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Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

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Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
4,4'-DDD	4,4'- dichlorodiphenyldichloroethane
4,4'-DDT	4,4'-dichlorodiphenyltrichloroethane
ARARs	applicable or relevant and appropriate requirements
Bay	Newark Bay
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BIC	benthic invertebrate community
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
CFT	contaminant fate and transport
CTE	central tendency exposure
DL	dioxin-like
FFS	focused feasibility study
FS	feasibility study
FS WP	feasibility study work plan
g/day	grams per day
GSH	Glenn Springs Holdings, Inc.
HI	hazard index
HQ	hazard quotient
HVCWCM	high volume chemical water column monitoring
ICT	Identification of Candidate Technologies
LOAEL	lowest observed adverse effect level
LPR	Lower Passaic River
LPRSA	Lower Passaic River Study Area
mg/kg	milligrams per kilogram
NBSA	Newark Bay Study Area
NCP	National Contingency Plan
ng/kg	nanograms per kilogram
ng/L	nanograms per liter
NJDEP	New Jersey Department of Environmental Protection
NOAEL	no observed adverse effect level

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OU	operable unit
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PRG	preliminary remedial goal
RAL	remedial action levels
RAO	remedial action objective
RAS	Remedial Alternatives Screening
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	record of decision
SQT	sediment quality triad
SSD	species sensitivity distribution
SumTU	sum of toxic units
SVCWCM	small volume chemical water column monitoring
TBCs	to be considered
TEF	toxicity equivalence factors
TEQ	toxicity equivalence
tetraPCBs	total tetra-chlorinated PCBs
Total DDx (4,4')	sum of 4,4'-dichlorodiphenyldichloroethane, 4,4'-dichlorodiphenyldichloroethylene, and 4,4'-dichlorodiphenyltrichloroethane
Total DDx (2,4' and 4,4')	sum of 2,4'-dichlorodiphenyldichloroethane, 2,4'-dichlorodiphenyldichloroethylene, 2,4'-dichlorodiphenyltrichloroethane, 4,4'-dichlorodiphenyldichloroethane, 4,4'-dichlorodiphenyldichloroethylene, and 4,4'-dichlorodiphenyltrichloroethane
TRVs	toxicity reference values
USEPA	U.S. Environmental Protection Agency
WQC	water quality criteria
µg/kg	micrograms per kilogram
%	percent

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1 Introduction

The Diamond Alkali Superfund Site was added to the Superfund National Priorities List on September 21, 1984 because of contaminants present at the site. Four different operable units (OUs) are associated with the site (Figure 1-1): the former manufacturing plant and surrounding properties at 80 and 120 Lister Avenue (OU1), the lower 8.3 miles of the Passaic River (OU2), the Newark Bay Study Area (NBSA; OU3), and the lower 17 miles of the Passaic River (OU4; Lower Passaic River Study Area [LPRSA]; U.S. Environmental Protection Agency [USEPA] 2016). Additional details on the site setting and NBSA characteristics are included in the Remedial Investigation Report (Glenn Springs Holdings, Inc. [GSH] 2022).

Pursuant to the Administrative Order on Consent under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; Index 02-2004-2010; USEPA 2004), GSH, on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]), is conducting a remedial investigation/feasibility study (RI/FS) for the NBSA. The Statement of Work includes preparation of a baseline human health risk assessment (BHHRA), baseline ecological risk assessment (BERA), and feasibility study (FS) report. The purpose of the RI/FS process is to characterize the nature and extent of chemical contamination, develop and evaluate appropriate remedial options, and gather necessary information to select an appropriate remedy for the site.

As part of the RI/FS process, the Feasibility Study Work Plan for the Newark Bay Study Area (FS WP; GSH 2017) was prepared to define the technical approach and seven associated technical tasks for completing the FS Report. This Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum (RAO/PRG Tech Memo) documents the results of the first task in the FS WP – Task 1: Description of Remedial Action Objectives and Preliminary Risk-Based Remediation Goals. This RAO/PRG Tech Memo has been prepared to:

1. Identify and conduct an analysis of the applicable or relevant and appropriate requirements (ARARs) – see Section 2.
2. Describe the remedial action objectives (RAOs) and relationship to preliminary remedial goals (PRGs) – see Section 3.
3. Identify the next steps in the FS process – see Section 4.

This RAO/PRG Tech Memo has been developed in consideration of the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988). This document considers the results of the RI, BHHRA, and BERA reports underway or completed for the NBSA. Each section will describe how the ARARs, RAOs, and PRGs will focus and form the framework for the FS Report consistent with the CERCLA guidance.

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2 ARARs

CERCLA specifies that "Superfund remedial actions must meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs)" (Section 121(d)(2)(A)). This also includes relevant state and/or local ARARs if they are more stringent than federal requirements. Waivers for ARARs may be justified based on specific circumstance. This section defines the ARAR categories, grounds for waivers, and provides potential ARARs for each category.

2.1 Identification of ARARs

The three broad categories of ARARs include chemical-specific, location-specific, and action-specific. Each of these categories are defined in the bullets below.

- Chemical-specific ARARs are numerical standards that specify the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment. These are specific to the type(s) of constituents, pollutants, or hazardous substances at a site, and include state and federal regulations pertaining to contaminant levels in various media.
- Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities, solely based on their geographic locations. They establish requirements that protect areas of special interest such as floodplains, wetlands, historic places, or sensitive ecosystems or habitats.
- Action-specific ARARs are technology- or activity-based requirements on potential remedial actions taken within the NBSA. Action-specific ARARs are regulatory requirements that define acceptable remedial technologies and are triggered by the remedial activities selected to accomplish a remedy.

In accordance with Section 121(d)(4) in CERCLA, there are six circumstances under which ARARs may be waived.

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.
- Compliance with an ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance using another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

If an ARAR waiver is determined to be appropriate, the reasons for the determination will be presented in FS Report for the alternative.

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In addition to ARARs, to be considered (TBCs) must also be identified as appropriate. These are non-promulgated advisories, criteria, or guidance developed by the USEPA, other federal agencies, states, or localities that may be useful in developing CERCLA remedies. TBCs are not legally binding and do not have the status of ARARs. NBSA alternatives will be screened against both identified ARARs and TBCs (where applicable) in the FS Report.

2.2 Summary of ARARs for the NBSA

Identification of ARARs and TBCs specific to the NBSA considers those identified in the OU2 Record of Decision (ROD; USEPA 2016) due to the contiguous relationship between the two waterbodies and various OUs of the site. These include federal and New Jersey State ARARs/TBCs. In addition, New York State ARARs were also identified, as the southern shoreline of Newark Bay (Bay) and the Kill Van Kull, and the eastern shoreline of the Arthur Kill, border Staten Island, New York.

Chemical-specific ARARs and TBCs were evaluated for surface water and sediment. Any ARARs or TBCs tied to remedial construction (e.g., air emissions, disposal requirements, etc.) are included as action-specific ARARs. Based on the risk assessment work, risks associated with current surface water conditions in the NBSA were below the risk range and goal of protection of a hazard index (HI) = 1 for the child and adult recreator. Exceedances of the water quality criteria (WQC) for 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT) (i.e., 1 nanograms per liter [ng/L]) among total DDx (4,4') (sum of 4,4'-dichlorodiphenyldichloroethane [4,4'-DDD], 4,4'-dichlorodiphenyldichloroethylene, and 4,4'-DDT)[1] results occurred at all NBSA stations however the station with the highest percentage of exceedances (i.e., 50 percent [%]) was located at the mouth of the Arthur Kill. The mean concentration at this location exceeds the WQC and is 1.6 ng/L. The combined rate of exceedances at other NBSA stations is 18% and all other station means are below 1 ng/L. The WQC was not exceeded for concentrations of the single isomer 4,4'-DDT; however, they occur for the summation of 4,4' isomers (i.e., total DDx (4,4')) when compared to the WQC for 4,4' DDT. The attainment of WQC for all chemicals of concern (COCs) in the NBSA (OU3) depends on future concentrations flowing into the Bay from tributaries (the Lower Passaic River [LPR] and the Hackensack River) and the kills (Kill Van Kull and Arthur Kill). Planned sediment remediation activities in the tributaries will contribute to these reductions. The future date at which attainment of surface water quality standards is achieved depends on the time frames for those projects to be completed, and other cleanup or source reduction programs to address sources that may also be needed. Therefore, the NBSA (OU3) FS will not provide surface water-specific ARARs or TBCs. There are also no chemical-specific ARARs identified for the NBSA sediments. As further described in Section 3, site-specific sediment PRGs have been defined based on risk assessment results and background values and these values will be used in development of remedial alternatives for the NBSA.

The location-specific and action-specific ARARs and TBCs for the NBSA are summarized in Tables 2-1 and 2-2, respectively. Note that the New York State ARARs apply to OU3 areas bordering Staten Island, while the New Jersey State ARARs apply elsewhere. Additional details on applying and assessing the State ARARs will be included in the forthcoming FS Report. Compliance with ARARs is one of the nine criteria considered under

[1] 4,4'-DDD was the COC evaluated in the Baseline Human Health Risk Assessment (BHHRA), whereas the BERA considered Total DDx (2,4' and 4,4') and Total DDx (4,4') when evaluating potential risk associated with sediment and aqueous exposures, respectively. As explained in Appendix A, Section 3.3, the contaminant fate and transport and bioaccumulation models predict concentrations of Total DDx (4,4') so the derivation of the sediment PRGs required conversion of the respective BHHRA and BERA tissue PRGs using regression relationships between Total DDx (4,4') and 4,4'-DDD and Total DDx (2,4' and 4,4'), respectively.

CERCLA in the evaluation of potential remedial alternatives in the FS Report. ARARs, along with RAOs, will support development of the remedial alternatives and implementation of the selected remedy. Note also that in accordance with CERCLA Section 121(e), permits required as part of the various ARARs are not required for onsite CERCLA response actions; however, the selected remedy must comply with the substantive requirements of regulations that otherwise would require permits.

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3 RAOs and PRGs

The USEPA develops RAOs and calculates PRGs for use in identifying and evaluating remedial action alternatives for Superfund sites with unacceptable human and ecological health risks. This section presents the proposed RAOs and describes the PRGs developed to achieve each of the RAOs.

3.1 Introduction

RAOs consist of site-specific and medium-specific goals for protecting human health and the environment. These objectives are based on potential human health and ecological risks and are identified to protect those receptors and associated exposure pathways where the risk assessments concluded risk was present or likely. Therefore, NBSA-specific RAOs were developed using the findings from the BHHRA and BERA, considering available information and standards (such as ARARs and/or TBCs), and in consultation with the USEPA. A summary of the baseline risk assessment information is provided in Section 3.2, and a list of the RAOs is presented in Section 3.3.

PRGs are chemical-specific cleanup goals established to protect human health and the environment. These goals serve as long-term targets to use during the analysis and selection of remedial alternatives. As stated in Section 2.1, PRGs are not required to comply with ARARs in the event that the ARAR was waived in accordance with the provisions outlined in CERCLA. The basis for developing PRGs is provided in Section 3.4.

3.2 Summary of Risk Assessments

Baseline human health and ecological risk assessments were conducted in the NBSA and resulted in the following key findings:

- Consumption of self-caught fish and consumption of self-caught crab by anglers are the only identified exposure pathways resulting in human health risk. The primary drivers of human health risk are 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), polychlorinated biphenyls (PCBs), 4,4'-DDD, and methylmercury.
- Potential ecological risks were found for the following receptors/COCs evaluated in the BERA:
  - Invertebrates: multiple COCs
  - Softshell clam [*Mya arenaria*]: 2,3,7,8-TCDD, total PCBs, arsenic, lead, mercury, nickel
  - Blue crab [*Callinectes sapidus*]: 2,3,7,8-TCDD, total PCBs, total DDx (2,4' and 4,4') (sum of 6 isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane), and mercury
  - Mummichog/Killifish [*Fundulus heteroclitus*]: 2,3,7,8-TCDD, total PCBs
  - American eel [*Anguilla rostrata*]: 2,3,7,8-TCDD
  - Summer flounder [*Paralichthys dentatus*]: 2,3,7,8-TCDD
  - White perch [*Morone americana*]: 2,3,7,8-TCDD, total DDx (2,4' and 4,4').

3.2.1 Baseline Human Health Risk Assessment Summary

A BHHRA was conducted for the NBSA (GSH 2019) in accordance with USEPA risk assessment guidance. The USEPA approved the Final BHHRA after conducting a technical review of the document. Human health risk was evaluated based on exposure to sediment or surface water or ingestion of biota in the NBSA. Two exposure scenarios were evaluated in the BHHRA: a reasonable maximum exposure (RME) and a central tendency exposure (CTE). The USEPA bases remedial decisions on the RME exposure scenario, the cancer risk range (10^{-6} to 10^{-4}) and/or the goal of protection from noncancer hazards based on a HI =1.

The exposure scenarios are based on the following assumptions:

- Adult RME fish ingestion rates are 34.6 grams per day (g/day) which equates to approximately 56 fish meals per year assuming a half-pound (227 grams) meal size
- Adult CTE fish ingestion rates are 3.9 g/day; which equates to approximately 6 half-pound fish meals per year
- Fish meals are comprised of equal proportions of five species: American eel, bluefish [Pomatomus saltatrix], striped bass [Morone saxatilis], summer flounder, and white perch (GSH 2019)
- Adult RME crab ingestion rates are 21 g/day which equates to 34 meals per year of 6 crabs per meal, or 28 to 43 crab meals per year assuming four to six crabs per meal and 45 grams of edible muscle and hepatopancreas tissue per crab
- Adult CTE crab ingestion rates are 3 g/day which equates to approximately four to six crab meals per year.

These scenarios provide risk managers with a range of risks for an exposed population. Consumption by anglers of self-caught fish or self-caught blue crab from the NBSA is the only exposure pathway for which risk to human health exceeded risk ranges established in the National Contingency Plan (NCP; USEPA 1990). Cumulative potential cancer risks and noncancer hazards associated with direct contact with accessible surface sediment and surface water in the NBSA while angling, swimming, wading, or boating, are within or below the NCP risk range of 10^{-6} to 10^{-4} and below the noncancer protection goal of a HI of 1. A summary of the key risk findings for consumption of self-caught fish and self-caught crab are presented in Tables 3-1 and 3-2, respectively.

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Table 3-1 Summary of Human Health Risks Due to Self-Caught Fish Consumption

	Summary of Key Findings Angler/Sportsman - Fish Consumption							
	RME				CTE			
	Child[a]	Adolescent	Adult	Combined Adult/Child	Child[a]	Adolescent	Adult	Combined Adult/Child
Cumulative Cancer Risk	3E-04	3E-04	6E-04	8E-04	9E-06	1E-05	2E-05	3E-05
Primary Contributors	PCB-126: 31% (38% for all DL-PCBs) 2,3,7,8-TCDD: 28% (33% for all PCDD/Fs) Non-DL PCBs: 18% Arsenic, inorganic: 4% Dieldrin: 3%				PCB-126: 35% (43% for all DL-PCBs) 2,3,7,8-TCDD: 29% (33% for all PCDD/Fs) Non-DL PCBs: 10% Arsenic, inorganic: 6% Dieldrin: 3%			
Cumulative Noncancer HI	4E+01	3E+01	3E+01	**NA**	4E+00	2E+00	2E+00	**NA**
Primary Contributors	Non-DL PCBs: 32% PCB-126: 20% (26% for all DL-PCBs) 2,3,7,8-TCDD: 19% (22% for all PCDD/Fs) Methylmercury: 6% 4,4'-DDD: 5%				Non-DL PCBs: 31% PCB-126: 20% (25% for all DL-PCBs) 2,3,7,8-TCDD: 17% (19% for all PCDD/Fs) Methylmercury: 8% 4,4'-DDD: 4%			
Noncancer Health Effects withHI>1	Reproductive (DL compounds) Whole-Body (non-DL PCBs) Liver (pesticides) Neurological (Methylmercury)				Reproductive (DL compounds)			

Notes:
[a]Child receptors are assumed to be consuming the catch of adult anglers.
Shading indicates that the cumulative potential carcinogenic risk exceeds 10^{-4}, or one or more target organ-specific HIs exceed 1.
Primary contributors for combined cancer risks include exposures for a total of 26 years (6 years as a child and 20 years as an adult).
The evaluation of the noncancer HI for all chemicals based on exposures to a young child (7 years and younger), which represents the highest HI for all age ranges evaluated (i.e., child 1-<7 years, adolescent 7-<19 years, and adult >18 years).
The RME scenario is defined as anglers who routinely consume their catch, or for a child, consuming the catch of adults (34.6 g/day for an adult, 23.1 g/day for an adolescent, and 11.5 g/day for a child over a period of 26 years).
The CTE scenario is defined as anglers who routinely consume their catch, or for a child, consuming the catch of adults (3.9 g/day for an adult, 2.6 g/day for an adolescent, and 1.3 g/day for a child over a period of 12 years).
DL = dioxin-like.

Table 3-2 Summary of Human Health Risks Due to Self-Caught Crab Consumption

	Summary of Key Findings Angler/Sportsman • Crab Consumption							
	RME				CTE			
	Child[a]	Adolescent	Adult	Combined Adult/Child	Child[a]	Adolescent	Adult	Combined Adult/Child
Cumulative Cancer Risk	3E-04	3E-04	6E-04	8E-04	2E-05	2E-05	4E-05	5E-05
Primary Contributors	2,3,7,8-TCDD: 52% (60% for all PCDD/Fs) PCB-126: 19% (23% for all DL-PCBs) Non-DL PCBs: 8% Arsenic, inorganic: 6%				2,3,7,8-TCDD: 54% (63% for all PCDD/Fs) PCB-126: 20% (24% for all DL-PCBs) Arsenic, inorganic: 6% Non-DL PCBs: 4%			
Cumulative Noncancer HI	5E+01	3E+01	3E+01	NA	7E+00	4E+00	4E+00	NA
Primary Contributors	2,3,7,8-TCDD: 33% (38% for all PCDD/Fs) Copper: 26% Non-DL PCBs: 14% PCB-126: 12% (15% for all DL-PCBs)				2,3,7,8-TCDD: 33% (38% for all PCDD/Fs) Copper: 26% Non-DL PCBs: 14% PCB-126: 12% (15% for all DL-PCBs)			
Noncancer Health Effects with HI>1	GI Tract (Copper) Reproductive (DL compounds) Whole-Body (non-DL PCBs)				GI Tract (Copper) Reproductive (DL compounds)			

Notes:
[a]Child receptors are assumed to be consuming the catch of adult anglers.
Shading indicates that the cumulative potential carcinogenic risk exceeds 10-4, or one or more target organ-specific HIs exceed 1.
Primary contributors for combined cancer risks include exposures for a total of 26 years (6 years as a child and 20 years as an adult).
The evaluation of the noncancer HI for all chemicals based on exposures to a young child (7 years and younger), which represents the highest HI for all age ranges evaluated (i.e., child 1-<7 years, adolescent 7-<19 years, and adult >18 years).
The RME scenario is defined as anglers who routinely consume their catch, or for a child, consuming the catch of adults (21 g/day for an adult, 14 g/day and 7 g/day for a child over a period of 26 years).
The CTE scenario is defined as anglers who routinely consume their catch, or for a child, consuming the catch of adults (3 g/day for an adult, 2 g/day for an adolescent, and 1 g/day for a child over a period of 12 years).
DL = dioxin-like, GI = gastrointestinal.

The cumulative potential cancer risk for the RME fish or crab consumption scenario is $8x10^{-4}$ (combined adult/child angler) assuming consumption over a 26 year period (6 years as a child and 20 years as an adult). The risk estimate assumes the RME individual consumed fish or crab but not both. Both fish and crab CTE consumption cancer risks are within the NCP range; however, noncancer hazards exceed 1. Cumulative potential noncancer hazard indices range from 2 to 40 (reproductive effects) depending upon exposure and are highest for the child consuming the catch of adult anglers. The primary contributors to risk are polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and PCBs (Tables 3-1 and 3-2). The total risk for PCDD/PCDFs is estimated by the toxicity equivalence (TEQ) which is a summation of the concentrations of the 17 2,3,7,8-chlorine substituted congeners multiplied by their toxicity equivalence factors (TEF), which are factors that weight the risk of individual congeners versus 2,3,7,8-TCDD which has a TEF equal to 1 (USEPA 2010). Individual coplanar PCB congeners (e.g., PCB-126) that have a similar toxicity mechanism as 2,3,7,8-TCDD are called dioxin-like (DL) congeners and their risks are estimated similarly using TEQ (USEPA 2010). Other non-DL PCB risks are estimated based on the summation of total non-DL PCB congeners. While all the individual PCDD/F and DL PCB congeners contribute to risk (Tables 3-1 and 3-2), only 2,3,7,8-TCDD is present at

concentrations that exceed a 10^{-4} cancer risk and had a noncancer hazard greater than 1. Therefore, PRGs for DL risk are calculated based on concentrations of 2,3,7,8-TCDD.

Of the other compounds contributing to risk, three - methylmercury, 4,4'-DDD, and copper - are present at concentrations in fish (4,4'-DDD and methylmercury) or crab (copper) that individually exceed the noncancer hazard of 1. Subsequent to the finalization of the BHHRA, USEPA re-evaluated the noncancer hazard associated with the consumption of blue crab and determined that PRGs were not necessary for copper (Attachment 1). Other compounds such as arsenic and other pesticides that had minor contributions to the cumulative cancer risk or noncancer hazard were within or below the NCP range. Therefore, human health based primary COCs for which PRGs are established in the NBSA are 2,3,7,8-TCDD, total PCBs, 4,4'-DDD and methylmercury.

3.2.2 Baseline Ecological Risk Assessment Summary

A BERA was conducted in the NBSA (GSH 2020b) in accordance with USEPA risk assessment guidance. Risks were evaluated for the following ecological receptors:

- Invertebrates (infaunal communities, softshell clam, and blue crab)
- Fish
- Birds
- Mammals
- Reptiles.

Risks were evaluated by comparing concentrations in the tissue or diet of the receptor (either measured directly or estimated by a model) to literature derived toxicity reference values (TRVs). TRVs are generally expressed in two ways: a no observed adverse effect level (NOAEL) is the lowest concentration in a study for which effects were not observed or for which observed effects were not statistically significant (i.e., not beyond that which might be observed by chance); a lowest observed adverse effect level (LOAEL) is the lowest concentration in a study[2] for which an effect was observed and was statistically significant. In the risk evaluation, the tissue (or dietary) concentration is divided by the NOAEL or LOAEL TRV to calculate a hazard quotient (HQ). When HQs exceed 1, it is indicative of potential risk to the receptor. The derivation of TRVs for the NBSA is described in the BERA and the TRVs are consistent with those derived for the Lower Passaic River Study Area (LPRSA BERA; Windward 2019). In addition, the TRVs developed by the USEPA for the Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River (LPR FFS; USEPA 2014) were evaluated in the BERA. The two sets of TRVs (OU3/4 and OU2) were used to bound potential ecological risks to support decision making. The intent of using both TRV sources, when available, is to understand the potential range of effects within a particular trophic category from more sensitive to less sensitive endpoint receptors. In general, the LPR FFS TRVs are lower (sometimes orders of magnitude lower) than comparable TRVs developed for the NBSA (and LPRSA). Therefore, in many cases, ecological risk is only suggested by the LPR FFS TRVs and not the NBSA TRVs. Nonetheless, the USEPA has requested that if any LOAEL HQ exceeds 1, under any exposure scenario for any receptor/COC combination evaluated in the BERA, that the receptor/COC be carried forward in the FS and that PRGs be calculated.

For each receptor, the tissue-based risk evaluation was conducted assuming NBSA-wide exposure (i.e., the receptor is exposed on average to all areas of the NBSA) and assuming exposure to separate subareas of the NBSA defined in the BERA. Sensitivity analyses were also conducted for some species whereby different

[2] In some cases LOAELs were derived as the 5th percentile of a species sensitivity distribution that combines the LOAELs of multiple species and studies as described in the BERA.

assumptions of exposure (e.g., different dietary compositions, different site use factors) were evaluated. This results in a range of HQs being calculated for each TRV. A summary of the receptors and COCs for which any LOAEL HQ exceeded one for any receptor/COC combination is provided in Table 3-3. Table 3-3 gives the LOAEL HQ for the NBSA-wide exposure assumption and the maximum HQ calculated for any other exposure assumptions evaluated in the BERA. The TRVs used in the LPR FFS are identified as "OU2 TRVs" while those that were derived for the LPRSA by Windward (2019) and which were subsequently evaluated in the BERA for OU3 are denoted as the "OU3/OU4 TRVs".

Table 3-3 Summary of Hazard Quotients for Ecological Receptors in the NBSA

Ecological Receptor	Tissue	COC	OU3/OU4 LOAEL Hazard Quotients (NBSA-wide: Maximum[a])	OU2 LOAEL Hazard Quotients (NBSA-wide: Maximum[a])
Softshell clam	Whole body	2,3,7,8-TCDD	0.002 : HQs < 1	**5 : 7**
		Total PCBs	0.3 : HQs < 1	**8 : 17**
		Arsenic	**9 : 14**	--
		Lead	0.7 : **2**	**11 : 36**
		Mercury[b]	**2 : 3**	**2 : 3**
		Nickel	**3 : 5**	--
Blue crab	Whole body	2,3,7,8-TCDD	0.008 : HQs <1	**19 : 27**
		Total PCBs	0.7 : HQs < 1	**21 : 28**
		Total DDx (2,4' and 4,4')[c]	**1 : 1** **12 : 16**	0.9 : **1**
		Mercury[b]	**1 : 2**	**1 : 2**
Mummichog/ Killifish	Whole body	2,3,7,8-TCDD	0.2 : **2**	**14 : 24**
		Total Dioxin/Furan TEQ	0.2 : **2**	**16 : 24**
		Total PCB TEQ	0.01 : HQs < 1	**1: 3**
		Total PCBs	0.4 : HQs < 1	**3 : 6**
	Egg[d]	2,3,7,8-TCDD	0.2 : HQs < 1	0.2 : HQs < 1
		Total Dioxin/Furan TEQ	0.2 : HQs < 1	0.2 : HQs < 1
		Total PCB TEQ	0.01 : HQs < 1	0.01
		Total PCBs	**3 : 5**	--
American eel	Whole body	2,3,7,8-TCDD	0.06 : HQs < 1	**4 : 9**
		Total Dioxin/Furan TEQ	0.09 : HQs < 1	**6 : 9**
Summer flounder	Whole body	2,3,7,8-TCDD	0.06 : HQs < 1	**4 : 8**
		Total Dioxin/Furan TEQ	0.07 : HQs < 1	**4 : 8**
White perch[e]	Whole body	2,3,7,8-TCDD	0.6 : **1**	**39 : 90**
		Total Dioxin/Furan TEQ	0.6 : **1**	**40 : 90**
		Total DDx (2,4' and 4,4')	**1 : 2**	**1 : 2**

Notes:
[a]The maximum HQ calculated under any exposure assumption such as exposure within a subarea of the NBSA or within any sensitivity evaluation. If all HQs are less than 1, then the maximum is reported as HQs <1.
[b]The OU2 and OU3/OU4 mercury TRVs are the same for invertebrates.
[c]Two LOAELs were derived for total DDx (2,4' and 4,4') based on two different distributional assumptions of a species sensitivity distribution.
[d]Egg concentrations were modeled based on measured tissue concentrations and hypothesized maternal transfer to eggs. OU2 and OU3/OU4 TRVs for 2,3,7,8-TCDD and TEQ in eggs are the same.
[e]HQs also exceeded 1 for copper in white perch whole body and liver tissue. The USEPA determined that copper is not an ecological risk driver based on a review of uncertainties and because the ingestion TRV was not exceeded.
HQs in bold are greater than one.
-- A TRV was not derived for this COC and receptor in the LPR FFS.

The risk of individual PCDD/PCDF congeners and DL PCB congeners was evaluated on a TEQ basis for receptors where appropriate and according to risk assessment guidance (USEPA 2008). Where total dioxin/furan TEQ presents a risk, it is largely due to concentrations of 2,3,7,8-TCDD, which represent a large proportion of the total TEQ. Therefore, PRGs are based on 2,3,7,8-TCDD concentrations in tissue rather than TEQ. The total PCB TEQ HQ exceeds one for mummichog/killifish. However, because the total PCB HQ exceeds 1 and is larger, the PRG is based on total PCBs for this receptor.

In addition to the tissue or diet-based risk evaluation, the risks to the benthic invertebrate community (BIC) were also assessed by a sediment quality triad (SQT) investigation. The SQT involves the collection of sediment samples for the co-located analysis of the following: 1) chemical concentrations (both sediment and porewater); 2) toxicity testing (acute and chronic endpoints based on the amphipod *Leptochirus plumulosus*); and 3) BIC abundance and taxa enumeration. The SQT data were then used in an exposure-effects evaluation relating the chemical concentrations in sediment or porewater to the results of the toxicity tests and BIC abundance and diversity metrics. BIC abundance and taxa richness were generally within the range of the reference area and not correlated with chemistry (GSH 2020b). Four toxicity endpoints were evaluated: 10-day survival, 28-day survival, 28-day growth, and 28-day reproduction. The results of the survival endpoints are depicted on Figure 3-1. Based on 10-day survival, two of 30 SQT stations were acutely toxic (defined as survival statistically significantly different from control). Based on 28-day survival, six of 30 SQT stations exhibited chronic toxicity (defined as survival statistically significantly different from control). All 28-day endpoints exhibited significant variability, particularly the growth and reproduction endpoints. In a sensitivity analysis, if chronic toxicity is re-defined as 28-day survival less than 80% of control survival regardless of statistical significance, a total of 11 stations are classified as toxic. Eighteen stations exhibited 28-day growth statistically significantly different than laboratory control. Thirteen stations exhibited 28-day reproduction significantly different from laboratory control. A multivariate exposure effects analysis (i.e., a principal component analysis that included a mixture of chemicals in sediments - metals, pesticides, PCBs, polycyclic aromatic hydrocarbons (PAHs), and PCDD/PCDFs - combined with dose response modeling) was used to predict the extent of toxicity in the NBSA using the larger Phase III sediment dataset (GSH 2020b). Figure 3-2 depicts the sample locations where acute toxicity is predicted – that is where 10-day amphipod survival is predicted to be less than 80% of the control survival in the NBSA. Similarly, Figure 3-3 depicts the sample locations where chronic toxicity is predicted – that is where 28-day amphipod survival is predicted to be less than 80% of the control survival in the NBSA. Predicted areas of acute toxicity are located on a portion of the southwestern subtidal flat (Figure 3-2). Predicted chronic toxicity is slightly larger in extent and includes portions of the southwestern subtidal flat along with historically disturbed areas of the northern subtidal flats. Porewater concentrations were evaluated as part of the risk assessment (GSH 2020b). Porewater concentrations exceeded WQC or guidelines for total DDx (4,4'), total PCBs, arsenic, PAHs, copper, and zinc, indicating the potential bioavailability of these chemicals at concentrations likely to cause toxicity. Presence in porewater at elevated concentrations and association with toxicity is used as a basis to derive sediment PRGs for a subset of potential risk drivers for toxicity in the NBSA, as described in Section 3.4.3. The primary COCs associated with BIC toxicity are PCBs, total DDx (4,4'), arsenic, and total alkylated PAHs.

3.3 Remedial Action Objectives

RAOs have been defined by the USEPA to reduce the risk to human and ecological receptors due to the presence of COC concentrations in sediments and the tissues of aquatic organisms. Aquatic organisms bioaccumulate COCs through direct exposure to contaminated sediments or through ingestion of contaminated prey exposed to sediments. Therefore, reduction of COC concentrations in sediments will result in a reduction of

COC concentrations in the tissues of aquatic organisms. The following three narrative RAOs have been developed for the NBSA.

- RAO 1 Human Health: Reduce cancer risks and noncancer health hazards for people eating fish and crab by reducing the concentrations of COCs in sediments.
- RAO 2 Ecological Receptors: Reduce the risk to ecological receptors by reducing the concentrations of COCs in sediments[3].
- RAO 3 Contaminant Migration: Reduce the migration of COC-contaminated sediments from the NBSA to connected waterways.

3.4 Preliminary Remedial Goals

PRGs were calculated for surface sediments on a dry weight basis (e.g., µg COC per kg solids [µg/kg]) using models that predict the tissue concentrations in biota associated with a given sediment concentration in the biologically active zone. For the organic COCs (2,3,7,8-TCDD, PCBs, and DDx), a bioaccumulation model was developed by the USEPA to predict tissue concentrations based on exposure concentrations in abiotic media (e.g., sediment, water column) predicted by the contaminant fate and transport (CFT) model developed for the NBSA (HDR 2019). The model is an extension of the bioaccumulation model developed for the LPRSA by the Cooperating Parties Group and uses the same model code and general development process as that model. Differences from that model include the fish species modeled, as more saline/estuarine species are found in the NBSA, and the implementation of an explicit migration routine to account for species that are onsite for only a portion of their life history. As this model is an extension of the LPRSA model, the Arnot and Gobas model (2004) forms the basis for the NBSA modeling effort. The bioaccumulation model has compartments that account for exposure within geographic subareas of the NBSA. These are biological exposure areas evaluated in the BERA (i.e., North, Southeast, and Southwest) and in other areas where migratory species are exposed such as the LPR, the Hackensack River, the Arthur Kill, the Kill Van Kull and the Atlantic Ocean. The bioaccumulation model and the methods used to derive PRGs for organic COCs are described in detail in Appendix A. The bioaccumulation model documentation is presented in Appendix J of the Remedial Investigation Report (GSH 2022).

For the inorganic COCs (arsenic, lead, mercury, and nickel), empirical regression models were derived to predict tissue concentrations from sediment concentrations. The models for softshell clam (arsenic, lead, mercury, and nickel) are based on the 18 co-located sediment and clam tissue concentrations collected during the RI. The models for fish and crab (mercury) combine RI data with other data collected in the New York/New Jersey Harbor estuary. The regressions were conducted by pairing individual tissue concentrations with average sediment concentrations within the exposure range of the tissue sample. These models are described in detail in Appendix B. Based on the direct exposure risk (i.e., toxicity) to the BIC, PRGs were developed to address local areas where toxicity is predicted based on the results of the SQT assessment from the BERA.

The CFT model and the bioaccumulation model predict concentrations of 2,3,7,8-TCDD, total tetra-chlorinated PCBs (tetraPCBs) and total DDx (4,4'). USEPA demonstrated that tetraPCBs are strongly correlated with both total PCB and total PCB TEQ (see Attachment 2). And because the CFT model was predicting tetraPCBs, the

[3] RAO 2 could potentially be satisfied by reduction of either total sediment concentration of contaminants, or bioavailable sediment concentrations. A reduction in sediment contaminant bioavailability can be measured by various methods. Some examples include the following: measurement of bioaccumulation in caged organisms, passive sampling, or evaluation of total organic carbon normalized chemical concentrations. If necessary, these methods will be developed in the FS.

bioaccumulation model was calibrated to tetraPCBs. Sediment PRGs for PCB risk are expressed as total PCBs. This requires a conversion of tetraPCBs to total PCBs using regression equations as described in detail in Appendix A. For DDx, human health risk is due to 4,4'-DDD while ecological risk is based on total DDx (2,4' and 4,4'). For consistency with the models and the remedial goals for OU2, sediment PRGs are expressed as total DDx (4,4'). Again, these require conversions which are fully described in Appendix A. Human health risk is based on concentrations of methylmercury in fish. Ecological TRVs generally apply to both mercury and methyl mercury in tissue. Most of the total mercury in tissue is in the form of methylmercury. In sediments, methyl mercury is a small fraction of the total mercury. Therefore, sediment PRGs are expressed on a total mercury basis. And this is consistent with the form of mercury predicted by the CFT model.

As described in Section 3.4.1, based on human health risk, sediment PRGs are derived for:

- 2,3,7,8-TCDD
- Total PCBs
- Total DDx (4,4')
- Methylmercury.

As described in Section 3.4.2, for ecological bioaccumulation risk, sediment PRGs are derived for:

- 2,3,7,8-TCDD
- Total PCBs
- Total DDx (4,4')
- Arsenic
- Lead
- Mercury
- Nickel.

As described in Section 3.4.3, for protection of the BIC due to direct toxicity, sediment PRGs were derived for:

- Total PCBs
- Total DDx (4,4')
- Total Alkylated PAHs
- Arsenic.

For human health and ecological bioaccumulation risk, sediment PRGs for the organic contaminants were calculated using bioaccumulation model output that results from the input of concentrations in abiotic media (e.g., sediment, water column) predicted by the CFT model two years after the remedial action in OU2 is implemented (i.e., dredging and/or capping of the lower eight miles of the LPR; USEPA 2016), along with concurrent surface weighted average concentration reduction in the upper nine miles of the Passaic River (Integral 2019), presumed to be the years 2031 to 2033. This scenario is denoted as "Current Conditions". The CFT model is run again under these conditions but assuming sediment concentrations of all COCs in the NBSA are zero at the beginning of the two-year period. Sediment PRGs are then calculated by interpolation between the two associated sediment and tissue output concentrations. This methodology is further detailed in Appendix A.

3.4.1 Sediment PRGs for the Protection of Human Health

Sediment PRGs are calculated by first establishing acceptable concentrations in fish and crab tissue that are protective of the angler consuming self-caught fish or crab from the NBSA. The bioaccumulation model is then used to estimate the average sediment concentration in the NBSA that would result in achieving acceptable tissue concentrations.

Based on the exposure scenarios evaluated in the BHHRA in accordance with USEPA guidance, acceptable levels in fish and crab tissue are provided in Table 3-4. USEPA bases risk management decisions on the RME scenario (USEPA 1989) and within the NCP range defined as cancer risks between 10^{-4} and 10^{-6} or a noncancer HI of 1. A target HI of 1 was used for each of the COCs because the health endpoints of 2,3,7,8-TCDD, PCBs, 4,4'-DDD, and methylmercury are distinctly different. USEPA (1991) states that an appropriate point of departure for remediation of carcinogenic risk is a concentration that corresponds to a risk of 10^{-6} for one chemical in a particular medium; however, concentrations corresponding to the other risk levels addressed in the NCP (e.g., 10^{-5} and 10^{-4}) also have been used as substituted target risk levels to provide a range of tissue PRGs to assist in the risk management decision process. The RME consumption rates are equivalent to 56 8-ounce fish meals or 34 8-ounce crab meals per year. In addition to the RME scenario, an interim scenario was evaluated based on an assumption of an adult angler consuming 12 fish or crab meals per year. This interim scenario formed the basis of the interim remedial milestones presented in the OU2 ROD (USEPA 2016).

As shown in Table 3-4, acceptable tissue concentrations for consumption by an adult are generally lower than those for adolescents and children. For example, the cancer risk-based fish tissue levels for 2,3,7,8-TCDD and total PCBs for an adult at the 1×10^{-6} risk level are lower than those for the child. And while the child noncancer hazard-based fish tissue levels are lower than those of the adult, they are greater than the 10^{-6} cancer risk-based tissue levels for the adult for total PCBs and 4,4'-DDD and greater than the 10^{-5} cancer risk tissue levels for the adult for 2.3.7.8-TCDD. Further, the adult noncancer acceptable tissue concentrations are lower than the 10^{-4} (2,3,7,8-TCDD) or 10^{-5} (PCBs) cancer-based acceptable concentrations for the child. For these reasons, sediment PRGs are developed based on the adult angler only and interim scenario concentrations are calculated for the adult angler only. This is consistent with PRG development presented in Appendix E of the FFS for OU2 (USEPA 2014) and with the PRGs presented in the OU2 ROD (USEPA 2016).

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Table 3-4 Fish and Crab Concentrations Protective of the Angler

Diet	Chemical (µg/kg)	Units	Receptor	Cancer Risk-Based Tissue Concentrations						Noncancer Hazard-Based Tissue Concentration	
				RME			Interim[a]			RME	Interim[a]
				10^{-6}	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-4}	HI=1[b]	
Fish[c]	2,3,7,8-TCDD	ng/kg	Adult	0.054	0.54	5.4	0.25	2.5	25	1.6	7.5
			Child	0.11	1.1	11.5	--	--	--	1.0	--
	Total PCBs	µg/kg	Adult	4	40	405	19	190	1,900	46	214
			Child	8.6	86	860	--	--	--	29	--
	4,4-DDD	µg/kg	Adult	34	340	3,400	160	1,600	16,000	69	322
			Child	72	720	7,200	340	3,400	34,000	44	--
	Methyl mercury	µg/kg	Adult	There is no quantitative estimate of carcinogenic risk from oral exposure.						230	1100
			Child							150	--
Crab[d]	2,3,7,8-TCDD	ng/kg	Adult	0.089	0.89	8.9	0.25	2.5	25	2.7	7.5
			Child	0.19	1.9	19	--	--	--	1.7	--
	Total PCBs	µg/kg	Adult	6.7	67	670	207	2,074	20,741	77	214
			Child	14	142	1,423	--	--	--	49	--

Notes:
Adult receptors are assumed to be consuming self-caught fish or crab. Child receptors are assumed to be consuming the catch of adults.
[a]The interim scenario is based on the adult consumption of 12 fish or crab meals per year and may be considered for evaluating progress toward remedial goals.
[b]A target HI of 1 was used for each of the COCs because the health endpoints of 2,3,7,8-TCDD, PCBs, 4,4'-DDD, and methylmercury are distinctly different.
[c]Consumption of fish fillet.
[d]Consumption of muscle and hepatopancreas.
'-- = not applicable.

Human health-based sediment PRGs for organic COCs are shown under the assumption of a blue crab or mixed fish diet (Table 3-5). The primary human health risk calculations in the BHHRA (Table 3-1) were based on a mixed fish diet to account for the presence of multiple fish species in Newark Bay that may be consumed by anglers. The mixed fish diet is assumed to comprise equal amounts (20%) of the five species for which fillet samples were collected as part of the RI/FS (American eel, bluefish, striped bass, summer flounder, and white perch).

Table 3-5 Sediment PRGs for Human Health Risk Based on Consumption of Fish or Crab

COC	Units	Species	Cancer Sediment PRG						Noncancer Sediment PRG	
			RME[a]			Interim[b]				
			10^{-6}	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-4}	RME[a]	Interim[b]
2,3,7,8-TCDD	ng/kg	Blue crab	**UA**	**UA**	49	**UA**	5.3	160	6.7	40
		Mixed Fillet[d]	**UA**	0.35	180	**UA**	75	930	41	260
Total PCBs	µg/kg	Blue crab	**UA**	**UA**	1,500	**UA**	240	4,500	**UA**	310
		Mixed Fillet[d]	**UA**	**UA**	790	**UA**	250	3,700	**UA**	320
Total DDx (4,4')[c]	µg/kg	Mixed Fillet[d]	130	2,200	23,000	960	11,000	110,000	360	2,100
Mercury	µg/kg	American eel	There is no quantitative estimate of carcinogenic risk from oral exposure.						1,100	18,000
		White perch							2,400	2.7×10^7

Notes:
PRGs for organic COCs (2,3,7,8-TCDD, Total PCBs and total 4,4'-DDx) were calculated using the Contaminant Fate and Transport Model and the Bioaccumulation Model. See Appendix A.
Mercury PRGs are calculated using an empirical regression model (Appendix B). Human health risk is due to methylmercury and it is assumed that all mercury in tissue is methyl mercury. The regression model does not account for the potential effects of remedial actions in OU2 and/or OU4. Empirical models were not developed for bluefish, striped bass, or summer flounder. These species were found to have similar mercury concentrations as those in reference areas. In addition, mercury concentrations in summer flounder are below acceptable human-health based tissue concentrations.
[a]RME for adult angler: 56 eight-ounce meals per year for fish or 34 eight-ounce meals per year for crab.
[b]Twelve eight-ounce meals per year of fish or crab for adult angler.
[c]Human health risk is due to 4,4'-DDD in fish. For consistency among receptors and with OU2 RGs, the PRGs are calculated in terms of total DDx (4,4').
[d]Mixed fillet PRG is based on the assumption that a fish diet for an adult angler is comprised of equal weights of five species: bluefish, American eel, striped bass summer flounder, and white perch. This was the assumption of the human health risk assessment (GSH 2019).
UA = Unattainable. According to the bioaccumulation model prediction, the acceptable tissue concentration cannot be attained when NBSA sediment is assumed to have 0 concentration of the COC. Therefore, a PRG could not be calculated.

For mercury, PRGs were calculated for American eel and white perch only (Table 3-5). As described in Appendix B, statistically significant regression models relating sediment concentrations to tissue concentrations for striped bass and bluefish could not be derived. Further as described in Appendix C, mercury concentrations in striped bass and bluefish are within the range of concentrations observed in reference areas. Therefore, mercury sediment PRGs were not derived for these species. Average mercury concentrations in summer flounder collected in the NBSA are below acceptable tissue concentrations and therefore there is no need to calculate sediment PRGs for mercury in summer flounder.

As further described in Appendix A, in the bioaccumulation model, migratory species are assumed to be exposed to contaminants both within the NBSA and outside it in tributaries, the kills, and the Atlantic Ocean. In addition to sediment exposure, aquatic biota are exposed to contaminants in the water column that would remain present even if all contaminants were removed from NBSA sediment. Therefore, in some cases, the acceptable tissue concentrations cannot be attained even when NBSA sediment concentrations are set to zero in the CFT model. In these instances, PRGs could not be calculated as they would be effectively less than 0. These cases appear as UA (unattainable) in Table 3-5. Human health goals in the 10^{-6} and 10^{-5} cancer risk range will not be achievable for 2,3,7,8-TCDD or total PCBs under any remedial scenario based on the CFT and bioaccumulation model predictions. In addition, the noncancer goal for total PCBs will not be achievable under any remedial scenario.

3.4.2 Sediment PRGs for the Protection of Ecological Receptors from Bioaccumulation Risk

Acceptable tissue concentrations used for the calculation of sediment PRGs are based on the TRVs used in ecological risk assessment. The USEPA (2020) provided guidance for selecting acceptable tissue concentrations (i.e., toxicity thresholds) to be used for PRG calculation for ecological receptors in the following cases:

- If a single TRV source was used in the BERA, the following should be used as the toxicity threshold for PRG calculation
  - For a single study, the geometric mean of the NOAEL and LOAEL
  - For multiple studies, the 5th percentile of the LOAEL species sensitivity distribution (SSD).
- If multiple TRVs were evaluated in the BERA, the following should be used as the toxicity thresholds for PRG calculation
  - Geometric mean of OU2 NOAEL and LOAEL TRVs
  - Geometric mean of OU3/OU4 and OU2 LOAEL TRVs
  - Geometric mean of OU3/OU4 NOAEL and LOAEL TRVs.

After this initial guidance from USEPA, another option, in the case of multiple TRVs, was developed to "integrate" the OU2 and OU3/OU4 TRVs in certain cases. Specifically, if the OU3/OU4 LOAEL TRV was developed from a SSD that did not include the OU2 study LOAEL, the SSD was recalculated to include the OU2 LOAEL and the resulting 5th percentile is used to calculate an "integrated" TRV and associated PRG. The threshold tissue values derived from TRVs to be used for PRG calculation are shown in Table 3-6. See Appendix D for a complete description of the derivation of these values, and a detailed discussion of the uncertainty in the TRVs.

The uncertainty related to each set of TRVs, as described in Appendix D, is summarized in Table 3-6 and classified as low, moderate, or high. Low uncertainty applies to values derived from multiple studies that demonstrate a range of species sensitivities and included chronic endpoints (e.g., growth and reproduction). High uncertainty applies to TRVs that are based on only one species and/or only measured an acute endpoint (i.e., survival). Other issues related to uncertainty are the following: presence of other contaminants that potentially contribute to toxicity (as in field studies); tissue concentration estimation (if not measured); measured endpoints that do not have a direct relationship to population effects (i.e., not growth, reproduction or mortality); use of uncertainty factors to extrapolate TRVs from unbounded NOAELs. The OU2 TRVs tend to be the lowest in value but are the most uncertain and their derivation method sometimes differs from guidance (USEPA 1997, 1998, 2007), as described in Appendix D and summarized in Table 3-6. The OU3/OU4 TRVs tend to have the lowest uncertainty because they are derived based on multiple studies, where available, with several species and chronic endpoints observed. Integration of the TRVs from OU2 and OU4/OU4 may increase or decrease the uncertainty depending on the quality of the TRVs that are combined. In general, USEPA acknowledges and GSH concurs that the OU-2 TRVs are more conservative than comparable TRVs developed for OU3/OU4. While the intent of using a range of TRV sources, when available, is to understand the potential range of effects within a particular trophic category from more sensitive to less sensitive endpoint receptors, the uncertainties in the TRVs should not be ignored.

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Table 3-6 Threshold Values in Tissue for Ecological PRG Calculation

Ecological Receptor	Toxicity Reference Values for PRG Calculations					
	OU2 TRVs[a]		Integrated OU2 and OU3/OU4 TRVs[b]		OU3/OU4 TRVs[c]	
	Value	Uncertainty Level	Value	Uncertainty Level	Value	Uncertainty Level
2,3,7,8-TCDD (ng/kg)						
Invertebrate	0.44	**HIGH**: Field study of oyster reproduction, no control group, no assessment of other contaminants present. TRVs for invertebrates are unlikely to be lower than for vertebrates due to lack of AhR.	62	**MODERATE TO HIGH**: Geometric mean of OU2 and OU3/OU4 LOAELs.	949	**HIGH**: Based on one study of survival in crayfish. Chronic endpoints not measured. NOAEL estimated by extrapolation factor.
Fish	1.3	**HIGH**: Based on a behavior endpoint in larval mummichog after topical exposure to eggs. Tissue concentrations were estimated based on a prior study. TRVs are an order of magnitude lower than those measured in multiple species for fish eggs.	3.9	**MODERATE TO HIGH**: Value is 5th percentile of SSD of 8 fish species. The 5th percentile value is strongly influenced by the lowest value, which is the highly uncertain OU2 LOAEL.	120	**LOW**: Value is the 5th percentile of SSD of 7 fish species that included chronic endpoints and known sensitive species.
Total PCBs (µg/kg)						
Invertebrate	10	**HIGH**: Based on one study of oyster reproduction. Tissue concentrations were estimated. No dose response relationship observed.	61	**MODERATE**: Value is 5th percentile of SSD that includes OU2 LOAEL which is highly uncertain and is not within the range of TRVs measured for oysters in other studies.	520	**LOW**: Value is the 5th percentile of SSD of 10 invertebrate species that included chronic endpoints and known sensitive species.
Fish	300	**MODERATE to HIGH**: Based on one short-term study of salmon with a behavioral endpoint that does not have a clear relationship with population effects.	590	**LOW TO MODERATE**: Value is 5th percentile of SSD that includes OU2 LOAEL.	1,200	**LOW**: Value is the 5th percentile of SSD of 11 fish species that included chronic endpoints and known sensitive species.

Ecological Receptor	Toxicity Reference Values for PRG Calculations					
	OU2 TRVs[a]		Integrated OU2 and OU3/OU4 TRVs[b]		OU3/OU4 TRVs[c]	
	Value	Uncertainty Level	Value	Uncertainty Level	Value	Uncertainty Level
Total DDx (2,4' and 4,4') (µg/kg)						
Invertebrate	88	**MODERATE TO HIGH**: Based on one study of survival pink shrimp. Laboratory "stress" was a potential confounder for mortality.	--[d]	--[d]	110	**LOW TO MODERATE**: Value is the 5th percentile of SSD of 6 invertebrate species that included chronic endpoints and known sensitive species. An alternate fitted model gave a LOAEL that was an order of magnitude lower.
Fish	390	**LOW**: Value is the 5th percentile of a SSD of 9 fish species that included chronic endpoints and known sensitive species.	450	**LOW**: Geometric mean of OU2 and OU3/OU4 LOAELs. Two separate multi-species SSDs had similar LOAEL TRVs.	520	**LOW**: Value is the 5th percentile of SSD of 7 fish species that included chronic endpoints and known sensitive species.
Arsenic (mg/kg)						
Invertebrate	--	--	--	--	0.64	**LOW TO MODERATE**: Value is the 5th percentile of SSD of 7 invertebrate species that included chronic endpoints and known sensitive species. The 5th percentile value is influenced by a freshwater species.
Lead (mg/kg)						
Invertebrate	1.2	**HIGH**: Based on a single study of survival in amphipods. Other metals were present in the field collected sediments at concentrations that could have contributed to toxicity.	10.2	**MODERATE**: Geometric mean of OU2 and OU3/OU4 LOAELs.	12.6	**MODERATE**: Lowest LOAEL of three invertebrate species.

Ecological Receptor	Toxicity Reference Values for PRG Calculations					
	OU2 TRVs[a]		Integrated OU2 and OU3/OU4 TRVs[b]		OU3/OU4 TRVs[c]	
	Value	Uncertainty Level	Value	Uncertainty Level	Value	Uncertainty Level
Mercury (µg/kg)						
Invertebrate	68	**MODERATE**: Same study as was selected for OU3/OU4.	--[e]	--[e]	68	**MODERATE**: Lowest LOAEL of three invertebrate species.
Nickel (mg/kg)						
Invertebrate	--	--	--	--	0.6	**HIGH**: Based on a single study of 28-day survival in amphipod. Field sediments may have contained other contaminants.

Notes:
See Appendix D for a discussion of the TRVs (LOAELs and NOAELs) used for PRG calculation.
[a]The PRG is based on a tissue concentration equal to the geometric mean the NOAEL and LOAEL for OU2 presented in the Lower Passaic River FFS and in the OU3 BERA (GSH 2020b).
[b]The PRG is based on the 5th percentile of a SSD that incorporates studies used in the OU3/OU4 SSDs (where available) with the OU2 TRV study. If an SSD is not available the PRG is based on the of the OU2 and OU3/OU4 LOAELs.
[c]The PRG is based on a tissue concentration equal to either the geometric mean of the NOAEL and LOAEL for OU3/OU4, or the LOAEL only, if the LOAEL was calculated as the 5th percentile of an SSD (GSH 2020b).
[d]The original OU3/OU4 LOAEL was based on and SSD that included the OU2 TRVs, therefore no further integration was necessary.
[e]OU2 and OU3/OU4 TRVs were based on the same study.
-- = not applicable

Sediment PRGs were calculated for each of the tissue values given in Table 3-6 using the bioaccumulation model for organic COCs (Appendix A) or using regression models for inorganic COCs (Appendix B). The sediment PRGs for the protection of ecological receptors are shown in Table 3-7. USEPA (2020) stated that "where multiple TRVs were used in the OU3 BERA, toxicity thresholds for use in calculating ecological PRGs should be based on OU2 FFS values unless GSH can support a determination that higher values would also be ecologically protective and more technically appropriate." While all TRVs are subject to uncertainty, the TRVs selected for OU3/OU4 have been documented to be technically appropriate in the approved BERAs for OU4 (Windward 2019) and OU3 (GSH 2020b). Further, the OU3/OU4 TRVs generally have low uncertainty where data from multiple species and chronic endpoints were available. As stated above, the integrated TRVs (i.e., those that consider both the OU2 and OU3/OU4 TRVs) may have higher or lower uncertainty than the OU3/OU-4 TRV depending on the quality of the combined TRVs. However, because the integrated TRVs include the more conservative OU2 TRVs, they afford a higher level of protection for sensitive species than the OU3/OU4 TRVs. Therefore, ecological PRGs based on the integrated TRVs (Table 3-7) shall be the primary basis for which to evaluate remedial alternatives in the FS with respect to reduction of ecological risk. The lowest attainable integrated PRGs for each COC are presented in Table 3-7.

Table 3-7 Sediment PRGs for Ecological Receptors Based on Bioaccumulation Risks

COC	Ecological Receptor	OU2[a]	Integrated OU2 and OU3/OU4[b]	OU3/OU4[c]	Lowest Attainable Integrated PRG
2,3,7,8-TCDD (ng/kg)	Softshell Clam	**UA**	7,900	120,000	38
	Blue Crab	**UA**	450	6,900	
	Mummichog	4.5	38	1,500	
	American eel	15	74	2,700	
	Summer flounder	3.8	38	1,600	
	White perch	**UA**	**UA**	880	
Total PCBs (µg/kg)	Softshell Clam	**UA**	2,000	18,000	360
	Blue Crab	**UA**	**UA**	1,200	
	Mummichog	25	360	1,100	
Total DDx (4,4') (µg/kg)	Blue Crab	91	130[d]	130	130
	White perch	**UA**	**UA**	**UA**	
Mercury (µg/kg)	Softshell Clam	270	--[e]	270	270
	Blue Crab	1200	--[e]	1200	
Arsenic	Softshell Clam	--	--	0.033	0.033
Lead	Softshell Clam	0.15	49	87	49
Nickel	Softshell Clam	--	--	0.0001	0.0001

Notes:
See Appendix D for a discussion of the TRVs (LOAELs and NOAELs) used for PRG calculation.
[a]The PRG is based on a tissue concentration equal to the geometric mean the NOAEL and LOAEL for OU2 presented in the Lower Passaic River FFS and in the OU3 BERA (GSH 2020b).
[b]The PRG is based on the 5th percentile of a SSD that incorporates studies used in the OU3/OU4 SSDs (where available) with the OU2 TRV study. If an SSD is not available the PRG is based on the geometric mean of the OU2 and OU3/OU4 LOAELs.
[c]The PRG is based on a tissue concentration equal to either the geometric mean of the NOAEL and LOAEL for OU3/OU4, or the LOAEL only, if the LOAEL was calculated as the 5th percentile of an SSD (GSH 2020b).
[d]The original OU3/OU4 LOAEL was based on and SSD that included the OU2 TRVs, therefore no further integration was necessary.
[e]OU2 and OU3/OU4 TRVs were based on the same study.
'-- = Value not applicable.
UA = Unattainable. According to the bioaccumulation model prediction, the acceptable tissue concentration cannot be attained when NBSA sediment is assumed to have 0 concentration of the COC. Therefore, a PRG could not be calculated. Cells are bolded and shaded.

3.4.3 Sediment PRGs for the Reduction of Risk of Toxicity to Benthic Invertebrates

As detailed in the BERA and described in Section 3.2.2, there was evidence of risk to the benthic invertebrate community in the NBSA, particularly in the southwestern subtidal flats. To understand and evaluate this risk, a SQT investigation was implemented. The SQT program included the following elements where data were collected synoptically at 30 stations: 1) sediment and porewater chemistry; 2) toxicity testing using the 10-day and 28-day amphipod (i.e., *Leptocheirus plumulosus*) bioassay; and 3) benthic invertebrate community taxa enumeration. The data are described and evaluated in the BERA (GSH 2020b). The evaluation was a two-pronged approach: 1) comparison of data to published values (e.g., sediment quality guidelines and WQC for aquatic life) or comparison to a reference site; and 2) a statistically based exposure-effects assessment. Acute toxicity, based on 10-day amphipod survival, was observed at two of the 30 SQT stations: stations 151 and 154

located in the southwest subtidal flats (Figure 3-1). Chronic toxicity, defined as 28-day amphipod survival significantly different than control, was observed at these stations as well as four others, two in the north assessment zone (i.e., 158 and 160) and two in the southeast assessment zones (i.e., 141 and 143) of the NBSA (Figure 3-1). There was considerably more variability in survival among test replicates in the 28-day tests compared to the 10-day tests. If chronic toxicity is more liberally defined as 28-day amphipod survival less than 80% of control regardless of statistical significance, a total of 11 stations would be classified as exhibiting chronic toxicity: five in the north assessment zone (i.e., 136, 138, 158,159, and 160); three in the southeast assessment zone (i.e., 142, 143, and 145); and three in the southwest assessment zone (i.e., 149, 151, and 154). Under this definition, station 141 would no longer be classified as chronically toxic because 28-day survival exceeded 80% of control at this station. Sublethal endpoints measured after completion of the 28-day tests are growth and reproduction (i.e., young per surviving adult). Eighteen stations exhibited growth that was significantly different from control. Twelve stations exhibited reproduction that was significantly different from control. As detailed in the BERA (GSH 2020b), studies have shown that interpretation of these sublethal endpoints are subject to considerable uncertainty compared to the survival endpoints due to: large variability among replicates both in test sediments and control sediments; frequent disagreement in inter-laboratory comparisons; and significant variability due to other stressors such as grain size. Given these factors and because there are no established control acceptability criteria for these sublethal endpoints, they were not considered for calculating PRGs. Neither sediment nor porewater chemistry were found to be associated with impact to the benthic invertebrate community metrics such as abundance, richness, diversity, etc.; therefore, only toxicity is considered in the determination of PRGs to reduce risk to the benthic invertebrate community based on direct contact with sediment.

Based on multivariate statistical analyses presented in the BERA (GSH 2020b), both acute and chronic toxicity were found to be associated with complex chemical mixtures in sediment and porewater. Toxicity occurred in samples with elevated concentrations of multiple chemicals including dioxins/furans; PCBs; pesticides (particularly total DDx, dieldrin, chlordane, and hexachlorobenzene); PAHs (both parent and alkylated); petroleum hydrocarbons; and most metals (e.g., arsenic, cadmium, chromium, copper, lead, mercury, and zinc). Multivariate statistical models were used to predict the probability of toxicity among all 254 surface sediment sampling locations in the NBSA between 2014 and 2016 (i.e., Phase III sampling). Based on this analysis, acute toxicity is predicted at 8.2% of all sampling locations (Figure 3-2) while chronic toxicity is predicted at 17.7% of all sampling locations (Figure 3-3). Although the evidence suggests that chronic effects may be more widespread than acute effects, the acute toxicity endpoint was selected as the more reliable basis for developing chemical-specific PRGs. However, the toxicity predictions based on the chronic endpoint (Figure 3-3) can also be considered in remedial decision making. Therefore, where significant relationships exist, PRGs were also calculated for the 28-day survival endpoint. It is challenging to ascribe causation based on bulk sediment concentrations because in addition to being correlated with toxicity and each other, all of these chemicals were found to exceed sediment quality guidelines. Therefore, porewater concentrations, which were collected for the BERA to more accurately assess likely bioavailability, were used to select a subset of chemicals that are the most likely drivers of toxicity and for which PRGs can be derived.

In its derivation of equilibrium partitioning sediment benchmarks for the protection of benthic organisms, USEPA (2003) conducted ancillary analyses that suggest the sensitivity distribution of benthic and epibenthic organisms is not significantly different from that of pelagic organisms; therefore, aquatic life WQC applied to porewater should be fully protective of benthic organisms. As part of the SQT evaluation presented in the BERA (GSH 2020b), porewater concentrations were compared to WQC for the protection of aquatic life in saline waters (New Jersey

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Department of Environmental Protection [NJDEP] 2016)[4]. The WQC were exceeded for the following chemicals in porewater: total 4,4'-DDx, total PCBs, arsenic, copper, and zinc. In addition, based on the narcosis model of PAH toxicity (USEPA 2017), risk was also demonstrated for PAHs in porewater where the sum of toxic units (SumTU), a unitless toxicity weighted sum of 34 PAHs, including both parent and alkylated PAHs, was greater than or equal to 1, the value at which the potential for toxicity is expected. The resulting subset of chemicals from the porewater evaluation is the basis for derivation of PRGs for the protection of benthic invertebrates.

Proposed sediment-based PRGs were developed based on the likelihood of concentrations to result in acute toxicity to benthic invertebrate communities in the NBSA. Where statistically significant relationships exist, PRGs were also calculated based on the 28-day survival endpoint. All of the data, data comparisons, and correlation analyses described below are detailed in Appendix A of the BERA (GSH 2020b). PRGs were developed for total DDx (4,4'), total PCBs, alkylated PAHs, and arsenic and are based on probit dose response models developed for each chemical using the 10-day (and 28-day where appropriate) amphipod mortality toxicity endpoint. The dose response modeling is detailed in Appendix E. The PRG is defined as the concentration at which 10-day or 28-day survival is predicted to be less than 80% of control, the definition of toxicity employed in the BERA. This corresponds to excess mortality (i.e., mortality beyond the control threshold value of 10% for 10-day survival and 19% for 28-day survival) of 20%. The PRGs are expressed in 2 significant figures in Table 3-8. PRGs were not developed for copper and zinc for reasons described below.

Table 3-8 Summary of Sediment PRGs for the Protection of the Benthic Invertebrate Community

Chemical	Units	Sediment Concentrations at Acutely Toxic Stations		Model-Predicted Value above which 10-day Survival is Predicted to be less than 80% of Control	Model-Predicted Value above which 28-day Survival is Predicted to be less than 80% of Control
		151	154		
Total DDx (4,4')	µg/kg	490	370	290	67
Total PCB Congeners	µg/kg	4,370	1,120	1,700	770
Total Alkylated PAHs[a]	µg/kg	30,400	37,800	29,000	--[b]
Arsenic	mg/kg	61.5	30.9[c]	34	--[b]
Copper	mg/kg	567[c]	545[c]	--[d]	--[d]
Zinc	mg/kg	681[c]	570[c]	--[d]	--[d]

Notes
[a]Sum of C1-Chrysenes, C1-Fluoranthenes/Pyrenes, C1-Fluorenes, C1-Naphthalenes, C1-Phenanthrenes/Anthracenes, C2-Chrysenes, C2-Fluoranthenes/Pyrenes, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Chrysenes, C3-Fluoranthenes/Pyrenes, C3-Fluorenes, C3-Naphthalenes, C3-Phenanthrenes/Anthracenes, C4-Chrysenes, C4-Naphthalenes, and C4-Phenanthrenes/Anthracenes.
--[b] A PRG was not derived for 28-day survival because the relationship was not statistically significant.
[c]Not detected in porewater at this location.
--[d] A PRG was not derived for this chemical since there is no evidence its presence in porewater is causing toxicity.

[4] For chemicals in which WQC were not available (e.g., 2,3,7,8-TCDD, hexachlorobenzene) other conservative water quality guidelines (Buchman 2008) were used for comparison, however none were exceeded.

Total DDx (4,4')

Total DDx (4,4') exceeded chronic WQC in 14 porewater samples (Appendix E, Table E-1), five of which exhibited chronic toxicity and two of which exhibited acute toxicity. Total DDx (4,4') in both sediment and porewater was significantly correlated with acute and chronic toxicity endpoints. Total DDx (4,4') was most elevated in both sediment and porewater at the two acutely toxic SQT stations. A dose response model (Appendix E, Figure E-1) predicts acute toxicity at a concentration of 290 µg/kg (Appendix E, Table E-3) of total DDx (4,4') in sediment. While the chronic endpoint is significantly correlated with total DDx (4,4') (Appendix E, Figure E-2), the confidence limits are much more variable (Appendix E, Table E-3) and therefore there is considerable uncertainty in the PRG based on the chronic endpoint (67 µg/kg). The PRG for the protection of benthic invertebrate communities from acute toxicity is 290 µg/kg (Table 3-8).

PCBs

Total PCBs (sum of 209 congeners) exceeded chronic WQC in three porewater samples (Appendix E, Table E-1), two of which exhibited acute toxicity. Total PCBs (and individual congeners) in both sediment and porewater were significantly correlated with acute and chronic toxicity endpoints. Total PCBs was most elevated in both sediment and porewater at the acutely toxic station 151 (Figure 3-1). The second highest concentration in sediment was observed at station 160, which while not exhibiting acute toxicity, did exhibit chronic toxicity and 100% mortality at 28 days. The third highest concentration in sediment was observed at station 154. Dose response models predict acute toxicity at a sediment concentration of 1,700 µg/kg total PCBs (Appendix E, Figure E-3) and chronic toxicity at 770 µg/kg total PCBs (Appendix E, Figure E-4). The PRG for the protection of benthic invertebrate communities from acute toxicity is 1,700 µg/kg (Table 3-8).

PAHs

Two porewater samples exhibited PAH concentrations in which the SumTU was greater than or equal to 1 and both locations were acutely toxic (Appendix E, Table E-1). All PAHs in porewater, both parent and alkylated, were significantly correlated with acute and chronic toxicity endpoints. In sediment, however, only the alkylated PAHs, both individual and expressed as a sum (i.e., total alkylated PAHs) were significantly correlated with toxicity. An examination of the individual PAHs that make up the SumTU at stations 151 and 154 indicate that 84% and 90%, respectively, of the SumTU value is comprised of toxic units of alkylated PAHs. This strongly suggests that it is the alkylated PAHs that are contributing to the toxicity at these stations. As such, PRGs were derived for total alkylated PAHs (i.e., the sum of 18 alkylated PAHs) rather than total PAHs (i.e., the sum of 17 parent PAHs). The dose response model (Appendix E, Figure E-5) predicts acute toxicity at a concentration of 29,000 µg/kg total alkylated PAHs in sediment. The dose response model for total alkylated PAHs and 28-day survival is not significant (Appendix E, Figure E-6), therefore a chronic PRG was not derived. The PRG for the protection of benthic invertebrate communities from acute toxicity is 29,000 µg/kg (Table 3-8).

Arsenic

Arsenic exceeded chronic WQC in three porewater samples (Appendix E, Table E-1) and acute criteria in one sample all of which exhibited toxicity. Arsenic was most elevated in both sediment and porewater at the acutely toxic station 151. The second highest concentration in porewater (but not sediment) was observed at station 160, which while not exhibiting acute toxicity, did exhibit chronic toxicity and complete amphipod mortality at 28 days. The second highest concentration in sediment was observed at station 154; although, arsenic was not detected in porewater at this station. The third highest concentration in both sediment and porewater was observed at station 143 where chronic toxicity was also exhibited. The dose response model (Appendix E, Figure E-7) predicts acute toxicity at a concentration of 34 milligrams per kilogram (mg/kg) arsenic in sediment. The dose response model

for arsenic and 28-day survival is not significant (Appendix E, Figure E-8), therefore a chronic PRG was not derived. The PRG for the protection of benthic invertebrate communities from acute toxicity is 34 mg/kg (Table 3-8).

Copper and Zinc

Copper was detected in porewater at five SQT stations, but WQC were exceeded in only two stations (Appendix E, Table E-1). One (i.e., 147) exceeded both acute and chronic WQC and another (i.e., 163) exceeded the chronic WQC. Acute toxicity was not observed at either station and 28-day survival was 98% and 85% of control survival at these stations, respectively. Therefore, there is no evidence copper is causing toxicity at those stations. While copper in sediment had the highest concentrations at the two acutely toxic stations (Table 3-8), it was not detected in the porewater at those stations further indicating there is no evidence copper is causing acute toxicity.

Zinc was detected in porewater at only three SQT stations (i.e., 141, 150, and 159), all at concentrations that exceeded acute WQC. At station 141, 28-day survival was significantly different from control although it was greater than 80% of control. The other two stations had 28-day survival that was not significantly different from control and none of the three stations were acutely toxic. Therefore, there is no evidence zinc is causing toxicity at those locations. While zinc was elevated at the two acutely toxic stations (Table 3-8), it was not detected in the porewater at those stations further indicating there is no evidence zinc is causing acute toxicity.

Copper and zinc were also evaluated in the BERA (GSH 2020b) as part of a simultaneously extracted metal mixture in sediment per USEPA guidance (USEPA 2005). This guidance explains that acid volatile sulfide in sediments binds to divalent metals (i.e., cadmium, copper, lead, nickel, and zinc) such that they are not bioavailable in sediments and, therefore, are non-toxic to benthic organisms. Results of the evaluation suggest that these metals are not bioavailable at the acutely toxic stations, 151 and 154. Metal mixtures in porewater were also evaluated according to USEPA guidance (USEPA 2005) with a SumTU approach. Cadmium and nickel were not detected in porewater; therefore, the SumTU was based on detections of copper, lead, and zinc only. SumTU exceeded 1 at six SQT stations (i.e., 139, 159, 163, 141, 147, and 150), one of which also exhibited chronic toxicity based on 28-day survival (141). However, none of these metals were detected in porewater at the acutely toxic stations.

In summary, although some exceedances of WQC were found for copper and zinc in porewater, they were not associated with toxicity and there is no evidence they are contributing to the observed toxicity. Copper and zinc were not present in the porewater of the stations with acute or chronic toxicity. In addition, acid volatile sulfide/simultaneous extracted metals analyses conducted according to USEPA guidance and presented in the BERA indicate these metals are not bioavailable in sediments. Therefore, no sediment PRGs were derived for these metals.

3.4.4 Background Values in Sediment

The NBSA is tidally connected to two major freshwater tributaries (Passaic River and Hackensack River) and the Arthur Kill and Kill Van Kull. All four of these connected waterways are influenced by other contaminated sites and Superfund sites (Figure 1-1). Because of the tidal exchange of contaminated solids across the boundaries with each of these waterways and the NBSA and the presence of Superfund sites and remediation sites along the tidal portion of these waterways, there is no upstream estuarine water body that would meet a strict definition of background. The upper Passaic River above the head of tide (i.e., above Dundee Dam) is the upstream freshwater background water body for the LPR (OU2/OU4) and is therefore important to consider as an upstream

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background source for the NBSA. The CFT model for the NBSA (HDR 2021) indicates that the Kill Van Kull provides the majority of net water column solids imported into the NBSA (Appendix C, Figure C-2). Therefore, the Kill Van Kull and the hydraulically connected Upper New York Bay (Figure 1-1) are also important to consider as a regional ongoing background source to the NBSA. As discussed in the Remedial Investigation Report (GSH 2022), particulate concentrations and the USEPA CFT model show the Kill Van Kull to be an ongoing source of PCBs to the Bay, while the Arthur Kill is an ongoing source of total DDx (4,4') to the sediments in the Bay. The Passaic River is an ongoing source of dioxins and other contaminants, and remedial actions have been completed and are planned to address these sources, but residual inputs from the Passaic River are projected by the USEPA CFT model to continue for many decades after remediation. Contamination is also present in the Hackensack River. USEPA has proposed adding the Lower Hackensack River to the National Priorities List (USEPA 2022c), which may lead to further actions in the Hackensack River under the Superfund Program. In consideration of all of these sources, estimates of future background sediment contamination that may be present in the Bay if all sources in the tidal portions of waterways connected to the Bay were eliminated is highly uncertain. This makes use of estimated external background concentrations (i.e., those outside of the adjacent waterways, or above the Dundee Dam in the Passaic River) as potential cleanup goals highly uncertain with respect to achievability.

An evaluation of the available background sediment data and water column solids data for the upper Passaic River and the Kill Van Kull is described in Appendix C.

Table 3-9 summarizes the average concentrations measured in the sediment and particulates. The Kill Van Kull estimates are combined to provide a "Kill Van Kull Background Estimate". Also, shown are the background concentrations for the upper Passaic River presented in the OU2 ROD (USEPA 2016). Background concentrations for 2,3,7,8-TCDD are 2 nanograms per kilogram (ng/kg) in the upper Passaic River and range from 4 to 20 ng/kg in the Kill Van Kull. For other COCs, there is a similar range of concentrations measured in the two water bodies. The following ranges of background concentrations are observed:

- Total PCB, 330 to 547 µg/kg;
- Total DDx (4,4'), 16 to 30 µg/kg;
- Arsenic, 3 to 11 mg/kg;
- Lead, 74 to 130 mg/kg;
- Mercury, 675 to 1020 µg/kg; and
- Nickel, 19 to 35 µg/kg.

The USEPA (USEPA 2022a, 2022b) states that "Diamond Alkali/Lower Passaic River is the principal source of dioxin contaminant loadings to the Bay" and has directed that the background value for 2,3,7,8-TCDD in OU3 should be the same as the background value specified in the ROD for OU2. This value is based on sediment data collected in the upper Passaic River above Dundee Dam (Table 3-9) and essentially presumes that any other sources to the NBSA would not limit achievement of this concentration, and that there are no other sources to the Bay that may be relevant at this concentration. Although USEPA states the Diamond Alkali/Lower Passaic River is the primary source historically and currently, these sources will be reduced by planned remediation, with other sources impacting long-term achievement of RGs in the Bay. The USEPA (USEPA 2022a, 2022b) further directs that background values for the other COCs should not be based on data from above Dundee Dam, but instead should be based on estimates of the concentrations on suspended solids transported from the Kill Van Kull (Table

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3-9) and that additional sampling may be needed during the FS or future baseline sampling program to update background concentrations in the Kill Van Kull.

While the Hackensack River and the Arthur Kill are not net sources of solids to the NBSA per the CFT model, tidal exchange between these tributaries are expected to impact future COC concentrations in the NBSA. Surface sediment data in the Arthur Kill, both historical and more recent (i.e., 2015), that were used to recalibrate the CFT model (HDR 2021) indicated elevated levels of PCBs, mercury, and in particular, DDx. Total DDx (4,4') was observed at concentrations exceeding 500,000 µg/kg, over 100 times greater than the maximum concentration observed in NBSA surface sediments. In the proposal to list the Lower Hackensack River to the NPL, USEPA states that sediments are contaminated with arsenic, chromium, lead, PAHs and PCBs. Advisories are in place for blue crabs ("do not eat or harvest"), and American eel and white perch ("do not eat") while other species are under limited meal advisories (i.e., white catfish and striped bass). Additional characterization of these tributaries may be necessary during the FS.

Table 3-9 Background Values in Sediment

Chemical	Units	Kill Van Kull Average Concentrations			Post Hurricane Sandy Sediment Sampling in the Kill Van Kull and Upper New York Bay (n=17)	Kill Van Kull Background Estimate[a]	OU2 ROD Background Upper Passaic River Above Dundee Dam (Sample Size)	USEPA Proposed Background for OU3
		Recently Deposited Channel Sediments near Mouth of Kill Van Kull (n=4)	HVCWCM Water Column Particulates (n=4)	SVCWCM Water Column Particulates (Sample Size)				
2,3,7,8-TCDD	ng/kg	19.6	10.2	--[a]	3.7	15	2 (9)	2
Total PCB Congeners	µg/kg	375	547	327 (8)	--[c]	400	460 (9)	400[d]
Total DDx (4,4')	µg/kg	16.4	--[b]	23.8 (6)	--[c]	20	30 (7)	20[d]
Arsenic	mg/kg	11.0	--[b]	9.91 (6)	10	10[e]	3 (11)	10[d]
Lead	mg/kg	90.7	--[b]	74.2 (10)	65	75[e]	130 (11)	75[d]
Mercury	µg/kg	1020	--[b]	675 (10)	710	700[e]	720 (11)	700[d]
Nickel	mg/kg	35.0	--[b]	33.9 (6)	33	35[e]	19 (11)	35[d]

Notes:
[a]Not calculated due to low frequency of detection.
[b]Not analyzed.
[c]Data not available or not validated.
[d]Estimated value based on available Kill Van Kull data. Additional sampling may be needed during the FS.
[e]Based on the estimated average solids concentration measured in the water column particulates in the SVCWCM program in the Kill Van Kull.
HVCWCM = high volume chemical water column monitoring
SVCWCM = small volume chemical water column monitoring

3.4.5 Summary

A summary of the sediment PRGs to address human health and ecological risks in the NBSA is shown in Table 3-10 and the PRG calculations are provided in Appendix F. Sediment PRGs for the protection of human health are derived based on the tissue levels protective of the adult angler consuming self-caught fish or crab (but not both) in the NBSA (Table 3-4). Sediment PRGs for the protection of ecological receptors from risk due to bioaccumulation are derived based on the TRVs used in risk assessment as detailed in Appendix D and

summarized in Table 3-6. PRGs for 2,3,7,8-TCDD, total PCBs, and total DDx (4,4') are based on predictions of protective tissue concentrations using the bioaccumulation model developed by the USEPA (Appendix A). PRGs for mercury and other metals (arsenic, lead, and nickel) were derived using regression models (Appendix B). Sediment PRGs were also derived for the protection of benthic invertebrate communities from acute and chronic toxicity due to direct contact with sediments (Table 3-8), although acute toxicity was selected as the more reliable endpoint for PRGs. Table 3-10 also shows background values measured in the upper Passaic River and the Kill Van Kull.

The USEPA (2022a, 2022b) has selected a single PRG for each COC and directed that "alternatives are to be assembled and evaluated to allow comparison of their ability to remediate NBSA sediments" to these selected PRGs[5]. The selected PRGs proposed by USEPA default to background values because many of the risk-based PRGs are lower than background (Table 3-10) and CERCLA guidance does not require cleanup of contamination to levels below background. For 2,3,7,8-TCDD, USEPA selected a PRG of 2 ng/kg based on data collected in the upper Passaic River (the OU2 ROD background). For the other COCs, USEPA has directed that the Kill Van Kull estimates are the appropriate background value to be used as selected PRGs but that additional sampling may be necessary to characterize Kill Van Kull background estimates.

[5] The use of the term "selected PRGs" was decided during a meeting with USEPA and GSH on July 7, 2022. In prior communications the values were referred to as "interim remedial goals" by USEPA (2022a, 2022b).

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4 Task Status and Next Steps

This RAO/PRG Tech Memo documents the results of Task 1 (Description of Remedial Action Objectives and Preliminary Risk-Based Remediation Goals) in the FS WP, and identifies applicable ARARs, RAOs, and PRGs.

The selected PRGs described in Section 3 will be used as the basis to identify the areal extent of sediment potentially subject to remediation and to develop a set of remedial alternatives to be evaluated in the detailed and comparative analysis in the FS. The potential to achieve the risk-based PRGs described herein will also be considered in the FS as follows. For human health, the PRGs based on the cancer and noncancer risks for RME fish and crab consumption will be evaluated. For ecological receptors, the lowest attainable integrated PRGs will be evaluated. For benthic toxicity risk, the potential to achieve COC concentrations that do not exceed the direct contact PRGs will also be evaluated. In addition, areas in the Bay where toxicity is predicted (Figure 3-2 and 3-3) based on analyses provided in the BERA will also be considered in evaluating the risk reduction potential of alternatives. The selected PRGs are subject to modification in coordination with USEPA during the FS following preliminary evaluation of remedial alternatives with respect to risk reduction and achievability of background values when estimates of future inputs of COCs to Newark Bay are developed through modeling of the remedial alternatives. Future inputs of COCs to Newark Bay will be developed through modeling of the remedial alternatives, which will be used to estimate risk reduction and achievability of background values. Those estimates will be based on assumed levels of source reduction from sediment remediation and source control from other programs that may be implemented in the connected waterways.

Development of remedial alternatives that will ultimately undergo evaluation in the FS Report first requires identification and screening of potential remediation technologies as well as a screening of alternatives that could potentially be applied - these are described below.

A technical memorandum was developed to describe the Identification of Candidate Technologies (ICT; GSH 2020a) and a future technical memorandum will be prepared to describe the Remedial Alternatives Screening (RAS) as outlined in the FS WP. These memoranda include the components summarized below.

- ICT included developing general response actions, technology types, and process options, with each potentially applicable technology type and process option screened based on effectiveness, implementability, and relative cost. The retained representative process options will be used to develop a list of initial alternatives for the RAS. USEPA reviewed and provided comments on this technical memorandum, and these comments and associated resolution will be incorporated into the forthcoming RAS technical memorandum. The ICT completes Task 5: Technology Identification & Treatability Studies. At this time, no treatability studies are planned as part of the NBSA FS process but may be considered during the pre-design investigation.
- RAS will include a description of the current situation (i.e., summary of site background and the nature and extent of COC-impacted materials as developed in the approved RI Report as well as a description of upcoming remedial actions at other sites that could influence conditions in OU3 [e.g., OUs 2 and 4]), development of alternatives, and the initial screening of alternatives. Remedial action levels (RALs) may be defined to identify areas where sediment concentrations could be addressed to achieve the selected PRGs defined defined in this RAO/PRG memo. These RALs, if developed as part of the RAS, would support identification of areas potentially subject to remediation (focus areas). Potential remedial alternatives will be developed considering this information and representative process options (developed in the ICT). An initial

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screening of potential remedial alternatives will be performed based on effectiveness, implementability, and relative cost to develop the list of alternatives that will be evaluated in the FS Report.

Approaches and concepts developed during the RAS process will be presented to USEPA for feedback prior to submittal of the RAS memorandum.

The completed and pending tasks listed below from the FS WP will be compiled into the RAS memorandum:

- Task 1 (Complete): Description of Remedial Action Objectives and Preliminary Risk-Based Remediation Goals – Content incorporated from this memorandum
- Task 2 (Complete): Description of Current Situation and Proposed Response – Content incorporated from the Remedial Investigation and this memorandum
- Task 3: Development of Alternatives – Content to be incorporated from the ICT memorandum and new content
- Task 4: Initial Screening of Alternatives – New content
- Task 5 (Complete): Technology Identification & Treatability Studies – Content incorporated from ICT memorandum and associated comments/responses.

The findings and results from the RAO/PRG, ICT, and RAS Technical Memoranda (FS WP Tasks 1 through 5) will be used as the basis for developing FS WP Task 6: Detailed Evaluation of Alternatives. This evaluation will include analysis of the potential remedial alternatives against the CERCLA criteria (detailed analysis) and analysis of the comparative advantages and disadvantages of each potential remedial alternative by CERCLA criteria (comparative analysis). The results of the detailed evaluation will be incorporated into the Draft FS Report per FS WP Task 7: Preparation of the Draft and Final FS Report and submitted to USEPA for review. The USEPA will select a remedy for the NBSA based on its review of the comparative evaluation of remedial alternatives in the Final FS Report.

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Tables

Table 2-1
Location-Specific Applicable Relevant and Appropriate Requirements (ARARs)
Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum Feasibility Study
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

Act/Regulation	Citation	ARAR	General Description
Federal ARARs			
Coastal Zone Management Act	16 USC §§ 1451-1465; 15 CFR Parts 923 and 930	ARAR	Establishes that Federal agencies that conduct or support activities that directly affect a coastal use or resource must undertake those activities in a manner that is consistent, to the maximum extent practicable, with State coastal zone management programs. The goal is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone."
Rivers and Harbors Act (Section 10)	33 USC § 403; 33 CFR Parts 320-330	ARAR	Prohibits unauthorized obstruction or alteration of any navigable water in the U.S. (dredging, fill, cofferdams, piers, etc.). USACE approval is required to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the U.S.
Endangered Species Act	16 USC §§ 1531-1544; 50 CFR Part 17, Subpart I; 50 CFR Part 402	ARAR	Establishes that Federal agencies are required to verify that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of a critical habitat of such species, unless such agency has been granted an appropriate exemption by the Endangered Species Committee.
Bald and Golden Eagle Protection Act	16 USC §§ 668	ARAR	Prohibits anyone, without a permit issued by the Secretary of the Interior, from knowingly taking and disturbing any bald eagle (commonly known as the American eagle), any golden eagle, or associated nest and/or egg. An active bald eagle nest has been observed at Kearny Point. Site-specific ARAR for OU3; not included in the OU2 ROD.
Migratory Bird Treaty Act	16 U.S.C. §703	ARAR	Requires that Federal agencies consult with the United States Fish & Wildlife Service to ensure that the cleanup of the site does not unnecessarily impact migratory birds.
Fish and Wildlife Coordination Act	16 USC §§ 662	ARAR	Requires the lead agency to develop measures to prevent "loss of and damage to" fish and wildlife resources "whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatsoever." This includes any department or agency of the United States, and such department or agency first shall consult with the United States Fish & Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State in which the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.
Magnuson-Stevens Fishery Conservation and Management Act	Public Law 94-265, as amended through October 11, 1996	ARAR	Legal provision for promoting optimal exploitation of U.S. coastal fisheries. Requires that Federal agencies consult with NMFS on actions that may adversely affect essential fish habitats, defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

Act/Regulation	Citation	ARAR	General Description
National Historic Preservation Act	16 USC §§ 470 – 470x-6; 36 CFR Part 800	ARAR	Establishes that response actions must consider effect on properties currently listed or eligible for inclusion on the National Registry of Historic Places. Requires Federal agencies to consider the effects of their undertakings on historic properties and afford the Council a reasonable opportunity to comment on such undertakings. This will include consultation with State and local governments, Indian tribes, and private organizations as necessary.
Floodplain Management	Executive Order 11988, 40 CFR Part 6	ARAR	Floodplain management requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists. (OU3 ROD identified as a TBC.)
Protection of Wetlands	Executive Order 11990, 40 CFR Part 6	ARAR	Protection of wetlands requires Federal agencies conducting certain activities to avoid, to the extent possible, adverse impacts associated with the destruction or loss of wetlands if a practicable alternative exists. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists. (OU3 ROD identified as a TBC.)
State ARARs			
NJ Soil Erosion and Sediment Control Act	N.J.S.A. 4 :24-39 et seq.	ARAR	Regulates construction that will potentially result in erosion of soils and sediment. Applicable to activities that disturb 5,000 square feet or more of land.
NJDEP New Jersey Freshwater Wetlands Protection Act	N.J.S.A. 13:9B-1, N.J.A.C. 7:7A	ARAR	Describes the activities that may and may not be conducted in and adjacent to freshwater wetlands and State open waters. Act passed to "preserve the purity and integrity of freshwater wetlands from random, unnecessary or undesirable alteration or disturbance." Regulates construction or other activities (including remedial action) that will have an impact on wetlands, including working and transporting across coastal zone to upland processing facility.
NJDEP New Jersey Flood Hazard Area Control Act	N.J.S.A. 58:16A-50, N.J.A.C. 7:13	ARAR	Regulates activities (including remedial action) within flood hazard areas that will impact stream carrying capacity or flow velocity to avoid increasing impacts of flood waters, to minimize degradation of water quality, protect wildlife and fisheries, and protect and enhance public health and welfare. Incorporates standards for development in flood hazard areas and adjacent to surface waters in order to mitigate the adverse impacts to flooding and the environment that can be caused by such development.
NJDEP New Jersey Tidelands Act	N.J.S.A. 12:3	ARAR	Requires a tidelands lease, grant or conveyance for use of State-owned riparian lands, including sediment removal and backfill. Tidelands (riparian lands) are all those lands now or formerly flowed by the mean high tide of a natural waterway, except for those lands for which the State has already conveyed its interest in the form of a riparian grant.

Act/Regulation	Citation	ARAR	General Description
New Jersey Endangered Species Act	N.J.S.A. 23:2A *et seq*	ARAR	The law is designed to protect species whose survival in New Jersey is imperiled by loss of habitat, over-exploitation, pollution, or other impacts. The act establishes a list of wildlife species designated by the State of New Jersey as threatened and endangered. The law prohibits taking, possessing, transporting, exporting, processing, selling, or shipping listed species. "Take" is defined by the law as harassing, hunting, capturing, or killing, or attempting to do so.
New Jersey Endangered Plant Species List Act	N.J.S.A. 7:5C-1.1 *et seq.*	ARAR	Establishes an official list of endangered plants that fall under the protected status. Site-specific ARAR for OU3; not included in the OU2 ROD.
NJDEP New Jersey Coastal Zone Management and New Jersey Waterfront Development Law	N.J.A.C. 7:7E, New Jersey Coastal Permit Program, N.J.A.C. 7:7; N.J.S.A. 12:5-3;	ARAR	Establishes the rules for the use and development of coastal resources within New Jersey's coastal zone. Regulates any waterfront development, including sediment removal and fill, at or below mean high water and up to 500 feet from mean high water in the coastal zone and tidal waters of the State.
NJDEP New Jersey Register of Historic Places Act	N.J.S.A. 13:1B-15.128 et seq.	ARAR	Requires consultation with the New Jersey Historic Preservation Office and other parties to develop ways to avoid, reduce, minimize, or mitigate any adverse impacts to any district, site, building, structure or object included in, or eligible for inclusion in, the National Register of Historic Places.
NYSDEC Natural Heritage Program (Division of Fish and Wildlife and Division of Marine Resources)	6 NYCRR Part 182	ARAR	Requires regulatory consultation to determine if any resources in the area.
NYSDEC Critical Environmental Areas (Division of Environmental Permits)	6 NYCRR 617.14(g)	ARAR	Requires regulatory consultation to determine if any critical environmental areas in the project area.
NYSDEC Tidal Wetlands	Article 25 ECL; 6 NYCRR Part 661	ARAR	Assess work within NYS tidal wetlands to determine if adverse impacts associated with the destruction or loss of wetlands if a practicable alternative exists. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists.
NYSDEC Protection of Waters	Article 15 ECL; 6 NYCRR Part 608	ARAR	Assess work within NYS waterways to determine if adverse impacts associated with the destruction or loss of wetlands if a practicable alternative exists. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists.

Act/Regulation	Citation	ARAR	General Description
New York Endangered Species Act	Article 11, Title 5; 6 NYCRR Part 182	ARAR	Lists endangered, threatened species and species of special concern. The taking of any endangered or threatened species is prohibited except under a permit or license issued by NYSDEC. The NYSDEC must be consulted for a determination of whether an activity is likely to result in the incidental take of a listed species.
New York State Protected Native Plants	Article 9, Title 16; 6 NYCRR Part 193	ARAR	Lists endangered, threatened, rare, and exploitable vulnerable native plants. All listed species are "protected plants" and may not be removed or damaged without consent of the owner.
Coastal Zone Management Act; NYS Waterfront Revitalization and Coastal Resources Act	Article 42: (910 – 923)	ARAR	Assessment of the NYSDOS Coastal Management Program Consistency Determination if project is consistent with coastal program.
Section 106 of the National Historic Preservation Act	36 CFR 800	ARAR	Confer with NYSOPRHP Cultural Resource to assess whether cultural resource impacts resulting from the project.
NYSOGS	9 NYCRR 274	ARAR	Review of water index mapping to determine if any State underwater land approval is required for work in State underwater lands.

Note: The table provides the list of preliminary Federal and State location specific ARARs for the NBSA. There were no location-specific TBCs identified. The listed ARARs, references, and descriptions have been pulled from the ARARs and TBCs outlined in the OU2 ROD due to the contiguous relationship between the two waterbodies and various OUs of the of Site. Additional ARARs have been added beyond the OU2 ROD due to potential applicability for the NBSA (these are noted under the General Description).

Acronyms and Abbreviations:
ARAR = applicable or relevant and appropriate requirements
CFR = Code of Federal Regulations
ECL = Environmental Conservation Law
LPR FFS = Focused Feasibility Study for OU2 in the Lower Passaic River
NBSA = Newark Bay Study Area
NJ = New Jersey
NJDEP = New Jersey Department of Environmental Protection
N.J.A.C. = New Jersey Administrative Code
N.J.S.A. = New Jersey Statutes Annotated
NMFS = National Marine Fisheries Service
NYCRR = New York Code of Rules and Regulations
NYS = New York State
NYSDEC = New York State Department of Environmental Conservation
NYSDOS = New York State Department of State
NYSOGS = New York State Office of General Services

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NYSOPRHP = NYS Office of Parks, Recreation & Historic Preservation
OU2 = Operable Unit 2, lower 8.3 miles of the Lower Passaic River
ROD = Record of Decision
TBC = to be considered criteria
U.S.C. = United States Code

Table 2-2
Action-Specific Applicable Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum Feasibility Study
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

Act/Regulation	Citation	ARAR or TBC	General Description
Federal ARARs and TBCs			
CWA	Section 401 WQC	ARAR	CWA §401 requires that an applicant for an USACE permit to conduct an authorized activity that may result in any discharge to navigable waters to provide the federal permitting agency (e.g., USACE) a water quality certification from the NJDEP and NYSDEC.
	Section 404	ARAR	CWA §404 regulates the discharge of dredged or fill material into waters of the U.S. No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge, which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. If there is no other practical alternative, impacts must be minimized. This program is implemented through regulations set forth in 33 CFR Parts 320 through 330 and 40 CFR Part 230.
	40 CFR Parts 230 [Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material]	ARAR	Guidelines for Specification of Disposal Sites for Dredged or Fill Material
CAA	42 USC §§ 7401 et seq; 40 CFR Parts 50-63	ARAR	Establishes emissions standards for the following pollutants: lead, N, CO, O_3, PM_{10}, and SO_2. Establishes emissions standards for hazardous air pollutants, which can contribute to air pollution, to protect the public health from such pollutants.
RCRA	42 U.S.C. § 6921 et seq; 40 CFR Parts 239 – 299	ARAR	Establishes requirements for generators, transporters, and facilities that manage non-hazardous solid waste and hazardous wastes. Provides for evaluation and control of materials that contain a listed waste, or that display a hazardous waste characteristic based on the TCLP test. Regulates storage, treatment and disposal of listed or characteristic waste unless an exemption applies. Specifies TCLP constituent levels for identifying wastes that exhibit toxicity characteristics. Includes manifest, record keeping and other requirements applicable to generators of hazardous waste. Sets forth standards for transporters of hazardous wastes, including the receipt of an USEPA identification number and manifesting requirements. Provides management standards including record keeping, requirements for units such as tanks or containers, and other requirements applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities. Places land disposal restrictions, including treatment standards and related testing, tracking and record keeping requirements, on hazardous waste(s).

