this response, we recommend that you visit the interactive NJ-GeoWeb website at the following URL, <http://www.state.nj.us/dep/gis/geoweb splash.htm> or contact the Division of Fish and Wildlife, Endangered and Nongame Species Program at (609) 292-9400.

PLEASE SEE 'CAUTIONS AND RESTRICTIONS ON NHP DATA', which can be downloaded from <http://www.state.nj.us/dep/parksandforests/natural/heritage/newcaution2008.pdf>.

Thank you for consulting the Natural Heritage Program. The attached invoice details the payment due for processing this data request. Feel free to contact us again regarding any future data requests.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Robert J. Cartica', with a long horizontal flourish extending to the right.

Robert J. Cartica  
Administrator

c: NHP File No. 12-4007462-1182

***Table 1: On Site Data Request Search Results (7 Possible Reports)***

Rare Plants/Ecological Communities Possibly On Site:	No
Rare Plants/Ecological Communities On Site/Immediate Vicinity:	No
Natural Heritage Priority Sites On Site:	No
Landscape 3.1 Species Based Patches On Site:	Yes
Landscape 3.1 Vernal Pool Habitat On Site:	No
Landscape 3.1 Stream/Mussel Habitat On Site:	No
Other Animals Tracked by ENSP On Site:	No

<p align="center"><b>Rare Wildlife Species or Wildlife Habitat on the Project Site Based on Search of Landscape Project 3.1 Species Based Patches</b></p>
---

Class	Common Name	Scientific Name	Feature Type	Rank	Federal Protection	State Protection	Grank	Srank
<i>Aves</i>								
	Black-crowned Night-heron	Nycticorax nycticorax	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Cattle Egret	Bubulcus ibis	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Glossy Ibis	Plegadis falcinellus	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Least Tern	Sternula antillarum	Foraging	4	NA	State Endangered	G4	S1B,S1N
	Little Blue Heron	Egretta caerulea	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Osprey	Pandion haliaetus	Foraging	3	NA	State Threatened	G5	S2B
	Peregrine Falcon	Falco peregrinus	Urban Nest	4	NA	State Endangered	G4	S1B,S3N
	Snowy Egret	Egretta thula	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Tricolored Heron	Egretta tricolor	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Yellow-crowned Night-heron	Nyctanassa violacea	Foraging	3	NA	State Threatened	G5	S2B,S2N
<i>Insecta</i>								
	Checkered White	Pontia protodice	Breeding/Courtship	3	NA	State Threatened	G4	S2
<i>Osteichthyes</i>								
	Shortnose Sturgeon	Acipenser brevirostrum	Migration Corridor - Adult Sighting	5	Federally Listed Endangered	State Endangered	G3	S1

***Table 2: Vicinity Data Request Search Results (6 possible reports)***

<b>Rare Plants/Ecological Communities within the Vicinity:</b>	No
<b>Natural Heritage Priority Sites within the Vicinity:</b>	No
<b>Landscape 3.1 Species Based Patches within the Vicinity:</b>	Yes
<b>Landscape 3.1 Vernal Pool Habitat within the Vicinity:</b>	No
<b>Landscape 3.1 Stream/Mussel Habitat within the Vicinity:</b>	No
<b>Other Animals Tracked by ENSP within the Vicinity:</b>	No

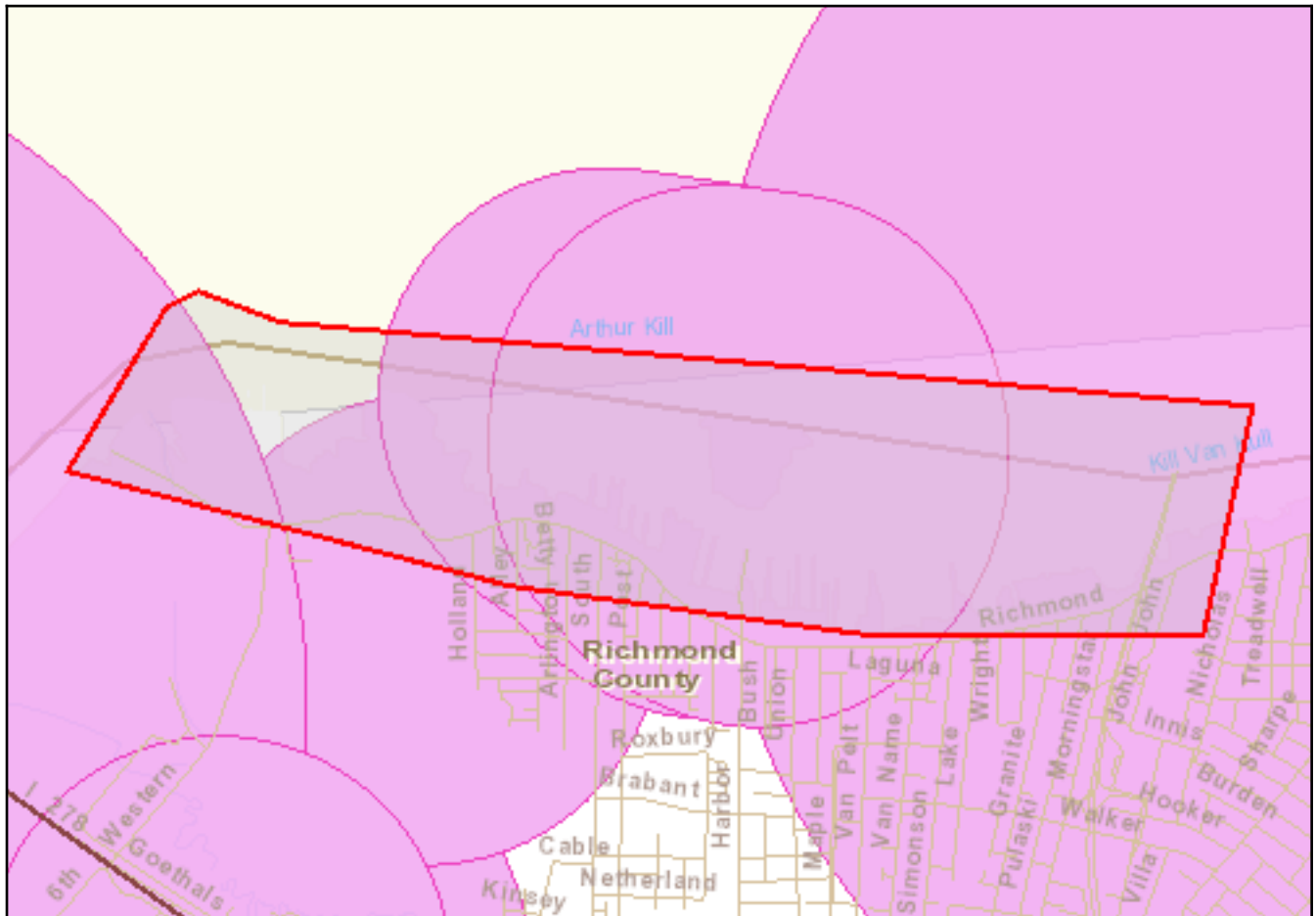
**Rare Wildlife Species or Wildlife Habitat Within the  
Immediate Vicinity of the Project Site Based on Search of  
Landscape Project 3.1 Species Based Patches**

<b>Class</b>	<b>Common Name</b>	<b>Scientific Name</b>	<b>Feature Type</b>	<b>Rank</b>	<b>Federal Protection</b>	<b>State Protection</b>	<b>Grank</b>	<b>Srank</b>
<i>Aves</i>								
	Black-crowned Night-heron	Nycticorax nycticorax	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Cattle Egret	Bubulcus ibis	Foraging	3	NA	State Threatened	G5	S2B,S3N
	Glossy Ibis	Plegadis falcinellus	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Least Tern	Sternula antillarum	Foraging	4	NA	State Endangered	G4	S1B,S1N
	Little Blue Heron	Egretta caerulea	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Osprey	Pandion haliaetus	Foraging	3	NA	State Threatened	G5	S2B
	Peregrine Falcon	Falco peregrinus	Urban Nest	4	NA	State Endangered	G4	S1B,S3N
	Snowy Egret	Egretta thula	Foraging	2	NA	Special Concern	G5	S3B,S4N
	Tricolored Heron	Egretta tricolor	Foraging	2	NA	Special Concern	G5	S3B,S3N
	Upland Sandpiper	Bartramia longicauda	Breeding Sighting	4	NA	State Endangered	G5	S1B,S1N
	Yellow-crowned Night-heron	Nyctanassa violacea	Foraging	3	NA	State Threatened	G5	S2B,S2N
<i>Insecta</i>								
	Checkered White	Pontia protodice	Breeding/Courtship	3	NA	State Threatened	G4	S2
<i>Osteicht</i>								
	Shortnose Sturgeon	Acipenser brevirostrum	Migration Corridor - Adult Sighting	5	Federally Listed Endangered	State Endangered	G3	S1

