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CHEMICAL LAND HOLDINGS, INC.

March 7, 2001

U.S. Environmental Protection Agency, Region II
Emergency and Remedial Response Division
290 Broadway, 19th Floor, Room W-20
New York, NY 10007-1866

Attention: Ms. Janet Conetta
Strategic Integration Manager

Subject: Resubmittal of ERAGS – First Interim Deliverable
Passaic River Study Area
Administrative Order on Consent Index No. II-CERCLA-0117

Reference: ERAGS – First Interim Deliverable
December 21, 2000

Dear Ms. Conetta:

Please recall that the December 21, 2000 submittal of the first ecological risk assessment interim deliverable contained a "placeholder" for the preliminary list of COPC pending validation of the Spring 2000 ESP data. The first interim deliverable is now complete and contains the following components:

- Summary of components of the SLHERA that focus on ERAGS requirements
- Selection of receptors of interest
- Conceptual site model
- Risk questions
- Identification of assessment and measurement endpoints
- Preliminary list of COPC.

Sincerely,

C. Firstenberg

Clifford E. Firstenberg
Project Manager
On behalf of Occidental Chemical Corporation
(as successor to Diamond Shamrock Chemicals Company)

Enclosure

(2 copies sent)

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4c: Section Chief
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TECHNICAL REPORT

Passaic River AOC Document

Ecological Risk Assessment Problem Formulation of the Passaic River Study Area

Chemical Land Holdings, Inc.
East Brunswick, NJ

March 2001

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1. Introduction

This Problem Formulation for the ecological risk assessment for the Passaic River Study Area (Study Area) is designed based on the U.S. Environmental Protection Agency's (U.S. EPA) regulatory framework for conducting ecological risk assessments, as described in key guidance documents, including:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (U.S. EPA 1997)
- Guidelines for Ecological Risk Assessment (U.S. EPA 1998)
- Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites (U.S. EPA 1999).

Consideration is also given to guidance documents for regulatory programs other than CERCLA, as appropriate, to attend to the needs of the natural resource trustees that are involved in the remedial investigation and feasibility study (RI/FS) process for the Study Area through the U.S. EPA's Region 2 Biological Technical Assistance group (BTAG).

1.1 Background

In April 1994, an Administrative Order on Consent (AOC) was signed by Occidental Chemical Corporation (OCC) and the U.S. EPA Region II. The AOC includes a requirement for the conduct an RI/FS for the Study Area. A substantial portion of this AOC deals with the regulatory process for conducting a human and ecological risk assessment (HERA) for the Study Area.

Pursuant to Section VII.39 of the AOC and Part B.3.a.ii.(2)(a)-(c) of the Statement of Work (SOW) that is appended to the AOC, Maxus (now Chemical Land Holdings, Inc.; CLH) on behalf of OCC, submitted to U.S. EPA in July 1995, a draft screening-level human health and ecological risk assessment (SLHERA) for the Study Area, based on data and information that were available and accessible through May 1995. The results of the ecological risk portion of the SLHERA are summarized in Section 2.0.

In September 1995, U.S. EPA provided detailed comments on the SLHERA to CLH. The comments described in detail the agency's concerns with the risk assessment methodologies, perceived data gaps, and findings. Based on these comments, U.S. EPA determined (pursuant to Section VII.39.b of the AOC) that insufficient information was

available to complete the HERA, and that an Ecological Sampling Plan (ESP) would be prepared and implemented prior to the conduct the HERA.

The SLHERA represented the first attempt to develop the appropriate risk assessment approach for the Study Area (human and ecological), based on the information base and regulatory guidance that were available at the time the assessment was developed. The SLHERA provided CLH and U.S. EPA a forum to begin discussions regarding the appropriate methods for conducting a risk assessment for the Study Area. In that regard, the comments received from U.S. EPA on the SLHERA have proved invaluable for the design of the ESP, as well as for the strategic discussions leading to the development of this protocol.