ARCADIS

Act/Regulation	Citation	ARAR or TBC	General Description
USEPA OSR	40 CFR 300.440	ARAR	Requires that CERCLA wastes be placed in a facility operating in compliance with the RCRA or other applicable federal or state requirements. Site-specific ARAR for OU3; not included in the OU2 ROD.
TSCA	15 U.S.C. §§ 2601 et seq.; 40 CFR Part 761	ARAR	Provides regulations for storage, handling, and disposal of sediment containing PCBs greater than 50 milligrams per kilogram.
Hazardous Materials Transportation Act	49 CFR Part 171-177	ARAR	Provides transportation and handling requirements of hazardous materials to off-site disposal facilities.
USEPA Remedial Design/Remedial Action Handbook	EPA 540-R-95-059 OSWER Directive 9355.0-4B	TBC	General reference manual that provides remedial project managers with an overview of the remedial design and remedial action processes. Site-specific TBC for OU3; not included in the OU2 ROD.
Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites	OSWER Directive 9285.6-08	TBC	Guidance document that helps USEPA site managers make scientifically sound and nationally consistent risk management decisions at contaminated sediment sites. Site-specific TBC for OU3; not included in the OU2 ROD.
Contaminated Sediment Remediation Guidance for Hazardous Waste Sites	EPA 540-R-05-012 OSWER 9355.0-85	TBC	Guidance document that provides technical and policy guidance for project managers and management teams making remedy decisions for contaminated sediment sites. Site-specific TBC for OU3; not included in the OU2 ROD.
State ARARs and TBCs			
NJPDES	N.J.A.C. 7:14A	ARAR	Regulates the discharge of pollutants to the surface and ground waters of the State. Details the specific permit requirements and effluent standards for the discharge to the waters of New Jersey.
New Jersey Water Pollution Control Act New Jersey Water Quality Planning Act, and New Jersey Surface Water Quality Standards	N.J.S.A. 58:10A, et seq.; N.J.S.A 58:11 A, et seq.; N.J.A.C. 7:9B	ARAR	Establishes the designated uses and antidegradation categories of the State's surface waters, classifies surface waters based on those uses (i.e., stream classifications), and specifies the water quality criteria and other policies and provisions necessary to attain those designated uses. Protects surface water resources. Contains stream classifications, water designated uses, water quality criteria to protect uses, antidegradation policies, and procedures for implementing water quality standards.

Act/Regulation	Citation	ARAR or TBC	General Description
NJ Stormwater Management Rules	N.J.A.C. 7:8	ARAR	Establishes the design and performance standards for stormwater management measures. Contains general requirements for stormwater management plans and stormwater control ordinances. Provides the content requirements and procedures for the adoption and implementation of regional stormwater management plans and municipal stormwater management plans. Establishes design and performance standards for stormwater management measures and establishes safety standards for stormwater management basins. Establishes the design and performance standards for stormwater management measures for major development, which includes any development that disturbs one (1) or more acre of land or increases existing impervious surface by ¼ acre or more.
Noise Control	N.J.A.C. 7:29	ARAR	Sets forth regulations relating to the control and abatement of noise. Defines acceptable noise levels for industrial, commercial, public service, or community service facilities.
NJSWMA and New Jersey Solid and Hazardous Waste Rules	N.J.S.A. §13:1E-1, et seq.; N.J.A.C. 7:26, 7:26B and 7:26G	ARAR	Establishes requirements for generators, transporters, and facilities that manage solid waste and hazardous waste, and for thermal destruction facilities. Establishes standards and requirements for the management of solid waste (including regulated medical waste) – including registration, operation, maintenance, and closure of solid waste facilities and registration, operation, and maintenance of solid waste transport vehicles.
New Jersey Air Pollution Control Act	N.J.S.A. § 26:2C et seq., N.J.A.C. 7:27	ARAR	Specific to the protection and improvement of air quality. Regulates emissions that introduce contaminants into the ambient atmosphere for a variety of substances and from a variety of sources; controls and prohibits air pollution, particle emissions, and toxic VOC emissions.
New Jersey Technical Requirements for Site Remediation	N.J.A.C. 7:26E	ARAR	Establishes technical requirements for investigation and remediation processes performed under the New Jersey cleanup programs.
NYSDEC 401 Water Quality Certification	Section 401 of the Clean Water Act	ARAR	Requires that NYSDEC assess whether the project will comply with State water quality standards. Issuance of a WQC is to support issuance of USACE concurrence.
NYSDEC SPDES General Permit for Stormwater Discharges from Construction Activity	6 NYCRR Parts 750-758	ARAR	Requires preparation of a SWPPP for land disturbance of one or more acres and acquisition of general permit prior to construction. Requires approval for discharge of dewatering effluent directly to surface water.
New York Air Pollution Control Law and New York State Air Quality Standards	NYS ECL Article 19, Title 3; 6 NYCRR Part 257	ARAR	Establishes that the emission of air contaminants to the outside atmosphere that jeopardize human, plant, or animal life, or are ruinous to property, or which unreasonably interfere with the comfortable enjoyment of life or property, is prohibited.

Act/Regulation	Citation	ARAR or TBC	General Description
NY Hazardous Waste Rules	NYS ECL, Article 27, Title 9; NYCRR Parts 371-373	ARAR	Establishes procedures for identifying solid wastes that are subject to regulation as hazardous wastes, including manifest system, treatment, storage, and disposal requirements.
NY Land Disposal Restrictions	NYS ECL, Article 27, Title 9; 6 NYCRR Part 376	ARAR	Identifies hazardous wastes that are restricted from land disposal and defines those circumstances under which an otherwise prohibited waste may be land disposed.
Use and Protection of Waters	NYS ECL Article 15, Title 5; Article 17, Title 3; 6 NYCRR Part 608	ARAR	Requires a permit to change, modify, or disturb any protected stream bed or banks, remove any material from the stream bed or banks, or excavate or place fill on any of the navigable waters of the state. Permit applicant must obtain a State Water Quality Certification under Section 401 of the Federal Water Pollution Control Act (CWA). CERCLA response actions are not required to obtain the permit, however actions would comply with the substantive requirements of this part.
Surface Water Regulations	NYS ECL 17-0501 and 17-0301; 6 NYCRR Parts 701 and 703	ARAR	Establishes that it is be unlawful for any person, directly or indirectly, to throw, drain, run or otherwise discharge into such waters organic or inorganic matter that shall cause or contribute to a condition in contravention of applicable standards adopted by NYSDEC pursuant to this regulation.
Fish and Wildlife Management Practices Cooperative Program – Polluting Stream Prohibited	NYS ECL 11-0503	ARAR	Establishes that no deleterious or poisonous substances shall be thrown or allowed to run into any public or private waters in quantities injurious to fish life, protected wildlife or waterfowl inhabiting those waters, or injurious to the propagation of fish, protected wildlife or waterfowl therein.
New York State Technical Guidance for Site Investigation and Remediation	DER-10	ARAR	Provides the site investigation and remediation process for the remedial programs administered by the Division of Environmental Remediation.

Note: The table provides the list of preliminary Federal and State action-specific ARARs and TBCs for the NBSA. The listed ARARs and TBCs, references, and descriptions have been pulled from the ARARs and TBCs outlined in the OU2 ROD due to the contiguous relationship between the two waterbodies and various OUs of the of Site. Additional ARARs and TBCs have been added beyond the OU2 ROD due to potential applicability for the NBSA (these are noted under the General Description).

Acronyms and Abbreviations:
ARAR = applicable or relevant and appropriate requirements
CAA = Clean Air Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CO = carbon monoxide

CWA = Clean Water Act
ECL = Environmental Conservation Law
LPR FFS = Focused Feasibility Study for OU2 in the Lower Passaic River
N = nitrogen
NBSA = Newark Bay Study Area
NJ = New Jersey
N.J.A.C. = New Jersey Administrative Code
NJDEP = New Jersey Department of Environmental Protection
NJPDES = New Jersey Pollutant Discharge Elimination System
N.J.S.A. = New Jersey Statutes Annotated
NJSWMA = New Jersey Solid Waste Management Act
NYSDEC = New York State Department of Environmental Conservation
OSR = Off-Site Rule
OU2 = Operable Unit 2, lower 8.3 miles of the Lower Passaic River
O_3 = Ozone
PCB = polychlorinated biphenyl
PM_{10}= Particulate matter equal to or less than 10 microns particle size
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
SO_2 = sulfur dioxide
SPDES = State Pollution Discharge Elimination System
SWPPP = Stormwater Pollution Prevention Plan
TBC = to be considered criteria
TCLP = Toxicity Characteristic Leaching Procedure
TSCA = Toxic Substances Control Act
USACE = U.S. Army Corps of Engineers
USEPA = U.S. Environmental Protection Agency
U.S.C. = United States Code
VOC = volatile organic compound
WQC = Water Quality Certificate

Table 3-10
Summary of Sediment PRGs
Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum Feasibility Study
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

		Human Health PRGs					Ecological PRGs					Background Estimates			
			Cancer Sediment PRG RME[a]			Noncancer Sediment PRG RME[a]		Bioaccumulation Risk							
COC	Units	Species	10^{-6}	10^{-5}	10^{-4}		Species	Lowest PRG	Lowest Integrated PRG	Lowest Attainable Integrated PRG[b]	Direct Contact Toxicity Risk to BIC[e]	Kill Van Kull	Upper Passaic River (OU2 ROD)	OU2 RGs (OU2 ROD)	USEPA Selected OU3 PRG[g]
2,3,7,8-TCDD	ng/kg	Blue crab	**UA**	**UA**	49	6.7	Fish (multiple), blue crab, softshell clam	**UA**	**UA**	38	--	15	2	8.3	2
		Mixed Fillet[d]	**UA**	0.35	180	41									
Total PCBs	µg/kg	Blue crab	**UA**	**UA**	1,500	**UA**	Mummichog, blue crab, softshell clam	**UA**	**UA**	360	1,700	400	460	50	400
		Mixed Fillet[d]	**UA**	**UA**	790	**UA**									
Total DDx (4,4')[c]	µg/kg	Mixed Fillet[d]	130	2,200	23,000	360	Blue crab, white perch	**UA**	130	130	290	20	30	0.3	20
Mercury	µg/kg	American eel	There is no quantitative estimate of carcinogenic risk from oral exposure.			1,100	Blue crab, softshell clam	270	270	270	--	700	720	74	700
		White perch				2,400									
Arsenic	mg/kg	--	--				Softshell clam	0.033	0.033	0.033	34	10	3	--	10
Lead	mg/kg	--					Softshell clam	0.15	49	49	--	75	130	--	75
Nickel	mg/kg	--					Softshell clam	0.0001	0.0001	0.0001	--	35	19	--	35
Total Alkylated PAHs	µg/kg	--					--	--	--	--	29,000	--	--	--	--

Notes:

PRGs for organic COCs (2,3,7,8-TCDD, Total PCBs and total 4,4'-DDx) were calculated using the Contaminant Fate and Transport Model and the Bioaccumulation Model. See Appendix A.

Mercury PRGs are calculated using an empirical regression model (Appendix B). Human health risk is due to methylmercury and it is assumed that all mercury in tissue is methyl mercury. The regression does not account for the potential effects of remedial actions in OU2 and/or OU4. Empirical models were not developed for bluefish, striped bass, or summer flounder. These species were found to have similar mercury concentrations as those in reference areas. In addition, mercury concentrations in summer flounder are below acceptable human-health based tissue concentrations.

Arsenic, lead and nickel PRGs are calculated using empirical regression models (Appendix B).

[a]Reasonable Maximum Exposure (RME) for adult angler: 56 eight-ounce meals per year for fish or 34 eight-ounce meals per year for crab.

[b]Lowest PRG based on integrated toxicity reference values for all species with ecological risk, that has a PRG that is not less than 0 (i.e., not unattainable). See Table 3-7.

[c]Human health risk is due to 4,4'-DDD in fish. For consistency among receptors and with OU2 RGs, the PRGs are calculated in terms of total DDx (4,4').

[d]Mixed fillet PRG is based on the assumption that a fish diet for an adult angler is comprised of equal weights of five species: bluefish, American eel, striped bass, summer flounder, and white perch. This was the assumption of the human health risk assessment (GSH 2019).

[e]Based on dose response models of 10-day *L. plumulosus* survival. The PRG is the value above which survival is predicted to be less than 80% of laboratory control survival. These PRGs are not-to-exceed values.

[f]The Kill Van Kull background values are estimates and additional data collection may be necessary (USEPA 2022a; 2022b).

[g]At the direction of USEPA, this selected PRG is to be the basis to evaluate alternatives in the Feasibility Study (FS) for the NBSA (USEPA 2022a;2022b). The use of the term "selected PRGs" was decided during a meeting by conference call between USEPA and GSH on July 7, 2022. In prior communications these values were referred to as "interim remedial goals" by USEPA (2022a, 2022b). The final remedial goals will be selected at the conclusion of the FS.

-- = not applicable
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
BIC = benthic invertebrate community
COC = chemical of concern
mg/kg = milligrams per kilogram
NA = Not applicable
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
PRG = preliminary remedial goal
OU = operable unit
ROD = record of decision
Total DDx (4,4') = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
UA = unattainable. According to the bioaccumulation model prediction, the acceptable tissue concentration can not be attained when NBSA sediment is assumed to have 0 concentration of the COC. Therefore, a PRG could not be calculated. Cells are bolded and shaded.
µg/kg = micrograms per kilogram
USEPA = United States Environmental Protection Agency

Figures

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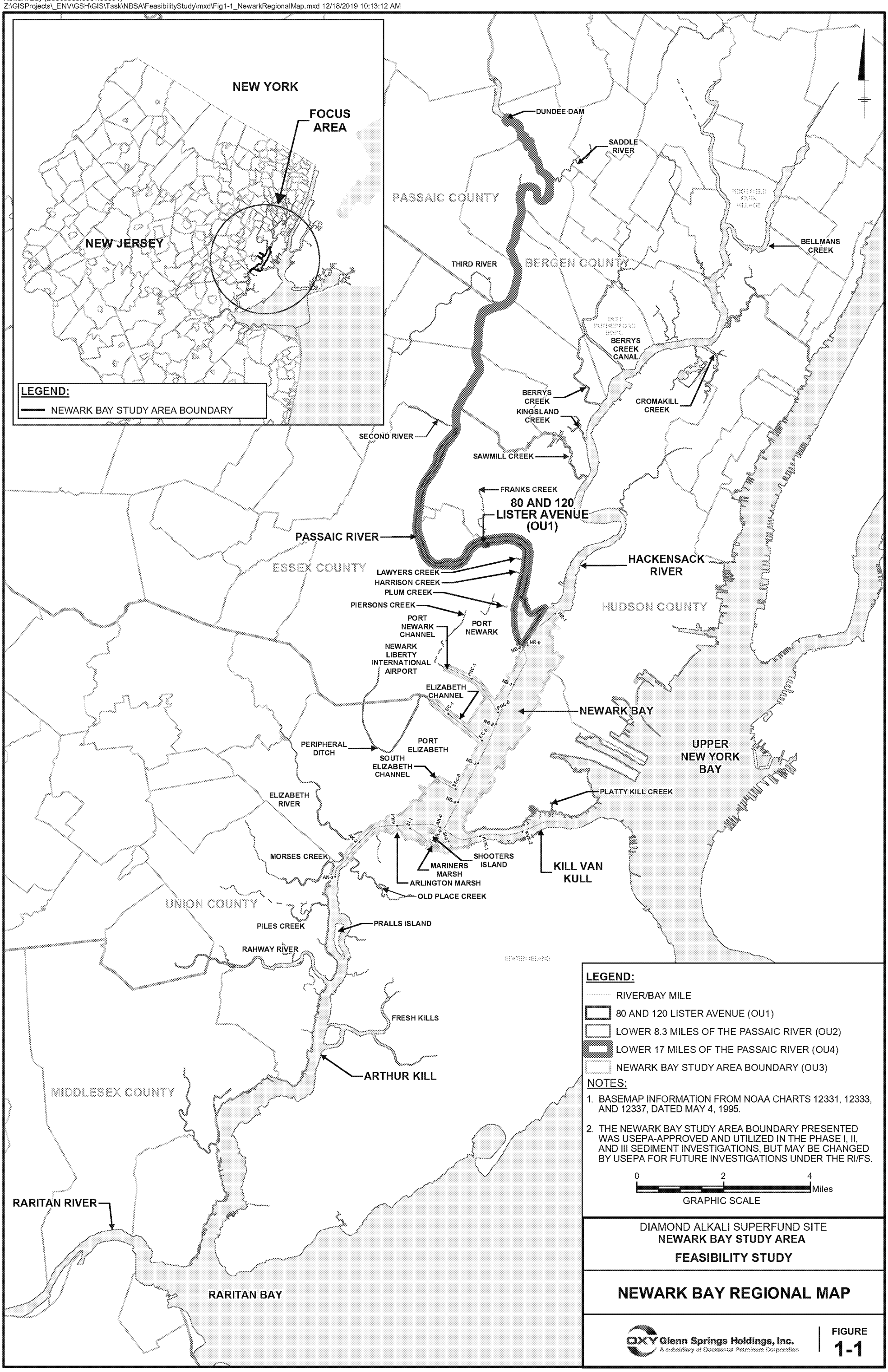

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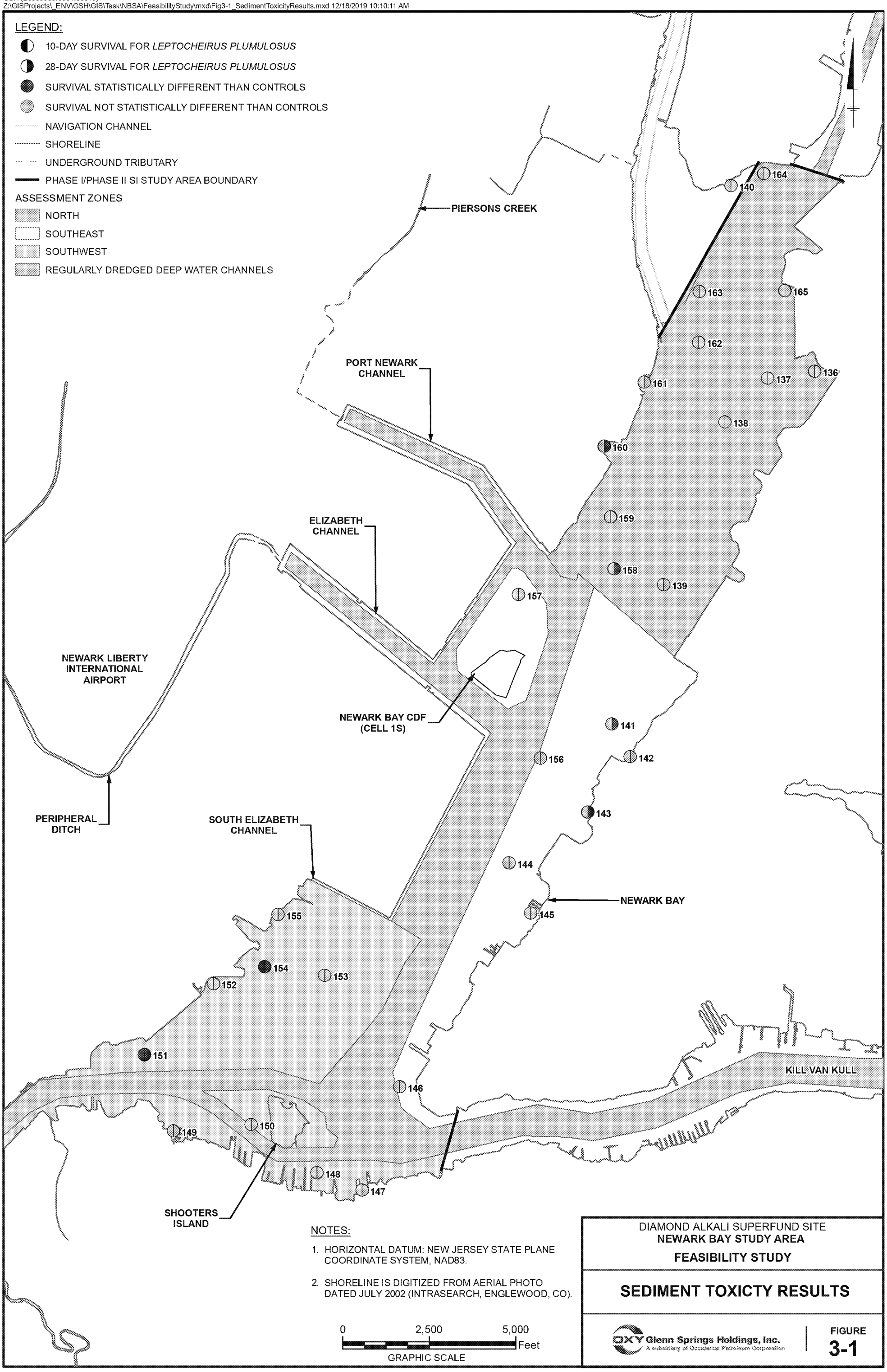


DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
FEASIBILITY STUDY

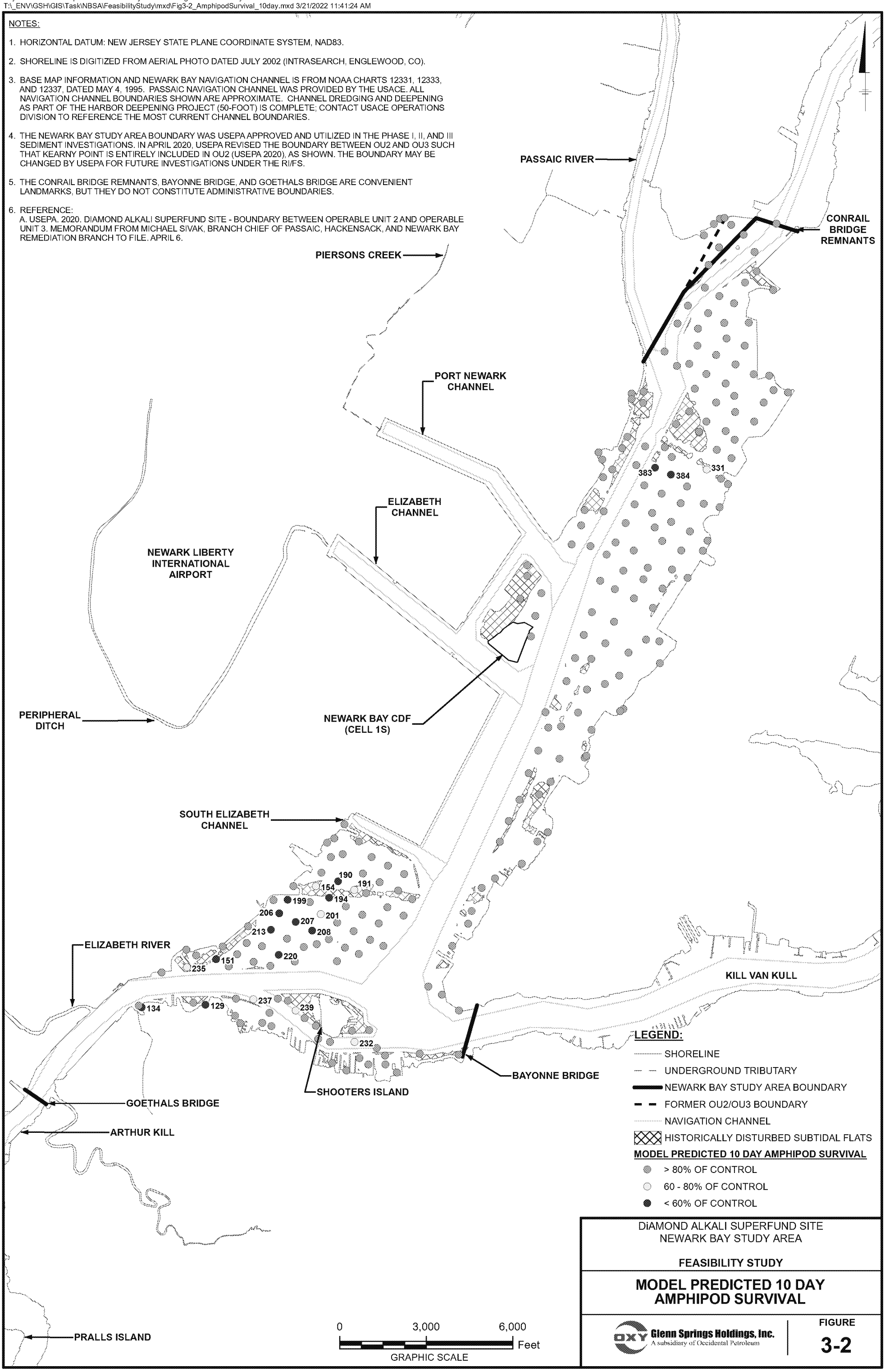
SEDIMENT TOXICTY RESULTS

Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
3-1

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. BASE MAP INFORMATION AND NEWARK BAY NAVIGATION CHANNEL IS FROM NOAA CHARTS 12331, 12333, AND 12337, DATED MAY 4, 1995. PASSAIC NAVIGATION CHANNEL WAS PROVIDED BY THE USACE. ALL NAVIGATION CHANNEL BOUNDARIES SHOWN ARE APPROXIMATE. CHANNEL DREDGING AND DEEPENING AS PART OF THE HARBOR DEEPENING PROJECT (50-FOOT) IS COMPLETE; CONTACT USACE OPERATIONS DIVISION TO REFERENCE THE MOST CURRENT CHANNEL BOUNDARIES.
4. THE NEWARK BAY STUDY AREA BOUNDARY WAS USEPA APPROVED AND UTILIZED IN THE PHASE I, II, AND III SEDIMENT INVESTIGATIONS. IN APRIL 2020, USEPA REVISED THE BOUNDARY BETWEEN OU2 AND OU3 SUCH THAT KEARNY POINT IS ENTIRELY INCLUDED IN OU2 (USEPA 2020), AS SHOWN. THE BOUNDARY MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
5. THE CONRAIL BRIDGE REMNANTS, BAYONNE BRIDGE, AND GOETHALS BRIDGE ARE CONVENIENT LANDMARKS, BUT THEY DO NOT CONSTITUTE ADMINISTRATIVE BOUNDARIES.
6. REFERENCE:
   A. USEPA. 2020. DIAMOND ALKALI SUPERFUND SITE - BOUNDARY BETWEEN OPERABLE UNIT 2 AND OPERABLE UNIT 3. MEMORANDUM FROM MICHAEL SIVAK, BRANCH CHIEF OF PASSAIC, HACKENSACK, AND NEWARK BAY REMEDIATION BRANCH TO FILE. APRIL 6.



DiAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA

FEASIBILITY STUDY

MODEL PREDICTED 10 DAY AMPHIPOD SURVIVAL

Glenn Springs Holdings, Inc.
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FIGURE
3-2

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. BASE MAP INFORMATION AND NEWARK BAY NAVIGATION CHANNEL IS FROM NOAA CHARTS 12331, 12333, AND 12337, DATED MAY 4, 1995. PASSAIC NAVIGATION CHANNEL WAS PROVIDED BY THE USACE. ALL NAVIGATION CHANNEL BOUNDARIES SHOWN ARE APPROXIMATE. CHANNEL DREDGING AND DEEPENING AS PART OF THE HARBOR DEEPENING PROJECT (50-FOOT) IS COMPLETE; CONTACT USACE OPERATIONS DIVISION TO REFERENCE THE MOST CURRENT CHANNEL BOUNDARIES.
4. THE NEWARK BAY STUDY AREA BOUNDARY WAS USEPA APPROVED AND UTILIZED IN THE PHASE I, II, AND III SEDIMENT INVESTIGATIONS. IN APRIL 2020, USEPA REVISED THE BOUNDARY BETWEEN OU2 AND OU3 SUCH THAT KEARNY POINT IS ENTIRELY INCLUDED IN OU2 (USEPA 2020), AS SHOWN. THE BOUNDARY MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
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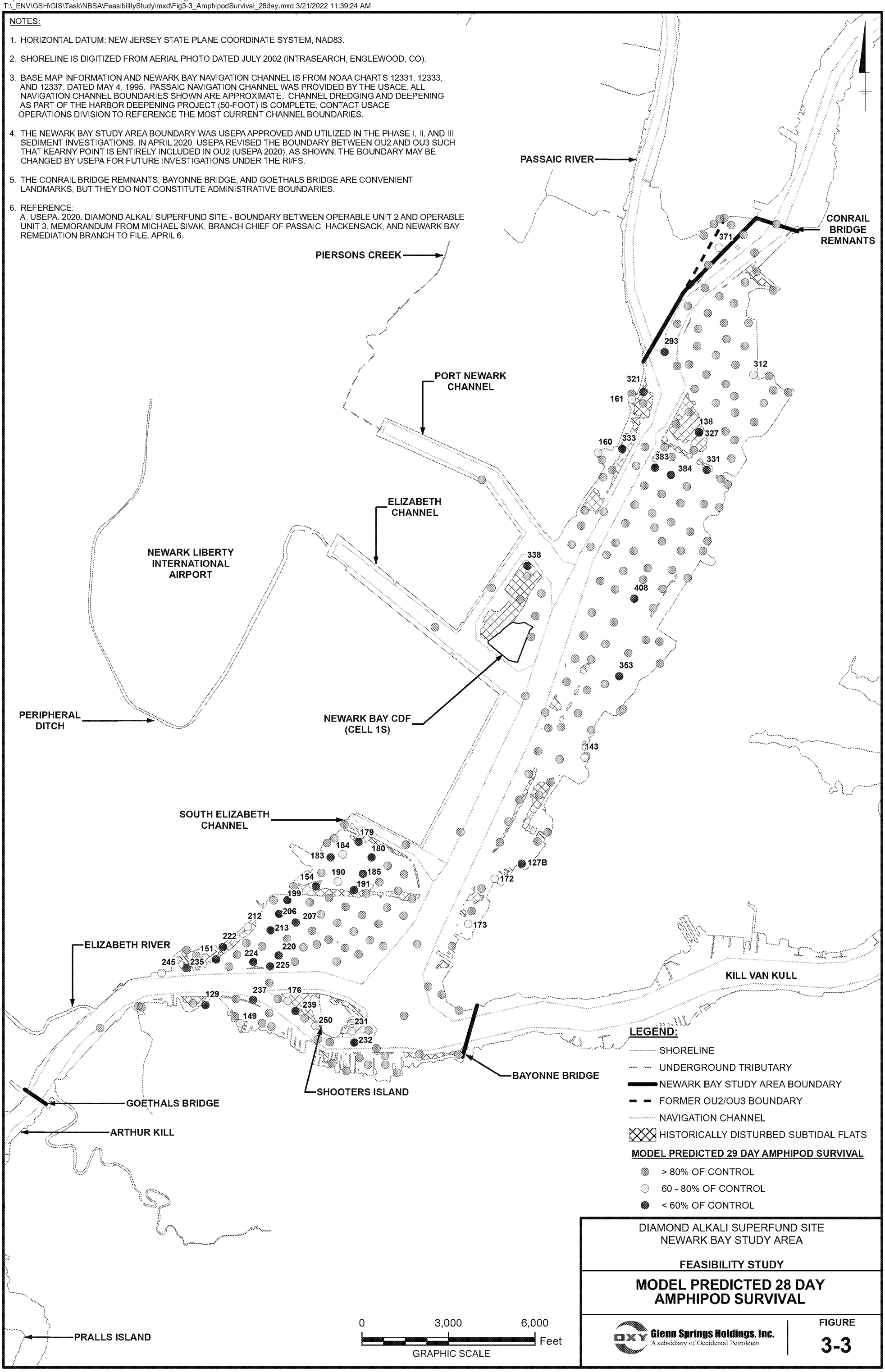

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA

FEASIBILITY STUDY

MODEL PREDICTED 28 DAY AMPHIPOD SURVIVAL

Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum

FIGURE
3-3

Appendix A

Bioaccumulation Model and PRG Calculation Method

ARCADIS

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Appendix A: Bioaccumulation Model and PRG Calculation Method

Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

August 2022

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Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
4,4'-DDD	4,4'- dichlorodiphenyldichloroethane
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CFT	contaminant fate and transport
COC	chemical of concern
FFS	focused feasibility study
GSH	Glenn Springs Holdings, Inc.
LPR	Lower Passaic River
LPRSA	Lower Passaic River Study Area
NBSA	Newark Bay Study Area
ng/kg	nanograms per kilogram
OU	operable unit
PCBs	polychlorinated biphenyls
PRGs	preliminary remedial goals
TRVs	toxicity reference values
USEPA	United States Environmental Protection Agency

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1 Bioaccumulation Model

Sediment-based preliminary remedial goals (PRGs) were calculated using models that predict the tissue concentrations in biota associated with a given sediment concentration. For the organic chemicals of concern (COCs), a bioaccumulation model was developed by the United States Environmental Protection Agency (USEPA) to predict tissue concentrations based on concentrations in abiotic media (e.g., sediment, water column) predicted by the contaminant fate and transport (CFT) model developed for the Newark Bay Study Area (NBSA; HDR 2021). The bioaccumulation model for the NBSA is an extension of the bioaccumulation model developed for the Lower Passaic River Study Area (LPRSA; Windward 2021) by the Cooperating Parties Group and uses the same model code and general development process as that model. Differences from that model include the fish species modeled, as more saline/estuarine species are found in the NBSA, and the implementation of an explicit migration routine to account for species that are onsite for only a portion of their life history. As this model is an extension of the LPRSA model, the Arnot and Gobas model (2004) forms the basis for the NBSA modeling effort. The bioaccumulation model has compartments that account for exposure within subareas of the NBSA that were exposure areas evaluated in the baseline ecological risk assessment (BERA; i.e. North, Southeast and Southwest) and in other areas where migratory species are exposed such as the Lower Passaic River, the Hackensack River, the Arthur Kill, the Kill Van Kull and the Atlantic Ocean. The model predicts whole body tissue concentrations in aquatic biota for the following organic chemicals: 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), total tetrachlorinated polychlorinated biphenyls (PCBs), and total DDx (4,4') (sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4- dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane). The methods used to derive PRGs for organic COCs are described in this appendix. The bioaccumulation model documentation is presented in Appendix J of the Remedial Investigation Report (GSH 2022).

The bioaccumulation model predicts whole body COC concentrations of aquatic biota in the NBSA, either specific species or representative trophic feeding guilds, based on the concentrations in abiotic media (i.e. sediment water, detritus, etc.) as predicted by the CFT model. The model was calibrated using tissue data collected for the NBSA remedial investigation and risk assessment activities from 2014 to 2016. The following species/feeding guilds represented in the model:

- Plankton - phytoplankton/algae and zooplankton
- Benthic Invertebrates - benthic invertebrate deposit feeder, benthic invertebrate filter feeder (i.e., softshell clam [*Mya arenaria*]), benthic invertebrate detritivore, and benthic invertebrate carnivore/omnivore
- Blue crab (*Callinectes sapidus)*
- Forage fish - Atlantic silverside (*Menidia menidia*) and small forage fish (i.e., *Fundulus spp.*)
- Benthic omnivorous/invertivorous fish - summer flounder (*Paralichthys dentatus*)
- Invertivorous fish - white perch (*Morone americana*)
- Piscivorous fish - small American eel (*Anguilla rostrata*; <50 centimeters (cm) in length), large American eel (>50 cm in length), bluefish (*Pomatomus saltatrix*), and striped bass (*Morone saxatilis*).

Tissue data were available for all listed fish species, blue crab and softshell clam and were utilized in model calibration.

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Linkage to the CFT model output includes the following parameters for each COC:

- Concentration in sediment solids
- Concentration in detrital particulates
- Bioavailable concentration in water
- Concentration in sediment porewater
- Concentration in near-bottom particulates
- Concentration in algal particulates.

Other physical, chemical and biological parameters used in modeling are described in the model documentation (GSH 2022).

The NBSA is a tidal estuary, and the exposure of aquatic biota is influenced by its major tributaries: the Passaic River, the Hackensack River, the Arthur Kill and the Kill Van Kull. This influence includes the tidal influx of water and water column solids from the tributaries into the NBSA and the migration of aquatic species from the NBSA to the tributaries where additional exposure occurs. The bioaccumulation model has built-in assumptions for migratory exposure to these tributaries as well to the Atlantic Ocean. In addition, within the NBSA organisms were assumed to have their exposure in one of three exposure areas: North, Southeast, and Southwest (Figure A-1). No exposure is assumed in the "regularly dredged deep water channels" (Figure A-1) and therefore this portion of the navigation channel is outside the bioaccumulation model domain. These exposure assumptions are based on where the target species were collected and were incorporated into the model calibration (GSH 2022). A further spatial assumption in the model is that small forage fish, mummichog (*Fundulus heteroclitus*) and striped killifish (*Fundulus majalis*), received all their exposure in "mudflats" defined as shallow areas of the NBSA where water depth is less than 2 meters.

An analysis of bioaccumulation model output found that a significant proportion of the COC concentrations in aquatic biota, particularly 2,3,7,8-TCDD, is attributable to exposure in the LPRSA. It is further assumed that water and water column solids entering the NBSA from the LPRSA increase exposure in the NBSA to COCs present in the LPRSA. Two remedial actions are planned in the LPRSA. In the lower eight miles (Operable Unit [OU] 2), a bank-to-bank remediation of sediments is planned (USEPA 2016). In the upper 9 miles, an interim action is planned to reduce sediment concentrations on a surface area weighted average concentration basis. These actions are expected to have significant effects on the COC concentrations in biota in the NBSA. Therefore, the USEPA made the decision to account for these effects in the calculation of PRGs for the NBSA and assume that "Current Conditions" is a period after the remedial actions have been implemented.

2 PRG Calculation

The "Current Conditions" time period for PRG calculation was established as a two year period after completion of the remedial actions in the LPRSA (2031 to 2033). The CFT model was initialized with the assumption of LPRSA actions being completed in 2031 and run for the two year period. The resulting CFT linkage output was input to the calibrated bioaccumulation model to predict biota concentrations under an assumption of no action in the NBSA, the baseline assumption. The CFT model was run again under a scenario where it is assumed all COC concentrations in sediment in the NBSA are zero. The CFT linkage was again input to the bioaccumulation model

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to predict the concentration in tissue if sediment concentrations are reduced to zero in the NBSA. These two scenarios are the endpoints of a line and under the assumption of linearity, interpolation can be used to find the sediment concentration associated with an acceptable tissue concentration. That value is the PRG. An example of the bioaccumulation output for blue crab is provided in Figure A-2. In this example, if a hypothetical risk-based acceptable 2,3,7,8-TCDD tissue concentration in blue crab were 3 nanograms per kilogram (ng/kg) the resulting sediment PRG would be 10 ng/kg as determined by linear interpolation.

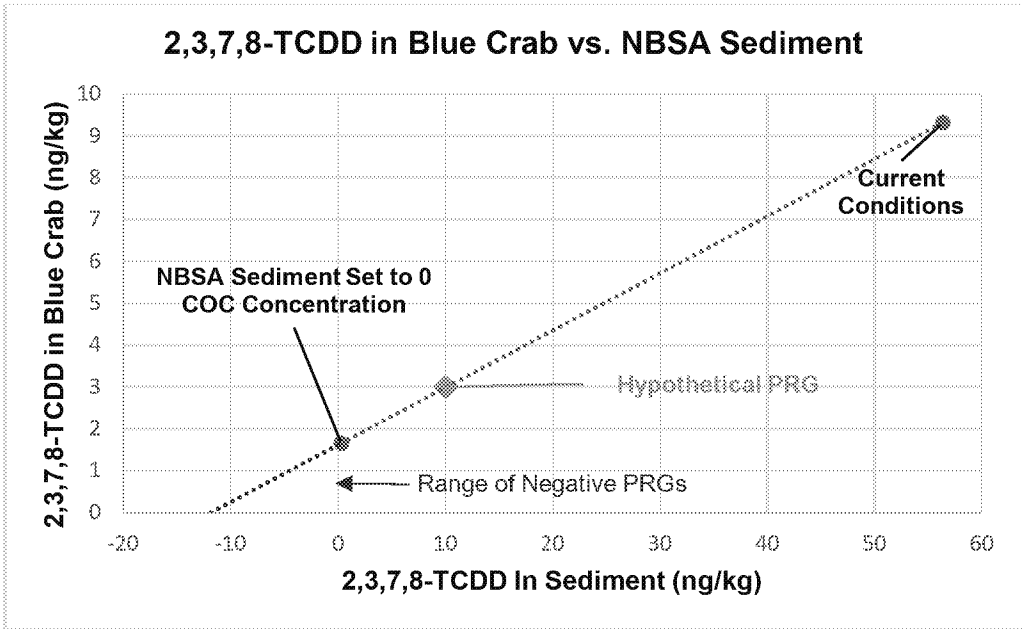

Figure A-2 Model Predicted 2,3,7,8-TCDD Concentrations in Blue Crab and Sediment

Note that even when NBSA sediment concentrations are set to 0, the blue crab and other organisms still have residual COC concentrations due to exposure to the water column and also due to recontaminated sediment. This occurs because the model is run for two years after the NBSA sediment is zeroed out and some recontamination occurs from the connected tributaries. If acceptable COC tissue concentrations are below the value of the y-intercept of the line (i.e., the tissue concentration associated with a zero sediment concentration), the sediment PRG as calculated by this methodology is effectively a negative number (Figure A-2). For example, when assuming zero concentration in NBSA sediment at the beginning of the two year period, the predicted sediment concentration of 2,3,7,8-TCDD after the two year period (2031 to 2033) is 0.29 ng/kg (Figure A-2) and this corresponds with a blue crab concentration of 1.66 ng/kg (Figure A-2, Table A-1). In cases where a risk-based acceptable tissue concentration is less than 1.66 ng/kg, the calculated sediment PRG becomes negative and would decrease negatively as the acceptable tissue concentration approaches zero. This issue of negative PRGs is further discussed in Section 4.

This calculation method assumes that the relationship is exactly linear between the two model prediction points. The linearity was tested by also running the CFT model assuming that the NBSA sediment is set to a concentration of approximately 10 percent of its current concentration, a point on the line between the current conditions and the zero point and closer to the zero point. Based on this output, it was determined that linearity, while approximate, was a reasonable assumption for PRG calculation. Therefore, all PRGs were calculated using

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linear interpolation between the current conditions and the zero point. The outputs for these two scenarios used in PRG calculation are provided in Table A-1.

3 Required Conversion Equations

The CFT model was set up to predict the following organic contaminants: 2,3,7,8-TCDD, total tetrachlorinated PCBs, and total DDx (4,4') (sum of three isomers). Therefore, the bioaccumulation model was calibrated to predict tissue concentrations for these same chemical/chemical groups. Risk-based acceptable tissue concentrations are not always expressed in the contaminant form predicted by the bioaccumulation model or for the same tissue type predicted by the model. Thus, conversion equations are needed to calculate sediment PRGs for 2,3,7,8-TCDD, total PCBs, and total DDx (4,4'), the form the PRGs should take to be consistent with the remedial goals set for OU2 (USEPA 2016).

Unacceptable human health risk due to consumption of the edible portions of fish (i.e., fillet) and crab (i.e., muscle/hepatopancreas) was found for 2,3,7,8-TCDD, total PCBs, and 4,4'-dichlorodiphenyldichloroethane (4,4'-DDD; Glenn Springs Holdings, Inc. [GSH] 2019). Unacceptable ecological risks were found due to whole body tissue concentrations of 2,3,7,8-TCDD, total PCBs, and total DDx (2,4' and 4,4') (GSH 2020). Conversion equations were thus required to express sediment PRGs in terms of total PCBs and total DDx (4,4'). For all COCs for human health risk, conversion factors were used to convert acceptable edible tissue concentrations to whole body tissue concentrations.

3.1 Edible to Whole Body Conversion

For fish species, the edible fillet to whole body conversion factors were established during the development and calibration of the bioaccumulation model and are based on factors calculated and presented in the Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River (LPR FFS; USEPA 2014). These factors were calculated using pooled data from multiple organic chemicals and therefore are the same for all organic chemicals. For blue crab, site specific and COC specific conversion factors were calculated using the 37 blue crab samples collected in the NBSA and are equal to the geometric mean ratio of whole body to edible (i.e., muscle/ hepatopancreas) COC concentrations for each sample. The following equation is used to convert an edible tissue concentration to a whole body concentration:

$$C_w = C_e * f$$

where C_w is the concentration in whole body tissue;

C_e is the concentration in edible tissue (fillet for fish or muscle/hepatopancreas for blue crab); and

and f is a conversion factor.

The conversion factors are presented in Table A-2. No conversion factor was required for DDx in blue crab as it was not found to be a risk for human health consumption.

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Table A-2 Edible to Whole Body Conversion Factors

Species	Chemical(s)	*f* (conversion factor)
American eel	2,3,7,8-TCDD, PCBs, DDx	1.65
All other fish species*	2,3,7,8-TCDD, PCBs, DDx	3.71
Blue crab	2,3,7,8-TCDD	0.937
Blue crab	PCBs	0.926

*Bluefish, striped bass, summer flounder, white perch

3.2 PCBs

The bioaccumulation model predicts concentrations of total tetrachlorinated PCBs in whole body tissue. In order to calculate sediment PRGs for the protection of human health, the following steps are taken:

1. Convert the acceptable edible total PCB tissue concentration to an acceptable edible total tetrachlorinated PCB tissue concentration using the equation derived from a species and tissue specific regression model (see Table A-3).
2. Convert the acceptable edible tetrachlorinated PCB tissue concentration to an acceptable whole body tetrachlorinated PCB tissue concentration using the appropriate conversion factor (Table A-2).
3. Use linear interpolation (described in Section 2) to determine the tetrachlorinated PCB concentration in sediment that corresponds to the acceptable whole body tetrachlorinated PCB tissue concentration.
4. To derive the final PRG, convert the acceptable sediment tetrachlorinated PCB concentration to a sediment total PCB concentration using the regression equation provided in Table A-3.

In order to calculate sediment PRGs for the protection of ecological receptors, the following steps are taken:

1. Convert the acceptable whole body total PCB tissue concentration to an acceptable whole body total tetrachlorinated PCB tissue concentration using the equation derived from a species and tissue specific regression model (see Table A-3).
2. Use linear interpolation (described in Section 2) to determine the tetrachlorinated PCB concentration in sediment that corresponds to the acceptable whole body tetrachlorinated PCB tissue concentration.
3. To derive the final PRG, convert the acceptable sediment tetrachlorinated PCB concentration to a sediment total PCB concentration using the regression equation provided in Table A-3.

The sediment regression is shown in Figure A-3. The species and tissue specific regressions are shown in Figures A-4 through A-12. All regression parameters are summarized in Table A-3.

3.3 DDx

The bioaccumulation model predicts concentrations of total DDx (4,4') in whole body tissue. In order to calculate sediment PRGs for the protection of human health, the following steps are taken:

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1. Convert the acceptable edible 4,4-DDD tissue concentration to an acceptable edible total DDx (4,4') tissue concentration using the equation derived from a species and tissue specific regression model (see Table A-3).
2. Convert the acceptable edible total DDx (4,4') tissue concentration to an acceptable whole body total DDx (4,4') tissue concentration using the appropriate conversion factor (Table A-2).
3. Use linear interpolation (described in section 2) to determine the total DDx (4,4') concentration in sediment that corresponds to the acceptable whole body total DDx (4,4') tissue concentration.

The bioaccumulation model predicts concentrations of total DDx (4,4') in whole body tissue. In order to calculate sediment PRGs for the protection of ecological receptors, the following steps are taken:

1. Convert the acceptable whole body total DDx (2,4' and 4,4') tissue concentration to an acceptable whole body total DDx (4,4') tissue concentration using the equation derived from a species and tissue specific regression model (see Table A-3).
2. Use linear interpolation (described in section 2) to determine the total DDx (4,4') concentration in sediment that corresponds to the acceptable whole body total DDx (4,4') tissue concentration.

The species and tissue specific regressions are shown in Figures A-13 through A-19. All regression parameters are summarized in Table A-3. For human health risk, in addition to the PRG calculation for each individual species, a PRG is calculated by assuming a mixed fish diet, a diet consisting of equal proportions of the five species: American eel, bluefish, striped bass, summer flounder, and white perch. This is the risk assumption that was evaluated in the baseline human health risk assessment (BHHRA; GSH 2019).

4 Results of PRG Calculation

The risk-based sediment PRGs for 2,3,7,8-TCDD, total PCBs, and total DDx (4,4') are presented in detail in Tables A-4 through A-6, respectively, and summarized in Table A-7. Acceptable tissue concentrations for human health PRGs are based on the adult angler consuming fish and crab. They are calculated under two consumption scenarios: reasonable maximum exposure (RME) assumption, which is 56 eight-ounce fish meals or 34 eight-ounce crab meals per year; and an interim assumption of 12 eight-ounce fish or crab meals per year (see Section 3.4.1 of the Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum Feasibility Study for details of these assumptions). PRGs are calculated for each of the five species evaluated in the BHHRA (GSH 2019) separately, as summarized in Tables A-4 through A-6, to provide supplementary information. As the primary human health risk calculations in the BHHRA were based on a mixed fish diet to account for the presence of multiple fish species in Newark Bay that may be consumed by anglers and others who consume the angler's catch (e.g., child receptors) (GSH 2019), PRGs calculated under the assumption of a mixed fish diet (Table A-7) consisting of equal proportions of the five species (American eel, bluefish, striped bass, summer flounder, and white perch), rather than assuming single species diets, will be used to assess protection of human health during remedy selection.

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Table A-7 Sediment PRG Summary

COC	Units	Human Health Sediment PRGs					Ecological Sediment PRGs			
		Receptor Diet	RME Cancer Risk			RME Noncancer Hazard	Receptor	TRVs		
			10^{-6}	10^{-5}	10^{-4}			OU2	Integrated OU2 and OU3/OU4	OU3/OU4
2,3,7,8-TCDD	ng/kg	Blue crab	-11	-5.7	49	6.7	Softshell clam	-9.9	7,900	120,000
		Mixed Fish Fillet	-18	0.35	180	41	Blue crab	-8.6	450	6,900
							Mummichog	4.5	38	1,500
							American eel	15	74	2,700
							Summer flounder	3.8	38	1,600
							White perch	-28	-8.4	880
Total PCBs	µg/kg	Blue crab	<0	<0	1,500	<0	Softshell clam	<0	2,000	18,000
		Mixed Fish Fillet	<0	<0	790	<0	Blue crab	<0	<0	1,200
							Mummichog	25	360	1,100
Total DDx (4,4')	µg/kg	Mixed Fish Fillet	130	2,200	23,000	360	Blue crab	91	130	130
							White perch	-75	-43	-6.9

Notes:
RME = Reasonable Maximum Exposure: 56 8-ounce meals per year for fish or 34 8-ounce meals per year for crab
Mixed Fish Fillet: PRGs are calculated under the assumption that the angler assume equal proportions of five species of fish: bluefish, American eel, striped bass, summer flounder and white perch.
Numbers in red are negative PRGs, see text for discussion.
<0 indicates that the calculated PRG for total Tetrachlorinated PCBs is negative. Therefore, a PRG for total PCBs could not be calculated by the sediment regression equation.

Ecological risk based PRGs are calculated based on the toxicity reference values (TRVs) for whole body concentrations in biota that were used to conduct the BERA (GSH 2020). TRVs used in the risk assessment for OU3 were based on those developed and presented in the ecological risk assessment for the LPRSA (Windward 2019). The set of TRVs developed for OU2 in the LPR FFS (USEPA 2014) were also evaluated in the BERA. PRGs were calculated based on each set of TRVs separately (i.e., OU2 vs. OU3/OU4). In addition, methods were established to integrate the two sets of TRVs to obtain a single value, identified as the "Integrated OU2 and OU3/OU4" value in Tables A-4 through A-7. See Appendix D for a detailed presentation of the TRVs, including effect levels, selected endpoints and calculation methods for integrated TRVs, used to calculate PRGs.

In many cases, the PRG is a negative number. This signifies that even when the sediment is assumed to have zero concentrations of COCs, the tissue is predicted to continue to have unacceptable concentrations of COCs. This occurs due to exposure of the organisms to sources of COCs other than the NBSA sediment such as the water column and offsite exposure during migration. In order to evaluate the effect that ongoing water column contamination has on the PRGs, they were re-calculated assuming that the water column contains 0 concentrations of COCs (Table A-8). These "no water column exposure" PRGs are considerably higher indicating that ongoing water column exposure should be considered in risk management decisions.

Table A-8 Sediment PRG Summary Under the Assumption of No Water Exposure

		Human Health Sediment PRGs					Ecological Sediment PRGs			
			RME Cancer Risk					TRVs		
COC	Units	Receptor Diet	10^{-6}	10^{-5}	10^{-4}	RME Noncancer Risk	Receptor	OU2	Integrated OU2 and OU3/OU4	OU3/ OU4
2,3,7,8-TCDD	ng/kg	Blue Crab	-0.020	6.4	70	21	Softshell clam	--[a]	--[a]	--[a]
		Mixed Fish Fillet	-5.8	16	235	64	Blue crab	3.0	530	8,000
							Mummichog	20	59	1,800
							American eel	35	100	3,200
							Summer flounder	16	56	1,800
							White perch	-15	9.4	1,100
Total PCBs	µg/kg	Blue Crab	<0	157	1,812	184	Softshell clam	--[a]	--[a]	--[a]
		Mixed Fish Fillet	<0	26	1,120	54	Blue crab	6.4	170	1,500
							Mummichog	270	590	1,300
Total DDx (4,4')	µg/kg	Mixed Fish Fillet	209	2,547	25,927	476	Blue crab	160	200	200
							White perch	-34	1.9	43

Notes:
PRGs were calculated under the assumption of 0 concentration in the water column as a sensitivity analysis to determine the contribution to of the water column to ongoing exposure.
RME = Reasonable Maximum Exposure: 56 8-ounce meals per year for fish or 34 8-ounce meals per year for crab
Mixed Fish Fillet: PRGs are calculated under the assumption that the angler assume equal proportions of five species of fish: bluefish, American eel, striped bass, summer flounder and white perch.
[a]Softshell clam tissue are assumed to have 0 concentration of COCs when not exposed to water.
Numbers in red are negative PRGs, see text for discussion.
<0 indicates that the calculated PRG for total Tetrachlorinated PCBs is negative. Therefore, a PRG for total PCBs could not be calculated by the sediment regression equation.

5 Uncertainty

There are several sources of uncertainty related to PRG calculation as follows:

Bioaccumulation Model Calibration: The model is calibrated based on existing data and using CFT output does a reasonable job at predicting the existing data set. However, the model is calibrated in only one point in time and there are many model parameters. There is uncertainty regarding how well the model can predict the future concentrations in tissue based on changing abiotic conditions.

Contaminant Fate and Transport Model: The PRGs are calculated based on conditions that are expected in the future after the remedial actions in OU2 and OU4 have been implemented. This leads to uncertainty in the quantification of concentrations in abiotic media to which risk receptors will be exposed both in the NBSA and during migration into tributaries.

Time Frame of Calculation: The “current conditions” period for PRG calculation occurs during the period two years after remediation has been implemented in OU2 and OU4. If some other time period were selected for PRG

calculation, the PRGs may be different and perhaps higher as the remedy has time to influence sediment and water conditions both in the NBSA and the tributaries.

Uncertainties related to the TRVs selected to calculate PRGs for ecological receptors are described in Appendix D.

6 References

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Tables

Table A-1
Bioaccululation Model Outputs for PRG Calculation
Appendix A: Bioaccumulation Model and PRG Calculation Method
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
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Percent of Current Conditions SWAC	COC	Species/Feeding Guild	Whole Body Concentration (µg/kg)					Sediment Concentration (µg/kg)			
			North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Average	Assume no water exposure*	North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Weighted Average
0	2,3,7,8-TCDD	Phytoplankton	0.0034852	0.0028332	0.0023033	0.0028739	0	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Zooplankton	0.0037358	0.0030780	0.0024610	0.0030916	0	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Benthic invert deposit feeder	0.0056235	0.0047228	0.0037316	0.0046926	0.0003468	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Benthic invert filter feeder	0.0004785	0.0005338	0.0005478	0.0005200	0	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Benthic invert detritivore	0.0110109	0.0096962	0.0075978	0.0094350	0.0000344	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Benthic invert carnivore/omnivore	0.0075146	0.0080379	0.0056933	0.0070820	0.0001088	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Atlantic Silverside	0.0008031	0.0008322	0.0006350	0.0007568	0.0000471	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Small forage fish	0.0009935	0.0011043	0.0008116	0.0009698	0.0000172	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Small American eel	0.0002083	0.0002252	0.0001669	0.0002002	0.0000048	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Blue crab	0.0016658	0.0019181	0.0013833	0.0016557	0.0001194	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Summer Flounder	0.0010194	0.0011118	0.0009665	0.0010326	0.0002408	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	White perch	0.0047557	0.0047775	0.0055766	0.0050366	0.0029421	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Large American eel	0.0006611	0.0006861	0.0005212	0.0006228	0.0000145	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Bluefish	0.0003259	0.0003681	0.0002698	0.0003213	0.0000193	0.0003026	0.0003332	0.0002003	0.0002870
0	2,3,7,8-TCDD	Striped Bass	0.0021269	0.0025316	0.0019368	0.0021984	0.0002761	0.0003026	0.0003332	0.0002003	0.0002870
0	Total Tetrachlorinated PCBs	Phytoplankton	15.328805	14.882568	13.727432	14.646268	0	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Zooplankton	20.578054	19.883883	18.267961	19.576632	0	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Benthic invert deposit feeder	31.287285	29.087436	28.024232	29.466318	1.154054	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Benthic invert filter feeder	5.949299	7.252234	9.064744	7.422092	0	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Benthic invert detritivore	50.390793	49.707500	46.829492	48.975928	0.106666	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Benthic invert carnivore/omnivore	42.292710	48.198682	42.389177	44.293523	0.376066	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Atlantic Silverside	38.684630	41.728352	39.721418	40.044800	4.572018	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Small forage fish	47.503730	59.562336	49.152010	52.072692	0.451426	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Small American eel	24.148065	31.280693	22.666202	26.031653	0.385925	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Blue crab	16.977159	19.725699	17.153821	17.952226	1.272091	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Summer Flounder	18.009542	20.628966	19.712137	19.450215	4.283567	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	White perch	102.563663	100.259060	185.140540	129.321088	85.501463	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Large American eel	40.316263	49.740596	44.049710	44.702190	2.026898	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Bluefish	36.678088	42.352297	35.118104	38.049496	4.961683	0.656103	0.831141	0.753437	0.728723
0	Total Tetrachlorinated PCBs	Striped Bass	148.779038	155.819240	150.290229	151.629503	37.050955	0.656103	0.831141	0.753437	0.728723
0	Total DDx (4,4')	Phytoplankton	14.597167	15.124933	21.823737	17.181946	0	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Zooplankton	28.117229	29.543823	43.036610	33.565887	0	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Benthic invert deposit feeder	27.701130	26.806716	46.240155	33.582667	1.333824	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Benthic invert filter feeder	2.806586	3.565398	8.778356	5.050113	0	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Benthic invert detritivore	45.744266	48.164388	80.681584	58.196746	0.114378	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Benthic invert carnivore/omnivore	39.806441	50.841519	76.980148	55.876036	0.506131	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Atlantic Silverside	36.843421	42.854828	59.846399	46.514883	11.169570	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Small forage fish	41.513883	57.938290	90.076242	63.176139	0.475737	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Small American eel	31.315420	47.874593	62.891431	47.360481	0.899447	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Blue crab	26.275665	33.240812	45.744424	35.086967	6.041851	0.355657	0.502151	0.920816	0.531313

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			North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Average	Assume no water exposure*	North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Weighted Average
0	Total DDx (4,4')	Summer Flounder	29.190346	35.237525	42.952160	35.793344	15.170207	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	White perch	96.105506	99.989291	1086.061478	427.385425	362.677901	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Large American eel	103.603480	154.837149	236.064056	164.834895	10.793199	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Bluefish	47.009653	59.740247	72.149639	59.633180	12.696801	0.355657	0.502151	0.920816	0.531313
0	Total DDx (4,4')	Striped Bass	101.241391	117.526716	147.569269	122.112459	43.291631	0.355657	0.502151	0.920816	0.531313
100	2,3,7,8-TCDD	Phytoplankton	0.0043803	0.0037510	0.0029372	0.0036895	0	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Zooplankton	0.0048660	0.0042518	0.0031944	0.0041040	0	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Benthic invert deposit feeder	0.0961689	0.0676164	0.0498158	0.0712004	0.0638783	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Benthic invert filter feeder	0.0009079	0.0010844	0.0008867	0.0009596	0	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Benthic invert detritivore	0.0275587	0.0242961	0.0160942	0.0226497	0.0063113	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Benthic invert carnivore/omnivore	0.0494308	0.0287010	0.0209601	0.0330306	0.0211109	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Atlantic Silverside	0.0044105	0.0024599	0.0018588	0.0029098	0.0017823	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Small forage fish	0.0078150	0.0045578	0.0036032	0.0053253	0.0037280	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Small American eel	0.0016575	0.0008835	0.0006614	0.0010675	0.0007396	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Blue crab	0.0144828	0.0076952	0.0057729	0.0093170	0.0067090	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Summer Flounder	0.0068362	0.0047996	0.0041326	0.0052561	0.0039450	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	White perch	0.0167918	0.0107555	0.0096158	0.0123877	0.0088402	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Large American eel	0.0047097	0.0026396	0.0020081	0.0031191	0.0021130	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Bluefish	0.0024740	0.0013607	0.0010065	0.0016138	0.0011095	0.0708721	0.0489554	0.0358922	0.0563660
100	2,3,7,8-TCDD	Striped Bass	0.0163658	0.0095365	0.0076633	0.0111885	0.0079631	0.0708721	0.0489554	0.0358922	0.0563660
100	Total Tetrachlorinated PCBs	Phytoplankton	18.053427	17.902341	15.895646	17.283805	0	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Zooplankton	24.191745	23.871337	21.070128	23.044403	0	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Benthic invert deposit feeder	172.164672	156.298194	219.029679	182.497515	148.596041	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Benthic invert filter feeder	7.432344	9.201232	10.632697	9.088758	0	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Benthic invert detritivore	73.178374	73.038011	71.567959	72.594781	13.691097	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Benthic invert carnivore/omnivore	113.059585	90.036978	106.011203	103.035922	50.289852	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Atlantic Silverside	77.663137	65.701583	72.626978	71.997232	30.109698	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Small forage fish	139.593226	118.050606	140.066405	132.570079	70.666101	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Small American eel	60.986288	55.888756	53.197249	56.690764	26.266750	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Blue crab	47.371861	37.346948	43.171200	42.630003	22.775460	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Summer Flounder	39.754849	38.579210	42.436191	40.256750	22.258398	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	White perch	172.012589	150.367068	236.643667	186.341108	133.900091	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Large American eel	96.241816	87.823270	100.759366	94.941484	44.325846	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Bluefish	82.340216	75.727016	74.225767	77.431000	38.118275	86.010066	78.445137	117.777548	91.415386
100	Total Tetrachlorinated PCBs	Striped Bass	311.330851	292.622797	304.716430	302.890026	166.796719	86.010066	78.445137	117.777548	91.415386
100	Total DDx (4,4')	Phytoplankton	16.267513	17.014442	23.817728	19.033228	0	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Zooplankton	31.303678	33.181153	46.886240	37.123690	0	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Benthic invert deposit feeder	79.762472	84.391272	299.731058	154.628267	118.461887	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Benthic invert filter feeder	3.238592	4.139870	9.754920	5.711127	0	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Benthic invert detritivore	55.959148	60.023529	110.341189	75.441289	10.076749	21.874208	24.979703	110.355575	43.766806

Table A-1
Bioaccululation Model Outputs for PRG Calculation
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Percent of Current Conditions SWAC	COC	Species/Feeding Guild	Whole Body Concentration (µg/kg)					Sediment Concentration (µg/kg)			
			North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Average	Assume no water exposure[a]	North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Weighted Average
100	Total DDx (4,4')	Benthic invert carnivore/omnivore	72.577894	73.868862	173.243088	106.563281	44.324990	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Atlantic Silverside	49.740160	52.039875	94.564368	65.448135	26.741836	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Small forage fish	72.278692	81.784005	202.747138	118.936612	49.758188	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Small American eel	54.734522	66.112489	132.124388	84.323799	33.504126	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Blue crab	43.270635	44.938480	93.320268	60.509794	28.485281	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Summer Flounder	39.993352	44.559443	72.226861	52.259885	29.576152	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	White perch	142.048453	135.455200	1191.145861	489.549838	417.394965	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Large American eel	166.767258	208.229109	475.681550	283.559306	115.072215	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Bluefish	70.246782	77.965080	133.135106	93.782323	42.321580	21.874208	24.979703	110.355575	43.766806
100	Total DDx (4,4')	Striped Bass	143.944478	150.593721	256.956273	183.831491	97.251387	21.874208	24.979703	110.355575	43.766806
10	2,3,7,8-TCDD	Phytoplankton	0.0036275	0.0029683	0.0024014	0.0029991	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Zooplankton	0.0039161	0.0032449	0.0025731	0.0032447	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Benthic invert deposit feeder	0.0136338	0.0089765	0.0131591	0.0119231	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Benthic invert filter feeder	0.0005497	0.0006031	0.0005946	0.0005825	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Benthic invert detritivore	0.0130560	0.0111646	0.0091159	0.0111122	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Benthic invert carnivore/omnivore	0.0115592	0.0098087	0.0087279	0.0100320	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Atlantic Silverside	0.0011425	0.0009720	0.0008716	0.0009953	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Small forage fish	0.0015977	0.0013629	0.0012422	0.0014009	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Small American eel	0.0003410	0.0002776	0.0002620	0.0002935	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Blue crab	0.0028672	0.0023959	0.0022420	0.0025017	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Summer Flounder	0.0015911	0.0014477	0.0014776	0.0015055	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	White perch	0.0059228	0.0053390	0.0063492	0.0058703	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Large American eel	0.0010319	0.0008400	0.0007976	0.0008898	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Bluefish	0.0005233	0.0004487	0.0004048	0.0004589	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	2,3,7,8-TCDD	Striped Bass	0.0034496	0.0031328	0.0029196	0.0031673	--[b]	0.0062754	0.0034337	0.0075470	0.0057737
10	Total Tetrachlorinated PCBs	Phytoplankton	15.829944	15.379773	14.061946	15.090554	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Zooplankton	21.238520	20.529491	18.695899	20.154637	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Benthic invert deposit feeder	47.383696	40.813872	45.438019	44.545196	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Benthic invert filter feeder	6.235218	7.543435	9.271360	7.683338	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Benthic invert detritivore	53.776313	52.538185	49.459120	51.924540	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Benthic invert carnivore/omnivore	51.041503	52.754299	48.688333	50.828045	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Atlantic Silverside	43.388060	44.400782	43.034112	43.607651	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Small forage fish	57.185087	64.526979	55.962224	59.224763	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Small American eel	28.420588	33.726126	25.381426	29.176047	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Blue crab	20.612988	21.563850	19.657645	20.611494	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Summer Flounder	20.552455	22.534274	22.004623	21.697117	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	White perch	110.890161	106.014617	189.802750	135.569176	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Large American eel	46.648356	53.410064	48.886672	49.648364	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Bluefish	41.757083	45.680781	38.697265	42.045043	--[b]	9.966976	7.647182	11.120026	9.584759
10	Total Tetrachlorinated PCBs	Striped Bass	166.289009	169.825356	165.529017	167.214461	--[b]	9.966976	7.647182	11.120026	9.584759

Table A-1
Bioaccululation Model Outputs for PRG Calculation
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Percent of Current Conditions SWAC[a]	COC	Species/Feeding Guild	Whole Body Concentration (µg/kg)					Sediment Concentration (µg/kg)			
			North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Average	Assume no water exposure[b]	North Assessment Zone	Southeast Assessment Zone	Southwest Assessment Zone	NBSA Weighted Average
10	Total DDx (4,4')	Phytoplankton	14.988176	15.517639	22.052088	17.519301	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Zooplankton	28.865264	30.297444	43.467377	34.210028	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Benthic invert deposit feeder	42.624794	35.205992	50.079615	42.636800	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Benthic invert filter feeder	2.915274	3.683540	8.843119	5.147311	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Benthic invert detritivore	48.423541	50.285036	81.655511	60.121363	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Benthic invert carnivore/omnivore	49.107068	54.586692	78.890269	60.861343	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Atlantic Silverside	40.382327	44.359089	60.676750	48.472722	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Small forage fish	49.572354	61.575226	91.211867	67.453149	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Small American eel	37.809476	50.683742	63.985682	50.826300	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Blue crab	30.958909	35.071016	46.661910	37.563945	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Summer Flounder	31.738160	36.607511	43.824056	37.389909	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	White perch	108.653458	107.562836	1087.918814	434.711702	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Large American eel	120.699538	163.022042	239.523080	174.414887	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Bluefish	52.913618	62.445396	73.368209	62.909074	--[b]	6.567818	3.963366	2.420487	4.846255
10	Total DDx (4,4')	Striped Bass	111.349104	122.220069	150.335604	127.968259	--[b]	6.567818	3.963366	2.420487	4.846255

Notes

[a]Input for the bioaccumulation model was prepared by the CFT model under three scenarios. "Current Conditions" is is established as the two year period after ompletion of the remedial actions in the LPRSA and the output is identified as 100 percent of the SWAC. The CFT model and bioaccumulation model were also run under the assumption that all sediment is reduced to 0 percent of the current condsitions SWAC and 10 percent of the current SWAC.

[b]Predicted concentrations in biota under the assumption of 0 concentration in the water column. This scenario was modeled to determine the effect that ongoing water column contamination has on the PRG calculations. Not calculated for the 10 percent SWAC scenario.

Assessment zones are depicted on Figure A-1.

Acronyms and Abbreviations:

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
CFT = contaminant fate and transport
COC = chemical of concern
NBSA = Newark Bay Study Area
PCBs = polychlorinated biphenyls
PRG = preliminary remedial goal
SWAC = surface weighted average concentration
Total DDx (4,4') = sum of three 4,4' isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane
µg/kg = micrograms per kilogram

Table A-3
Regression Parameters used in Calculation of PRGs
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COC	Units	Matrix/Tissue Type	Species	Model	Model Parameter Values	
					α	β
PCBs	ng/kg	Sediment	--	$\log_e [C_{TPCB}] = \alpha + \beta \log_e [C_{TetraPCB}]$	3.0586	0.8460
PCBs	ng/kg	Edible Tissue	Blue crab	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-4.1501	1.2086
PCBs	ng/kg	Fillet (Edible)	American eel	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-2.9043	1.0895
PCBs	ng/kg	Fillet (Edible)	Bluefish	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-6.1282	1.3609
PCBs	ng/kg	Fillet (Edible)	Striped bass	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-5.5150	1.2978
PCBs	ng/kg	Fillet (Edible)	Summer flounder	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-0.3590	0.9126
PCBs	ng/kg	Fillet (Edible)	White perch	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-1.8686	1.0577
PCBs	ng/kg	Whole body	Softshell Clam	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-1.3193	1.0234
PCBs	ng/kg	Whole body	Blue crab	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-3.5872	1.1679
PCBs	ng/kg	Whole body	*Fundulus spp.*	$\log_e [C_{TetraPCB}] = \alpha + \beta \log_e [C_{TPCB}]$	-6.2456	1.3611
DDx	ng/kg	Fillet (Edible)	American eel	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{44DDD}]$	2.0944	0.9208
DDx	ng/kg	Fillet (Edible)	Bluefish	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{44DDD}]$	3.5298	0.7741
DDx	ng/kg	Fillet (Edible)	Striped bass	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{44DDD}]$	2.7715	0.8457
DDx	ng/kg	Fillet (Edible)	Summer flounder	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{44DDD}]$	1.6188	0.9660
DDx	ng/kg	Fillet (Edible)	White perch	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{44DDD}]$	3.8070	0.7390
DDx	ng/kg	Whole body	White perch	$\log_e [C_{T44DDx}] = \alpha + \beta \log_e [C_{T2444DDx}]$	0.6892	0.9308

Notes:
Blue crab edible tissue consists of muscle and hepatopancreas.
Fundulus spp. includes mummichog and striped killifish.
$\log_e$ = natural logarithm
α = intercept parameter
β = slope parameter
-- = not applicable
C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$C_{T2444DDx}$ = concentration of total DDx (2,4' and 4,4')
C_{TPCB} = Concentration of total PCBs
$C_{TetraPCB}$ = Concentration of total tetrachlorinated PCBs

Acronyms and Abbreviations:
4,4'-DDD = 4,4'-dichlorodiphenyldichloroethane
COC = chemical of concern
PCBs = polychlorinated biphenyls
PRG = preliminary remedial goal
ng/kg = nanograms per kilogram
Total DDx (4,4') = sum of three 4,4' isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane
Total DDx (2,4' and 4,4') = sum of six isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane

Table A-4
Sediment PRGs for 2,3,7,8-TCDD
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Risk Type	Species	Acceptable Edible Tissue Concentration (ng/kg)	Acceptable Whole Body Tissue Concentration (ng/kg)	Calculated Sediment PRG (ng/kg)	Basis
Human Health	Blue Crab	2.7	2.5	6.7	RME: Noncancer Risk
	Blue Crab	8.9	8.3	49	RME: 10^{-4} Cancer Risk
	Blue Crab	0.89	0.83	-5.73	RME: 10^{-5} Cancer Risk
	Blue Crab	0.089	0.083	-11.2	RME: 10^{-6} Cancer Risk
Human Health	Blue Crab	7.5	7.0	39.6	Interim: Noncancer Risk
	Blue Crab	25	23	160	Interim: 10-4 Cancer Risk
	Blue Crab	2.5	2.3	5.32	Interim: 10-5 Cancer Risk
	Blue Crab	0.25	0.23	-10.1	Interim: 10-6 Cancer Risk
Human Health	Bluefish	1.6	5.9	244	RME: Noncancer Risk
	American eel	1.6	2.6	45.8	RME: Noncancer Risk
	Striped Bass	1.6	5.9	23.6	RME: Noncancer Risk
	Summer Flounder	1.6	5.9	65.4	RME: Noncancer Risk
	White perch	1.6	5.9	7.15	RME: Noncancer Risk
	Mixed Fish Fillet	1.6	--[a]	40.5	RME: Noncancer Risk
Human Health	Bluefish	5.4	20	856	RME: 10^{-4} Cancer Risk
	American eel	5.4	8.9	187	RME: 10^{-4} Cancer Risk
	Striped Bass	5.4	20	112	RME: 10^{-4} Cancer Risk
	Summer Flounder	5.4	20	253	RME: 10^{-4} Cancer Risk
	White perch	5.4	20	115	RME: 10^{-4} Cancer Risk
	Mixed Fish Fillet	5.4	--[a]	184	RME: 10^{-4} Cancer Risk
Human Health	Bluefish	0.54	2.0	73.3	RME: 10^{-5} Cancer Risk
	American eel	0.54	0.89	6.36	RME: 10^{-5} Cancer Risk
	Striped Bass	0.54	2.0	-0.93	RME: 10^{-5} Cancer Risk
	Summer Flounder	0.54	2.0	13.2	RME: 10^{-5} Cancer Risk
	White perch	0.54	2.0	-22.9	RME: 10^{-5} Cancer Risk
	Mixed Fish Fillet	0.54	--[a]	0.35	RME: 10^{-5} Cancer Risk
Human Health	Bluefish	0.054	0.20	-4.96	RME: 10^{-6} Cancer Risk
	American eel	0.054	0.09	-11.7	RME: 10^{-6} Cancer Risk
	Striped Bass	0.054	0.20	-12.2	RME: 10^{-6} Cancer Risk
	Summer Flounder	0.054	0.20	-10.8	RME: 10^{-6} Cancer Risk
	White perch	0.054	0.20	-36.6	RME: 10^{-6} Cancer Risk
	Mixed Fish Fillet	0.054	--[a]	-18.1	RME: 10^{-6} Cancer Risk
Human Health	Bluefish	7.5	28	1,194	Interim: Noncancer Risk
	American eel	7.5	12	265	Interim: Noncancer Risk
	Striped Bass	7.5	28	160	Interim: Noncancer Risk
	Summer Flounder	7.5	28	356	Interim: Noncancer Risk
	White perch	7.5	28	174	Interim: Noncancer Risk
	Mixed Fish Fillet	7.5	--[a]	264	Interim: Noncancer Risk
Human Health	Bluefish	25	93	4,010	Interim: 10-4 Cancer Risk
	American eel	25	41	915	Interim: 10-4 Cancer Risk
	Striped Bass	25	93	565	Interim: 10-4 Cancer Risk
	Summer Flounder	25	93	1,218	Interim: 10-4 Cancer Risk
	White perch	25	93	669	Interim: 10-4 Cancer Risk
	Mixed Fish Fillet	25	--[a]	927	Interim: 10-4 Cancer Risk
Human Health	Bluefish	2.5	9.3	389	Interim: 10-5 Cancer Risk
	American eel	2.5	4.1	79.2	Interim: 10-5 Cancer Risk
	Striped Bass	2.5	9.3	44.4	Interim: 10-5 Cancer Risk
	Summer Flounder	2.5	9.3	110	Interim: 10-5 Cancer Risk
	White perch	2.5	9.3	32.6	Interim: 10-5 Cancer Risk
	Mixed Fish Fillet	2.5	--[a]	74.6	Interim: 10-5 Cancer Risk

Table A-4
Sediment PRGs for 2,3,7,8-TCDD
Appendix A: Bioaccumulation Model and PRG Calculation Method
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Risk Type	Species	Acceptable Edible Tissue Concentration (ng/kg)	Acceptable Whole Body Tissue Concentration (ng/kg)	Calculated Sediment PRG (ng/kg)	Basis
Human Health	Bluefish	0.25	0.93	26.6	Interim: 10-6 Cancer Risk
	American eel	0.25	0.41	-4.4	Interim: 10-6 Cancer Risk
	Striped Bass	0.25	0.93	-7.6	Interim: 10-6 Cancer Risk
	Summer Flounder	0.25	0.93	-1.1	Interim: 10-6 Cancer Risk
	White perch	0.25	0.93	-31.1	Interim: 10-6 Cancer Risk
	Mixed Fish Fillet	0.25	--[a]	-10.6	Interim: 10-6 Cancer Risk
Ecological Risk	Softshell Clam	--[b]	0.44	-9.9	OU2
	Softshell Clam	--[b]	62	7,900	Integrated OU2 and OU3/OU4
	Softshell Clam	--[b]	949	120,000	OU3/OU4
Ecological Risk	Blue Crab	--[b]	0.44	-8.6	OU2 FFS
	Blue Crab	--[b]	62	445	Integrated OU2 and OU3/OU4
	Blue Crab	--[b]	949	6,900	OU3/OU4
Ecological Risk	*Fundulus spp.*	--[b]	1.3	4.5	OU2 FFS
	Fundulus spp.	--[b]	3.9	38	Integrated OU2 and OU3/OU4
	Fundulus spp.	--[b]	120	1,500	OU3/OU4
Ecological Risk	American eel	--[b]	1.3	15	OU2 FFS
	American eel	--[b]	3.9	74	Integrated OU2 and OU3/OU4
	American eel	--[b]	120	2,700	OU3/OU4
	Summer Flounder	--[b]	1.3	3.8	OU2 FFS
Ecological Risk	Summer Flounder	--[b]	3.9	38	Integrated OU2 and OU3/OU4
	Summer Flounder	--[b]	120	1,600	OU3/OU4
	White perch	--[b]	1.3	-28	OU2 FFS
	White perch	--[b]	3.9	-8.4	Integrated OU2 and OU3/OU4
	White perch	--[b]	120	877	OU3/OU4

Notes:
Human health risk is due to consumption of fish or crab. Acceptable tissue concentrations shown are for an adult angler as described in Section 3.4.1 of the RAO-PRG Technical Memorandum.
RME: 56 8-ounce meals per year for fish or 34 8-ounce meals per year for crab
Interim: 12 8-ounce meals per year of fish or crab. PRGs for this scenario were set as interim remedial milestones for OU2 (USEPA 2016).
Mixed Fish Fillet: PRGs are calculated under the assumption that the angler assume equal proportions of five species of fish: bluefish, American eel, striped bass, summer flounder and white perch.
The development of acceptable tissue concentrations for ecological receptors are detailed in Appendix D.
Numbers in red are negative PRGs, see text for discussion.
--[a] not applicable. Interpolation values were converted to fillet concentrations. See the calculation workbook in Appendix F.
--[b] not applicable. Ecological risk is based on whole body concentrations.

Acronyms and Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
FFS = Focused Feasibility Study
ng/kg = nanograms per kilogram
OU = operable unit
PRG = preliminary remedial goal
RME = Reasonable Maximum Exposure
USEPA = United States Environmental Protection Agency

References:
USEPA. 2016. Record of Decision. Lower 8.3 Miles of the Lower Passaic River Part of the Diamond Alkali Superfund Site Essex and Hudson Counties, New Jersey. March 3.

Table A-5
Sediment PRGs for Total PCBs
Appendix A: Bioaccumulation Model and PRG Calculation Method
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

Risk Type	Species	Tissue Type	Acceptable Tissue Concentration Total PCBs (µg/kg)	Calculated Sediment PRG Total PCBs (µg/kg)	Basis
Human Health	Blue Crab	Edible	77	<0	RME: Noncancer Risk
	Blue Crab	Edible	670	1,469	RME: 10^{-4} Cancer Risk
	Blue Crab	Edible	67	<0	RME: 10^{-5} Cancer Risk
	Blue Crab	Edible	6.7	<0	RME: 10^{-6} Cancer Risk
Human Health	Blue Crab	Edible	214	309	Interim: Noncancer Risk
	Blue Crab	Edible	1,880	4,533	Interim: 10-4 Cancer Risk
	Blue Crab	Edible	188	240	Interim: 10-5 Cancer Risk
	Blue Crab	Edible	18.8	<0	Interim: 10-6 Cancer Risk
Human Health	Bluefish	Edible	46	<0	RME: Noncancer Risk
	American eel	Edible	46	<0	RME: Noncancer Risk
	Striped Bass	Edible	46	<0	RME: Noncancer Risk
	Summer Flounder	Edible	46	419	RME: Noncancer Risk
	White perch	Edible	46	<0	RME: Noncancer Risk
	Mixed Fish Fillet	Edible	46	<0	RME: Noncancer Risk
Human Health	Bluefish	Edible	400	1,867	RME: 10^{-4} Cancer Risk
	American eel	Edible	400	444	RME: 10^{-4} Cancer Risk
	Striped Bass	Edible	400	289	RME: 10^{-4} Cancer Risk
	Summer Flounder	Edible	400	3,327	RME: 10^{-4} Cancer Risk
	White perch	Edible	400	1,557	RME: 10^{-4} Cancer Risk
	Mixed Fish Fillet	Edible	400	790	RME: 10^{-4} Cancer Risk
Human Health	Bluefish	Edible	40	<0	RME: 10^{-5} Cancer Risk
	American eel	Edible	40	<0	RME: 10^{-5} Cancer Risk
	Striped Bass	Edible	40	<0	RME: 10^{-5} Cancer Risk
	Summer Flounder	Edible	40	346	RME: 10^{-5} Cancer Risk
	White perch	Edible	40	<0	RME: 10^{-5} Cancer Risk
	Mixed Fish Fillet	Edible	40	<0	RME: 10^{-5} Cancer Risk
Human Health	Bluefish	Edible	4	<0	RME: 10^{-6} Cancer Risk
	American eel	Edible	4	<0	RME: 10^{-6} Cancer Risk
	Striped Bass	Edible	4	<0	RME: 10^{-6} Cancer Risk
	Summer Flounder	Edible	4	<0	RME: 10^{-6} Cancer Risk
	White perch	Edible	4	<0	RME: 10^{-6} Cancer Risk
	Mixed Fish Fillet	Edible	4	<0	RME: 10^{-6} Cancer Risk
Human Health	Bluefish	Edible	214	778	Interim: Noncancer Risk
	American eel	Edible	214	112	Interim: Noncancer Risk
	Striped Bass	Edible	214	<0	Interim: Noncancer Risk
	Summer Flounder	Edible	214	1,971	Interim: Noncancer Risk
	White perch	Edible	214	624	Interim: Noncancer Risk
	Mixed Fish Fillet	Edible	214	320	Interim: Noncancer Risk
Human Health	Bluefish	Edible	1,880	12,112	Interim: 10-4 Cancer Risk
	American eel	Edible	1,880	2,623	Interim: 10-4 Cancer Risk
	Striped Bass	Edible	1,880	2,862	Interim: 10-4 Cancer Risk
	Summer Flounder	Edible	1,880	11,415	Interim: 10-4 Cancer Risk
	White perch	Edible	1,880	7,731	Interim: 10-4 Cancer Risk
	Mixed Fish Fillet	Edible	1,880	3,710	Interim: 10-4 Cancer Risk

Table A-5
Sediment PRGs for Total PCBs
Appendix A: Bioaccumulation Model and PRG Calculation Method
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Risk Type	Species	Tissue Type	Acceptable Tissue Concentration Total PCBs (µg/kg)	Calculated Sediment PRG Total PCBs (µg/kg)	Basis
Human Health	Bluefish	Edible	188	632	Interim: 10-5 Cancer Risk
	American eel	Edible	188	57	Interim: 10-5 Cancer Risk
	Striped Bass	Edible	188	<0	Interim: 10-5 Cancer Risk
	Summer Flounder	Edible	188	1,762	Interim: 10-5 Cancer Risk
	White perch	Edible	188	480	Interim: 10-5 Cancer Risk
	Mixed Fish Fillet	Edible	188	246	Interim: 10-5 Cancer Risk
Human Health	Bluefish	Edible	18.8	<0	Interim: 10-6 Cancer Risk
	American eel	Edible	18.8	<0	Interim: 10-6 Cancer Risk
	Striped Bass	Edible	18.8	<0	Interim: 10-6 Cancer Risk
	Summer Flounder	Edible	18.8	<0	Interim: 10-6 Cancer Risk
	White perch	Edible	18.8	<0	Interim: 10-6 Cancer Risk
	Mixed Fish Fillet	Edible	18.8	<0	Interim: 10-6 Cancer Risk
Ecological Risk	Softshell Clam	Whole Body	10	<0	OU2
	Softshell Clam	Whole Body	61	1,978	Integrated OU2 and OU3/OU4
	Softshell Clam	Whole Body	520	17,623	OU3/OU4
Ecological Risk	Blue Crab	Whole Body	10	<0	OU2 FFS
	Blue Crab	Whole Body	61	<0	Integrated OU2 and OU3/OU4
	Blue Crab	Whole Body	520	1,209	OU3/OU4
Ecological Risk	*Fundulus spp.*	Whole Body	300	25	OU2 FFS
	Fundulus spp.	Whole Body	590	357	Integrated OU2 and OU3/OU4
	Fundulus spp.	Whole Body	1,200	1,051	OU3/OU4

Notes:
Human health risk is due to consumption of fish or crab. Acceptable tissue concentrations shown are for an adult angler as described in section 3.4.1 of the RAO-PRG Technical Memorandum.
RME: 56 8-ounce meals per year for fish or 34 8-ounce meals per year for crab
Interim: 12 8-ounce meals per year of fish or crab. PRGs for this scenario were set as interim remedial milestones for OU2 (USEPA 2016).
Mixed Fish Fillet: PRGs are calculated under the assumption that the angler assume equal proportions of five species of fish: bluefish, American eel, striped bass, summer flounder and white perch.
The development of acceptable tissue concentrations for ecological receptors are detailed in Appendix D.
<0 indicates that the calculated PRG for total Tetrachlorinated PCBs is negative. Therefore, a PRG for total PCBs could not be calculated by the sediment regression equation.
--[a] not applicable. Interpolation values were converted to fillet concentrations. See the calculation workbook in Appendix F.
--[b] not applicable. Ecological risk is based on whole body concentrations.

Acronyms and Abbreviations:
Alt = Alternative Consumption Rate
OU = operable unit
PCBs = polychlorinated biphenyls
PRG = preliminary remedial goal
RME = Reasonable Maximum Exposure
USEPA = United States Environmental Protection Agency
µg/kg = micrograms per kilogram

References:
USEPA. 2016. Record of Decision. Lower 8.3 Miles of the Lower Passaic River Part of the Diamond Alkali Superfund Site Essex and Hudson Counties, New Jersey. March 3.

Table A-6
Sediment PRGs for Total DDx (4,4')
Appendix A: Bioaccumulation Model and PRG Calculation Method
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

Risk Type	Species	Acceptable Edible Tissue Concentration 4,4' DDD (µg/kg)	Acceptable Whole Body Tissue Concentration Total 2,4' and 4,4' DDx (µg/kg)	Acceptable Whole Body Tissue Concentration Total 4,4' DDx (µg/kg)	Calculated Sediment PRG Total 4,4' DDx (µg/kg)	Basis
Human Health	Bluefish	69	--[a]	705	817	RME: Noncancer Risk
	American eel	69	--[a]	384	80	RME: Noncancer Risk
	Striped Bass	69	--[a]	733	429	RME: Noncancer Risk
	Summer Flounder	69	--[a]	884	2,228	RME: Noncancer Risk
	White perch	69	--[a]	629	141	RME: Noncancer Risk
	Mixed Fish Fillet	69	--[a]	254	363	RME: Noncancer Risk
Human Health	Bluefish	3,400	--[a]	14,394	18,149	RME: 10^{-4} Cancer Risk
	American eel	3,400	--[a]	13,889	4,999	RME: 10^{-4} Cancer Risk
	Striped Bass	3,400	--[a]	19,809	13,791	RME: 10^{-4} Cancer Risk
	Summer Flounder	3,400	--[a]	38,148	100,071	RME: 10^{-4} Cancer Risk
	White perch	3,400	--[a]	11,204	7,496	RME: 10^{-4} Cancer Risk
	Mixed Fish Fillet	3,400	--[a]	12,522	22,685	RME: 10^{-4} Cancer Risk
Human Health	Bluefish	340	--[a]	2,422	2,991	RME: 10^{-5} Cancer Risk
	American eel	340	--[a]	1,667	547	RME: 10^{-5} Cancer Risk
	Striped Bass	340	--[a]	2,826	1,894	RME: 10^{-5} Cancer Risk
	Summer Flounder	340	--[a]	4,126	10,740	RME: 10^{-5} Cancer Risk
	White perch	340	--[a]	2,044	1,125	RME: 10^{-5} Cancer Risk
	Mixed Fish Fillet	340	--[a]	1,252	2,179	RME: 10^{-5} Cancer Risk
Human Health	Bluefish	34	--[a]	407	441	RME: 10^{-6} Cancer Risk
	American eel	34	--[a]	200	13	RME: 10^{-6} Cancer Risk
	Striped Bass	34	--[a]	403	197	RME: 10^{-6} Cancer Risk
	Summer Flounder	34	--[a]	446	1,078	RME: 10^{-6} Cancer Risk
	White perch	34	--[a]	373	-37	RME: 10^{-6} Cancer Risk
	Mixed Fish Fillet	34	--[a]	125	129	RME: 10^{-6} Cancer Risk
Human Health	Bluefish	322	--[a]	2,322	2,865	Interim: Noncancer Risk
	American eel	322	--[a]	1,585	518	Interim: Noncancer Risk
	Striped Bass	322	--[a]	2,699	1,805	Interim: Noncancer Risk
	Summer Flounder	322	--[a]	3,915	10,185	Interim: Noncancer Risk
	White perch	322	--[a]	1,963	1,069	Interim: Noncancer Risk
	Mixed Fish Fillet	322	--[a]	1,186	2,059	Interim: Noncancer Risk
Human Health	Bluefish	15,867	--[a]	47,429	59,974	Interim: 10-4 Cancer Risk
	American eel	15,867	--[a]	57,376	20,835	Interim: 10-4 Cancer Risk
	Striped Bass	15,867	--[a]	72,887	50,974	Interim: 10-4 Cancer Risk
	Summer Flounder	15,867	--[a]	168,929	443,457	Interim: 10-4 Cancer Risk
	White perch	15,867	--[a]	34,975	24,029	Interim: 10-4 Cancer Risk
	Mixed Fish Fillet	15,867	--[a]	58,434	106,227	Interim: 10-4 Cancer Risk
Human Health	Bluefish	1,587	--[a]	7,979	10,027	Interim: 10-5 Cancer Risk
	American eel	1,587	--[a]	6,885	2,448	Interim: 10-5 Cancer Risk
	Striped Bass	1,587	--[a]	10,397	7,199	Interim: 10-5 Cancer Risk
	Summer Flounder	1,587	--[a]	18,271	47,879	Interim: 10-5 Cancer Risk
	White perch	1,587	--[a]	6,379	4,140	Interim: 10-5 Cancer Risk
	Mixed Fish Fillet	1,587	--[a]	5,843	10,534	Interim: 10-5 Cancer Risk
Human Health	Bluefish	159	--[a]	1,342	1,625	Interim: 10-6 Cancer Risk
	American eel	159	--[a]	826	241	Interim: 10-6 Cancer Risk
	Striped Bass	159	--[a]	1,483	954	Interim: 10-6 Cancer Risk
	Summer Flounder	159	--[a]	1,976	5,095	Interim: 10-6 Cancer Risk
	White perch	159	--[a]	1,164	513	Interim: 10-6 Cancer Risk
	Mixed Fish Fillet	159	--[a]	584	964	Interim: 10-6 Cancer Risk
Ecological Risk	Blue crab	--[b]	88	88	90.5	OU2 FFS
	Blue crab	--[b]	110	110	128	OU3/OU4[c]
Ecological Risk	White perch	--[b]	390	319	-34.1	OU2 FFS
	White perch	--[b]	450	364	-43.2	Integrated OU2 and OU3/OU4
	White perch	--[b]	520	417	-6.91	OU3/OU4

Notes:

Human health risk is due to consumption of fish or crab. Acceptable tissue concentrations shown are for an adult angler as described in section 3.4.1 of the RAO-PRG Technical Memorandum.

RME: 56 8-ounce meals per year for fish or 34 8-ounce meals per year for crab

Interim: 12 8-ounce meals per year of fish or crab. PRGs for this scenario were set as interim remedial milestones for OU2 (USEPA 2016).

Mixed Fish Fillet: PRGs are calculated under the assumption that the angler assume equal proportions of five species of fish: bluefish, American eel, striped bass, summer flounder and white perch.

The development of acceptable tissue concentrations for ecological receptors are detailed in Appendix D.

Numbers in red are negative PRGs, see text for discussion.

--[a] not applicable for human health risk.

--[b] not applicable for ecological risk.

[c]The OU3/OU4 TRVs were based on a species sensitivity distribution that included the OU2 TRV. Therefore no further integration of the TRVs was applied. (See Appendix D).