# New York Nature Explorer

## User Defined Results Report

Criteria: Selected Map Area



Common Name	Subgroup	Distribution Status	Year Last Documented	Protection Status State	Conservation Rank State	Conservation Rank Global
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### Animal: Birds

Barn Owl	Owls	Recently Confirmed	2002	Protected Bird	S1S2	G5
<i>Tyto alba</i>						
Cattle Egret	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2004	Protected Bird	S2	G5
<i>Bubulcus ibis</i>						
Glossy Ibis	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird	S2	G5
<i>Plegadis falcinellus</i>						
Great Egret	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird	S2	G5
<i>Ardea alba</i>						
Little Blue Heron	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird	S2	G5
<i>Egretta caerulea</i>						

# New York Nature Explorer

Common Name	Subgroup	Distribution Status	Year Last Documented	Protection Status		Conservation Rank	
				State	Federal	State	Global

Snowy Egret	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2S3	G5
<i>Egretta thula</i>							
Yellow-crowned Night-Heron	Hérons, Bitterns, Egrets, Ibises	Recently Confirmed	2007	Protected Bird		S2	G5
<i>Nyctanassa violacea</i>							

## Animal: Dragonflies and Damselflies

Mocha Emerald	Dragonflies	Historically Confirmed	1926			S2S3	G5
<i>Somatochlora linearis</i>							
Rambur's Forktail	Damselflies	Historically Confirmed	1913			S2	G5
<i>Ischnura ramburii</i>							

## Animal: Animal Assemblages

Colonial Waterbird Nesting Area	Animal Assemblages	Recently Confirmed	1998			S3	GNR
<i>Colonial Waterbird Nesting Area</i>							
Gull Colony	Animal Assemblages	Recently Confirmed	1995			SNR	GNR
<i>Gull Colony</i>							

## Plant: Flowering Plants

Angled Spikerush	Sedges	Recently Confirmed	1998	Endangered		S1	G4
<i>Eleocharis quadrangulata</i>							

Note: Restricted plants and animals may also have also been documented in one or more of the Towns or Cities in which your user-defined area is located, but are not listed in these results. This application does not provide information at the level of Town or City on state-listed animals and on other sensitive animals and plants. A list of the restricted animals and plants documented at the corresponding county level can be obtained via the County link(s) on the original User Defined Search Results page. Any individual plant or animal on this county's restricted list may or may not occur in this particular user-defined area.

This list only includes records of rare species and significant natural communities from the databases of the NY Natural Heritage Program. This list is not a definitive statement about the presence or absence of all plants and animals, including rare or state-listed species, or of all significant natural communities. For most areas, comprehensive field surveys have not been conducted, and this list should not be considered a substitute for on-site surveys.

## **Appendix B**

Current and Future Land Use and  
Access to the Shoreline

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**Appendix B****Current and Future Land Use  
and Access to the Shoreline****1. Current Land Use – Zoning and Access**

All land with boundaries comprising the shoreline of the Newark Bay Study Area (NBSA) was evaluated for the potential for humans to contact sediments and surface water. Reconnaissance was carried out using a series of approaches to assess every tenth of a mile of the shoreline. First, area zoning maps from Kearny, Jersey City, Bayonne, New York City, Elizabeth, and Newark were studied to determine the current designated land use of all bounding properties (City of Bayonne 2001, City of Elizabeth 2012, City of Newark 2004, Jersey City 2001, Kearny Zoning 2009, New York City 2011a). Second, Google Earth (imagery date: June 17, 2010) was used to determine whether the shoreline and sediments could be easily accessed. For areas in which this determination was not clear from Google Earth imagery, on-site reconnaissance was conducted (Appendix C). Ground-truthing of the Google Earth images by taking additional photos and documenting the shoreline type will be conducted during sampling. These assessments and findings will be included in later documents.

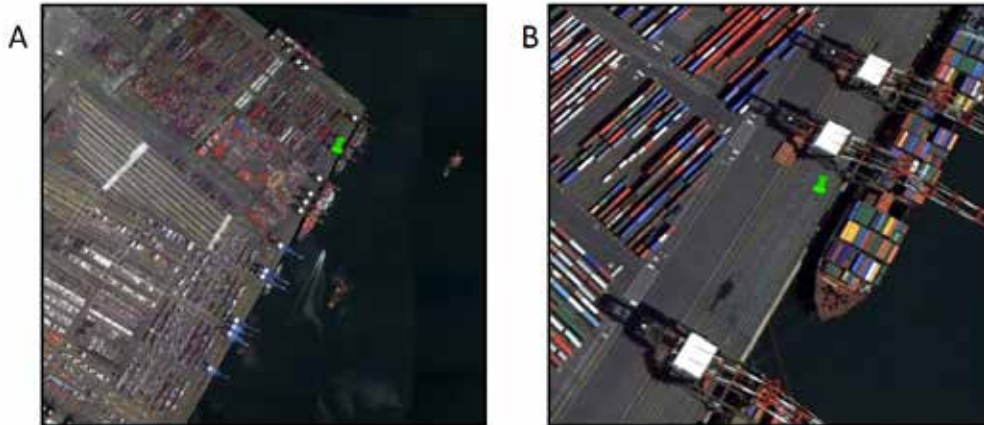
Categories of shoreline accessibility were generally based first on whether the land was zoned industrial/manufacturing/commercial (associated with limited accessibility) or residential (greater potential for accessibility), then further classified by the type of access as follows (representative photographs of each category identified on the NBSA are presented as Figures B1 through B4):

- Industrial/Manufacturing/Commercial Zoning – No Access – An area of shoreline that is zoned for industrial, manufacturing or commercial purposes and has no readily available access to sediment or surface water by humans.
- Industrial/Manufacturing/Commercial Zoning – With Access – An area of shoreline that is zoned for industrial, manufacturing or commercial purposes that provides the potential for access to the sediment and/or surface water by humans.
- Residential Zoning – With Recreational Access – A residentially zoned area of shoreline that provides the possibility of recreational access to sediment and/or surface water by humans. The public could access NBSA sediment and surface water for activities such as wading, swimming, boating, canoeing, and fishing or crabbing.
- Residential Zoning – No Access – A residentially zoned area of shoreline that does not provide for the possibility for residential or recreational land use due to physical conditions/barriers such as steep rocky slopes.
- Residential Zoning – With Residential Access – A residentially zoned area of shoreline that provides the possibility for residential access to sediment, with residential access defined as exposure 350 days per year for 30 years.

## Appendix B

### Current and Future Land Use and Access to the Shoreline

Additionally, segment lengths for each category were measured using Google Earth from an altitude of 200 meters.



**Figure B1 Industrial/Manufacturing/Commercial Zoning – No Access**  
Representative photos: A) Aerial view. B) Zoomed view.