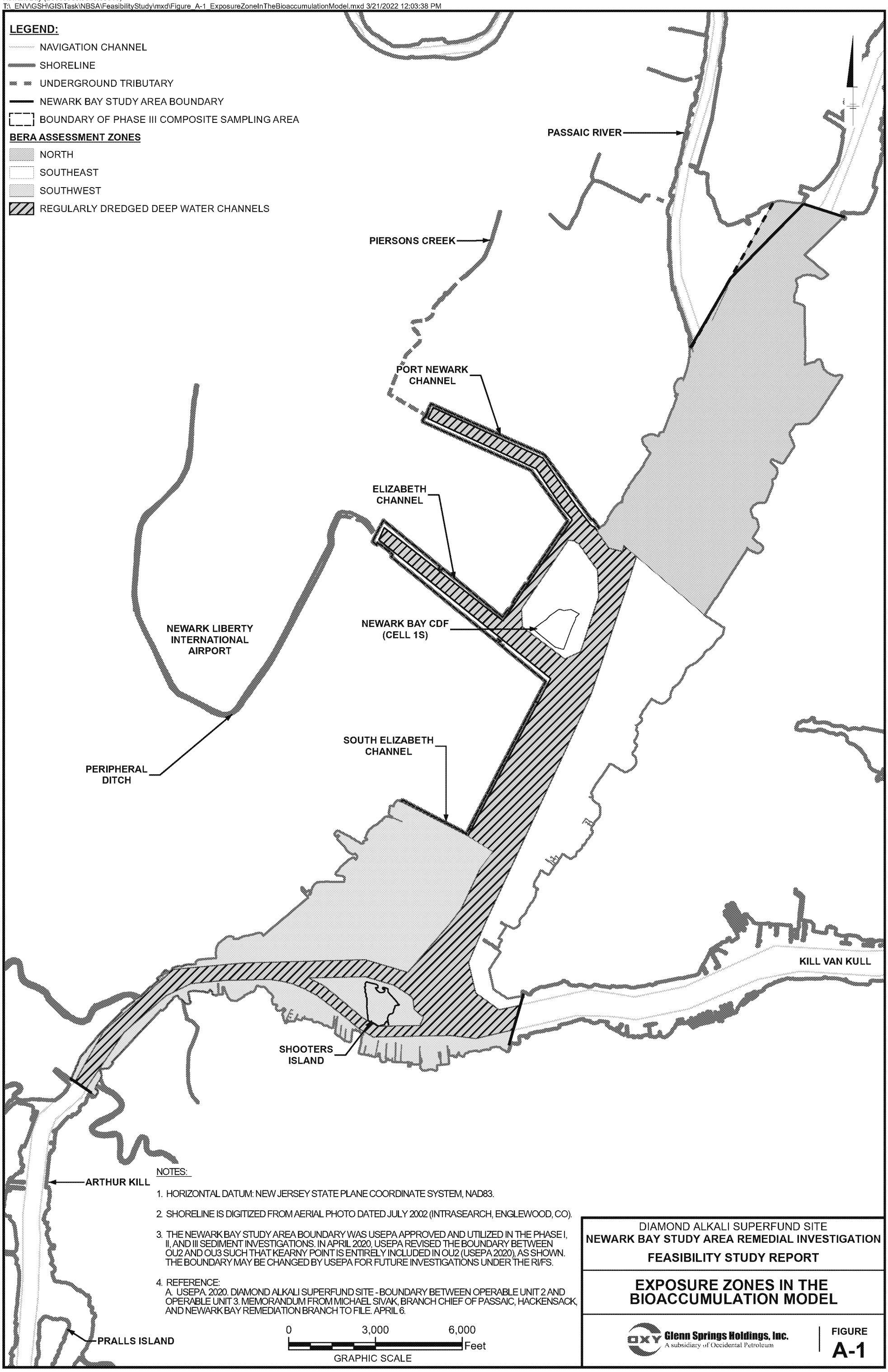
Acronyms and Abbreviations:

Alt = Alternative Consumption Rate
OU = operable unit
PRG = preliminary remedial goal
RME = Reasonable Maximum Exposure
Total 4,4'-DDx = sum of three 4,4' isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane
TRVs = toxicity reference values
USEPA = United States Environmental Protection Agency
µg/kg = micrograms per kilogram

References:

USEPA. 2016. Record of Decision. Lower 8.3 Miles of the Lower Passaic River Part of the Diamond Alkali Superfund Site Essex and Hudson Counties, New Jersey. March 3.

Figures



NOTES:

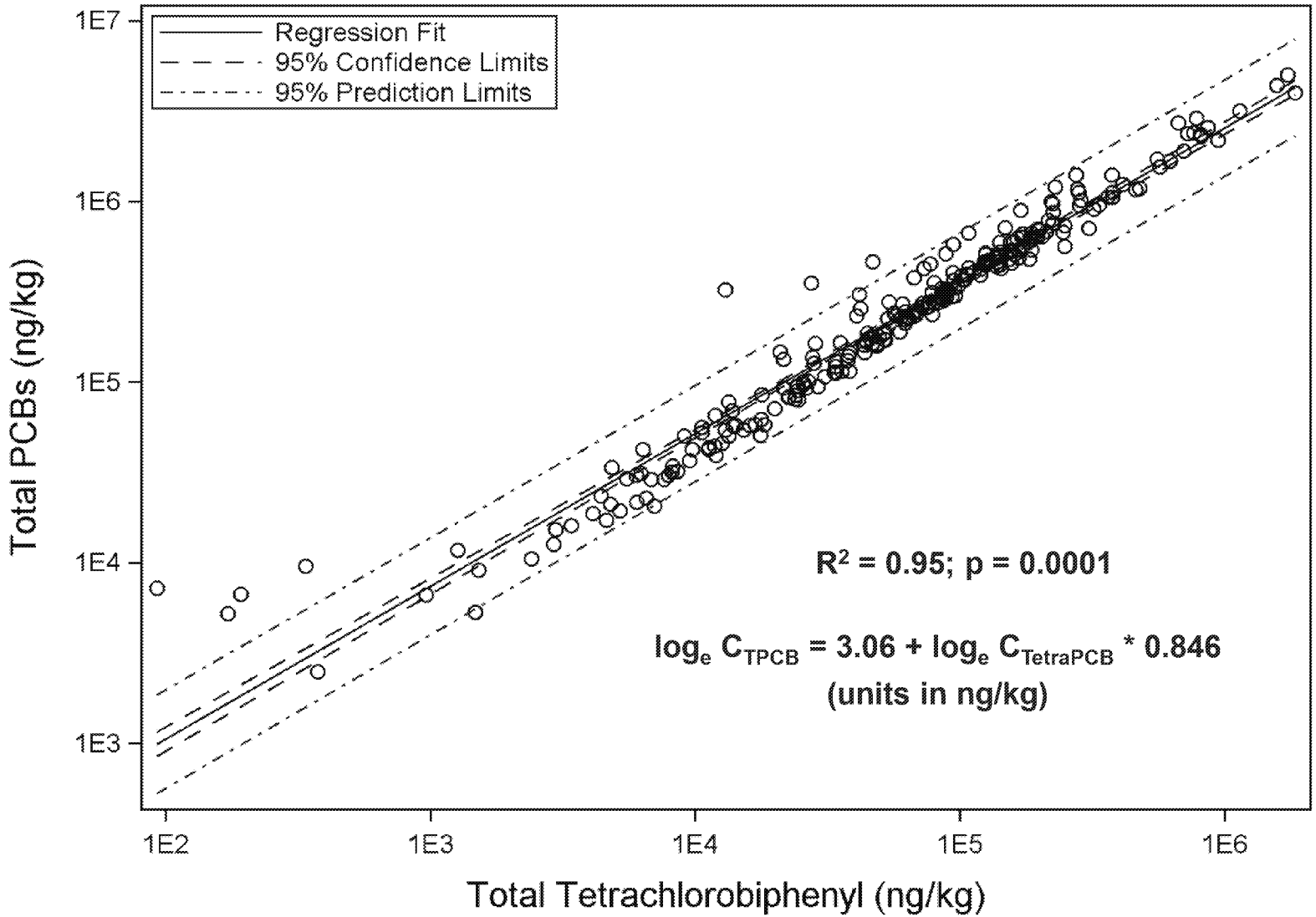
1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. THE NEWARK BAY STUDY AREA BOUNDARY WAS USEPA APPROVED AND UTILIZED IN THE PHASE I, II, AND III SEDIMENT INVESTIGATIONS. IN APRIL 2020, USEPA REVISED THE BOUNDARY BETWEEN OU2 AND OU3 SUCH THAT KEARNY POINT IS ENTIRELY INCLUDED IN OU2 (USEPA 2020), AS SHOWN. THE BOUNDARY MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
4. REFERENCE:
   A. USEPA. 2020. DIAMOND ALKALI SUPERFUND SITE - BOUNDARY BETWEEN OPERABLE UNIT 2 AND OPERABLE UNIT 3. MEMORANDUM FROM MICHAEL SIVAK, BRANCH CHIEF OF PASSAIC, HACKENSACK, AND NEWARK BAY REMEDIATION BRANCH TO FILE. APRIL 6.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
FEASIBILITY STUDY REPORT

EXPOSURE ZONES IN THE BIOACCUMULATION MODEL

Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum

FIGURE
A-1



Notes.
Data shown are Phase III sediment samples collected in the Newark Bay Study Area in 2014-2016.

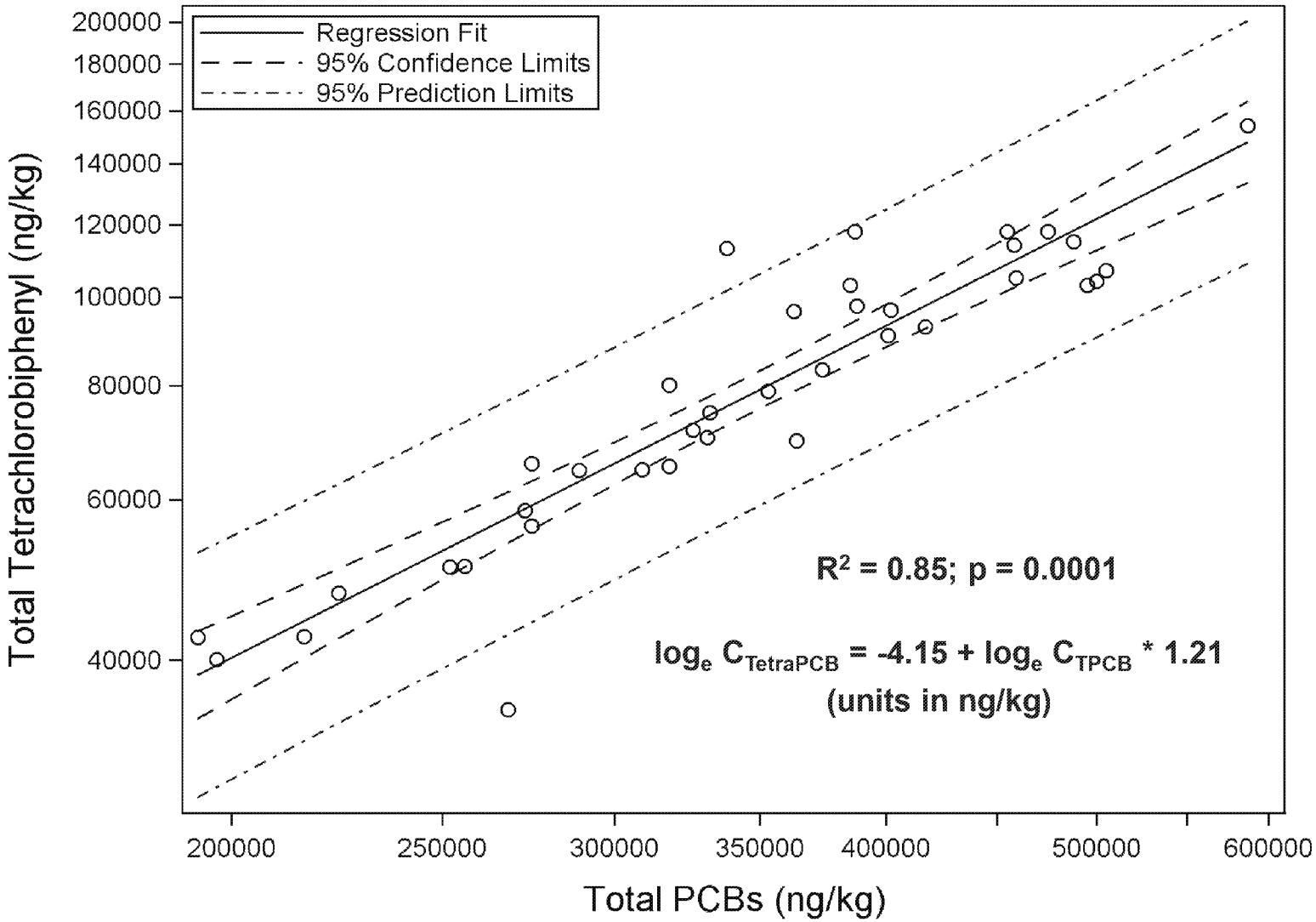
C_{TPCB} = concentration of total PCBs
$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX A: BIOACCUMULATION MODEL AND PRG CALCULATION METHOD

SEDIMENT REGRESSION: TOTAL PCBS VERSUS TOTAL TETRACHLORINATED PCBS

OXY Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
A-3



Notes:
Data shown are blue crab samples collected in the Newark Bay Study Area. Edible tissue consists of muscle and hepatopancreas.

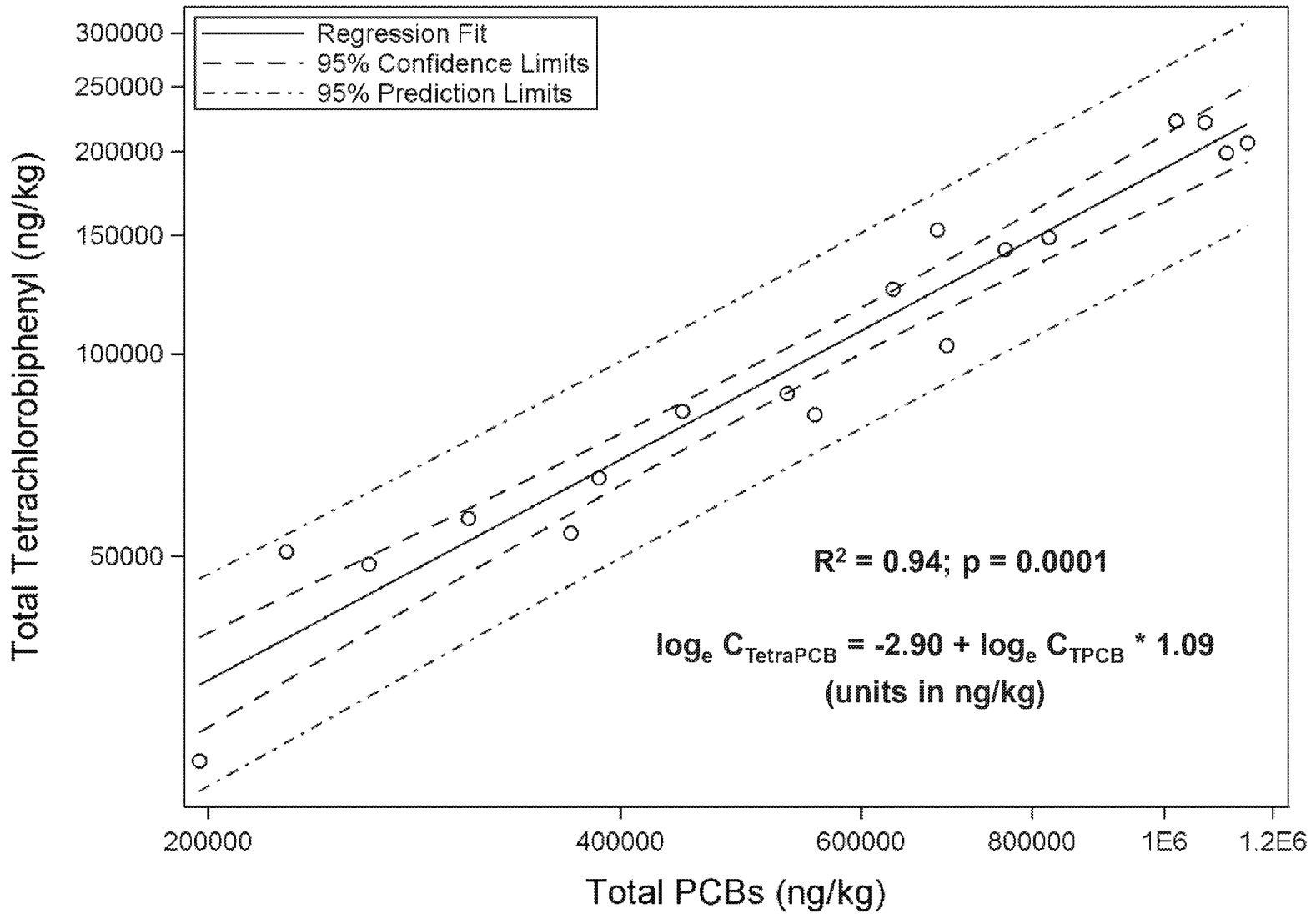
$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX A: BIOACCUMULATION MODEL AND PRG CALCULATION METHOD

EDIBLE BLUE CRAB REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

OXY Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
A-4



Notes:
Data shown are American eel fillet samples collected in the Newark Bay Study Area.

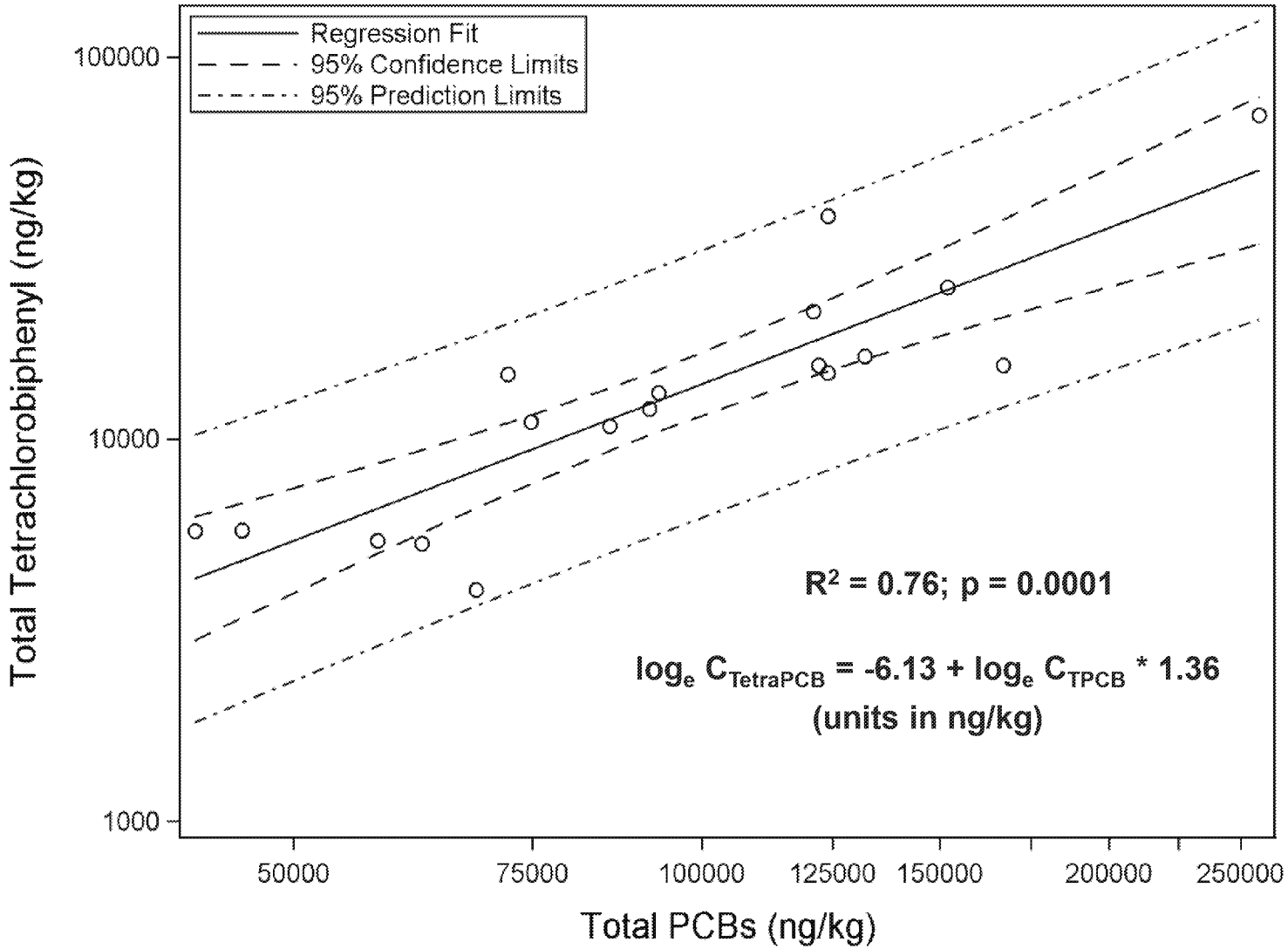
$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX A: BIOACCUMULATION MODEL AND PRG CALCULATION METHOD

AMERICAN EEL FILLET REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

OXY Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
A-5



Notes:
Data shown are bluefish fillet samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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BLUEFISH FILLET REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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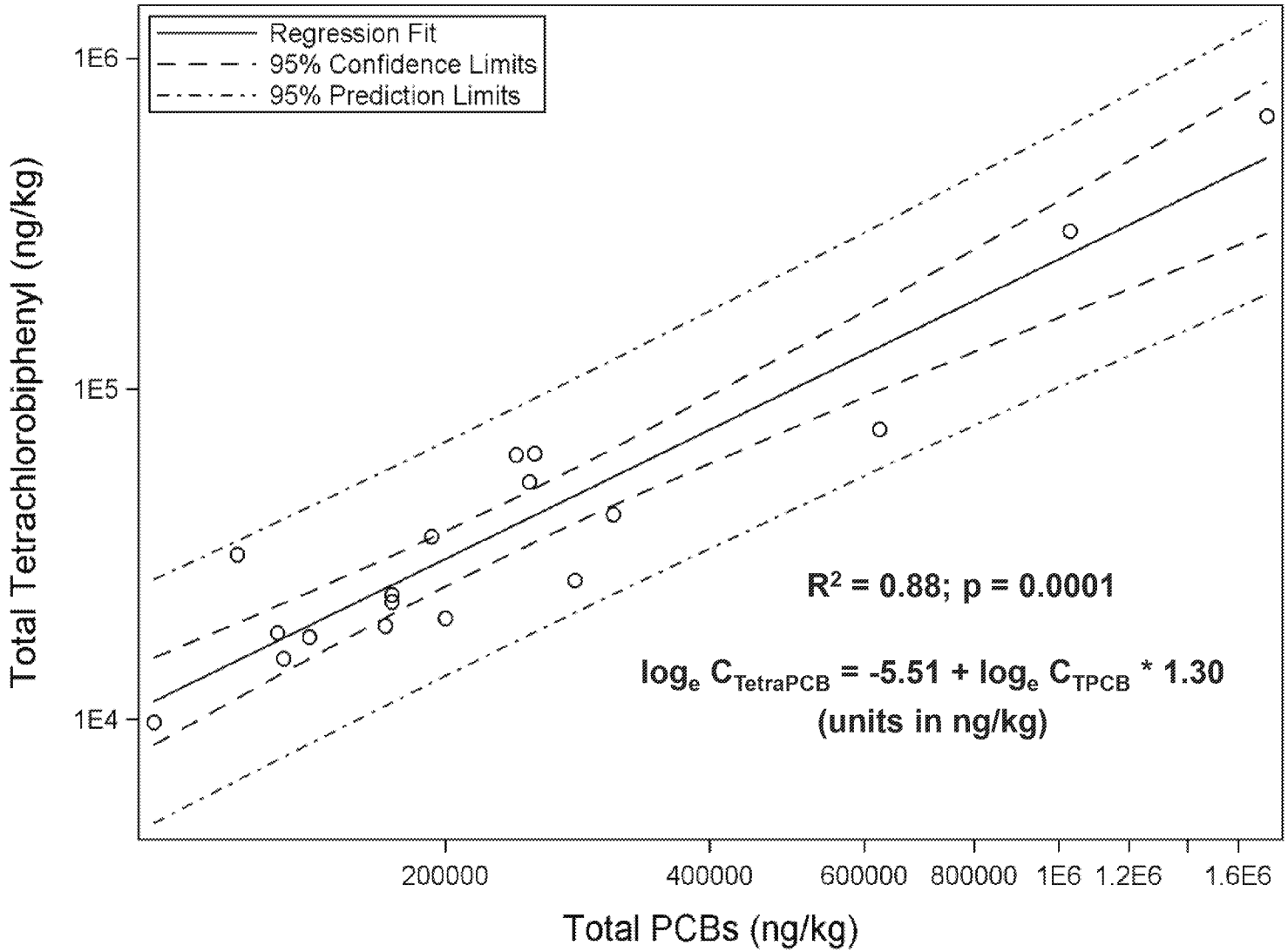
FIGURE
A-6



Notes:
Data shown are striped bass fillet samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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STRIPED BASS FILLET REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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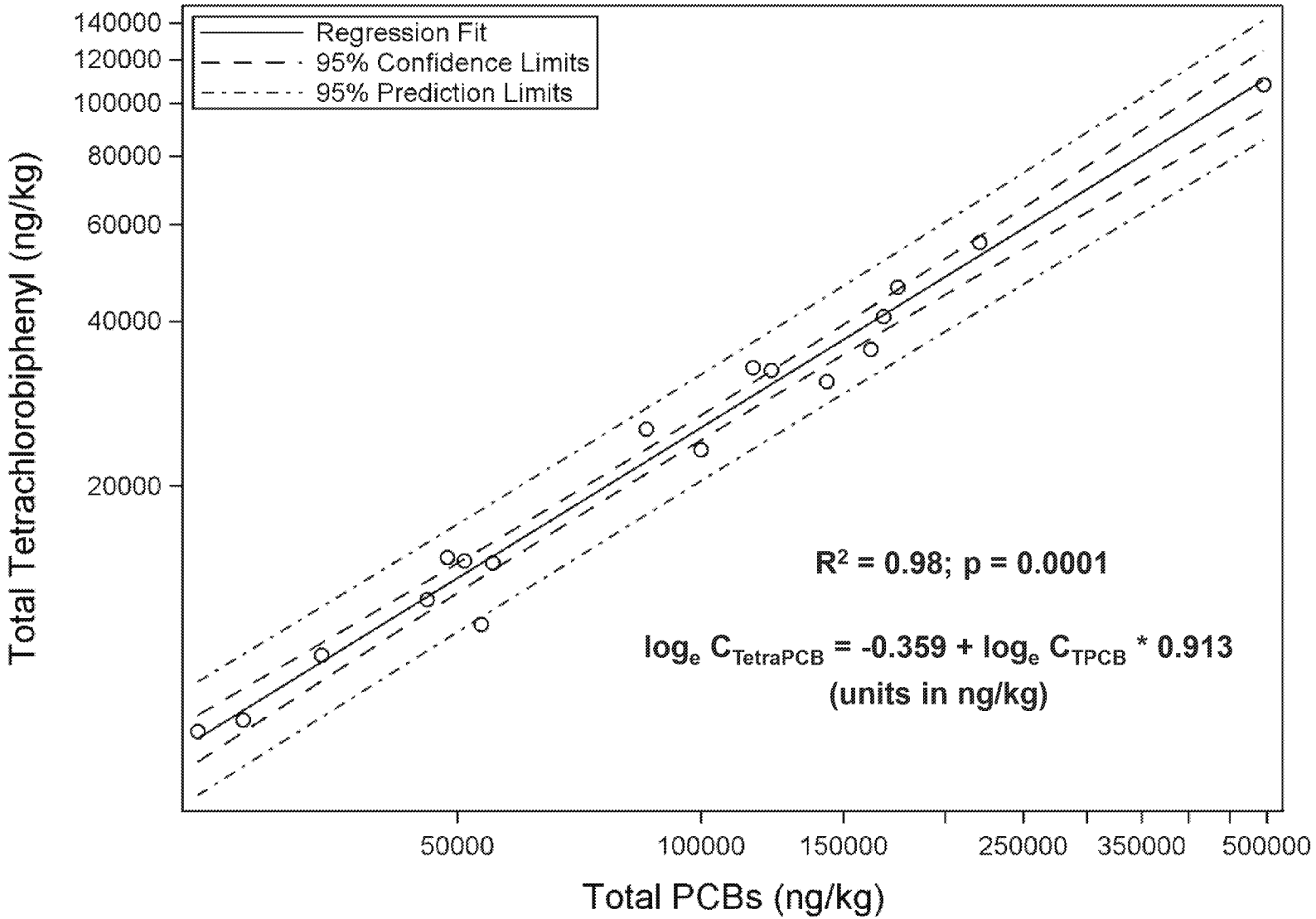
FIGURE
A-7



Notes:
Data shown are summer flounder fillet samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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SUMMER FLOUNDER FILLET REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

OXY Glenn Springs Holdings, Inc.
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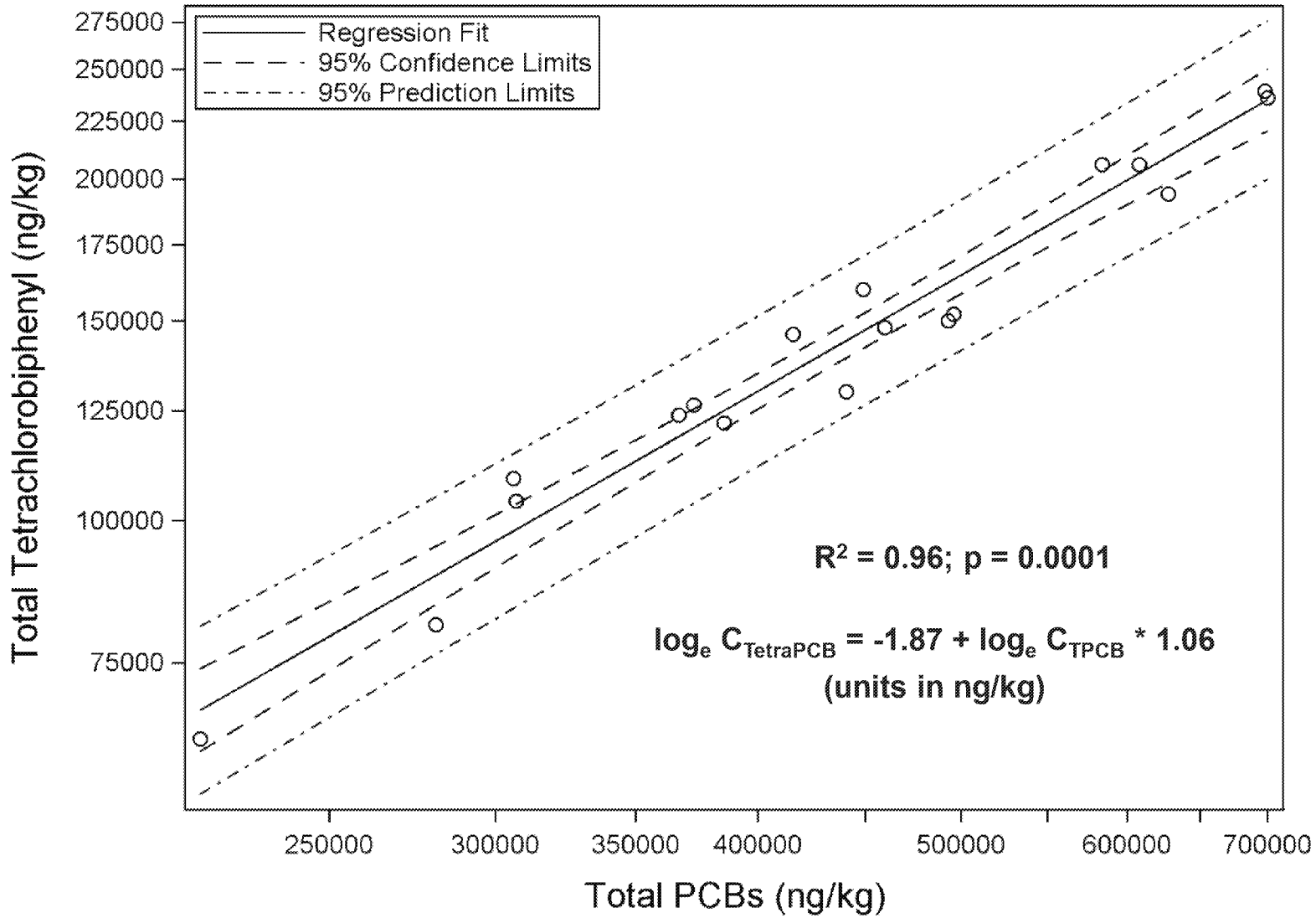
FIGURE
A-8



Notes:
Data shown are white perch fillet samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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WHITE PERCH FILLET REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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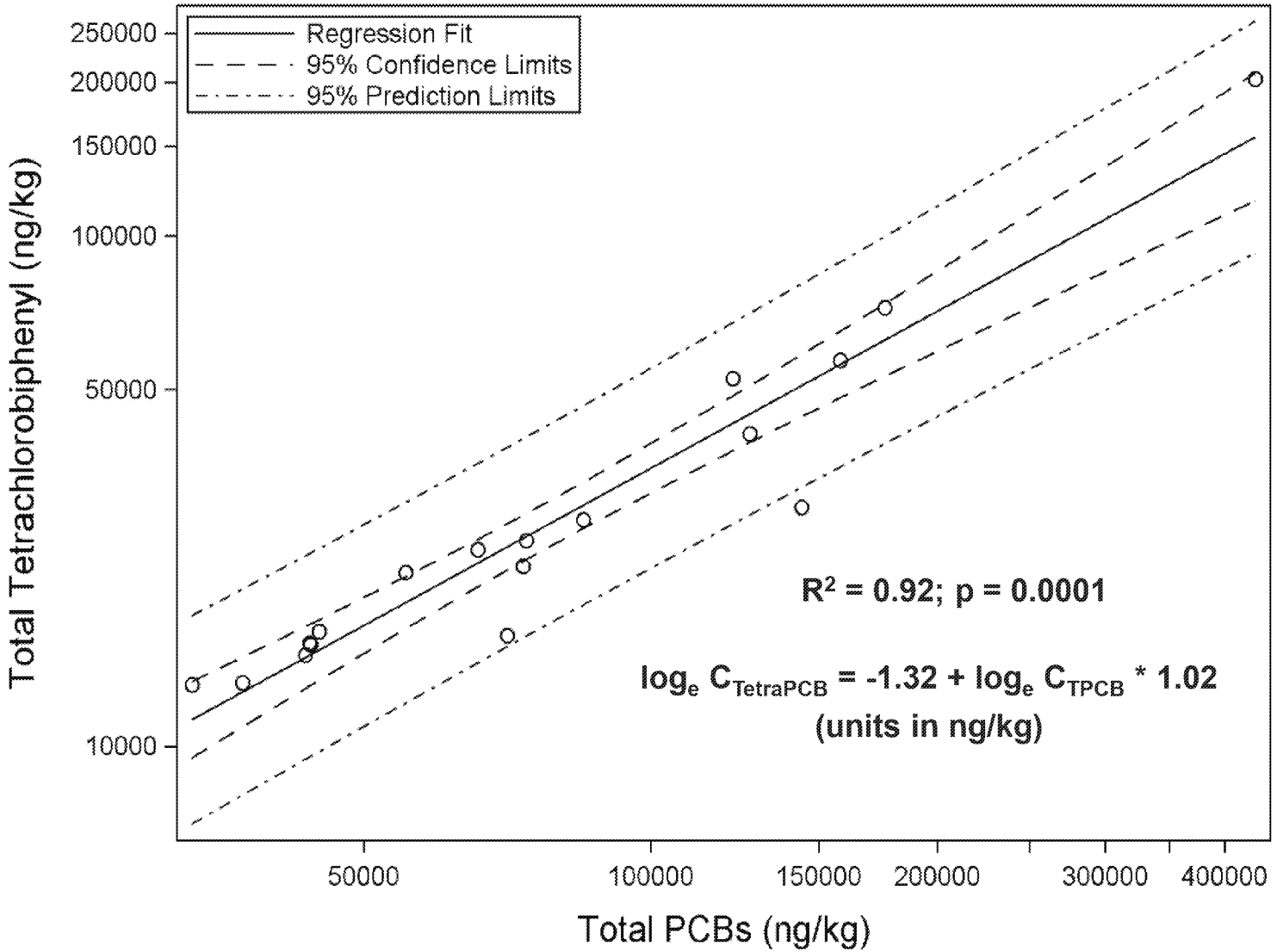
FIGURE
A-9



Notes:
Data shown are softshell clam samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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WHOLE BODY SOFTSHELL CLAM REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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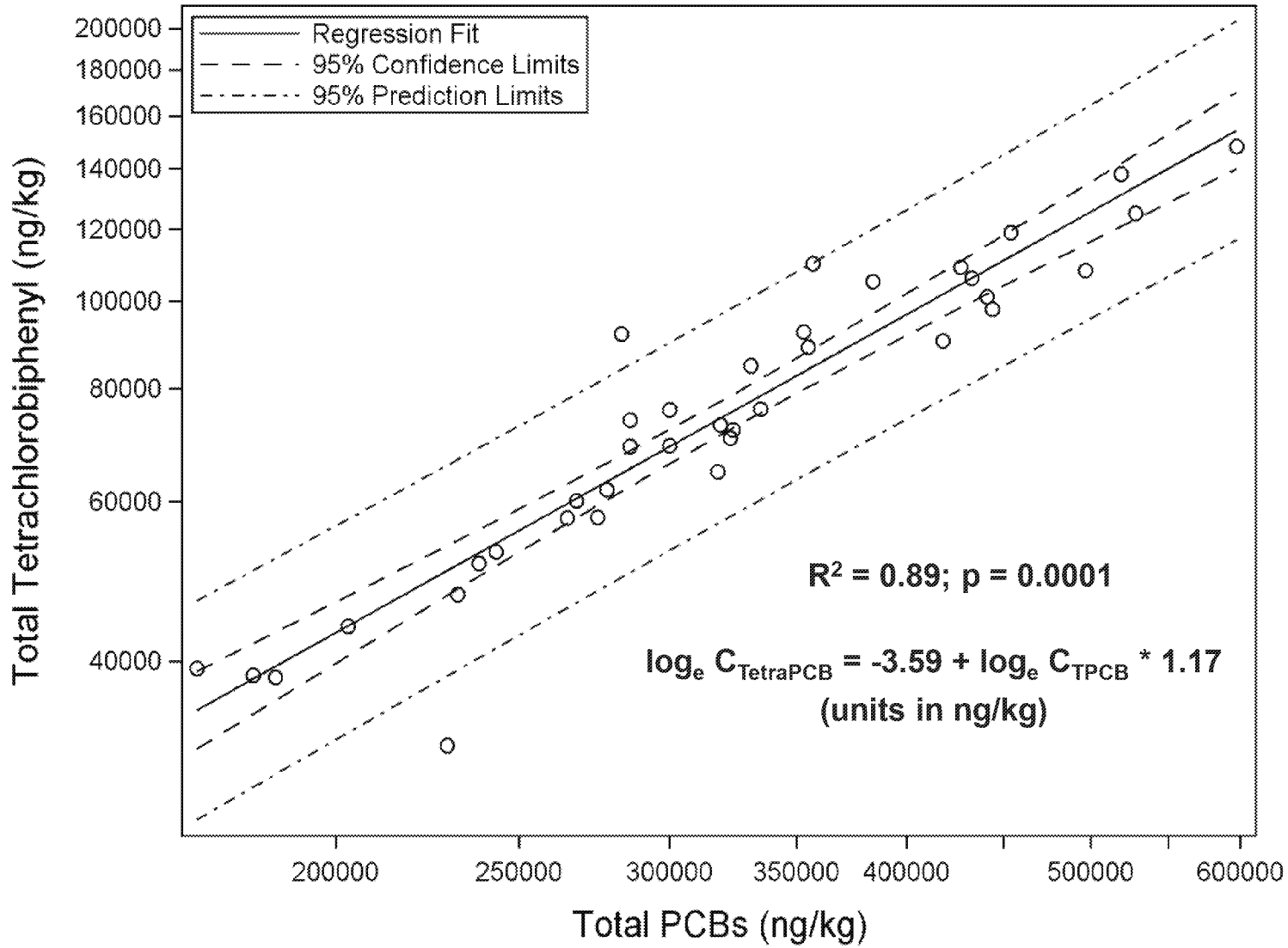
FIGURE
A-10



Notes:
Data shown are softshell clam samples collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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WHOLE BODY BLUE CRAB REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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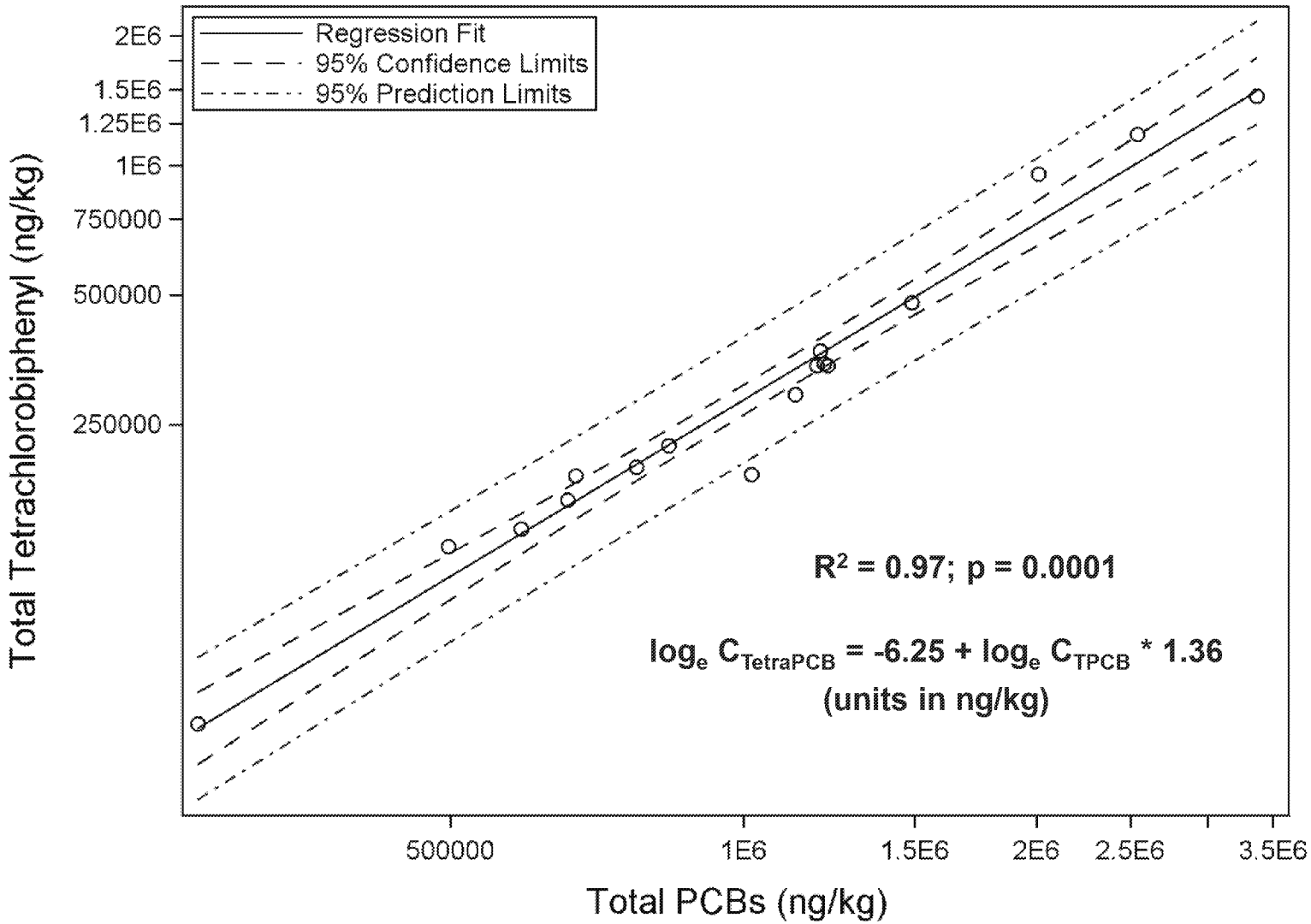
FIGURE
A-11



Notes:
Data shown are samples of mummichog and striped killifish collected in the Newark Bay Study Area.

$C_{TetraPCB}$ = concentration total tetrachlorinated PCBs
C_{TPCB} = concentration of total PCBs
log_e = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
PCBs = polychlorinated biphenyls

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WHOLE BODY *FUNDULUS SPP*. REGRESSION: TOTAL TETRACHLORINATED PCBS VERSUS TOTAL PCBS

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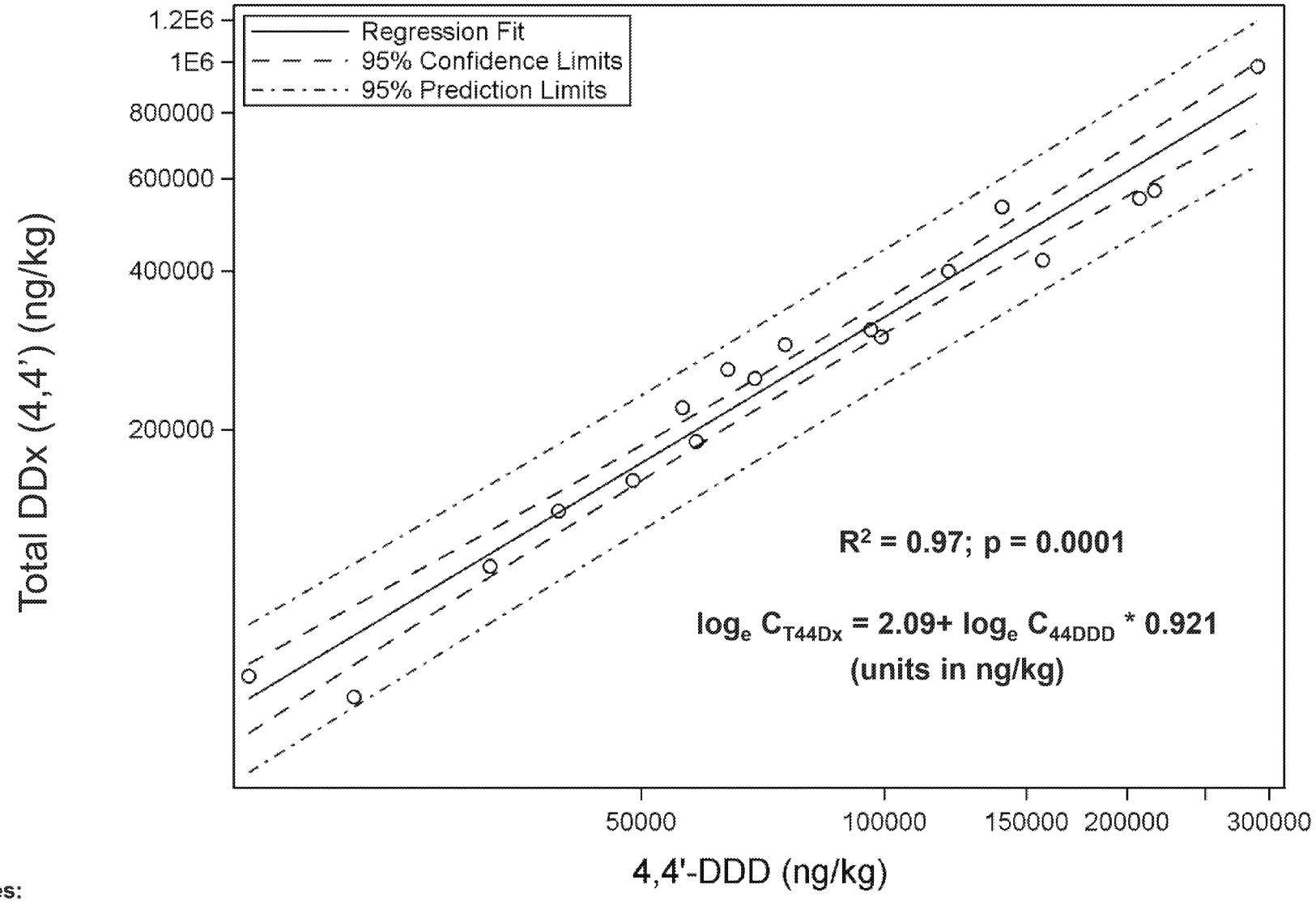
FIGURE
A-12



Notes:

Data shown are samples of American eel fillet collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
4,4'-DDD = 4,4'- dichlorodiphenyldichloroethane
total DDx (4,4') = sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4-dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane

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AMERICAN EEL FILLET REGRESSION:
TOTAL DDX (4,4') VERSUS 4,4'-DDD

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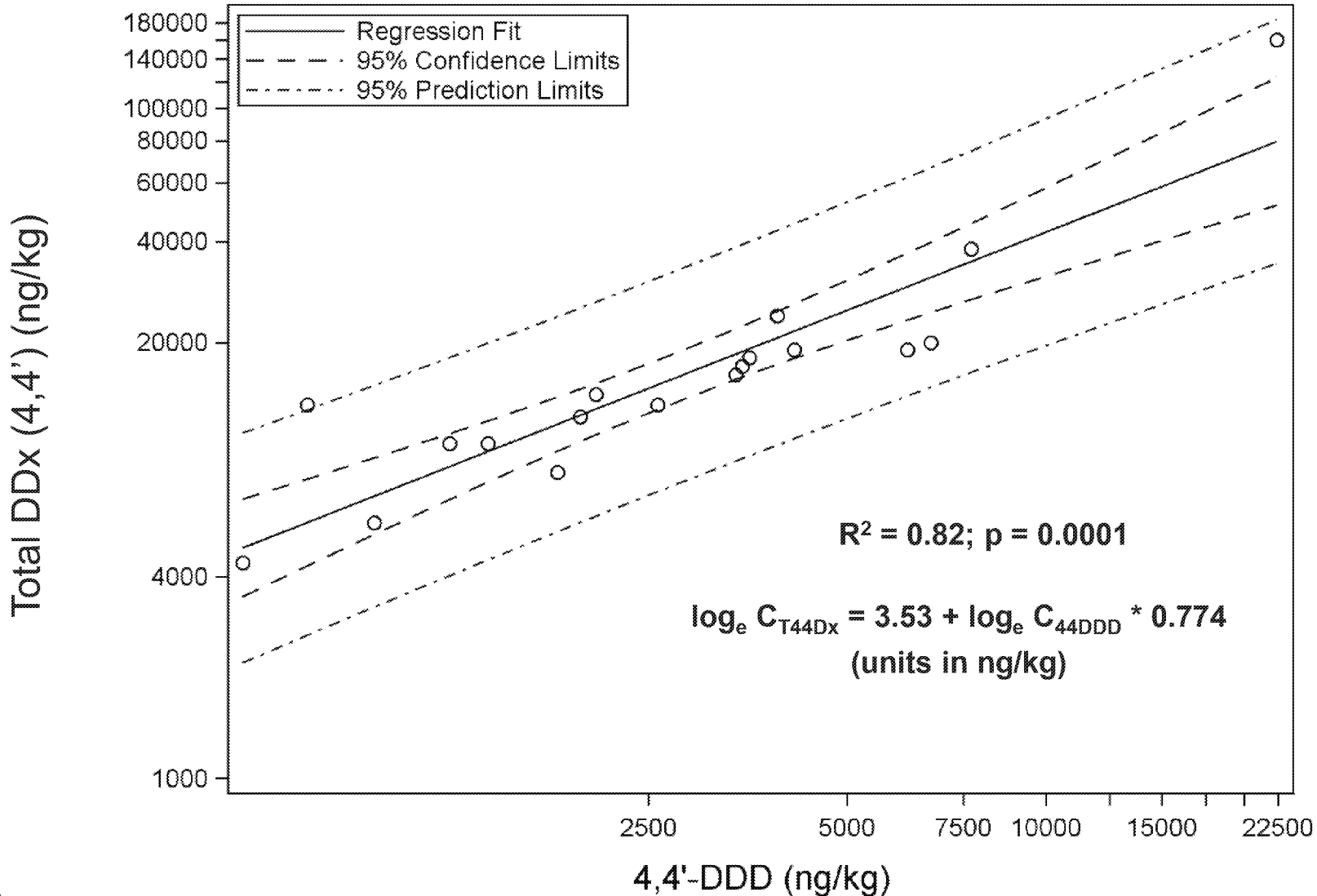
FIGURE
A-13



Notes:
Data shown are samples of bluefish fillet collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
4,4'-DDD = 4,4'- dichlorodiphenyldichloroethane
total DDx (4,4') = sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4-dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane

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BLUEFISH FILLET REGRESSION:
TOTAL DDX (4,4') VERSUS 4,4'-DDD

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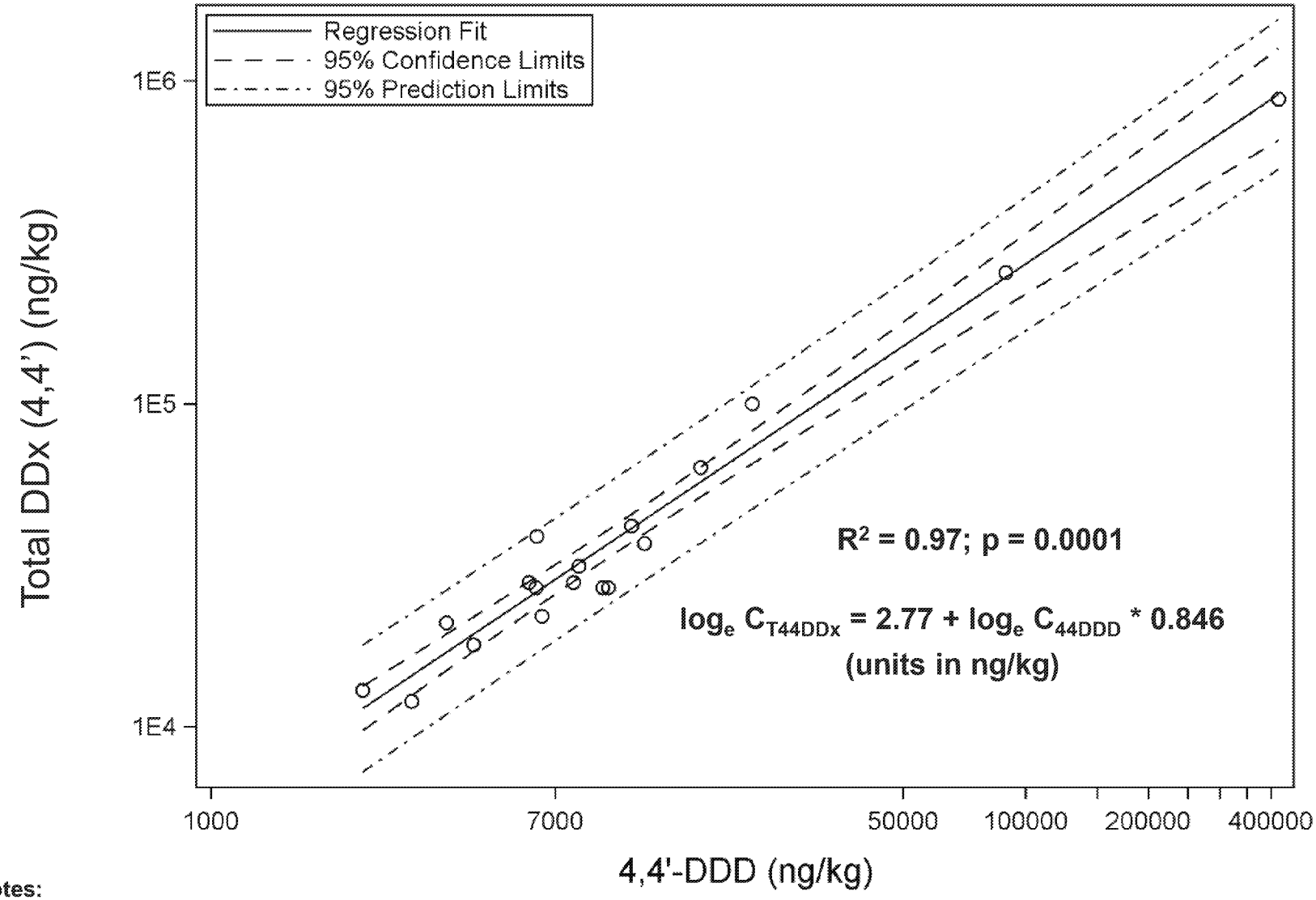
FIGURE
A-14



Notes:

Data shown are samples of striped bass collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
4,4'-DDD = 4,4'- dichlorodiphenyldichloroethane
total DDx (4,4') = sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4-dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane

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STRIPED BASS FILLET REGRESSION: TOTAL DDX (4,4') VERSUS 4,4'-DDD

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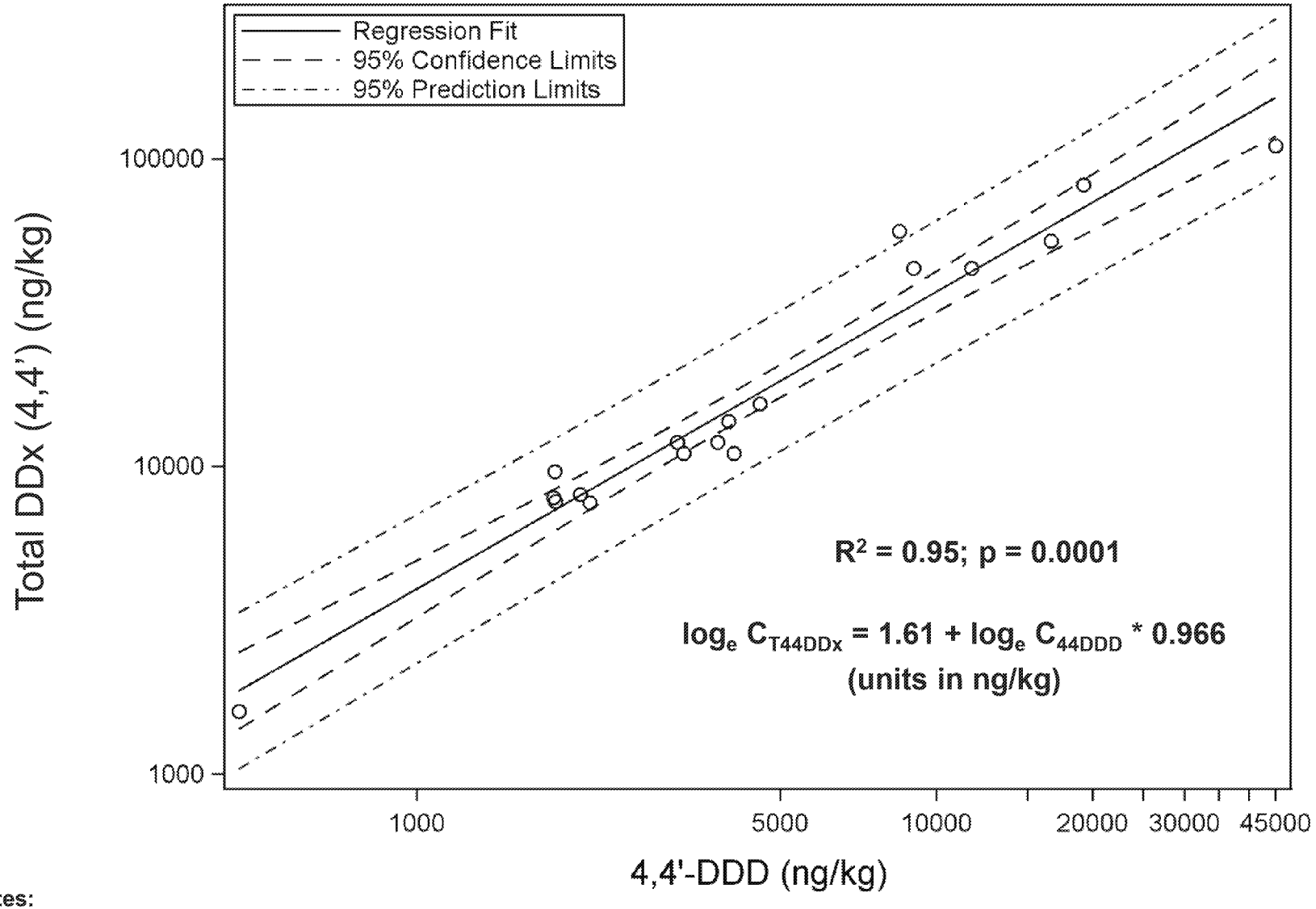
FIGURE
A-15



Notes:

Data shown are samples of summer flounder fillet collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
4,4'-DDD = 4,4'- dichlorodiphenyldichloroethane
total DDx (4,4') = sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4-dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane

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SUMMER FLOUNDER FILLET REGRESSION: TOTAL DDX (4,4') VERSUS 4,4'-DDD

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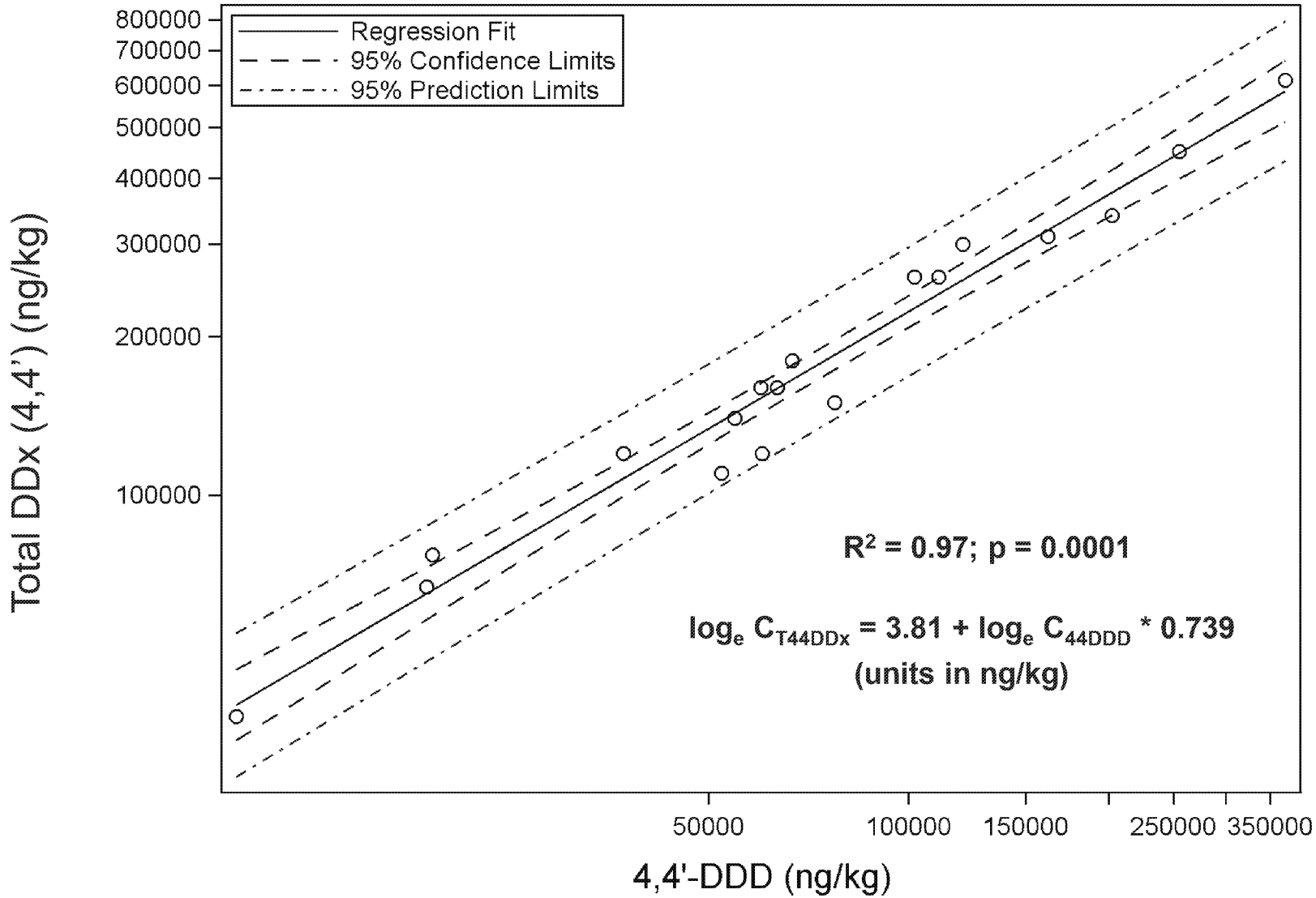
FIGURE
A-16



Notes:
Data shown are samples of white perch fillet collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
C_{44DDD} = concentration of 4,4'-DDD
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
4,4'-DDD = 4,4'- dichlorodiphenyldichloroethane
total DDx (4,4') = sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4-dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane

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WHITE PERCH FILLET REGRESSION:
TOTAL DDX (4,4') VERSUS 4,4'-DDD

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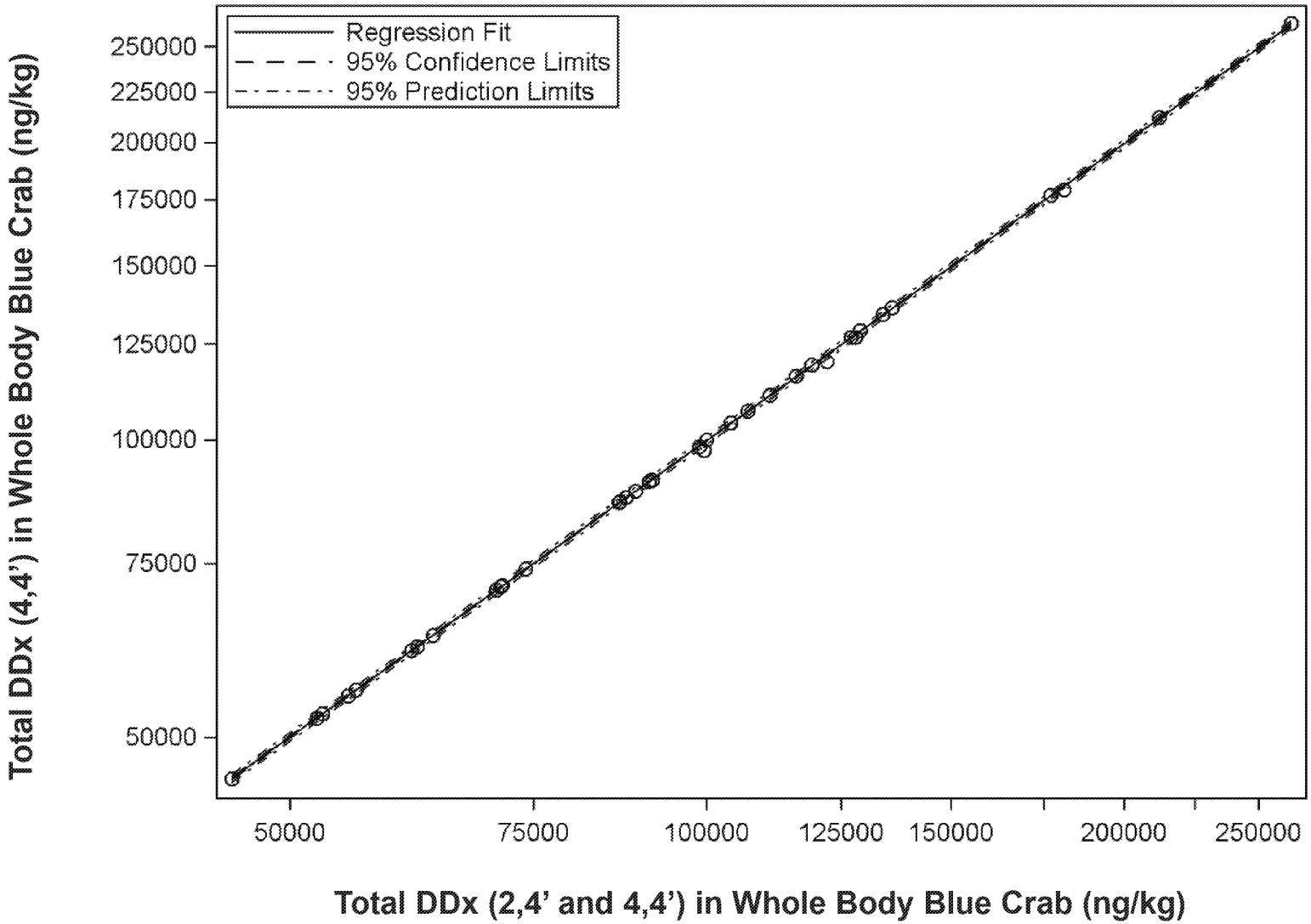
FIGURE
A-17



Notes:

Data shown are samples of blue crab collected in the Newark Bay Study Area.
Most summations of total DDx (2,4' and 4,4') are equal to that of total DDx (4,4') because detections of 4,4'-DDD and 4,4'-DDE are orders of magnitude greater than the other isomers in blue crab. For PRG calculation the concentration of acceptable total DDx (2,4' and 4,4') is assumed to be equal to the concentration of acceptable total DDx (4,4').

DDx = isomers of dichlorodiphenyldichloroethylene, dichlorodiphenyldichloroethane, and dichlorodiphenyltrichloroethane
ng/kg = nanograms per kilogram
total DDx (4,4') = sum of three isomers
total DDx (2,4' and 4,4') = sum of six isomers

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WHOLE BODY BLUE CRAB REGRESSION: TOTAL DDX (4,4') VERSUS DDX TOTAL (2,4' AND 4,4')

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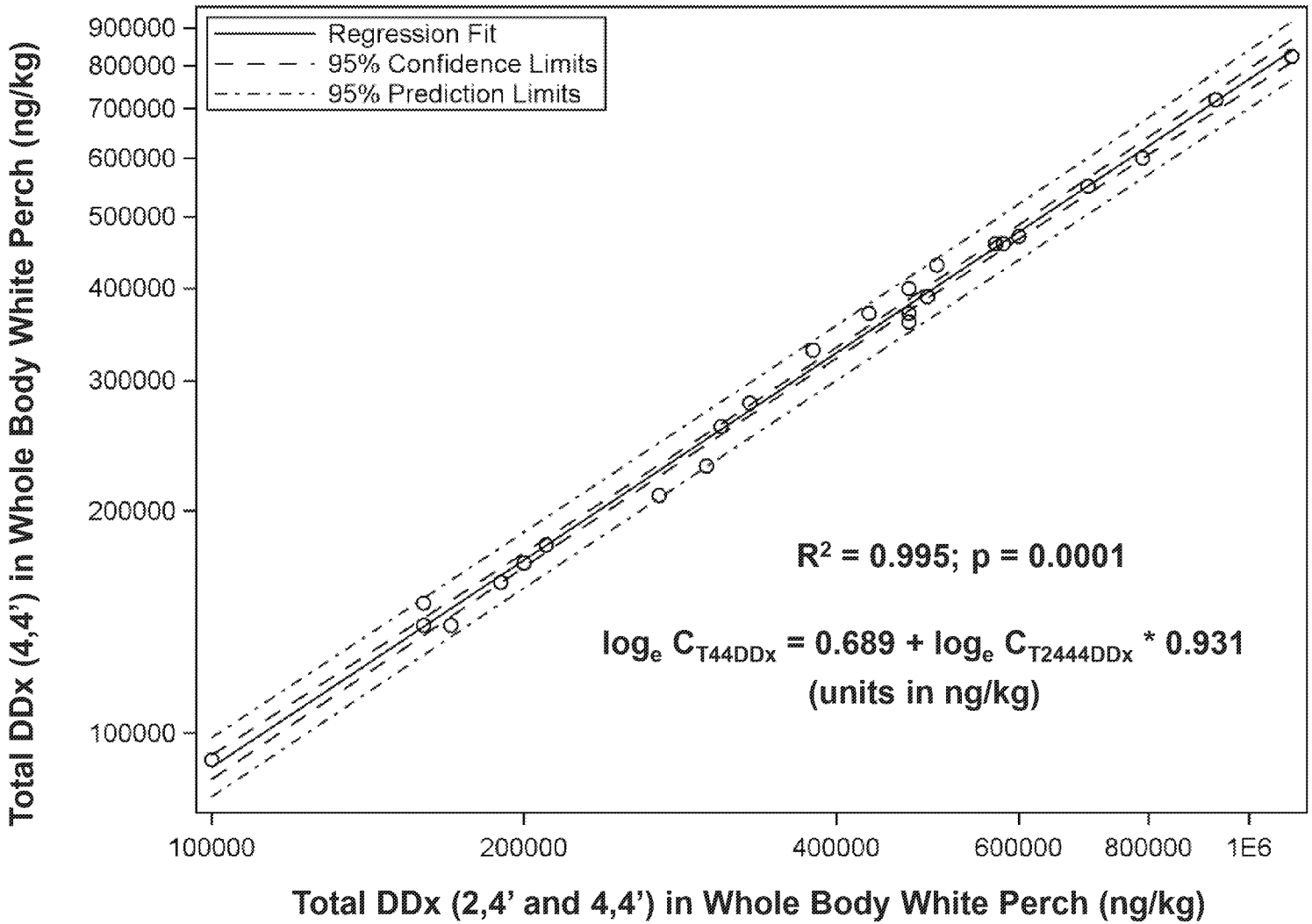
FIGURE
A-18



Notes:
Data shown are samples of white perch fillet collected in the Newark Bay Study Area.

C_{T44DDx} = concentration total DDx (4,4')
$C_{T2444DDx}$ = concentration of total DDx (2,4' and 4,4')
DDx = isomers of dichlorodiphenyldichloroethylene, dichlorodiphenyldichloroethane, and dichlorodiphenyltrichloroethane
$\log_e$ = natural logarithm
ng/kg = nanograms per kilogram
R^2 = coefficient of determination
p = probability value
total DDx (4,4') = sum of three isomers
total DDx (2,4' and 4,4') = sum of six isomers

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WHOLE BODY WHITE PERCH REGRESSION: TOTAL DDX (4,4') VERSUS TOTAL DDX (2,4' AND 4,4')

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FIGURE
A-19

Appendix B

Regression Models for the Calculation of PRGs for Inorganic Compounds

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Appendix B: Regression Models for the Calculation of PRGs for Inorganic Compounds

Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

August 2022

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Table B-4 Summary of PRGs for Softshell Clam (in text)
Table B-5 Mercury PRG for Blue Crab (in text)
Table B-6 Mercury PRGs for Fish (in text)

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Figure B-1 Crab, Clam and Sediment Sampling Locations
Figure B-2 Biota Sampling Areas from the Contaminant Assessment and Reduction Program

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Figure B-3 **Biota Sampling Reference Areas: Newtown Creek RI**

Figure B-4 **Biota Sampling Reference Areas: Berry's Creek RI**

Figure B-5 **Bioaccumulation Regression: Arsenic in Softshell Clam**

Figure B-6 **Bioaccumulation Regression: Lead in Softshell Clam**

Figure B-7 **Bioaccumulation Regression: Mercury in Softshell Clam**

Figure B-8 **Bioaccumulation Regression: Nickel in Softshell Clam**

Figure B-9 **Bioaccumulation Regression: Mercury in Edible Blue Crab**

Figure B-10 **Edible to Whole Body Blue Crab Regression for Mercury**

Figure B-11 **Methylmercury vs. Mercury in American Eel Fillet**

Figure B-12 **Bioaccumulation Regression: Mercury in American Eel Fillet**

Figure B-13 **Methylmercury vs. Mercury in White Perch Fillet**

Figure B-14 **Bioaccumulation Regression: Mercury in White Perch Fillet**

Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
BERA	baseline ecological risk assessment
CARP	Contaminant Assessment and Reduction Program
COC	chemical of concern
CPG	Cooperating Parties Group
GSH	Glenn Springs Holdings, Inc.
LPRSA	Lower Passaic River Study Area
NBSA	Newark Bay Study Area
NYSDEC	New York State Department of Environmental Conservation
PCBs	polychlorinated biphenyls
PRGs	preliminary remedial goals
RI	remedial investigation
Tierra	Tierra Solutions, Inc.
USEPA	United States Environmental Protection Agency

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1 Introduction

The Newark Bay Study Area (NBSA) bioaccumulation model was used for the calculation of sediment preliminary remedial goals (PRGs) for the organic chemicals of concern (COCs) (i.e., 2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD], total polychlorinated biphenyls [PCBs] and total DDx (4,4') [sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4- dichlorodiphenyldichloroethane, and 4,4'- dichlorodiphenyltrichloroethane]). Inorganic compounds were not evaluated using the bioaccumulation model. Therefore, empirical models relating sediment and tissue concentrations were developed for the calculation of the PRGs needed for inorganic COCs (i.e., arsenic, lead, mercury, and nickel). Tissue and sediment data from the remedial investigation (RI) program together with data from other sampling programs in the New York/New Jersey Harbor Estuary were used to quantify sediment and tissue relationships. The COC concentrations of individual biota tissue samples were paired with the average COC concentrations of available sediment samples collected within the exposure area of the biota sample to create species specific linear regression models designed to predict biota COC concentrations from sediment concentrations. Regressions were developed relating mercury in sediment and tissue for softshell clam (*Mya arenaria*), blue crab (*Callinectes sapidus)*, American eel (*Anguilla rostrata*), and white perch (*Morone americana*). For other species associated with mercury risk due to fish consumption (i.e., bluefish [*Pomatomus saltatrix*], striped bass [*Morone saxatilis*], and summer flounder [*Paralichthys dentatus*]), regression models were not developed because these species were found to have similar mercury concentrations to reference areas (bluefish and striped bass, see Appendix C), or to have NBSA concentrations below acceptable levels (summer flounder). In addition, regression models were developed for arsenic, lead, and nickel in softshell clam. Data from the following sampling programs were used in the regressions where available.

2 Data used in Regression Analyses

2.1 NBSA RI Data

Softshell clam samples were collected in 2014 (Tierra Solutions, Inc. [Tierra] 2014a; Glenn Springs Holdings, Inc. [GSH] 2017a) and were co-located with sediment grab samples. The co-located tissue and sediment samples were directly paired in the regression analyses. These were the only samples used for softshell clam regressions. Sample locations are shown in Figure B-1. The paired data are shown in Table B-1.

Blue crab samples were also collected in 2014 (Tierra 2014a; Normandeau 2017; GSH 2017a). Some crab samples were collected in specific locations in intertidal areas while others were composited from various locations within an assessment zone (Figure B-1). During the period from 2014 through 2016, 254 surface sediment samples were collected in the NBSA with 244 located within the assessment zones depicted on Figure B-1. (The remaining ten samples were composites collected within the regularly maintained navigation channel.) Each tissue sample was paired with the average sediment concentration in the assessment zone in which it was collected. The locations and assessment zones are shown on Figure B-1. The data are shown in Table B-2.

American eel fillet and white perch fillet samples were collected in the NBSA in 2015 and 2016 (Tierra 2014b; Tierra 2017). Fish were composited from multiple locations within the assessment zones shown on Figure B-1. Each fillet tissue sample was paired with the average sediment concentration in the assessment zone in which it was collected (Table B-2).

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Surface sediment samples (0 to 0.5 foot) were collected in 2014 (Tierra 2014a; GSH 2017a), 2015 (Tierra 2015; GSH 2017b) and 2016 (Tierra 2016; GSH 2017c). All RI surface sediment samples collected from 2014 through 2016 within the assessment zones were included in the sediment averages that are paired with crab and fish tissue for regression analyses. Summary statistics are shown in Table B-3. (Note: Ten composite samples collected in 2016 in the dredged navigation channel are not included as they are outside the assessment zone boundaries).

Table B-3 Summary Statistics for Mercury and Methylmercury in Phase III Surface Sediment: 2014-2016

Chemical (µg/kg)	Assessment Zone	Number of Samples	Number of Detects	Mean	Standard Deviation	Minimum	Maximum
Mercury	North	104	104	1,605	1,663	54.6	10,400
Mercury	Southeast	50	50	1,805	1,600	5.11	9,440
Mercury	Southwest	90	90	3,629	3,973	34.2	22,100
Methyl mercury	North	104	104	0.93	0.78	0.065	4.43
Methyl mercury	Southeast	50	49	1.02	0.82	0.027	4.8
Methyl mercury	Southwest	90	90	1.30	1.55	0.056	11.9

2.2 LPRSA Risk Assessment

American eel fillet, white perch fillet and blue crab edible tissue samples were collected by the Cooperating Parties Group (CPG) in 2009 in the Lower Passaic River Study Area (LPRSA) for use in the baseline human health risk assessment. The fillet data are reported by river mile in Appendix K (Table K.2) of the LPRSA Baseline Ecological Risk Assessment (BERA, Windward 2019). Surface sediment samples were collected by the CPG in seven sampling programs over the period from 2008 through 2013 and these data are also reported in the BERA (Windward 2019). The sediment mercury concentrations were averaged by two-mile river reach and paired with tissue samples collected within each two-mile reach (Table B-2).

2.3 Contaminant Assessment and Reduction Program

In 1999, American eel, white perch, and blue crab samples were collected by the New York State Department of Environmental Conservation (NYSDEC) in several sampling zones (Figure B-2) within the New York/New Jersey Harbor Estuary (NYSDEC 2004). In the Focused Feasibility Study for Operable Unit 2 (United States Environmental Protection Agency [USEPA] 2014), USEPA paired tissue samples with sediment samples collected in the sampling zones under both the Contaminant Assessment and Reduction Program (CARP) and Regional Environmental Monitoring and Assessment Program (USEPA 2003) programs. Tissue samples were paired with the average concentrations of surface sediment samples collected within each biota sampling zone (Table B-2) and these paired data were incorporated into the regressions calculated herein. Additional CARP data for American eel collected in the Hudson River at Haverstraw Bay were paired with CARP sediment samples in that area (Table B-2).

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2.4 Newtown Creek RI Sampling

Biota samples were collected in reference areas in support of the Newtown Creek Superfund Site RI (Ancor QEA 2017). Blue crab samples were collected from three reference creeks in the Jamaica Bay watershed (i.e., Gerritsen Creek, Head of Bay, and Spring Creek) and from Westchester Creek which empties into the East River (Figure B-3). White perch were collected from Westchester Creek only. Tissue samples were paired with the average concentrations of surface sediment samples also collected within these creeks (Table B-2).

2.5 Berry's Creek RI Sampling

Blue crab and white perch samples were collected in two reference creeks (i.e., Mills Creek and Bellmans Creek) that empty into the Hackensack River upstream of Berry's Creek (Figure B-4) in support of the Berry's Creek Superfund Site RI (BCSA Group 2018). Tissue samples were paired with the average concentrations of surface sediment samples also collected in these creeks (Table B-2).

3 Regression Models for PRGs

3.1 Softshell Clam

Ecological risks to softshell clam were determined for four inorganic compounds requiring that PRGs be calculated. Regression models for softshell clam are shown in Figures B-5 through B-8[1] for arsenic, lead, mercury, and nickel, respectively. The regression equations shown in Figures B-5 through B-8 were rearranged to solve for the sediment concentration that would result in an acceptable[2] tissue concentration for softshell clam. Outliers were removed from the final regression models. The outliers were a result of tissue concentrations with very low or non-detect concentrations for arsenic, lead and nickel from station 129 (Table B-1). The resulting PRGs are given in Table B-4.

Table B-4 Summary of PRGs for Softshell Clam

COC	Basis of Acceptable Tissue Concentration[a]	Acceptable Tissue Concentration for Ecological Risk	Sediment PRG
Arsenic (mg/kg)	OU3/OU4 TRV	0.64	0.033
Lead (mg/kg)	OU2 TRV	1.2	0.15
	Integrated OU2 and OU3/OU4	10.2	49
	OU3/OU4 TRV	12.6	87
Mercury (µg/kg)	OU2/OU3/OU4 TRV	68	270
Nickel (mg/kg)	OU3/OU4 TRV	0.6	0.0001

[a]See Appendix D for the derivation of tissue concentrations used for PRG calculation.
TRV = toxicity reference value

[1] Note that the model for nickel in softshell clam was prepared by USEPA (WSP 2020).
[2] The derivation of acceptable tissue concentrations is described in Appendix D.

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3.2 Blue Crab

Ecological risk to blue crab were determined for mercury. Ecological risk is evaluated on a whole body basis for blue crab. However, much of the data available for regression analyses were based on edible tissue samples that comprise the muscle and hepatopancreas tissue of the crab. Therefore, two regressions were used to calculate ecological sediment PRGs for blue crab. First, a regression model was developed for edible tissue versus sediment for blue crab (Figure B-9) using the dataset shown in Table B-2 for blue crab. In addition to the NBSA RI, data used in the regression were from the LPRSA RI, CARP (Upper Bay, Raritan Bay, Jamaica Bay), the Newtown Creek RI (four reference areas), and the Berry's Creek RI (Bellmans Creek, Mill Creek). Using NBSA RI data, a second regression model was developed to convert the acceptable whole body concentration to an equivalent acceptable edible tissue concentration (Figure B-10). The regression model in Figure B-9 was then used to calculate the sediment PRG based on the equivalent acceptable edible concentration (Table B-5).

Table B-5 Mercury PRG for Blue Crab

COC	Acceptable Whole Body Tissue Concentration[a]	Regression- Based Equivalent Acceptable Edible Tissue Concentration	Sediment PRG
Mercury (µg/kg)	68	84	1,160
[a]See Appendix D for the derivation of tissue concentrations used for PRG calculation.			

3.3 Fish

Human health risk from fish consumption was found due to methylmercury concentrations in fillet. The Baseline Human Health Risk Assessment (GSH 2019) assessed risk based on an equally weighted mixed fish diet (i.e., edible fillet) of five species: American eel, bluefish, striped bass, summer flounder, and white perch. An evaluation of background concentrations in these species (see Appendix C) found that mercury concentrations in bluefish, striped bass, and summer flounder in the NBSA are consistent with concentrations in reference areas. In addition, mercury concentrations in summer flounder are below the acceptable concentrations for human health risk. Therefore, mercury PRGs have been developed only for American eel and white perch. The PRGs are based on fillet concentrations and therefore only fillet data were used in the regression model.

While human health risk is based on methylmercury concentrations, methylmercury is not always measured in the tissue of the secondary data sampling programs. Further, sediment PRGs need to be developed based on total mercury in sediments. Therefore, total mercury in both tissue and sediment was used in regression models. Further, it is assumed that all mercury in tissue is methylmercury. Therefore, sediment PRGs that would result in acceptable mercury in tissue is assumed to also result in acceptable methylmercury in tissue. These assumptions are further evaluated for each species described in the following sections.

3.3.1 American eel

Sediment and American eel fillet data were available from the NBSA RI program, the LPRSA RI program, and the CARP program (Upper Bay, Hudson River). Mercury and methylmercury were found to have good agreement in tissue (Figure B-11) indicating that the assumption that mercury concentrations in tissue are representative of

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methylmercury is valid. The regression is shown in Figure B-12 and was used to calculate a sediment PRG (Table B-6).

3.3.2 White Perch

Sediment and white perch fillet data were available from the NBSA RI program, the LPRSA RI program, the CARP program (Upper Bay, Raritan Bay), the Newtown Creek RI (Westchester Creek), and the Berry's Creek RI (Mill Creek and Bellmans Creek). Mercury and methylmercury were found to have moderate agreement in tissue (Figure B-13). The regression is shown in Figure B-14 and was used to calculate a sediment PRG (Table B-6).

Table B-6 Mercury PRGs for Fish

COC	Species	Acceptable Tissue Concentration for Human Health Risk[a]	Sediment PRG
Mercury (µg/kg)	American eel	230	1,100
Mercury (µg/kg)	White perch	230	2,400

[a]See Table 3-4 of the RAO and PRG Technical Memorandum.

4 References

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Tables

Table B-1
Arsenic, Lead, Mercury, and Nickel in Co-located Softshell Clam and Sediment Samples in the NBSA
Appendix B: Regression Models for the Calculation of PRGs for Inorganic Compounds
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
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NBSA Assessment Zone	Location Name	Chemical Name	Units	Tissue Sample ID	Tissue Result	Tissue Detect?	Sediment Sample ID	Sediment Result	Sediment Detect?	Notes
North	NB03SED122ACL	Arsenic	mg/kg	NB03CLM122A	6.65	Yes	NB03SED122A	14.4	Yes	
North	NB03SED122BCL	Arsenic	mg/kg	NB03CLM122B	4.95	Yes	NB03SED122B	10	Yes	
North	NB03SED122CCL	Arsenic	mg/kg	NB03CLM122C	6.52	Yes	NB03SED122C	9.33	Yes	
North	NB03SED123ACL	Arsenic	mg/kg	NB03CLM123A	3.73	Yes	NB03SED123A	4.53	Yes	
North	NB03SED123BCL	Arsenic	mg/kg	NB03CLM123B	4.25	Yes	NB03SED123B	7.62	Yes	
North	NB03SED132ACL	Arsenic	mg/kg	NB03CLM132A	4.82	Yes	NB03SED132A	9.17	Yes	
North	NB03SED132BCL	Arsenic	mg/kg	NB03CLM132B	3.73	Yes	NB03SED132B	1.18	Yes	
North	NB03SED133CL	Arsenic	mg/kg	NB03CLM133	8.67	Yes	NB03SED133	15.4	Yes	
Southeast	NB03SED124CL	Arsenic	mg/kg	NB03CLM124	2.12	Yes	NB03SED124	8.02	Yes	
Southeast	NB03SED125CL	Arsenic	mg/kg	NB03CLM125	2.21	Yes	NB03SED125	7.31	Yes	
Southeast	NB03SED127ACL	Arsenic	mg/kg	NB03CLM127A	1.43	Yes	NB03SED127A	6.4	Yes	
Southeast	NB03SED127BCL	Arsenic	mg/kg	NB03CLM127B	2.86	Yes	NB03SED127B	13.3	Yes	
Southwest	NB03SED129CL	Arsenic	mg/kg	NB03CLM129	1.97	Yes	NB03SED129	115	Yes	Regression Outlier[a]
Southwest	NB03SED130CL	Arsenic	mg/kg	NB03CLM130	4.18	Yes	NB03SED130	11.8	Yes	
Southwest	NB03SED131ACL	Arsenic	mg/kg	NB03CLM131A	2.69	Yes	NB03SED131A	6.715	Yes	
Southwest	NB03SED131BCL	Arsenic	mg/kg	NB03CLM131B	8.93	Yes	NB03SED131B	4.26	Yes	
Southwest	NB03SED134CL	Arsenic	mg/kg	NB03CLM134	12.4	Yes	NB03SED134	69.5	Yes	
Southwest	NB03SED135CL	Arsenic	mg/kg	NB03CLM135	1.59	Yes	NB03SED135	6.5	Yes	
North	NB03SED122ACL	Lead	mg/kg	NB03CLM122A	27.1	Yes	NB03SED122A	74.2	Yes	
North	NB03SED122BCL	Lead	mg/kg	NB03CLM122B	19.1	Yes	NB03SED122B	41.2	Yes	
North	NB03SED122CCL	Lead	mg/kg	NB03CLM122C	21.2	Yes	NB03SED122C	60.7	Yes	
North	NB03SED123ACL	Lead	mg/kg	NB03CLM123A	12.6	Yes	NB03SED123A	115	Yes	
North	NB03SED123BCL	Lead	mg/kg	NB03CLM123B	9.75	Yes	NB03SED123B	76.3	Yes	
North	NB03SED132ACL	Lead	mg/kg	NB03CLM132A	4.98	Yes	NB03SED132A	90.1	Yes	
North	NB03SED132BCL	Lead	mg/kg	NB03CLM132B	12.7	Yes	NB03SED132B	10.6	Yes	
North	NB03SED133CL	Lead	mg/kg	NB03CLM133	20.8	Yes	NB03SED133	254	Yes	
Southeast	NB03SED124CL	Lead	mg/kg	NB03CLM124	8.66	Yes	NB03SED124	64.7	Yes	
Southeast	NB03SED125CL	Lead	mg/kg	NB03CLM125	11	Yes	NB03SED125	105	Yes	
Southeast	NB03SED127ACL	Lead	mg/kg	NB03CLM127A	4.89	Yes	NB03SED127A	41.7	Yes	
Southeast	NB03SED127BCL	Lead	mg/kg	NB03CLM127B	9.26	Yes	NB03SED127B	110	Yes	
Southwest	NB03SED129CL	Lead	mg/kg	NB03CLM129	0.2	No	NB03SED129	2190	Yes	Regression Outlier[a]
Southwest	NB03SED130CL	Lead	mg/kg	NB03CLM130	7.42	Yes	NB03SED130	108	Yes	
Southwest	NB03SED131ACL	Lead	mg/kg	NB03CLM131A	4.61	Yes	NB03SED131A	36.4	Yes	
Southwest	NB03SED131BCL	Lead	mg/kg	NB03CLM131B	21.4	Yes	NB03SED131B	26.1	Yes	
Southwest	NB03SED134CL	Lead	mg/kg	NB03CLM134	94.8	Yes	NB03SED134	1160	Yes	
Southwest	NB03SED135CL	Lead	mg/kg	NB03CLM135	4.79	Yes	NB03SED135	84	Yes	
North	NB03SED122ACL	Mercury	µg/kg	NB03CLM122A	105	Yes	NB03SED122A	523	Yes	
North	NB03SED122BCL	Mercury	µg/kg	NB03CLM122B	68.2	Yes	NB03SED122B	676	Yes	
North	NB03SED122CCL	Mercury	µg/kg	NB03CLM122C	91	Yes	NB03SED122C	778	Yes	

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NBSA Assessment Zone	Location Name	Chemical Name	Units	Tissue Sample ID	Tissue Result	Tissue Detect?	Sediment Sample ID	Sediment Result	Sediment Detect?	Notes
North	NB03SED123ACL	Mercury	µg/kg	NB03CLM123A	64.1	Yes	NB03SED123A	334	Yes	
North	NB03SED123BCL	Mercury	µg/kg	NB03CLM123B	50.5	Yes	NB03SED123B	414	Yes	
North	NB03SED132ACL	Mercury	µg/kg	NB03CLM132A	125	Yes	NB03SED132A	935	Yes	
North	NB03SED132BCL	Mercury	µg/kg	NB03CLM132B	70.5	Yes	NB03SED132B	54.6	Yes	
North	NB03SED133CL	Mercury	µg/kg	NB03CLM133	391	Yes	NB03SED133	3700	Yes	
Southeast	NB03SED124CL	Mercury	µg/kg	NB03CLM124	72.1	Yes	NB03SED124	1790	Yes	
Southeast	NB03SED125CL	Mercury	µg/kg	NB03CLM125	65.3	Yes	NB03SED125	171	Yes	
Southeast	NB03SED127ACL	Mercury	µg/kg	NB03CLM127A	55.3	Yes	NB03SED127A	401	Yes	
Southeast	NB03SED127BCL	Mercury	µg/kg	NB03CLM127B	101	Yes	NB03SED127B	1980	Yes	
Southwest	NB03SED129CL	Mercury	µg/kg	NB03CLM129	213	Yes	NB03SED129	7390	Yes	
Southwest	NB03SED130CL	Mercury	µg/kg	NB03CLM130	78	Yes	NB03SED130	1060	Yes	
Southwest	NB03SED131ACL	Mercury	µg/kg	NB03CLM131A	94.4	Yes	NB03SED131A	618	Yes	
Southwest	NB03SED131BCL	Mercury	µg/kg	NB03CLM131B	67	Yes	NB03SED131B	142	Yes	
Southwest	NB03SED134CL	Mercury	µg/kg	NB03CLM134	95.6	Yes	NB03SED134	1600	Yes	
Southwest	NB03SED135CL	Mercury	µg/kg	NB03CLM135	62.3	Yes	NB03SED135	1420	Yes	
North	NB03SED122ACL	Nickel	mg/kg	NB03CLM122A	2.13	Yes	NB03SED122A	22.7	Yes	
North	NB03SED122BCL	Nickel	mg/kg	NB03CLM122B	2.25	Yes	NB03SED122B	15.7	Yes	
North	NB03SED122CCL	Nickel	mg/kg	NB03CLM122C	2.05	Yes	NB03SED122C	16.4	Yes	
North	NB03SED123ACL	Nickel	mg/kg	NB03CLM123A	3.01	Yes	NB03SED123A	12.4	Yes	
North	NB03SED123BCL	Nickel	mg/kg	NB03CLM123B	1.35	Yes	NB03SED123B	55.4	Yes	
North	NB03SED132ACL	Nickel	mg/kg	NB03CLM132A	4.19	Yes	NB03SED132A	31.3	Yes	
North	NB03SED132BCL	Nickel	mg/kg	NB03CLM132B	2.91	Yes	NB03SED132B	5.89	Yes	
North	NB03SED133CL	Nickel	mg/kg	NB03CLM133	1.88	Yes	NB03SED133	24.1	Yes	
Southeast	NB03SED124CL	Nickel	mg/kg	NB03CLM124	2.56	Yes	NB03SED124	15.7	Yes	
Southeast	NB03SED125CL	Nickel	mg/kg	NB03CLM125	1.79	Yes	NB03SED125	20.6	Yes	
Southeast	NB03SED127ACL	Nickel	mg/kg	NB03CLM127A	2.11	Yes	NB03SED127A	13.2	Yes	
Southeast	NB03SED127BCL	Nickel	mg/kg	NB03CLM127B	1.64	Yes	NB03SED127B	33.9	Yes	
Southwest	NB03SED129CL	Nickel	mg/kg	NB03CLM129	0.4	No	NB03SED129	104	Yes	Regression Outlier[a]
Southwest	NB03SED130CL	Nickel	mg/kg	NB03CLM130	1.51	Yes	NB03SED130	23.5	Yes	
Southwest	NB03SED131ACL	Nickel	mg/kg	NB03CLM131A	1.41	Yes	NB03SED131A	19.3	Yes	
Southwest	NB03SED131BCL	Nickel	mg/kg	NB03CLM131B	1.72	Yes	NB03SED131B	10.3	Yes	
Southwest	NB03SED134CL	Nickel	mg/kg	NB03CLM134	4.99	Yes	NB03SED134	124	Yes	
Southwest	NB03SED135CL	Nickel	mg/kg	NB03CLM135	1.03	Yes	NB03SED135	19.9	Yes	

Notes:
[a]Regression Outliers were excluded from the final regression models for softshell clam.
All tissue concentrations are reported on a wet weight basis.

Acronyms and Abbreviations:
mg/kg = milligrams per kilogram
NBSA = Newark Bay Study Area
PRGs = preliminary remediation goal
µg/kg = micrograms per kilogram

Table B-2
Mercury and Methylmercury in Edible Crab Tissue, American Eel Fillet, and White Perch Fillet and Paired Sediment Concentrations
Appendix B: Regression Models for the Calculation of PRGs for Inorganic Compounds
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
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Species	Tissue Type	Location	Reach	Sampling Event	Tissue Sample ID	Units	Mercury in Tissue		Methylmercury in Tissue		Average Mercury in Sediment	Number of Sediment Samples in Reach	Data Source
							Value	Detect?	Value	Detect?			
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP01	µg/kg	342	Yes	373	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP02	µg/kg	368	Yes	249	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP03	µg/kg	482	Yes	564	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP04	µg/kg	638	Yes	764	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP05	µg/kg	466	Yes	481	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	North	NBSA RI	NB03FAEN-COMP06	µg/kg	635	Yes	700	Yes	1605	104	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC-COMP01	µg/kg	294	Yes	311	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC-COMP02	µg/kg	274	Yes	325	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC-COMP03	µg/kg	249	Yes	284	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC076	µg/kg	511	Yes	513	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC502	µg/kg	205	Yes	194	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southeast	NBSA RI	NB03FAEC508	µg/kg	529	Yes	533	Yes	1805	50	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES-COMP01	µg/kg	184	Yes	184	Yes	3629	90	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES018	µg/kg	199	Yes	329	Yes	3629	90	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES019	µg/kg	193	Yes	334	Yes	3629	90	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES347	µg/kg	396	Yes	418	Yes	3629	90	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES364	µg/kg	264	Yes	252	Yes	3629	90	NBSA RI Data
American eel	Fillet	NBSA	Southwest	NBSA RI	NB03FAES365	µg/kg	172	Yes	170	Yes	3629	90	NBSA RI Data
American eel	Fillet	LPRSA	RM 0-2	2009 Tissue	LPR1-ARFT-Comp01	µg/kg	440	Yes	440	Yes	2215	46	LPRSA BERA
American eel	Fillet	LPRSA	RM 0-2	2009 Tissue	LPR1-ARFT-Comp02	µg/kg	260	Yes	220	Yes	2215	46	LPRSA BERA
American eel	Fillet	LPRSA	RM 0-2	2009 Tissue	LPR1-ARFT-Ind085	µg/kg	340	Yes	380	Yes	2215	46	LPRSA BERA
American eel	Fillet	LPRSA	RM 2-4	2009 Tissue	LPR2-ARFT-Comp04	µg/kg	320	Yes	350	Yes	2601	49	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Comp05	µg/kg	330	Yes	360	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Comp06	µg/kg	280	Yes	310	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Comp20	µg/kg	200	Yes	230	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Ind005	µg/kg	570	Yes	610	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Ind010	µg/kg	530	Yes	520	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-ARFT-Ind014	µg/kg	720	Yes	640	Yes	2506	41	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Comp07	µg/kg	460	Yes	520	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Comp08	µg/kg	290	Yes	360	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Ind022	µg/kg	590	Yes	610	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Ind026	µg/kg	400	Yes	470	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Ind034	µg/kg	320	Yes	340	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-ARFT-Ind044	µg/kg	460	Yes	540	Yes	3417	55	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Comp09	µg/kg	320	Yes	330	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Comp10	µg/kg	280	Yes	320	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Comp12	µg/kg	300	Yes	340	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind021	µg/kg	270	Yes	280	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind030	µg/kg	470	Yes	450	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind040	µg/kg	860	Yes	1100	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind048	µg/kg	510	Yes	610	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind049	µg/kg	530	Yes	640	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-ARFT-Ind086	µg/kg	750	Yes	630	Yes	1872	62	LPRSA BERA
American eel	Fillet	LPRSA	RM 10-12	2009 Tissue	LPR6-ARFT-Ind065	µg/kg	450	Yes	550	Yes	2455	100	LPRSA BERA
American eel	Fillet	LPRSA	RM 10-12	2009 Tissue	LPR6-ARFT-Ind073	µg/kg	280	Yes	230	Yes	2455	100	LPRSA BERA
American eel	Fillet	LPRSA	RM 12-14	2009 Tissue	LPR7-ARFT-Ind071	µg/kg	390	Yes	360	Yes	1356	44	LPRSA BERA
American eel	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-ARFT-Comp14	µg/kg	200	Yes	210	Yes	561	32	LPRSA BERA
American eel	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-ARFT-Comp17	µg/kg	180	Yes	170	Yes	561	32	LPRSA BERA
American eel	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-ARFT-Comp21	µg/kg	160	Yes	190	Yes	561	32	LPRSA BERA
American eel	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-ARFT-Comp22	µg/kg	190	Yes	190	Yes	561	32	LPRSA BERA
American eel	W-H/V	Upper Bay	North	CARP (1999)	2DMR00212	µg/kg	274	Yes			877	11	LPR FFS Paired Data
American eel	W-H/V	Upper Bay	North	CARP (1999)	2DMR00229	µg/kg	301	Yes			877	11	LPR FFS Paired Data
American eel	W-H/V	Upper Bay	North	CARP (1999)	2DMR00240	µg/kg	117	Yes			877	11	LPR FFS Paired Data
American eel	W-H/V	Upper Bay	North	CARP (1999)	2DMR00241	µg/kg	191	Yes	217	Yes	877	11	LPR FFS Paired Data
American eel	W-H/V	Upper Bay	South	CARP (1999)	2DMR00247	µg/kg	233	Yes	275	Yes	1267	31	LPR FFS Paired Data
American eel	W-H/V	Upper Bay	South	CARP (1999)	2DMR00248	µg/kg	152	Yes			1267	31	LPR FFS Paired Data
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00213	µg/kg	167	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00243	µg/kg	264	Yes	327	Yes	645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00249	µg/kg	246	Yes	325	Yes	645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00226	µg/kg	48.6	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00227	µg/kg	182	Yes	168	Yes	645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00239	µg/kg	73.5	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00214	µg/kg	242	Yes			645	2	CARP

Table B-2
Mercury and Methylmercury in Edible Crab Tissue, American Eel Fillet, and White Perch Fillet and Paired Sediment Concentrations
Appendix B: Regression Models for the Calculation of PRGs for Inorganic Compounds
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Species	Tissue Type	Location	Reach	Sampling Event	Tissue Sample ID	Units	Mercury in Tissue		Methylmercury in Tissue		Average Mercury in Sediment	Number of Sediment Samples in Reach	Data Source
							Value	Detect?	Value	Detect?			
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00245	µg/kg	128	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00242	µg/kg	108	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00217	µg/kg	65.2	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00225	µg/kg	79.4	Yes			645	2	CARP
American eel	W-H/V	Hudson River	Haverstraw Bay	CARP (1999)	2DMR00238	µg/kg	110	Yes			645	2	CARP
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRB122-ED	µg/kg	191	Yes	119	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRB123-ED	µg/kg	190	Yes	142	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRB132-ED	µg/kg	130	Yes	93.7	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRB133-ED	µg/kg	160	Yes	156	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR1-ED	µg/kg	142	Yes	184	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR2-ED	µg/kg	224	Yes	235	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR3-ED	µg/kg	177	Yes	180	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR4-ED	µg/kg	154	Yes			1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR5-ED	µg/kg	123	Yes	121	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR6-ED	µg/kg	205	Yes	173	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR7-ED	µg/kg	168	Yes	168	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	North	NBSA RI	NB03CRBNOR8-ED	µg/kg	127	Yes	242	Yes	1605	104	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRB124-ED	µg/kg	159	Yes			1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRB125-ED	µg/kg	134	Yes			1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRB126-ED	µg/kg	175	Yes	267	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRB127-ED	µg/kg	136	Yes	125	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN1-ED	µg/kg	139	Yes	67.1	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN2-ED	µg/kg	179	Yes	182	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN3-ED	µg/kg	137	Yes	101	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN4-ED	µg/kg	130	Yes	261	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN5-ED	µg/kg	158	Yes	129	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN6-ED	µg/kg	174	Yes	174	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN7-ED	µg/kg	146	Yes	122	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBCEN8-ED	µg/kg	155	Yes	158	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southeast	NBSA RI	NB03CRBSOU2-ED	µg/kg	140	Yes	155	Yes	1805	50	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRB129-ED	µg/kg	116	Yes	123	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRB130-ED	µg/kg	98	Yes	134	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRB131-ED	µg/kg	105	Yes	121	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRB134-ED	µg/kg	47.5	Yes	38.3	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU1-ED	µg/kg	134	Yes	115	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU3-ED	µg/kg	117	Yes	222	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU4-ED	µg/kg	138	Yes	136	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU5-ED	µg/kg	112	Yes	179	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU6-ED	µg/kg	108	Yes	228	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU7-ED	µg/kg	104	Yes	190	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU8-ED	µg/kg	123	Yes	169	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	NBSA	Southwest	NBSA RI	NB03CRBSOU9-ED	µg/kg	133	Yes	136	Yes	3629	90	NBSA RI Data
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp01	µg/kg	200	Yes	180	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp02	µg/kg	190	Yes	180	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp03	µg/kg	240	Yes	230	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp04	µg/kg	220	Yes	200	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp06	µg/kg	210	Yes	190	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp07	µg/kg	210	Yes	190	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp11	µg/kg	160	Yes	150	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 0-2	2009 Tissue	LPR1-CSMH-Comp13	µg/kg	190	Yes	190	Yes	2215	46	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp14	µg/kg	160	Yes	150	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp15	µg/kg	230	Yes	210	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp17	µg/kg	180	Yes	160	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp18	µg/kg	170	Yes	160	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp19	µg/kg	250	Yes	200	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 2-4	2009 Tissue	LPR2-CSMH-Comp20	µg/kg	210	Yes	190	Yes	2601	49	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 4-6	2009 Tissue	LPR3-CSMH-Comp24	µg/kg	110	Yes	89	Yes	2506	41	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 4-6	2009 Tissue	LPR3-CSMH-Comp26	µg/kg	120	Yes	97	Yes	2506	41	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 4-6	2009 Tissue	LPR3-CSMH-Comp27	µg/kg	130	Yes	130	Yes	2506	41	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 4-6	2009 Tissue	LPR3-CSMH-Comp28	µg/kg	160	Yes	120	Yes	2506	41	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 6-8	2009 Tissue	LPR4-CSMH-Comp30	µg/kg	120	Yes	120	Yes	3417	55	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 6-8	2009 Tissue	LPR4-CSMH-Comp31	µg/kg	150	Yes	130	Yes	3417	55	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 6-8	2009 Tissue	LPR4-CSMH-Comp32	µg/kg	120	Yes	94	Yes	3417	55	LPRSA BERA

Table B-2
Mercury and Methylmercury in Edible Crab Tissue, American Eel Fillet, and White Perch Fillet and Paired Sediment Concentrations
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Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Species	Tissue Type	Location	Reach	Sampling Event	Tissue Sample ID	Units	Mercury in Tissue		Methylmercury in Tissue		Average Mercury in Sediment	Number of Sediment Samples in Reach	Data Source
							Value	Detect?	Value	Detect?			
Blue crab	Muscle/hepatopancreas	LPRSA	RM 6-8	2009 Tissue	LPR4-CSMH-Comp33	µg/kg	160	Yes	140	Yes	3417	55	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 8-10	2009 Tissue	LPR5-CSMH-Comp34	µg/kg	99	Yes	74	Yes	1872	62	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 8-10	2009 Tissue	LPR5-CSMH-Comp35	µg/kg	110	Yes	97	Yes	1872	62	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 10-12	2009 Tissue	LPR6-CSMH-Comp37	µg/kg	110	Yes	99	Yes	2455	100	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 10-12	2009 Tissue	LPR6-CSMH-Comp38	µg/kg	120	Yes	100	Yes	2455	100	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 10-12	2009 Tissue	LPR6-CSMH-Comp41	µg/kg	110	Yes	100	Yes	2455	100	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 10-12	2009 Tissue	LPR6-CSMH-Comp42	µg/kg	110	Yes	110	Yes	2455	100	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 10-12	2009 Tissue	LPR6-CSMH-Comp44	µg/kg	120	Yes	110	Yes	2455	100	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp45	µg/kg	85	Yes	80	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp46	µg/kg	72	Yes	71	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp48	µg/kg	69	Yes	69	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp49	µg/kg	100	Yes	95	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp50	µg/kg	71	Yes	73	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 12-14	2009 Tissue	LPR7-CSMH-Comp53	µg/kg	110	Yes	110	Yes	1356	44	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp54	µg/kg	96	Yes	89	Yes	561	32	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp55	µg/kg	77	Yes	66	Yes	561	32	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp56	µg/kg	96	Yes	91	Yes	561	32	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp57	µg/kg	120	Yes	140	Yes	561	32	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp58	µg/kg	85	Yes	72	Yes	561	32	LPRSA BERA
Blue crab	Muscle/hepatopancreas	LPRSA	RM 14-16	2009 Tissue	LPR8-CSMH-Comp61	µg/kg	100	Yes	100	Yes	561	32	LPRSA BERA
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR00994	µg/kg	90.5	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR00995	µg/kg	69.8	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR00998	µg/kg	63.1	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR00999	µg/kg	47.3	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR01000	µg/kg	90.3	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 3.0	CARP (1999)	2DMR01001	µg/kg	98.7	Yes			2127		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 2.8	CARP (1999)	2DMR01002	µg/kg	83.2	Yes			2128		LPR FFS Paired Data
Blue crab	Edible Tissue	LPRSA	RM 2.8	CARP (1999)	2DMR01003	µg/kg	118	Yes			2128		LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00792	µg/kg	96.4	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00801	µg/kg	60.5	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00802	µg/kg	63.3	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00864	µg/kg	44.9	Yes	31.4	Yes	877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00865	µg/kg	57.4	Yes	46.8	Yes	877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00896	µg/kg	48.1	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00897	µg/kg	60	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00898	µg/kg	66	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00899	µg/kg	29.6	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Upper Bay	North	CARP (1999)	2DMR00900	µg/kg	47.9	Yes			877	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00775	µg/kg	73	Yes	47.7	Yes	834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00776	µg/kg	28.7	Yes	23.7	Yes	834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00779	µg/kg	114	Yes			834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00780	µg/kg	33.3	Yes			834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00930	µg/kg	30.1	Yes			834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Raritan Bay	Middle	CARP (1999)	2DMR00931	µg/kg	109	Yes			834	11	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00805	µg/kg	52.4	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00806	µg/kg	51.7	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00815	µg/kg	42.7	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00816	µg/kg	89.3	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00819	µg/kg	55.7	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	East	CARP (1999)	2DMR00820	µg/kg	42.6	Yes			458	13	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	Middle	CARP (1999)	2DMR01008	µg/kg	71.2	Yes			305	23	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	Middle	CARP (1999)	2DMR01009	µg/kg	77.3	Yes			305	23	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	Middle	CARP (1999)	2DMR01010	µg/kg	76.2	Yes	43.9	Yes	305	23	LPR FFS Paired Data
Blue crab	Edible Tissue	Jamaica Bay	Middle	CARP (1999)	2DMR01011	µg/kg	60.2	Yes	49.5	Yes	305	23	LPR FFS Paired Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Gerritsen Creek	2014	FRZGCBC-R-001-20140826-HM	µg/kg	25.6	Yes	26.7	Yes	550	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Gerritsen Creek	2014	FRZGCBC-R-002-20140826-HM	µg/kg	31.1	Yes	25.3	Yes	550	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Gerritsen Creek	2014	FRZGCBC-R-003-20140826-HM	µg/kg	25.1	Yes	28.2	Yes	550	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Gerritsen Creek	2014	FRZGCBC-R-004-20140820-HM	µg/kg	35.2	Yes	30.8	Yes	550	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Gerritsen Creek	2014	FRZGCBC-R-005-20140826-HM	µg/kg	42.9	Yes	51.6	Yes	550	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Head of Bay	2014	FRZHBBC-R-001-20140829-HM	µg/kg	21.3	Yes	25.8	Yes	355	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Head of Bay	2014	FRZHBBC-R-002-20140829-HM	µg/kg	43.1	Yes	32.9	Yes	355	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Head of Bay	2014	FRZHBBC-R-003-20140829-HM	µg/kg	38.5	Yes	27.8	Yes	355	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Head of Bay	2014	FRZHBBC-R-004-20140828-HM	µg/kg	26.8	Yes	26.7	Yes	355	8	Newtown Creek RI Data

Table B-2
Mercury and Methylmercury in Edible Crab Tissue, American Eel Fillet, and White Perch Fillet and Paired Sediment Concentrations
Appendix B: Regression Models for the Calculation of PRGs for Inorganic Compounds
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Species	Tissue Type	Location	Reach	Sampling Event	Tissue Sample ID	Units	Mercury in Tissue		Methylmercury in Tissue		Average Mercury in Sediment	Number of Sediment Samples in Reach	Data Source
							Value	Detect?	Value	Detect?			
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Head of Bay	2014	FRZHBBC-R-005-20140829-HM	µg/kg	31.4	Yes	28.4	Yes	355	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Spring Creek	2014	FRZSPBC-R-001-20140829-HM	µg/kg	31.4	Yes	26.0	Yes	300	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Spring Creek	2014	FRZSPBC-R-002-20140829-HM	µg/kg	31.6	Yes	36.4	Yes	300	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Spring Creek	2014	FRZSPBC-R-003-20140829-HM	µg/kg	32.6	Yes	33.0	Yes	300	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Spring Creek	2014	FRZSPBC-R-004-20140829-HM	µg/kg	40.2	Yes	44.8	Yes	300	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Spring Creek	2014	FRZSPBC-R-005-20140829-HM	µg/kg	39.9	Yes	31.6	Yes	300	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Westchester Creek	2014	FRZWEBC-R-001-20140814-HM	µg/kg	40.8	Yes	29.0	Yes	1249	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Westchester Creek	2014	FRZWEBC-R-002-20140814-HM	µg/kg	36.6	Yes	27.3	Yes	1249	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Westchester Creek	2014	FRZWEBC-R-004-20140814-HM	µg/kg	41.1	Yes	26.9	Yes	1249	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Westchester Creek	2014	FRZWEBC-R-005-20140814-HM	µg/kg	48.8	Yes	38.4	Yes	1249	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	NC RI Reference Areas	Westchester Creek	2014	FRZWEBC-R-006-20140814-HM	µg/kg	64.2	Yes	53.9	Yes	1249	8	Newtown Creek RI Data
Blue crab	Muscle/hepatopancreas	Bellmans Creek	Primary Subtidal Chan	2010	BTA-B202	µg/kg	215	Yes	185	Yes	3573	19	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Bellmans Creek	Primary Subtidal Chan	2010	BTA-B203	µg/kg	151	Yes	126	Yes	3573	19	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Bellmans Creek	Primary Subtidal Chan	2010	BTA-B204	µg/kg	98.6	Yes	205	Yes	3573	19	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Bellmans Creek	Primary Subtidal Chan	2010	BTA-B205	µg/kg	89.1	Yes	233	Yes	3573	19	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Mill Creek	Primary Channel	2010	BTA-M201	µg/kg	114	Yes	162	Yes	1763	8	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Mill Creek	Primary Channel	2010	BTA-M202	µg/kg	108	Yes	258	Yes	1763	8	Berry's Creek RI Data
Blue crab	Muscle/hepatopancreas	Mill Creek	Primary Channel	2010	BTA-M203	µg/kg	140	Yes	211	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP07	µg/kg	161	Yes	269	Yes	1605	104	NBSA RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP08	µg/kg	199	Yes	224	Yes	1605	104	NBSA RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP09	µg/kg	320	Yes	473	Yes	1605	104	NBSA RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP10	µg/kg	175	Yes	175	Yes	1605	104	NBSA RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP11	µg/kg	246	Yes			1605	104	NBSA RI Data
White perch	Fillet	NBSA	North	NBSA RI	NB03FWPN-COMP12	µg/kg	364	Yes	463.5	Yes	1605	104	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP07	µg/kg	195	Yes	317	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP08	µg/kg	341	Yes	421	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP09	µg/kg	359	Yes	489	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP10	µg/kg	354	Yes	438	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP11	µg/kg	264	Yes	366	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southeast	NBSA RI	NB03FWPC-COMP12	µg/kg	429.5	Yes	657	Yes	1805	50	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP07	µg/kg	326	Yes	440	Yes	3629	90	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP08	µg/kg	208	Yes	210	Yes	3629	90	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP09	µg/kg	133	Yes	153	Yes	3629	90	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP10	µg/kg	224	Yes	253	Yes	3629	90	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP11	µg/kg	213	Yes			3629	90	NBSA RI Data
White perch	Fillet	NBSA	Southwest	NBSA RI	NB03FWPS-COMP12	µg/kg	328	Yes	283	Yes	3629	90	NBSA RI Data
White perch	Fillet	LPRSA	RM 0-2	2009 Tissue	LPR1-MAFT-Comp01	µg/kg	320	Yes	170	Yes	2215	46	LPRSA BERA
White perch	Fillet	LPRSA	RM 0-2	2009 Tissue	LPR1-MAFT-Ind145	µg/kg	700	Yes	300	Yes	2215	46	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp02	µg/kg	210	Yes	110	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp03	µg/kg	160	Yes	90	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp04	µg/kg	210	Yes	120	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp05	µg/kg	190	Yes	100	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp07	µg/kg	260	Yes	150	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp08	µg/kg	170	Yes	96	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 4-6	2009 Tissue	LPR3-MAFT-Comp13	µg/kg	160	Yes	120	Yes	2506	41	LPRSA BERA
White perch	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-MAFT-Comp16	µg/kg	260	Yes	130	Yes	3417	55	LPRSA BERA
White perch	Fillet	LPRSA	RM 6-8	2009 Tissue	LPR4-MAFT-Comp17	µg/kg	240	Yes	120	Yes	3417	55	LPRSA BERA
White perch	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-MAFT-Comp20	µg/kg	300	Yes	180	Yes	1872	62	LPRSA BERA
White perch	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-MAFT-Comp21	µg/kg	180	Yes	120	Yes	1872	62	LPRSA BERA
White perch	Fillet	LPRSA	RM 8-10	2009 Tissue	LPR5-MAFT-Comp22	µg/kg	170	Yes	85	Yes	1872	62	LPRSA BERA
White perch	Fillet	LPRSA	RM 10-12	2009 Tissue	LPR6-MAFT-Comp24	µg/kg	460	Yes	380	Yes	2455	100	LPRSA BERA
White perch	Fillet	LPRSA	RM 10-12	2009 Tissue	LPR6-MAFT-Ind122	µg/kg	740	Yes	550	Yes	2455	100	LPRSA BERA
White perch	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-MAFT-Comp26	µg/kg	150	Yes	150	Yes	561	32	LPRSA BERA
White perch	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-MAFT-Comp27	µg/kg	190	Yes	110	Yes	561	32	LPRSA BERA
White perch	Fillet	LPRSA	RM 14-16	2009 Tissue	LPR8-MAFT-Comp31	µg/kg	320	Yes	190	Yes	561	32	LPRSA BERA
White perch	Fillet	Upper Bay	North	CARP (1999)	2DMR00207	µg/kg	319	Yes	344	Yes	877	11	LPR FFS Paired Data
White perch	Fillet	Upper Bay	North	CARP (1999)	2DMR00370	µg/kg	378	Yes			877	11	LPR FFS Paired Data
White perch	Fillet	Upper Bay	North	CARP (1999)	2DMR00371	µg/kg	182	Yes			877	11	LPR FFS Paired Data
White perch	Fillet	Upper Bay	North	CARP (1999)	2DMR00374	µg/kg	220	Yes			877	11	LPR FFS Paired Data
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00385	µg/kg	160	Yes			1224	7	LPR FFS Paired Data
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00386	µg/kg	131	Yes			1224	7	LPR FFS Paired Data
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00387	µg/kg	163	Yes			1224	7	LPR FFS Paired Data
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00390	µg/kg	319	Yes			1224	7	LPR FFS Paired Data

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Diamond Alkali Superfund Site
Newark Bay Study Area

Species	Tissue Type	Location	Reach	Sampling Event	Tissue Sample ID	Units	Mercury in Tissue		Methylmercury in Tissue		Average Mercury in Sediment	Number of Sediment Samples in Reach	Data Source
							Value	Detect?	Value	Detect?			
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00392	µg/kg	181	Yes			1224	7	LPR FFS Paired Data
White perch	Fillet	Raritan Bay	West	CARP (1999)	2DMR00393	µg/kg	160	Yes			1224	7	LPR FFS Paired Data
White perch	Fillet	NC RI Reference Areas	Westchester Creek	2014 Fish/Crab	2200-U0-FRZWEWP-F1-20140610	µg/kg	97.7	Yes	64.1	Yes	1249	8	Newtown Creek RI Data
White perch	Fillet	NC RI Reference Areas	Westchester Creek	2014 Fish/Crab	2200-U0-FRZWEWP-F2-20140611	µg/kg	50.5	Yes	54.2	Yes	1249	8	Newtown Creek RI Data
White perch	Fillet	NC RI Reference Areas	Westchester Creek	2014 Fish/Crab	2200-U0-FRZWEWP-F3-20140610	µg/kg	88.2	Yes	89.9	Yes	1249	8	Newtown Creek RI Data
White perch	Fillet	NC RI Reference Areas	Westchester Creek	2014 Fish/Crab	2200-U0-FRZWEWP-F4-20140610	µg/kg	114	Yes	118	Yes	1249	8	Newtown Creek RI Data
White perch	Fillet	NC RI Reference Areas	Westchester Creek	2014 Fish/Crab	2200-U0-FRZWEWP-F5-20140610	µg/kg	84.9	Yes	81.4	Yes	1249	8	Newtown Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-201-11220	µg/kg	220	Yes	19	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-201-12205	µg/kg	250	Yes	210	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-201-13211	µg/kg	230	Yes	370	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-201-15222	µg/kg	220	Yes	210	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-202-11221	µg/kg	200	Yes	17	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-202-12206	µg/kg	230	Yes	210	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-202-13211	µg/kg	260	Yes	390	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-202-15223	µg/kg	180	Yes	180	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-203-11220	µg/kg	150	Yes	150	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-203-12206	µg/kg	260	Yes	230	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-203-13211	µg/kg	200	Yes	270	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-203-15224	µg/kg	170	Yes	180	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-204-11224	µg/kg	160	Yes	150	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-204-12206	µg/kg	220	Yes	200	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-204-13211	µg/kg	210	Yes	310	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-204-15225	µg/kg	260	Yes	190	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-205-11227	µg/kg	350	Yes	310	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-205-12206	µg/kg	190	Yes	170	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-205-13212	µg/kg	260	Yes	360	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-205-15225	µg/kg	200	Yes	150	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-206-11221	µg/kg	210	Yes	170	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-206-12208	µg/kg	270	Yes	260	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-206-13211	µg/kg	290	Yes	420	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-206-15225	µg/kg	52	Yes	220	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-207-11227	µg/kg	190	Yes	150	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-207-12206	µg/kg	300	Yes	240	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-207-13211	µg/kg	160	Yes	300	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-207-15225	µg/kg	200	Yes	180	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-208-11224	µg/kg	190	Yes	140	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-208-12206	µg/kg	290	Yes	230	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-208-13213	µg/kg	210	Yes	310	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-208-15222	µg/kg	220	Yes	160	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-209-11224	µg/kg	160	Yes	130	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-209-12205	µg/kg	210	Yes	130	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-209-13212	µg/kg	220	Yes	300	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-209-15222	µg/kg	190	Yes	190	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2011 Baseline Biota	BBMWP-210-11227	µg/kg	210	Yes	160	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2012 Baseline Biota	BBMWP-210-12205	µg/kg	250	Yes	190	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2013 Baseline Biota	BBMWP-210-13211	µg/kg	180	Yes	270	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	2015	BBMWP-210-15226	µg/kg	140	Yes	160	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	Biota	BWF-M201-10229	µg/kg	290	Yes	210	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	Biota	BWF-M202-10230	µg/kg	420	Yes	220	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Mill Creek	Primary Channel	Biota	BWF-M203-10230	µg/kg	390	Yes	200	Yes	1763	8	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-301-11221	µg/kg	480	Yes	300	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-301-12208	µg/kg	250	Yes	230	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-301-13218	µg/kg	230	Yes	360	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-301-15223	µg/kg	270	Yes	270	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-302-11222	µg/kg	350	Yes	200	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-302-12208	µg/kg	280	Yes	280	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-302-13220	µg/kg	290	Yes	440	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-302-15226	µg/kg	310	Yes	280	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-303-11221	µg/kg	220	Yes	170	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-303-12208	µg/kg	300	Yes	270	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-303-13218	µg/kg	220	Yes	340	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-303-15232	µg/kg	200	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-304-11222	µg/kg	190	Yes	160	Yes	3573	19	Berry's Creek RI Data

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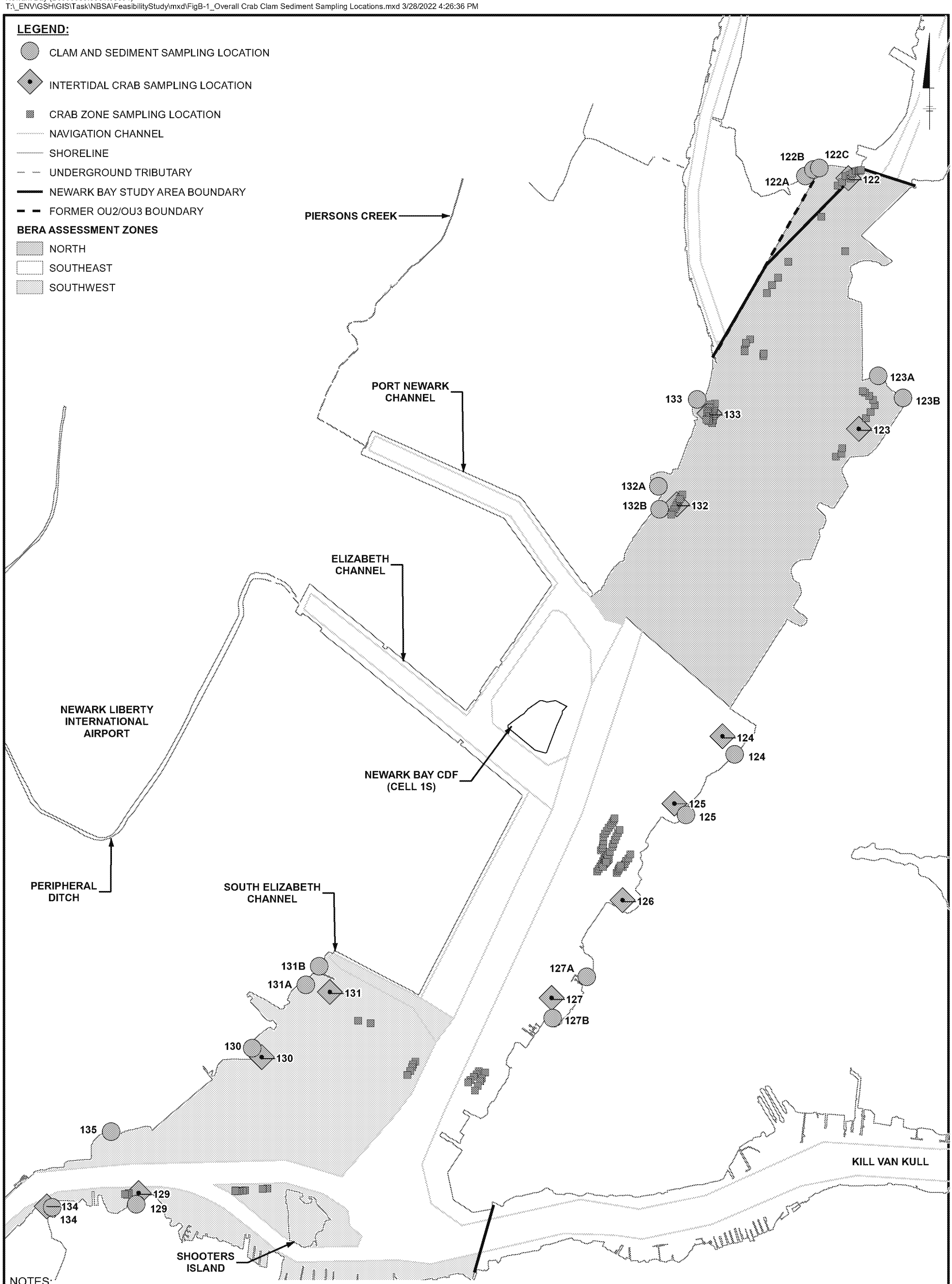
							Value	Detect?	Value	Detect?			
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-304-12208	µg/kg	250	Yes	220	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-304-13218	µg/kg	190	Yes	270	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-304-15236	µg/kg	200	Yes	240	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-305-11221	µg/kg	170	Yes	88	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-305-12208	µg/kg	310	Yes	260	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-305-13218	µg/kg	260	Yes	340	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-305-15232	µg/kg	200	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-306-11222	µg/kg	230	Yes	170	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-306-12208	µg/kg	350	Yes	300	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-306-13218	µg/kg	250	Yes	430	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-306-15230	µg/kg	230	Yes	190	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-307-11222	µg/kg	210	Yes	180	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-307-12208	µg/kg	210	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-307-13218	µg/kg	280	Yes	340	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-307-15232	µg/kg	160	Yes	160	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-308-11222	µg/kg	220	Yes	140	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-308-12208	µg/kg	280	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-308-13218	µg/kg	270	Yes	390	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-308-15230	µg/kg	200	Yes	180	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2011 Baseline Biota	BBMWP-309-11222	µg/kg	260	Yes	150	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2012 Baseline Biota	BBMWP-309-12212	µg/kg	220	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-309-13232	µg/kg	260	Yes	360	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-309-15230	µg/kg	260	Yes	200	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-310-13231	µg/kg	340	Yes	480	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-310-15236	µg/kg	180	Yes	190	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-311-13232	µg/kg	200	Yes	300	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-311-15232	µg/kg	190	Yes	190	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-312-13231	µg/kg	180	Yes	260	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-312-15232	µg/kg	170	Yes	120	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-313-13217	µg/kg	250	Yes	380	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-313-15237	µg/kg	190	Yes	170	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-314-13217	µg/kg	230	Yes	300	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-314-15237	µg/kg	310	Yes	290	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-315-13231	µg/kg	220	Yes	270	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-315-15231	µg/kg	210	Yes	160	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-316-13217	µg/kg	250	Yes	360	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-317-15237	µg/kg	210	Yes	170	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-318-15231	µg/kg	200	Yes	140	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-319-13217	µg/kg	230	Yes	260	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2013 Baseline Biota	BBMWP-320-13217	µg/kg	200	Yes	330	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	2015	BBMWP-320-15237	µg/kg	110	Yes	110	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	Biota	BWF-B201-10237	µg/kg	390	Yes	110	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	Biota	BWF-B202-10232	µg/kg	370	Yes	290	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	Biota	BWF-B203-10231	µg/kg	340	Yes	210	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	Biota	BWF-B204-10237	µg/kg	330	Yes	280	Yes	3573	19	Berry's Creek RI Data
White perch	Fillet	Bellmans Creek	Primary Subtidal Chan	Biota	BWF-B205-10232	µg/kg	360	Yes	280	Yes	3573	19	Berry's Creek RI Data

Notes:
All tissue concentrations are reported on a wet weight basis.

Acronyms and Abbreviations:
BERA = Baseline Ecological Risk Assessment
CARP = Contaminant Assessment and Reduction Program
FFS = focused feasibility study
LPR = Lower Passaic River
LPRSA = Lower Passaic River Study Area
mg/kg = milligrams per kilogram
NBSA = Newark Bay Study Area
NC = Newtown Creek
PRGs = preliminary remediation goal
RI = remedial investigation
µg/kg = micrograms per kilogram
W-H/V = whole body with head and viscera removed

Figures



NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. THE GRAY SQUARES REPRESENT LOCATIONS WHERE CRAB TRAPS WERE PLACED TO COLLECT INDIVIDUAL CRABS TO COMPRISE THE COMPOSITE CRAB ZONE SAMPLED (NEWARK BAY NORTH, CENTRAL, AND SOUTH). COMPOSITE CRAB ZONE SAMPLES WERE NOT GEOREFERENCED AND ARE NOT SHOWN ON THIS FIGURE. THE GREEN DIAMONDS REPRESENT INTERTIDAL CRAB SAMPLE LOCATIONS THAT WERE GEOREFERENCED.
4. ZONES WERE ADDED TO THE BIOTA SAMPLING PROGRAM TO CONFIRM ADEQUATE COVERAGE AND DO NOT REPRESENT DECISION UNITS.
5. THE NEWARK BAY STUDY AREA BOUNDARY WAS USEPA APPROVED AND UTILIZED IN THE PHASE I, II, AND III SEDIMENT INVESTIGATIONS. IN APRIL 2020, USEPA REVISED THE BOUNDARY BETWEEN OU2 AND OU3 SUCH THAT KEARNY POINT IS ENTIRELY INCLUDED IN OU2 (USEPA 2020), AS SHOWN. THE BOUNDARY MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.
6. REFERENCE:
   A. USEPA. 2020. DIAMOND ALKALI SUPERFUND SITE - BOUNDARY BETWEEN OPERABLE UNIT 2 AND OPERABLE UNIT 3. MEMORANDUM FROM MICHAEL SIVAK, BRANCH CHIEF OF PASSAIC, HACKENSACK, AND NEWARK BAY REMEDIATION BRANCH TO FILE. APRIL 6.

0 2,500 5,000 Feet
GRAPHIC SCALE

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
FEASIBILITY STUDY REPORT

CRAB, CLAM, AND SEDIMENT SAMPLING LOCATIONS

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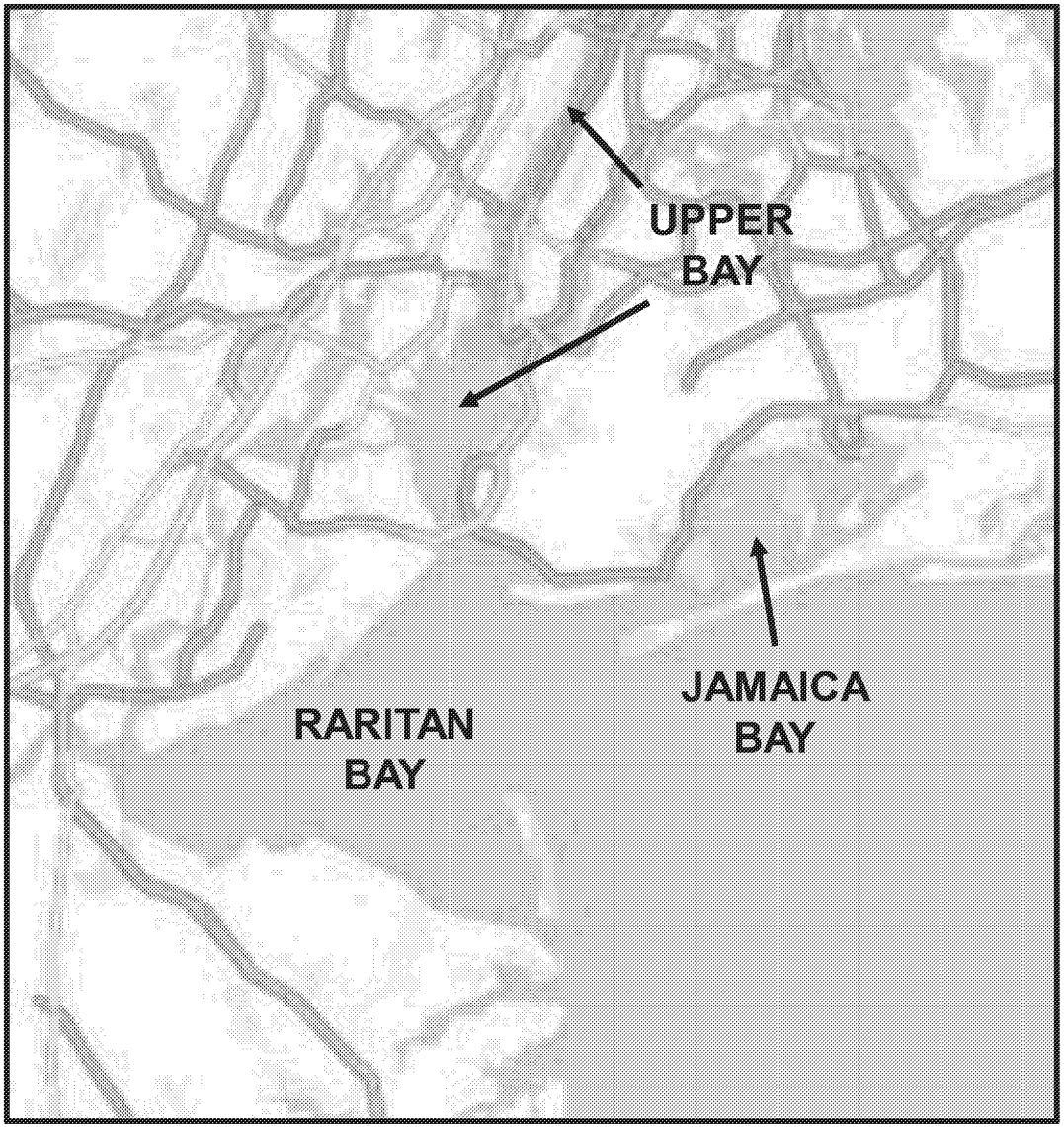
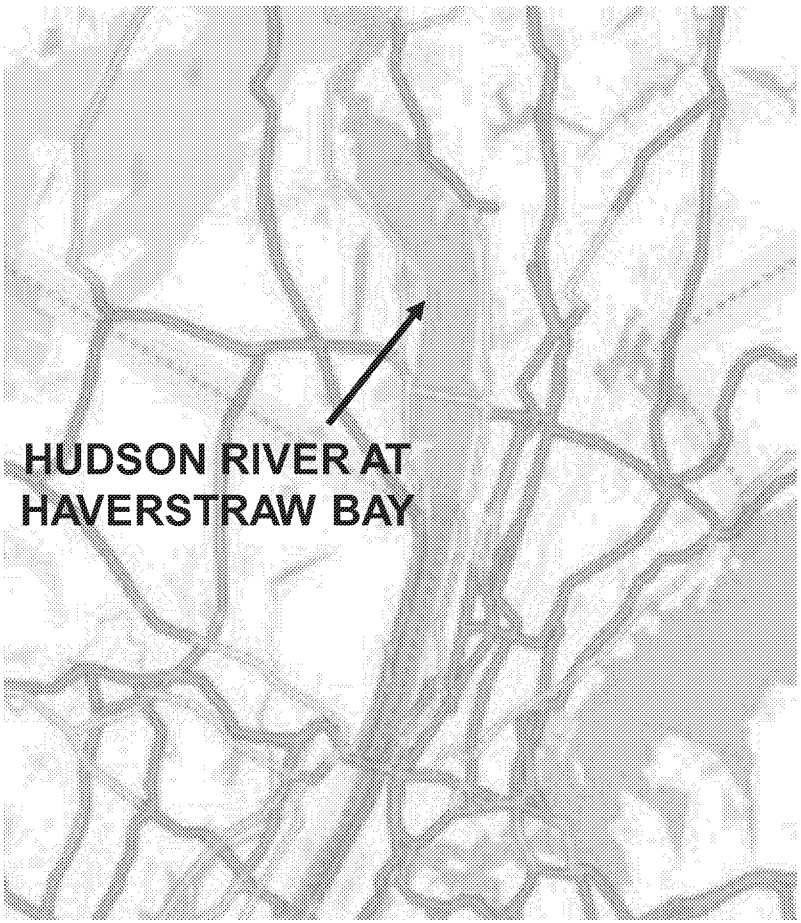
FIGURE
B-1





Reference:

NYSDEC. 2004. Mercury, Methylmercury, Cadmium and Lead in Five Fish Species, Blue Crabs, Invertebrates and Zooplankton from the New York-New Jersey Harbor Estuary. New York State Department of Environmental Conservation.

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DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

BIOTA SAMPLING AREAS FROM THE CONTAMINANT ASSESSMENT AND REDUCTION PROGRAM

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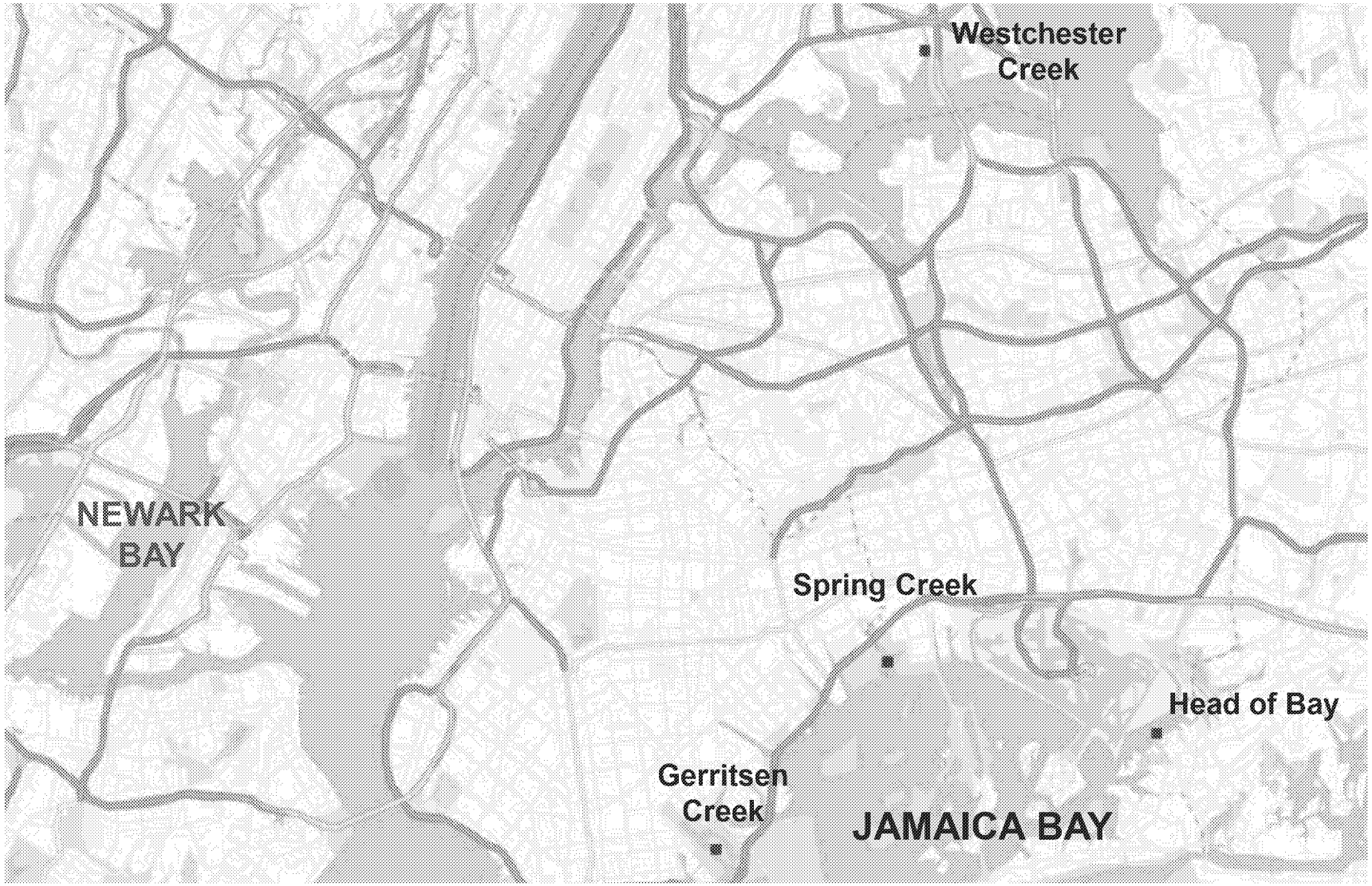
FIGURE
B-2



Reference Biota Sampling Area

Reference:

Anchor QEA. 2017. Baseline Human Health Risk Assessment. Remedial Investigation/Feasibility Study. Newtown Creek. June. Available at newtowncreek.com.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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BIOTA SAMPLING REFERENCE AREAS: NEWTOWN CREEK RI

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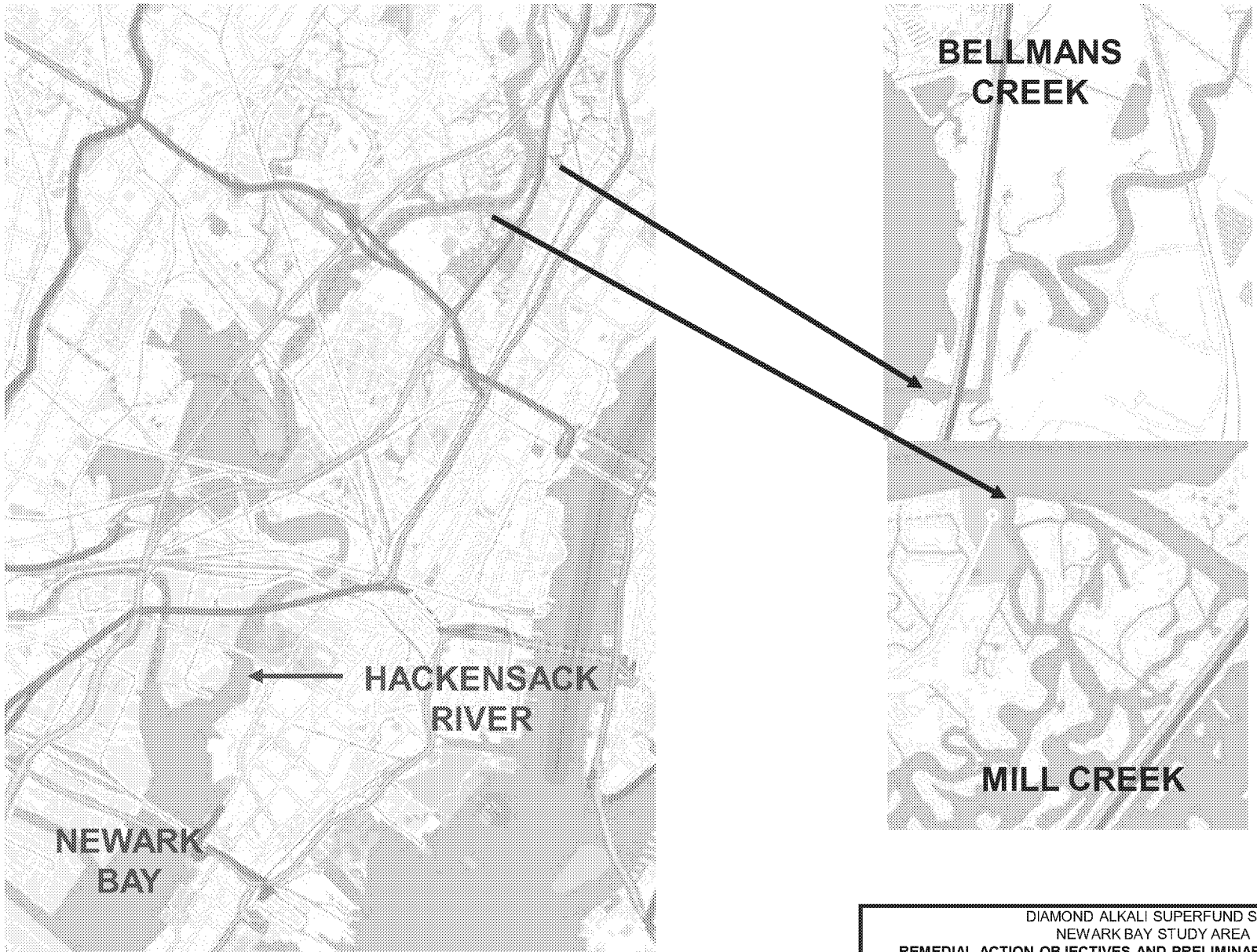
FIGURE
B-3



Reference:

BCSA Group. 2018. Final Remedial Investigation Report. Berry's Creek Study Area. Berry's Creek Cooperating Parties Group. August. Available at berryscreekstudyarea.com.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

BIOTA SAMPLING REFERENCE AREAS:
BERRY'S CREEK RI

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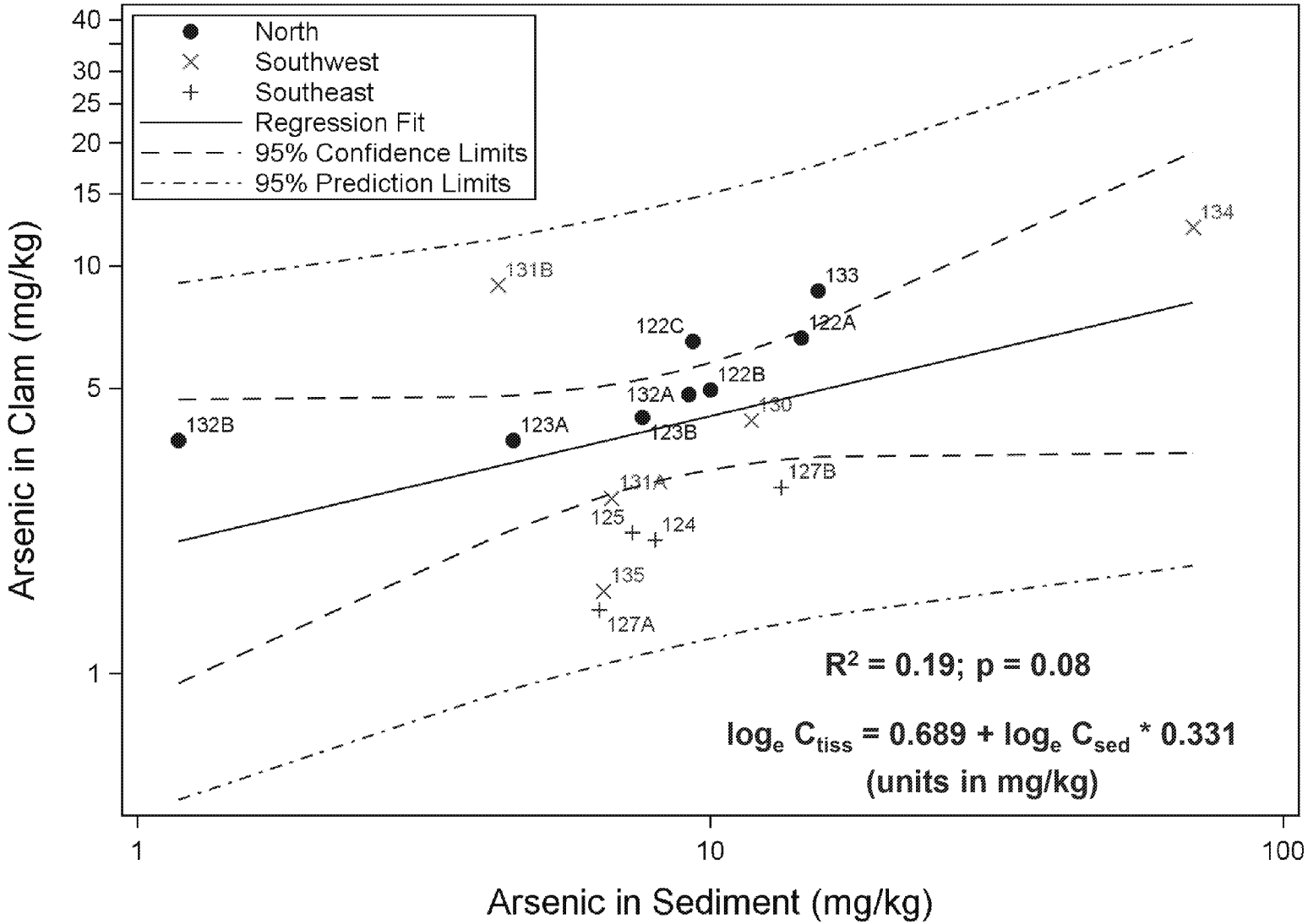
FIGURE
B-4



Notes:
Data shown are from co-located softshell clam and sediment samples collected in the Newark Bay Study Area in 2014 (Tierra 2014a; GSH 2017a). An outlier at station 129 was removed from the data set.

C_{tiss} = concentration in tissue
C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
mg/kg = milligrams per kilogram
R^2 = coefficient of determination
p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

BIOACCUMULATION REGRESSION:
ARSENIC IN SOFTSHELL CLAM

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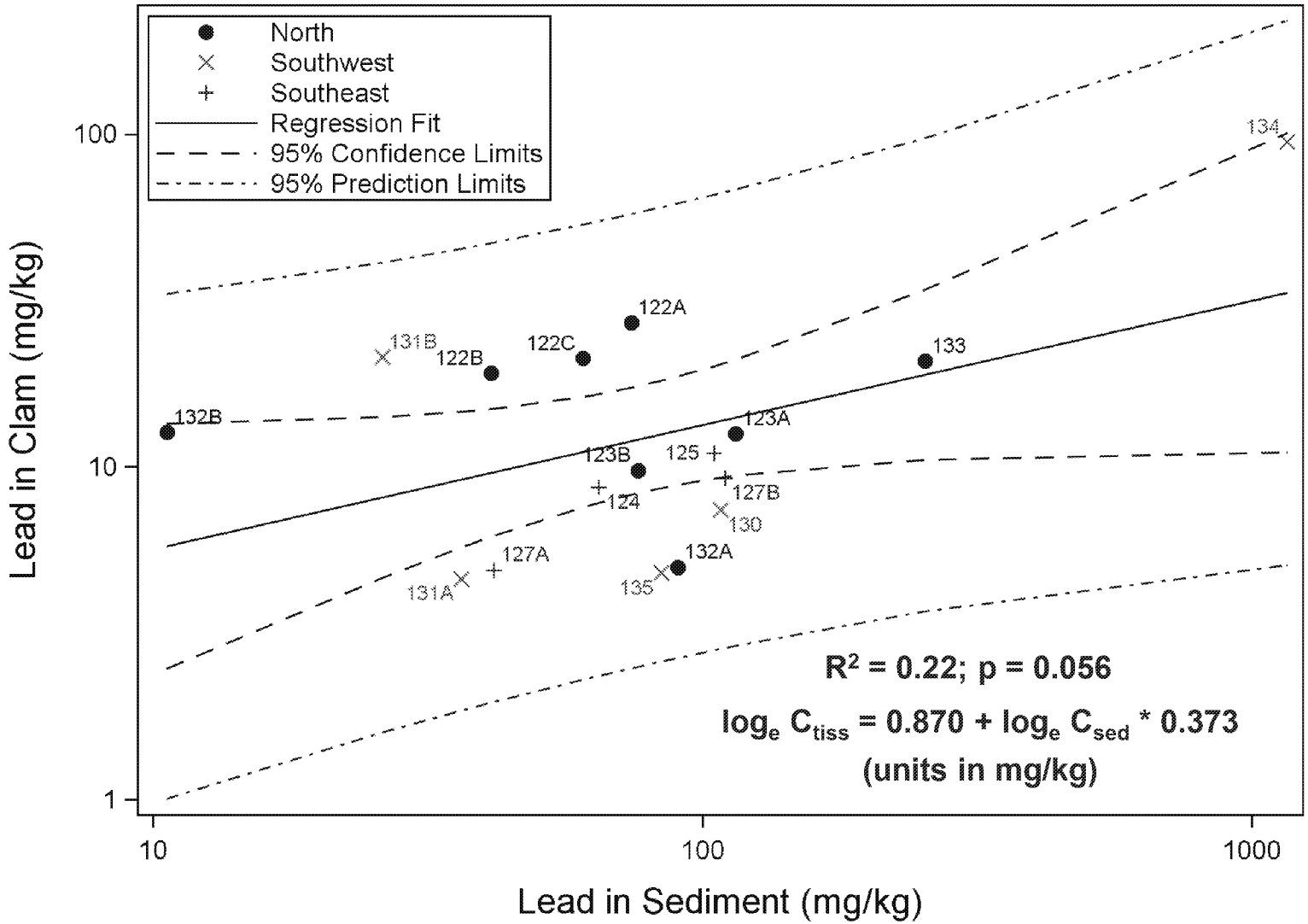
FIGURE
B-5



Notes:
Data shown are from co-located softshell clam and sediment samples collected in the Newark Bay Study Area in 2014 (Tierra 2014a; GSH 2017a). An outlier at station 129 was removed from the data set.

C_{tiss} = concentration in tissue
C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
mg/kg = milligrams per kilogram
R^2 = coefficient of determination
p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

BIOACCUMULATION REGRESSION:
LEAD IN SOFTSHELL CLAM

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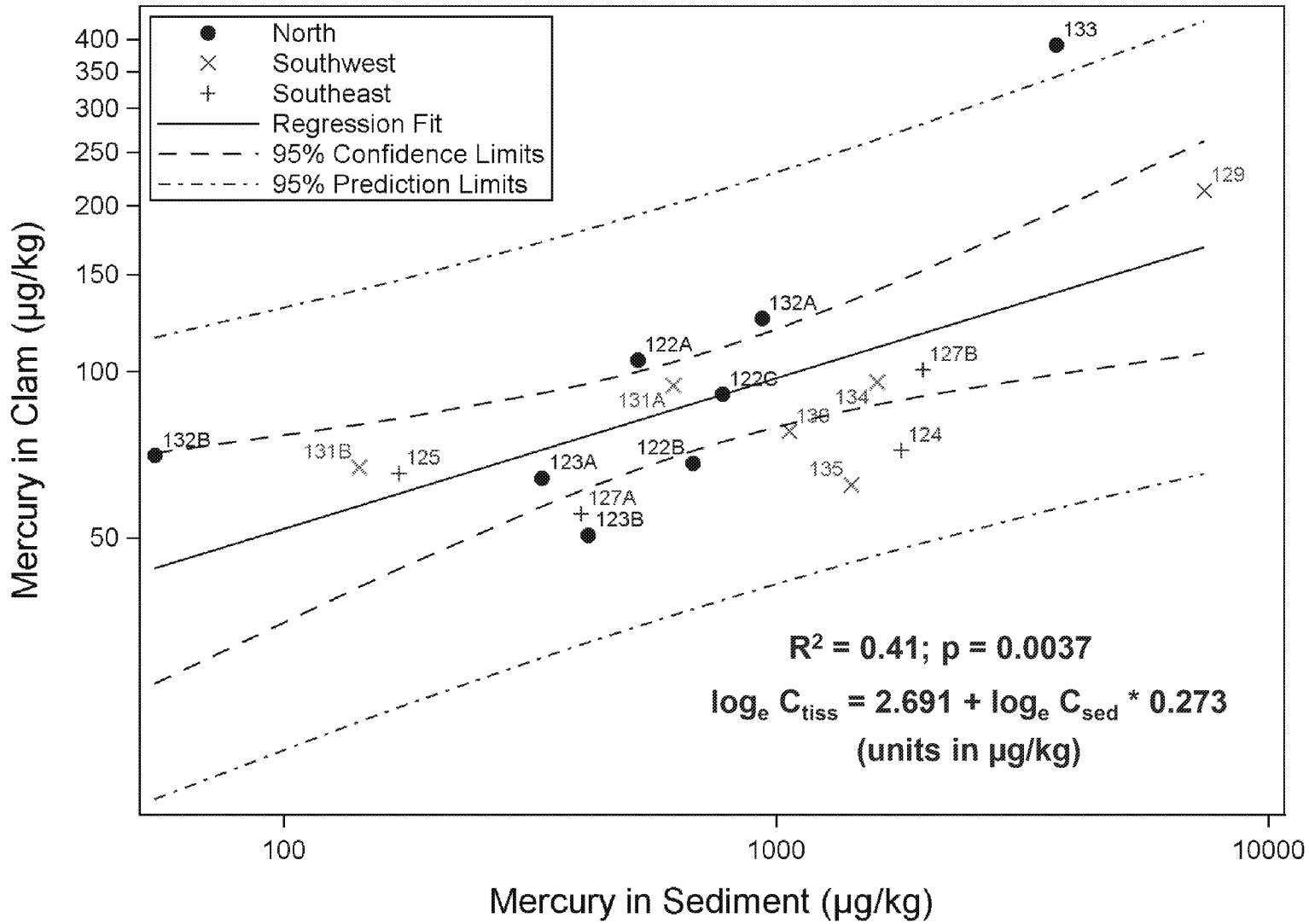
FIGURE
B-6



Notes:
Data shown are from co-located softshell clam and sediment samples collected in the Newark Bay Study Area in 2014 (Tierra 2014a; GSH 2017a).

C_{tiss} = concentration in tissue
C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
µg/kg = microrams per kilogram
R^2 = coefficient of determination
p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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BIOACCUMULATION REGRESSION:
MERCURY IN SOFTSHELL CLAM

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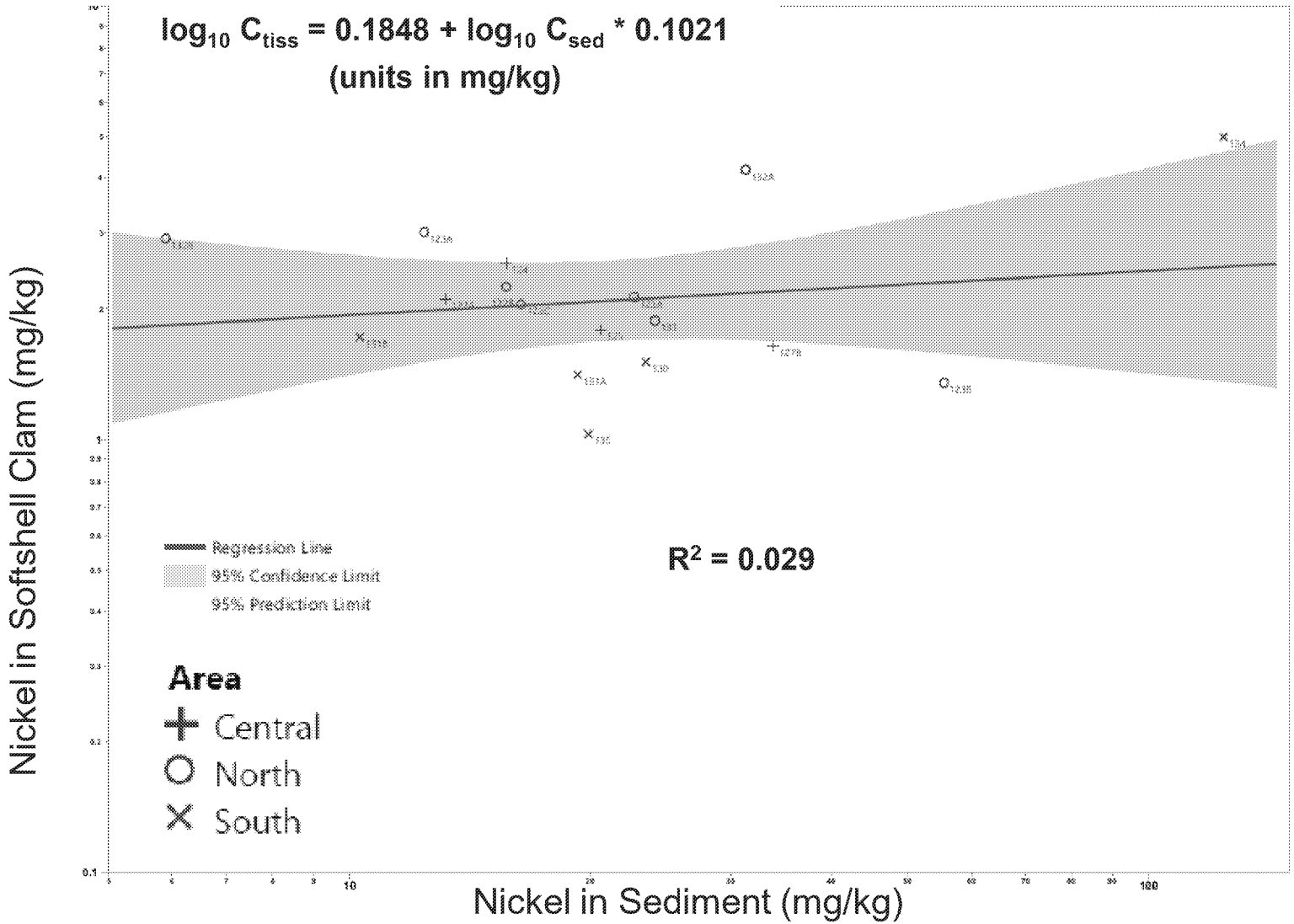
FIGURE
B-7



Notes:
Data shown are from co-located softshell clam and sediment samples collected in the Newark Bay Study Area in 2014 (Tierra 2014a; GSH 2017a). Station 129 excluded as nickel was not detected in clam tissue. Modelling for nickel was conducted by USEPA (WSP 2020).

C_{tiss} = concentration in tissue
C_{sed} = concentration in sediment
$\log_{10}$ = base 10 logarithm
mg/kg = milligrams per kilogram
R^2 = coefficient of determination

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

BIOACCUMULATION REGRESSION:
NICKEL IN SOFTSHELL CLAM

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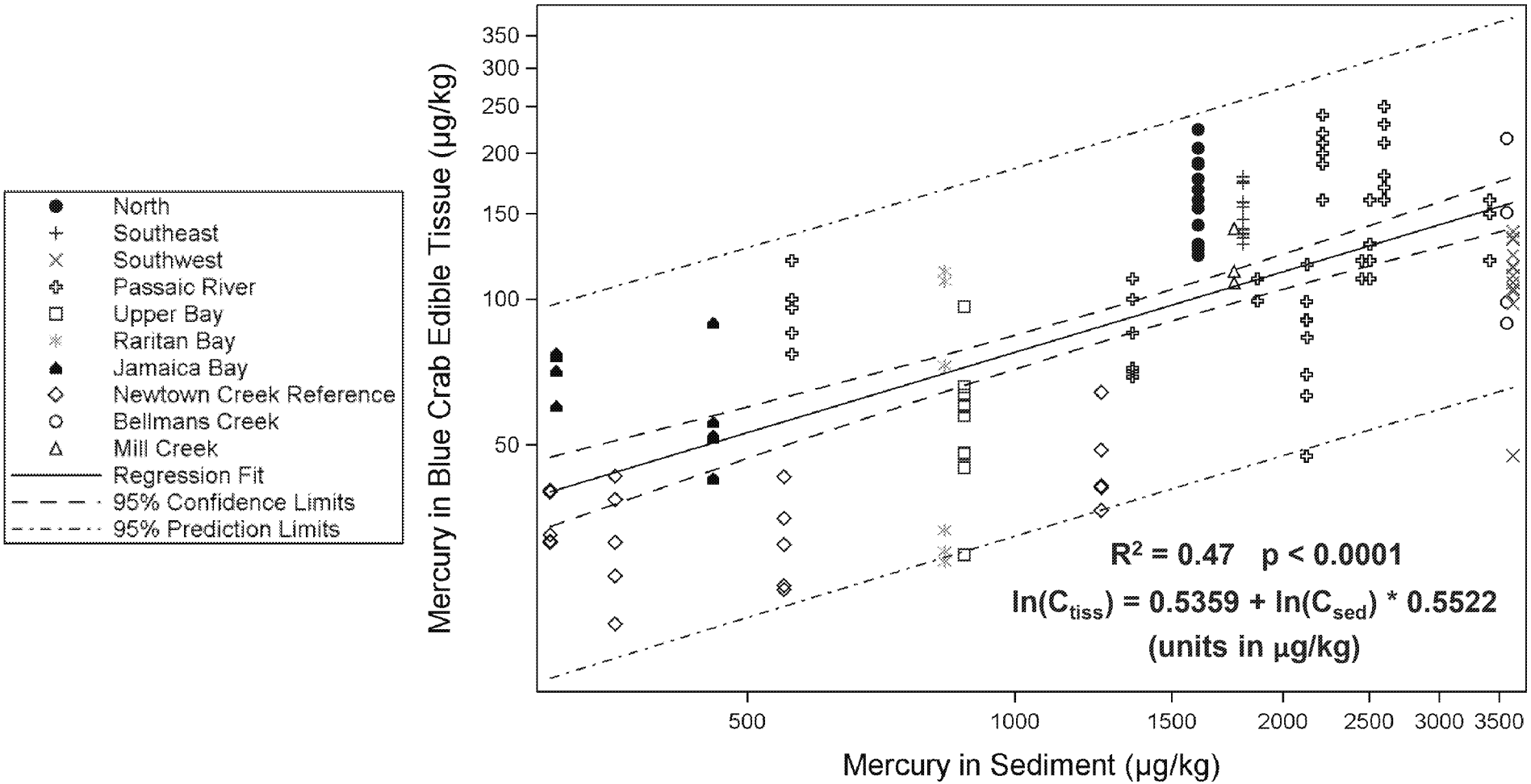
FIGURE
B-8



Notes:

Edible crab tissue samples are paired with average sediment concentrations in the areas they were collected. See Table A-2 for data sources. North, Southeast, and Southwest are Newark Bay Study Area assessment zones.

C_{tiss} = concentration in tissue
C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
µg/kg = micrograms per kilogram
R^2 = coefficient of determination
p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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BIOACCUMULATION REGRESSION:
MERCURY IN EDIBLE BLUE CRAB

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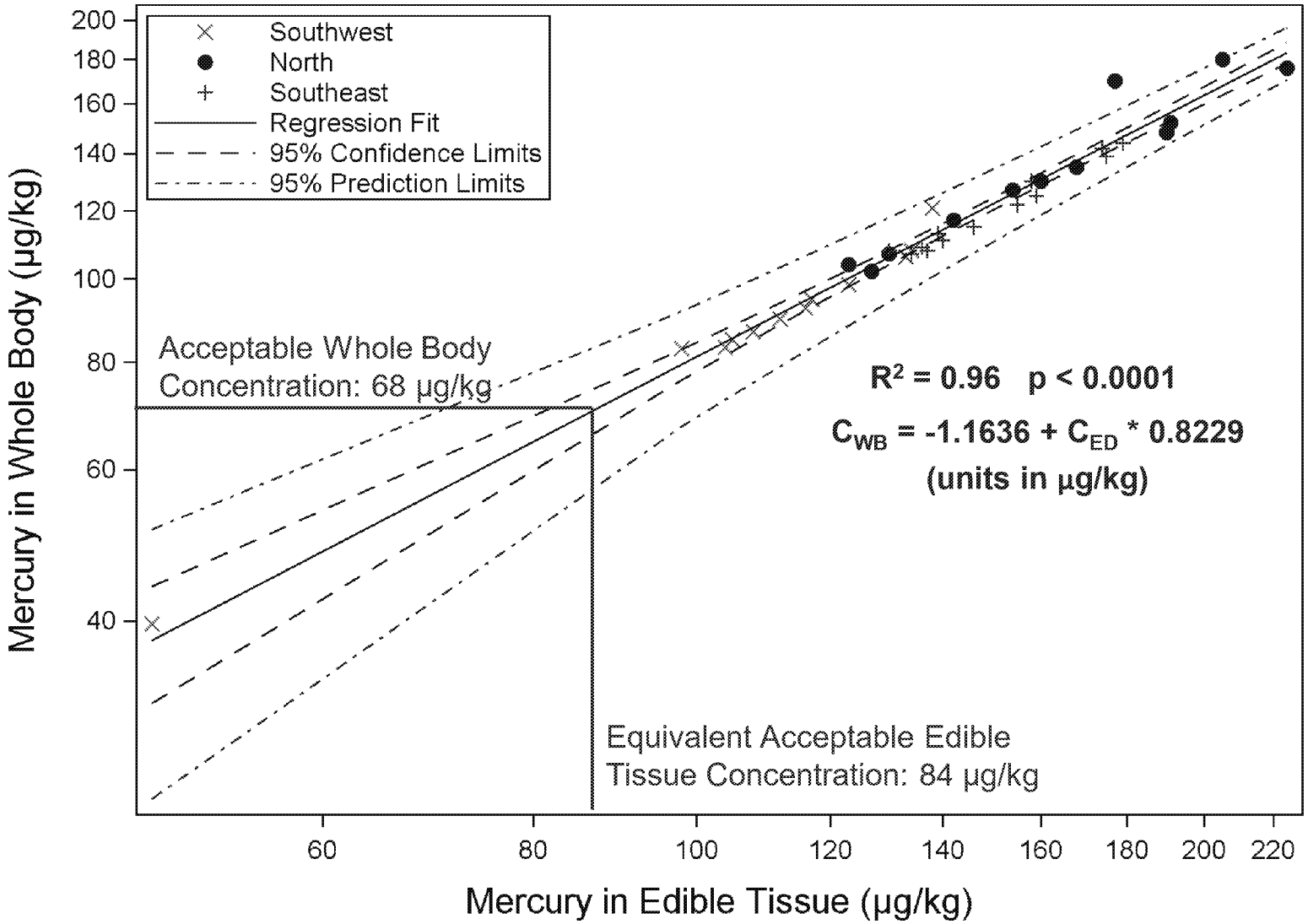
FIGURE
B-9



Notes:
All tissue concentrations are detected values. North, Southeast, and Southwest are Newark Bay Study Area assessment zones.

C_{ED} = Concentration in Edible Tissue (i.e., muscle and hepatopancreas)
C_{WB} = Concentration in Whole Body
µg/kg = micrograms per kilogram
R^2 = coefficient of determination
p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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EDIBLE TO WHOLE BODY BLUE CRAB REGRESSION FOR MERCURY

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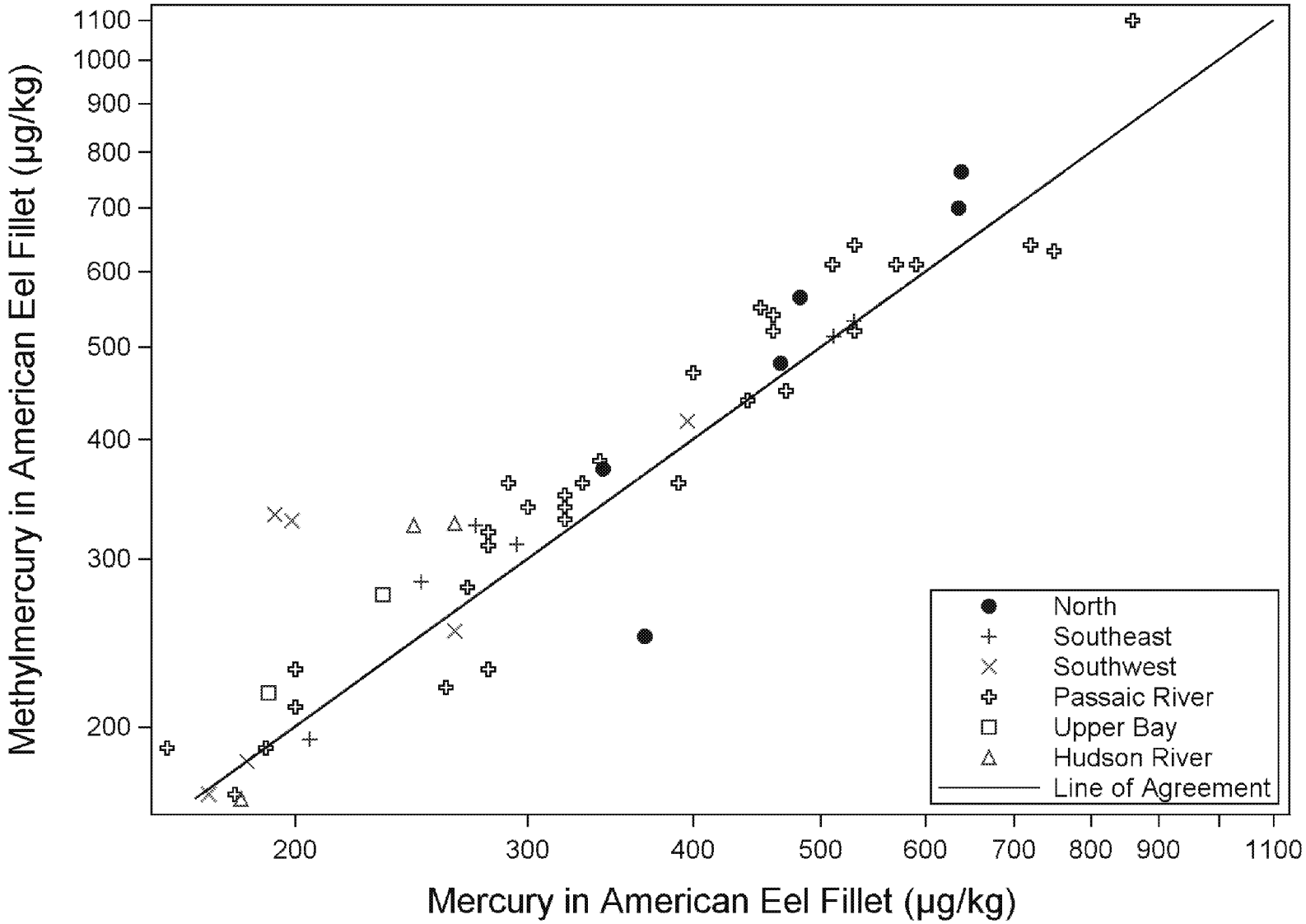
FIGURE
B-10



Notes:
All tissue concentrations are detected values. Tissue samples are grouped by location. North, Southeast, and Southwest are Newark Bay Study Area assessment zones. Methylmercury was not measured in all samples from the Hudson River and Upper Bay.

µg/kg = micrograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX B: REGRESSION MODELS FOR THE CALCULATION OF PRGS FOR INORGANIC COMPOUNDS

METHYLMERCURY VS. MERCURY IN AMERICAN EEL FILLET

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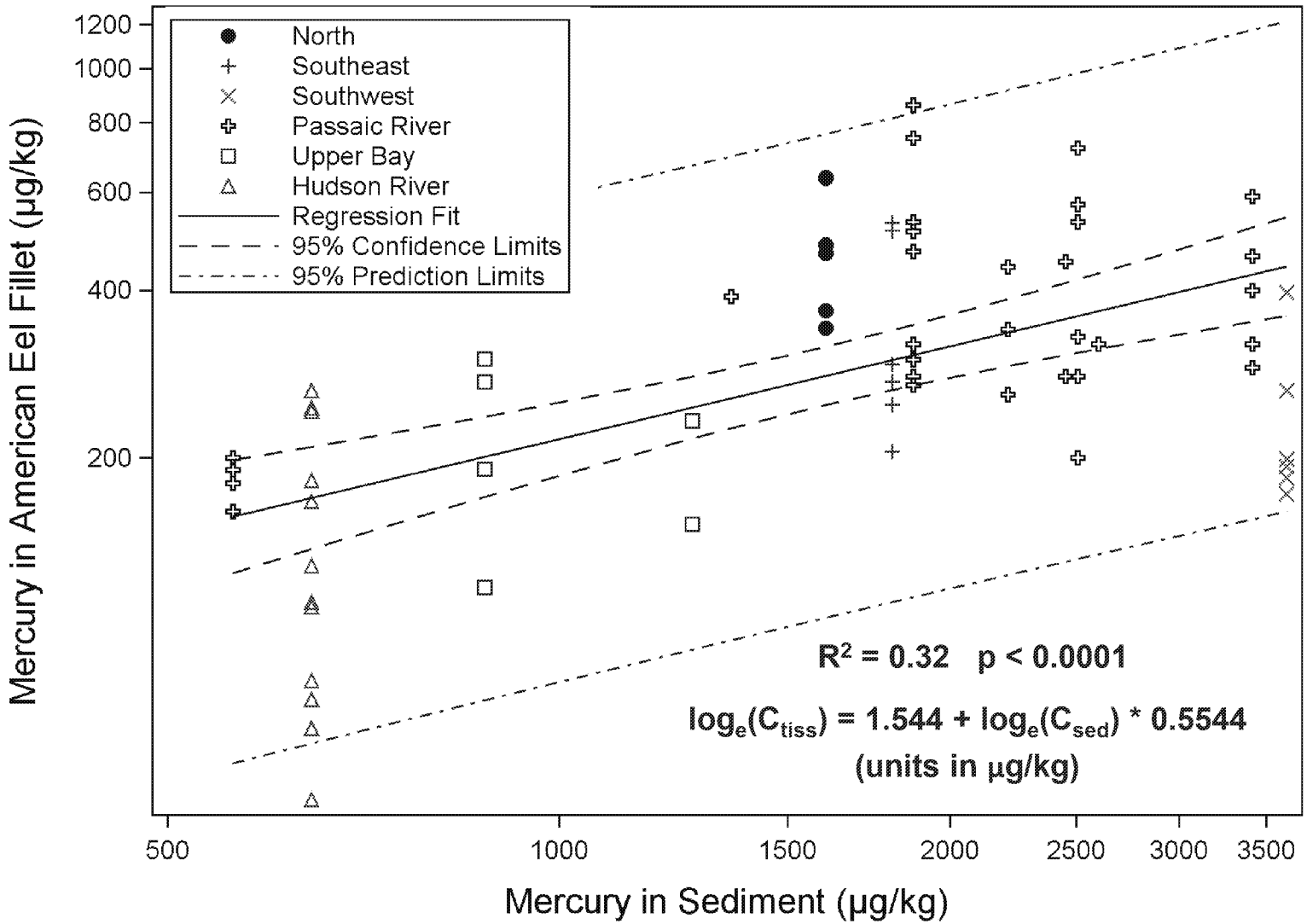
FIGURE
B-11



Notes:
American eel tissue samples are paired with average sediment concentrations in the areas they were collected. Only fillet data are used in regression except for Upper Bay and Hudson R. samples which are whole body with head and viscera removed. See Table A-3 for data sources. North, Southeast, and Southwest are Newark Bay Study Area assessment zones.

C_{tiss} = concentration in tissue; C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
µg/kg = microrams per kilogram
R^2 = coefficient of determination; p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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BIOACCUMULATION REGRESSION:
MERCURY IN AMERICAN EEL FILLET

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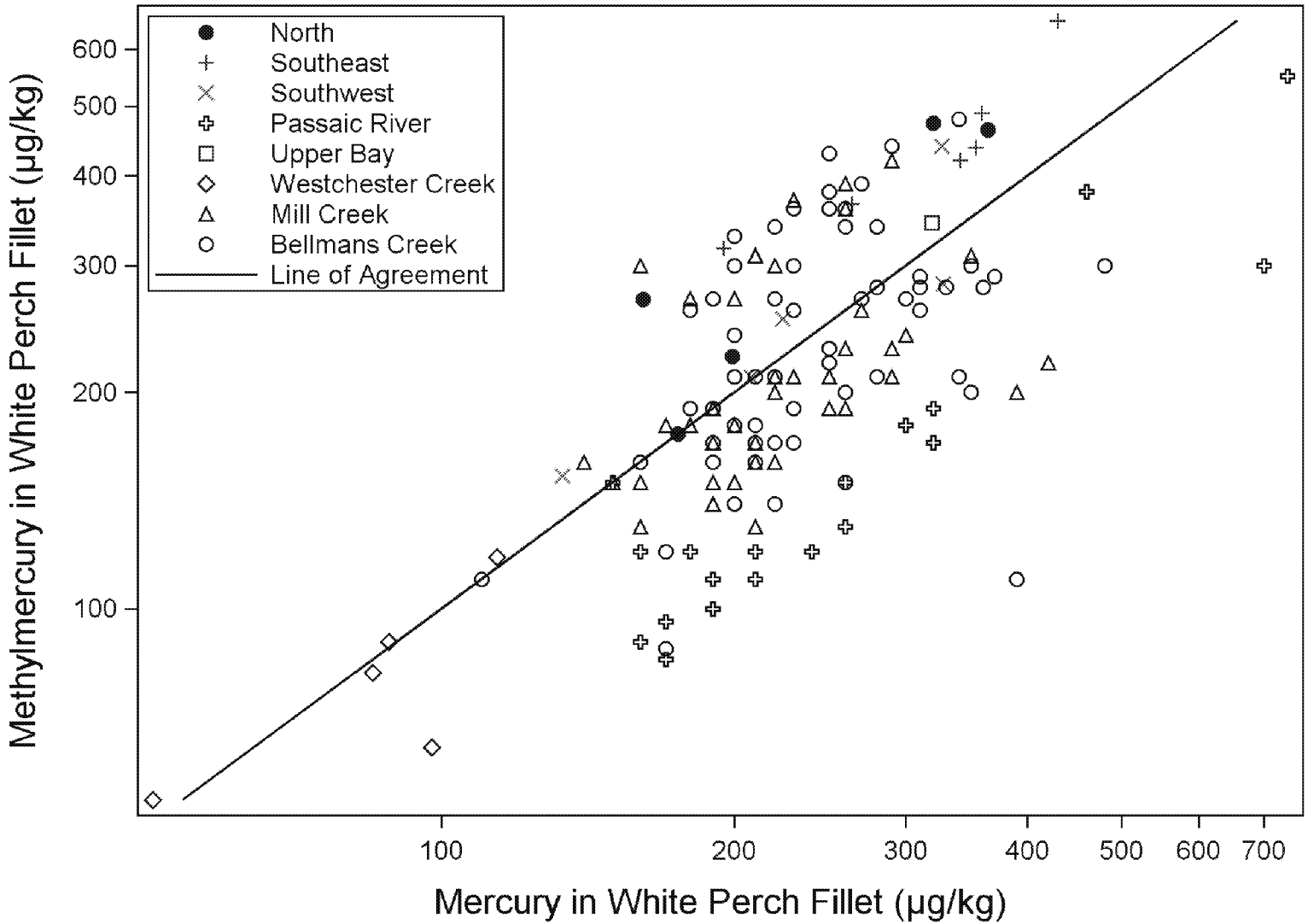
FIGURE
B-12



Notes:
All tissue concentrations are detected values. Tissue samples are grouped by location. North, Southeast, and Southwest are Newark Bay Study Area assessment zones. Methylmercury was measured in only one Upper Bay sample and no Raritan Bay samples.

µg/kg = micrograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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METHYLMERCURY VS. MERCURY IN WHITE PERCH FILLET

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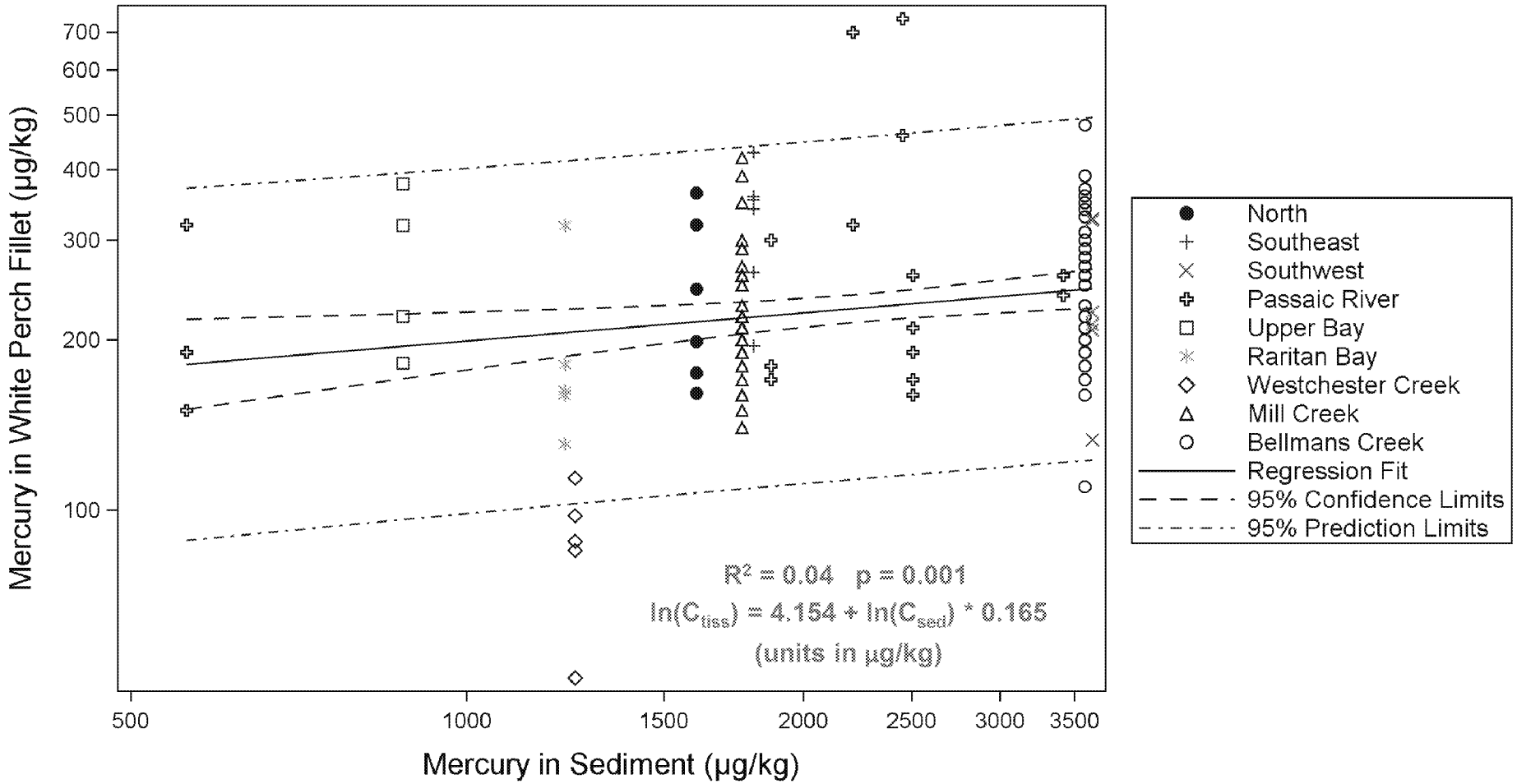
FIGURE
B-13



Notes:
White perch tissue samples are paired with average sediment concentrations in the areas they were collected. See Table A-3 for data sources. North, Southeast, and Southwest are Newark Bay Study Area assessment zones.

C_{tiss} = concentration in tissue; C_{sed} = concentration in sediment
$\log_e$ = natural logarithm
µg/kg = microrams per kilogram
R^2 = coefficient of determination; p = probability value

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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BIOACCUMULATION REGRESSION:
MERCURY IN WHITE PERCH FILLET

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FIGURE
B-14

Appendix C

Evaluation of Background and Reference Data

ARCADIS

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Appendix C: Evaluation of Background and Reference Data

Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

August 2022

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4.3 Summary 5
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Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
BHHRA	baseline human health risk assessment
COC	chemical of concern
GSH	Glenn Springs Holdings, Inc.
NBSA	Newark Bay Study Area
ng/kg	nanograms per kilogram
NJDEP	New Jersey Department of Environmental Protection
OU	operable unit
PCBs	polychlorinated biphenyls
PRGs	preliminary remedial goals
RI	remedial investigation
ROD	Record of Decision
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram

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1 Introduction

Regional data sets were reviewed to evaluate and compare concentrations of chemicals of concern (COCs) in background and reference sediment and biota tissue to those in the Newark Bay Study Area (NBSA), Operable Unit (OU) 3, and to the risk-based preliminary remedial goals (PRGs). United States Environmental Protection Agency (USEPA) guidance (USEPA 1989) characterizes background samples and areas as follows:

"*Background samples are collected at or near the hazardous waste site in areas not influenced by site contamination… but that do have the same basic characteristics as the medium of concern at the site.*

Identifying background locations requires knowing which direction is upgradient/upwind/upstream."