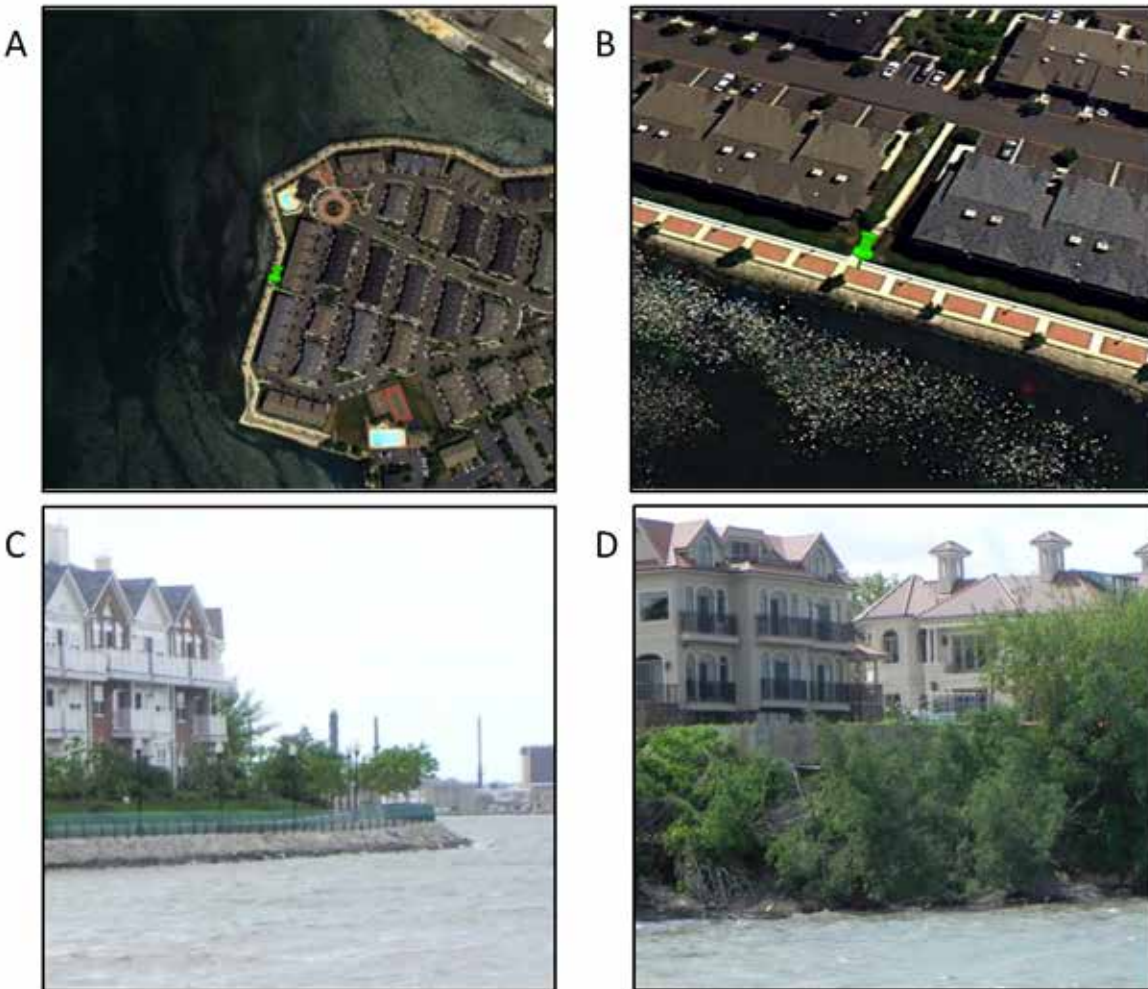
**Figure B2 Industrial/Manufacturing/Commercial Zoning – With Access**  
Representative photos: A) Aerial view. B) Zoomed view.

Based on the findings from this series of evaluations, zoning (land use) and shoreline accessibility were characterized, summarized in Tables B1, B2a and B2b, and shown graphically in Figures B5 and B6. Table B2a contains a summary of the general exposure characterization categories for the Newark Bay shoreline, and Table B2b shows additional detail, including zoning designations. Further site reconnaissance will be

## Appendix B

### Current and Future Land Use and Access to the Shoreline

conducted to assess areas with potential human access and will be discussed in future documents. The majority of property around the NBSA was zoned as industrial (76%) – most of which (73%) was determined to have “no access.” For the residentially-zoned property, 13% of the total perimeter of the NBSA was found to have access consistent with recreational exposures. Notably, no properties or shoreline land segments were identified that would be characteristic of a standard residential exposure scenario (e.g., exposure to sediments 350 days/year). Specifically, based on current information, there were no areas of residentially zoned land in which there was readily available access to the shoreline, nor was there evidence (e.g., picnic tables along the shoreline, walkways/stairs indicating use of the shoreline area) of a scenario in which residents were interacting with the shoreline in a manner equivalent to the residential exposure scenario. Most residentially zoned properties had significant land elevation differences inhibiting direct contact with NBSA surface water and sediment (Figure B3-D).

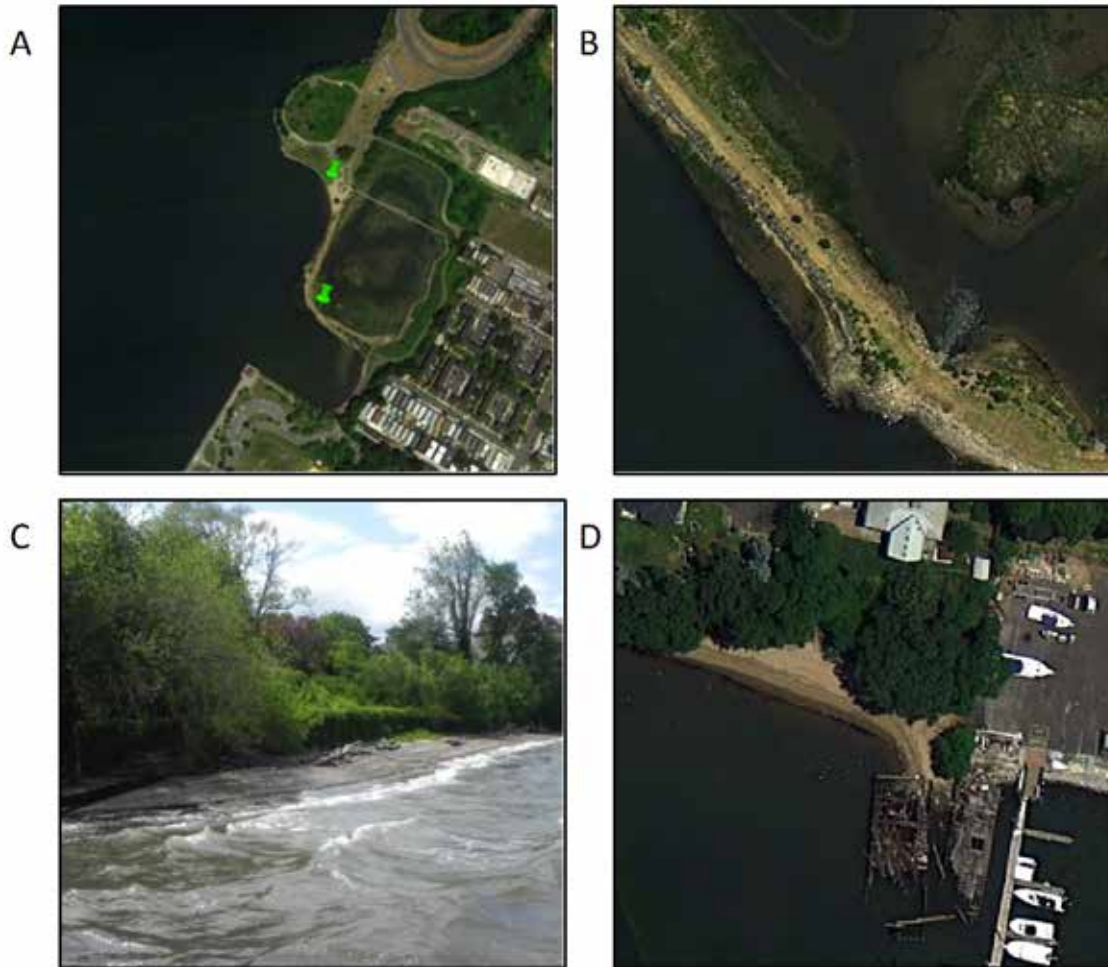


**Figure B3 Residential Zoning – No Access**

Representative photos: A) Aerial view. B) Zoomed view. C) 2012 photograph of walkway with no access. D) 2012 photograph of residential zoned property with steep slope and no access

## Appendix B

Current and Future Land Use  
and Access to the Shoreline



**Figure B4 Residential Zoning – With Recreational Access**

Representative photos: A) Aerial view. B) Zoomed view. C) Beach area. D) Boating docks.

## Appendix B

Current and Future land Use  
and Access to the Shoreline

Table B1 NBSA Shoreline Segment Information – Current Land Use

No.	Location	Description	Length (mile[s])	Zoning Category	Shoreline Access Characterization
1	Kearny, NJ	Kearny Point	0.4	Industrial	Industrial/Manufacturing/Commercial Zoning – With Access
2	Jersey City, NJ	Kellogg St	0.2	Redevelopment Area	Industrial/Manufacturing/Commercial Zoning – No Access
3	Jersey City, NJ	Droyers Point (1)	0.1	Redevelopment Area	Residential Zoning – With Recreational Access
4	Jersey City, NJ	Droyers Point (2)	0.9	Redevelopment Area	Residential Zoning – No Access
5	Jersey City, NJ	The Thomas M. Gerrity Athletic Complex	0.2	Residential	Residential Zoning – With Recreational Access
6	Jersey City, NJ; Bayonne, NJ	Route 440	0.9	Community Commercial	Residential Zoning – No Access
7	Bayonne, NJ	Route 440, south of railroad bridge	0.1	Community Commercial	Residential Zoning – With Recreational Access
8	Bayonne, NJ	Route 440 to Rutkowski Park	0.2	Community Commercial	Residential Zoning – No Access
9	Bayonne, NJ	Rutkowski Park	0.6	Residential	Residential Zoning – With Recreational Access
10	Bayonne, NJ	Bayonne Park	0.8	Residential	Residential Zoning – No Access
11	Bayonne, NJ	Park Drive to Benmore Terrace	0.1	Residential	Residential Zoning – With Recreational Access
12	Bayonne, NJ	Benmore Terrace to W 31 <sup>st</sup> Street	0.4	Residential	Residential Zoning – No Access
13	Bayonne, NJ	W 31 <sup>st</sup> Street to W 30 <sup>th</sup> Street	0.1	Residential	Residential Zoning – With Recreational Access
14	Bayonne, NJ	Bayonne High School (North)	0.1	Residential	Residential Zoning – No Access
15	Bayonne, NJ	Bayonne High School to W 24 <sup>th</sup> Street	0.4	Residential	Residential Zoning – With Recreational Access (rocky shoreline; elevation differences between land and water)
16	Bayonne, NJ	W 23 <sup>rd</sup> Street	0.1	Residential	Residential Zoning – No Access
17	Bayonne, NJ	W 22 <sup>nd</sup> Street	0.1	Residential	Residential Zoning – With Recreational Access
18	Bayonne, NJ	Between W 22 <sup>nd</sup> and W 21 <sup>st</sup> Streets	0.1	Residential	Residential Zoning – No Access