The NBSA is tidally connected to four major tributaries (Passaic River, Hackensack River, Arthur Kill, and Kill Van Kull) all of which are influenced by other contaminated sites and Superfund sites (Figure C-1). Because of the tidal exchange of contaminated solids with the NBSA, there is no upstream estuarine water body that would meet a strict definition of background. The upper Passaic River above the head of tide (i.e., above Dundee Dam) is the upstream freshwater background water body for the Lower Passaic River (OU2/OU4) and is therefore important to consider as an upstream background source for the NBSA. The contaminant fate and transport model for the NBSA (HDR 2021) indicates that the Kill Van Kull provides the majority of net water column solids imported into the NBSA (Figure C-2). Therefore, the Kill Van Kull and the hydraulically connected Upper New York Bay (Figure C-1) should be considered as a regional ongoing background source to the NBSA. Sediment data from the upper Passaic River, Kill Van Kull, and Upper New York Bay are described in Section 2.

Risk-based PRGs for organic COCs in biota (i.e., 2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD], polychlorinated biphenyls [PCBs], and total DDx (4,4') [sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane) are calculated based on the bioaccumulation model independent of background considerations (Appendix A). For mercury and other metals (i.e., arsenic, lead, and nickel) in biota, empirical models were developed to calculate risk-based PRGs (Appendix B). For softshell clam (*Mya arenaria*), the paired clam and sediment data collected in the NBSA were used to develop regression models for arsenic, lead, mercury, and nickel. For other species with a larger home range and for which mercury was the only COC associated with risk, these regression models required using regional data for which pairing of sediment and biota concentrations was possible. For some species, statistically significant models could not be developed due to the fact that mercury was somewhat elevated throughout the region (i.e., resulting in regression lines with a slope not significantly different than 0). To further examine this issue, mercury concentrations in biota in the NBSA were compared to those of biota in reference areas. In cases where NBSA concentrations were not elevated in species compared to reference areas, no PRGs were developed for those species. These comparisons are described in Section 3. No reference data were available for softshell clam comparisons.

USEPA guidance (USEPA 1997) defines reference areas as follows:

"A reference area is an area that is outside the chemical influence of the site but possesses similar characteristics (such as habitat and substrate type) that allows for the comparison of data between the impacted area (i.e., the site) and the unimpacted area (i.e., the reference area)."

"Reference areas can provide information regarding concentrations of naturally-occurring compounds and the existence of any regional contamination independent of the site."

"Reference areas can help to determine if contaminants are ubiquitous in the region of the site and to separate site-related impacts from non-site related impacts."

The primary urban estuarine reference area defined for the NBSA is Jamaica Bay (Figure C-3). In addition to Jamaica Bay, reference areas for biota samples were identified in other estuarine and coastal waters of New Jersey and New York (Figure C-3).

2 Background Datasets for Sediment

Estimates of background concentrations were made from several data sources.

Phase I/II Recently Deposited Sediment - These are four samples that were collected in the navigation channel in the NBSA near the mouth of the Kill Van Kull and were determined to comprise recently deposited sediments due to their Beryllium-7 content (GSH 2022). These samples were identified by the USEPA in a presentation (WSP 2021) to Glenn Springs Holdings, Inc. (GSH) as one line of evidence to estimate incoming solids from the Kill Van Kull. See Table C-1.

High Volume Chemical Water Column Monitoring Program - Two samples (each with field duplicates, for a total of four samples) were collected in the Kill Van Kull at two separate sampling events (AECOM 2019). Sampling in the Kill Van Kull targeted the incoming (flood) tide, "to best represent incoming boundary conditions" (AECOM 2019). Particulate concentrations of polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans, and PCB congeners were measured. See Table C-2.

Small Volume Chemical Water Column Monitoring Program - Six to ten samples were collected at separate events on an incoming tide in the Kull Van Kull (AECOM 2010, 2011). Particulate concentrations are estimated from water concentrations. No particulate concentrations were estimated for 2,3,7,8-TCDD due to a very low frequency of detection (i.e., 25 percent). See Tables C-3 and C-4.

2013 Post-Hurricane Sandy Sediment Quality Sampling - With multi-agency coordination, sediment quality sampling was conducted in 2013 in coastal areas of New York and New Jersey that were inundated during flooding that occurred in October 2012 during Hurricane Sandy (U.S. Geological Survey [USGS] 2015). Sediment samples from the top 2 cm were collected from two locations in the Kill Van Kull and 15 locations in Upper New York Bay (USEPA 2018; Figure C-4). Data are available online (NWQMC 2019) for 2,3,7,8-TCDD, arsenic, lead mercury and nickel. Total PCBs and DDx were analyzed by a different method and were not validated and are not included in this evaluation. See Table C-5.

OU2 Record of Decision (ROD) - These are the background concentrations recognized in the ROD for OU2 (USEPA 2016) and are based on recently deposited[1] surface sediment samples collected in the upper Passaic River above Dundee Damn and in sediment trap samples from above and below the dam. These samples were used to characterize the suspended solids being transported over the dam (Table C-6).

Table C-6 summarizes the average concentrations measured in the samples from each data source. The Kill Van Kull estimates based on the four data sources are combined to provide a "Kill Van Kull Background Estimate". It is anticipated that additional sampling will need to be conducted during the Feasibility Study to estimate background concentrations more precisely. Background concentrations for 2,3,7,8-TCDD are 2 nanograms per kilogram (ng/kg) in the upper Passaic River and range from 4 to 20 ng/kg in the Kill Van Kull. For other COCs, there is a

[1] Recently deposited sediments are defined as samples that have Beryllium-7 concentrations greater than or equal to 0.5 picocuries per gram.

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similar range of concentrations measured in the two water bodies. The following ranges of background are observed: total PCB concentrations, 330 to 547 micrograms per kilogram (µg/kg); total DDx (4,4'), 16 to 30 µg/kg; arsenic, 3 to 11 mg/kg; lead, 74 to 130 mg/kg; mercury, 675 to 1020 µg/kg; and nickel, 19 to 35 µg/kg.

3 Reference Datasets for Mercury in Biota

For mercury in biota, empirical models were developed to calculate risk-based PRGs (Appendix B) for each species for which human health and/or ecological risk was demonstrated. These regression models required using regional data for which pairing of sediment and biota concentrations was possible. For some species, statistically significant models could not be developed due to the fact that mercury was somewhat elevated throughout the region (i.e., resulting in regression lines with a slope not significantly different than 0). To further examine this issue, mercury concentrations in biota in the NBSA were compared to those of biota in reference areas. Data were limited to samples collected after the year 2000. The data are summarized by species and location in Tables C-7 through C-12. The following data sets were used to describe reference concentrations for mercury.

New Jersey Toxics Monitoring Program - A monitoring program was developed by the New Jersey Department of Environmental Protection (NJDEP) and implemented by the Academy of Natural Sciences. The program focuses on collection of species currently under consumption advisories from waterways identified as having specified chemical contamination. There were five sampling events in different regions of the state starting 2002 and each event resulted in a report. Only data from sample collections in estuarine water bodies (i.e., the second and third sampling events in the program) were included in this evaluation (Horwitz et al. 2006; Horwitz et al. 2008). Data for the following NBSA species are available: American eel (*Anguilla rostrata*), blue crab (*Callinectes sapidus)*, bluefish (*Pomatomus saltatrix)*, striped bass (*Morone saxatilis)*, and white perch (*Morone americana)*. Tissue types were either fillet (fish) or muscle and hepatopancreas (blue crab). Sampling areas are shown on Figure C-5.

Newtown Creek Remedial Investigation (RI) Sampling - Biota samples were collected in reference areas in New York State in support of the Newtown Creek Superfund Site RI (Anchor QEA 2017). Striped bass and blue crab samples were collected from three reference creeks in the Jamaica Bay watershed (i.e., Gerritsen Creek, Head of Bay, and Spring Creek) and from Westchester Creek which empties into the East River (Figure C-6). White perch were collected from Westchester Creek only.

Berry's Creek RI Sampling - Blue crab and white perch samples were collected in two reference creeks (i.e., Mills Creek and Bellman's Creek) that empty into the Hackensack River upstream of Berry's Creek (Figure C-7) in support of the Berry's Creek Superfund Site RI (BCSA Group 2018). These sites are presented as reference areas in the Berry's Creek RI; however, it is important to note that because they are within the tidal range of the Hackensack River, it is possible these sites are affected by mercury that was released into Berry's Creek, a tributary of the Hackensack River.

Coastal New Jersey Fish Survey (Burger and Gochfeld 2011) – Researchers collected and analyzed various species of fish in coastal areas of New Jersey. Most samples were collected from recreational anglers at various locations shown in Figure C-8. In addition, they obtained fish collected by NJDEP with trawls and seines (Figure C-8). The authors provided statistics for all fish and by size ranges. Where possible, size ranges were matched up with the size ranges of fish caught in the NBSA for reporting statistics.

4 Comparison of NBSA Mercury in Tissue to Reference

The mean mercury tissue concentration in reference areas is compared to the mean mercury tissue concentration in the NBSA (Table C-13). The individual reference locations are grouped by region and a range of means in the region are presented where there is more than one location with data.

4.1 Fish

Human health risk from fish consumption was found due to methylmercury concentrations in fillet. The Baseline Human Health Risk Assessment (BHHRA; GSH 2019) assessed risk based on an equally weighted mixed fish diet (i.e., edible fillet) of five species: American eel, bluefish, striped bass, summer flounder, and white perch. An acceptable level of methylmercury in edible fillet was calculated in the BHHRA and determined to be 230 µg/kg wet weight. Therefore, the expectation is that sediment PRGs would be calculated for each of the five species separately using regression models of paired tissue and sediment concentrations (Appendix B). However, if tissue concentrations in a species are found to be similar to background, a sediment PRG will not be calculated for that species. While human health risk is based on methylmercury concentrations, methylmercury is not always measured in tissue of the secondary data sampling programs and therefore not available for reference comparisons. Various studies have estimated that the methylmercury to total mercury ratio in the muscle tissue of fish generally ranges from 0.85 to 1 (e.g., Suzuki et al. 1973; Storelli et al. 2003). Therefore, in the following discussion, NBSA fillet data are compared to reference using total mercury concentrations under the assumption that all mercury in tissue is methylmercury. This assumption is found to be valid with the present dataset as described in Appendix B.

American eel – Mercury concentrations in American eel fillet were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2006). American eel were collected in various estuaries along the coast of New Jersey and in Delaware Bay (Table C-7). The average mercury concentration in American eel fillet in the NBSA (360 µg/kg) exceeds the average mercury concentration measured in other estuaries (all less than 240 µg/kg) as shown in Table C-13. Therefore, an empirical model was developed to predict American eel fillet concentrations from sediment concentrations and this model was used to calculate a sediment PRG for the protection of human health (Appendix B).

Bluefish – Reference data were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2006) and from Burger and Gochfeld (2011). Bluefish were collected from various New Jersey estuaries and from the Atlantic Ocean (Table C-8). The average mercury concentration in bluefish fillet in the NBSA (290 µg/kg) is within the range measured in other estuaries and the Atlantic Ocean (Table C-13). Therefore, a sediment PRG was not derived for bluefish.

Striped bass - Reference data were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2006; Burger and Gochfeld 2011); and the Newtown Creek RI reference areas in New York (Anchor QEA 2017). Striped bass were collected from various estuaries in New Jersey and New York and from the Atlantic Ocean (Table C-9). The average mercury concentration in striped bass fillet in the NBSA (250 µg/kg) is within the range measured in New Jersey estuaries and the Atlantic Ocean but is higher than those in the New York estuaries (Table C-13). Due to the similarity of striped bass concentrations to other New Jersey reference areas, a sediment PRG was not derived for striped bass.

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Summer flounder - Reference data were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2008) and from Burger and Gochfeld (2011). Summer flounder were collected from various estuaries in New Jersey and from the Atlantic Ocean (Table C-10). The average mercury concentration in summer flounder fillet in the NBSA (150 µg/kg) is generally greater than reference areas (Table C-13); although, the concentration is similar to the average (140 µg/kg) measured by Burger and Gochfeld (2011), which is based on a much larger sample (n=260) than the other areas. In addition, the average concentration in summer flounder does not exceed the acceptable tissue concentration established for the protection of human health (i.e., 230 µg/kg). Therefore, a sediment PRG was not derived for summer flounder.

White perch - Mercury concentrations in white perch fillet were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2006), and the Newtown Creek (Anchor QEA 2017) and Berry's Creek (BCSA Group 2018) reference areas. White perch were collected in the Hackensack River and tributaries, the Raritan River, and in Westchester Creek (Table C-11). The average mercury concentration in white perch fillet in the NBSA (270 µg/kg) is at the upper end of the range for the Hackensack River and is greater than that of other locations (Table C-13). An empirical model was developed to predict white perch fillet concentrations from sediment concentrations and this model was used to calculate a sediment PRG for the protection of human health (Appendix B).

4.2 Blue Crab

The Baseline Ecological Risk Assessment for the NBSA (GSH 2020) found unacceptable risk to blue crab due to mercury in tissue. Ecological risk is evaluated on a whole body basis for blue crab. However, much of the data available for reference comparisons were based on edible tissue samples of muscle and hepatopancreas. Therefore, this evaluation uses the data for individual tissue types for the comparison. It should be noted that mercury is more likely to accumulate in the muscle tissue in crabs than in the hepatopancreas, making the muscle comparisons more important in evaluating similarity to reference.

Mercury concentrations in blue crab tissue were available from the New Jersey Toxics Monitoring Program (Horwitz et al. 2006; Horwitz et al. 2008), and the Newtown Creek (Anchor QEA 2017) and Berry's Creek (BCSA Group 2018) reference areas. Blue crabs were collected in the Hackensack River and tributaries, several New Jersey estuaries, Jamaica Bay tributaries, and Westchester Creek (Table C-12). The average mercury concentration in hepatopancreas tissue in the NBSA (68 µg/kg) is within a similar range of reference areas except for the Jamaica Bay tributaries and Westchester Creek (Table C-13). The average mercury concentration in muscle tissue in the NBSA (170 µg/kg) is similar to that of some reference locations but is greater than the average in Raritan Bay, Jamaica Bay tributaries, and Westchester Creek (Table C-13). An empirical model was developed to predict blue crab concentrations from sediment concentrations and this model was used to calculate an ecological risk-based sediment PRG for blue crab (Appendix B).

4.3 Summary

Mercury concentrations in American eel, white perch, and blue crab generally exceeded reference concentrations. Therefore, risk-based sediment mercury PRGs were calculated for these species (Appendix B).

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Tables

Table C-1
Concentrations in Recently Deposited Surface Sediments near the Mouth of the Kill Van Kull
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Chemical	Units	Depth	Concentrations by Core Location				Average
			Phase I			Phase II	
			006A	016	017	113	
2,3,7,8-TCDD	ng/kg	0 to 0.5 feet	21.4	24.2	17.6	15	**19.6**
Total PCB Congeners	µg/kg	0 to 0.5 feet	425	395	293	386	**375**
Total DDx (4,4')	µg/kg	0 to 0.5 feet	16	23	<19	17	**16.4**
Arsenic	mg/kg	0 to 0.5 feet	10.2	12.6	10.3	10.8	**11.0**
Lead	mg/kg	0 to 0.5 feet	94.8	100	83.6	84.2	**90.7**
Mercury	µg/kg	0 to 0.5 feet	1200	1000	980	890	**1020**
Nickel	mg/kg	0 to 0.5 feet	32	39.5	34.5	34	**35.0**
Beryllium-7	pCi/g	0 to 1 inch	1.95	1.06	1.58 [1.52]	1.04 [1.43]	**1.45**

Notes:
Sediment samples were collected from the navigation channel near the mouth of the Kill Van Kull during the Phase I and Phase II NBSA RI sampling events in 2005 and 2007, respectively. Core 017 and 113 are colocated.
Beryllium-7 concentrations greater than 0.5 pCi/g are indicative of recent deposition (GSH 2022).
1/2 reporting limit substituted for non-detects.

Acronyms and Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
< = less than
GSH = Glenn Springs Holdings, Inc.
mg/kg = milligrams per kilogram
ng/kg = nanogram per kilogram
PCB = polychlorinated biphenyl
pCi/g = picocuries per gram
RI = remedial investigation
Total DDx (4,4') = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
µg/kg = micrograms per kilogram

References:
GSH. 2022. Final Remedial Investigation Report - Newark Bay Study Area, Newark, NJ. May.

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Table C-2
Calculated Water and Solid-Phase Concentrations in the Kill Van Kull from the High Volume Water Sampling Program
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

			2,3,7,8-TCDD						Total PCB Congeners					
				Filtrate Sorption Media		Calculated Water Concentration				Filtrate Sorption Media		Calculated Water Concentration		
Sample Identification	Sample Volume (L)	Suspended Solids (mg/L)	Filtered Solids (pg/sample)	PUF1 (pg/sample)	PUF2 (pg/sample)	Whole[c] (pg/L)	Dissolved[c] (pg/L)	Concentration in Water Column Solids[a] (ng/kg)	Filtered Solids (ng/sample)	PUF1 (pg/sample)	PUF2 (pg/sample)	Whole[c] (ng/L)	Dissolved[c] (ng/L)	Concentration in Water Column Solids[a] (µg/kg)
N08-CE05-TKVK	290	13.1	27.1	< 1.06	1.05	0.097	0.005	7.12	1,360,000	242,000	61,200	5.7	1.05	357
N08-CE05-TKVK (dup)	290	14.0	38.7	0.988	< 0.775	0.14	0.005	9.5	2,120,000	233,000	156,000	8.7	1.34	523
N10-CE05-TKVK	222	20	44.5	1.82	< 0.927	0.21	0.010	10.0	2,850,000	441,000	63,300	15	2.27	642
N10-CE05-TKVK (dup)	222	21.1	66.2	1.85	< 1.22	0.31	0.011	14.2	3,110,000	547,000	105,000	17	2.94	666
							Average	**10.2**					Average	**547**

Notes:
Data were collected during two sampling events in 2012 and 2013 during the HVCWCM program and reported by AECOM (2019).
Kill Van Kull samples were collected on an incoming tide.
1/2 reporting limit substituted for non-detect values in calculation of dissolved water concentration.
[a]Calculated as the sum of the mass in filtered solids and sorption media (i.e., PUF1 and PUF2) divided by the sample volume.
[b]Calculated as the sum of the mass in the sorption media (i.e., PUF1 and PUF2) divided by the sample volume.
[c]Calculated as the whole water concentration minus the dissolved fraction and then divided by the suspended solids concentration and appropriate unit conversion factors.

Acronyms and Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
< = less than and indicates a non-detect value reported at the reporting limit.
HVCWCM = high volume chemical water column monitoring
L = liter
mg/L =milligrams per liter
NBSA = Newark Bay Study Area
ng/kg = nanogram per kilogram
ng/L =nanograms per liter
PCB = polychlorinated biphenyl
pg = picograms
pg/L = picograms per liter
PUF = Polyurethane Foam
TCDD = tetrachlorodibenzo-p-dioxin

Reference:
AECOM. 2019. High Volume Chemical Water Column Monitoring Sampling Program Characterization Summary. Lower Passaic River Study Area RI/FS. May 2019.

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Table C-3
Calculated Particulate Concentrations for Organic COCs in the Kill Van Kull for the Small Volume Chemical Water Column Monitoring Program
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Sampling Event	Tide	Sample Name	Collection Date	Water Depth	Chemical	Total Water (ng/L)	Suspended Solids in Water (mg/L)	Estimated Particulate Concentration (µg/kg)	Mean Particulate Concentration (µg/kg)
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Total PCB Congeners	4.7468	8.8	539	
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Total PCB Congeners	9.0962	29	314	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-AS	2/23/2012	At Surface	Total PCB Congeners	4.3794	11.6	378	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-BS	2/23/2012	Below Surface	Total PCB Congeners	5.6664	26.4	215	**327**
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Total PCB Congeners	3.0929	6	515	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Total PCB Congeners	4.0325	9.8	411	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Total PCB Congeners	5.9805	36.9	162	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Total PCB Congeners	7.5329	88.3	85	
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Total DDx (4,4')	0.5705	8.8	65	
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Total DDx (4,4')	0.65	29	22	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Total DDx (4,4')	<0.11	6	9	**23.8**
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Total DDx (4,4')	<0.103	9.8	5	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Total DDx (4,4')	1.01	36.9	27	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Total DDx (4,4')	1.22	88.3	14	

Notes:
Particulate concentrations are estimated from water and suspended solids concentrations measured in the small volume chemical water column monitoring program. For organic coumpounds for which only total concentrations were measured, solids concentrations were estimated by dividing the total water concentration by the suspended solids concentration. Sampling was conducted from 2011 through 2013 as described in the Quality Assurance Project Plan, AECOM (2011). 1/2 reporting limit substituted for non-detects.
To estimate the concentrations of incoming solids from the Kill Van Kull, only the samples collected during flood tide were used in calculations.

Acronyms and Abbreviations:
mg/L = milligrams per liter
ng/L =nanograms per liter
PCB = polychlorinated biphenyl
Total DDx (4,4') = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
µg/kg = micrograms per kilogram

References:
AECOM. 2010. Remedial Investigation Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay and Wet weather monitoring: Lower Passaic River Restoration Project. Quality Assurance Project Plan. Revision 5.
AECOM. 2011. Quality Assurance Project Plan/Field Sampling Plan Addendum. Remedial Investigation Water Column Monitoring/Small Volume Chemical Data Collection. Lower Passaic River Restoration Project. Revision 2. August, 2011.

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Table C-4
Calculated Particulate Concentrations for Metals in the Kill Van Kull for the Small Volume Chemical Water Column Monitoring Program
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Sampling Event	Tide	Sample Name	Collection Date	Water Depth	Chemical	Total Water	Total Water Minus Dissolved Concentration	Suspended Solids in Water	Estimated Particulate Concentration	Mean Particulate Concentration
					Units:	µg/L	µg/L	mg/L	mg/kg	mg/kg
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Arsenic	1.55	0.05	8.8	5.68	9.91
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Arsenic	1.6	0.14	29	4.83	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Arsenic	1.04	0.09	6	15.0	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Arsenic	1.12	0.1	9.8	10.2	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Arsenic	1.7	0.5	36.9	13.6	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Arsenic	2.1	0.9	88.3	10.2	
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Lead	0.863	0.794	8.8	90.2	74.2
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Lead	1.94	1.87	29	64.4	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-AS	2/23/2012	At Surface	Lead	0.741	0.689	11.6	59.4	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-BS	2/23/2012	Below Surface	Lead	1.61	1.34	26.4	50.8	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Lead	0.466	0.41	6	68.3	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Lead	1	0.935	9.8	95.4	
2012 CPG CWCM Sampling – Round 4	Maximum flood tide	N06-CE02-TKVK-AS	6/7/2012	At Surface	Lead	1.31	1.19	14.6	81.4	
2012 CPG CWCM Sampling – Round 4	Maximum flood tide	N06-CE02-TKVK-BS	6/7/2012	Below Surface	Lead	5.84	2.9	98.3	29.5	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Lead	4.05	3.98	36.9	108	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Lead	8.48	8.36	88.3	94.7	
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Nickel	1.65	0.25	8.8	28.4	33.9
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Nickel	2.5	1.4	29	48.3	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Nickel	0.86	0.18	6	30.0	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Nickel	1.11	0.39	9.8	39.8	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Nickel	1.85	1	36.9	27.1	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Nickel	3.53	2.65	88.3	30.0	
					Units:	ng/L	ng/L	µg/L	µg/kg	µg/kg
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-AS	8/17/2011	At Surface	Mercury	7.58	7.11	8.8	808	675
2011 CPG CWCM Sampling - Round 1	Maximum flood tide	N02-CE02-TKVK-BS	8/17/2011	Below Surface	Mercury	24	23.6	29	814	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-AS	2/23/2012	At Surface	Mercury	6.08	6.08	11.6	524	
2012 CPG CWCM Sampling – Round 2	Maximum flood tide	N03-CE02-TKVK-BS	2/23/2012	Below Surface	Mercury	12	10.5	26.4	399	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-AS	3/29/2012	At Surface	Mercury	5.09	4.44	6	740	
2012 CPG CWCM Sampling – Round 3	Maximum flood tide	N05-CE02-TKVK-BS	3/29/2012	Below Surface	Mercury	10.4	9.96	9.8	1016	
2012 CPG CWCM Sampling – Round 4	Maximum flood tide	N06-CE02-TKVK-AS	6/7/2012	At Surface	Mercury	12.6	12.6	14.6	863	
2012 CPG CWCM Sampling – Round 4	Maximum flood tide	N06-CE02-TKVK-BS	6/7/2012	Below Surface	Mercury	61.6	26.9	98.3	274	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-AS	12/13/2012	At Surface	Mercury	28.8	27.9	36.9	757	
2012 CPG CWCM Sampling - Round 5	Maximum flood tide	N07-CE02-TKVK-BS	12/13/2012	Below Surface	Mercury	50	49.1	88.3	555	

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Notes:
Particulate concentrations are estimated from water and suspended solids concentrations measured in the small volume chemical water column monitoring program. Particulate concentrations were estimated by dividing the total water concentration, minus the dissolved water concentration if detected, by the suspended solids concentration, and using the appropriate unit conversions. Sampling was conducted from 2011 through 2013 as described in the Quality Assurance Project Plan, AECOM (2011).
To estimate the concentrations of incoming solids from the Kill Van Kull, only the samples collected during flood tide were used in calculations.

Acronyms and Abbreviations:
mg/kg = milligrams per kilogram
ng/L =nanograms per liter
µg/kg = micrograms per kilogram
µg/L = micrograms per liter

References:
AECOM. 2010. Remedial Investigation Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay and Wet weather monitoring: Lower Passaic River Restoration Project. Quality Assurance Project Plan. Revision 5.
AECOM. 2011. Quality Assurance Project Plan/Field Sampling Plan Addendum. Remedial Investigation Water Column Monitoring/Small Volume Chemical Data Collection. Lower Passaic River Restoration Project. Revision 2. August, 2011.

Table C-5
Concentrations of 2,3,7,8-TCDD in Kill Van Kull and Upper Harbor: 2013 Post Superstorm Sandy
Appendix C: Evaluation of Background and Reference Data
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Location	Station Identifier	Chemical	Units	Concentration	Qualifier	Quantitation Limit	Average by Location	Average
Kill Van Kull	NB407	2,3,7,8-TCDD	ng/kg	2.5		0.570	4.1	3.7
Kill Van Kull	NB418	2,3,7,8-TCDD	ng/kg	5.6		0.580		
Upper New York Bay	UH401	2,3,7,8-TCDD	ng/kg	9.4		0.640	3.7	
Upper New York Bay	UH402	2,3,7,8-TCDD	ng/kg	1.2		0.630		
Upper New York Bay	UH408	2,3,7,8-TCDD	ng/kg	3.7		0.590		
Upper New York Bay	UH409	2,3,7,8-TCDD	ng/kg	7.8		0.620		
Upper New York Bay	UH414	2,3,7,8-TCDD	ng/kg	4.9		0.620		
Upper New York Bay	UH415	2,3,7,8-TCDD	ng/kg	1.1		0.640		
Upper New York Bay	UH416	2,3,7,8-TCDD	ng/kg	2.1		0.530		
Upper New York Bay	UH419	2,3,7,8-TCDD	ng/kg	2.8		0.670		
Upper New York Bay	UH452	2,3,7,8-TCDD	ng/kg	0.61	U	0.610		
Upper New York Bay	UH454	2,3,7,8-TCDD	ng/kg	4.9		0.630		
Upper New York Bay	UH458	2,3,7,8-TCDD	ng/kg	2.9		0.650		
Upper New York Bay	UH460	2,3,7,8-TCDD	ng/kg	4.5		0.660		
Upper New York Bay	UH462	2,3,7,8-TCDD	ng/kg	3.1		0.520		
Upper New York Bay	UH466	2,3,7,8-TCDD	ng/kg	2.3		0.740		
Upper New York Bay	UH468	2,3,7,8-TCDD	ng/kg	4.4		0.600		
Kill Van Kull	NB407	Arsenic	mg/kg	4.5		0.025	6.7	10
Kill Van Kull	NB418	Arsenic	mg/kg	8.9		0.025		
Upper New York Bay	UH401	Arsenic	mg/kg	15.7		0.025	11	
Upper New York Bay	UH402	Arsenic	mg/kg	22.6		0.025		
Upper New York Bay	UH408	Arsenic	mg/kg	14.2		0.025		
Upper New York Bay	UH409	Arsenic	mg/kg	8		0.025		
Upper New York Bay	UH414	Arsenic	mg/kg	12		0.025		
Upper New York Bay	UH415	Arsenic	mg/kg	5.5		0.025		
Upper New York Bay	UH416	Arsenic	mg/kg	8		0.025		
Upper New York Bay	UH419	Arsenic	mg/kg	6		0.025		
Upper New York Bay	UH452	Arsenic	mg/kg	5		0.025		
Upper New York Bay	UH454	Arsenic	mg/kg	13.8		0.025		
Upper New York Bay	UH458	Arsenic	mg/kg	8.2		0.025		
Upper New York Bay	UH460	Arsenic	mg/kg	12.7		0.025		
Upper New York Bay	UH462	Arsenic	mg/kg	14.9		0.025		
Upper New York Bay	UH466	Arsenic	mg/kg	6.9		0.025		
Upper New York Bay	UH468	Arsenic	mg/kg	10.2		0.025		
Kill Van Kull	NB407	Lead	mg/kg	15.1		0.025	27	65
Kill Van Kull	NB418	Lead	mg/kg	39.7		0.025		
Upper New York Bay	UH401	Lead	mg/kg	123		0.025	70	
Upper New York Bay	UH402	Lead	mg/kg	167.6		0.025		
Upper New York Bay	UH408	Lead	mg/kg	117.6		0.025		
Upper New York Bay	UH409	Lead	mg/kg	41.2		0.025		
Upper New York Bay	UH414	Lead	mg/kg	78.8		0.025		
Upper New York Bay	UH415	Lead	mg/kg	22.6		0.025		
Upper New York Bay	UH416	Lead	mg/kg	46.9		0.025		
Upper New York Bay	UH419	Lead	mg/kg	35.9		0.025		
Upper New York Bay	UH452	Lead	mg/kg	14.5		0.025		
Upper New York Bay	UH454	Lead	mg/kg	82.6		0.025		
Upper New York Bay	UH458	Lead	mg/kg	47.6		0.025		
Upper New York Bay	UH460	Lead	mg/kg	75		0.025		
Upper New York Bay	UH462	Lead	mg/kg	88.1		0.025		
Upper New York Bay	UH466	Lead	mg/kg	42.4		0.025		
Upper New York Bay	UH468	Lead	mg/kg	65.4		0.025		
Kill Van Kull	NB407	Mercury	mg/kg	0.03		0.01	0.16	0.71
Kill Van Kull	NB418	Mercury	mg/kg	0.29		0.01		
Upper New York Bay	UH401	Mercury	mg/kg	1.61		0.01	0.78	
Upper New York Bay	UH402	Mercury	mg/kg	1.77		0.01		
Upper New York Bay	UH408	Mercury	mg/kg	0.64		0.01		
Upper New York Bay	UH409	Mercury	mg/kg	0.55		0.01		
Upper New York Bay	UH414	Mercury	mg/kg	1.48		0.01		
Upper New York Bay	UH415	Mercury	mg/kg	0.15		0.01		
Upper New York Bay	UH416	Mercury	mg/kg	0.63		0.01		
Upper New York Bay	UH419	Mercury	mg/kg	0.52		0.01		
Upper New York Bay	UH452	Mercury	mg/kg	0.09		0.01		
Upper New York Bay	UH454	Mercury	mg/kg	1.06		0.01		
Upper New York Bay	UH458	Mercury	mg/kg	0.48		0.01		
Upper New York Bay	UH460	Mercury	mg/kg	0.87		0.01		
Upper New York Bay	UH462	Mercury	mg/kg	0.83		0.01		
Upper New York Bay	UH466	Mercury	mg/kg	0.48		0.01		
Upper New York Bay	UH468	Mercury	mg/kg	0.61		0.01		

Table C-5
Concentrations of 2,3,7,8-TCDD in Kill Van Kull and Upper Harbor: 2013 Post Superstorm Sandy
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Location	Station Identifier	Chemical	Units	Concentration	Qualifier	Quantitation Limit	Average by Location	Average
Kill Van Kull	NB407	Nickel	mg/kg	51.2		0.025	58	33
Kill Van Kull	NB418	Nickel	mg/kg	65		0.025		
Upper New York Bay	UH401	Nickel	mg/kg	42.2		0.025	30	
Upper New York Bay	UH402	Nickel	mg/kg	42.3		0.025		
Upper New York Bay	UH408	Nickel	mg/kg	33.1		0.025		
Upper New York Bay	UH409	Nickel	mg/kg	28.1		0.025		
Upper New York Bay	UH414	Nickel	mg/kg	33.4		0.025		
Upper New York Bay	UH415	Nickel	mg/kg	10.5		0.025		
Upper New York Bay	UH416	Nickel	mg/kg	24.3		0.025		
Upper New York Bay	UH419	Nickel	mg/kg	23.3		0.025		
Upper New York Bay	UH452	Nickel	mg/kg	9.9		0.025		
Upper New York Bay	UH454	Nickel	mg/kg	34.6		0.025		
Upper New York Bay	UH458	Nickel	mg/kg	18.4		0.025		
Upper New York Bay	UH460	Nickel	mg/kg	36.8		0.025		
Upper New York Bay	UH462	Nickel	mg/kg	42.1		0.025		
Upper New York Bay	UH466	Nickel	mg/kg	23.1		0.025		
Upper New York Bay	UH468	Nickel	mg/kg	46.5		0.025		

Notes:
Data were collected from the top 2 centimeters of sediment in 2013 after a large storm event, Hurricane Sandy.

Acronyms and Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
ng/kg = nanogram per kilogram

Table C-6
Summary of Background Concentrations in Sediments and Water Column Particulates
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Chemical	Units	Kill Van Kull Average Concentrations			Post Hurricane Sandy Sediment Sampling Kill Van Kull and Upper New York Bay (n=17)	Kill Van Kull Background Estimate	Upper Passaic River Average (Sample Size)
		Recently Deposited Channel Sediments near Mouth of Kill Van Kull (n=4)	HVCWCM Water Column Particulates (n=4)	SVCWCM Water Column Particulates (Sample Size)			
2,3,7,8-TCDD	ng/kg	19.6	10.2	--[a]	3.7	15	2 (9)
Total PCB Congeners	µg/kg	375	547	327 (8)	--[c]	400	460 (9)
Total DDx (4,4')	µg/kg	16.4	--[b]	23.8 (6)	--[c]	20	30 (7)
Arsenic	mg/kg	11.0	--[b]	9.91 (6)	10	10	3 (11)
Lead	mg/kg	90.7	--[b]	74.2 (10)	65	75	130 (11)
Mercury	µg/kg	1020	--[b]	675 (10)	710	700	720 (11)
Nickel	mg/kg	35.0	--[b]	33.9 (6)	33	35	19 (11)

Notes:
[a]Not calculated due to low frequency of detection.
[b]Not analyzed.
[c]Data not available or not validated.

Acronyms and Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
HVCWCM = high volume chemical water column monitoring
mg/kg = milligrams per kilogram
n = sample size
ng/kg = nanogram per kilogram
PCB = polychlorinated biphenyl
SVCWCM = small volume chemical water column monitoring
Total DDx (4,4') = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
µg/kg = micrograms per kilogram

Table C-7
Mercury Concentrations in American Eel Fillet in New Jersey in 2004
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Location	Mercury (µg/kg)			
	N	Mean	Minimum	Maximum
Barnegat Bay near Toms River	5	240	100	300
Delaware Bay near Camden	5	240	100	500
Mullica River	5	240	200	300
Navesink River	5	180	100	300
Shrewsbury River	4	100	100	100
Shark River	2	200	200	200

Notes
Samples were collected in 2004 from estuarine waters as part of the Routine Monitoring Program for Toxics in Fish and were reported in Horwitz et al. 2006.
All tissue concentrations are reported on a wet weight basis.
Reference locations are shown on Figure C-4.

Acronyms and Abbreviations:
µg/kg = micrograms per kilogram

Reference
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. December.

Table C-8
Mercury Concentrations in Bluefish Fillet in Reference Areas
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Location	Collection Year	Mercury (µg/kg)				Data Source
		N	Mean (Standard Deviation)	Minimum	Maximum	
Atlantic Ocean at Belmar	2004	5	480	200	700	Horwitz et al. 2006
Atlantic Ocean Island Beach	2004	3	430	300	700	Horwitz et al. 2006
Atlantic Ocean Sandy Hook	2004	2	350	300	400	Horwitz et al. 2006
Atlantic Ocean Sea Isle City to Cape May	2004	5	300	200	500	Horwitz et al. 2006
Barnegat Bay near Toms River	2004	1	300	300	300	Horwitz et al. 2006
Delaware Bay Middle	2004	3	170	100	200	Horwitz et al. 2006
Raritan Bay @ Port Monmouth	2004	5	520	300	800	Horwitz et al. 2006
Raritan R. at Rte 35	2004	3	130	100	200	Horwitz et al. 2006
Sandy Hook	2004	3	200	200	200	Horwitz et al. 2006
Coastal New Jersey (all fish)	2005-2008	206	350 (300)	--	--	Burger and Gochfeld 2011
Coastal New Jersey (30-60 cm. length only)[a]	2005-2008	102	250 (100)	--	--	Burger and Gochfeld 2011

Notes:
All tissue concentrations are reported on a wet weight basis.
Standard deviation is not reported when unavailable in the data source or not calculable from raw data.
Reference locations are shown on Figures C-4 and C-7.
[a]Weighted average of two size class datasets that are closest to the length range of bluefish caught in the NBSA (31 to 47 cm.)

Acronyms and Abbreviations:
-- = not reported
cm = centimeter
µg/kg = micrograms per kilogram

Reference:
Burger, J. and M. Gochfeld. 2011. Mercury and selenium levels in 19 species of saltwater fish from New Jersey as a function of species, size, and season. Sci Total Environ. 409(8): 1418-1429.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. December.

Table C-9
Mercury Concentrations in Striped Bass Fillet in Reference Areas
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Location	Collection Year	Mercury (µg/Kg)				Data Source
		N	Mean (Standard Deviation)	Minimum	Maximum	
Atlantic Ocean Island Beach	2004	1	300	300	300	Horwitz et al. 2006
Atlantic Ocean Sandy Hook	2004	5	280	200	400	Horwitz et al. 2006
Atlantic Ocean Sea Isle City to Cape May	2004	10	230	200	300	Horwitz et al. 2006
Barnegat Bay near Toms River	2004	4	230	200	300	Horwitz et al. 2006
Delaware Bay Middle	2004	5	260	200	300	Horwitz et al. 2006
Coastal New Jersey (all fish)	2005-2008	178	390 (270)	--	--	Burger and Gochfeld 2011
Coastal New Jersey (70-100 cm length only)[a]	2005-2008	90	360 (200)	--	--	Burger and Gochfeld 2011
Three Jamaica Bay Tributaries	2014	15	110 (65)	51	315	Anchor QEA 2017
Westchester Creek	2014	5	120 (28)	92	152	Anchor QEA 2017

Notes:
All tissue concentrations are reported on a wet weight basis.
Standard deviation is not reported when unavailable in the data source or not calculable from raw data.
Reference locations are shown on Figures C-4, C-5, and C-7.
[a]Weighted average of two size class datasets that are closest to the length range of striped bass caught in the NBSA (63 to 98 cm.)

Acronyms and Abbreviations:
-- = not reported
cm = centimeter
µg/kg = micrograms per kilogram

Reference:
Anchor QEA. 2017. Baseline Human Health Risk Assessment. Remedial Investigation/Feasibility Study. Newtown Creek. June.
Burger, J. and M. Gochfeld. 2011. Mercury and selenium levels in 19 species of saltwater fish from New Jersey as a function of species, size, and season. Sci Total Environ. 409(8): 1418-1429.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. December.

Table C-10
Mercury Concentrations in Summer Flounder Fillet in Reference Areas
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Location	Collection Year	Mercury (µg/kg)				Data Source
		N	Mean (Standard Deviation)	Minimum	Maximum	
Atlantic Ocean North	2006	3	87.3	79	92	Horwitz et al. 2008
Raritan Bay at Keanberg	2006	3	91.3	78	113	Horwitz et al. 2008
Raritan Bay Lower Bay	2006	3	95	69	119	Horwitz et al. 2008
Sandy Hook Bay	2006	3	100	81	118	Horwitz et al. 2008
Coastal New Jersey (all fish)	2005-2008	260	140 (80)	--	--	Burger and Gochfeld 2011
Coastal New Jersey (34-59 cm length)[a]	2005-2008	193	140 (80)	--	--	Burger and Gochfeld 2011

Notes:
All tissue concentrations are reported on a wet weight basis.
Standard deviation is not reported when unavailable in the data source or not calculable from raw data.
Reference locations are shown on Figures C-4 and C-7.
[a]Weighted average of three size class datasets that are closest to the length range of summer flounder caught in the NBSA (38 to 57 cm)

Acronyms and Abbreviations:
-- = not reported
cm = centimeter
µg/kg = micrograms per kilogram

Reference:
Burger, J. and M. Gochfeld. 2011. Mercury and selenium levels in 19 species of saltwater fish from New Jersey as a function of species, size, and season. Sci Total Environ. 409(8): 1418-1429.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2008. Final Report: Routine Monitoring of Toxics in New Jersey Fish, Third Year (2006) of Routine Monitoring Program. Patrick Center for Environmental Research. Academy of Natural Sciences. December.

Table C-11
Mercury Concentrations in White Perch Fillet in Reference Areas
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Location	Collection Year	Mercury (µg/kg)				Data Source
		N	Mean (Standard Deviation)	Minimum	Maximum	
Raritan R. at Rte 35 Victory Bridge	2004	3	100	100	100	Horowitz et al. 2006
Hackensack R. at Laurel Hill	2004	3	270	100	400	Horowitz et al. 2006
Westchester Creek	2014	5	87 (23)	51	110	Anchor QEA 2017
Bellman Creek	2010-2015	59	250 (66)	110	480	BCSA Group 2018
Mill Creek	2010-2015	43	220 (65)	52	420	BCSA Group 2018

Notes:
All tissue concentrations are reported on a wet weight basis.
Standard deviation is not reported when unavailable in the data source or not calculable from raw data.
Reference locations are shown on Figures C-4, C-5, and C-6.

Acronyms and Abbreviations:
µg/kg = micrograms per kilogram

References:
Anchor QEA. 2017. Baseline Human Health Risk Assessment. Remedial Investigation/Feasibility Study. Newtown Creek. June.
BCSA Group. 2018. Final Remedial Investigation Report. Berry's Creek Study Area. Berry's Creek Cooperating Parties Group. August.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. December.

Table C-12
Mercury Concentrations in Blue Crab in Reference Areas
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Location	Collection Year	Tissue Type	Mercury (µg/kg)					Data Source
			N	FOD	Mean (Standard Deviation)	Minimum	Maximum	
Barnegat Bay near Toms River	2004	Hepatopancreas	5	--	90	--	110	Horwitz et al. 2008
Raritan Bay at Keanberg	2006	Hepatopancreas	3	100%	57 (20)	37	76	Horwitz et al. 2008
Eastern Raritan Bay	2004	Hepatopancreas	3	--	100	100	100	Horwitz et al. 2006
Raritan R. at Rte 35 Victory Bridge	2004	Hepatopancreas	3	--	100	100	100	Horwitz et al. 2006
Western Raritan Bay	2004	Hepatopancreas	3	--	100	100	100	Horwitz et al. 2006
Hackensack R. at Laurel Hill	2004	Hepatopancreas	3	--	130	100	200	Horwitz et al. 2006
Bellman Creek	2010	Hepatopancreas	4	100%	81 (27)	50	110	BCSA Group 2018
Mill Creek	2010-2016	Hepatopancreas	3	100%	140 (5.8)	130	140	BCSA Group 2018
Three Jamaica Bay Tributaries	2014	Hepatopancreas	15	100%	27 (6.5)	18	37	Anchor QEA 2017
Westchester Creek	2014	Hepatopancreas	5	100%	33 (5.2)	28	41	Anchor QEA 2017
Barnegat Bay near Toms River	2004	Muscle	5	--	190	--	260	Horwitz et al. 2008
Raritan Bay at Keanberg	2006	Muscle	3	100%	86 (23)	60	102	Horwitz et al. 2008
Eastern Raritan Bay	2004	Muscle	3	--	100	100	100	Horwitz et al. 2006
Raritan R. at Rte 35 Victory Bridge	2004	Muscle	3	--	100	100	100	Horwitz et al. 2006
Western Raritan Bay	2004	Muscle	3	--	100	100	100	Horwitz et al. 2006
Hackensack R. at Laurel Hill	2004	Muscle	3	--	330	300	400	Horwitz et al. 2006
Bellman Creek	2010	Muscle	10	90%	140 (63)[a]	<45	240	BCSA Group 2018
Mill Creek	2010-2016	Muscle	4	100%	105 (30)	68	140	BCSA Group 2018
Three Jamaica Bay Tributaries	2014	Muscle	15	100%	35 (8.2)	23	52	Anchor QEA 2017
Westchester Creek	2014	Muscle	5	100%	53 (16)	41	80	Anchor QEA 2017

Table C-12
Mercury Concentrations in Blue Crab in Reference Areas
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Notes:
All tissue concentrations are reported on a wet weight basis.
Standard deviation is not reported when unavailable in the data source or not calculable from raw data.
Reference locations are shown on Figures C-4, C-5, and C-6.
[a]One-half of the method detection limit was substituted for non-detect values in calculateion of mean and standard deviation.

Acronyms and Abbreviations:
-- = not reported
< = less than
% = percent
FOD = frequency of detection
µg/kg = micrograms per kilogram

References:
Anchor QEA. 2017. Baseline Human Health Risk Assessment. Remedial Investigation/Feasibility Study. Newtown Creek. June.
BCSA Group. 2018. Final Remedial Investigation Report. Berry's Creek Study Area. Berry's Creek Cooperating Parties Group. August.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. Patrick Center for Environmental Research. Academy of Natural Sciences. December.
Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2008. Final Report: Routine Monitoring of Toxics in New Jersey Fish, Third Year (2006) of Routine Monitoring Program. Patrick Center for Environmental Research. Academy of Natural Sciences. December.

Table C-13
Comparison of Average Mercury Tissue Concentrations in Reference Areas and the NBSA
Appendix C: Evaluation of Background and Reference Data
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

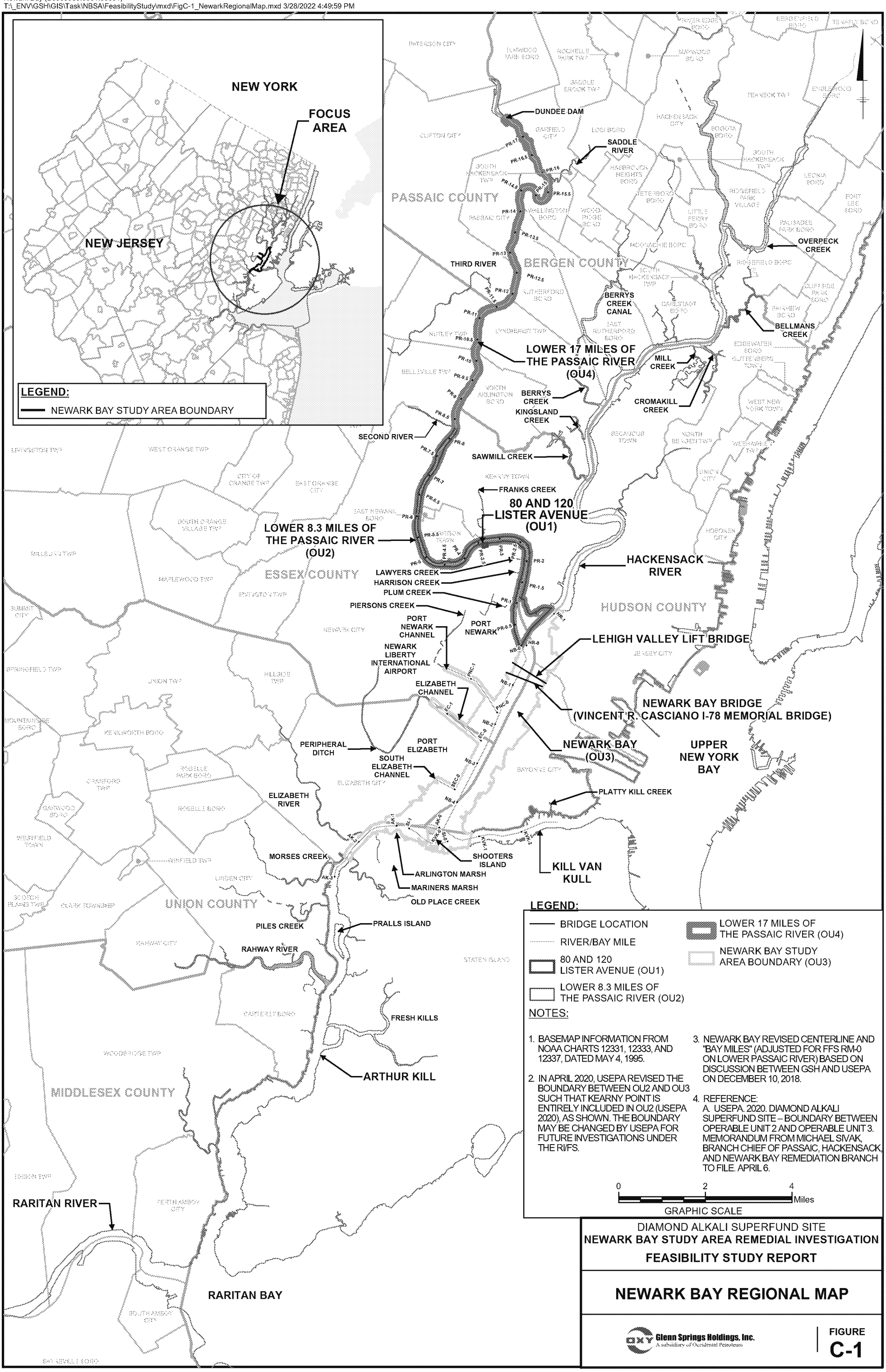
		Mercury (µg/kg)										
		NBSA				Range of Means in Reference Areas						
Species	Tissue	N	FOD	Mean	Standard Deviation	Hackensack River[a]	Raritan[b]	Mid-Coast Estuaries[c]	Delaware Bay	Atlantic Ocean	Miscellaneous Coastal[d]	New York[e]
American Eel	Fillet	18	100%	360	155	--	--	100 - 240	240	--	--	--
Bluefish	Fillet	18	100%	290	79	--	130 - 520	300	170	300 - 480	250 - 350	--
Striped Bass	Fillet	18	100%	250	78	--	--	230	260	230 - 300	360 - 390	110 - 120
Summer Flounder	Fillet	18	100%	150	67	--	91 - 100	--	--	87	140	--
White Perch	Fillet	18	100%	270	85	220 - 270	100	--	--	--	--	87
Blue Crab	Hepatopancreas	37	100%	68	21	81 - 140	57 - 100	90	--	--	--	27 - 33
Blue Crab	Muscle	37	100%	170	43	105 - 330	86 - 100	190	--	--	--	35 - 53

Notes:
All tissue concentrations are reported on a wet weight basis.
NBSA samples were collected during RI sampling conducted from 2014 to 2016 (GSH 2022).
[a]Includes locations in the Hackensack River or tributaries, Bellman's Creek and Mill Creek.
[b]Includes location in the Raritan River, Raritan Bay and Sandy Hook.
[c]Includes the Navesink River, Shrewsbury River, Shark River, Barnegat Bay and Mullica River.
[d]Data reported in Burger and Gochfeld (2011) combined from multiple coastal areas of New Jersey.
[e]Includes tributaries to Jamaica Bay (i.e., Gerritsen Creek, Spring Creek and Head of Bay) and Westchester Creek.

Acronyms and Abbreviations:
-- = no data
FOD = frequency of detecttion
GSH = Glenn Springs Holdings, Inc.
N = sample size
NBSA = Newark Bay Study Area

Reference:
GSH. 2022. Final Remedial Investigation Report - Newark Bay Study Area, Newark, NJ. May.

Figures



DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
FEASIBILITY STUDY REPORT

NEWARK BAY REGIONAL MAP

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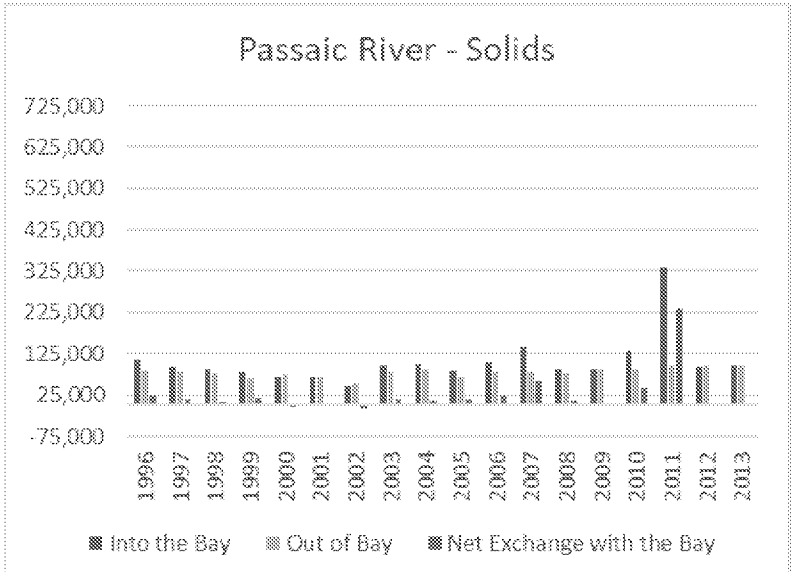
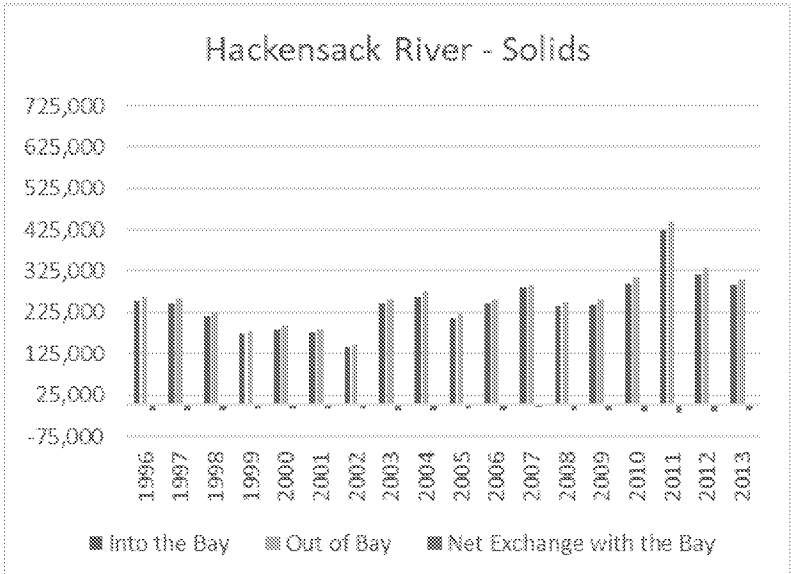
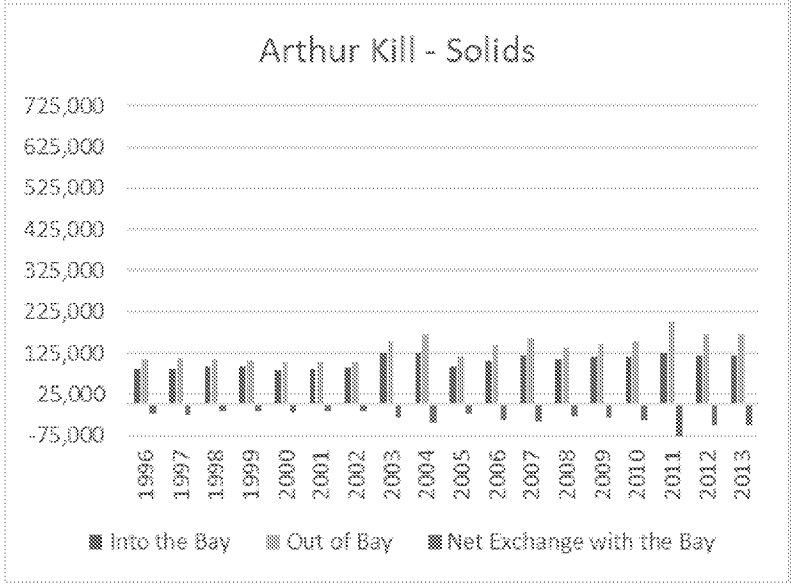
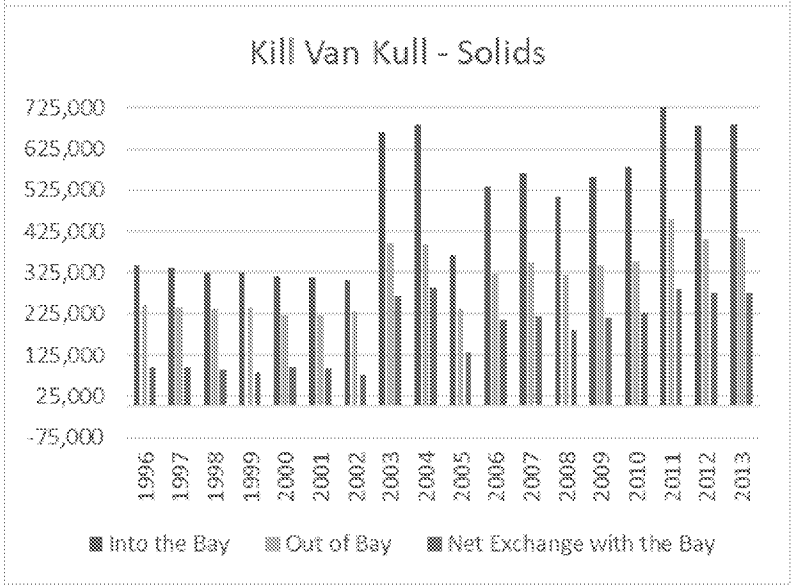
FIGURE
C-1









Notes:
Total flux for 1996-2013.

Negative values indicate losses from Newark Bay.

Results are computed from model output summaries from the fate and transport model jointly developed by USEPA and the Cooperating Parties Group that were provided by HDR.

Source:
GSH 2022. Final Remedial Investigation Report – Newark Bay Study Area, Newark, NJ. May.

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NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX C: EVALUATION OF BACKGROUND AND REFERENCE DATA

MODELED 1996-2013 ANNUAL SOLIDS FLUX BETWEEN NBSA AND CONNECTED WATERWAYS

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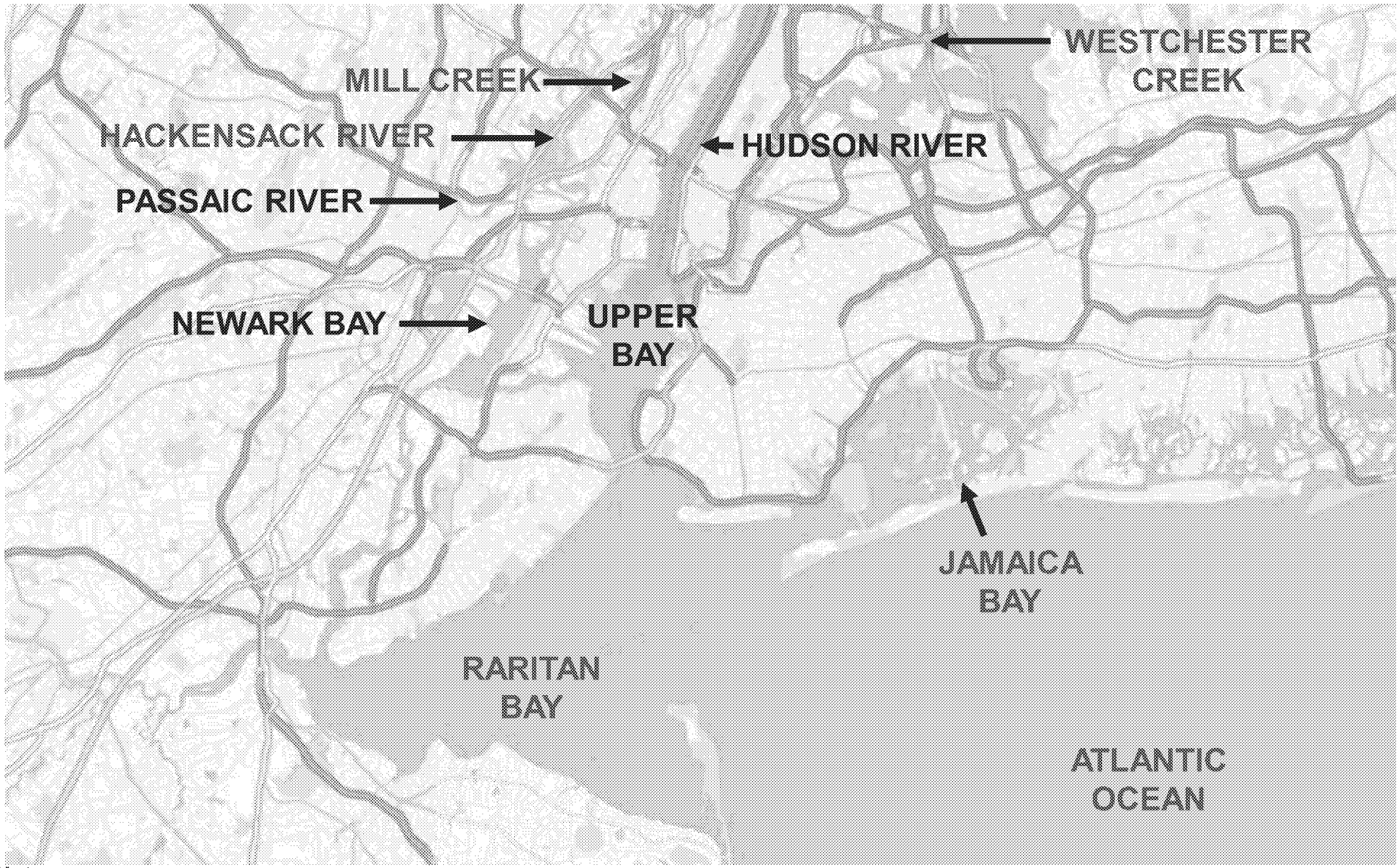
FIGURE
C-2



Notes:
Reference areas are shown in blue font.

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NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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REFERENCE AREAS IN NEW YORK/NEW JERSEY ESTUARINE AND COASTAL WATERS

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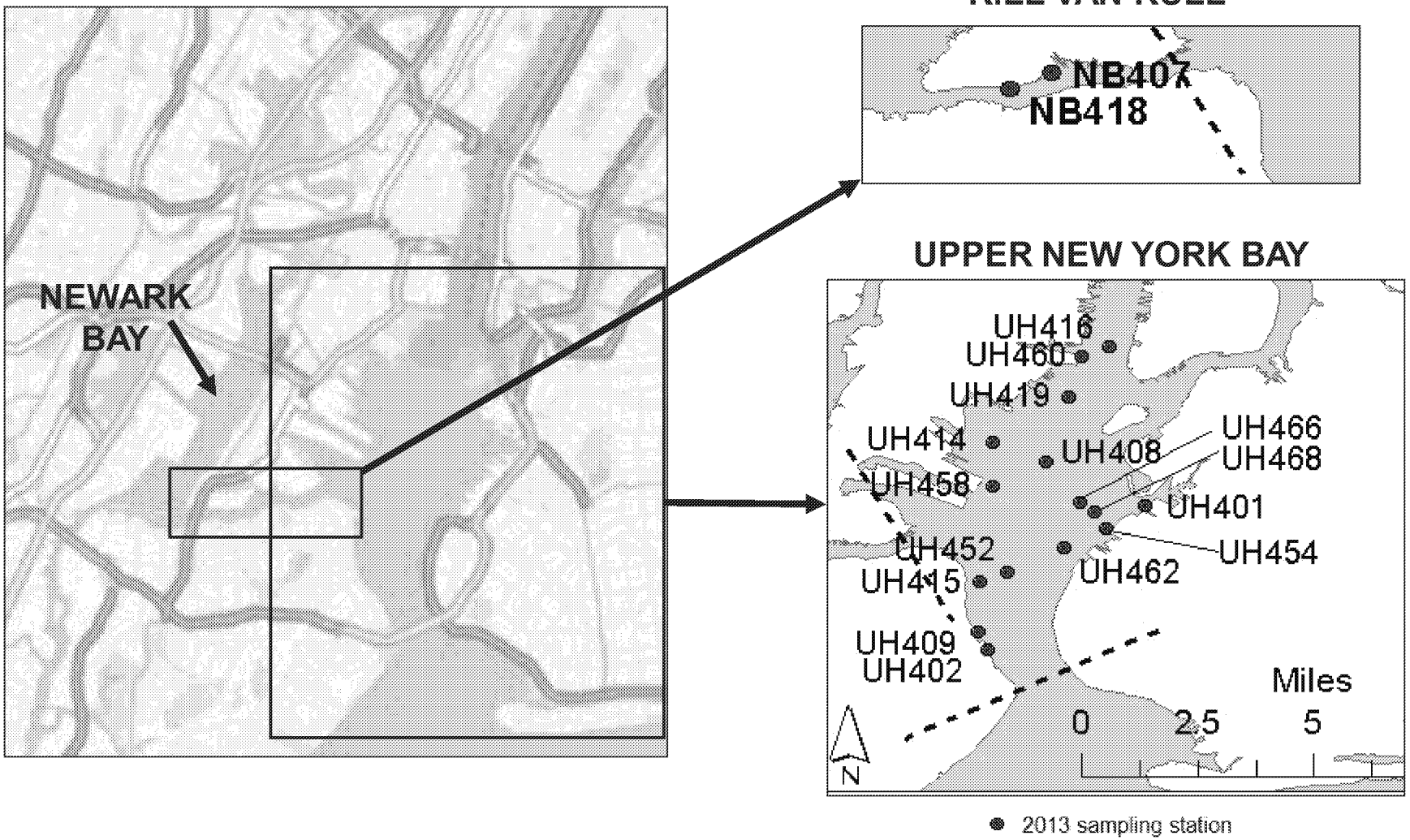
FIGURE
C-3



● 2013 sampling station

Source:
USEPA. 2018. 2013 REMAP NY/NJ Harbor dioxin/furan data. E-mail communication from Darvene Adams to Eugenia Naranjo and Arcadis. Monitoring Operations Section Monitoring and Assessment Branch Division of Environmental Science and Assessment U.S. EPA - Region 2. Edison, NJ. December 17, 2018.

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POST HURRICANE SANDY SAMPLING LOCATIONS IN KILL VAN KULL AND UPPER NEW YORK BAY

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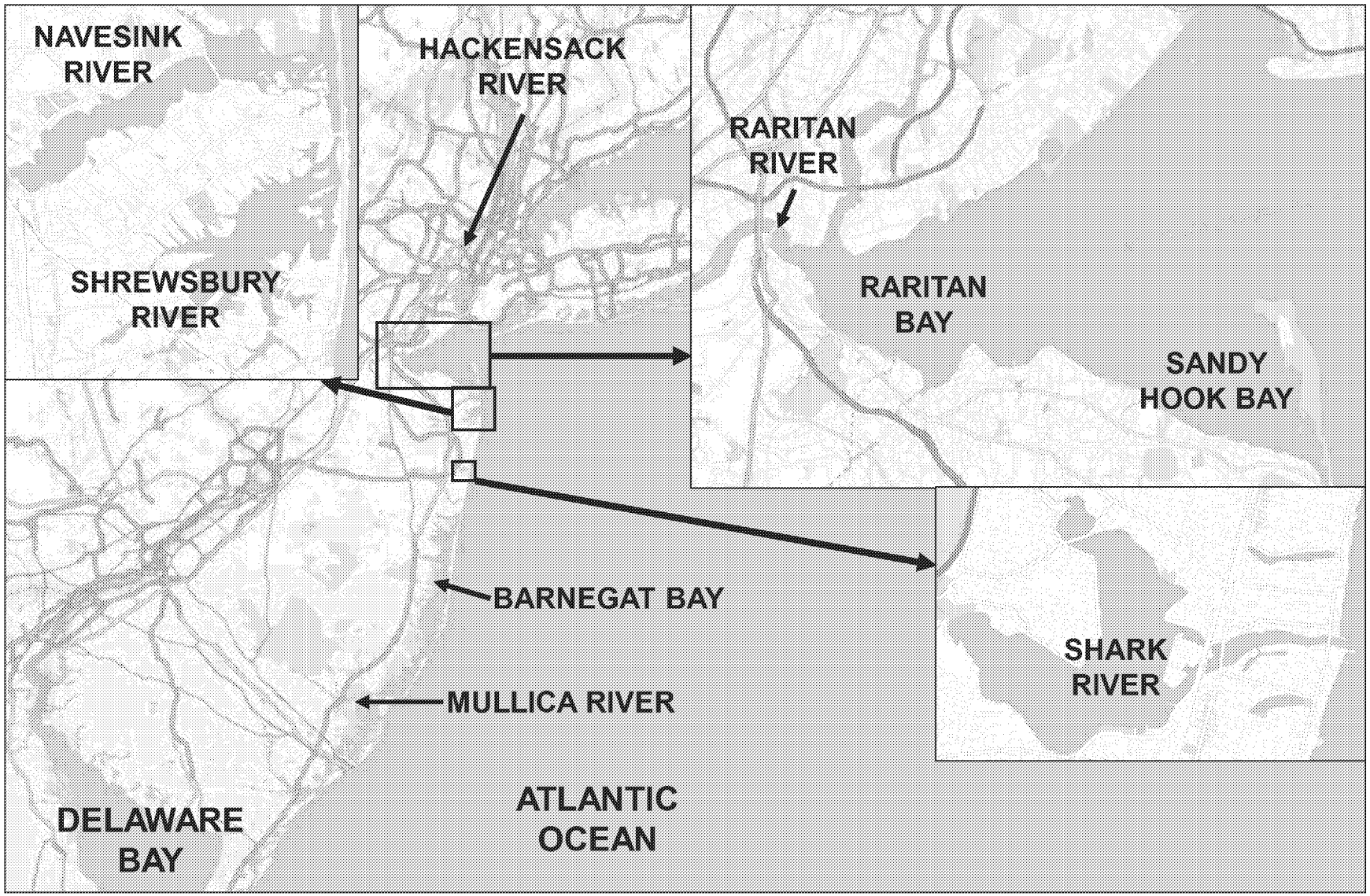
FIGURE
C-4



References:

Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2006. Final Report: 2004 Monitoring Program for Chemical Contaminants in Fish from the State of New Jersey, Second Year of Routine Monitoring Program. Report No. 06-04F. December.

Horwitz, R. J., P. Overbeck, J. Ashley, D. Velinsky and L. Zadoudeh. 2008. Final Report: Routine Monitoring of Toxics in New Jersey Fish, Third Year (2006) of Routine Monitoring Program. Patrick Center for Environmental Research. Academy of Natural Sciences. December.

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BIOTA SAMPLING AREAS FROM THE NEW JERSEY TOXICS MONITORING PROGRAM

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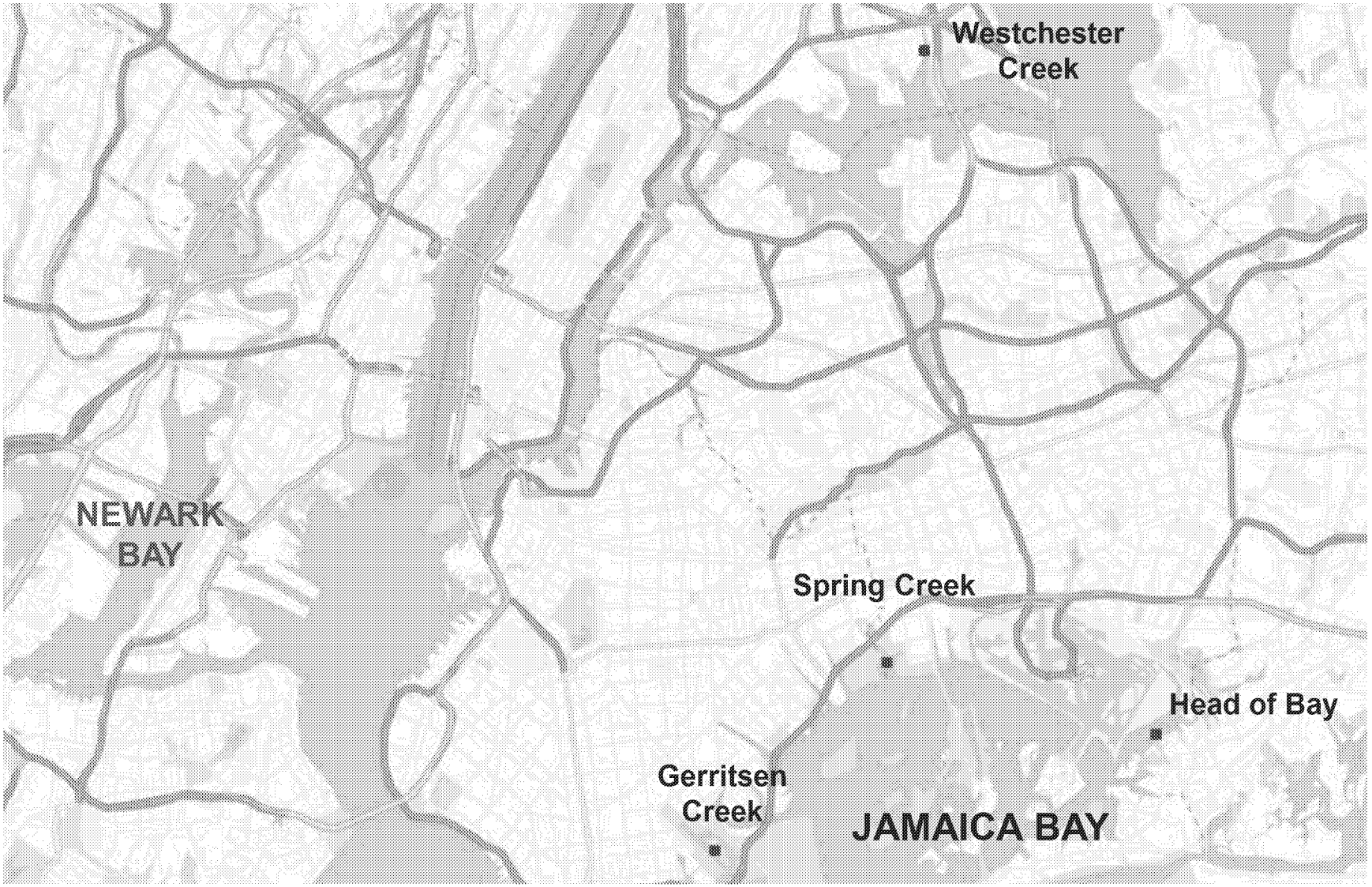
FIGURE
C-5



Reference Biota Sampling Area

Reference:
Anchor QEA. 2017. Baseline Human Health Risk Assessment. Remedial Investigation/Feasibility Study. Newtown Creek. June. Available at newtowncreek.com.

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APPENDIX C: EVALUATION OF BACKGROUND AND REFERENCE DATA

BIOTA SAMPLING REFERENCE AREAS: NEWTOWN CREEK RI

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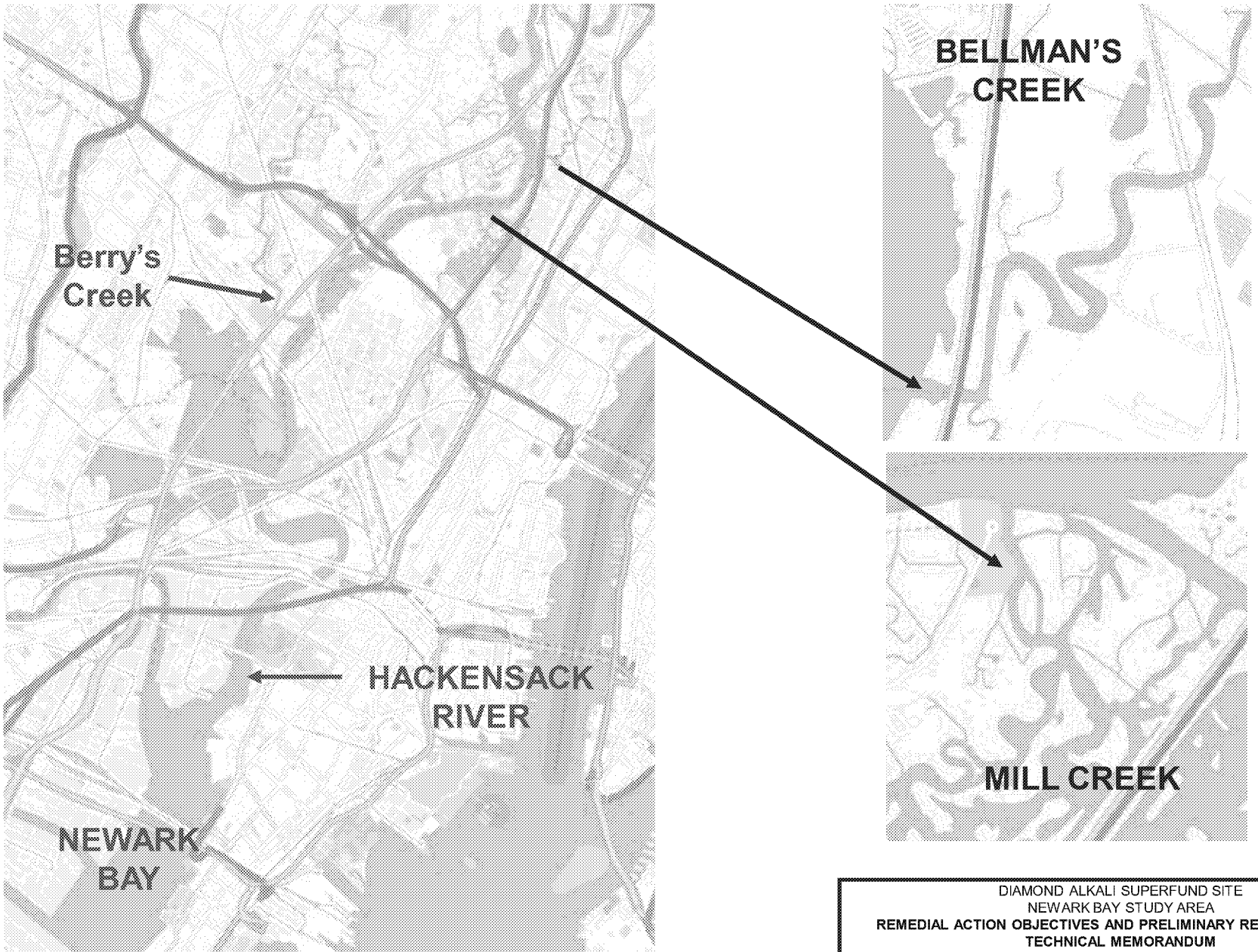
FIGURE
C-6



Reference:
BCSA Group. 2018. Final Remedial Investigation Report. Berry's Creek Study Area. Berry's Creek Cooperating Parties Group. August. Available at berryscreekstudyarea.com.

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BIOTA SAMPLING REFERENCE AREAS: BERRY'S CREEK RI

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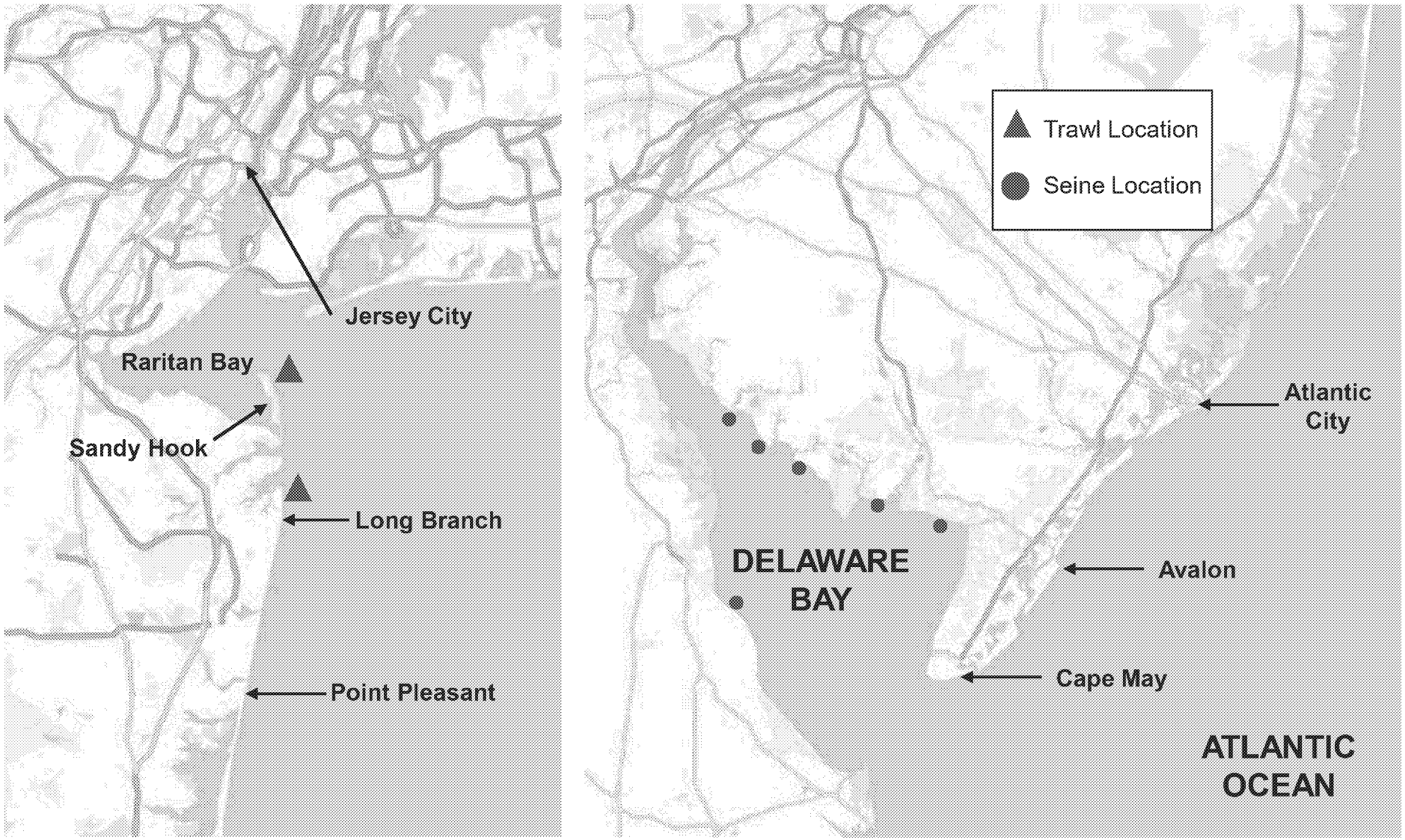
FIGURE
C-7



Notes:
Trawl or seine locations were fish collected by the New Jersey Department of Environmental Protection. Other fish were collected from recreational anglers at the locations shown.

Reference:
Burger, J. and M. Gochfeld. 2011. Mercury and selenium levels in 19 species of saltwater fish from New Jersey as a function of species, size, and season. *Sci Total Environ*. 409(8): 1418-1429..

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BIOTA SAMPLING AREAS IN COASTAL NEW JERSEY FISH SURVEY

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FIGURE
C-8

Appendix D

Toxicity Reference Values and Species Sensitivity Distributions

ARCADIS

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Appendix D: Toxicity Reference Values and Species Sensitivity Distributions

Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

August 2022

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Figure D-7 **Species Sensitivity Distribution for Arsenic in Invertebrates**

Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
ACRs	acute-to-chronic ratios
AhR	aryl hydrocarbon receptor
BERA	baseline ecological risk assessment
COC	chemical of concern
DDT	dichlorodiphenyltrichloroethane
FFS	focused feasibility study
FS	feasibility study
GOF	goodness-of-fit
GSH	Glenn Springs Holdings, Inc.
HQ	hazard quotient
LOAEL	lowest observed adverse effect level
LPR	Lower Passaic River
LPRSA	Lower Passaic River Study Area
mg/kg	milligrams per kilogram
NBSA	Newark Bay Study Area
ng/kg	nanogram per kilogram
NOAEL	no observed adverse effect level
OU	operable unit
PCBs	polychlorinated biphenyls
PRGs	preliminary remedial goals
SSD	sensitivity distribution
TEFs	toxicity equivalency factors
TEQ	toxic equivalency
TRVs	toxicity reference values
USEPA	United States Environmental Protection Agency
%	percent
µg/kg	micrograms per kilogram
µg/L	microgram per liter

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1 Introduction

A Baseline Ecological Risk Assessment (BERA) was conducted for the Newark Bay Study Area (NBSA), Operable Unit (OU) 3, to evaluate the risk to ecological receptors from exposure to contaminants present in the NBSA (Glenn Springs Holdings, Inc. [GSH] 2020). Risks were evaluated for the following ecological receptors:

- Invertebrates (infaunal communities, softshell clam [*Mya arenaria]*, and blue crab [*Callinectes sapidus]*)
- Fish
- Birds
- Mammals
- Reptiles.

The literature was reviewed to find concentration values in the tissue and diet of potential ecological receptors that are thought to be toxic based on scientific studies. These toxicity reference values (TRVs) were used to assess ecological risk to the benthic invertebrates, fish, birds, and mammals exposed to the NBSA by direct contact with sediments or through the ingestion of prey. TRVs are generally expressed in two ways: a no observed adverse effect level (NOAEL), which is the lowest concentration in a study for which effects were not observed or for which observed effects were not statistically significant (i.e., not beyond that which might be observed by chance); and a lowest observed adverse effect level (LOAEL), which is the lowest concentration in a study for which an effect was observed and was statistically significant. Measured tissue concentrations are divided by the NOAEL/LOAEL to derive a hazard quotient (HQ). HQs that exceed one are suggestive of risk to the receptor. For consistency with the BERA for the Lower Passaic River Study Area (LPRSA), i.e., OU4, the TRVs adopted for OU3 were consistent, to the extent feasible, with the TRVs for the different constituents of potential concern and receptor groups from the OU4 BERA (Windward 2019).

The OU4 TRVs used in risk calculations were selected from a larger dataset of NOAELs and LOAELs in one of two ways: 1) a TRV (representing a LOAEL TRV) was derived as the 5th percentile value of a species sensitivity distribution (SSD[1]) curve if toxicity data were sufficient and the highest NOAEL below the 5th percentile SSD value was selected as the NOAEL, or 2) a study-specific NOAEL TRV and a LOAEL TRV were selected (if toxicity data were not sufficient to develop an SSD). When data were not sufficient to derive a TRV from an SSD, the lowest acceptable LOAEL and the highest NOAEL below the LOAEL from the same study were selected as the TRVs. The development and selection process for the TRVs used in the OU4 BERA are described in detail in the main text and Appendix E of that document (Windward 2019).

In addition, the TRVs developed by the United States Environmental Protection Agency (USEPA) for OU2 in the Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River (LPR FFS; USEPA 2014) were evaluated in the NBSA BERA (GSH 2020) for risk bounding purposes. The intent of using both TRV sources, when available, is to understand the potential range of effects within a particular trophic category from more sensitive to less sensitive endpoint receptors. In general, the OU2 TRVs are lower (sometimes orders of magnitude lower) than comparable TRVs developed for OU3/OU4. Therefore, in many cases, ecological risk is only suggested by the OU2 TRVs and not the OU3/OU4 TRVs. Nonetheless, the USEPA has requested that if any LOAEL HQ exceeds one, under any exposure scenario for any receptor and chemical of concern (COC)

[1] An SSD is a statistical model that can be used to calculate a chemical concentration protective of a predetermined percentage of a group of species.

ED_014250_00000156-00179

combination evaluated in the BERA, that the receptor/COC be carried forward in the feasibility study (FS) and that preliminary remedial goals (PRGs) be calculated. Therefore, based on the evaluations presented in the BERA (GSH 2020), PRGs were calculated for the following ecological receptors and COCs:

- Softshell clam: 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), total polychlorinated biphenyls (PCBs), arsenic, lead, mercury, nickel
- Blue crab: 2,3,7,8-TCDD, total PCBs, total DDx (2,4' and 4,4') (sum of 6 isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane), and mercury
- Mummichog [*Fundulus heteroclitus*]/Killifish [*Fundulus majalis]*: 2,3,7,8-TCDD, total PCBs
- American eel (*Anguilla rostrata)*: 2,3,7,8-TCDD
- Summer flounder (*Paralichthys dentatus)*: 2,3,7,8-TCDD
- White perch (*Morone americana)*: 2,3,7,8-TCDD, total DDx (2,4' and 4,4')

2 Preliminary Remedial Goal Calculation and TRVs

A sediment PRG is defined as the concentration in sediment that will result in a tissue concentration associated with acceptable risk to the receptor. Sediment PRGs are calculated using models that predict the tissue concentrations in biota associated with a given sediment concentration. For the organic COCs (2,3,7,8-TCDD, PCBs, and DDx), a bioaccumulation model (see Appendix A) was developed by USEPA to predict tissue concentrations based on concentrations in abiotic media (e.g., sediment, water column) predicted by the contaminant fate and transport model developed for the NBSA. For the inorganic COCs (arsenic, lead, mercury, and nickel), empirical regression models were derived to predict tissue concentrations from sediment concentrations (see Appendix B). Acceptable tissue concentrations for the derivation of PRGs are based on the TRVs evaluated in the BERA.

The USEPA (2020) provided guidance for selecting acceptable tissue concentrations (i.e., toxicity thresholds) to be used for PRG calculation for ecological receptors in the following cases:

- If a single TRV source was used in the BERA, the following should be used as the toxicity threshold for PRG calculation
  - For a single study, the geometric mean of the NOAEL and LOAEL
  - For multiple studies, the 5th percentile of the LOAEL SSD.
- If multiple TRVs were evaluated in the BERA, the following should be used as the toxicity thresholds for PRG calculation
  - Geometric mean of OU2 NOAEL and LOAEL TRVs
  - Geometric mean of OU3/OU4 and OU2 LOAEL TRVs
  - Geometric mean of OU3/OU4 NOAEL and LOAEL TRVs.

After this initial guidance from USEPA, another option, in the case of multiple TRVs, was developed to "integrate" the OU2 and OU3/OU4 TRVs in certain cases. Specifically, if the OU3/OU4 LOAEL was developed from an SSD

that did not include the OU2 study LOAEL, the SSD was recalculated to include that study and the resulting 5th percentile is used to calculate a PRG. The SSD calculation is further discussed in Section 3.

USEPA further stated that "*where multiple TRVs were used in the OU3 BERA, toxicity thresholds for use in calculating ecological PRGs should be based on OU2 FFS values unless GSH can support a determination that higher values would also be ecologically protective and more technically appropriate.*" While all TRVs are subject to uncertainty (see Section 5), the TRVs selected for OU3/OU4 have been documented to be technically appropriate in the approved BERAs for OU4 (Windward 2019) and OU3 (GSH 2020). Therefore, PRGs were calculated using the range of available TRVs as described above. Table D-1 presents the TRVs evaluated in the BERA (GSH 2020) for the ecological receptors and COCs requiring PRG calculation.

3 Revised SSDs

Using the 5th percentile of an SSD as a toxicity threshold for PRG calculation is a conservative means to ensure protection of a range of potentially sensitive species/endpoints. Many of the OU3/OU4 TRVs are based on SSDs that were conducted after the LPR FFS was conducted and therefore were not considered in the LPR FFS. In addition, some of the SSDs evaluated in the OU4 BERA (and used in the OU3 BERA) did not include the TRV studies upon which the LPR TRVs were based. In these cases, the SSDs were updated to include all studies evaluated for OU2 and OU3/OU4 and to recalculate a 5th percentile.

In the BERA (GSH 2020), LOAEL TRVs were based on the 5th percentile of an SSD for the following receptors/COCs requiring PRG calculation (Table D-1):

- Invertebrates (total PCBs, total DDx (2,4' and 4,4') and arsenic)
- Fish (2,3,7,8-TCDD, total PCBs and total DDx (2,4' and 4,4')).

Three of these SSD were updated for the FS to include LOAELs from the OU2 TRV studies as follows: total PCBs (invertebrates and fish) and 2,3,7,8-TCDD for fish. The other SSDs already included the OU2 TRVs where available or in the case of total DDx (2,4' and 4,4') in fish, the OU2 TRV was already based on a prior study that evaluated an SSD. SSDs were modeled using the USEPA tool called the Species Sensitivity Distribution Generator (USEPA 2017) that fits a log-probit model to the distribution.

Table D-2 shows the species and endpoints used in the revised SSDs. Consistent with the methods established for the OU4 BERA (Windward 2019), only one LOAEL was included for each species in the SSD. Where multiple LOAELs were available for a single species, the most sensitive endpoint among mortality, growth, or reproduction was selected for inclusion in the SSD. Where multiple LOAELs were available for the most sensitive endpoint for a single species, the geometric mean of the LOAELs for the most sensitive endpoint for that species was selected for inclusion in the SSD. Figure D-1 shows the revised SSD for 2,3,7,8-TCDD in fish. Figure D-2 shows the revised SSD for total PCBs in invertebrates. When reviewing the data to be included in the SSD for PCBs in fish, it was observed that in the original SSD provided in the OU4 BERA (Windward 2019), the LOAEL for the species *Barbus* (520 micrograms per kilogram [µg/kg])[2] was not included. Therefore, the SSD for PCBs in fish was revised to include this species and the resulting OU3/OU4 LOAEL TRV was changed from 3,800 µg/kg (Table D-1) to 1,200 µg/kg (Figure D-3). The SSD for PCBs in fish was further revised to include the LOAEL from the OU2 TRV (Figure D-4). Table D-3 summarizes the 5th percentiles of the revised SSDs.

[2] All TRVs are reported on a wet weight basis.

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Table D-3 Summary of LOAELs based on Revised and Integrated SSDs

COC	Receptor Type	LOAEL (5th Percentile of SSD)	Notes
2,3,7,8-TCDD	Fish	3.9 ng/kg	SSD revised to include OU2 LOAEL. See Figure D-1.
Total PCBs	Invertebrate	61 µg/kg	SSD revised to include OU2 LOAEL. See Figure D-2.
	Fish	1,200 µg/kg	SSD revised to include *B. barbus.* See Figure D-3.
		590 µg/kg	SSD revised to include *B. barbus* and OU2 LOAEL. See Figure D-4.

Note: All TRVs are reported on a wet weight basis.

4 Selected Toxicity Threshold Values for PRG Development

Based on the initial guidance provided by USEPA (2020) and subsequent communications between USEPA and GSH (USEPA 2021; WSP 2021), a set of toxicity threshold values for acceptable tissue concentrations in aquatic biota were derived for the calculation of PRGs (Table D-4). PRGs were calculated based on OU2 and OU3/OU4 TRVs. In addition, PRGs were calculated based on the integrated OU2 and OU3/OU4 TRVs. The integrated TRVs are either based on the 5th percentile of the integrated SSDs (described in Section 3) or based on the geometric mean of the OU2 and OU3/OU4 LOAELS. These threshold values for tissue were used to calculate sediment PRGs as described in Appendix A for organic compounds and in Appendix B for metals. Sediment PRGs based on these thresholds are expected to be protective of most species; however, there is uncertainty in their derivation as described in Section 5.

5 Uncertainty in TRVs used in the Calculation of PRGs

The uncertainty of assessing ecological risk based on the TRVs from literature was acknowledged in the BERA (GSH 2020). This uncertainty extends to the protectiveness of the sediment PRGs that are based on these TRVs. To reduce uncertainty in risk assessment, the TRVs used were already accepted by USEPA in other regional assessments. Further, uncertainty was quantified by calculating a range of HQs using multiple sets of TRVs. Two sets of TRVs available from regional ecological risk assessment were evaluated in the NBSA BERA:

1. TRVs developed for the LPRSA (OU4) BERA (Windward 2019)
2. TRVs developed for the LPR (OU2) FFS (USEPA 2014).

In general, USEPA acknowledges and GSH concurs that the LPR FFS TRVs are more conservative than comparable TRVs developed for OU4. The intent of using both TRV sources, when available, is to understand the potential range of effects within a particular trophic category from more sensitive to less sensitive endpoint

receptors. The uncertainty in TRVs affects the magnitude and direction (over- or under-estimation) of risk estimates. This uncertainty in TRVs can result in PRGs that are over- or under-protective of ecological receptors. Uncertainty in the TRV and subsequent PRG development results from the following issues:

- Limited studies/species evaluated
- Unbounded TRVs estimated by extrapolation factors
- Extrapolation of laboratory-based TRVs based on studies with individual animals to wildlife populations
- Use of acute to chronic ratios where studies of chronic impacts are limited
- Representativeness of species and statistical models used to evaluate SSDs.