## Appendix B

Current and Future land Use  
and Access to the Shoreline

No.	Location	Description	Length (mile[s])	Zoning Category	Shoreline Access Characterization
19	Bayonne, NJ	W 21 <sup>st</sup> Street to Marina	0.8	Residential	Residential Zoning – With Recreational Access
20	Bayonne, NJ	Marina to W 8 <sup>th</sup> Street	0.2	Residential	Residential Zoning – No Access
21	Bayonne, NJ	W 8 <sup>th</sup> Street to Marina 2	0.2	Residential	Residential Zoning – With Recreational Access
22	Bayonne, NJ	South of Marina 2	0.1	Residential	Residential Zoning – No Access
23	Bayonne, NJ	Community commercial area	0.3	Community Commercial	Residential Zoning – With Recreational Access
24	Bayonne, NJ	Heavy Industrial area	0.4	Industrial	Industrial/Manufacturing/Commercial Zoning – No Access
25	Bayonne, NJ	Waterfront Development District	0.8	Waterfront Development District	Industrial/Manufacturing/Commercial Zoning – With Access
26	Staten Island, NY	Staten Island (small section by bridge)	0.1	Manufacturing	Industrial/Manufacturing/Commercial Zoning – With Access
27	Staten Island, NY	Staten Island East	3.2	Manufacturing	Industrial/Manufacturing/Commercial Zoning – No Access
28	Staten Island, NY	Staten Island West	1.6	Manufacturing	Industrial/Manufacturing/Commercial Zoning – With Access
29	Staten Island, NY	Shooters Island	0.8	Manufacturing	Industrial/Manufacturing/Commercial Zoning – With Access
30	Elizabeth, NJ	MRC	0.4	Manufacturing, Research, Commercial	Residential Zoning – With Recreational Access
31	Elizabeth, NJ	MRC 2	1.0	Manufacturing, Research, Commercial	Industrial/Manufacturing Commercial Zoning – No Access
32	Elizabeth, NJ	Kapkowski	1.1	Kapkowski Road Redevelopment Area	Industrial/Manufacturing Commercial Zoning – With Access
33	Newark, NJ	Port Newark	8.4	Industrial	Industrial/Manufacturing Commercial Zoning – No Access
34	Newark, NJ	Area near highway and railroad bridges	0.9	Industrial	Industrial/Manufacturing Commercial Zoning – With Access
35	Newark, NJ	North of railroad bridge	0.4	Industrial	Industrial/Manufacturing Commercial Zoning – No Access

**Appendix B**

Current and Future land Use  
and Access to the Shoreline

No.	Location	Description	Length (mile[s])	Zoning Category	Shoreline Access Characterization
36	Newark, NJ	North of Hess Plant	0.2	Industrial	Industrial/Manufacturing Commercial Zoning – With Access
37	Newark, NJ	Final NW Segment	0.6	Industrial	Industrial/Manufacturing Commercial Zoning – No Access

Notes:

MRC = Manufacturing, Research, Commercial

NW = northwest

W = west

**Appendix B**Current and Future Land Use  
and Access to the Shoreline**Table B2a NBSA Summary of Exposure Characterizations – Current Land Use**

<b>Characterization</b>	<b>Total Length (miles)</b>	<b>Percentage of Total Perimeter (%)</b>
Industrial/Manufacturing/Commercial Zoning – No Access	15.1	55.3
Industrial/Manufacturing/Commercial Zoning – With Access	5.6	20.5
Residential Zoning – No Access	2.9	10.6
Residential Zoning – With Recreational Access	3.7	13.6
Residential Zoning – With Residential Access	0	0
All Characterizations	27.3	100

**Table B2b Detailed Exposure Characterizations Using Actual Zoning Categories Utilized by Municipalities – Current Land Use**

<b>Zoning Category as Listed by Municipalities</b>	<b>Total Length (miles)</b>	<b>Percentage of Total Perimeter (%)</b>
Industrial/Manufacturing Zoning – No Access	13.0	47.6
Industrial/Manufacturing/ Zoning – With Access	4.8	17.6
Bayfront I Redevelopment Area – No Access*	0.2	0.7
Droyers Point Redevelopment Area – No Access*	0.9	3.3
Droyers Point Redevelopment Area – With Recreational Access*	0.1	0.4
Kapkowski Road Redevelopment Area – With Access*	1.1	4.0
Residential Zoning – No Access*	1.8	6.6
Residential Zoning – With Recreational Access*	2.5	9.2
Residential Zoning – With Residential Access*	0	0
Commercial Zoning – No Access*	1.1	4.0
Commercial Zoning – With Access*	0.4	1.5
Industrial/Manufacturing Zoning – No Access	13.0	47.6
All characterizations	27.3	100

\*Non-industrial area

## Appendix B

### Current and Future Land Use and Access to the Shoreline

## 2. Current Land Use – Marinas and Boat Ramps

Using Google Earth (imagery date: June 17, 2010)) of the shoreline and internet searches, marinas and boat ramps in the NBSA were identified (Figure B7). Boat/kayak rental businesses were also researched, but none were specifically identified along the perimeter of the NBSA. Marina, boat ramp and boat rental locations will be further researched during the site reconnaissance to be conducted during sampling.

## 3. Future Land Use

There are four areas (see Table B3 below and Figure B8) along the perimeter of the NBSA that have the potential to undergo future residential development. These areas were identified by regional zoning maps and further investigated by reviewing development plans from the respective cities or counties surrounding the NBSA to determine any potential differences between current and future land use with respect to potential exposures to sediments.

**Table B3 NBSA Areas Slated for Alternative Future Development (Including Residential)**

Zone	Length (mile[s])	Current Shoreline Access Characterization	Potential Future Use (and Shoreline Access Characterization)
Bayfront I Redevelopment Zone	0.2	Industrial/Manufacturing – No Access	Mixed-use residential, retail, parks or recreation, and commercial area (non-industrial area with no access)
Waterfront Development District	0.8	Industrial/Manufacturing – With Access	Mixed-use residential, parks, and commercial area (non-industrial area with recreational access)
Kapkowski Road Redevelopment Area	1.0	Industrial/Manufacturing – With Access	Mixed-use residential and commercial area (non-industrial area with recreational access)
Staten Island – North Shore	NA	Industrial/Manufacturing – With Access	Mixed-use recreational and commercial (non-industrial area with recreational access)

NA = not available

The Bayfront I Redevelopment Plan involves redeveloping the industrial area to a mixed-use community that will provide “access to an enhanced waterfront to the benefit of the entire Jersey City community.” (Jersey City 2008). Specifically, this area will include (when completed) new housing, retail, office space, parkland, and other amenities. Planning recommendations include a waterfront walkway:

“the riverfront walkway will be continued from the Droyers Point project along the Hackensack Riverfront to the adjacent property to the north.” (Jersey City 2008).

**Appendix B**Current and Future Land Use  
and Access to the Shoreline

This plan would change the shoreline access characterization (above section) for the affected 0.2-mile stretch from an industrial area with no access to a non-industrial area with no access, given that the walkway will be continued (and the walkway is constructed so that it borders the shoreline but does not allow access). This change in categorization would not impact how exposure is assessed in the human health risk assessment (i.e., current and future plans involve recreational exposures).

The Waterfront Development District (also referred to as the Texaco Site) is currently zoned for a mix of residential and commercial uses, including one- and two-family dwellings, multi-family housing, retail, offices, restaurants, theaters, commercial recreation, and marinas. It is anticipated that the site will accommodate a mixed-use development with a significant portion earmarked for residential use. Notably, the area is currently being remediated due to contamination, though the plan states that it has the potential to be cleaned to residential site standards. According to the redevelopment plan (City of Bayonne 2000):

“a remediation plan is being prepared for the remaining contaminated area adjacent to the Bayonne Bridge. The initial evaluation indicates that this small portion of the site may be unsuitable for residential use. This is a condition that should be factored into overall site development.”

The plan also states that the District should incorporate a waterfront walkway and that this walkway should conform to New Jersey Department of Environmental Protection (NJDEP) standards and has an inviting public access environment. There is also discussion regarding the existing pier as part of the recreational landscape, with the text stating that “the existing pier may be suitable for recreational use and/or a limited commercial use such as a restaurant.” This area is currently considered an industrial/manufacturing location where recreational access is possible, so the future plans would not change how exposure is characterized (i.e., recreational access under current and future scenarios).

The Kapkowski Road Redevelopment Area will be another mixed-use area, although limited information was available from the City of Elizabeth (Construction Journal 2012; Schoor DePalma, Inc. 2005) to specifically characterize future plans. The current shoreline access characterization of this 1-mile zone allows for possible recreational access. This area is currently considered an industrial/manufacturing location where recreational access is possible, so the future plans would not change how exposure is characterized (i.e., recreational access under current and future scenarios).

The North Shore of Staten Island is not currently zoned for redevelopment, but a task force, North Shore 2030, has been initiated as part of a comprehensive planning effort looking at Staten Island’s future (New York City 2011b). Literature from the task force indicates that small sections of the shore could become park or mixed-use areas, while others will remain waterfront-manufacturing locations. This change would have minimal impact on the current shoreline characterization of the NBSA as a whole. The North Shore of Staten Island consists of two areas of land, totaling 0.4 mile, which are described in the North Shore 2030 plan as

## **Appendix B**

### **Current and Future Land Use and Access to the Shoreline**

"New waterfront open space public access," but are currently characterized as industrial/manufacturing – no access. Depending on the final outcome of the redevelopment, this 0.4 mile could become areas with recreational access to the NBSA. With the exception of a 0.4-mile stretch on the North Shore of Staten Island, none of the redevelopment plans indicate that future exposures to sediments and water will be different than current exposures.

## **Appendix B**

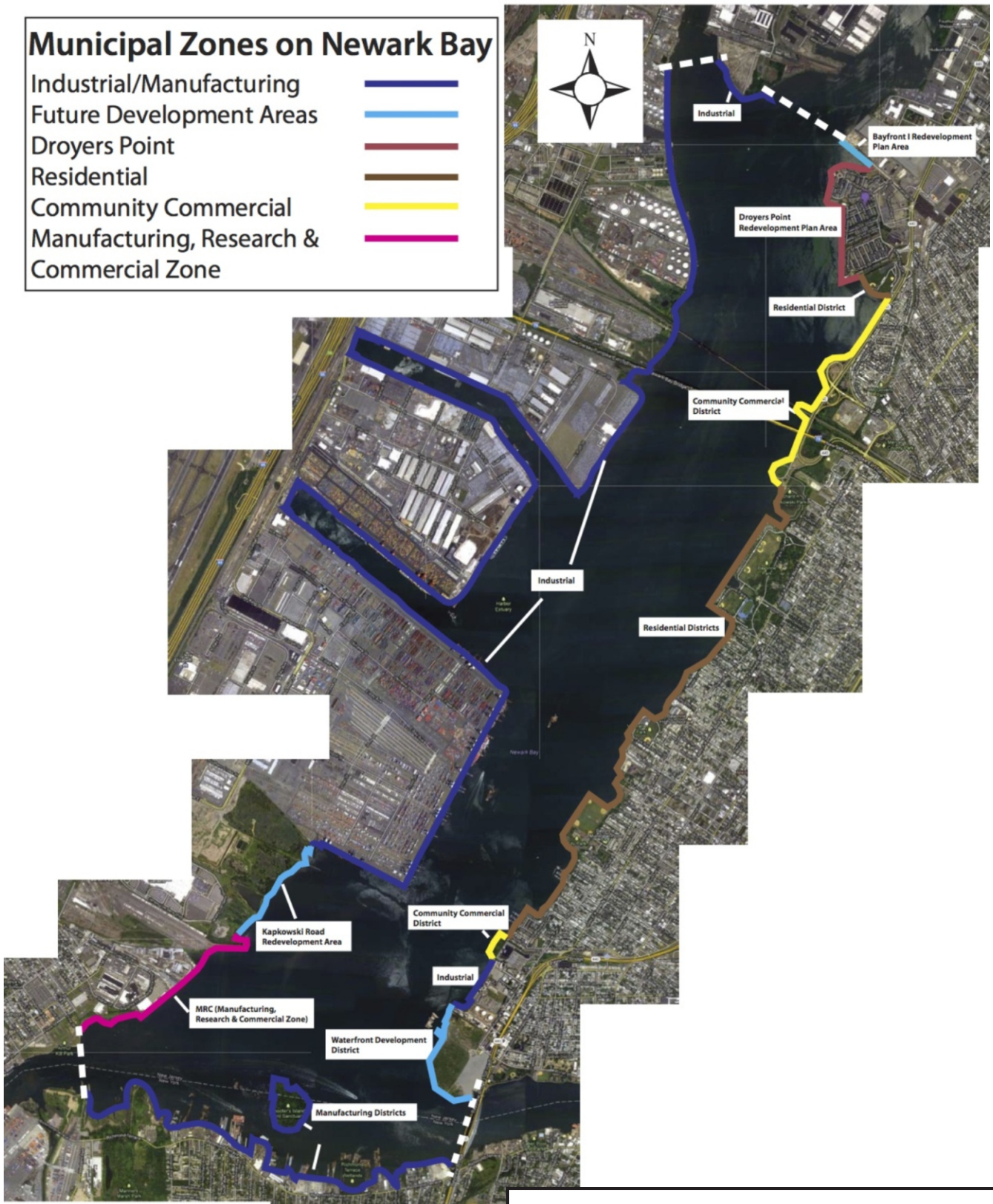
Current and Future Land Use  
and Access to the Shoreline

### **4. References**

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## Municipal Zones on Newark Bay

Industrial/Manufacturing	
Future Development Areas	
Droyers Point	
Residential	
Community Commercial	
Manufacturing, Research & Commercial Zone	