For the OU4 BERA, Windward (2019) developed a process for tissue TRV selection in consultation with USEPA. A thorough literature search for relevant toxicological studies was conducted. These studies were then evaluated for use based on a set of acceptability criteria that limited them to those studies that measured NOAELs and LOAELs for appropriate endpoints (i.e., survival, growth, or reproduction) in a controlled manner using peer-reviewed experiment methods and for which a clear concentration- or dose-response relationship was reported. For those studies considered acceptable, NOAEL TRVs and LOAEL TRVs were derived. Final TRVs were then selected based on an evaluation of all acceptable NOAEL and LOAEL TRVs. Details regarding the literature search and study acceptability are presented in Appendix E of the OU4 BERA (Windward 2019). When sufficient data were available (i.e., data for at least five species), TRVs were generated using an SSD approach. When data were insufficient, the lowest acceptable LOAEL and highest NOAEL below the LOAEL from the same study were selected as TRVs.

For toxicity datasets representing at least five species, Windward (2019) developed TRVs using an SSD approach. The LOAEL TRV was selected as the 5th percentile of the SSD, and the NOAEL TRV was extrapolated from the LOAEL TRV using an uncertainty factor of 10. Though there is uncertainty associated with the use of extrapolation factors for NOAELs, this has no bearing on the selected LOAEL upon which the toxicity threshold is based for PRG calculation when an SSD is available for the receptor/COC combination. The SSD approach has been used by USEPA to develop National Ambient Water Quality Criteria and is intended to include the range and distribution of species sensitivities in natural communities, even though these actual sensitivities are unknown and dependent on the communities present. This approach is intended to be less uncertain than TRVs developed from one study by incorporating toxicity data for many species as well as, in some cases, multiple toxicity values for the same species from different studies. Beginning in the early 1990s, SSDs were proposed as ecological risk assessment models. In risk assessment guidance, USEPA (1998) provided an example use of an SSD, referred to as a cumulative exposure and effects distribution, as one way to calculate risks to species by environmental contaminants. USEPA (2003) proposed an SSD approach for evaluating risks to avian species from dioxin-like chemicals.

An SSD is a statistical model that can be used to calculate a chemical concentration protective of a predetermined percentage of a group of species. SSDs are intended to provide an indication of both the total range and distribution of species sensitivities in natural communities, even when the actual range of sensitivities is unknown. Typically, SSDs are presented as a cumulative distribution function of the toxicity of a chemical to a group of laboratory test species. Inherent uncertainties with this approach include: the number of samples and

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species represented by the SSD and the suitability of the distribution used to fit the SSD (i.e., the best-fit model). The more toxicological data available for the development of the SSD, the more certainty there is in the SSD.

All toxicity data for various species meeting the TRV selection criteria were considered in constructing the SSDs (Windward 2019). LOAELs represent the lowest concentrations at which an adverse effect is observed, whereas NOAELs indicate the concentration at which no adverse effect is observed. However, NOAELs do not indicate whether an adverse effect can be expected. Therefore, LOAELs were considered appropriate for developing SSDs to determine the potential for an adverse effect. For each chemical, a single effects threshold (the final species LOAEL) was determined for inclusion in the SSD considering all acceptable LOAELs for that species. Because mortality is a less sensitive endpoint than growth or reproduction effects, for studies reporting only acute LOAELs (i.e., mortality endpoints with < 28 days of observation and no growth or reproduction data reported in the same study), chronic LOAELs as inputs into the SSD dataset were estimated using chemical-specific acute-to-chronic ratios from the literature.

When multiple studies evaluated the same species, the data were processed before being incorporated into the SSD (Windward 2019). For any given toxicological endpoint (i.e., survival, growth, or reproduction), including sub-lethal effects related to population-level effects, the geometric mean of all chronic LOAELs for that endpoint was calculated to determine the final endpoint value. If LOAELs for multiple endpoints were available, the lowest value among the endpoints was selected. For example, if toxicological data for survival and growth were reported in multiple studies for a particular species, first the geometric mean of all survival data and the geometric mean of all growth data were independently calculated, then the lower of the survival and growth geometric means was selected as the final species LOAEL.

Compared to a LOAEL based on a single study and test species, tissue-based SSDs provide a measure of community sensitivity by incorporating not only toxicity data for many species, but also multiple toxicity values (typically LOAELs) for the same species from different studies. The use of SSDs is also conservative, in that the SSD TRV tends to be selected from the lower tail of the SSD, most often the 5th percentile value. An advantage of the SSD approach for selecting TRVs is that it is less sensitive to moderately small data sets (e.g., four to ten species) than the conventional use of the most sensitive tested species (USEPA 2003) and because the 5th percentile can be lower than the lowest measured LOAEL from the tested species.

SSDs are based on several statistical and biological assumptions resulting in potential uncertainty. The statistical assumptions pertain to: 1) the number of samples included in the SSD, 2) the type of effects associated with the toxicity values included in the SSDs (i.e., ACR-adjusted acute values versus chronic values), and 3) the appropriateness (e.g., goodness-of-fit) of the distribution(s) used to describe the SSDs. Biological assumptions were made regarding whether the actual community of interest was sufficiently protected by the SSD TRV (i.e., 5th percentile value), which was typically based on non-site-specific species, and whether the theoretical distribution fit to the SSD data was representative of the actual community of interest.

The number of samples included in an SSD impacts the reliability and stability of the TRV derived from that SSD. As the number of samples increases, the stability of the TRV tends to increase. This is particularly true of TRVs selected from the tail of an SSD, which is associated with a greater level of uncertainty (than the median or similar percentiles). Wheeler et al. (2002) and Newman et al. (2000) indicated that datasets of between 10 and 55 data points, depending on the distribution and spread of the data, were required for a low-percentile SSD TRV (e.g., 5th percentile) to be stable, regardless of the dataset from which the SSD was developed. Roman et al. (1999) concluded that when fewer than five data points are available to derive an SSD, a TRV based on the lowest toxicity value is an estimated low-percentile SSD TRV, but that increasing the number of toxicity values (i.e., n >

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5) in the SSD allows for greater confidence in a low-percentile TRV. These minimum dataset size criteria were used to determine if data were sufficient to generate an SSD.

While the use of acute-to-chronic ratios (ACRs) allows for more data to be used in SSD development, uncertainty in the use of an ACR to calculate chronic LOAELs for use in the SSD should be considered. Allard et al. (2010) highlights how adsorption, distribution, metabolism, and excretion rates vary considerably between acute and chronic exposures and concludes that it is unwise to use TRVs based on acute studies when assessing risks from chronic exposures. ACRs were not available from specific studies or for species associated with the acute tissue LOAELs; instead, they were based on ACRs calculated from aquatic toxicity data. The applicability of water exposure-based ACRs to acute tissue-based toxicity data is unknown, but this approach has been used previously for assessments of the LPR (USEPA 2014).

Windward (2019) evaluated multiple distributions for fitting SSDs and used goodness-of-fit (GOF) statistics to select the best model. The selection of a theoretical distribution to represent the empirical toxicity values in an SSD can have a substantial effect on a calculated TRV. Depending on the shape of a distribution and its GOF to the lower tail of the empirical data, SSD TRVs can differ by one or more orders of magnitude. Visual inspection of curve fits to the empirical data, while essential for making informed statistical decisions, is subjective. GOF statistics provide an objective means of ranking distributions against one another, but statistics may not reflect the GOF of a curve to the lower tail of a distribution. Instead, GOF statistics can be biased toward the fit at the middle of a distribution and/or be heavily influenced by the fit of a distribution to the upper tail, rather than the lower tail from which the SSD TRV is estimated. In some cases (i.e., when several distributions provide similar results), neither the visual fit nor GOF statistics provide an unambiguous “best” distribution.

The SSD TRVs used to derive toxicity thresholds for PRG calculation were either obtained from the LPRSA BERA (Windward 2019) using the process described above or recalculated as described herein after adding the OU2 study to the list of studies evaluated by Windward (2019). For the recalculated or “integrated” SSDs, the same process used by Windward (2019) was used to select the final species LOAELs for inclusion in the SSD. However, only one model was considered for the integrated SSDs. The USEPA’s Species Sensitivity Distribution Generator tool (USEPA 2017) was used for all integrated SSDs. This tool applies the log-probit distribution to all SSDs. This may result in some uncertainty based on the fact that some distribution other than the log-probit may provide a better fit to the data. However, due to the difficulties of finding an unambiguous “best” fit for an SSD as described above, the USEPA tool was selected for objectivity.

SSD models based on the method utilized by Windward (2019) of evaluating multiple distributions and selecting a “best” fit can be compared to SSDs based on the USEPA tool to get an idea of the uncertainty involved in calculating the 5th percentile of the SSD as a representative LOAEL. For example, Windward (2019) derived a LOAEL for total PCBs in invertebrates of 520 µg/kg based on the 5th percentile of a gamma distribution. If the same data are evaluated by the USEPA tool (USEPA 2017), the 5th percentile is 884 µg/kg. Other examples of differences between the methods are found in Table D-5 where it is shown that depending on the distribution chosen, estimates of the 5th percentile of an SSD can vary as much as 10-fold.

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Table D-5 Comparison of Methods to Compute SSDs

Receptor Category	COC	USEPA SSD Generator 5th Percentile of the Log-Probit Distribution*	Windward (2019) SSD 5th Percentile Estimates (Distribution)
Invertebrate	Total PCBs	884 µg/kg	520 µg/kg (Gamma)
	Total DDx (2,4' and 4,4')	110 µg/kg	110 µg/kg (Gamma) 10 µg/kg (Beta General)
	Arsenic	0.37 mg/kg	0.64 mg/kg (Levy)
Fish	2,3,7,8-TCDD TEQ	95 ng/kg	120 ng/kg (geometric mean of 5th percentiles of the Pearson 6, log-logistic and Weibull distributions) 23 ng/kg (Beta General)
	Total DDx (2,4' and 4,4')	1000 µg/kg	520 µg/kg (Weibull)

*Calculated using the same data set as the SSDs presented in Windward (2019).
All TRVs are reported on a wet weight basis.
mg/kg = milligrams per kilogram
ng/kg = nanograms per kilogram

A discussion of the uncertainties of the TRVs specifically used to derive ecological sediment PRGs are described below. For a complete discussion of the toxicological profiles of the COCs and the uncertainty of all TRVs used to evaluate risk in the NBSA, see Appendix D of the NBSA BERA (GSH 2020). For a list of al toxicological studies reviewed for the OU4 TRV selection, see Appendix E of the OU4 BERA (Windward 2019).

5.1 Dioxins/Furans

The dioxin congener 2,3,7,8-TCDD is part of a group of compounds called polychlorinated dibenzo-p-dioxins and dibenzofurans (dioxins/furans) that contain one to eight chlorine atoms attached to the carbon atoms of the parent chemical and are persistent environmental contaminants. The list of 17 dioxin/furan congeners that are most toxic and with a similar mode of action have chlorine substitution at the 2, 3, 7, and 8 positions. In order to assess the toxicity of dioxins and furans as a mixture, a system of toxicity equivalency factors (TEFs) was developed based on the toxicity of 2,3,7,8-TCDD (USEPA 2008), generally the most toxic on the list. In this system, each of the 17 congeners is assigned a factor (i.e., TEF) based on its potency relative to 2,3,7,8-TCDD; the estimated toxicity of all congeners present is summed to come up with an overall estimate of toxicity, called the 2,3,7,8-TCDD toxic equivalency (TEQ). Ecological risks were evaluated based on 2,3,7,8-TCDD alone and based on the total dioxin/furan TEQ. In the NBSA, 2,3,7,8-TCDD is generally associated with greater than 90 percent (%) of the TEQ estimates, therefore, PRGs calculated based on 2,3,7,8-TCDD alone are expected to be protective of all dioxin/furan toxicity.

5.1.1 Invertebrates

Most toxic effects of dioxins and furans are initiated by activation of the cellular aryl hydrocarbon receptor (AhR), a ligand-activated transcription factor that is involved in the regulation of biological responses to planar aromatic

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hydrocarbons. While invertebrates can accumulate these compounds, they lack an AhR receptor and, as such, are not considered to be sensitive to the cellular mediated effects of these compounds like vertebrate organisms. There is a great deal of uncertainty regarding the potential effects of dioxins/furans on invertebrates, and the scientific literature on effects is relatively sparse and variable, compared to vertebrate organisms.

Windward (2019) found only one study that met TRV acceptability criteria (Table D-1). Ashley et al. (1996) is the only study identified that reported a 2,3,7,8-TCDD TRV for crustaceans. A LOAEL of 3,000 nanogram per kilogram (ng/kg) was reported for the survival of crayfish; a 25% mortality was observed after a 45-day exposure via cephalothoracic injection. No NOAEL was identified from this study. A NOAEL of 300 ng/kg was estimated from the LOAEL using an extrapolation factor of 10. Several uncertainties are associated with these TRVs: mortality is generally not the most sensitive endpoint based on chemical exposure, injection exposures do not accurately replicate environmental exposure routes, tissue concentrations were not reported, the test individuals were wild-caught, and only three or four individuals were exposed per treatment. However, it is a reported TRV for a crustacean species, and the derivation of the NOAEL was conservative to account for the uncertainties.

The LPR FFS (USEPA 2014) derived a LOAEL TRV of 1.3 ng/kg and a NOAEL TRV of 0.15 ng/kg based on a 10-month field study of adult eastern oysters (*Crassostrea virginica*) transplanted to two locations in New Jersey (Wintermyer and Cooper 2003). The tissue concentrations from one location (Arthur Kill), where 23% fertilization success occurred, became the LOAEL and the tissue concentrations from the other location (Sandy Hook), where 54% fertilization success occurred, became the NOAEL. There are several uncertainties with this study: reported tissue concentrations were based on one composite of seven oysters from each site, the endpoint, fertilized egg development was based on one sample, the presence of other contaminants was not considered or evaluated, and a true control group was not used for comparison. The application of this oyster TRV to blue crab is uncertain given the cross-taxonomic extrapolation, but provides for a bounding of risk estimates given the lack of available TRVs for blue crab or crustaceans for non-survival endpoints. Based on the information presented above regarding the lack of the AhR in invertebrates, the invertebrate TRVs would not be expected to be lower than that for vertebrates (fish), which is another indication of the uncertainty in these values.

For the reasons discussed both sets of TRVs have a high degree of uncertainty. Due to the uncertainty in these values, PRGs were calculated based on each set of TRVs and an integrated value representative of both sets of TRVs (Table D-4). A sediment PRG based on the OU2 TRVs is highly uncertain due to the uncertainties described in this study. Multiple legacy chemicals are found in the Arthur Kill and therefore chemicals other than 2,3,7,8-TCDD may have been responsible for or may have contributed to the reduction in fertilization in oysters. Resident aquatic invertebrate receptors in the NBSA such as softshell clam may not be as sensitive as the eastern oyster. Further, a sediment PRG based on an oyster study may not be applicable to the protection of blue crab, a crustacean and is likely to be over-protective based on the findings in Ashley et al. (1996). A PRG based on the integrated TRVs is considered to have somewhat less uncertainty in evaluating risk to aquatic invertebrates in the NBSA because it incorporates data from both studies.

5.1.2 Fish

Dioxins and furans have been reported to generate a broad range of toxic effects in fish under controlled exposure conditions, including reduced survival, body weight loss, edema, hemorrhaging, craniofacial malformations, toxemia, and reproductive, developmental, and behavioral effects and multiple studies were available for review.

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The LPR FFS (USEPA 2014) LOAEL and NOAEL of 1.8 and 0.89 ng/kg, respectively, for 2,3,7,8-TCDD and TEQ were developed based on reported impacts on prey capture behavior in newly hatched mummichogs following topical exposure of the eggs to PCB 126[3] at doses of 50 kilograms per liter (Couillard et al. 2011). Larvae tissue concentrations were estimated from empirical data on the ratio of larval tissue concentration to topical dose measured in a previous study (Couillard et al. 2008). The estimated larval tissue concentrations (355 and 178 ng/kg) were converted to estimated TEQ concentrations by multiplying the fish TEF for PCB 126 (0.005), resulting in the LOAEL and NOAEL of 1.8 and 0.89 ng/kg, respectively. These LPR FFS (USEPA 2014) TRVs are highly uncertain for the following reasons: 1) this study is more relevant to the fish egg assessment than adult fish; 2) the assessment endpoints of growth, reproduction, and survival showed no adverse effects, even at the highest doses; 3) relating a study on the toxicity of one PCB congener (126) to the toxicity of a sum of toxic dioxin congeners and dioxin-like PCBs; and 4) concentrations in mummichog larvae were not measured in the same study that recorded impacts on behavior. The larval tissue concentrations were estimated from data in another study that provided a ratio of larval tissue concentration to topical, and this ratio was based on one data point (Couillard et al. 2008, 2011). These extrapolated TRVs in fish larvae are also an order of magnitude lower than the measured TRVs for 2,3,7,8-TCDD in fish eggs from multiple species evaluated in an SSD (Steevens et al. 2005) where the upper and lower 95% confidence limits on the 5th percentile were 86 and 7.2 ng/kg, respectively. There is large degree of uncertainty with the derivation/use of this TRV.

Windward (2019) found nine studies examining reproduction, growth, and survival effects of dioxins and furans that were found to meet TRV acceptability criteria. Eleven LOAELs were identified for seven fish species (whitefish [*Coregonus clupeaformis*], common carp [*Cyprinus carpio*], zebrafish [*Danio rerio*], coho salmon [*Oncorhynchus kisutch*], rainbow trout [*Oncorhynchus mykiss*], Japanese medaka [*Oryzias latipes*], and fathead minnow [*Pimephales promelas*]), ranging from 85 to 14,400 ng/kg using both aqueous and diet-based exposures. Study durations ranged from 6 hours to 71 days. An ACR of 8.3 (Raimondo et al. 2007) was applied to one acute LOAEL value to derive a chronic LOAEL value. An SSD was developed using chronic LOAELs and ACR-derived LOAELs, and two 5th percentile TRVs were developed by fitting several theoretical distributions to the SSD data. The geometric mean 5th percentile of the three best fitting models, visually and statistically (i.e., the Pearson6, log-logistic, and Weibull distributions), was calculated as the LOAEL TRV (120 ng/kg). The NOAEL TRV (12 ng/kg) was extrapolated from the LOAEL TRV using an uncertainty factor of 10.

The Couillard et al. (2008, 2011) studies did not meet the TRV acceptability criteria and were not included in the SSD evaluation for the OU4 BERA (Windward 2019). However, to develop a threshold toxicity value that would include the studies, the SSD model was revised to integrate the OU2 LOAEL along with the other LOAELs listed in Table D-2 and the 5th percentile LOEAL was recalculated using the USEPA SSD tool (Figure D-1).

The toxicity thresholds derived for PRG calculation are summarized in Table D-4. Sediment PRGs based on the integrated SSD toxicity threshold (3.9 ng/kg) would be expected to be protective of most fish species in the NBSA, even the most sensitive given that the SSD includes eight species evaluated in ten studies. Sources of uncertainty include 1) the inclusion of the Couillard et al. (2008, 2011) studies into the SSD given that they did not meet the established acceptability criteria and 2) the choice of statistical model. Sediment PRGs based on the geometric mean of the OU2 NOAEL/LOAEL (1.3 ng/kg) are highly uncertain for the reasons discussed above regarding the TRV derivation process, that the OU-2 NOAEL/LOAEL geomean value is based on data from a single study rather than a SSD, and the fact that the NOAEL and LOAEL are an order of magnitude lower than values found in multiple other studies/species on 2,3,7,8-TCDD egg dosing (Steevens et al. 2005). Therefore,

[3] PCB-126 is a coplanar PCB congener that is known to have dioxin-like toxicity (USEPA 2008).

they are likely to be over-protective of NBSA fish species. The threshold value for the SSD that excludes the Couillard et al. (2008, 2011) studies (120 ng/kg) provides an upper bound for risk but is still inclusive of sensitive species such as rainbow trout and therefore may be most representative of risk in the NBSA due to low uncertainty. All three LOAEL TRV values (OU2, OU3/OU4, and Integrated) were used for PRG calculation.

5.2 Total PCBs

The effects of the 209 PCB congeners found in the environment may be associated with the survival, growth, and reproduction of individuals within the local populations of fish and wildlife species. A subset of PCB congeners, known as coplanar PCBs, also have "dioxin-like" toxicity initiated by activation of the cellular AhR receptor (USEPA 2008). The risk of these coplanar PCBs were evaluated as a sum of PCB TEQ (USEPA 2008) that is compared to the same TRVs developed for dioxins/furans. The TRVs discussed in this section refer to TRVs based on concentrations of total PCBs (sum of 209 congeners) in biota.

5.2.1 Invertebrates

Adverse ecotoxicological effects of PCBs on various aquatic invertebrates, including eastern oysters, sea urchins (*Arbacia punctulata*), grass shrimp (*Palaemonetes pugio*), pink shrimp (*Penaeus duorarum*), and blue crabs, have been observed and include decreased shell growth, reduced fertilization success, reduced reproductive success, and increased mortality.

The OU2 TRVs are based on Chu et al. (2000) where eastern oysters were exposed for 30 days to an algal diet contaminated with a PCB Aroclor mixture and total PCB accumulation within the oysters was measured. A later study, Chu et al. (2003), examined PCB accumulation and reported adverse reproductive effects measured by reduced number of spawned oysters after 76 days of exposure to 0.35 µg/L, and no-adverse-effect on reproduction after 30 days of exposure to 0.10 µg/L PCBs (Chu et al. 2003). An extrapolated LOAEL egg tissue concentration of 52 µg/kg was derived for the exposure of 0.35 µg/L using a regression based on the exposure concentrations (0.1 and 1 µg/L) and egg tissue concentrations (20 and 134 µg/kg) reported by Chu et al. (2000). The egg tissue LOAEL and NOAEL of 52 and 20 µg/kg, respectively, were converted to an adult tissue LOAEL and NOAEL of 17 and 6.4 µg/kg, respectively, using the adult:egg lipid ratio of 0.25:0.08 (Windward 2019). These TRVs are highly uncertain due to the following: 1) no dose-responsive relationship was observed among the females that had spawned (Chu et al. 2003); 2) no PCB analysis was conducted on eggs, and the authors believed that PCB concentrations in the 2003 study might have exceeded those found in 2000 (Chu et al. 2003); and 3) the two studies used different doses and exposure conditions and assumed a linear relationship between dose and egg tissue.

Windward (2019) found nine studies that examined the growth, reproduction, and mortality endpoints for various Aroclors or PCB mixtures and that met acceptability criteria. For 10 invertebrate species (three species of shrimp [*Penaeus aztecus, Palaemontes pugio, and Penaeus duorarum*], two species of amphipod [*Gammarus psuedolimnaeus and D. magna*], two species of arthropod *[Limulus polyphemus and Chironomus riparius*], two species of polychaete [*Armandia brevis and Nereis diversicolor*], and one species of bivalve [*C. virginica*]), 16 LOAELs were identified, ranging from 1,100 to 552,000 µg/kg, using both aqueous and sediment-based exposures. An ACR of 8.4 (USEPA 1980) was applied to five acute LOAEL values to derive chronic LOAEL values, and the range of LOAELs including ACR-adjusted values was 130 to 552,000 µg/kg. An SSD was developed using both chronic and ACR-derived LOAELs. The best-fit distribution curve was described by a gamma distribution. The 5th percentile of the SSD (520 µg/kg) was selected as the LOAEL TRV. This LOAEL has

low uncertainty since the SSD included a broad range of taxa that could be considered representative of the types of invertebrates found in the NBSA. There is uncertainty related to the ACR-derived LOAELs for the three species of shrimp. Further, as previously described, there is uncertainty based on model selection (Table D-5).

Windward (2019) did not include the OU2 TRVs based on Chu et al. (2000, 2003) studies in the SSD evaluation because the study did not meet the established acceptability criteria. To develop a threshold toxicity value that would include the OU2 TRVs, the SSD model was revised to integrate the OU2 LOAEL along with the other LOAELs used in the Windward (2019) SSD (Table D-2) and the 5th percentile LOEAL was recalculated using the USEPA SSD tool (Figure D-2). The effect of adding this study to the SSD was to change the final species LOAEL for eastern oyster from 50,000 µg/kg (which was previously based on the geometric mean of three LOAELs from three separate growth studies) to 17 µg/kg (the OU2 LOAEL based on reproduction). The result was a reduction of the 5th percentile of the SSD from 520 to 61 µg/kg (Table D-3; Figure D-2).

The toxicity thresholds derived for PRG calculation are presented in Table D-4. Sediment PRGs based on the geometric mean of the OU2 NOAEL/LOAEL (10 µg/kg) are highly uncertain based on the reasons described above for the Chu et al. studies (2000, 2003). Sediment PRGs based on the integrated SSD toxicity threshold (61 µg/kg) would be expected to be protective of most invertebrate species in the NBSA, even the most sensitive given that it includes ten species evaluated in ten studies. In addition to the uncertainties described for the included studies, there is uncertainty due to the selected statistical model (i.e., log-probit). Sediment PRGs based on the original SSD (520 µg/kg) might be the most representative given the uncertainty of the Chu studies and the large difference in growth LOAELs observed in the other oyster studies.

5.2.2 Fish

Adverse effects on fish reported in toxicological studies for 14 fish species (i.e., Atlantic croaker [*Micropogonias undulatus*], Atlantic salmon [*Salmo salar*], brook trout [*Salvelinus fontinalis*], channel catfish [*Ictalurus punctatus*], Chinook salmon [*Oncorhynchus tshawytscha*], coho salmon, common barbel [*Barbus barbus*], fathead minnow, goldfish [*Carassius auratus*], mummichog, pinfish [*Lagodon rhomboides*], rainbow trout, sheepshead minnow [*Cyprinodon variegatus*], and spot [*Leiostomus xanthurus*]) include reduced body weight; mortality; reduced early life stage or fry growth and survival; behavioral effects; and reduced fecundity, hatchability, and spawning success following exposure to PCBs via diet, water, or maternal transfer to eggs.

A NOAEL and LOAEL of 170 and 530 µg/kg, respectively, were selected for OU2 (USEPA 2014) based on the behavioral endpoint of smolt seawater preference in Atlantic salmon during a three-week exposure to Aroclor 1254 (Lerner et al. 2007). The selected tissue-based NOAEL and LOAEL were based on Atlantic salmon exposed to 1 and 10 µg/L Aroclor 1254, respectively. There is high uncertainty associated with these TRVs because it is unclear how the effect on salmon smolt seawater preference is relevant to the potential for adverse effects on fish populations in the NBSA. The use of these TRVs assumes that behavioral alterations that result in decreased foraging efficiency could correlate with growth effects, and that those alterations that affect predator avoidance and/or critical life stage-specific dispersal/migratory stages could result in reduced survival (Weis et al. 2001, 2011).

Windward (2019) found 12 studies examining growth and mortality effects of PCBs that met TRV acceptability criteria. Fourteen LOAELs were identified for 11 fish species (goldfish, sheepshead minnow, channel catfish, pinfish, spot, coho salmon, rainbow trout, minnow, fathead minnow, guppy [*Poecillia reticulate*], and brook trout), ranging from 9,300 to 645,000 µg/kg using both aqueous and diet-based acute and chronic PCB exposures. Study duration ranged from 5 to 260 days. An ACR of 8.4 (USEPA 1980) was applied to four acute LOAEL values

to derive chronic LOAEL values; the range of LOAELs, including ACR-adjusted values, was 1,670 to 645,000 µg/kg. An SSD was developed using both chronic and ACR-derived LOAELs. The distribution of LOAELs was best described by a log-logistic distribution. The 5th percentile TRV based on the SSD was 3,800 µg/kg. The NOAEL TRV (380 µg/kg wet weight) was extrapolated from the LOAEL TRV using an uncertainty factor of 10. It was noted by USEPA (WSP 2021) that a study that met the inclusion criteria was not included in the SSD and requested that the SSD be revised to include it. When the LOAEL for the species *Barbus* (520 µg/kg) is added, the 5th percentile of the SSD becomes 1,200 µg/kg (Figure D-3). Due to the range of species evaluated, these TRVs have low uncertainty.

Windward (2019) did not include the OU2 LOAEL in the SSD because it did not meet the established TRV acceptability criteria. However, to develop a threshold toxicity value that would include the OU2 study, the SSD model was revised to integrate the OU2 LOAEL (530 µg/kg) along with the other LOAELs used in the Windward (2019) SSD and the *Barbus* LOAEL (Table D-2). The 5th percentile LOEAL was recalculated using the USEPA SSD calculator (Figure D-4).

The toxicity thresholds derived for PRG calculation are summarized in Table D-4. Sediment PRGs based on the integrated SSD toxicity threshold (590 µg/kg) would be expected to be protective of most fish species in the NBSA, even the most sensitive given that it includes 12 species evaluated in 13 studies. Sources of uncertainty include the incorporation of the OU2 LOAEL into the SSD given that it did not meet the established acceptability criteria, is based on behavioral endpoints with uncertain linkage to adverse effects on fish, and the choice of statistical model. Sediment PRGs based on the geometric mean of the OU2 NOAEL/LOAEL (300 µg/kg) are highly uncertain as the TRV is based on a single behavioral study based on egg dosing on a species that is not present in the NBSA. The threshold value based on the original set of LOAELs (1,200 µg/kg) may be the most representative of the species sensitivities in the NBSA.

5.3 Total DDx (2,4' and 4,4')

Dichlorodiphenyltrichloroethane (DDT) is an organochlorine pesticide widely used before it was banned in 1972. Total DDx (2,4' and 4,4'), the sum of six DDT isomers resulting from metabolism or degradation of DDT, is toxic to both invertebrate and vertebrate species.

5.3.1 Invertebrates

Adverse effects on reproduction, survival, and growth due to DDT exposure were observed in various aquatic invertebrates such as pink shrimp (*Penaeus duorarum*), the amphipod (*Hyallela azteca*), the water flea (*Daphnia magna*), the amphipod (*Leptocheirus plumulosus*), and the polychaete worm (*Armandia brevis*) exposed to DDT. These studies observed adverse effects on reproduction, survival, and growth.

The OU2 LOAEL and NOAEL TRVs of 130 and 60 µg/kg are from a study of pink shrimp exposed to aqueous DDx compounds for 56 days (Nimmo et al. 1970). The LOAEL was based on the body burdens of pink shrimp that had died at day 28 of the experiment, and the NOAEL concentration represents where no mortality occurred. These TRVs are moderately uncertain since the study authors noted that "stress related to laboratory confinement was probably responsible for a portion of the mortalities;" however, the degree to which this impacted the TRV cannot be quantified (Nimmo et al. 1970).

Windward (2019) developed an SSD based on eight studies examining mortality, growth, and reproductive endpoints that were found to meet TRV acceptability criteria. Eleven LOAELs were identified for six species (three

amphipod species [*D. magna, H. azteca, and Leptocherius plumulosus*], two polychaete species [*Armandia brevis and Neanthes arenaceodentata*], and one decapod crustacean [*P. duorarum*]), with LOAELs ranging from 130 to 266,000 µg/kg. Five of these studies were aqueous exposures, five were sediment-based exposures, and one was a diet-based exposure. An ACR of 3.6 (Raimondo et al. 2007) was applied to four acute LOAEL values to derive chronic LOAELs, and the range of LOAELs including ACR-adjusted values was 130 to 74,000 µg/kg. An SSD (Figure D-5) was developed using both chronic and ACR-derived LOAELs. Too few chronic studies were available to derive an SSD without ACR-estimated chronic LOAELs. There is uncertainty associated with the use of ACR-estimated chronic LOAELs however the ACR derived LOAELs are within a similar range as the measured chronic LOAELs suggesting that the ACR provides a good approximation of the chronic LOAEL from an acute endpoint. The gamma distribution was determined to best fit the SSD based on GOF statistics and a visual examination. The 5th percentile of the SSD was selected as the LOAEL TRV (110 µg/kg). The NOAEL TRV (11 µg/kg) was extrapolated from the LOAEL TRV using an uncertainty factor of 10. At the request of USEPA, Windward (2019) also fitted an alternative distribution (beta general) resulting in a 5th percentile LOAEL TRV of 10 µg/kg, a "conservative SSD-derived estimate" (Figure D-5). An alternative NOAEL (1.0 µg/kg) was extrapolated from the alternative 5th percentile LOAEL TRV using an uncertainty factor of 10. USEPA stated that for PRG development, the gamma-based SSD should be used as it provided a better fit to the data (WSP 2021). The LOAEL from the Nimmo et al. (1970) study met the acceptability criteria and therefore had been included in the SSD. Therefore, no revision of the SSD to include the OU2 TRVs was needed.

The toxicity thresholds selected for PRG calculation are summarized in Table D-4. Sediment PRGs based on the SSD toxicity threshold (110 µg/kg) would be expected to be protective of most invertebrate species in the NBSA, given that it includes six species evaluated in eight studies. In addition to the uncertainty related to ACR-adjusted values, there is uncertainty related to the chosen statistical model for the SSD (Table D-5). Sediment PRGs based on the geometric mean of the OU2 NOAEL/LOAEL (88 µg/kg) are less certain as the TRV is based on data from a single study; however, it is similar to the value obtained from the SSD using the gamma or log-probit distributions.

5.3.2 Fish

Several studies have been conducted to examine the adverse toxicological effects on various fish species (sailfin molly [*Poecilia latipinna*], fathead minnow, goldfish, and several salmonid species) as a result of exposure to DDT. These studies observed adverse effects on reproduction, survival, and growth. Increased mortality as a result of DDT exposure was observed in studies of coho and Chinook salmon, goldfish, and fathead minnow. Decreased growth was observed in studies of sailfin molly exposed to DDT. Embryo mortality of yearling brook trout chronically exposed to DDT was also observed.

Windward (2019) found six studies examining reproduction and survival effects of total DDx that met TRV acceptability criteria. Seven LOAELs were identified for seven fish species (goldfish, sunfish [*Lepomis sp.*], cutthroat trout [*Oncorhynchus clarkii*], coho salmon, Chinook salmon, fathead minnow, and brook trout), ranging from 1,100 to 200,000 µg/kg using both aqueous and diet-based DDx exposures. Study duration ranged from 38 to 612 days. An SSD was developed using chronic LOAELs. The distribution of final species LOAELs was best described by a Weibull distribution (Figure D-6). The 5th percentile LOAEL TRV based on the SSD is 520 µg/kg. The NOAEL TRV (52 µg/kg) was extrapolated from the LOAEL TRV using an uncertainty factor of 10.

The OU2 LOAEL of 390 µg/kg (USEPA 2014) was based on the 5th percentile LOAEL of an SSD developed by Beckvar et al. (2005) using data derived from studies reported in United States Army Corps of Engineers

Environmental Residue-Effects Database. The NOAEL of 78 µg/kg (Beckvar et al. 2005) was based on the use of an uncertainty factor of 5 and the SSD-derived LOAEL. As reported by Beckvar et al. (2005), 10 LOAELs were selected to derive a total DDx 5th percentile LOAEL for nine species of fish. LOAELs ranged from 290 to 112,700 µg/kg for survival, growth, reproduction, and behavior endpoints. There is some uncertainty associated with the LOAELs used in the SSD derived by Beckvar et al. (2005). The lowest LOAEL of 290 µg/kg was based on data from Berlin et al. (1981), wherein survival of lake trout (*Salvelinus namaycush*) was affected based on data collected from fish hatched from field-collected eggs from Lake Michigan. These eggs had high concentrations of PCBs, DDx, and mercury; the elevated tissue burdens of PCBs and other contaminants may have contributed to toxicity. The next lowest LOAEL of 550 µg/kg was based on data from Butler (1969), wherein pinfish survival was affected; however, study data demonstrated that survival was not tissue concentration dependent. Finally, the third-lowest LOAEL of 1,650 µg/kg was based on goldfish behavior (locomotor activity) reported by Davy et al. (1972). It is unclear how locomotor activity is a direct measure of survival, growth, or reproduction.

The toxicity threshold values derived for PRG calculation are summarized in Table D-4. The values are within a similar range (390 to 520 µg/kg). Sediment PRGs based on these values are of low uncertainty and would likely be protective of most fish species and the uncertainty is lessened by the fact that two independent SSDs based on studies of multiple species derived 5th percentile LOAELs within a similar range.

5.4 Metals

5.4.1 Arsenic

Arsenic was found to be a risk to softshell clam in the NBSA (GSH 2020) based on concentrations in tissue. Exposure to arsenic in invertebrate species including amphipods (*Hyalella azteca*), bay scallop (*Argopecten irradians*), brown shrimp (*Crangon crangon*), periwinkle snail (*Littorina littorea*), amphipod (*Corophium volutator*), Baltic clam (*Macoma balthica*), copepod (*Eurytemora affinis*), and oligochaete worm (*Tubifex costatum*) resulted in increased mortality, reduced juvenile survival, and reduced growth.

Windward (2019) found seven studies examining growth and mortality effects in seven species of invertebrate that met TRV acceptability criteria. These studies reported seven LOAEL values ranging from 0.63 to 92 milligrams per kilogram (mg/kg). An ACR of 3.8 (USEPA 1985) was applied to three acute LOAEL values to derive chronic LOAELs. An SSD (Figure D-7) was developed using both chronic LOAELs and ACR-derived LOAELs. Six of the studies used aqueous arsenic exposures; the remaining study was a combined diet- and water-based exposure. Study duration ranged from 96 hours to 30 days. The distribution of final species LOAELs was best described by a Levy distribution (Figure D-7). The 5th percentile of the SSD was selected as the LOAEL TRV (0.64 mg/kg). The SSD-derived LOAEL was similar to the lowest LOAEL value derived from the literature: a residue of 0.63 mg/kg associated with reduced growth in mayflies after 12 days of exposure. The NOAEL TRV (0.064 mg/kg) was extrapolated from the LOAEL TRV using an uncertainty factor of 10.

Arsenic in invertebrates was not evaluated in the LPR FFS (USEPA 2014) and therefore no OU-2 TRV is available.

The toxicity threshold selected for PRG calculation (0.64 mg/kg) is based on the 5th percentile of an SSD (Table D-4) and is of low to moderate uncertainty. Sediment PRGs based on this value would likely be protective of most invertebrate species in the NBSA given the range of species tested and evaluated in the SSD. However, the lower tail of the SSD is heavily influenced by the growth endpoint from a freshwater species (mayfly) and may not be

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representative the marine invertebrates present in the NBSA such as the softshell clam. There is uncertainty related to the use of ACR-adjusted values and to the selected statistical model (Table D-5).

5.4.2 Lead

Lead was found to be a risk to softshell clam in the NBSA (GSH 2020) based on concentrations in tissue. Lead bioaccumulation in aquatic species is usually highest in algae and benthic organisms and lowest in upper-trophic-level predators, but lead has been shown to be toxic to all trophic levels. Lead exposure increased mortality for Indian prawn shrimp (*Penaeus indicus*), reduced reproductive output and caused immobilization in *Daphnia magna*, reduced hatching success in the snail (*Lymnaea palustris*), inhibited development in the sea urchin (*Anthocidaris crassispina*), and inhibited reproduction in the polychaete *Neanthes arenaceodentata*.

Windward (2019) found three studies examining mortality were found to meet TRV acceptability criteria. LOAELs were available for only three species (two amphipods [*H. azteca and Gammarus psuedolimnaeus]* and a decapod crustacean [*Penaeus indicus*]), and data were therefore insufficient to develop an SSD. These studies reported LOAEL values ranging from 40 to 200 mg/kg. Spehar et al. (1978) reported the lowest LOAEL of 40 mg/kg after exposing the amphipod *G. psuedolimnaeus* to water-based lead concentrations for 28 days; this study was selected for TRV derivation. A LOAEL of 40 mg/kg was reported and selected as the LOAEL TRV. No NOAEL was identified in the study; therefore, the NOAEL TRV (4.0 µg/kg) was extrapolated from the LOAEL TRV using an uncertainty factor of 10making these TRVs of moderate uncertainty.

The LOAEL (2.6 mg/kg) and NOAEL (0.52 mg/kg) derived in the LPR FFS (USEPA 2014) for OU2 were from a study (Borgmann and Norwood 1999) that found increased mortality of the amphipod *H. azteca* in a four-week spiked sediment toxicity test. The LOAEL TRV was derived from the reported LOAEL of 5.2 mg/kg by applying an interspecies extrapolation factor of 2 to the LC25 (Borgmann and Norwood 1999). The NOAEL TRV was derived by extrapolating by a factor of 5 from the LOAEL TRV. There is uncertainty associated with the derivation of a NOAEL based on an extrapolation factor. Additionally, the use of field-collected sediment from the western basin of Hamilton Harbor creates uncertainty surrounding the presence of additional metals within the exposure sediment (as reported in dry weight: 12 mg/kg cobalt, 1198 mg/kg chromium, 101 mg/kg copper, 45,400 mg/kg iron, 1,720 mg/kg manganese, 47 mg/kg nickel, 113 mg/kg lead, and 1,240mg/kg zinc). Several of these other metals exceed threshold effects concentrations (i.e., copper and nickel) or probable effect concentrations (i.e., chromium and zinc) in sediment (MacDonald et al. 2000). Therefore, the presence of additional metals or other contaminants likely played a role in observed toxicity making these TRVs highly uncertain.

The toxicity threshold derived for PRG calculation are summarized in Table D-4. An integrated value was calculated based on the geometric means of the OU2 and OU3/OU4 LOAELs (10.2 mg/kg). Sediment PRGs based on these values would likely be protective of most invertebrate species in the NBSA given that sensitive amphipod species were tested.

5.4.3 Mercury/Methylmercury

Mercury was found to be a risk to softshell clam and blue crab in the NBSA (GSH 2020) based on concentrations in tissue. Mercury exposure adversely affects the reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange of marine and freshwater organisms. In general, the accumulation of mercury by aquatic biota is rapid, and depuration is slow. Organomercury compounds, especially methylmercury, were significantly more likely to induce adverse effects than inorganic mercury. Mercury exposure caused adverse effects on the reproduction (spawning delay, reduced fecundity, population declines) of sensitive species

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of aquatic organisms, including slipper limpet (*Crepidula fornicate*) and mysid shrimp (*Mysidopsis bahia*). Reduced growth of sensitive species of aquatic organisms was found in the marine mollusc (*Crepidula fornicate*) and sea urchin larvae. In marine molluscs exposed to mercury, the feeding of adults ceased, and the swimming rate of larval stages declined.

Windward (2019) found three acceptable TRV studies that evaluated the toxicity of mercury or methylmercury to benthic invertebrates based on whole-body tissue concentrations of total mercury that resulted in LOAELs. LOAELs were available for only three species or types of invertebrates (a copepod [*Acartia tonsa*], a cladocern [*D. magna*], and a bivalve [*Crassostrea virginica*]), and were therefore insufficient to develop an SSD. Tissue LOAELs ranged from 95 µg/kg for reproductive effects in marine copepods (Hook and Fisher 2002) to 23,000 µg/kg. The lowest LOAEL (95 µg/kg) based on whole-body copepod tissue following exposure to metal-contaminated phytoplankton food was selected as the LOAEL TRV, and the NOAEL from the same study (48 µg/kg) was selected as the NOAEL TRV. Due to the wide range of LOAELs observed these TRVs are of moderate uncertainty. These same TRVs were also selected for OU2 in the LPR FFS (USEPA 2014) based on Hook and Fisher (2002). There are uncertainties associated with the selected TRVs due to the limited dataset (three studies).The toxicity threshold derived for PRG calculation (68 µg/kg) is based on the geometric mean of the NOAEL/LOAEL (Table D-4). Sediment PRGs based on this value would likely be protective of most invertebrate species in the NBSA.

5.4.4 Nickel

Adverse effects of nickel on aquatic invertebrates observed in laboratory studies include inhibited reproduction of daphnids, reduced growth in northern quahog (*Mercenaria mercenaria*), impaired reproduction and growth in water fleas, and abnormal development of sea urchin embryos.

Windward (2019) found one study that met acceptability criteria. The nickel TRV for invertebrates was derived from a study conducted by Borgmann et al. (2001) that exposed the amphipod *Hyalella azteca* to nickel-spiked field-collected sediments for 28 days and reported mortality. The LOAEL of 1.1 mg/kg (assuming 80% moisture) associated with a 75% increase in mortality was selected as the LOAEL TRV. The NOAEL TRV of 0.10 mg/kg (assuming 80% moisture) was estimated using a safety factor of 10.

Nickel in invertebrates was not evaluated in the LPR FFS (USEPA 2014) and therefore no OU-2 TRV is available.

The toxicity threshold derived for PRG calculation (0.6 mg/kg; Table D-4) is based on the arithmetic mean rather than a geometric mean of the OU3/OU4 NOAEL/LOAEL because the NOAEL was estimated by a safety factor of 10.. An uncertainty specifically related to this study was the use of field-collected sediments with pre-spiked sediment chemistry that was not reported. The presence of sediment contaminants other than nickel could have played a role in the observed effects making these TRVs of high uncertainty. A sediment PRG based on only one study is subject to uncertainty. However, it may be protective of most species since it is based on a sensitive species (i.e., *Hyalella azteca*).

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WSP. 2021. Comments on GSH Preliminary Remediation Goal Calculation Sheet. Memorandum from AmyMarie Accardi-Dey, WSP to Beth Franklin, USACE-KC and Eugenia Naranjo, USEPA. June 11, 2021.

Tables

Table D-1
Toxicity Reference Values for Ecological Receptors at Risk in the NBSA
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

COC	Species at Risk	Units	NBSA (OU3) TRVs			OU2 TRVs		
			NOAEL	LOAEL	Source	NOAEL	LOAEL	Source
Invertebrates								
2,3,7,8-TCDD	Softshell clam, Blue crab	ng/kg	300*	3,000	Crayfish; survival (Ashley et al. 1996)	0.15	1.3	Eastern oyster; reproduction (Wintermeyer and Cooper 2003)
Total PCBs	Softshell clam, Blue crab	µg/kg	52*	520	OU3/OU4 SSD for 10 species (Windward 2019)	6.4	17	Eastern oyster; reproduction (Chu et al. 2000; 2003)
Total DDx (2,4' and 4,4')	Blue crab	µg/kg	11*	110	OU3/OU4 SSD for 6 species using a gamma model (Windward 2019)	60	130	Pink shrimp; mortality (Nimmo et al. 1970)
			1*	10	OU3/OU4 SSD for 6 species using a beta general model (Windward 2019)			
Arsenic	Softshell clam	mg/kg	0.064*	0.64	OU3/OU4 SSD (Windward 2019)	--	--	--
Lead	Softshell clam	mg/kg	4	40	Amphipod; survival (Spehar et al. 1978)	0.52	2.6	Amphipod (Hyallela); survival (Borgmann and Norwood 1999)
Mercury (Methylmercury)	Softshell clam, Blue crab	µg/kg	48	95	Whole body copepod; reproduction (Hook and Fisher 2002)	48	95	Whole body copepod; reproduction (Hook and Fisher 2002)
Nickel	Softshell clam	mg/kg	0.1*	1.1	Amphipod; survival (Borgmann et al. 2001)	--	--	--
Fish								
2,3,7,8-TCDD	Mummichog, American Eel, summer flounder, white perch	ng/kg	12*	120	OU3/OU4 SSD for 7 species (Windward 2019)	0.89	1.8	Mummichog; prey capture behavior (Couillard et al. 2011)
Total PCBs	Mummichog	µg/kg	380*	3,800[a]	OU3/OU4 SSD for 11 species (Windward 2019)[a]	170	530	Atlantic salmon smolt seawater preference; behavior (Lerner et al. 2007)
Total DDx (2,4' and 4,4')	White perch	µg/kg	52*	520	OU3/OU4 SSD for 7 species (Windward 2019)	78	390	SSD for 9 species (Beckvar et al. 2005)

Notes:

All units are wet weight tissue based.

Where an SSD was conducted, the LOAEL is the 5th percentile of the SSD of the LOAELs for the species included. The NOAEL was then derived by dividing the LOAEL by 10. The methodolgy and description of SSD modeling is presented in Appendix E of the LPRSA BERA (Windward 2019).

[a]The SSD for PCBs in fish has been subsequently revised because it was noted by USEPA (WSP 2021) during this FS process and after finalization of the BERA that the LOAEL for one species from a study that met acceptability criteria had not been included in the SSD which is inconsistent with the methodology established and approved by USEPA in the LPRSA BERA (Windward 2019). The 5th percentile of the revised SSD is 1200 µg/kg-ww rather than the 3,800 µg/kg-ww value used in the BERA. See section 3.0 of Appendix D for further details.

Acronyms and Abbreviations:

* = The NOAEL was derived by dividing the LOAEL by 10.
-- = Not evaluated
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
BERA = baseline ecological risk assessment
COC = chemical of concern
LOAEL = lowest observed adverse effect level
LPSRA = Lower Passaic River Study Area
mg/kg = milligrams per kilogram
NBSA = Newark Bay Study Area
ng/kg = nanograms per kilogram
NOAEL = no observed adverse effect level
OU = operable unit
PCBs = polychlorinated biphenyls
SSD = species sensitivity distribution
ww = wet weight
Total DDx (2,4' and 4,4') = sum of 6 isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane
TRV = toxicity reference value
µg/kg = micrograms per kilogram

References:

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WSP. 2021. Comments on GSH Preliminary Remediation Goal Calculation Sheet. Memorandum from AmyMarie Accardi-Dey, WSP to Beth Franklin, USACE-KC and Eugenia Naranjo, USEPA. June 11, 2021.

Table D-2
LOAELs used in Revised Species Sensitivity Distributions
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

SSD	Species	Endpoint	LOAEL TRV	Source
2,3,7,8-TCDD in Fish (ng/kg)	Mummichog	behavior	1.8	OU2 FFS (USEPA 2014)
	Lake whitefish (*Coregonus clupeaformis*)	growth	85	OU4 BERA (Windward 2019)
	Rainbow trout (*Oncorhynchus mykiss*)	growth	726	OU4 BERA (Windward 2019)
	Japanese medaka (*Oryzias latipes*)	growth	1,628	OU4 BERA (Windward 2019)
	Fathead minnow (*Pimephales promelas*)	mortality	1,687	OU4 BERA (Windward 2019)
	Coho salmon (*Oncorhynchus kisutch*)	mortality	2,170	OU4 BERA (Windward 2019)
	Carp (*Cyprinus carpio*)	mortality	2,200	OU4 BERA (Windward 2019)
	Zebrafish (*Danio rerio*)	reproduction	12,440	OU4 BERA (Windward 2019)
Total PCBs in Invertebrates (µg/kg)	Eastern oyster (*Crassostrea virginica*)	reproduction	17	OU2 FFS (USEPA 2014)
	Grass shrimp (*Palaemonetes pugio*)	mortality	645	OU4 BERA (Windward 2019)
	Pink shrimp (*Penaeus duorarum*)	mortality	3,069	OU4 BERA (Windward 2019)
	Brown shrimp (*Penaeus aztecus*)	mortality	5,000	OU4 BERA (Windward 2019)
	Water flea (*Daphnia magna*)	mortality	11,600	OU4 BERA (Windward 2019)
	Horseshoe crab (*Limulus polyphemus*)	mortality	31,900	OU4 BERA (Windward 2019)
	Polychaete (*Armandia brevis*)	growth	35,800	OU4 BERA (Windward 2019)
	Midge (*Chironomus riparius*)	mortality	89,000	OU4 BERA (Windward 2019)
	Polychaete (*Nereis diversicolor*)	mortality	200,000	OU4 BERA (Windward 2019)
	Amphipod (*Gammarus pseudolimnaeus*)	reproduction	204,822	OU4 BERA (Windward 2019)
Total PCBs in Fish (µg/kg)	Barbel (*Barbus barbus*)	reproduction	520	OU4 BERA (Windward 2019)[a]
	Atlantic salmon (*Salmo salar*)	behavior	530	OU2 FFS (USEPA 2014)
	Spot (*Leiostomus xanthurus*)	mortality	5,476	OU4 BERA (Windward 2019)
	Sheepshead minnow (*Cyprinodon variegatus*)	reproduction	9,300	OU4 BERA (Windward 2019)
	Pinfish (*Lagodon rhomboides*)	mortality	13,292	OU4 BERA (Windward 2019)
	Channel catfish (*Ictalurus punctatus*)	growth	14,300	OU4 BERA (Windward 2019)
	Common minnow (*Phoxinus phoxinus*)	reproduction	25,000	OU4 BERA (Windward 2019)
	Goldfish (*Carassius auratus*)	mortality	29,762	OU4 BERA (Windward 2019)
	Fathead minnow (*Pimephales promelas*)	growth	50,000	OU4 BERA (Windward 2019)
	Rainbow trout (*Oncorhynchus mykiss*)	growth	120,000	OU4 BERA (Windward 2019)
	Brook trout (*Salvelinus fontinalis*)	mortality	125,000	OU4 BERA (Windward 2019)
	Guppy (*Poecilia reticulata*)	mortality	190,000	OU4 BERA (Windward 2019)
	Coho salmon (*Oncorhynchus kisutch*)	mortality	645,000	OU4 BERA (Windward 2019)

Notes:

[a]The LOAEL for this species was not included in the original SSD presented in the OU4 BERA (Windward 2019). USEPA has requested that it be included in revised SSDs (WSP 2021).

Acronyms and Abbreviations:

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
BERA = baseline ecological risk assessment
FFS = Focused Feasibility Study
LOAEL = lowest observed adverse effect level
TRV = toxicity reference value
OU = operable unit
PCBs = polychlorinated biphenyls
SSD = species sensitivity distribution
µg/kg = micrograms per kilogram

References:

USEPA. 2014. Focused Feasibility Study Report for the Lower Eight Miles of the Lower Passaic River. Prepared by The Louis Berger Group, Inc. in conjunction with Battelle and HDR|HydroQual.

Windward. 2019. Lower Passaic River Study Area Baseline Ecological Risk Assessment. Final. June 17.

Table D-4
Threshold Values in Tissue for Ecological PRG Calculation
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

ARCADIS

COC	Units	Ecological Receptor	Toxicity Threshold Values for PRG Calculations					
			OU3/OU4 TRVs		OU2 TRVs		Integrated OU2 and OU3/OU4 TRVs	
			Value	Basis	Value	Basis	Value	Basis
2,3,7,8-TCDD	ng/kg	Invertebrate	949	Geomean NOAEL/LOAEL	0.44	Geomean NOAEL/LOAEL	62	Geomean OU2 and OU3/OU4 LOAELs
		Fish	120	5th percentile of SSD	1.3	Geomean NOAEL/LOAEL	3.9	5th percentile of SSD[a]
Total PCBs	µg/kg	Invertebrate	520	5th percentile of SSD	10	Geomean NOAEL/LOAEL	61	5th percentile of SSD[a]
		Fish	1,200[b]	5th percentile of SSD	300	Geomean NOAEL/LOAEL	590	5th percentile of SSD[a]
Total DDx (2,4' and 4,4')	µg/kg	Invertebrate	110[c]	5th percentile of SSD	88	Geomean NOAEL/LOAEL	--[d]	--[d]
		Fish	520	5th percentile of SSD	390	5th percentile of SSD	450	Geomean OU2 and OU3/OU4 LOAELs
Arsenic	mg/kg	Invertebrate	0.64	5th percentile of SSD	--	Not evaluated for OU2	--	--
Lead	mg/kg	Invertebrate	12.6	Geomean NOAEL/LOAEL	1.2	Geomean NOAEL/LOAEL	10.2	Geomean OU2 and OU3/OU4 LOAELs
Mercury	µg/kg	Invertebrate	68	Geomean NOAEL/LOAEL	68	Geomean NOAEL/LOAEL	--[e]	--[e]
Nickel	mg/kg	Invertebrate	0.6	Arithmetic Mean NOAEL/LOAEL[f]	--	Not evaluated for OU2	--	--

Notes:

[a]A revised SSD that combines the LOAELs used in the OU3/OU4 SSD with the OU2 LOAEL TRV presented in the LPRSA FFS (USEPA 2014). See Figures D-1, D-2, and D-4.

[b]The SSD for PCBs in fish has been revised because it was noted by USEPA (WSP 2021) during the FS process and after finalization of the BERA that the LOAEL for one species from a study that met acceptability criteria had not been included in the SSD presented in the LPRSA BERA (Windward 2019). See section 3.0 of Appendix D and Figure D-3.

[c]USEPA requested that the value be chosen based on the gamma fitted model of the SSD (USEPA 2021; WSP 2021).

[d]The original OU3/OU4 SSD already included the OU2 LOAEL.

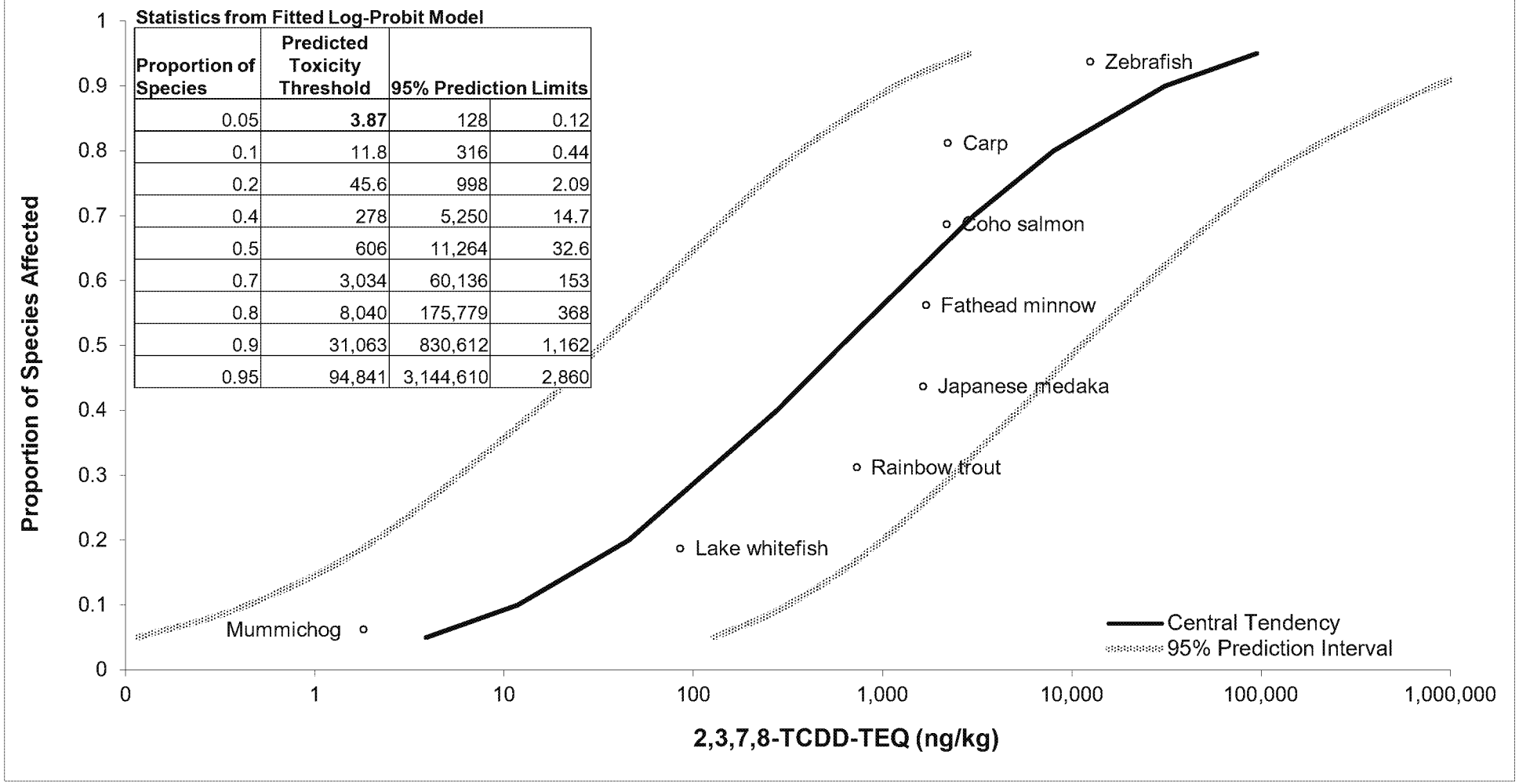
[e]OU2 and OU3/OU4 TRVs were based on the same study.

[f]The arithmetic mean was used to derive the PRG because the NOAEL was not reported in the study and was therefore derived using a safety factor of 10.

References:

-- = Not Applicable
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
COC = chemical of concern
Geomean = geometric mean of the NOAEL and/or LOAEL values shown on Table D-1
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
NOAEL = no observed adverse effect level
OU = operable unit
PCBs = polychlorinated biphenyls
PRG = preliminary remediation goal
SSD = species sensitivity distribution
Total DDx (2,4' and 4,4') = sum of 6 isomers of dichlorodiphenyldichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyltrichloroethane
TRV = toxicity reference value
µg/kg = micrograms per kilogram

Figures



Statistics from Fitted Log-Probit Model

Proportion of Species	Predicted Toxicity Threshold	95% Prediction Limits	
0.05	**3.87**	128	0.12
0.1	11.8	316	0.44
0.2	45.6	998	2.09
0.4	278	5,250	14.7
0.5	606	11,264	32.6
0.7	3,034	60,136	153
0.8	8,040	175,779	368
0.9	31,063	830,612	1,162
0.95	94,841	3,144,610	2,860

Notes:
A log-probit model was fitted to the LOAEL TRVs. See Table D-2 for data.

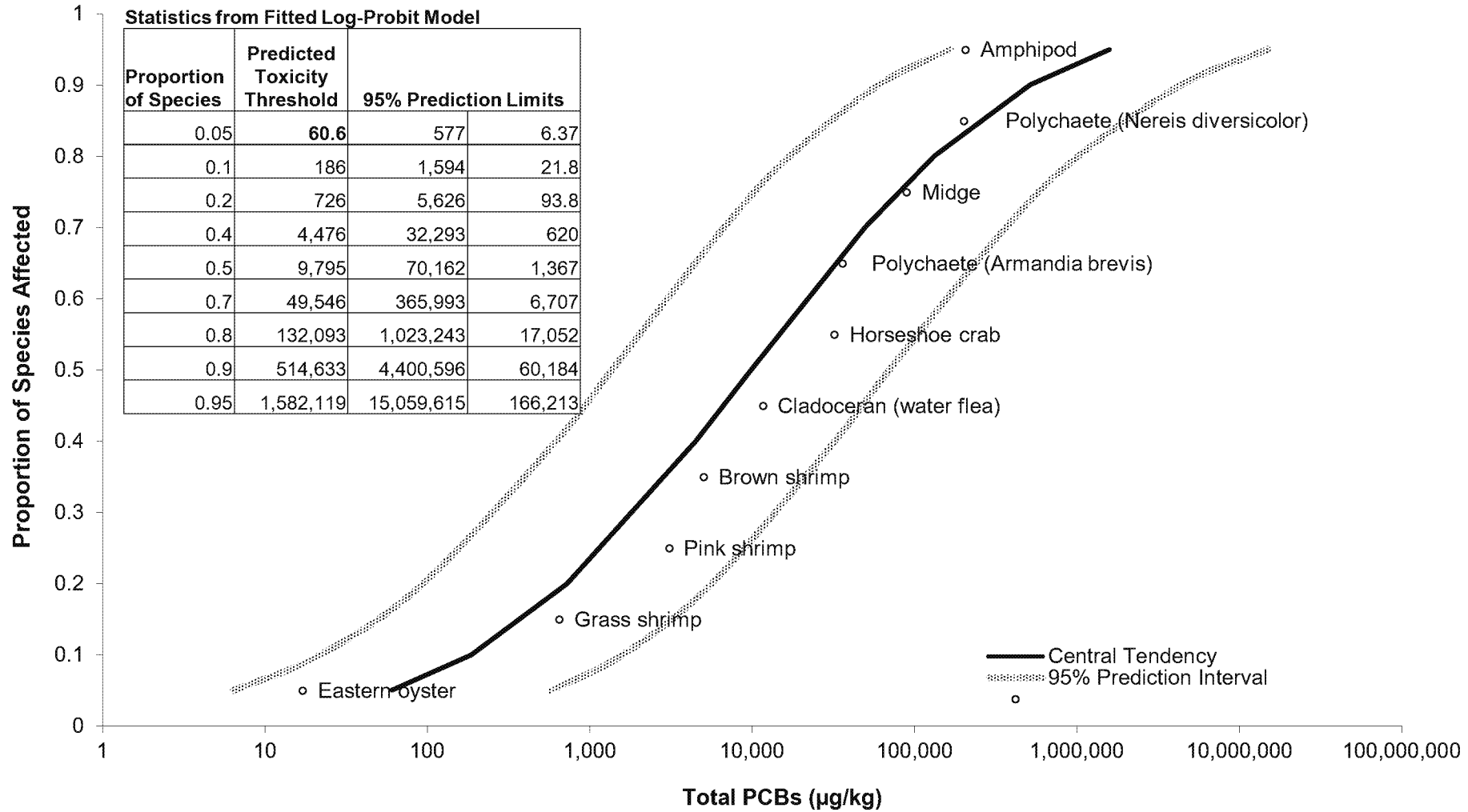
LOAEL = Lowest Observed Adverse Effect Level
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxic equivalent
ng/kg = nanograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS
TECHNICAL MEMORANDUM
APPENDIX D: TOXICITY REFERENCE VALUES AND SPECIES SENSITIVITY DISTRIBUTIONS

INTEGRATED SPECIES SENSITIVITY DISTRIBUTION FOR 2,3,7,8-TCDD IN FISH

OXY Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
D-1



Statistics from Fitted Log-Probit Model

Proportion of Species	Predicted Toxicity Threshold	95% Prediction Limits	
0.05	**60.6**	577	6.37
0.1	186	1,594	21.8
0.2	726	5,626	93.8
0.4	4,476	32,293	620
0.5	9,795	70,162	1,367
0.7	49,546	365,993	6,707
0.8	132,093	1,023,243	17,052
0.9	514,633	4,400,596	60,184
0.95	1,582,119	15,059,615	166,213

Notes:
A log-probit model was fitted to the LOAEL TRVs. See Table D-2 for data.

LOAEL = Lowest Observed Adverse Effect Level
PCB = polychlorinated biphenyl
µg/kg = micrograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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INTEGRATED SPECIES SENSITIVITY DISTRIBUTION FOR TOTAL PCBS IN INVERTEBRATES

OXY Glenn Springs Holdings, Inc.
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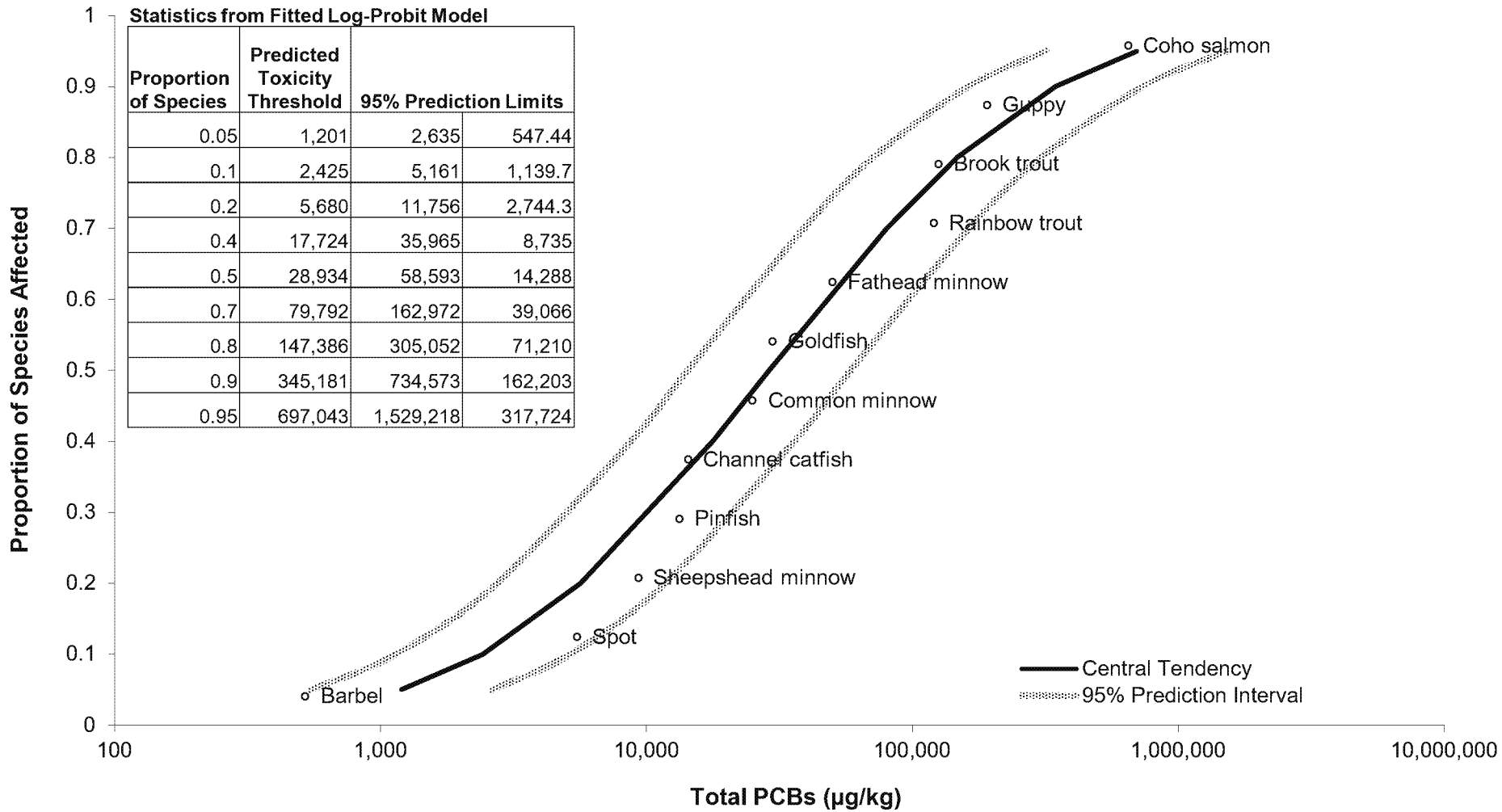
FIGURE
D-2



Statistics from Fitted Log-Probit Model

Proportion of Species	Predicted Toxicity Threshold	95% Prediction Limits	
0.05	1,201	2,635	547.44
0.1	2,425	5,161	1,139.7
0.2	5,680	11,756	2,744.3
0.4	17,724	35,965	8,735
0.5	28,934	58,593	14,288
0.7	79,792	162,972	39,066
0.8	147,386	305,052	71,210
0.9	345,181	734,573	162,203
0.95	697,043	1,529,218	317,724

Notes:
A log-probit model was fitted to the LOAEL TRVs. See Table D-2 for data.

LOAEL = Lowest Observed Adverse Effect Level
PCB = polychlorinated biphenyl
µg/kg = micrograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
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SPECIES SENSITIVITY DISTRIBUTION FOR TOTAL PCBS IN FISH: REVISED FOR OU3/OU4 LOAEL

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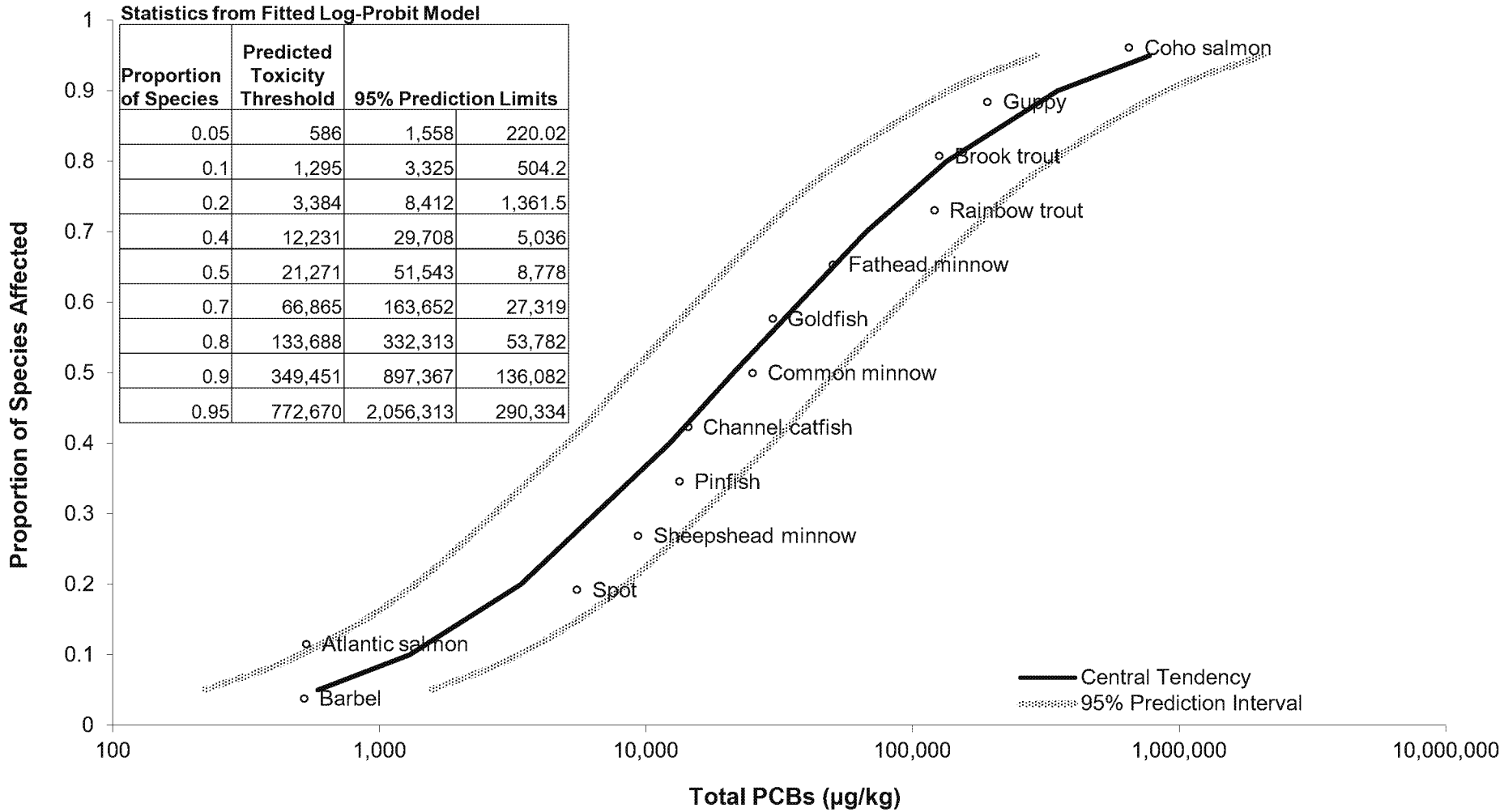
FIGURE
D-3



Statistics from Fitted Log-Probit Model

Proportion of Species	Predicted Toxicity Threshold	95% Prediction Limits	
0.05	586	1,558	220.02
0.1	1,295	3,325	504.2
0.2	3,384	8,412	1,361.5
0.4	12,231	29,708	5,036
0.5	21,271	51,543	8,778
0.7	66,865	163,652	27,319
0.8	133,688	332,313	53,782
0.9	349,451	897,367	136,082
0.95	772,670	2,056,313	290,334

Notes:
A log-probit model was fitted to the LOAEL TRVs. See Table D-2 for data.

LOAEL = Lowest Observed Adverse Effect Level
PCB = polychlorinated biphenyl
µg/kg = micrograms per kilogram

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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INTEGRATED SPECIES SENSITIVITY DISTRIBUTION FOR TOTAL PCBS IN FISH: REVISED FOR ALL TRVS

OXY Glenn Springs Holdings, Inc.
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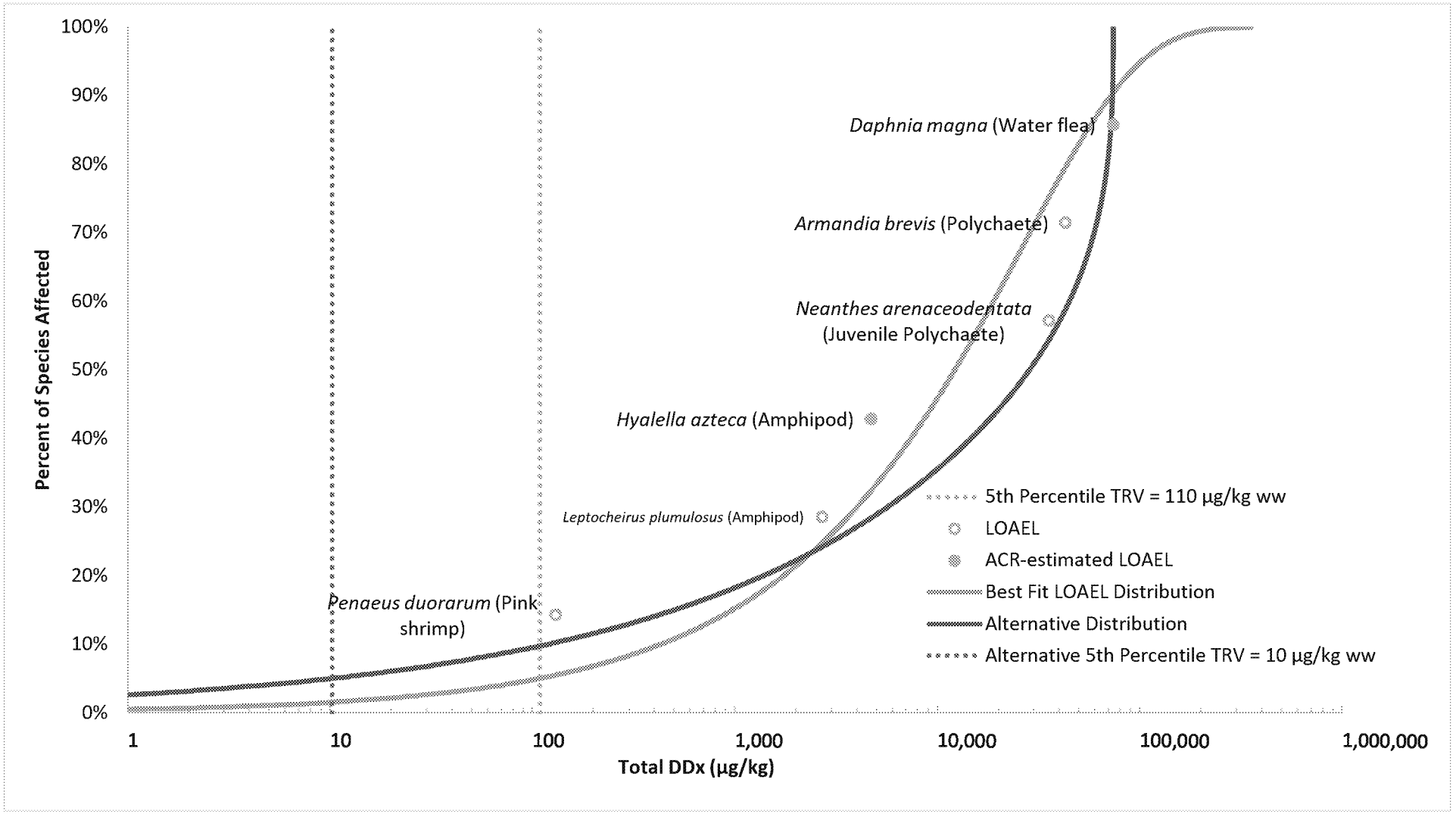
FIGURE
D-4



Source: Windward (2019)

DDx = isomers of dichlorodiphenyltrichloroethane
LOAEL = Lowest Observed Adverse Effect Level
µg/kg = micrograms per kilogram

Windward. 2019. Lower Passaic River Study Area Baseline Ecological Risk Assessment. Final. June 17.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX D: TOXICITY REFERENCE VALUES AND SPECIES SENSITIVITY DISTRIBUTIONS

SPECIES SENSITIVITY DISTRIBUTION FOR TOTAL DDX (2,4' AND 4,4') IN INVERTEBRATES

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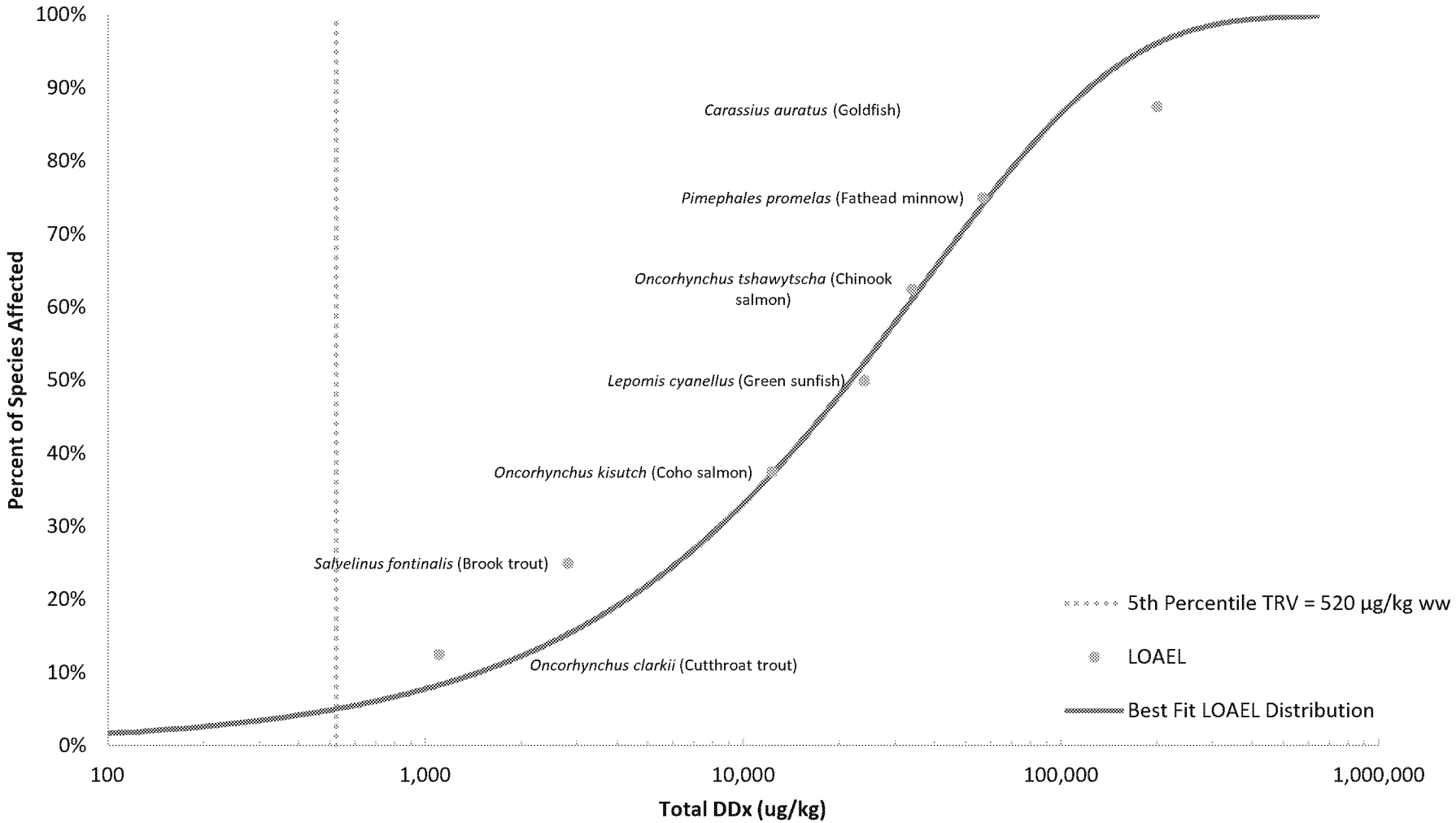
FIGURE
D-5



Source: Windward (2019)

DDx = isomers of dichlorodiphenyltrichloroethane
LOAEL = Lowest Observed Adverse Effect Level
µg/kg = micrograms per kilogram

Windward. 2019. Lower Passaic River Study Area Baseline Ecological Risk Assessment. Final. June 17.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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SPECIES SENSITIVITY DISTRIBUTION FOR TOTAL DDX (2,4' AND 4,4') IN FISH

OXY Glenn Springs Holdings, Inc.
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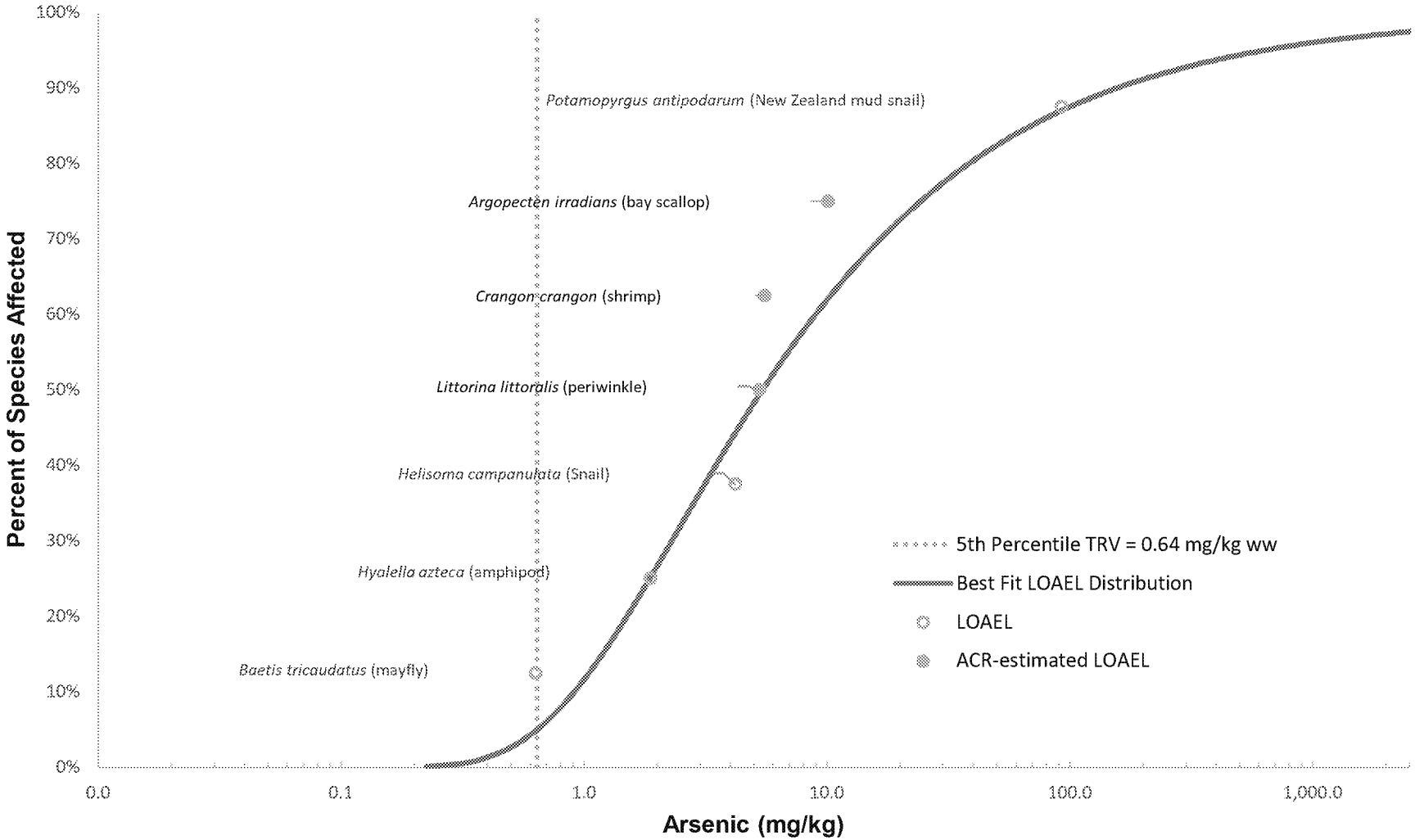
FIGURE
D-6



Source: Windward (2019)

LOAEL = Lowest Observed Adverse Effect Level
mg/kg = milligrams per kilogram

Windward. 2019. Lower Passaic River Study Area Baseline Ecological Risk Assessment. Final. June 17.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX D: TOXICITY REFERENCE VALUES AND SPECIES SENSITIVITY DISTRIBUTIONS

SPECIES SENSITIVITY DISTRIBUTION FOR ARSENIC IN INVERTEBRATES

OXY Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

FIGURE
D-7

Appendix E

Benthic Invertebrate Dose Response Models

ARCADIS

Glenn Springs Holdings, Inc.
A subsidiary of Occidental Petroleum Corporation

Appendix E: Benthic Invertebrate Dose Response Models

Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum

Newark Bay Study Area
Newark, New Jersey

August 2022

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Attachments

Attachment E-1 SAS Statistical Output Files from the PROBIT Procedure

Acronyms and Abbreviations

Alpha	Type I error rate for statistical significance
COCs	chemicals of concern
GSH	Glenn Springs Holdings, Inc.
mg/kg	milligrams per kilogram
ng/kg	nanograms per kilogram
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PRGs	preliminary remedial goals
RAO	remedial action objective
SQT	sediment quality triad
Total DDx (4,4')	sum of 4,4'-dichlorodiphenyldichloroethane, 4,4'-dichlorodiphenyldichloroethylene, and 4,4'-dichlorodiphenyltrichloroethane
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram
%	percent

ED_014250_00000156-00216

1 Introduction

To evaluate risk to the benthic invertebrate community, a sediment quality triad (SQT) investigation was conducted (Glenn Springs Holdings, Inc. [GSH] 2020). The SQT program included the following elements where data were collected synoptically at 30 stations: 1) sediment and porewater chemistry; 2) toxicity testing using the 10-day and 28-day amphipod (i.e., *Leptocheirus plumulosus*) bioassay; and 3) benthic invertebrate community taxa enumeration. Based on the amphipod bioassay, both acute and chronic toxicity was observed, and survival and growth endpoints were correlated with multiple chemicals in sediment and porewater (GSH 2020). Neither sediment nor porewater chemistry were found to be associated with impact to the benthic invertebrate community metrics such as abundance, richness, diversity, etc.; therefore, only toxicity is considered in the determination of preliminary remedial goals (PRGs) to reduce risk to the benthic invertebrate community based on direct contact with sediment. As described in Section 3.4.3 of the Remedial Action Objectives (RAO) & PRGs Technical Memorandum, due to the considerable variability and uncertainty in the chronic endpoints, acute toxicity, based on 10-day amphipod survival was chosen as the most reliable endpoint for the calculation of PRGs.

As described in Section 3.4.3 of the RAO and PRG Technical Memorandum, four chemicals of concern (COCs) were identified as the most likely drivers of acute toxicity to benthic invertebrates in the Newark Bay Study Area: total DDx (4,4') (sum of 4,4'- dichlorodiphenyldichloroethylene, 4,4- dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane), total polychlorinated biphenyls (PCBs), total alkylated polycyclic aromatic hydrocarbons (PAHs), and arsenic[1]. Toxicity was correlated with these COCs in sediment and porewater (GSH 2020). In addition, porewater concentrations for these COCs exceeded water quality criteria in samples exhibiting acute and chronic toxicity (Table E-1) providing evidence that these COCs are the most likely drivers of toxicity.

In the baseline ecological risk assessment (GSH 2020), acute toxicity was defined as 10-day survival that is significantly different from control and less than 80 percent (%) of control. This 80% criterion for defining toxicity is consistent with that used by USEPA to define toxicity for Regional Environmental Monitoring and Assessment Program (United States Environmental Protection Agency [USEPA] 2003) and is consistent with the criterion in the testing manual for discharge to United States waters (USEPA and United States Army Corps of Engineers [USACE] 1998). To calculate PRGs for the protection of the benthic invertebrate community based on direct contact with sediment; a statistical model was used to find the concentration for each COC at which 10-day survival is predicted to be equal to 80% on control survival.

While 28-day survival was a much more variable endpoint, in order to support remedial decision-making, dose response modeling was also conducted using this endpoint and chronic PRGs were calculated for those COCs for which the dose response model was statistically significant (alpha = 0.05).

2 Dose Response Modeling

The survival endpoint in toxicity testing is a binary response variable, that is, a variable that has two possible outcomes (i.e., alive/dead). Therefore, as suggested by Agresti (2002), a binary response model, the probit model, was chosen for dose response modeling of 10-day and 28-day survival. Because of the natural, or

[1] As described in Section 3.4.3 of the Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum, exceedances of water quality criteria were also observed for copper and zinc (Table E-1) but exceedances were not associated with toxicity. Therefore, PRGs were not calculated for these chemicals.

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threshold, mortality expected during the test, as measured in the control, it is more convenient to model mortality rather than survival: (%Mortality = 100-%Survival). The probit model has the following form:

$$\pi = C + (1 - C)F(\alpha + \beta x) + \varepsilon$$

where:

π = probability of mortality

C = threshold mortality (i.e., mean laboratory control mortality)

F = cumulative probability distribution function

α = intercept parameter

β = slope parameter of the predictor variable

x = predictor variable (i.e., natural log transformed COC concentration in sediment)

ε = random error.

The cumulative distribution function (F) maps the range of the linear function ($-\infty,\infty$) onto the range of probability (0,1). The standard normal distribution (called a probit model) was chosen as the distribution for modelling. (Note: The logistic distribution was also tested but it did not result in an appreciable difference in calculated PRGs.) Binary response models were fitted using the PROBIT procedure (PROC PROBIT) in SAS© 9.4 (SAS 2012). The PROBIT procedure calculates maximum likelihood estimates of regression parameters. It also provides estimates of the predictor variable (i.e., in this case sediment concentration) with confidence intervals at any specified probability of excess mortality (i.e., mortality in excess of the threshold or laboratory control mortality). This function of the procedure was used to calculate the sediment concentration at which 80% of control survival (i.e., 20% excess mortality) is expected. Sediment and toxicity input data used for modelling are shown in Table E-2. All COCs were detected in all 30 SQT samples. Each bioassay sample was conducted with a total of 100 organisms (i.e., 5 replicates of 20 organisms each). Therefore, percent mortality is multiplied by 100 to obtain the number of deaths in each sample for model input. Statistical output files for the PROBIT procedure are attached (Attachment E-1).

Models for each COC are depicted in Figures E-1 through E-8. The threshold mortality C, specified in the model is the average mortality observed in the laboratory control sample during the 10-day or 28-day *Leptocheirus plumulosus* bioassay. Ten-day survival in the laboratory control was 90%, therefore threshold mortality C is specified at 0.1 (i.e., 10% mortality) in the model. Twenty-eight-day survival in the laboratory control was 81%, therefore threshold mortality C is specified at 0.19. The estimated model parameters are provided in Table E-3. Twenty-eight day survival models were not significant for total alkylated PAHs or arsenic.

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Table E-3 Dose Response Model Parameters and PRGs

COC	Units	Survival Endpoint	Model Parameters		p-value	Concentration at 80% Control Survival		
			α	β		Estimate[a]	90% Confidence Limits	
Total DDx (4,4')	ng/kg	10-day	-32.4512	2.5134	**<0.0001**	290,000	235,000	329,000
		28-day	-9.5894	0.7876	**0.024**	67,000	8,060	115,000
Total PCBs	ng/kg	10-day	-19.5061	1.3006	**<0.0001**	1,700,000	1,195,000	2,500,000
		28-day	-71.7915	5.2359	**0.0016**	770,000	613,000	858,000
Total Alkylated PAHs[b]	µg/kg	10-day	-23.2454	2.1797	**0.0052**	29,000	21,900	34,500
		28-day	-4.6556	0.4267	0.1132	7,600	--	--
Arsenic	mg/kg	10-day	-8.351	2.1228	**<0.0001**	34	28.8	41.5
		28-day	-35.704	10.6752	0.2496	26	--	--

[a]Sediment concentration predicted by the model above which survival is expected to be less than 80% of the laboratory control survival. This value is the sediment PRG.
[b]Sum of C1-Chrysenes, C1-Fluoranthenes/Pyrenes, C1-Fluorenes, C1-Naphthalenes, C1-Phenanthrenes/Anthracenes, C2-Chrysenes, C2-Fluoranthenes/Pyrenes, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Chrysenes, C3-Fluoranthenes/Pyrenes, C3-Fluorenes, C3-Naphthalenes, C3-Phenanthrenes/Anthracenes, C4-Chrysenes, C4-Naphthalenes, and C4-Phenanthrenes/Anthracenes.
mg/kg = milligrams per kilogram; ng/kg = nanograms per kilogram; µg/kg = micrograms per kilogram
p-value = Wald chi-square probability. Significant models with p-value less than 0.05 shown in bold.
-- Confidence limits not calculable for insignificant models.