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

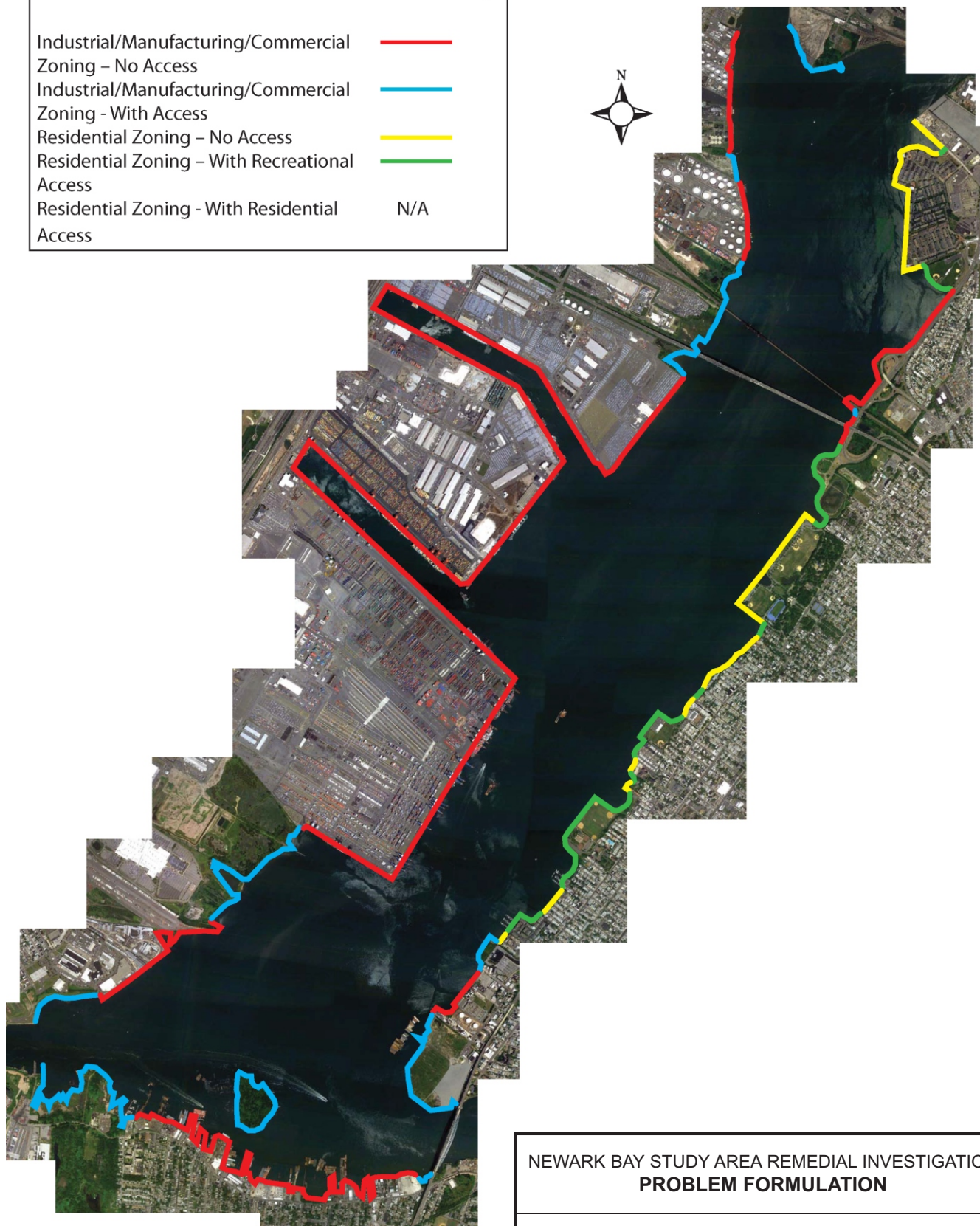
NBSA ZONING PERIMETER MAP

JUNE 2013

FIGURE  
**B5**

# Characterization of land areas on Newark Bay

- Industrial/Manufacturing/Commercial Zoning – No Access —
- Industrial/Manufacturing/Commercial Zoning - With Access —
- Residential Zoning – No Access —
- Residential Zoning – With Recreational Access —
- Residential Zoning - With Residential Access N/A



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

**NBSA SHORELINE ACCESS  
CHARACTERIZATION**

**JUNE 2013**

FIGURE  
**B6**



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

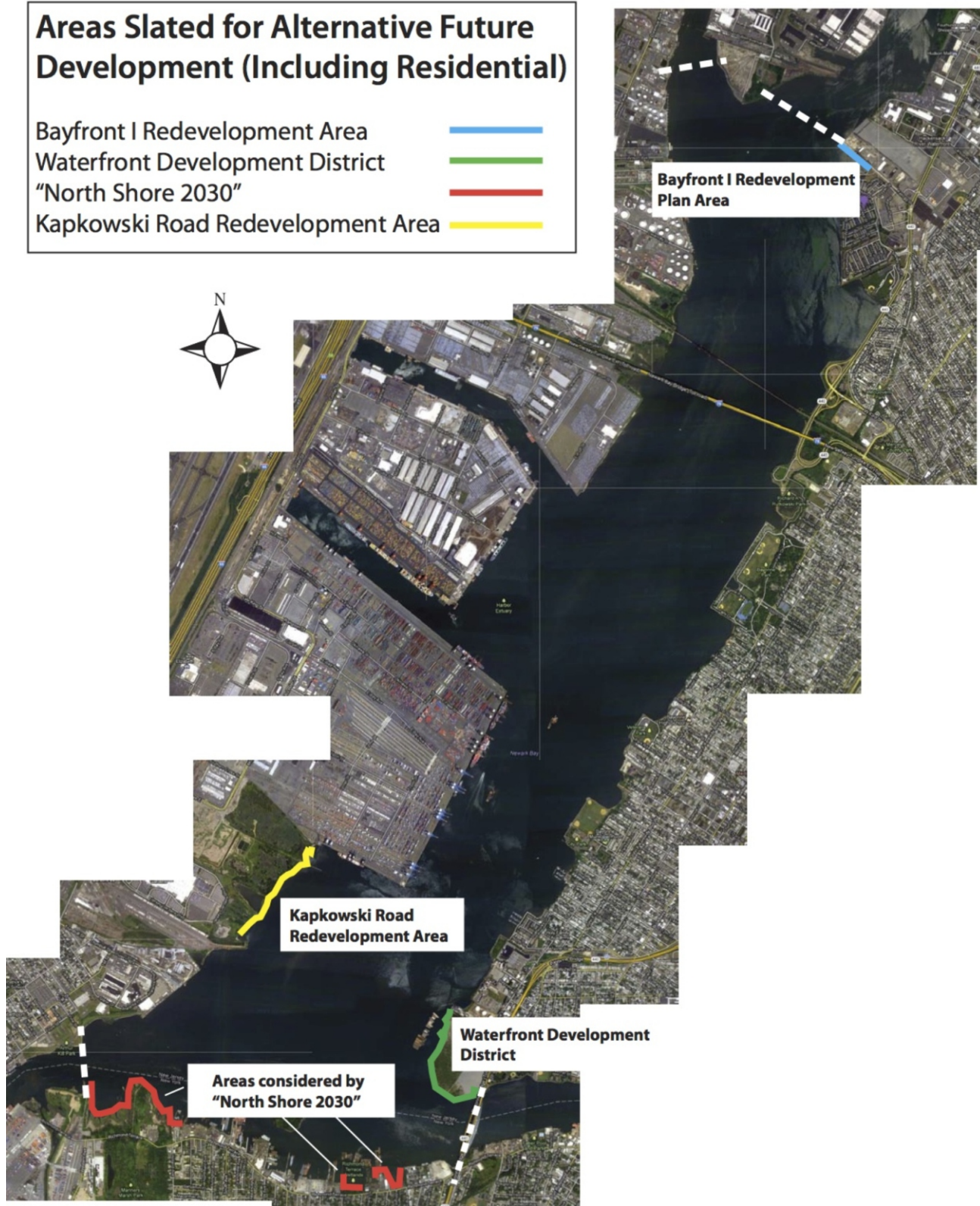
MARINAS AND BOAT RAMPS

JUNE 2013

FIGURE  
**B7**

# Areas Slated for Alternative Future Development (Including Residential)

- Bayfront I Redevelopment Area —
- Waterfront Development District —
- "North Shore 2030" —
- Kapkowski Road Redevelopment Area —



NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION  
PROBLEM FORMULATION

NBSA FUTURE LAND USE  
CHARACTERIZATION

JUNE 2013

FIGURE  
**B8**

Note:  
Only showing potential changes from current use.

## **Appendix C**

The Intelligence Group (TIG)  
Reconnaissance Survey

**Table C1 The Intelligence Group (TIG) Reconnaissance Field Notes**

City	General Area	Specific Area	Reason Follow Up Requested	Notes During Reconnaissance	Characterization of Shoreline Access
Jersey City	Droyers Point	Open field area	Need to see if there is access to the sediment in the open field area	Easy access to water by walking across open field; water level appears to be 10 feet or less from ground	Recreational Access
Bayonne	Park Drive	Southeast end of park, where Hackensack Riverwalk ends	Appears to have stairs, but it is unclear if this is the case or where potential stairs lead	Small shoreline area, appears to be inaccessible to public; terrain at end of W37th Street, Wesley Court, Benmore Terrace, etc. from street level down to water very steep, brush covered, rocky; would be very difficult & dangerous for public to navigate; no steps observed from street level down to water; barrier walls seen in backyards of some homes	Recreational Access
Bayonne	W 37 <sup>th</sup> Street	End of Street	Determine if there is access from the house on the end of W 37th	Road dead-ends; no observed pathways down to water; based on vantage point, terrain at end of W37th Street from street level down to water very steep, brush covered, rocky; would be very difficult and dangerous for public to navigate	Recreational Access
Bayonne	Benmore Terrace	End of Street	Determine if there is access from the house on the end of Benmore Terrace	It does not appear as if there is access from the house down to the water; based on observations from Hackensack River Walkway, terrain from house to water would be an extremely steep drop down to water level	No Access
Bayonne	Lincoln Parkway	End of Street	Determine if there is access to the bay off to the left	Locked fence with steep road down to what is believed to be Bayonne Sewage Pumping Station; fence continues along side of residence	No Access
Bayonne	W 24 <sup>th</sup> Street	End of Street	Characterize access from the community of trailers	Mobile home park with Bayfront parking lot for residents' vehicles; certain vehicles appear to be filled to window-level with belongings and/or garbage; easy shoreline access to water via parking lot; some mobile homes are waterfront and have fences	Recreational Access (will be assessed with additional reconnaissance)
Bayonne	W 8 <sup>th</sup> Street	End of Street	Determine if there is access from the house on the end of W 8th St (see photo)	Road dead-ends; no observed pathways down to water; terrain at end of W8th Street from street level down to water very steep, brush covered, rocky; would be very difficult and dangerous for public to navigate	No Access



**Jersey City – Droyers Point**



**Bayonne – Park Drive**



**Bayonne W 37<sup>th</sup> Strreet**



**Bayonne – Benmore Terrace**



**Bayonne – Lincoln Parkway**



**Bayonne – West 24th**



**Bayonne West 8th**

## **Appendix D**

Land Use Research Log

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Response Received?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
NJ State Police, Newark Bay Marine Services Bureau at Port Newark	973-578-8173	4/30/2012	No	--	Commercial diving, recreational activities/boating, hunting	--
NJ State Police, Maritime Questions	lppmsb@gw.njsp.org & roic@gw.njsp.org	5/2/2012	Yes	5/13/2012	Commercial diving, recreational activities/boating, hunting, shooting	Contact NJSP Newark Bay Station personnel (973-578-8189).
Port Authority, NY/NJ	panynj.gov/feedback/ (submitted questions online)	3/30/12 & 4/30/12	Yes	5/18/2012 (from Kathy Kovach, kkovach@panynj.gov)	Commercial diving, recreational activities/boating	The Port Authority regularly inspects its underwater infrastructure. Diving work is subject to OSHA Commercial Diving requirements. Port Authority does not serve as a harbormaster; rather, the U.S Coast Guard is responsible for enforcement of waterway regulations & activities, as well as possibly municipal, county & state agencies having similar jurisdiction. Information on recreational activity can be requested from local jurisdictions.
Port Authority, NY/NJ	212-435-3008	4/2/2012	No	--	Commercial diving, recreational activities/boating	--
US Coast Guard (response from Jeff Yunker)	LNMD1@uscg.mil	4/2/12 & 4/30/12	Yes	5/3/2012	Commercial diving	Questions regarding bridge work in Newark Bay may be addressed to Joe Arca at 212-668-7069 or Joe.M.Arca@uscg.mil. OSHA diving regulations are published in Title 29 CFR Part 1910 Subpart T and are available at ecfr.gpoaccess.gov.
US Coast Guard (response from Jeff Yunker)	LNMD1@uscg.mil	4/2/12 & 4/30/12	Yes	5/3/2012	Recreational activities/boating	Recreational boating information is available at New Jersey State Boating Law Administration, Newark Bay, state.nj.us/njsp/maritime/msb-location.html or 973-578-8173. The Marine Trades Association of NJ publishes a Boater's Directory and Boat Ramp Guide. They are available online or to order at mtanj.org in the "Boater Information" section or 732-292-1051.
Randive	randive.com/contact-us.php; divingservices@randive.com	4/30/2012 & 5/1/12	Yes	5/1/2012	Commercial diving	All commercial diving operations are covered by OSHA, USCG and ADC International. We engage in every aspect of commercial diving, including general maintenance and repair work on either a scheduled or emergent basis.
Dryden Diving Company	drydiv@hotmail.com	5/1/2012	Yes	5/1/2012	Commercial diving	Our divers are subject to commercial diving regulations as established in the OSHA regulations. Many divers in the New York area work 200 or more days per year for 6 or more hours per day. There is no limit on the consecutive days worked for a diver.
John Christenson of Pile Test Inc; also listed for Coastal U/W Service M&J Marine	732-899-3034	4/30/2012	Yes	4/30/2012	Commercial diving	Company has commercial diving year-round; does work in Newark Bay. Time spent diving varies greatly with project; no limit on days in a row divers can work. Follow OSHA commercial diving regulations. Work 8-10 hour days. Perform contamination work, piles, on-going work in Bay for Honeywell.
Leah Graziano, ATSDR, NYC	escobar.leah@epa.gov	4/30/2012	No	--	Commercial diving, recreational activities/boating	--
NJDOT	maritime@dot.state.nj.us	5/2/2012	No	--	Commercial diving, recreational activities/boating	--
Manhattan Kayak Company	info@manhattankayak.com	3/30/2012	Yes	4/1/2012	Recreational activities/boating	We do not offer kayak trips on Newark Bay, and we don't have any specific information re: outfitters offering services for that body of water.

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Response Received?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
Passaic River Boat Club	passaicriverboatclub.info/P RBC/Joomla/index.php?opti on=com_contact&view=con tact&id=2&Itemid=9 (online request)	5/2/2012	No	--	Recreational activities/boating	--
Bill Sheehan, Hackensack Riverkeeper	info@hackensackriverkeep er.org	5/2/2012	No	--	Recreational activities/boating	--
Essex County Dept of Parks, Rec & Cultural Affaris	joedi@admin.essexcountyn j.org	4/2/2012	No	--	Recreational activities/boating	--
Hudson County Div of Parks, Director	bruttler@hcnj.us	4/2/2012	No	--	Recreational activities/boating	--
Union County Parks	nyc.gov/html/mail/html/mail dpr.html (online request; response from parksinfo@ucnj.org)	4/2/2012	Yes	4/2/2012	Recreational activities/boating	Passed along contact information for City of Elizabeth's Recreation Department & Union County Police Marine Unit.
New York Commissioner, Dept of Parks & Recreation	nyc.gov/html/mail/html/mail dpr.html (online request)	4/2/2012	No	--	Recreational activities/boating	--
City of Elizabeth Parks & Recreation	908-820-4226	4/3/2012	Yes	4/3/2012	Recreational activities/boating	Ashley believes there are no Bay recreational exposures. She has lived in the area 20 years and has never seen anyone go into Bay water; hasn't observed any recreational activities on the Bay.
Union County Department of Emergency Management	908-654-9800	4/3/2012	Yes	4/3/2012	Recreational activities/boating	Kelly believes there are no recreational activities on Newark Bay; has never seen anyone boating, canoeing, etc. in the Bay.
Lynette Lurig, NJDEP	609-633-1314	4/30/2012	Yes (response to later email)	4/30/2012	Recreational activities/boating	Tied up until late week of 5/7/12; will be available to talk then.
Lynette Lurig, NJDEP	Lynette.Lurig@dep.state.nj. us	5/1/2012	Yes	5/1/2012	Recreational activities/boating	Tied up until late week of 5/7/12; will be available to talk then.
Lynette Lurig, NJDEP	609-633-1314	5/18/2012	Yes	5/18/2012	Recreational activities/boating	New park in Newark to open soon; Passaic now has more access points for fishing than did previously. Recreational activity on Bay has increased in the past 6-7 years. Most recreational water activity is on nearby waterbodies, but has also observed it in the Bay. Has observed sailboating; a livery is present on the Bay. Has seen canoes, kayaks & boat ramps in Meadowlands, Woodbridge. Boats go through Arthur Kill to Bay; has observed people putting in kayaks in Elizabeth, above Secaucus behind Meadowlands. New facilities and jet ski companies in the area; some in the Bay, some closer to the coast. Re: marinas/boat rental facilities on Bay - Robbins Reef Yachtclub in Bayonne; Hackensack Riverkeeper has livery which rents canoes/kayaks. Marinas in Arthur Kill, Perth Amboy. Has observed people bird watching. The Bay is somewhat dangerous for small boats, as large container ships are often present. Condos/townhouses in Bayonne which have moorings. Sailboats are docked in Newark Bay (may go out to ocean).
Debbie Mans (NY/NJ Baykeeper)	debbie@nynjbaykeeper.org	5/1/2012	Yes	5/1/2012	Recreational activities/boating	Passed along websites for Hackensack Riverkeeper, Passaic River Boat Club, & Passaic River Yacht Club.