3 References

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Tables

Table E-1
Porewater Concentrations in the NBSA for Selected COCs
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Acute NJ WQC	Chronic NJ WQC	Result	Detect
NORTH	136	NB03SED-POR136	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	137	NB03SED-POR137	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	138	NB03SED-POR138	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	139	NB03SED-POR139	Arsenic	mg/L	0.069	0.036	0.0191	Yes
NORTH	140	NB03SED-POR140	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	158	NB03SED-POR158	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	159	NB03SED-POR159	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	160	NB03SED-POR160	Arsenic	mg/L	0.069	0.036	**0.05**	Yes
NORTH	161	NB03SED-POR161	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	162	NB03SED-POR162	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	163	NB03SED-POR163	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	164	NB03SED-POR164	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	165	NB03SED-POR165	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHEAST	141	NB03SED-POR141	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHEAST	142	NB03SED-POR142	Arsenic	mg/L	0.069	0.036	0.0209	Yes
SOUTHEAST	143	NB03SED-POR143	Arsenic	mg/L	0.069	0.036	**0.0371**	Yes
SOUTHEAST	144	NB03SED-POR144	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHEAST	145	NB03SED-POR145	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHEAST	146	NB03SED-POR146	Arsenic	mg/L	0.069	0.036	0.033	Yes
SOUTHEAST	156	NB03SED-POR156	Arsenic	mg/L	0.069	0.036	0.0227	Yes
SOUTHEAST	157	NB03SED-POR157	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHWEST	147	NB03SED-POR147	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHWEST	148	NB03SED-POR148	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHWEST	149	NB03SED-POR149	Arsenic	mg/L	0.069	0.036	0.0268	Yes
SOUTHWEST	150	NB03SED-POR150	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHWEST	151	NB03SED-POR151	Arsenic	mg/L	0.069	0.036	**0.0748**	Yes
SOUTHWEST	152	NB03SED-POR152	Arsenic	mg/L	0.069	0.036	0.0054	No
SOUTHWEST	153	NB03SED-POR153	Arsenic	mg/L	0.069	0.036	0.0183	Yes
SOUTHWEST	154	NB03SED-POR154	Arsenic	mg/L	0.069	0.036	0.0054	No
NORTH	136	NB03SED-POR136	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	137	NB03SED-POR137	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	138	NB03SED-POR138	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	139	NB03SED-POR139	Copper	mg/L	0.0079	0.0056	0.0042	Yes
NORTH	140	NB03SED-POR140	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	158	NB03SED-POR158	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	159	NB03SED-POR159	Copper	mg/L	0.0079	0.0056	0.0021	Yes
NORTH	160	NB03SED-POR160	Copper	mg/L	0.0079	0.0056	0.0022	Yes
NORTH	161	NB03SED-POR161	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	162	NB03SED-POR162	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	163	NB03SED-POR163	Copper	mg/L	0.0079	0.0056	**0.0073**	Yes
NORTH	164	NB03SED-POR164	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	165	NB03SED-POR165	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	141	NB03SED-POR141	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	142	NB03SED-POR142	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	143	NB03SED-POR143	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	144	NB03SED-POR144	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	145	NB03SED-POR145	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	146	NB03SED-POR146	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	156	NB03SED-POR156	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHEAST	157	NB03SED-POR157	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	147	NB03SED-POR147	Copper	mg/L	0.0079	0.0056	**0.0155**	Yes
SOUTHWEST	148	NB03SED-POR148	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	149	NB03SED-POR149	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	150	NB03SED-POR150	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	151	NB03SED-POR151	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	152	NB03SED-POR152	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	153	NB03SED-POR153	Copper	mg/L	0.0079	0.0056	0.002	No
SOUTHWEST	154	NB03SED-POR154	Copper	mg/L	0.0079	0.0056	0.002	No
NORTH	136	NB03SED-POR136	Total DDx (4,4')	µg/L	0.13	0.001	0.0006	Yes

Table E-1
Porewater Concentrations in the NBSA for Selected COCs
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
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Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Acute NJ WQC	Chronic NJ WQC	Result	Detect
NORTH	137	NB03SED-POR137	Total DDx (4,4')	µg/L	0.13	0.001	0.00056	Yes
NORTH	138	NB03SED-POR138	Total DDx (4,4')	µg/L	0.13	0.001	0.00071	Yes
NORTH	139	NB03SED-POR139	Total DDx (4,4')	µg/L	0.13	0.001	0.001	Yes
NORTH	140	NB03SED-POR140	Total DDx (4,4')	µg/L	0.13	0.001	**0.0012**	Yes
NORTH	158	NB03SED-POR158	Total DDx (4,4')	µg/L	0.13	0.001	0.0007	Yes
NORTH	159	NB03SED-POR159	Total DDx (4,4')	µg/L	0.13	0.001	0.00066	Yes
NORTH	160	NB03SED-POR160	Total DDx (4,4')	µg/L	0.13	0.001	**0.0014**	Yes
NORTH	161	NB03SED-POR161	Total DDx (4,4')	µg/L	0.13	0.001	0.00068	Yes
NORTH	162	NB03SED-POR162	Total DDx (4,4')	µg/L	0.13	0.001	0.00072	Yes
NORTH	163	NB03SED-POR163	Total DDx (4,4')	µg/L	0.13	0.001	0.00072	Yes
NORTH	164	NB03SED-POR164	Total DDx (4,4')	µg/L	0.13	0.001	0.00084	Yes
NORTH	165	NB03SED-POR165	Total DDx (4,4')	µg/L	0.13	0.001	0.00064	Yes
SOUTHEAST	141	NB03SED-POR141	Total DDx (4,4')	µg/L	0.13	0.001	0.00062	Yes
SOUTHEAST	142	NB03SED-POR142	Total DDx (4,4')	µg/L	0.13	0.001	0.00047	Yes
SOUTHEAST	143	NB03SED-POR143	Total DDx (4,4')	µg/L	0.13	0.001	**0.0034**	Yes
SOUTHEAST	144	NB03SED-POR144	Total DDx (4,4')	µg/L	0.13	0.001	**0.0011**	Yes
SOUTHEAST	145	NB03SED-POR145	Total DDx (4,4')	µg/L	0.13	0.001	**0.0011**	Yes
SOUTHEAST	146	NB03SED-POR146	Total DDx (4,4')	µg/L	0.13	0.001	**0.0017**	Yes
SOUTHEAST	156	NB03SED-POR156	Total DDx (4,4')	µg/L	0.13	0.001	0.00063	Yes
SOUTHEAST	157	NB03SED-POR157	Total DDx (4,4')	µg/L	0.13	0.001	0.00077	Yes
SOUTHWEST	147	NB03SED-POR147	Total DDx (4,4')	µg/L	0.13	0.001	**0.0016**	Yes
SOUTHWEST	148	NB03SED-POR148	Total DDx (4,4')	µg/L	0.13	0.001	**0.0012**	Yes
SOUTHWEST	149	NB03SED-POR149	Total DDx (4,4')	µg/L	0.13	0.001	**0.0017**	Yes
SOUTHWEST	150	NB03SED-POR150	Total DDx (4,4')	µg/L	0.13	0.001	**0.0016**	Yes
SOUTHWEST	151	NB03SED-POR151	Total DDx (4,4')	µg/L	0.13	0.001	**0.0058**	Yes
SOUTHWEST	152	NB03SED-POR152	Total DDx (4,4')	µg/L	0.13	0.001	**0.00475**	Yes
SOUTHWEST	153	NB03SED-POR153	Total DDx (4,4')	µg/L	0.13	0.001	0.00096	Yes
SOUTHWEST	154	NB03SED-POR154	Total DDx (4,4')	µg/L	0.13	0.001	**0.01**	Yes
SOUTHWEST	155	NB03SED-POR155	Total DDx (4,4')	µg/L	0.13	0.001	**0.0018**	Yes
NORTH	136	NB03SED-POR136	Total Alkylated PAHs	ng/L	--	--	40.3	Yes
NORTH	137	NB03SED-POR137	Total Alkylated PAHs	ng/L	--	--	68.3	Yes
NORTH	138	NB03SED-POR138	Total Alkylated PAHs	ng/L	--	--	48.9	Yes
NORTH	139	NB03SED-POR139	Total Alkylated PAHs	ng/L	--	--	72.2	Yes
NORTH	140	NB03SED-POR140	Total Alkylated PAHs	ng/L	--	--	67.3	Yes
NORTH	158	NB03SED-POR158	Total Alkylated PAHs	ng/L	--	--	759.8	Yes
NORTH	159	NB03SED-POR159	Total Alkylated PAHs	ng/L	--	--	61.9	Yes
NORTH	160	NB03SED-POR160	Total Alkylated PAHs	ng/L	--	--	79.0	Yes
NORTH	161	NB03SED-POR161	Total Alkylated PAHs	ng/L	--	--	49.4	Yes
NORTH	162	NB03SED-POR162	Total Alkylated PAHs	ng/L	--	--	261.2	Yes
NORTH	163	NB03SED-POR163	Total Alkylated PAHs	ng/L	--	--	201.8	Yes
NORTH	164	NB03SED-POR164	Total Alkylated PAHs	ng/L	--	--	49.2	Yes
NORTH	165	NB03SED-POR165	Total Alkylated PAHs	ng/L	--	--	46.1	Yes
SOUTHEAST	141	NB03SED-POR141	Total Alkylated PAHs	ng/L	--	--	34.3	Yes
SOUTHEAST	142	NB03SED-POR142	Total Alkylated PAHs	ng/L	--	--	113	Yes
SOUTHEAST	143	NB03SED-POR143	Total Alkylated PAHs	ng/L	--	--	355	Yes
SOUTHEAST	144	NB03SED-POR144	Total Alkylated PAHs	ng/L	--	--	99.9	Yes
SOUTHEAST	145	NB03SED-POR145	Total Alkylated PAHs	ng/L	--	--	321	Yes
SOUTHEAST	156	NB03SED-POR156	Total Alkylated PAHs	ng/L	--	--	37.1	Yes
SOUTHEAST	157	NB03SED-POR157	Total Alkylated PAHs	ng/L	--	--	43.8	Yes
SOUTHWEST	146	NB03SED-POR146	Total Alkylated PAHs	ng/L	--	--	158	Yes
SOUTHWEST	147	NB03SED-POR147	Total Alkylated PAHs	ng/L	--	--	612	Yes
SOUTHWEST	148	NB03SED-POR148	Total Alkylated PAHs	ng/L	--	--	91.1	Yes
SOUTHWEST	149	NB03SED-POR149	Total Alkylated PAHs	ng/L	--	--	114	Yes
SOUTHWEST	150	NB03SED-POR150	Total Alkylated PAHs	ng/L	--	--	73.2	Yes
SOUTHWEST	151	NB03SED-POR151	Total Alkylated PAHs	ng/L	--	--	2,918	Yes
SOUTHWEST	152	NB03SED-POR152	Total Alkylated PAHs	ng/L	--	--	62.7	Yes
SOUTHWEST	153	NB03SED-POR153	Total Alkylated PAHs	ng/L	--	--	48.7	Yes
SOUTHWEST	154	NB03SED-POR154	Total Alkylated PAHs	ng/L	--	--	3,803	Yes
SOUTHWEST	155	NB03SED-POR155	Total Alkylated PAHs	ng/L	--	--	62.7	Yes

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Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Acute NJ WQC	Chronic NJ WQC	Result	Detect
NORTH	136	NB03SED-POR136	Sum of Toxic Units PAHs	unitless	--	--	0.04	Yes
NORTH	137	NB03SED-POR137	Sum of Toxic Units PAHs	unitless	--	--	0.06	Yes
NORTH	138	NB03SED-POR138	Sum of Toxic Units PAHs	unitless	--	--	0.04	Yes
NORTH	139	NB03SED-POR139	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
NORTH	140	NB03SED-POR140	Sum of Toxic Units PAHs	unitless	--	--	0.06	Yes
NORTH	158	NB03SED-POR158	Sum of Toxic Units PAHs	unitless	--	--	0.33	Yes
NORTH	159	NB03SED-POR159	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
NORTH	160	NB03SED-POR160	Sum of Toxic Units PAHs	unitless	--	--	0.07	Yes
NORTH	161	NB03SED-POR161	Sum of Toxic Units PAHs	unitless	--	--	0.04	Yes
NORTH	162	NB03SED-POR162	Sum of Toxic Units PAHs	unitless	--	--	0.08	Yes
NORTH	163	NB03SED-POR163	Sum of Toxic Units PAHs	unitless	--	--	0.12	Yes
NORTH	164	NB03SED-POR164	Sum of Toxic Units PAHs	unitless	--	--	0.04	Yes
NORTH	165	NB03SED-POR165	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
SOUTHEAST	141	NB03SED-POR141	Sum of Toxic Units PAHs	unitless	--	--	0.03	Yes
SOUTHEAST	142	NB03SED-POR142	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
SOUTHEAST	143	NB03SED-POR143	Sum of Toxic Units PAHs	unitless	--	--	0.27	Yes
SOUTHEAST	144	NB03SED-POR144	Sum of Toxic Units PAHs	unitless	--	--	0.08	Yes
SOUTHEAST	145	NB03SED-POR145	Sum of Toxic Units PAHs	unitless	--	--	0.41	Yes
SOUTHEAST	156	NB03SED-POR156	Sum of Toxic Units PAHs	unitless	--	--	0.03	Yes
SOUTHEAST	157	NB03SED-POR157	Sum of Toxic Units PAHs	unitless	--	--	0.03	Yes
SOUTHWEST	146	NB03SED-POR146	Sum of Toxic Units PAHs	unitless	--	--	0.13	Yes
SOUTHWEST	147	NB03SED-POR147	Sum of Toxic Units PAHs	unitless	--	--	0.24	Yes
SOUTHWEST	148	NB03SED-POR148	Sum of Toxic Units PAHs	unitless	--	--	0.07	Yes
SOUTHWEST	149	NB03SED-POR149	Sum of Toxic Units PAHs	unitless	--	--	0.09	Yes
SOUTHWEST	150	NB03SED-POR150	Sum of Toxic Units PAHs	unitless	--	--	0.06	Yes
SOUTHWEST	151	NB03SED-POR151	Sum of Toxic Units PAHs	unitless	--	--	**1.0**	Yes
SOUTHWEST	152	NB03SED-POR152	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
SOUTHWEST	153	NB03SED-POR153	Sum of Toxic Units PAHs	unitless	--	--	0.04	Yes
SOUTHWEST	154	NB03SED-POR154	Sum of Toxic Units PAHs	unitless	--	--	**1.3**	Yes
SOUTHWEST	155	NB03SED-POR155	Sum of Toxic Units PAHs	unitless	--	--	0.05	Yes
NORTH	136	NB03SED-POR136	Total PCB Congeners (209)	ng/L	--	30	5.14	Yes
NORTH	137	NB03SED-POR137	Total PCB Congeners (209)	ng/L	--	30	4.79	Yes
NORTH	138	NB03SED-POR138	Total PCB Congeners (209)	ng/L	--	30	**34.9**	Yes
NORTH	139	NB03SED-POR139	Total PCB Congeners (209)	ng/L	--	30	6.84	Yes
NORTH	140	NB03SED-POR140	Total PCB Congeners (209)	ng/L	--	30	12.3	Yes
NORTH	158	NB03SED-POR158	Total PCB Congeners (209)	ng/L	--	30	4.6	Yes
NORTH	159	NB03SED-POR159	Total PCB Congeners (209)	ng/L	--	30	6.62	Yes
NORTH	160	NB03SED-POR160	Total PCB Congeners (209)	ng/L	--	30	23.2	Yes
NORTH	161	NB03SED-POR161	Total PCB Congeners (209)	ng/L	--	30	5.27	Yes
NORTH	162	NB03SED-POR162	Total PCB Congeners (209)	ng/L	--	30	4.95	Yes
NORTH	163	NB03SED-POR163	Total PCB Congeners (209)	ng/L	--	30	5.76	Yes
NORTH	164	NB03SED-POR164	Total PCB Congeners (209)	ng/L	--	30	5.46	Yes
NORTH	165	NB03SED-POR165	Total PCB Congeners (209)	ng/L	--	30	6.04	Yes
SOUTHEAST	141	NB03SED-POR141	Total PCB Congeners (209)	ng/L	--	30	5.13	Yes
SOUTHEAST	142	NB03SED-POR142	Total PCB Congeners (209)	ng/L	--	30	4.09	Yes
SOUTHEAST	143	NB03SED-POR143	Total PCB Congeners (209)	ng/L	--	30	6.51	Yes
SOUTHEAST	144	NB03SED-POR144	Total PCB Congeners (209)	ng/L	--	30	17.8	Yes
SOUTHEAST	145	NB03SED-POR145	Total PCB Congeners (209)	ng/L	--	30	15.3	Yes
SOUTHEAST	146	NB03SED-POR146	Total PCB Congeners (209)	ng/L	--	30	7.41	Yes
SOUTHEAST	156	NB03SED-POR156	Total PCB Congeners (209)	ng/L	--	30	3.99	Yes
SOUTHEAST	157	NB03SED-POR157	Total PCB Congeners (209)	ng/L	--	30	5.89	Yes
SOUTHWEST	147	NB03SED-POR147	Total PCB Congeners (209)	ng/L	--	30	20.4	Yes
SOUTHWEST	148	NB03SED-POR148	Total PCB Congeners (209)	ng/L	--	30	18.9	Yes

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Assessment Zone	SQT Station	Sample ID	Chemical	Units	Acute NJ WQC	Chronic NJ WQC	Result	Detect
SOUTHWEST	149	NB03SED-POR149	Total PCB Congeners (209)	ng/L	--	30	7.9	Yes
SOUTHWEST	150	NB03SED-POR150	Total PCB Congeners (209)	ng/L	--	30	11.2	Yes
SOUTHWEST	151	NB03SED-POR151	Total PCB Congeners (209)	ng/L	--	30	**152**	Yes
SOUTHWEST	152	NB03SED-POR152	Total PCB Congeners (209)	ng/L	--	30	10.9	Yes
SOUTHWEST	153	NB03SED-POR153	Total PCB Congeners (209)	ng/L	--	30	4.82	Yes
SOUTHWEST	154	NB03SED-POR154	Total PCB Congeners (209)	ng/L	--	30	**32.2**	Yes
SOUTHWEST	155	NB03SED-POR155	Total PCB Congeners (209)	ng/L	--	30	8.05	Yes
NORTH	136	NB03SED-POR136	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	137	NB03SED-POR137	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	138	NB03SED-POR138	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	139	NB03SED-POR139	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	140	NB03SED-POR140	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	158	NB03SED-POR158	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	159	NB03SED-POR159	Zinc	mg/L	0.09	0.081	**0.176**	Yes
NORTH	160	NB03SED-POR160	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	161	NB03SED-POR161	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	162	NB03SED-POR162	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	163	NB03SED-POR163	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	164	NB03SED-POR164	Zinc	mg/L	0.09	0.081	0.037	No
NORTH	165	NB03SED-POR165	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	141	NB03SED-POR141	Zinc	mg/L	0.09	0.081	**0.0967**	Yes
SOUTHEAST	142	NB03SED-POR142	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	143	NB03SED-POR143	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	144	NB03SED-POR144	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	145	NB03SED-POR145	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	146	NB03SED-POR146	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	156	NB03SED-POR156	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHEAST	157	NB03SED-POR157	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	147	NB03SED-POR147	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	148	NB03SED-POR148	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	149	NB03SED-POR149	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	150	NB03SED-POR150	Zinc	mg/L	0.09	0.081	**0.402**	Yes
SOUTHWEST	151	NB03SED-POR151	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	152	NB03SED-POR152	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	153	NB03SED-POR153	Zinc	mg/L	0.09	0.081	0.037	No
SOUTHWEST	154	NB03SED-POR154	Zinc	mg/L	0.09	0.081	0.037	No

Notes:

NJ WQC = New Jersey Surface Water Quality Standards, New Jersey Administrative Code, re-adopted October 17, 2016 (New Jersey Administrative Code 7:9B), for the protection of aquatic life in saline waters. Values that exceed WQC are bolded.

Sum of toxic units is the sum of the detected concentration of each PAH compound in porewater divided by its final chronic value, as described in USEPA 2017. Values that exceed one are bolded.

Total 4,4-DDx is compared to the WQC for 4,4'-dichlorodiphenyltrichloroethane (CAS Number 50-29-3).

Total Alkylated PAHs is the sum of C1-Chrysenes, C1-Fluoranthenes/Pyrenes, C1-Fluorenes, C1-Naphthalenes, C1-Phenanthrenes/Anthracenes, C2-Chrysenes, C2-Fluoranthenes/Pyrenes, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Chrysenes, C3-Fluoranthenes/Pyrenes, C3-Fluorenes, C3-Naphthalenes, C3-Phenanthrenes/Anthracenes, C4-Chrysenes, C4-Naphthalenes,and C4-Phenanthrenes/Anthracenes.

Field duplicates averaged.

SQT stations are shown on Figure 3-1.

Acronyms and Abbreviations:

-- = Not applicable or available
mg/L = milligrams per liter
ng/L = nanograms per liter
NJ = New Jersey
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SQT = sediment quality triad
Total (4,4') DDx = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
USEPA = United States Environmental Protection Agency
WQC = water quality criteria

References

USEPA. 2017. Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. EPA/600/R. Office of Research and Development. Washington, DC.

Table E-2
Sediment and Toxicity Data
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Result	Detect	Percent Survival at 10 Days	Percent Survival at 28 Days
Laboratory Control							**90**	**81**
North	136	NB03SED-CHM136	Arsenic	mg/kg	11.6	Yes	92	63
North	137	NB03SED-CHM137	Arsenic	mg/kg	8.24	Yes	96	75
North	138	NB03SED-CHM138	Arsenic	mg/kg	12.9	Yes	89	46
North	139	NB03SED-CHM139	Arsenic	mg/kg	9.77	Yes	92	92
North	140	NB03SED-CHM140	Arsenic	mg/kg	7.1	Yes	81	79
North	158	NB03SED-CHM158	Arsenic	mg/kg	8.48	Yes	93	**39**
North	159	NB03SED-CHM159	Arsenic	mg/kg	8.11	Yes	90	62
North	160	NB03SED-CHM160	Arsenic	mg/kg	7.87	Yes	90	**0**
North	161	NB03SED-CHM161	Arsenic	mg/kg	12.2	Yes	95	96
North	162	NB03SED-CHM162	Arsenic	mg/kg	14.1	Yes	92	86
North	163	NB03SED-CHM163	Arsenic	mg/kg	9.64	Yes	94	69
North	164	NB03SED-CHM164	Arsenic	mg/kg	6.76	Yes	96	84
North	165	NB03SED-CHM165	Arsenic	mg/kg	12.9	Yes	95	88
Southeast	141	NB03SED-CHM141	Arsenic	mg/kg	11.7	Yes	92	**67**
Southeast	142	NB03SED-CHM142	Arsenic	mg/kg	5.59	Yes	98	53
Southeast	143	NB03SED-CHM143	Arsenic	mg/kg	29.7	Yes	90	**30**
Southeast	144	NB03SED-CHM144	Arsenic	mg/kg	13.5	Yes	93	65
Southeast	145	NB03SED-CHM145	Arsenic	mg/kg	9.45	Yes	97	59
Southeast	146	NB03SED-CHM146	Arsenic	mg/kg	9.32	Yes	83	84
Southeast	156	NB03SED-CHM156	Arsenic	mg/kg	11.2	Yes	96	86
Southeast	157	NB03SED-CHM157	Arsenic	mg/kg	10.6	Yes	92	80
Southwest	147	NB03SED-CHM147	Arsenic	mg/kg	20.6	Yes	90	79
Southwest	148	NB03SED-CHM148	Arsenic	mg/kg	18.7	Yes	97	92
Southwest	149	NB03SED-CHM149	Arsenic	mg/kg	26.8	Yes	98	63
Southwest	150	NB03SED-CHM150	Arsenic	mg/kg	17.3	Yes	89	73
Southwest	151	NB03SED-CHM151	Arsenic	mg/kg	61.5	Yes	**37.5**	**0**
Southwest	152	NB03SED-CHM152	Arsenic	mg/kg	15.45	Yes	97	86
Southwest	153	NB03SED-CHM153	Arsenic	mg/kg	9.48	Yes	98	83
Southwest	154	NB03SED-CHM154	Arsenic	mg/kg	30.9	Yes	**39**	**9**
Southwest	155	NB03SED-CHM155	Arsenic	mg/kg	5.92	Yes	95	70
North	136	NB03SED-CHM136	Total DDx (4,4')	ng/kg	37,000	Yes	92	63
North	137	NB03SED-CHM137	Total DDx (4,4')	ng/kg	31,000	Yes	96	75
North	138	NB03SED-CHM138	Total DDx (4,4')	ng/kg	58,000	Yes	89	46
North	139	NB03SED-CHM139	Total DDx (4,4')	ng/kg	78,000	Yes	92	92
North	140	NB03SED-CHM140	Total DDx (4,4')	ng/kg	24,000	Yes	81	79
North	158	NB03SED-CHM158	Total DDx (4,4')	ng/kg	20,000	Yes	93	**39**
North	159	NB03SED-CHM159	Total DDx (4,4')	ng/kg	22,000	Yes	90	62
North	160	NB03SED-CHM160	Total DDx (4,4')	ng/kg	47,000	Yes	90	**0**
North	161	NB03SED-CHM161	Total DDx (4,4')	ng/kg	49,000	Yes	95	96
North	162	NB03SED-CHM162	Total DDx (4,4')	ng/kg	29,000	Yes	92	86
North	163	NB03SED-CHM163	Total DDx (4,4')	ng/kg	33,000	Yes	94	69
North	164	NB03SED-CHM164	Total DDx (4,4')	ng/kg	28,000	Yes	96	84
North	165	NB03SED-CHM165	Total DDx (4,4')	ng/kg	41,000	Yes	95	88
Southeast	141	NB03SED-CHM141	Total DDx (4,4')	ng/kg	26,000	Yes	92	**67**
Southeast	142	NB03SED-CHM142	Total DDx (4,4')	ng/kg	9,500	Yes	98	53
Southeast	143	NB03SED-CHM143	Total DDx (4,4')	ng/kg	190,000	Yes	90	**30**
Southeast	144	NB03SED-CHM144	Total DDx (4,4')	ng/kg	42,000	Yes	93	65
Southeast	145	NB03SED-CHM145	Total DDx (4,4')	ng/kg	26,000	Yes	97	59
Southeast	146	NB03SED-CHM146	Total DDx (4,4')	ng/kg	19,000	Yes	83	84
Southeast	156	NB03SED-CHM156	Total DDx (4,4')	ng/kg	20,000	Yes	96	86
Southeast	157	NB03SED-CHM157	Total DDx (4,4')	ng/kg	27,000	Yes	92	80

Table E-2
Sediment and Toxicity Data
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Result	Detect	Percent Survival at 10 Days	Percent Survival at 28 Days
Southwest	147	NB03SED-CHM147	Total DDx (4,4')	ng/kg	85,500	Yes	90	79
Southwest	148	NB03SED-CHM148	Total DDx (4,4')	ng/kg	50,000	Yes	97	92
Southwest	149	NB03SED-CHM149	Total DDx (4,4')	ng/kg	120,000	Yes	98	63
Southwest	150	NB03SED-CHM150	Total DDx (4,4')	ng/kg	66,000	Yes	89	73
Southwest	151	NB03SED-CHM151	Total DDx (4,4')	ng/kg	490,000	Yes	**37.5**	**0**
Southwest	152	NB03SED-CHM152	Total DDx (4,4')	ng/kg	180,000	Yes	97	86
Southwest	153	NB03SED-CHM153	Total DDx (4,4')	ng/kg	16,000	Yes	98	83
Southwest	154	NB03SED-CHM154	Total DDx (4,4')	ng/kg	370,000	Yes	**39**	**9**
Southwest	155	NB03SED-CHM155	Total DDx (4,4')	ng/kg	20,000	Yes	95	70
North	136	NB03SED-CHM136	Total Alkylated PAHs	µg/kg	4,054	Yes	92	63
North	137	NB03SED-CHM137	Total Alkylated PAHs	µg/kg	7,414	Yes	96	75
North	138	NB03SED-CHM138	Total Alkylated PAHs	µg/kg	6,492	Yes	89	46
North	139	NB03SED-CHM139	Total Alkylated PAHs	µg/kg	19,130	Yes	92	92
North	140	NB03SED-CHM140	Total Alkylated PAHs	µg/kg	2,997	Yes	81	79
North	158	NB03SED-CHM158	Total Alkylated PAHs	µg/kg	13,040	Yes	93	**39**
North	159	NB03SED-CHM159	Total Alkylated PAHs	µg/kg	9,110	Yes	90	62
North	160	NB03SED-CHM160	Total Alkylated PAHs	µg/kg	6,082	Yes	90	**0**
North	161	NB03SED-CHM161	Total Alkylated PAHs	µg/kg	4,888	Yes	95	96
North	162	NB03SED-CHM162	Total Alkylated PAHs	µg/kg	10,940	Yes	92	86
North	163	NB03SED-CHM163	Total Alkylated PAHs	µg/kg	3,906	Yes	94	69
North	164	NB03SED-CHM164	Total Alkylated PAHs	µg/kg	2,636	Yes	96	84
North	165	NB03SED-CHM165	Total Alkylated PAHs	µg/kg	4,854	Yes	95	88
Southeast	141	NB03SED-CHM141	Total Alkylated PAHs	µg/kg	1,273	Yes	92	**67**
Southeast	142	NB03SED-CHM142	Total Alkylated PAHs	µg/kg	4,144	Yes	98	53
Southeast	143	NB03SED-CHM143	Total Alkylated PAHs	µg/kg	5,651	Yes	90	**30**
Southeast	144	NB03SED-CHM144	Total Alkylated PAHs	µg/kg	5,705	Yes	93	65
Southeast	145	NB03SED-CHM145	Total Alkylated PAHs	µg/kg	3,278	Yes	97	59
Southeast	146	NB03SED-CHM146	Total Alkylated PAHs	µg/kg	2,235	Yes	83	84
Southeast	156	NB03SED-CHM156	Total Alkylated PAHs	µg/kg	3,750	Yes	96	86
Southeast	157	NB03SED-CHM157	Total Alkylated PAHs	µg/kg	4,916	Yes	92	80
Southwest	147	NB03SED-CHM147	Total Alkylated PAHs	µg/kg	8,887	Yes	90	79
Southwest	148	NB03SED-CHM148	Total Alkylated PAHs	µg/kg	20,690	Yes	97	92
Southwest	149	NB03SED-CHM149	Total Alkylated PAHs	µg/kg	3,140	Yes	98	63
Southwest	150	NB03SED-CHM150	Total Alkylated PAHs	µg/kg	38,040	Yes	89	73
Southwest	151	NB03SED-CHM151	Total Alkylated PAHs	µg/kg	30,422	Yes	**37.5**	**0**
Southwest	152	NB03SED-CHM152	Total Alkylated PAHs	µg/kg	10,190	Yes	97	86
Southwest	153	NB03SED-CHM153	Total Alkylated PAHs	µg/kg	3,056	Yes	98	83
Southwest	154	NB03SED-CHM154	Total Alkylated PAHs	µg/kg	37,800	Yes	**39**	**9**
Southwest	155	NB03SED-CHM155	Total Alkylated PAHs	µg/kg	215	Yes	95	70
North	136	NB03SED-CHM136	Total PCB Congeners (209)	ng/kg	295,000	Yes	92	63
North	137	NB03SED-CHM137	Total PCB Congeners (209)	ng/kg	115,000	Yes	96	75
North	138	NB03SED-CHM138	Total PCB Congeners (209)	ng/kg	909,000	Yes	89	46
North	139	NB03SED-CHM139	Total PCB Congeners (209)	ng/kg	234,000	Yes	92	92
North	140	NB03SED-CHM140	Total PCB Congeners (209)	ng/kg	211,000	Yes	81	79
North	158	NB03SED-CHM158	Total PCB Congeners (209)	ng/kg	92,700	Yes	93	**39**
North	159	NB03SED-CHM159	Total PCB Congeners (209)	ng/kg	290,000	Yes	90	62
North	160	NB03SED-CHM160	Total PCB Congeners (209)	ng/kg	1,200,000	Yes	90	**0**
North	161	NB03SED-CHM161	Total PCB Congeners (209)	ng/kg	713,000	Yes	95	96
North	162	NB03SED-CHM162	Total PCB Congeners (209)	ng/kg	507,000	Yes	92	86
North	163	NB03SED-CHM163	Total PCB Congeners (209)	ng/kg	301,000	Yes	94	69
North	164	NB03SED-CHM164	Total PCB Congeners (209)	ng/kg	221,000	Yes	96	84
North	165	NB03SED-CHM165	Total PCB Congeners (209)	ng/kg	524,000	Yes	95	88

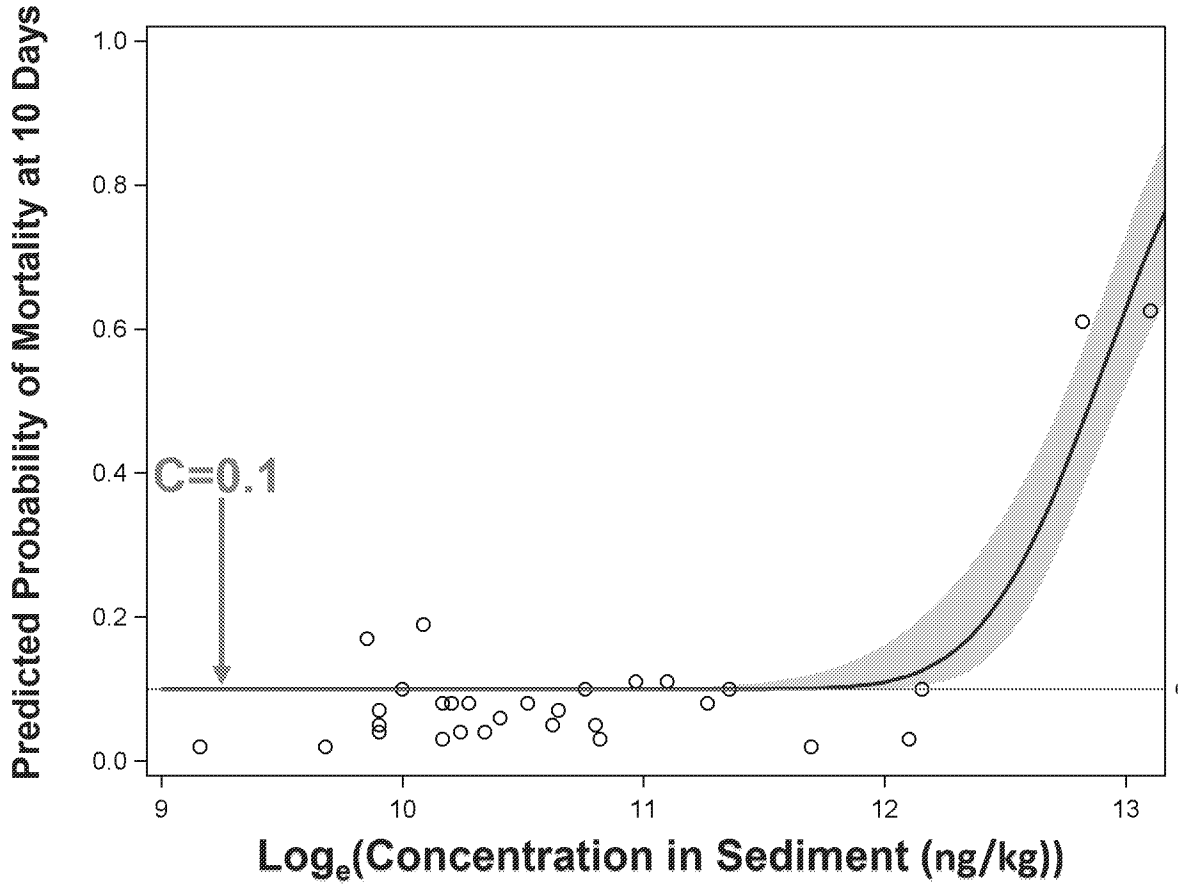
Table E-2
Sediment and Toxicity Data
Appendix D: Toxicity Reference Values and Species Sensitivity Distributions
Remedial Action Objectives and Preliminary Remedial Goals Technical Memorandum
Diamond Alkali Superfund Site
Newark Bay Study Area

Assessment Zone	SQT Station	Sample ID	Chemical	Units	Result	Detect	Percent Survival at 10 Days	Percent Survival at 28 Days
Southeast	141	NB03SED-CHM141	Total PCB Congeners (209)	ng/kg	462,000	Yes	92	**67**
Southeast	142	NB03SED-CHM142	Total PCB Congeners (209)	ng/kg	94,400	Yes	98	53
Southeast	143	NB03SED-CHM143	Total PCB Congeners (209)	ng/kg	424,000	Yes	90	**30**
Southeast	144	NB03SED-CHM144	Total PCB Congeners (209)	ng/kg	757,000	Yes	93	65
Southeast	145	NB03SED-CHM145	Total PCB Congeners (209)	ng/kg	407,000	Yes	97	59
Southeast	146	NB03SED-CHM146	Total PCB Congeners (209)	ng/kg	167,000	Yes	83	84
Southeast	156	NB03SED-CHM156	Total PCB Congeners (209)	ng/kg	404,000	Yes	96	86
Southeast	157	NB03SED-CHM157	Total PCB Congeners (209)	ng/kg	490,000	Yes	92	80
Southwest	147	NB03SED-CHM147	Total PCB Congeners (209)	ng/kg	540,500	Yes	90	79
Southwest	148	NB03SED-CHM148	Total PCB Congeners (209)	ng/kg	632,000	Yes	97	92
Southwest	149	NB03SED-CHM149	Total PCB Congeners (209)	ng/kg	636,000	Yes	98	63
Southwest	150	NB03SED-CHM150	Total PCB Congeners (209)	ng/kg	701,000	Yes	89	73
Southwest	151	NB03SED-CHM151	Total PCB Congeners (209)	ng/kg	4,370,000	Yes	**37.5**	**0**
Southwest	152	NB03SED-CHM152	Total PCB Congeners (209)	ng/kg	637,500	Yes	97	86
Southwest	153	NB03SED-CHM153	Total PCB Congeners (209)	ng/kg	140,000	Yes	98	83
Southwest	154	NB03SED-CHM154	Total PCB Congeners (209)	ng/kg	1,120,000	Yes	**39**	**9**
Southwest	155	NB03SED-CHM155	Total PCB Congeners (209)	ng/kg	50,600	Yes	95	70

Notes:
Survival data measured in *L.plumulosus* bioassay tests.
Bolded survival data indicates that it is statistically significantly different from control survival.
Total Alkylated PAHs is the sum of C1-Chrysenes, C1-Fluoranthenes/Pyrenes, C1-Fluorenes, C1-Naphthalenes, C1-Phenanthrenes/Anthracenes, C2-Chrysenes, C2-Fluoranthenes/Pyrenes, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Chrysenes, C3-Fluoranthenes/Pyrenes, C3-Fluorenes, C3-Naphthalenes, C3-Phenanthrenes/Anthracenes, C4-Chrysenes, C4-Naphthalenes, and C4-Phenanthrenes/Anthracenes.
Field duplicates averaged.
SQT stations are shown on Figure 3-1 in the Remedial Action Objectives & Preliminary Remedial Goals Technical Memorandum.

Acronyms and Abbreviations:
mg/kg = milligrams per kilogram
ng/kg = nanograms per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SQT = sediment quality triad
Total DDx (4,4') = sum of 4,4'-dichlorodiphenyldichloroethylene, 4,4'-dichlorodiphenyldichloroethane, and 4,4'-dichlorodiphenyltrichloroethane
µg/kg = micrograms per kilogram

Figures



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 10 days
C = 0.1 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -32.4512
β = 2.5134
x = $\log_e$(Concentration)
p <0.0001

Notes;
Model is based on 10-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
ng/kg = nanograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX E: BENTHIC INVERTEBRATE DOSE RESPONSE MODELS

ACUTE TOXICITY DOSE RESPONSE MODEL FOR TOTAL DDX (4,4')

OXY Glenn Springs Holdings, Inc.
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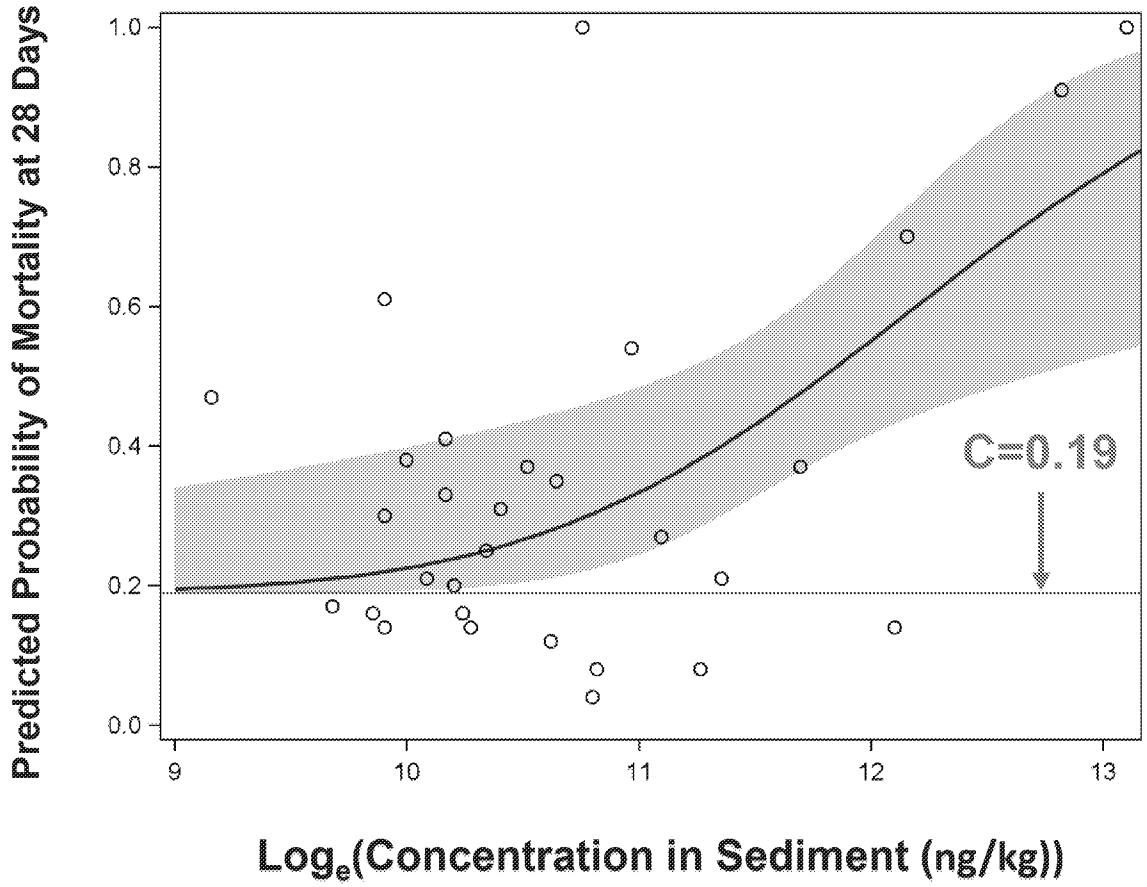
FIGURE
E-1



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 28 days
C = 0.19 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -9.5894
β = 0.7876
x = $\log_e$(Concentration)
p =0.024

Notes;
Model is based on 28-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
ng/kg = nanograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
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CHRONIC TOXICITY DOSE RESPONSE MODEL FOR TOTAL DDX (4,4')

OXY Glenn Springs Holdings, Inc.
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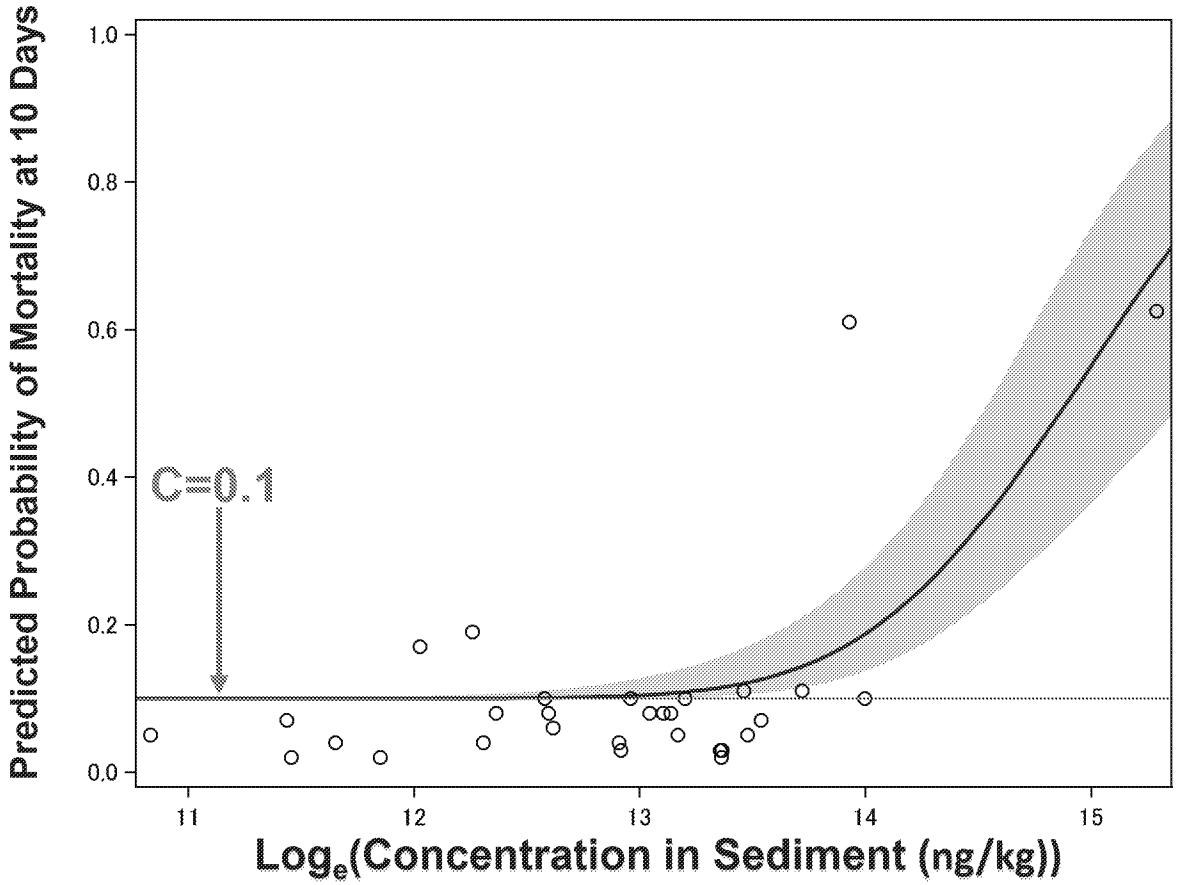
FIGURE
E-2



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 10 days
C = 0.1 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -19.5061
β = 1.3006
$x = \log_e$(Concentration)
p <0.0001

Notes;
Model is based on 10-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
ng/kg = nanograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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ACUTE TOXICITY DOSE RESPONSE MODEL FOR TOTAL PCB CONGENERS

OXY Glenn Springs Holdings, Inc.
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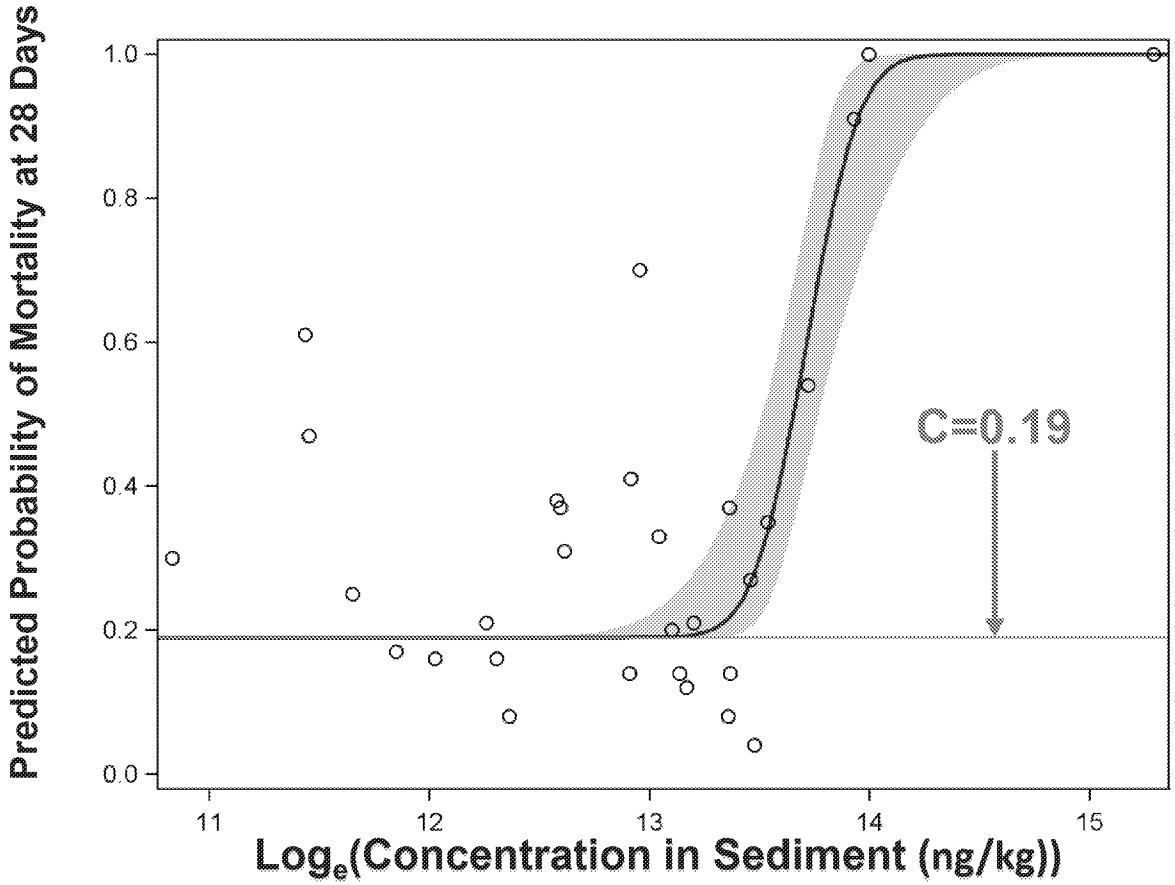
FIGURE
E-3



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 28 days
C = 0.19 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -71.792
β = 5.2359
x = $\log_e$(Concentration)
p =0.0016

Notes;
Model is based on 28-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
ng/kg = nanograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX E: BENTHIC INVERTEBRATE DOSE RESPONSE MODELS

CHRONIC TOXICITY DOSE RESPONSE MODEL FOR TOTAL PCB CONGENERS

OXY Glenn Springs Holdings, Inc.
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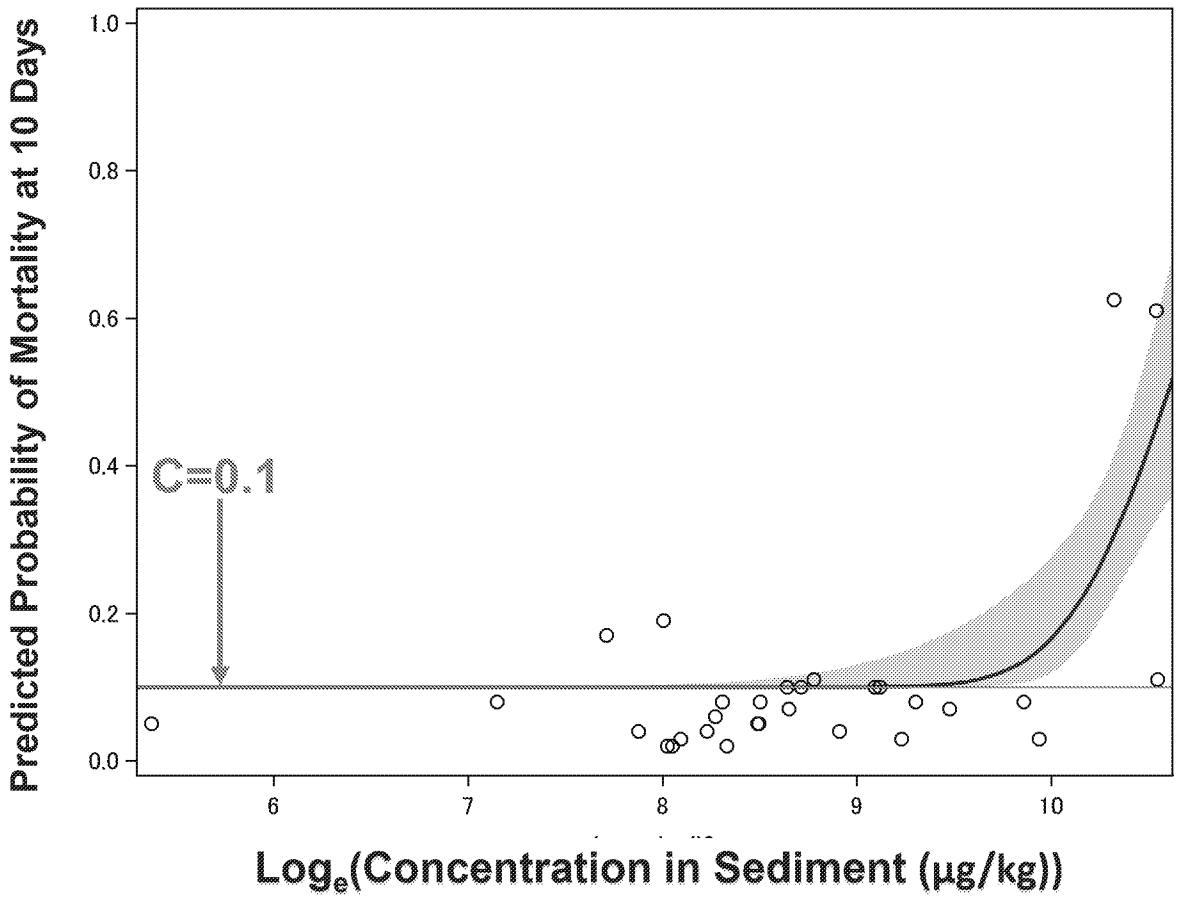
FIGURE
E-4



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 10 days
C = 0.1 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -23.2454
β = 2.1797
x = $\log_e$(Concentration)
p =0.0052

Notes;
Model is based on 10-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
µg/kg = micrograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX E: BENTHIC INVERTEBRATE DOSE RESPONSE MODELS

ACUTE TOXICTY DOSE RESPONSE MODEL FOR TOTAL ALKYLATED PAHS

OXY Glenn Springs Holdings, Inc.
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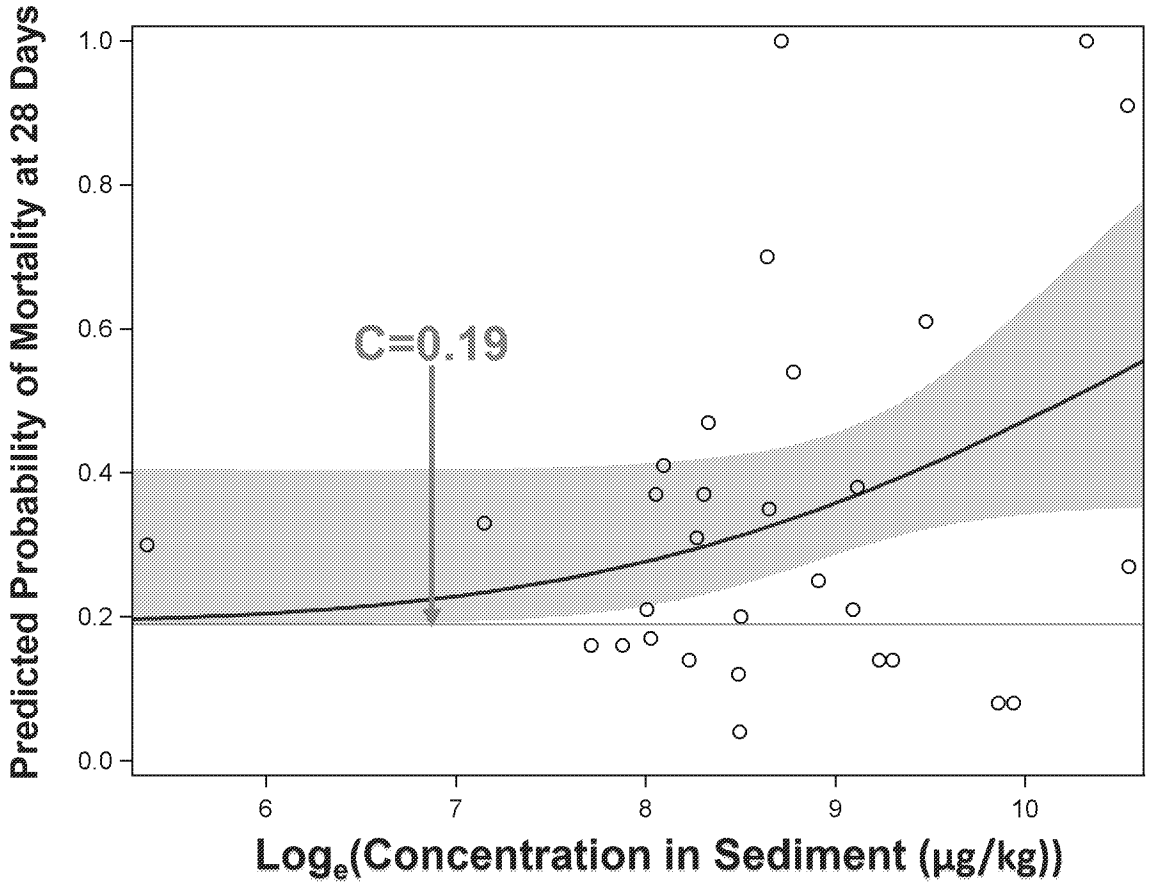
FIGURE
E-5



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 28 days
C = 0.19 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -4.6556
β = 0.4267
x = $\log_e$(Concentration)
p =0.1132

Notes;
Model is based on 28-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
µg/kg = micrograms per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
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CHRONIC TOXICITY DOSE RESPONSE MODEL FOR TOTAL ALKYLATED PAHS

OXY Glenn Springs Holdings, Inc.
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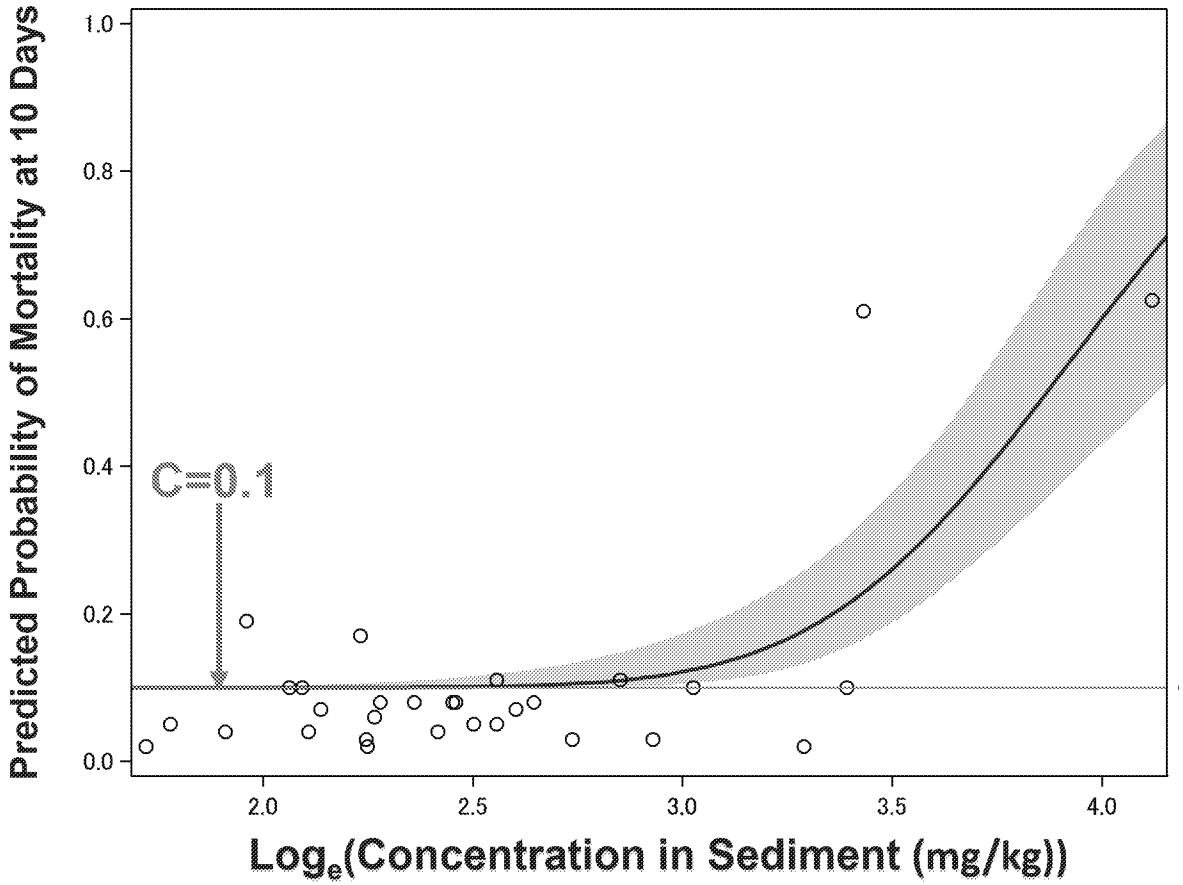
FIGURE
E-6



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 10 days
C = 0.1 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -8.351
β = 2.1228
x = $\log_e$(Concentration)
p <0.0001

Notes;
Model is based on 10-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
mg/kg = milligrams per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX E: BENTHIC INVERTEBRATE DOSE RESPONSE MODELS

ACUTE TOXICITY DOSE RESPONSE MODEL FOR ARSENIC

OXY Glenn Springs Holdings, Inc.
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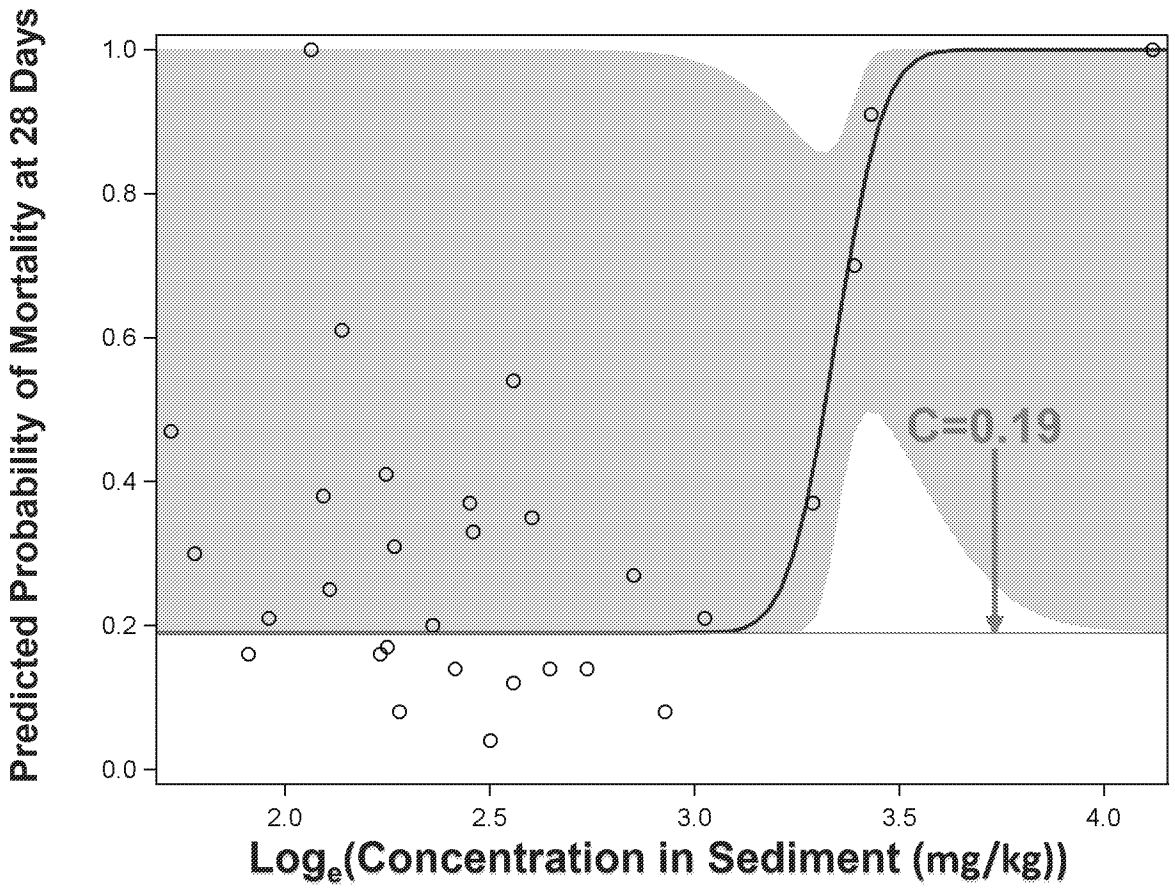
FIGURE
E-7



Fitted Probit Model:

$\pi = C+(1-C)F(\alpha + \beta x)$

π = Probability of mortality at 28 days
C = 0.19 (i.e., control mortality)
F = Cumulative Standard Normal Distribution Function
α = -35.704
β = 10.6752
x = $\log_e$(Concentration)
p =0.2496

Notes;
Model is based on 28-day *L. plumulosus* mortality observed in the NBSA Sediment Quality Triad Investigation.

$\log_e$ = natural log transformation
mg/kg = milligrams per kilogram
p = Wald Chi-square probability value. Values less than 0.05 indicate model is statistically significant.

DIAMOND ALKALI SUPERFUND SITE
NEWARK BAY STUDY AREA
REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS TECHNICAL MEMORANDUM
APPENDIX E: BENTHIC INVERTEBRATE DOSE RESPONSE MODELS

CHRONIC TOXICITY DOSE RESPONSE MODEL FOR ARSENIC

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FIGURE
E-8

Attachment E-1

SAS Statistical Output Files from the PROBIT Procedure

10-day Mortality: Test fit Probit
Total DDx (4,4) Total Fraction

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_10
Trials Variable	n
Number of Observations	30
Number of Events	323.5
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-875.3168107

Number of Observations Read	30
Number of Observations Used	30
Number of Events	323.5
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	93.4579	28	3.3378	<.0001
L.R. Chi-Square	112.3141	28	4.0112	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	3.3378
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 3.3378.

Note: Please check to be sure that the large chi-square ($p < 0.0001$) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	22.5745	<.0001

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-32.4512	6.8045	-43.6435	-21.2588	22.74	<.0001
l_result_dl2	1	2.5134	0.5290	1.6433	3.3835	22.57	<.0001
_C_	0	0.1000	0.0000	0.1000	0.1000		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
12.9114588	0.39787339

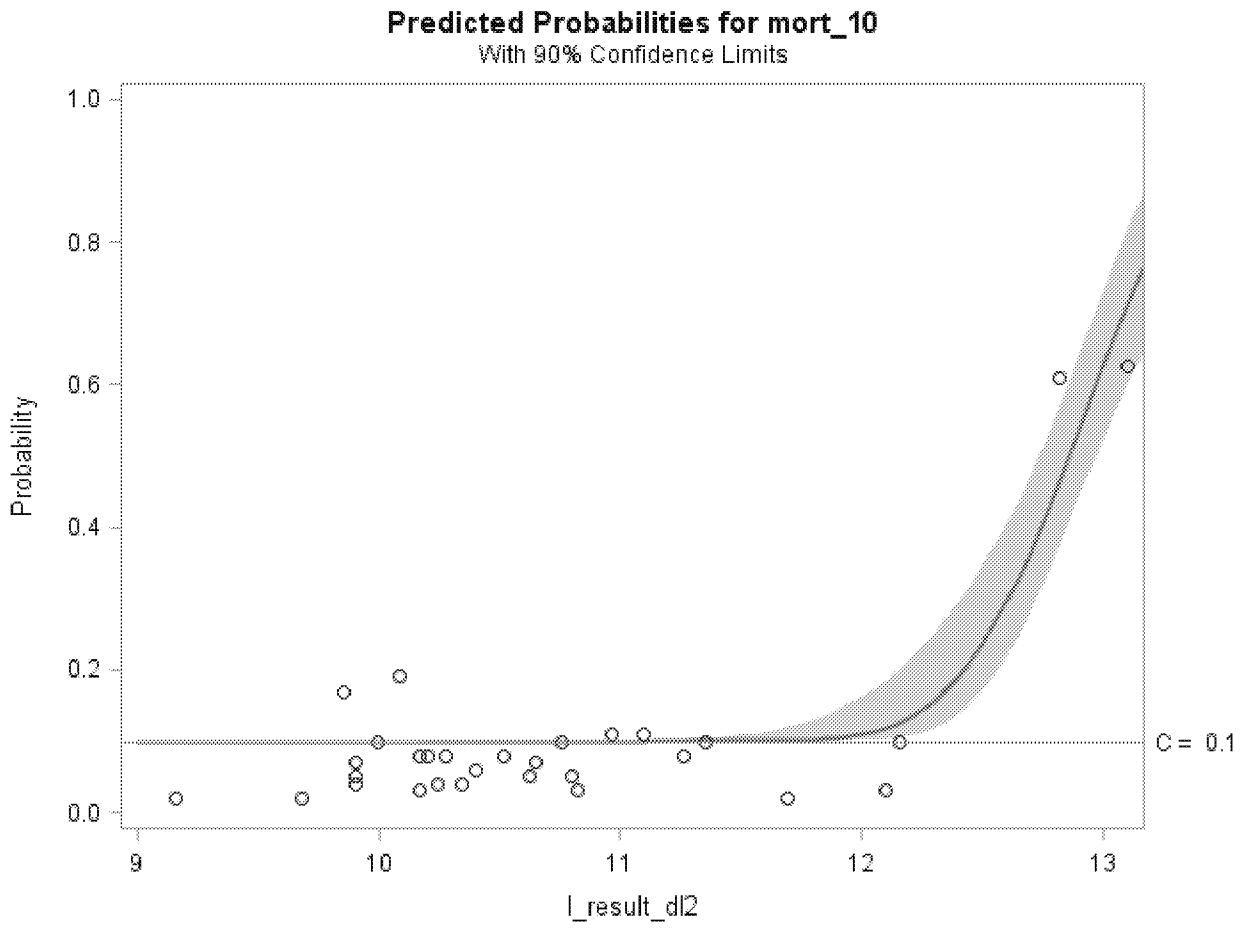
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.004748	0.000923
SIGMA	0.000923	0.007012

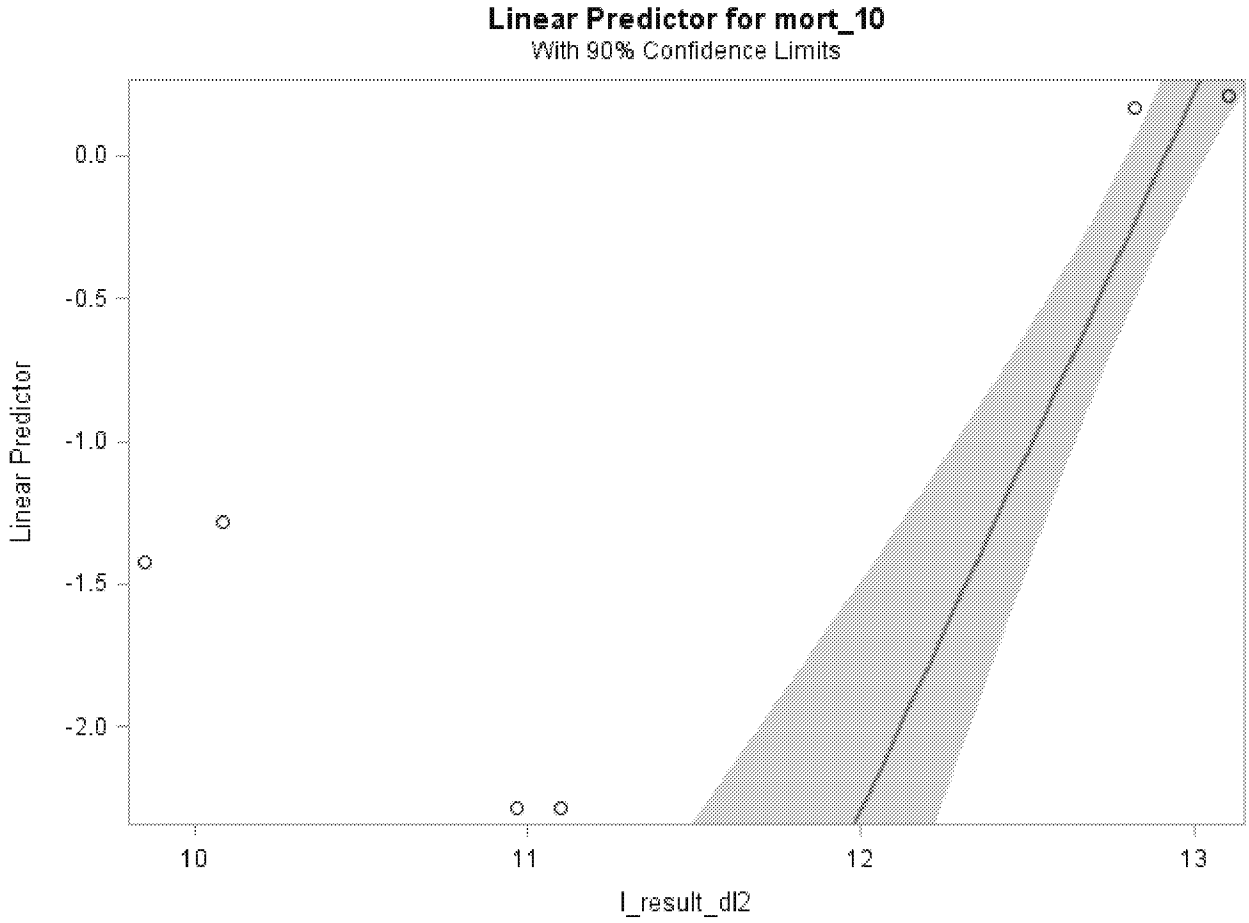
10-day Mortality: Test fit Probit
Total DDx (4,4) Total Fraction

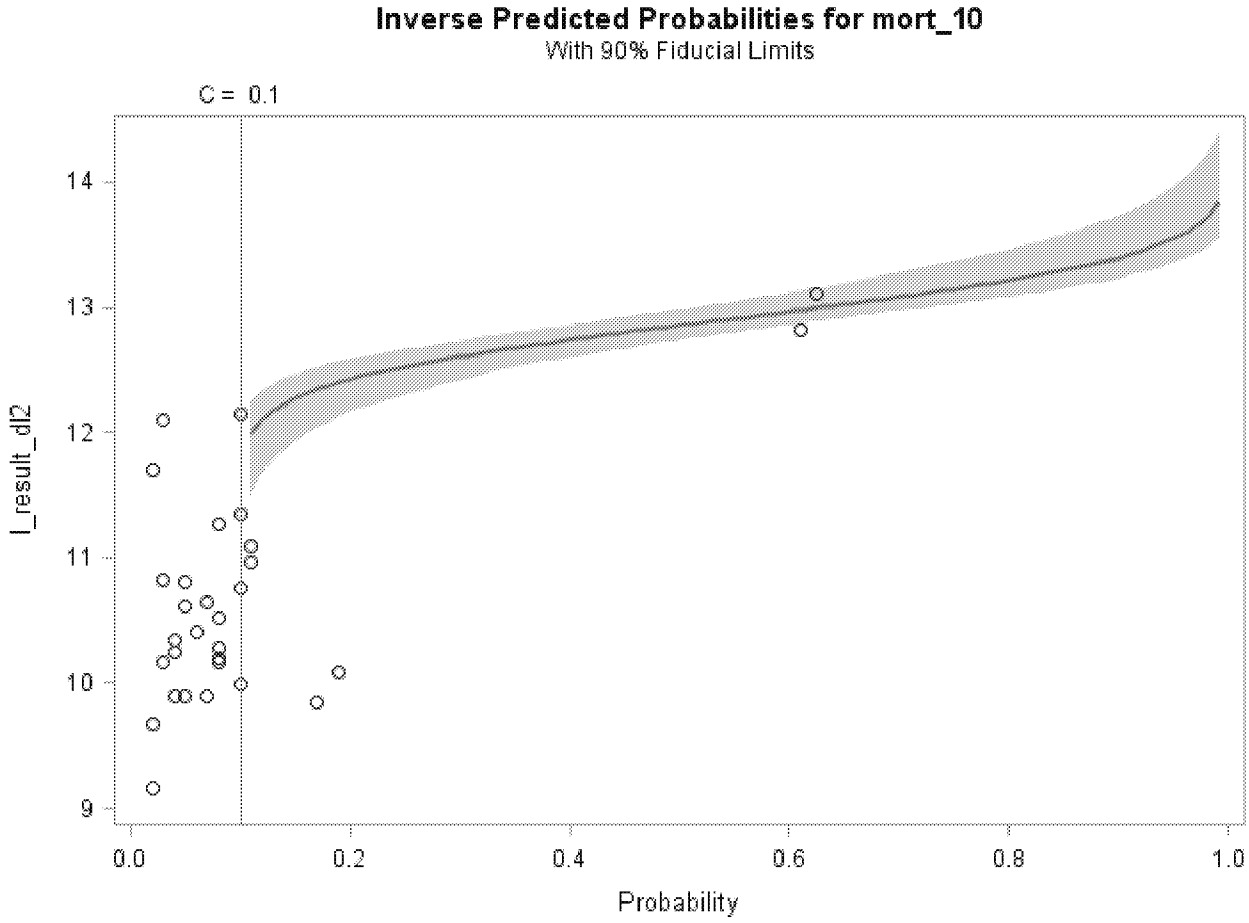
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	12.2570	11.8919	12.4451
0.10	12.4016	12.1092	12.5594
0.20	12.5766	12.3653	12.7048
0.50	12.9115	12.7934	13.0449

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_10
With 90% Confidence Limits
Linear Predictor
0.0
-0.5
-1.0
-1.5
-2.0
10
11
12
13
l_result_dl2


Inverse Predicted Probabilities for mort_10
With 90% Fiducial Limits
C = 0.1
l_result_dl2
14
13
12
11
10
9
0.0
0.2
0.4
0.6
0.8
1.0
Probability

10-day Mortality: Test fit Probit
Total PCBs congener (209 specified)

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_10
Trials Variable	n
Number of Observations	30
Number of Events	323.5
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-926.4992305

Number of Observations Read	30
Number of Observations Used	30
Number of Events	323.5
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	229.4374	28	8.1942	<.0001
L.R. Chi-Square	214.6790	28	7.6671	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	8.1942
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 8.1942.

Note: Please check to be sure that the large chi-square (p < 0.0001) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	22.0549	<.0001

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-19.5061	3.9592	-26.0184	-12.9938	24.27	<.0001
l_result_dl2	1	1.3006	0.2770	0.8451	1.7562	22.05	<.0001
_C_	0	0.1000	0.0000	0.1000	0.1000		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
14.997213	0.76884752

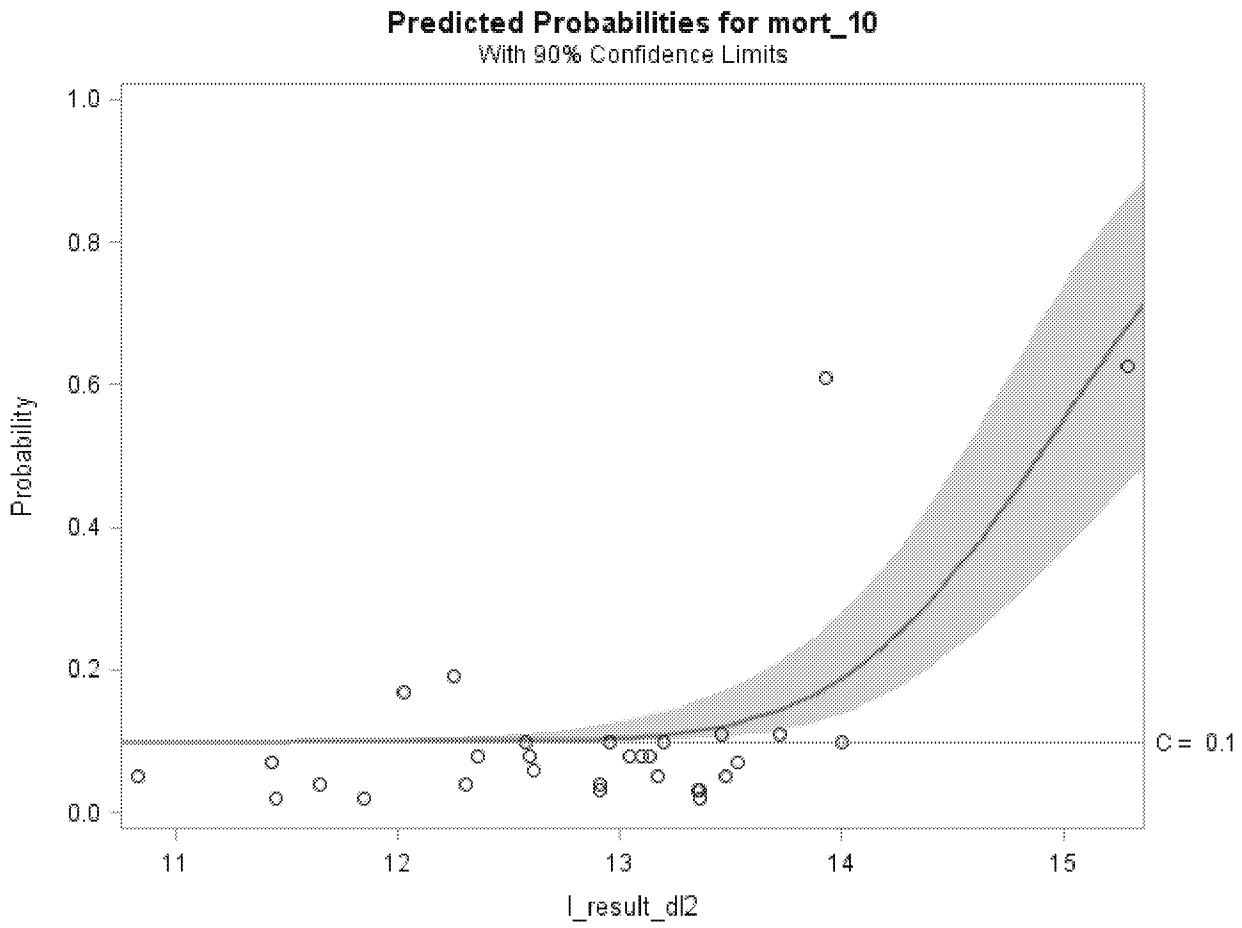
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.065056	0.025557
SIGMA	0.025557	0.026802

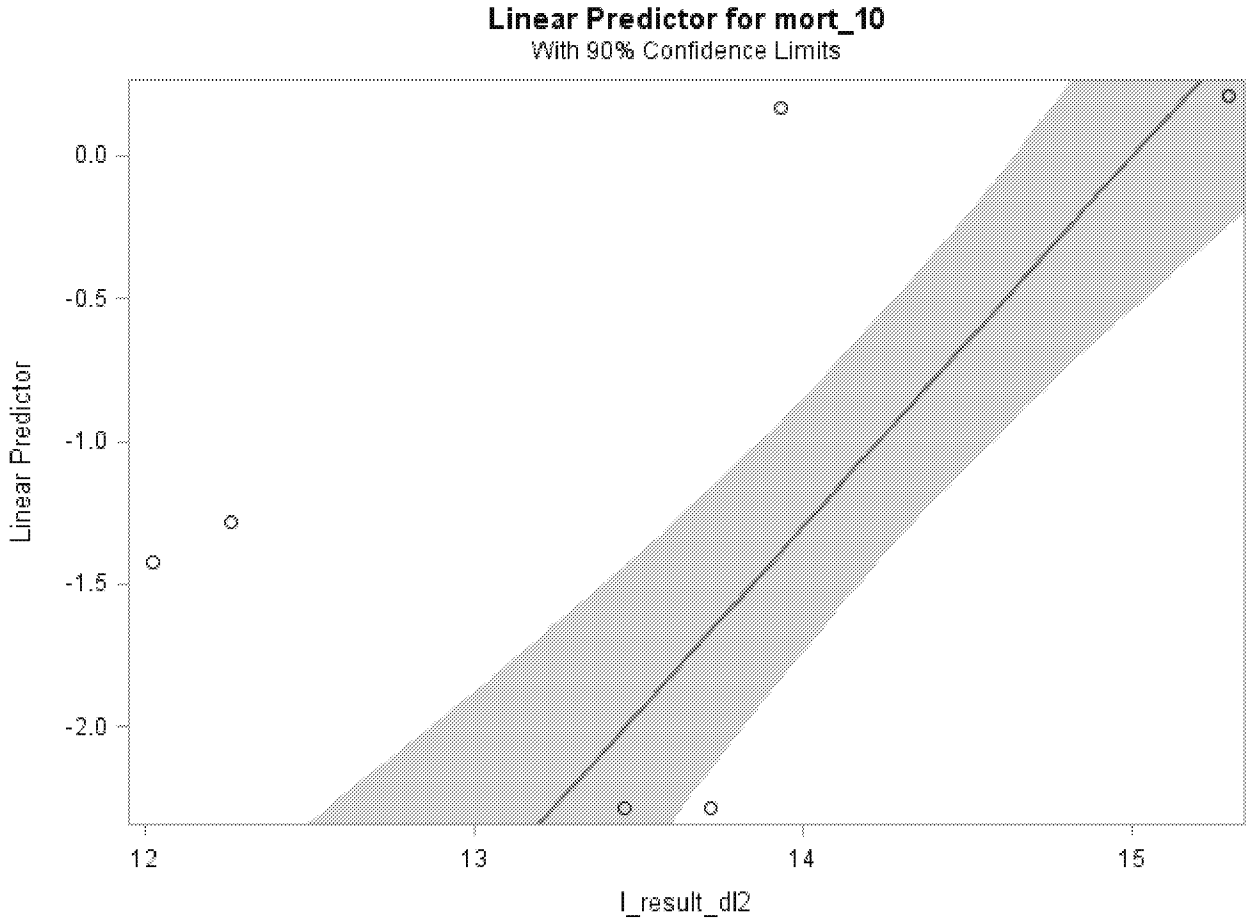
10-day Mortality: Test fit Probit
Total PCBs congener (209 specified)

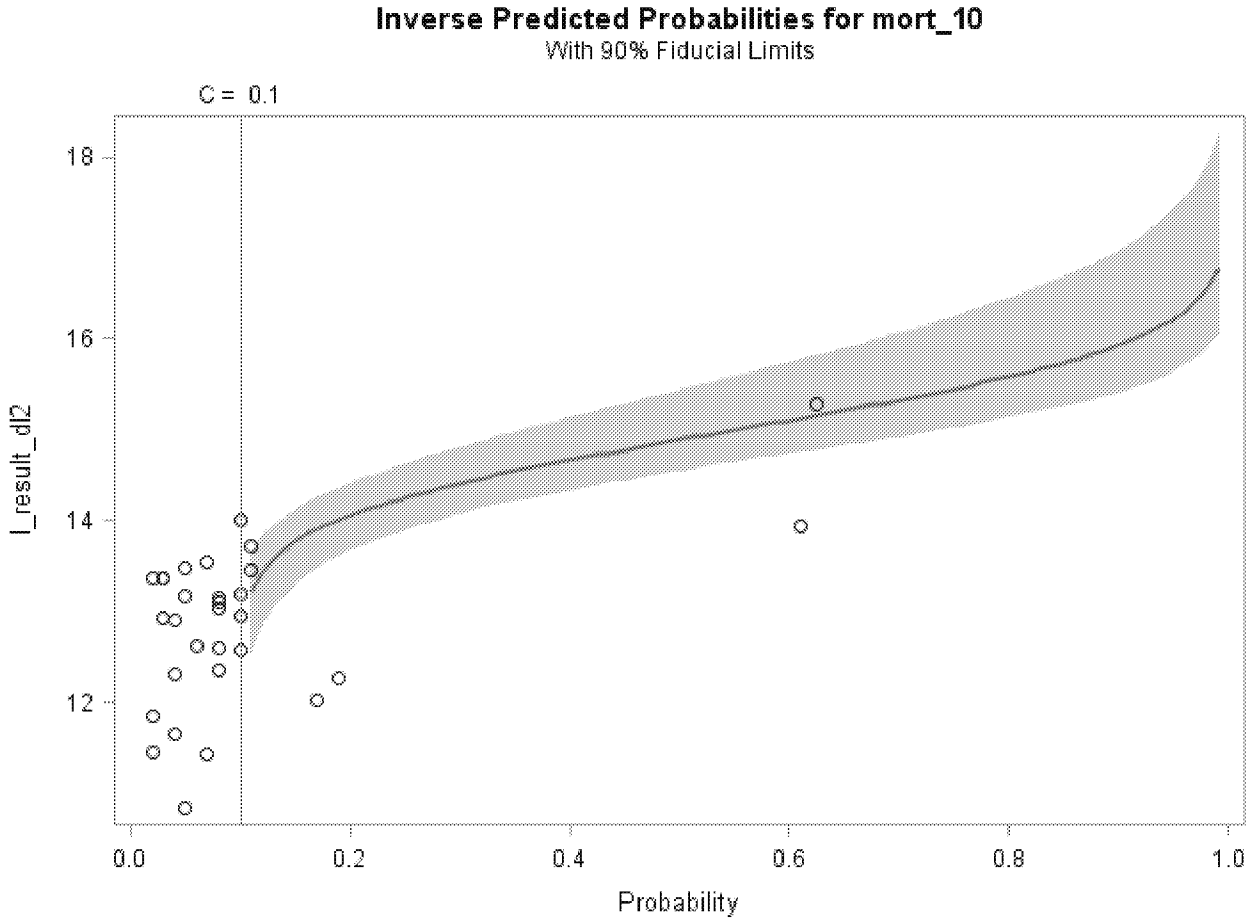
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	13.7326	13.2226	14.0820
0.10	14.0119	13.5910	14.3567
0.20	14.3501	13.9933	14.7330
0.50	14.9972	14.6294	15.5864

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_10
With 90% Confidence Limits
Linear Predictor
0.0
-0.5
-1.0
-1.5
-2.0
12
13
14
15
l_result_dl2


Inverse Predicted Probabilities for mort_10
With 90% Fiducial Limits
C = 0.1
l_result_dl2
18
16
14
12
0.0
0.2
0.4
0.6
0.8
1.0
Probability

10-day Mortality: Test fit Probit
Total Alkylated PAHs

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_10
Trials Variable	n
Number of Observations	30
Number of Events	323.5
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-928.4377585

Number of Observations Read	30
Number of Observations Used	30
Number of Events	323.5
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	194.0398	28	6.9300	<.0001
L.R. Chi-Square	218.5560	28	7.8056	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	6.9300
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 6.93.