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Response Received?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
Tim Iannuzzi & Melissa Beauchemin, ARCADIS	Tim.Iannuzzi@arcadis-us.com, Melissa.Beauchemin@arcadis-us.com	4/30/2012	Yes, from Melissa	4/30/2012	Types of birds that may be hunted in/around Newark Bay, contacts for boating companies, contacts for harbor staff (e.g., for opening bridges)	Provided names of Miller's Launch Marina & Elco Boat Basin; attached draft document from site reconnaissance.
Luxergy (Jet Skiing)	luxergy.com	3/30/2012	No	--	Some info found on website	Website says Luxergy no longer offers jet skiing in Bayonne, Elizabeth, Newark, or Passaic.
Luxergy (Jet Skiing)	888-589-3749	4/30/2012	No	--	Asked why no longer offer jet skiing in the 4 cites listed above	--
Sven VanBatavia, Miller's Launch	sven@millerslaunch.com	4/30/2012	No	--	Recreational activities/boating, contact information for Harbormaster	--
Chief Mark Chicketano, NJ Div of Fish & Wildlife, Bureau of Law Enforcement, Trenton	Mark.Chicketano@dep.state.nj.us	1/20/12 (Response forwarded by E Naranjo)	Yes	1/20/12 (Response forwarded by E Naranjo)	Is hunting legal in Newark Bay?	It is entirely legal to hunt in Newark Bay. All hunting regulations which are applicable elsewhere would of course apply. There is no generalized prohibition against it; it is inherently legal.
Chief Mark Chicketano, NJ Div of Fish & Wildlife, Bureau of Law Enforcement, Trenton	Mark.Chicketano@dep.state.nj.us	4/3/2012	Yes	4/4/2012	Likelihood of fowl and amphibian consumption by people in the vicinity of Newark Bay.	After 28 yrs in law enforcement, I have NEVER heard of anyone hunting waterfowl or collecting amphibians in Newark Bay. There is however, a fairly large group of hunters who hunt waterfowl in the Hackensack River, mostly on the Sawmill Creek Wildlife Management Area located in Lyndhurst, Carlstadt, and Secaucus and a very limited number of waterfowl hunters in the lower Passaic River. I've not heard of anyone in this area (the Hackensack or Passaic Rivers) collecting amphibians.
Reyhan Mehran & Jay Field, NOAA	reyhan.mehran@noaa.gov, jay.field@noaa.gov	4/10/2012	Yes (From R Mehran)	4/12/2012	Commercial diving	In addition to the USCG and the PA, reach out to ATSTDR in NYC (Leah Graziano). For commercial divers, try contacting Dryden Diver Co, K B Commercial Diving, North Atlantic Commerical Diving, and M&J Marine & see if they have any work going on now or know of anything planned. Also see if Marion Olsen at EPA, Anne Hayton at NJDEP, or Tim Kubiak at USFWS have other suggestions (if you haven't checked with them already; I have copied them on this email).
Reyhan Mehran & Jay Field, NOAA	reyhan.mehran@noaa.gov, jay.field@noaa.gov	4/10/2012	Yes (From R Mehran)	4/12/2012	Recreational activities/boating	For recreational activities, contact the NY/NJ Baykeeper (Debbie Mans) & the various boat clubs.
Anne Hayton, NJDEP	Anne.Hayton@dep.state.nj.us	4/12/2012	Yes (Reyhan forwarded Anne my original email)	4/12/2012	Commercial diving	For commercial divers or construction workers, seek information from both private & government agencies which fund marine-related maintenance work, e.g., Port Authority of NY/NJ, dredging companies, USACE (Bryce Wisemiller), NJDOT, & NJ State Police. Eugenia Naranjo (USEPA) may be able to provide contact names/numbers, email addresses for other Bay Agency Coordination participants.
Anne Hayton, NJDEP	Anne.Hayton@dep.state.nj.us	4/12/2012	Yes (Reyhan forwarded Anne my original email)	4/12/2012	Recreational activities/boating	For recreational activities, please contact Lynette Lurig, NJDEP & the NJ State Police.

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Response Received?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
Bryce Wisemiller, USACE	bryce.w.wisemiller@usace.army.mil	4/10/2012	Yes	4/10/2012	Commercial diving	Would be difficult to estimate any time spent by divers related to our HDP construction. The Corps generally does not allow for any diving in our contracts unless an unexpected occurrence in a contract happens. Contact one of the commercial diving companies that work for the various dredging or marine construction companies (e.g., Randdive) to obtain actual exposure information.
Bryce Wisemiller, USACE	bryce.w.wisemiller@usace.army.mil	4/10/2012	Yes	4/10/2012	Recreational activities/boating	The only information I would have on recreational usage in the Newark Bay would be anecdotal based on my own personal experience in the Bay. The most prevalent recreational usage of the Newark Bay I'm aware of, by far, is recreational fishing, particularly at publically accessible locations such as the Elizabeth Marina. While I would hope that these fishermen do not consume the fish they catch (as the signs everywhere advocate), I know from speaking to several of them over the years, that many do indeed consume the fish that are caught from the Bay.
US Coast Guard	Joe.M.Arca@uscg.mil	5/7/2012	Yes	5/8/2012	Commercial diving, construction	We do not keep a list of divers that work in our area. However, David J. Sheridan, Sr. does a lot work in the area and can probably assist (908-685-0456, southtrader@mindspring.com).
Marine Trades Association of New Jersey	info@mtanj.org	5/7/2012	Yes	5/7/2012	Recreational activities/boating	Forwarded inquiry to staff at NJOT, Coast Guard & Ray Fusco (consultant). Ray Fusco said he could provide information.
Ray Fusco	m: 410-299-1917, o: 845-509-5999	5/7/2012	Yes	5/7/2012	Recreational activities/boating	Mr. Fusco has projects on Port of NY/NJ; has NJDOT Harbor Safety Grant. Some recreational boating on Bay, since is an industrial area with shipping traffic, it seems boating in Bay is mainly to get to other recreational areas (e.g., Hackensack, Passaic, Arthur Kill, Kill Van Kull). Fishing is common. Robbins Reef Marina (in Bayonne) is only marina he's seen on the Bay. Recommended search list of NJ marine boat launches to see proximity; perhaps boat launch in Laurel Hill or Lincoln Park. He doesn't know of any canoe/kayak rentals in the Bay.
7 boating companies/marinas listed on the Marine Trades Association of New Jersey's website	debbie@grassysoundmarina.com, deelvmm@aol.com, marina@irwinmarinenj.com, lakeviewdocks@comcast.net, info@pier47.com, SShoreMma@aol.com, emccann@vikingyachts.com	5/7/2012	Yes; from Irwin Marine	5/7/2012	Recreational activities/boating	Recommended contacting the Marine Trades Office directly.
List of New Jersey Marinas	jerseymarinas.com/ramp.htm	6/6/2012	Located marina list on website	6/6/2012	Located marina list on website	One boatramp listed in Newark Bay: Bayonne Municipal Launching Ramp, West Shore Drive & West 16th Street, Bayonne, NJ, 201-858-612.

Table D1 – Land Use Research Log

Person/Entity Contacted	Contact Info Used	Date of Contact	Response Received?	Date Response Received	Nature of Questions	Summary of Information Provided by Person
National Park Service (NPS)	Jill_Hawk@nps.gov, David@patersongreatfalls.org	3/27/2013	Yes; from Darren Boch, Superintendent Paterson Great Falls NHP	3/28/2013	Recreational activities/boating; new canoe/kayak trail along Passaic thru Newark Bay	Recommended contacting Ella Fillipone at the Passaic River Coalition ( <a href="http://www.passaicriver.org">www.passaicriver.org</a> ) and Jerry Willis with Rivers Trails Conservation Assoc. ( <a href="mailto:jerry_willis@nps.gov">jerry_willis@nps.gov</a> , 908-461-7596)
Ella Fillipone, Passaic River Coalition	prcwater@aol.com	3/28/13 & 4/3/13	No	--	Recreational activities/boating; new canoe/kayak trail along Passaic thru Newark Bay	--
Jerry Willis with Rivers Trails Conservation Assoc. (NPS)	jerry_willis@nps.gov; 908-461-7596	3/28/13, 4/3/13; 4/4/13	Yes	4/5/2013	Recreational activities/boating; new canoe/kayak trail along Passaic thru Newark Bay	Mr. Willis is more familiar with recreational activities on the Lower Passaic and Hackensack than the Bay. He provided a draft plan for a proposed canoe/kayak trail along the Passaic ending at Kearny Point, but the trail has not been developed. The Lower Passaic is heavily used for kayaking and by rowing clubs. Regarding recreational activities on the Bay, Mr. Willis indicated that it is likely that only very experienced paddlers would kayak/canoe there, due to the tanker traffic. Also the large sewage treatment plant in the area may be a deterrent.

**Abbreviations**

ADC - Association of Diving Contractors

Assoc - Association

ATSDR - Agency for Toxic Substances and Disease Registry

CFR - Code of Federal Regulations

Dept - Department

Div - Division

HDP - Harbor Deepening Project

NJ - New Jersey

NJ - New Jersey

NJDEP - New Jersey Department of Environmental Protection

NJDOT - New Jersey Department of Transportation

NJSP - New Jersey State Police

NOAA - National Oceanic and Atmospheric Administration

NPS - National Park Service

NY - New York

NY/NJ - New York/New Jersey

NYC - New York City

OHSA - Occupational Safety and Health Administration

PA - Port Authority

Rec - Recreation

USACE - US Army Corps of Engineers

USCG - United States Coast Guard

USEPA - US Environmental Protection Agency

USFWS - US Fish and Wildlife Service