Note: Please check to be sure that the large chi-square (p < 0.0001) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	7.8257	0.0052

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-23.2454	8.0886	-36.5499	-9.9409	8.26	0.0041
l_result_dl2	1	2.1797	0.7792	0.8981	3.4613	7.83	0.0052
_C_	0	0.1000	0.0000	0.1000	0.1000		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
10.664648	0.45878544

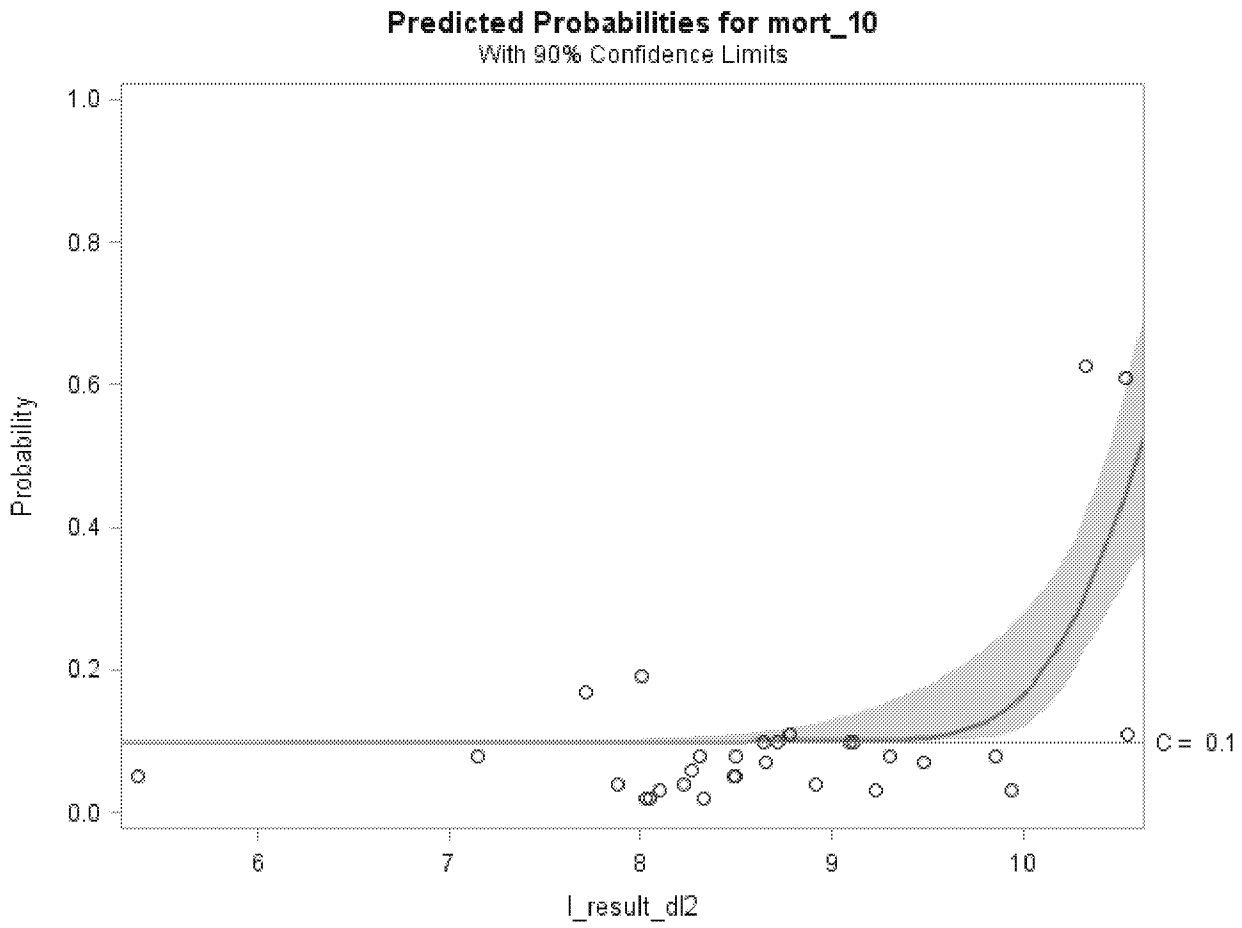
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.019906	0.016833
SIGMA	0.016833	0.026897

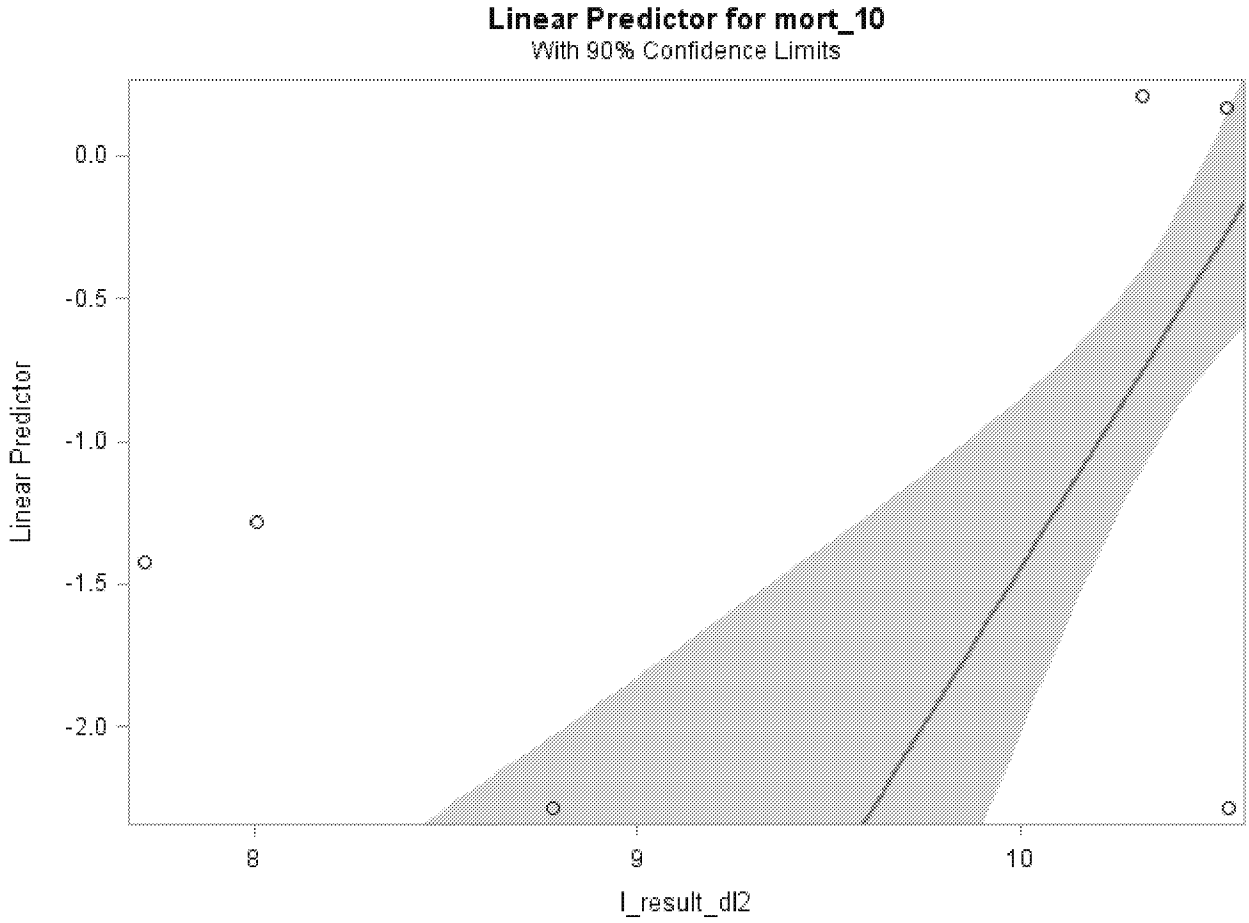
10-day Mortality: Test fit Probit
Total Alkylated PAHs

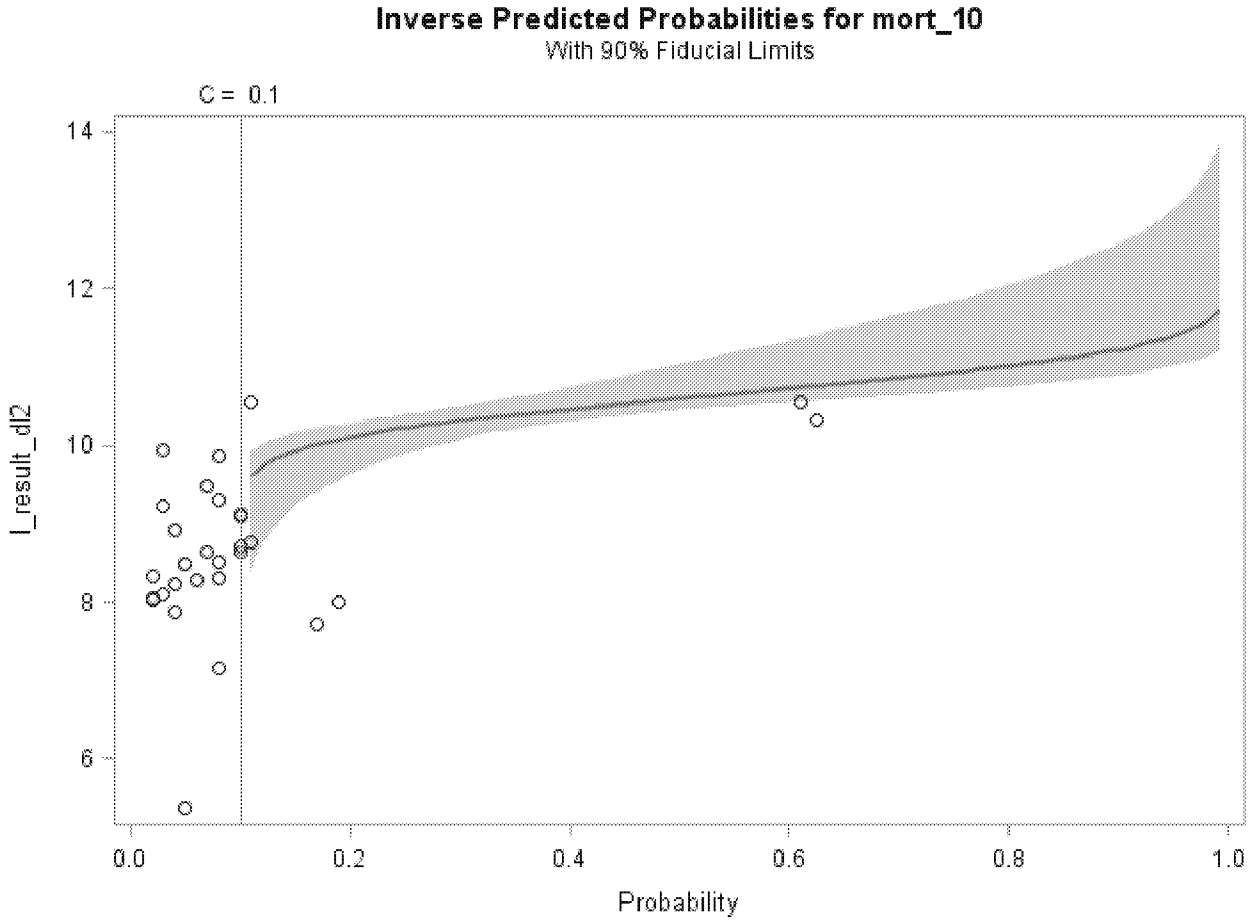
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	9.9100	9.1392	10.1322
0.10	10.0767	9.5434	10.2570
0.20	10.2785	9.9920	10.4488
0.50	10.6646	10.4870	11.1792

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_10
With 90% Confidence Limits
Linear Predictor
0.0
-0.5
-1.0
-1.5
-2.0
8
9
10
l_result_dl2


Inverse Predicted Probabilities for mort_10
With 90% Fiducial Limits
C = 0.1
l_result_dl2
14
12
10
8
6
0.0
0.2
0.4
0.6
0.8
1.0
Probability

10-day Mortality: Test fit Probit
Arsenic

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_10
Trials Variable	n
Number of Observations	30
Number of Events	323.5
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-915.9227755

Number of Observations Read	30
Number of Observations Used	30
Number of Events	323.5
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	183.5863	28	6.5567	<.0001
L.R. Chi-Square	193.5261	28	6.9116	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	6.5567
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 6.5567.

Note: Please check to be sure that the large chi-square (p < 0.0001) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	20.8019	<.0001

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-8.3510	1.6859	-11.1241	-5.5779	24.54	<.0001
l_result_dl2	1	2.1228	0.4654	1.3572	2.8884	20.80	<.0001
_C_	0	0.1000	0.0000	0.1000	0.1000		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
3.9339518	0.47107418

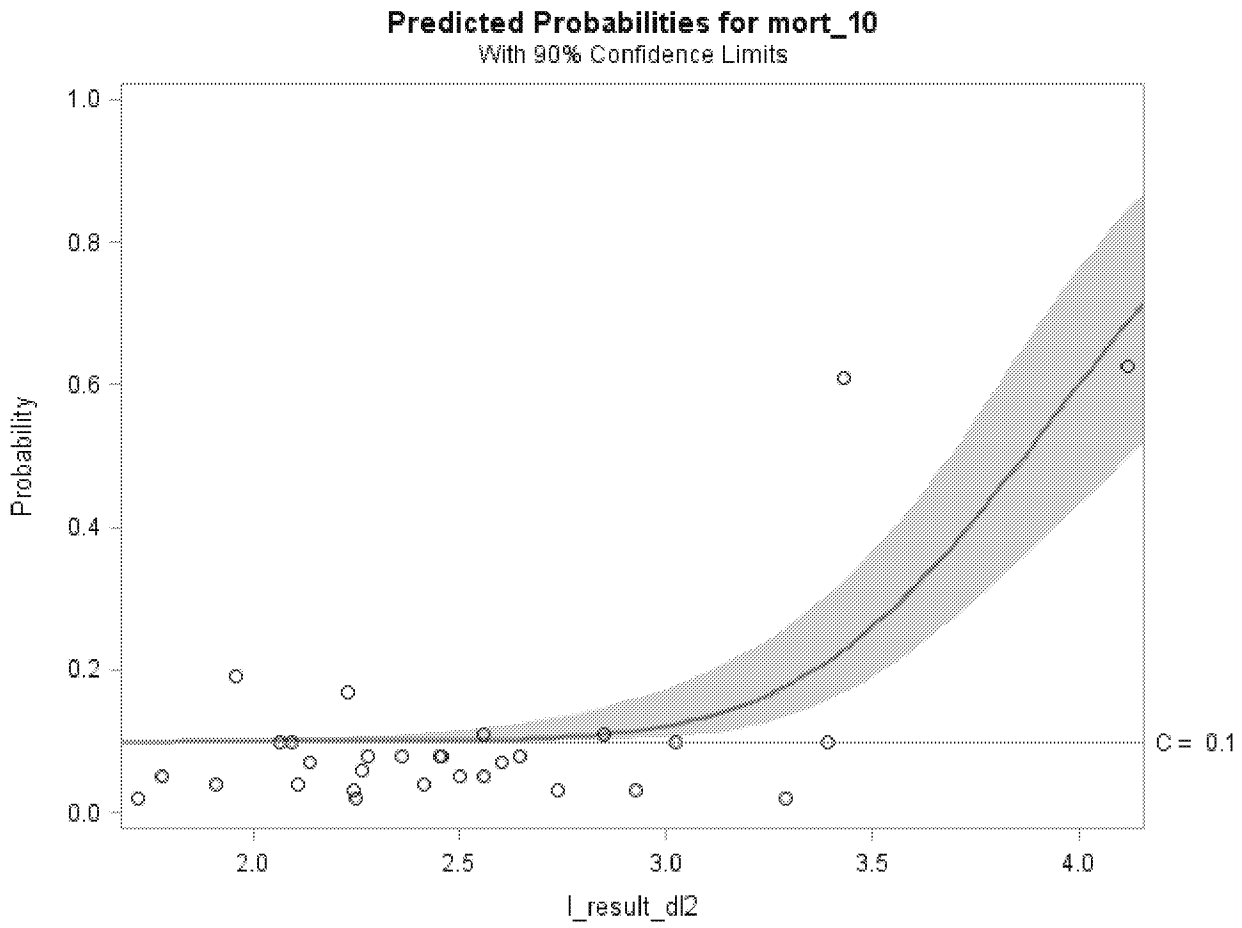
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.017039	0.007798
SIGMA	0.007798	0.010668

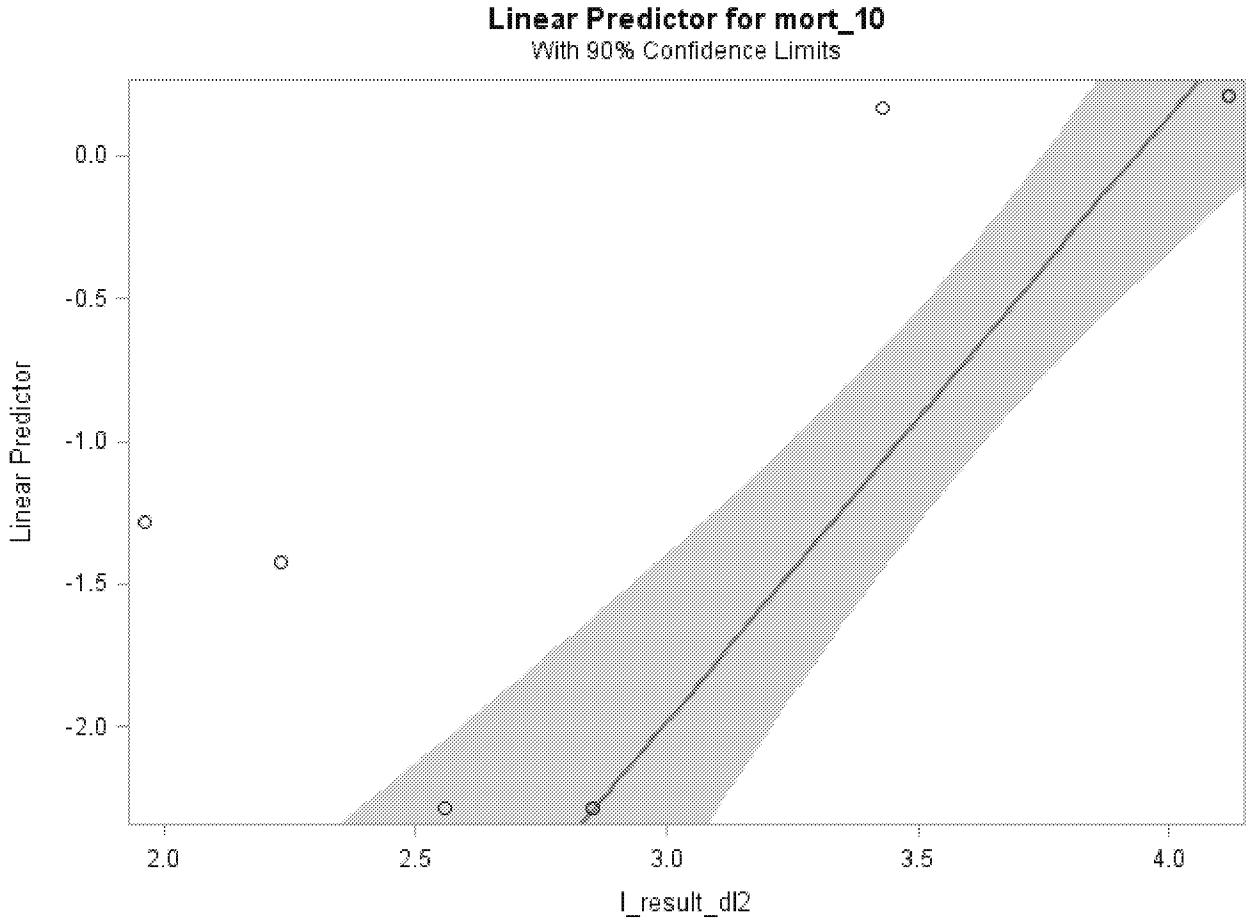
10-day Mortality: Test fit Probit
Arsenic

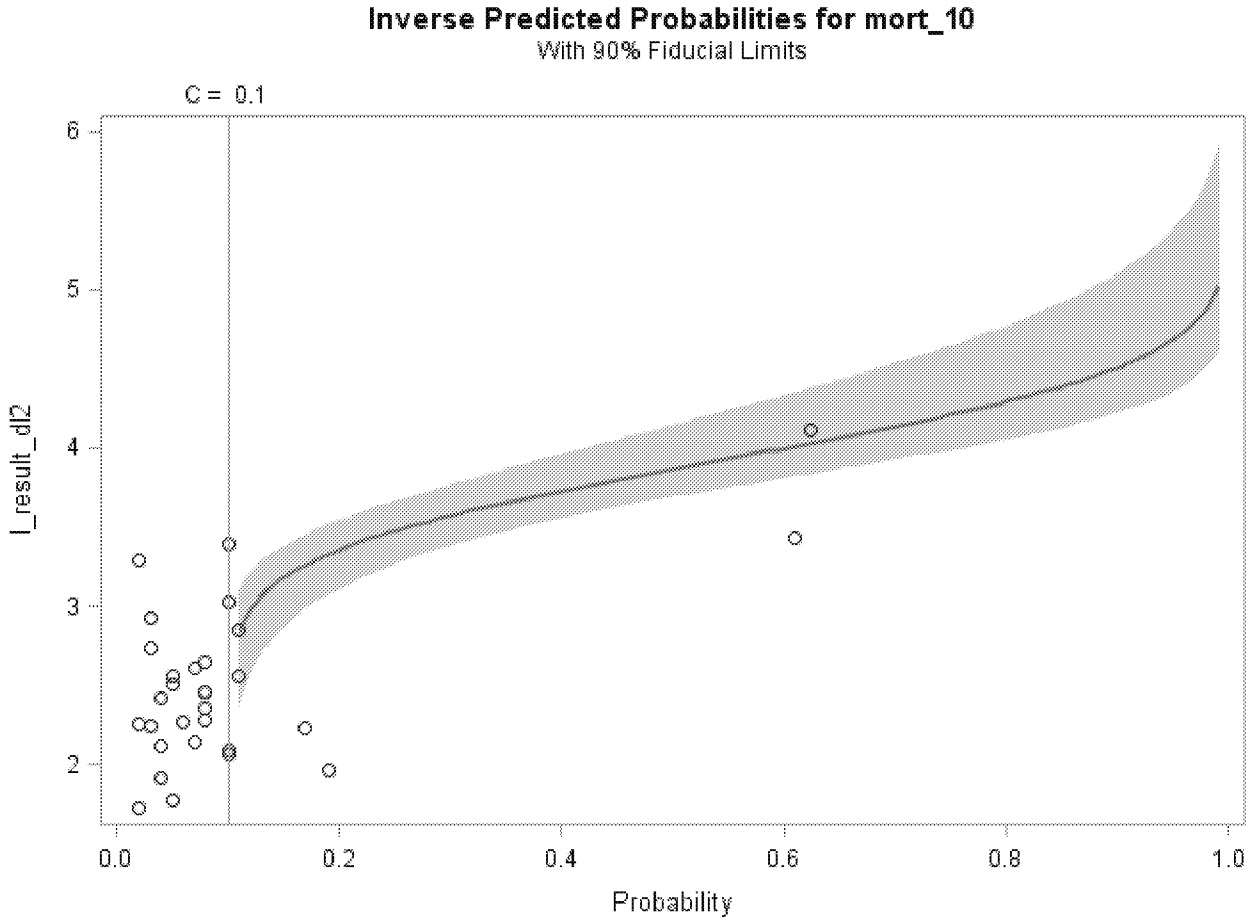
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	3.15910	2.81954	3.35954
0.10	3.33025	3.06308	3.51359
0.20	3.53749	3.33254	3.72560
0.50	3.93395	3.74389	4.23531

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_10
With 90% Confidence Limits
Linear Predictor
0.0
-0.5
-1.0
-1.5
-2.0
2.0
2.5
3.0
3.5
4.0
l_result_dl2


Inverse Predicted Probabilities for mort_10
With 90% Fiducial Limits
C = 0.1
l_result_dl2
6
5
4
3
2
0.0
0.2
0.4
0.6
0.8
1.0
Probability

28-day Mortality: Test fit Probit
Total DDx (4,4) Total Fraction

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_28
Trials Variable	n
Number of Observations	30
Number of Events	1042
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-1815.136711

Number of Observations Read	30
Number of Observations Used	30
Number of Events	1042
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	708.0396	28	25.2871	<.0001
L.R. Chi-Square	740.2137	28	26.4362	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	25.2871
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 25.287.

Note: Please check to be sure that the large chi-square ($p < 0.0001$) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	5.0694	0.0244

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-9.5894	4.0991	-16.3319	-2.8469	5.47	0.0193
l_result_dl2	1	0.7876	0.3498	0.2122	1.3630	5.07	0.0244
_C_	0	0.1900	0.0000	0.1900	0.1900		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
12.1750528	1.26963434

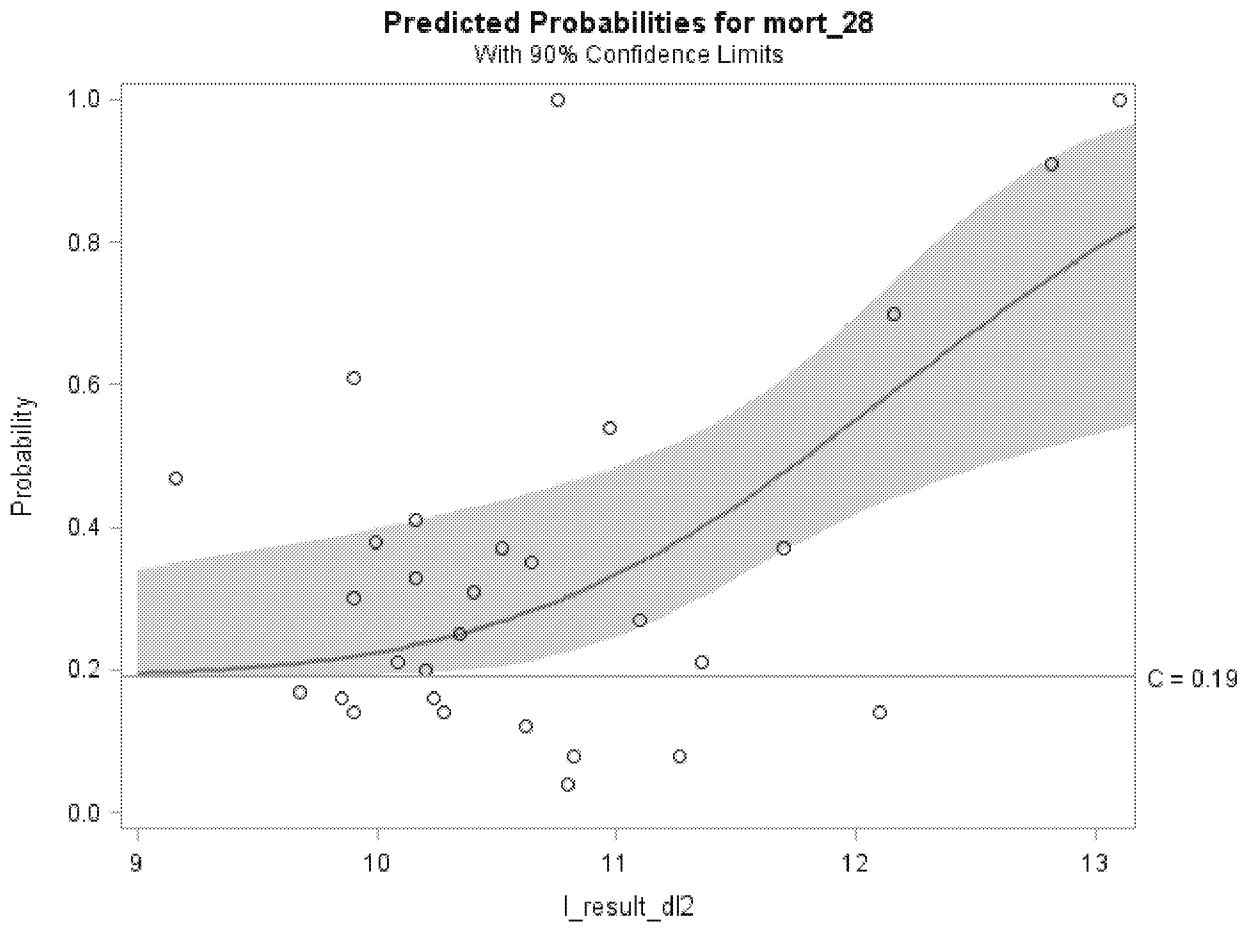
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.147052	0.120007
SIGMA	0.120007	0.317980

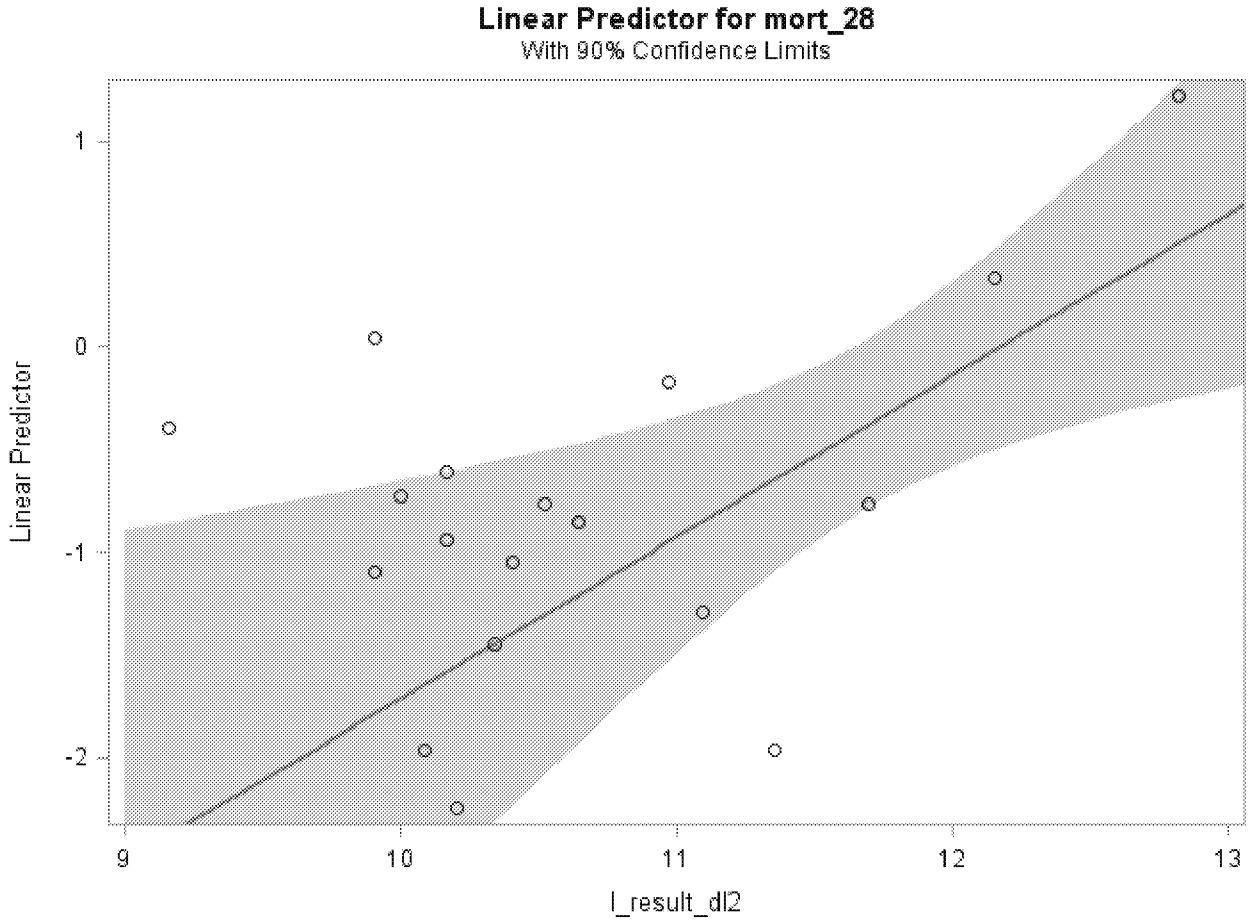
28-day Mortality: Test fit Probit
Total DDx (4,4) Total Fraction

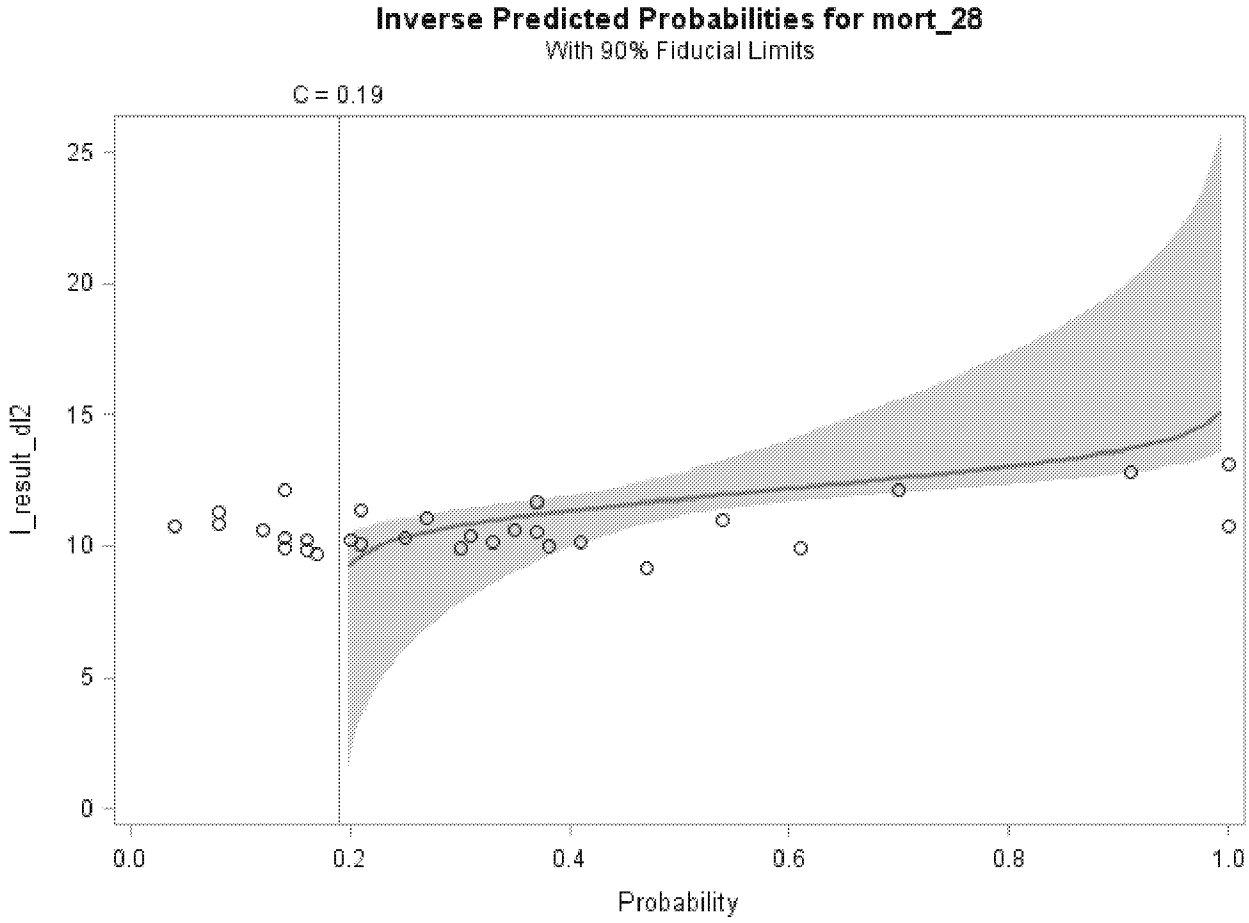
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	10.0867	4.9945	10.8979
0.10	10.5480	6.8369	11.2052
0.20	11.1065	8.9948	11.6503
0.50	12.1751	11.6301	13.9947

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_28
With 90% Confidence Limits
Linear Predictor
1
0
-1
-2
9
10
11
12
13
l_result_dl2


Inverse Predicted Probabilities for mort_28
With 90% Fiducial Limits
C = 0.19
l_result_dl2
25
20
15
10
5
0
0.0
0.2
0.4
0.6
0.8
1.0
Probability

28-day Mortality: Test fit Probit
Total PCBs congener (209 specified)

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_28
Trials Variable	n
Number of Observations	30
Number of Events	1042
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-1665.461972

Number of Observations Read	30
Number of Observations Used	30
Number of Events	1042
Number of Trials	3000

WARNING: The relative gradient convergence criterion of 0.006497652 is greater than the limit of 0.0001. The convergence is questionable.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	523.7648	28	18.7059	<.0001
L.R. Chi-Square	440.8643	28	15.7452	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	18.7059
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 18.706.

Note: Please check to be sure that the large chi-square ($p < 0.0001$) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile	
Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	9.9479	0.0016

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-71.7915	22.7250	-109.171	-34.4121	9.98	0.0016
l_result_dl2	1	5.2359	1.6601	2.5053	7.9665	9.95	0.0016
_C_	0	0.1900	0.0000	0.1900	0.1900		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
13.711297	0.1909878

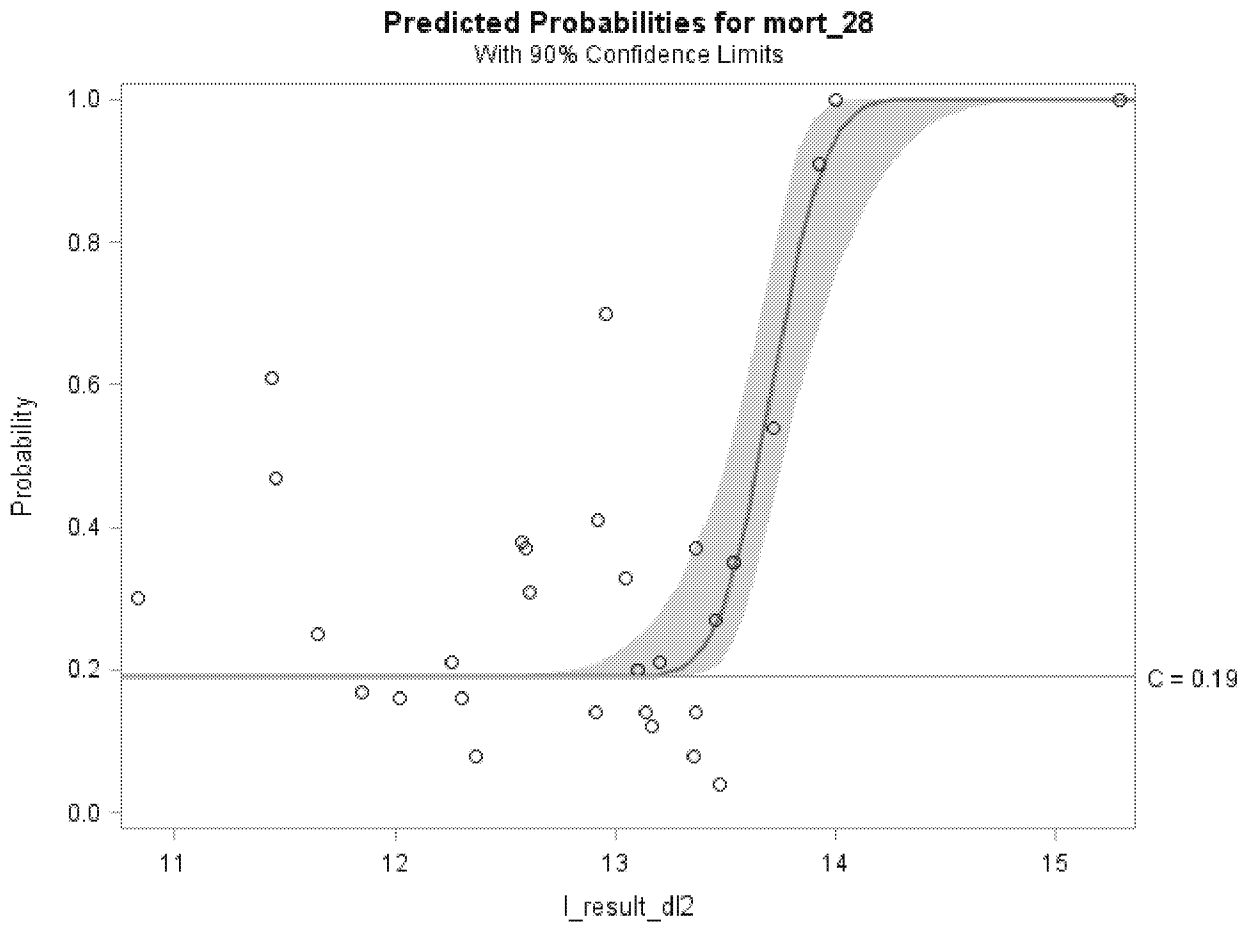
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.004294	0.000456
SIGMA	0.000456	0.003667

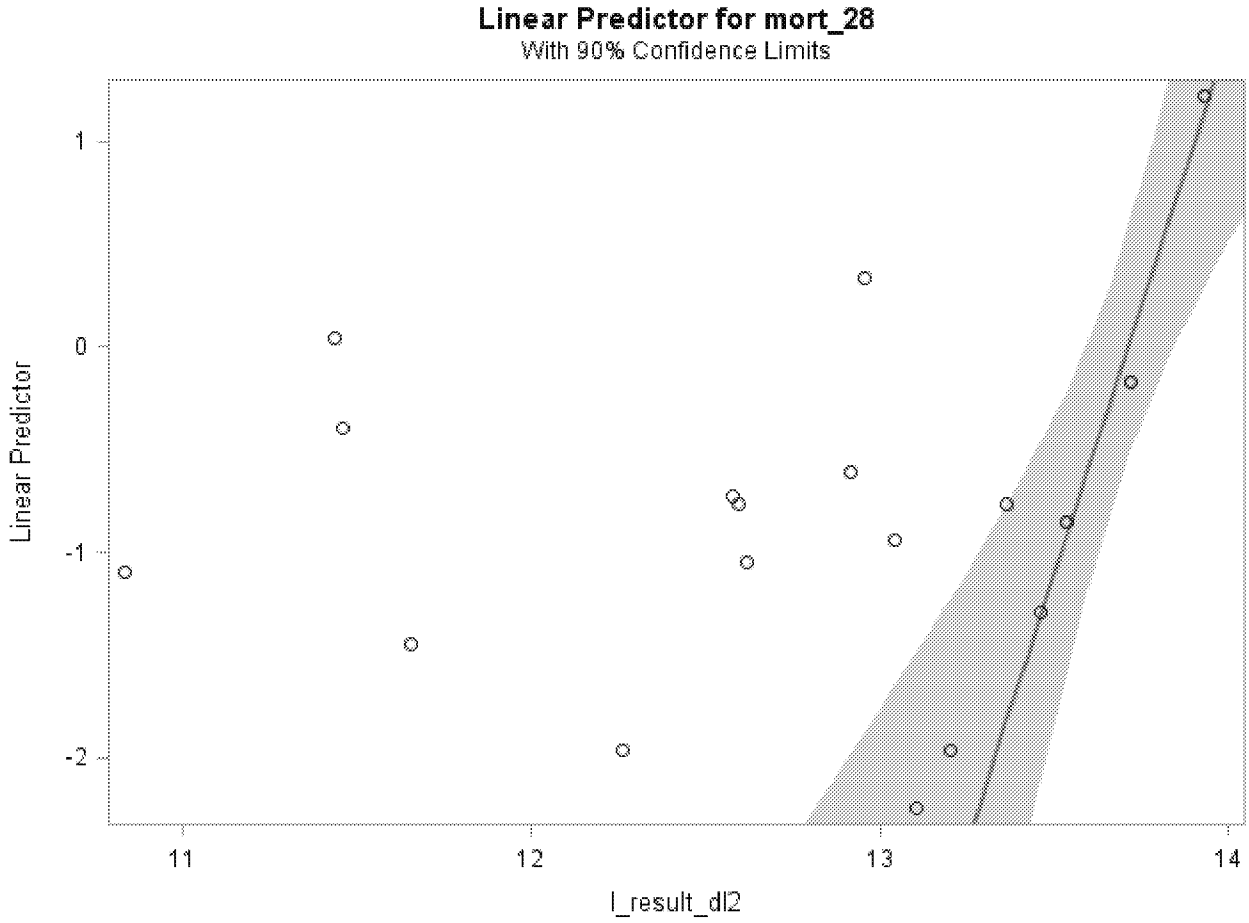
28-day Mortality: Test fit Probit
Total PCBs congener (209 specified)

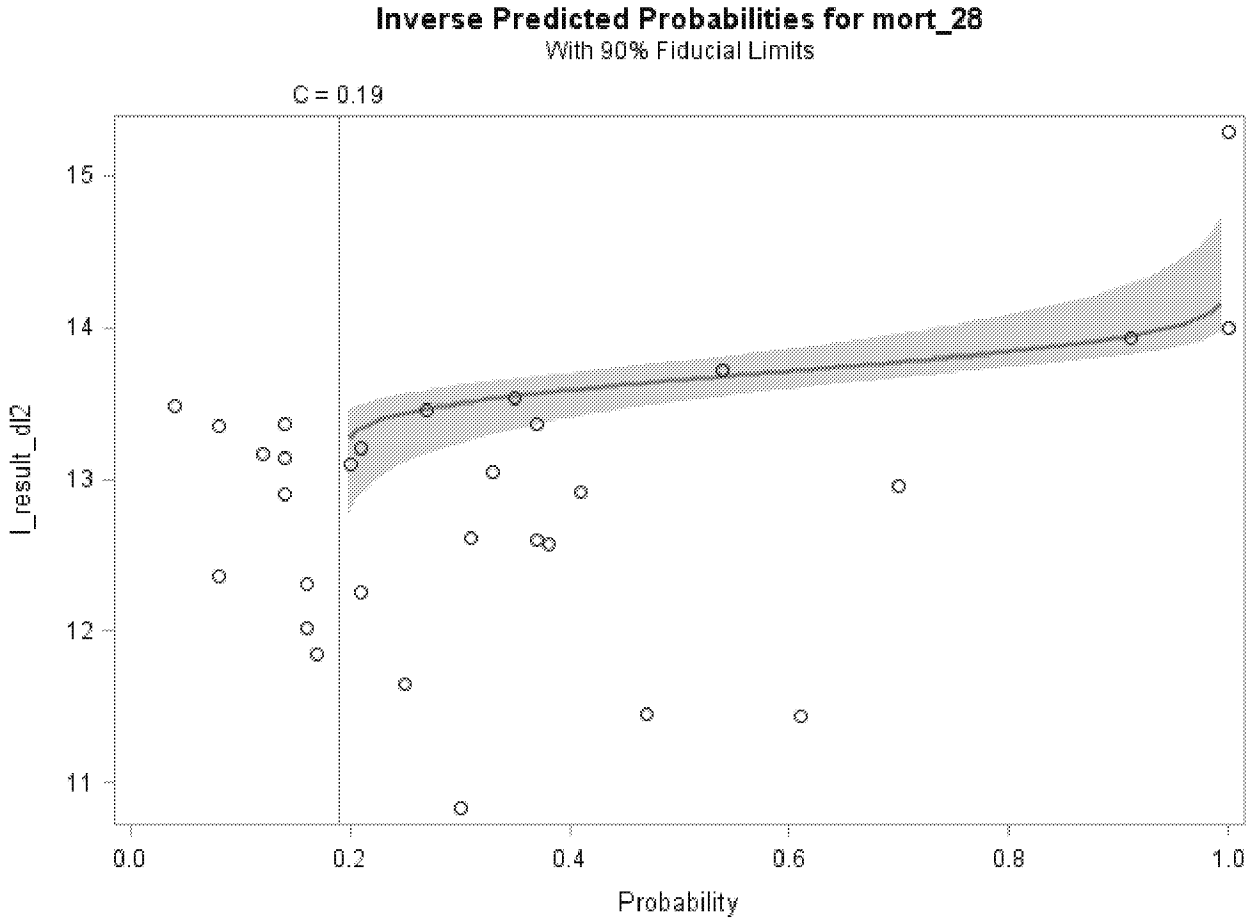
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	13.3972	13.0209	13.5351
0.10	13.4665	13.1624	13.5893
0.20	13.5506	13.3266	13.6621
0.50	13.7113	13.5883	13.8538

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_28
With 90% Confidence Limits
Linear Predictor
1
0
-1
-2
11
12
13
14
l_result_dl2


Inverse Predicted Probabilities for mort_28
With 90% Fiducial Limits
C = 0.19
l_result_dl2
15
14
13
12
11
0.0
0.2
0.4
0.6
0.8
1.0
Probability

28-day Mortality: Test fit Probit
Total Alkylated PAHs

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_28
Trials Variable	n
Number of Observations	30
Number of Events	1042
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-1896.559484

Number of Observations Read	30
Number of Observations Used	30
Number of Events	1042
Number of Trials	3000

Algorithm converged.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	790.8422	28	28.2444	<.0001
L.R. Chi-Square	903.0593	28	32.2521	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	28.2444
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 28.244.

Note: Please check to be sure that the large chi-square (p < 0.0001) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile

Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	2.5093	0.1132

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-4.6556	2.4900	-8.7513	-0.5600	3.50	0.0615
l_result_dl2	1	0.4267	0.2694	-0.0164	0.8698	2.51	0.1132
_C_	0	0.1900	0.0000	0.1900	0.1900		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
10.9108096	2.34356923

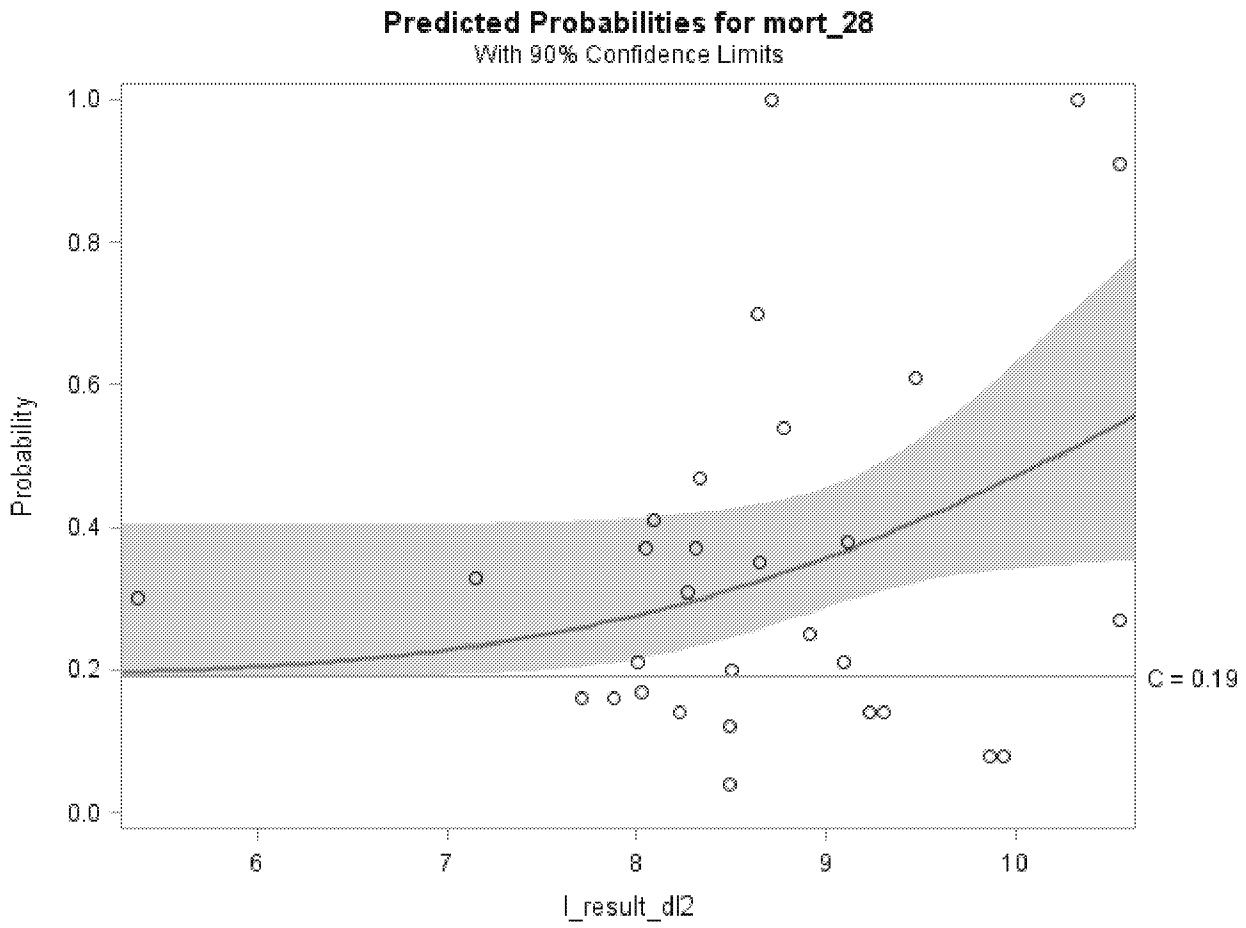
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	1.415666	1.590025
SIGMA	1.590025	2.188772

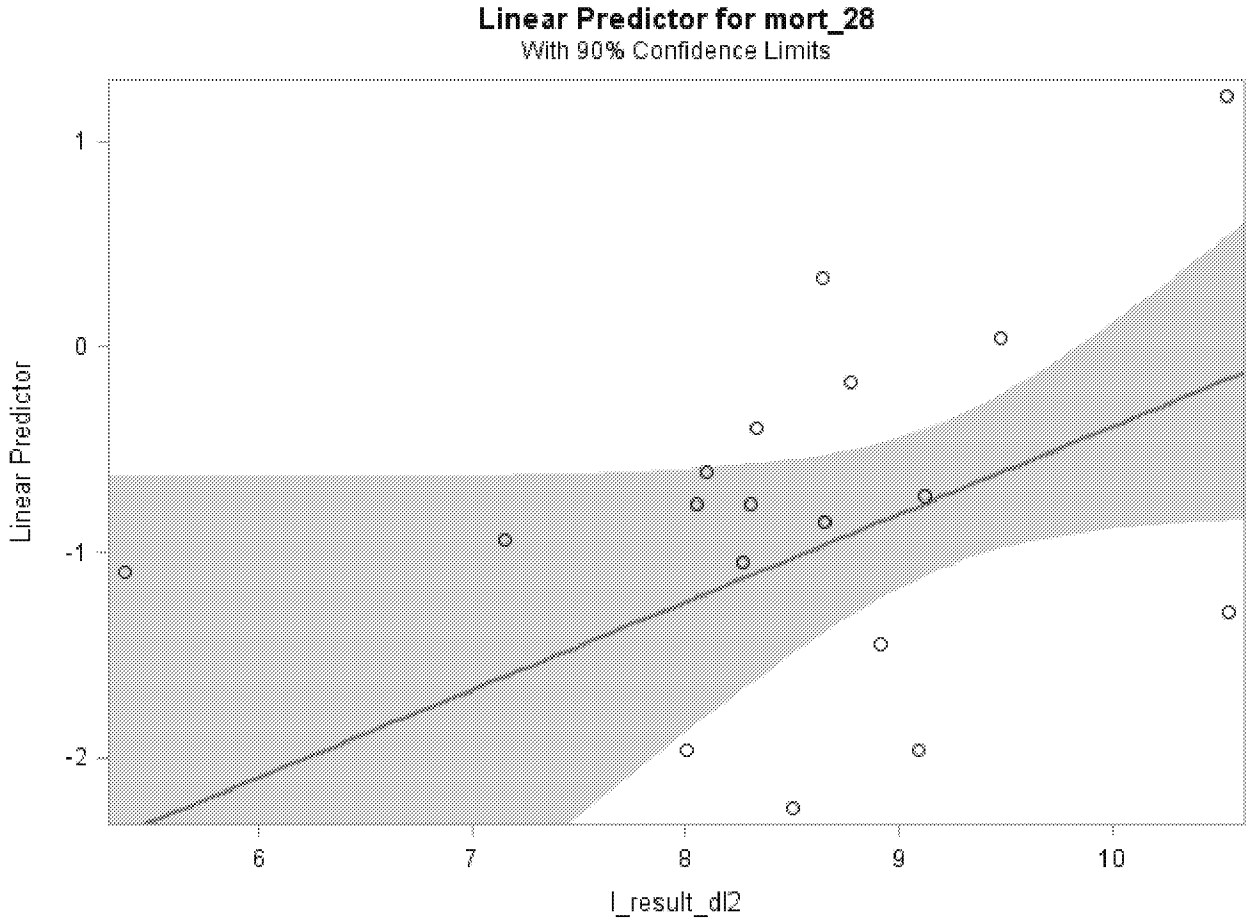
28-day Mortality: Test fit Probit
Total Alkylated PAHs

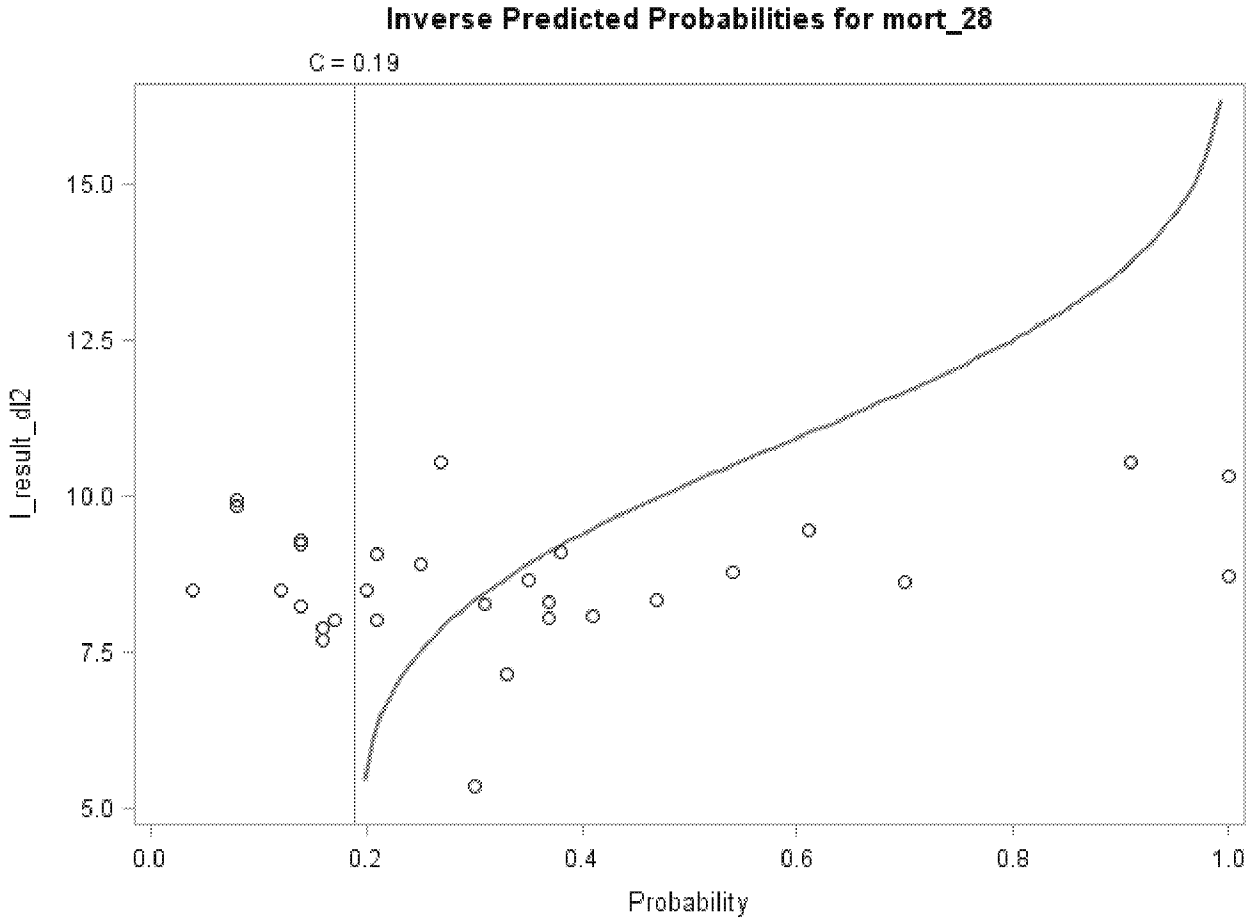
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	7.0560	.	.
0.10	7.9074	.	.
0.20	8.9384	.	.
0.50	10.9108	.	.

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_28
With 90% Confidence Limits
Linear Predictor
1
0
-1
-2
6
7
8
9
10
l_result_dl2


Inverse Predicted Probabilities for mort_28
C = 0.19
15.0
12.5
10.0
7.5
5.0
l_result_dl2
0.0
0.2
0.4
0.6
0.8
1.0
Probability

28-day Mortality: Test fit Probit
Arsenic

The Probit Procedure

Model Information	
Data Set	WORK.SQT_FS
Events Variable	mort_28
Trials Variable	n
Number of Observations	30
Number of Events	1042
Number of Trials	3000
Name of Distribution	Normal
Log Likelihood	-1786.280799

Number of Observations Read	30
Number of Observations Used	30
Number of Events	1042
Number of Trials	3000

WARNING: The relative gradient convergence criterion of 0.0010624301 is greater than the limit of 0.0001. The convergence is questionable.

Goodness-of-Fit Tests				
Statistic	Value	DF	Value/DF	Pr > ChiSq
Pearson Chi-Square	845.3831	28	30.1923	<.0001
L.R. Chi-Square	682.5019	28	24.3751	<.0001

Heterogeneity Correction	
Pearson Test Level	0.1000
Heterogeneity Factor	30.1923
Fiducial Limit Quantile	1.7011

Note: Since the Pearson Chi-Square exceeds the test level (0.1000), the covariance matrix has been multiplied by the heterogeneity factor (Pearson Chi-Square / DF) 30.192.

Note: Please check to be sure that the large chi-square ($p < 0.0001$) is not caused by systematic departure from the model. A t value of 1.70 will be used in computing fiducial limits.

Response-Covariate Profile	
Response Levels	2
Number of Covariate Values	30

Type III Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
l_result_dl2	1	1.3257	0.2496

Analysis of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	90% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-35.7040	31.2826	-87.1594	15.7513	1.30	0.2537
l_result_dl2	1	10.6752	9.2716	-4.5753	25.9257	1.33	0.2496
_C_	0	0.1900	0.0000	0.1900	0.1900		

Probit Model in Terms of Tolerance Distribution	
MU	SIGMA
3.34458451	0.09367524

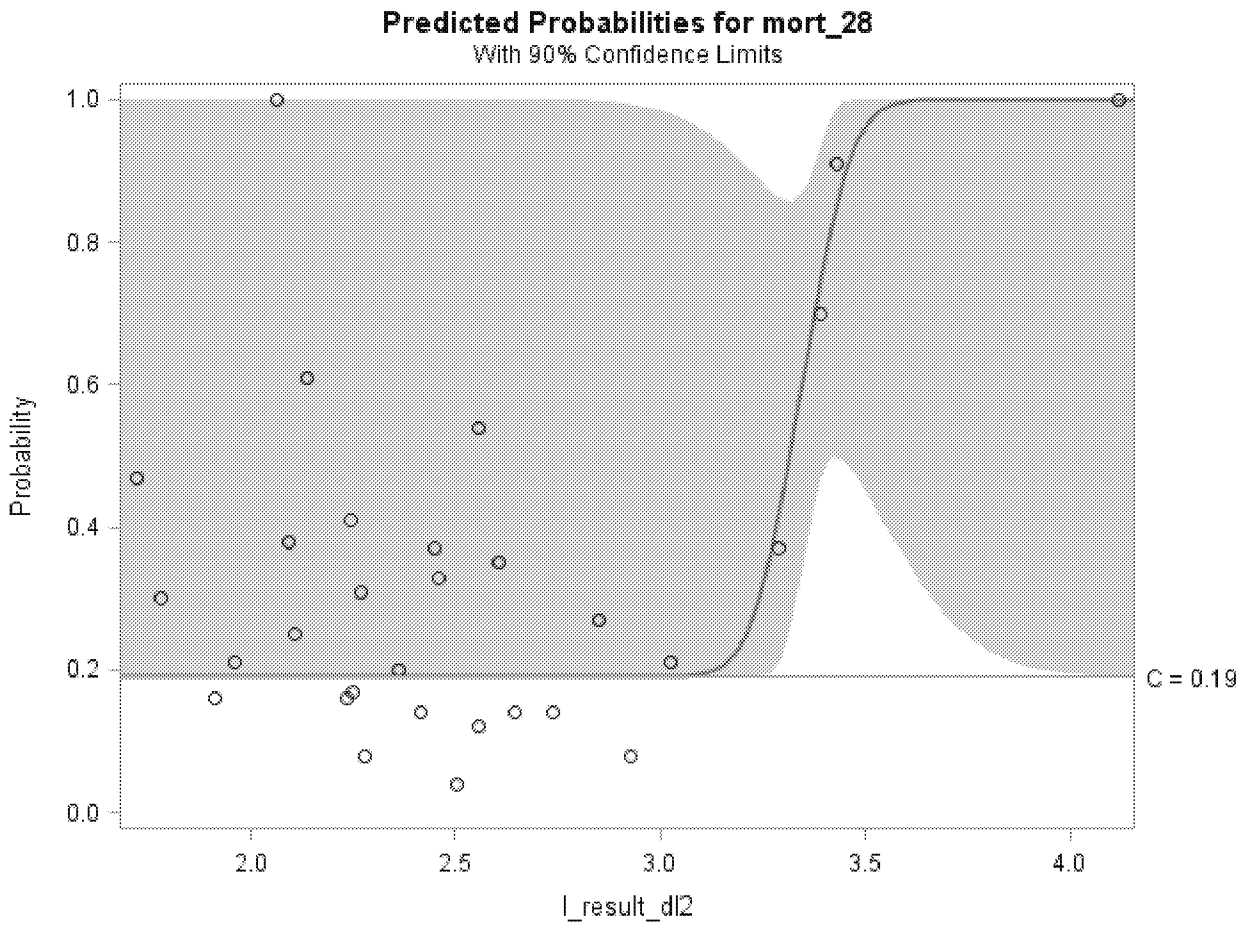
Estimated Covariance Matrix for Tolerance Parameters		
	MU	SIGMA
MU	0.003025	-0.002046
SIGMA	-0.002046	0.006619

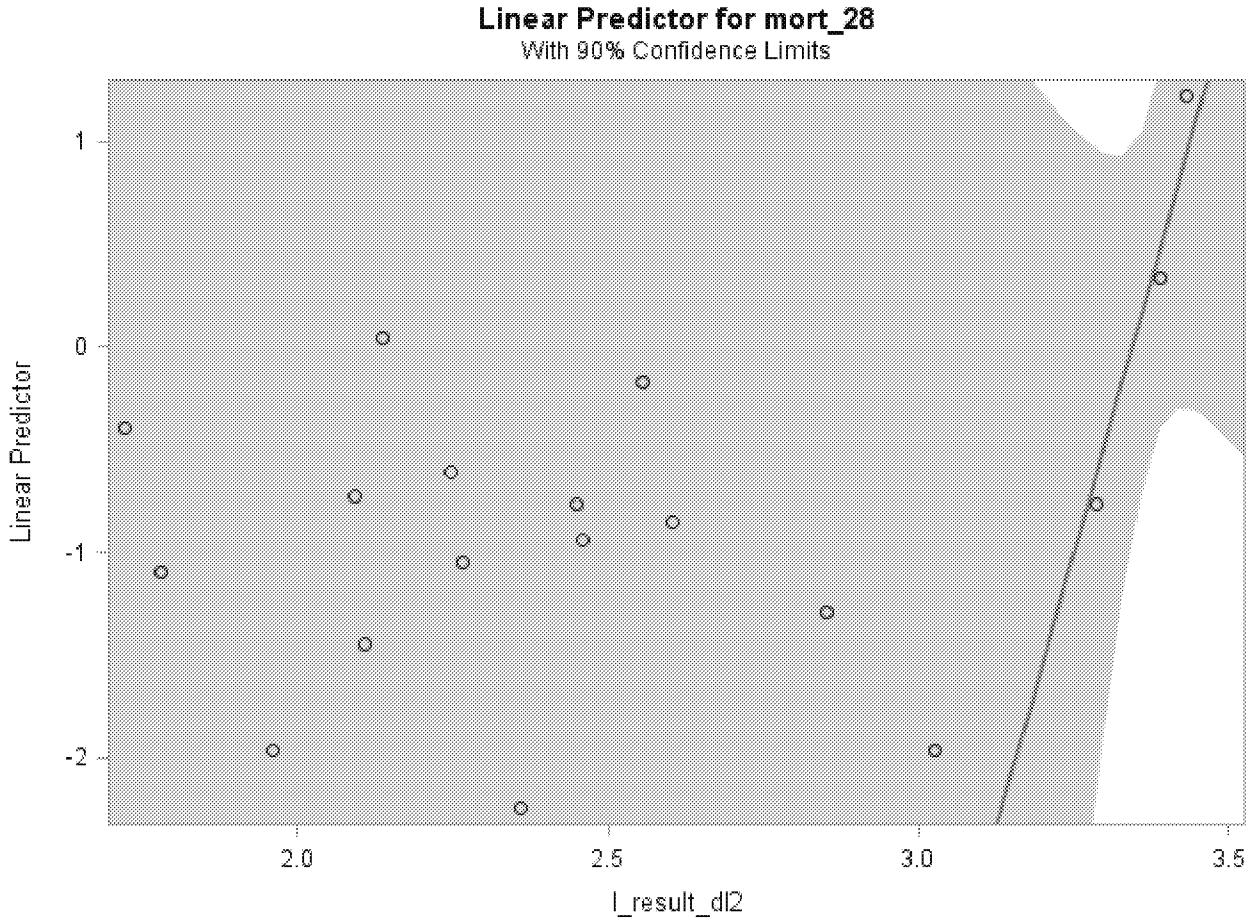
28-day Mortality: Test fit Probit
Arsenic

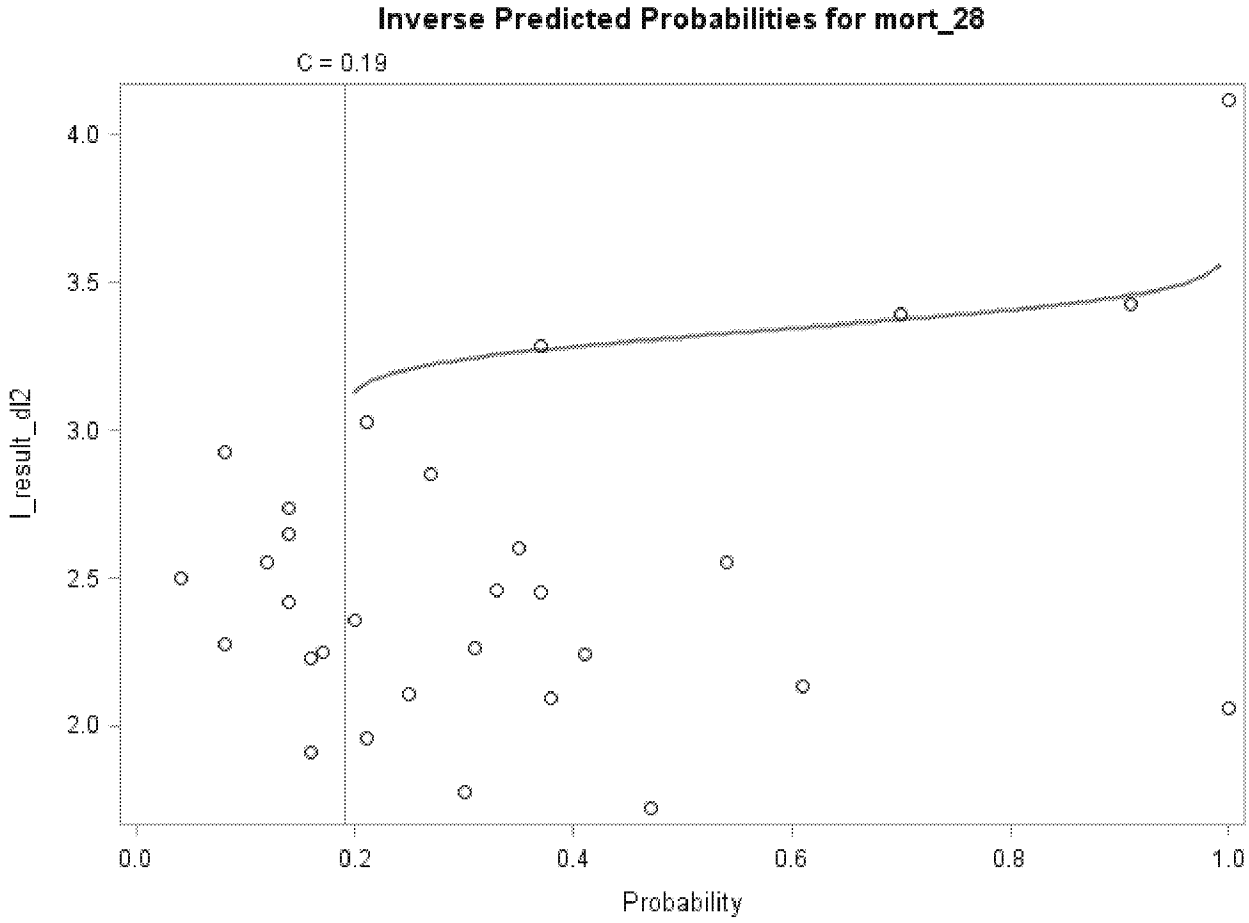
The Probit Procedure

Probit Analysis on l_result_dl2			
Probability	l_result...	90% Fiducial Limits	
0.05	3.19050	.	.
0.10	3.22453	.	.
0.20	3.26575	.	.
0.50	3.34458	.	.

NOTE: The above quantiles and fiducial limits refer to effects due to the independent variable and do not include any effect due to the natural threshold.




Linear Predictor for mort_28
With 90% Confidence Limits
Linear Predictor
1
0
-1
-2
2.0
2.5
3.0
3.5
l_result_dl2


Inverse Predicted Probabilities for mort_28
C = 0.19
4.0
3.5
3.0
2.5
2.0
l_result_dl2
0.0
0.2
0.4
0.6
0.8
1.0
Probability

Appendix F

PRG Calculation Spreadsheet (provided electronically)

Attachment 1

Copper Toxicity in the Newark Bay Study Area Human Health Risk Assessment: USEPA Transmittal, January 14, 2021

January 14, 2021

Copper Toxicity in the Newark Bay Study Area Human Health Risk Assessment

The Baseline Human Health Risk Assessment for the Newark Bay Study Area (NBSA) identified consumption of self-caught fish or blue crabs as the main exposure pathways of concern. The non-cancer hazards that were calculated identified copper as contributing to unacceptable hazard from consumption of blue crabs. Due to the toxicity value and uncertainty factors (UF) that were used to estimate the non-cancer hazards associated with copper (Hazard Quotient [HQ]) = 10 (one significant figure) for the child (7 years or younger), EPA Region 2 has determined that the non-cancer hazard may be over-estimated, and we are seeking direction from Headquarters to remove copper as a Contaminant of Potential Concern (COPC).

Issue. The human health risk assessment for this site utilized the Agency for Toxic Substances and Disease Registry (ATSDR) intermediate minimal risk level (MRL) as the oral reference dose (RfD) with an UF of 10 since the ATSDR MRL was a subchronic value. The application of the UF of 10 is consistent with the Risk Assessment Guidance for Superfund Part A (Section 7.2.2) regarding extrapolation from subchronic to chronic exposures. Upon further review of the use of the UF of 10 during the development of preliminary remediation goals (PRGs) for the feasibility study (FS), EPA Region 2 determined that the use of the UF was overly conservative considering that copper is an essential nutrient. Recalculating the non-cancer hazards associated with the consumption of crab tissue without the UF of 10 indicates that copper would no longer be associated with an unacceptable HQ (see table below). Uncertainties exist in the evaluation of non-cancer hazards associated with copper in blue crab tissue based on the available toxicity values and use of toxicity UFs. Based on these uncertainties it is proposed to remove copper as a COC as outlined below.

- Three non-cancer toxicity values exist for copper.
    - The RfD of 0.04 mg/kg-day is listed in the Health Effects Assessment Summary Tables (HEAST),
    - The RfD of 0.01 mg/kg-day based on the unadjusted ATSDR intermediate MRL, and
    - The RfD of 0.001 mg/kg-day based on the adjusted ATSDR intermediate MRL with an Uncertainty Factor of 10 applied.

This table shows that using either the HEAST value, or the ATSDR intermediate MRL toxicity value without a UF, results in copper HQs less than or equal to 1 for the child receptor who consumes crab tissue consisting of muscle and hepatopancreas.

Source of Copper Toxicity Value	Toxicity Value (mg/kg-day)	Non-cancer Hazard (Adult)*	Non-cancer Hazard (Child)*
HEAST	0.04	0.2	0.3
ATSDR intermediate MRL	0.01	0.8	1
ATSDR intermediate MRL with UF of 10	0.001	8	10

- Values rounded to 1 significant figure.

Conclusion: Revaluating the non-cancer hazard associated with consumption of blue crab tissue using the ATSDR intermediate MRL without a UF, results in non-cancer hazards equal to 1, therefore copper should be removed as a COC and a PRG does not need to be calculated.

Attachment 2

Selected Slides from USEPA Presentation to GSH on the Bioaccumulation Model, July 25, 2019

This attachment includes an excerpt of the slides from the July 25, 2019 meeting.

Newark Bay Bioaccumulation Meeting, July 25th, 2019

Chemicals to Include in Bioaccumulation Model

- Eco Risk Analysis -- 2,3,7,8 TCDD is sufficient from eco-risk standpoint
- Examination of BHHRA draft to assess human-health risk
  - BHHRA– "Consumption of fish or crab represents the primary source of risk to human health in the NBSA"
  - Examined primary contributors to human-health risk from BERA executive summary

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	Summary of Key Findings Angler/Sportsman - Fish Consumption (a)							
	RME				CTE			
	Child	Adolescent	Adult	Combined Adult/Child	Child	Adolescent	Adult	Combined Adult/Child
Cumulative Cancer Risk	3E-04	3E-04	6E-04	8E-04	9E-06	1E-05	2E-05	3E-05
Primary Contributors (b)	PCB-126: 31% (38% for all DL-PCBs) 2,3,7,8-TCDD: 28% (33% for all PCDD/Fs) Non-DL PCBs: 18% Arsenic, inorganic: 4% Dieldrin: 3%				PCB-126: 35% (43% for all DL-PCBs) 2,3,7,8-TCDD: 29% (34% for all PCDD/Fs) Non-DL PCBs: 10% Arsenic, inorganic: 6% Dieldrin: 3%			
Cumulative Noncancer HI	4E+01	3E+01	3E+01	NA	4E+00	2E+00	2E+00	NA
Primary Contributors (b)	Non-DL PCBs: 32% PCB-126: 21% (26% for all DL-PCBs) 2,3,7,8-TCDD: 19% (22% for all PCDD/Fs) Methyl mercury: 6% 4,4'-DDD: 5%				Non-DL PCBs: 31% PCB-126: 20% (25% for all DL-PCBs) 2,3,7,8-TCDD: 17% (20% for all PCDD/Fs) Methyl mercury: 8% 4,4'-DDD: 4%			
Noncancer Health Effects with HI>1	Reproductive (DL compounds) Whole-Body (non-DL PCBs) Liver (pesticides) Neurological (Methyl mercury)				Reproductive (DL compounds)			

Notes:

Shading indicates that the cumulative potential carcinogenic risk exceeds 10-4, or one or more target organ-specific hazard indices exceed one.

(a) Cumulative cancer risks differ only minimally based on the method for estimating toxicity equivalency (TEQ) concentration (Kaplan-Meier [KM] TEQ calculator vs. manual calculations); therefore, the results presented are those based on the KM TEQ calculator.

(b) Primary contributors for cancer risk are based on the combined adult/child scenario and primary contributors for noncancer hazard index are based on the child scenario.

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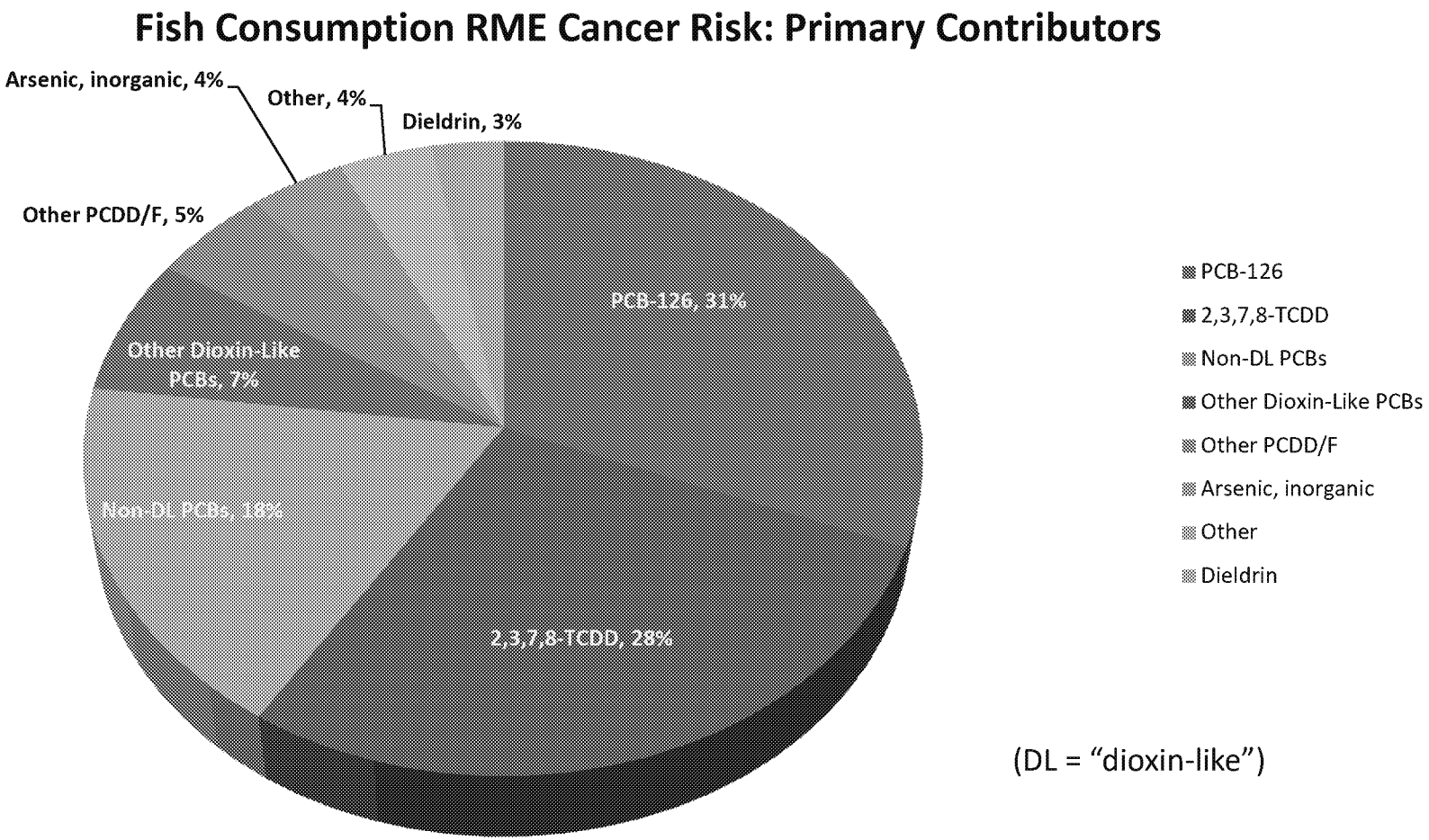
Fish RME Cancer

(data taken from tables in the executive summary of BHHRA)



(DL = “dioxin-like”)

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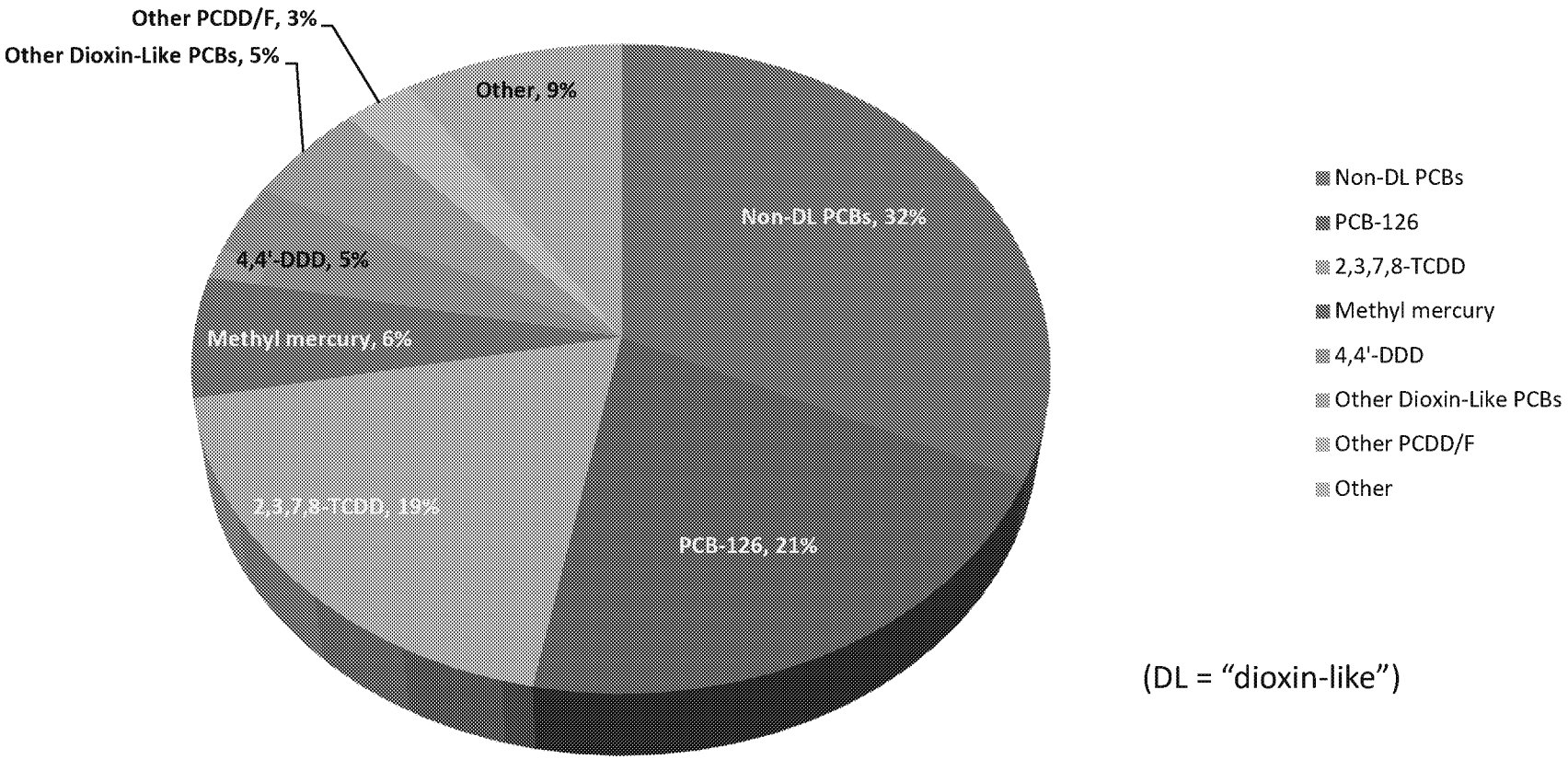
Fish RME Noncancer

(from executive summary of BHHRA)

Fish Consumption RME Non Cancer Risk: Primary Contributors



(DL = “dioxin-like”)

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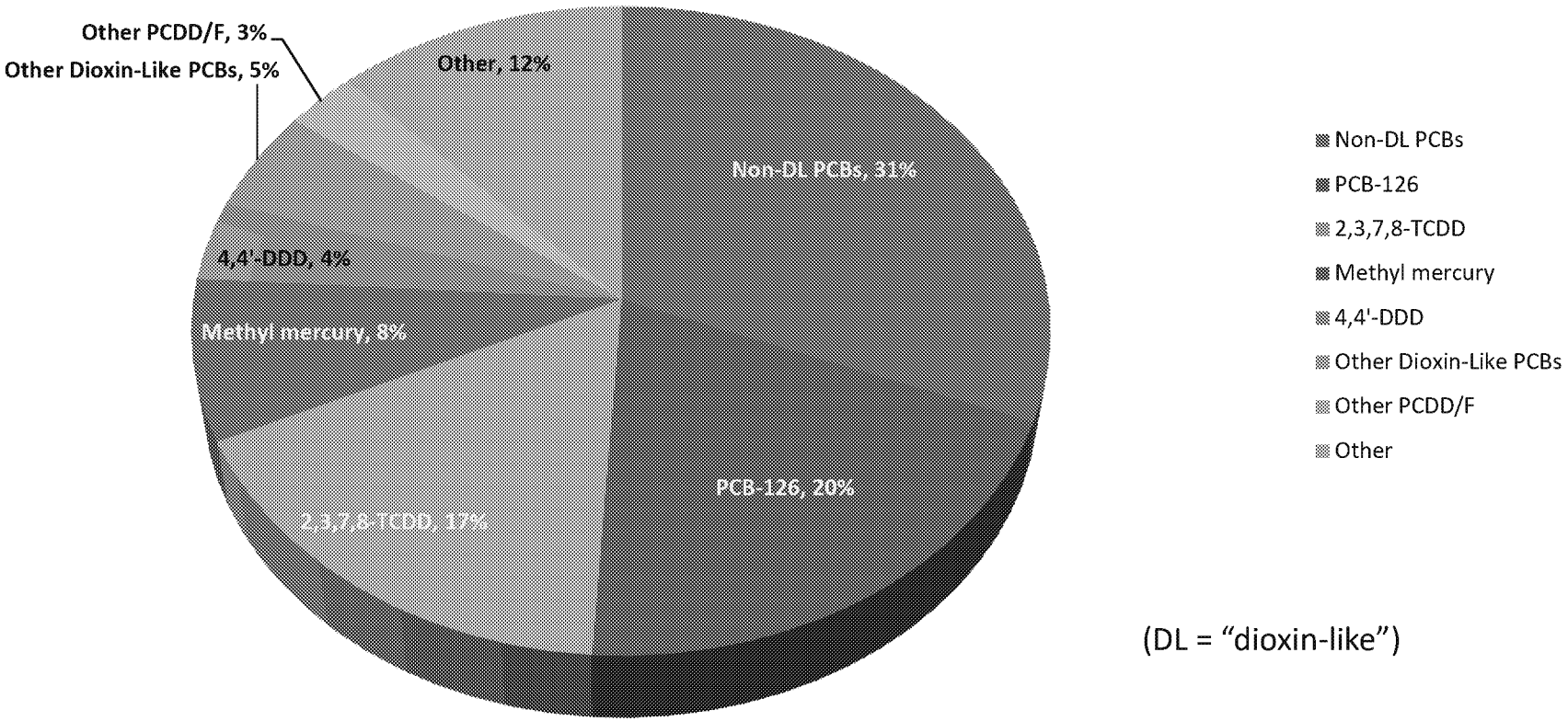
Fish CTE Noncancer

(from executive summary of BHHRA)

Fish Consumption CTE Non Cancer Risk: Primary Contributors



(DL = “dioxin-like”)

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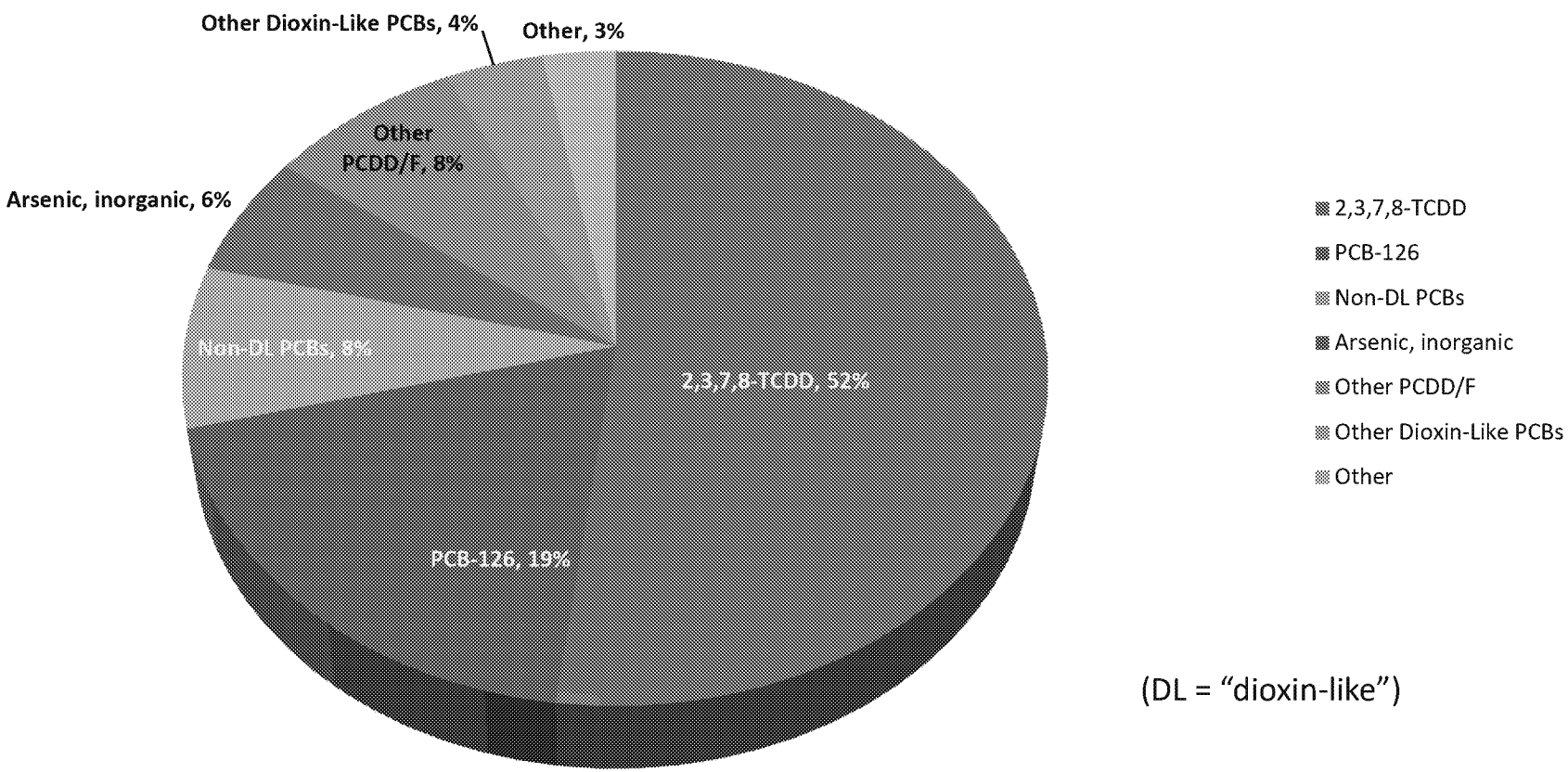
Crab RME Cancer

(from executive summary of BHHRA)

Crab Consumption RME Cancer Risk: Primary Contributors



(DL = “dioxin-like”)

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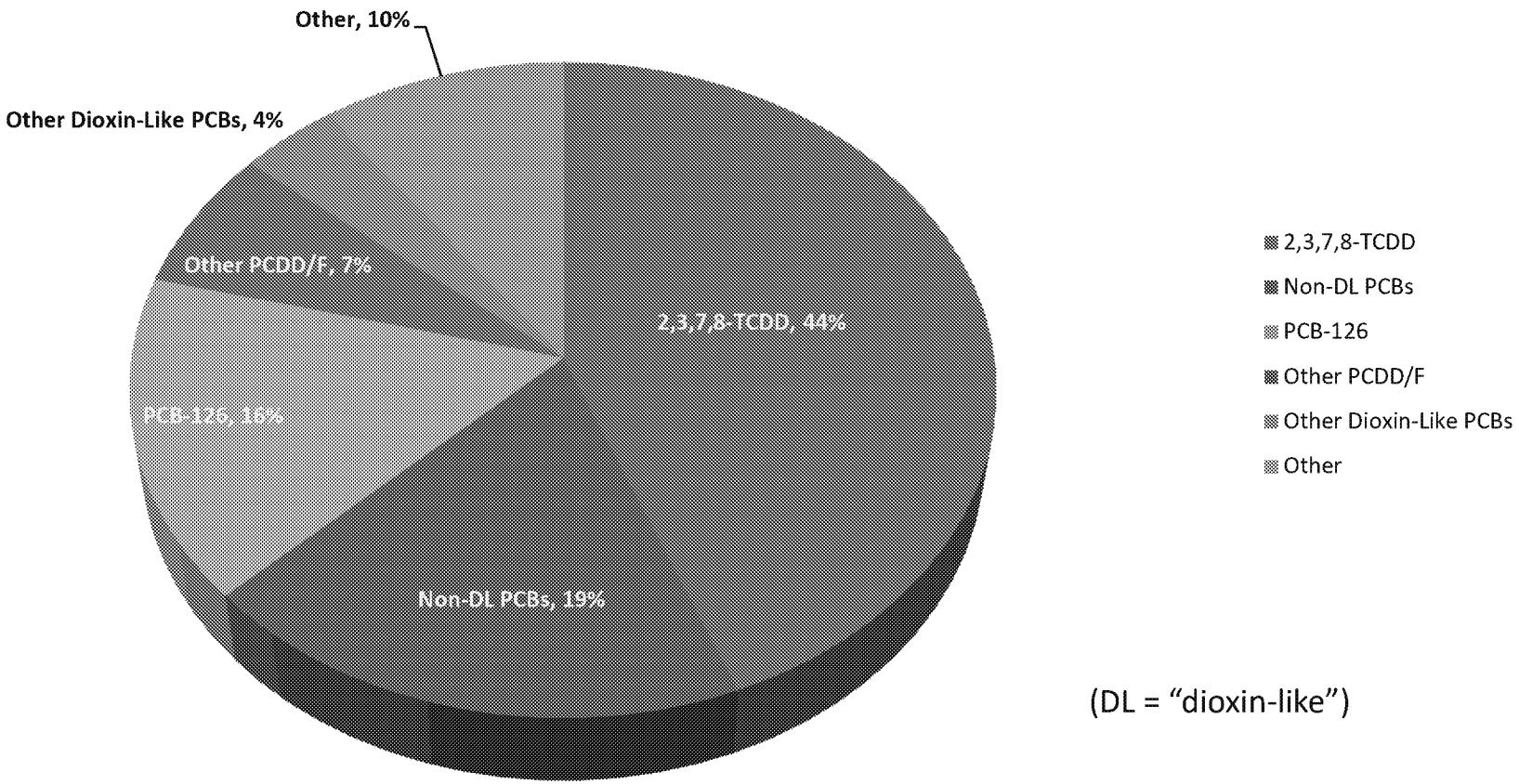
Crab RME and CTE Noncancer

(from executive summary of BHHRA)

Crab Consumption RME Non Cancer Risk: Primary Contributors



(DL = “dioxin-like”)

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Chemicals Driving Risk

(Average Contribution over 6 endpoints)

- 2,3,7,8 TCDD (34%)
  - Other PCDD/F (6%)
- PCBs
  - Non-dioxin-like PCBs (21%)
  - PCB 126 (21%)
  - Other dioxin-like PCBs (5%)
- Methyl Mercury (2.3%)
- Arsenic (1.7%)
- 4,4'-DDD (1.5%)
- Dieldrin (0.5%)

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Chemicals with Lower Contributions

- Average contribution to risk < 5%
  - Methyl Mercury (2.3%)
  - Arsenic, inorganic (1.7%)
  - 4,4'-DDD (1.5%)
  - Dieldrin (0.5%)

Chemicals for FWM from CF&T

- 2,3,7,8 TCDD
  - Regression approach to other PCDD/F risk
    - 2,3,7,8 TCDD to TEQ D/F
- Tetra CB
  - Regression approach to assess PCB-126 and non-dioxin-like risks
    - Tetra CB to Total PCB
    - Tetra CB to Total PCB TEQ

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