The ESP was developed to collect field and laboratory data that are necessary to assess risks from chemicals to human and ecological receptors in the Study Area. The ecological receptor groups and respective assessment endpoints for which the ESP was designed are described in Section 3 of this report. The purpose of the work being conducted under the ESP is to collect data to be used, in conjunction with historical data and that collected under the RI/FS Work Plan, to complete the HERA, and to support the FS for the Study Area.

1.2 CERCLA Ecological Risk Assessment Guidance

In 1997, (three years after the signing of the AOC, and nearly two years after the submission of the first draft of the ESP), U.S. EPA released an interim final version of its Ecological Risk Assessment Guidance for Superfund (ERAGS). This document was developed as programmatic guidance on ecological risk assessment pursuant to the guidelines set forth in the U.S. EPA's 1998 Final Guidelines for Ecological Risk Assessments (a draft of which was published by U.S. EPA in the Federal Register for use by the program offices and regions on September 16, 1996; 61 FR 47552-47631).

The 1998 guidelines, published by the Office of Research and Development at U.S. EPA, are not specific to any particular regulatory program within U.S. EPA. Instead, they provide a framework and general guidance regarding the focus, technical components, and procedural considerations that should be used to design and conduct an ecological risk assessment under any regulatory program. In short, they were meant to guide regulators in the program offices (including CERCLA) and regions in the development of programmatic guidelines. These guidelines underwent an extensive peer review process by U.S. EPA's Risk Assessment Forum, Federal interagency subcommittees of the Committee on Environment and Natural Resources of the Office of Science and Technology Policy, the U.S. EPA's Science Advisory Board, as well as the public.

The ERAGS contains an eight-step process that has been adapted from the framework described above (Figure 1). Most steps of this process end in a scientific/management decision point (SMDP) (Figure 2). Because the RI/FS activities required by the AOC for the Study Area were already underway when ERAGS was issued in 1997, it is appropriate to consider and define where the ERA for the Study Area now stands in the eight-step ERAGS process.

The SLHERA has sufficiently covered Steps 1 and 2 of the eight-step process. The SMDP that was made by U.S. EPA at the end of Step 2 was that sufficient information was not available to complete the HERA, and more data were needed before this could be done. Although a formal Problem Formulation (Step 3) has not been completed for the Study Area, the components of this process have each been completed and documented, either in the SLHERA or the ESP. These components have been synthesized and refined into this Problem Formulation.

The ESP encompasses Step 4 and Step 5 of the ERA process: Study Design and Data Quality Objectives (DQO) Process, and Verification of Field Sampling Design, respectively. The SMDPs that were made by U.S. EPA at the end of Steps 4 and 5 are the same: that the ESP contains a study design and appropriate quality assurance plan to adequately address the ecological assessment endpoints defined in the ESP.

At present, the CLH project team is in the process of implementing Step 6 - Site Investigation and Data Analysis. Once Step 6 is completed, then Step 7 – Risk Characterization, which will comprise the design and development of the ERA, will be completed. Step 8 – Risk Management, will be completed as part of the FS process.

2. Summary of Screening-Level Ecological Risk Assessment

The results of the SLHERA, with respect to ecological risks in the Study Area, suggested the following:

- There may be ecological risks from bioaccumulation of chemicals from sediments to fish and blue crab
- Sediment toxicity to benthic invertebrates may be substantial due to the occurrence of a wide variety of chemicals in sediments at elevated levels.

However, it was clear to both CLH and U.S. EPA that there were substantial data and information gaps in the SLHERA that had to be filled prior to the conduct of the HERA. From an ecological risk assessment perspective, these gaps fall into seven major categories:

- Insufficient data on chemical concentrations in tissues of food web organisms;
- Insufficient data regarding critical tissue residues to assess the toxicity of bioaccumulative chemicals;
- Need for direct measures and apportionment of sediment toxicity to benthic invertebrates at spatially appropriate intervals in the Study Area;
- Need for a more rigorous food web model including the addition of more parameters and species;
- Need to characterize/quantify the exposure areas for each risk receptor group;
- Development of procedures to assess the risks to fish from chemicals that are taken up and rapidly metabolized and, therefore, are not typically detected in fish tissue samples (particularly PAHs and related compounds); and
- Development of procedures to assess the risks to fish-eating birds that utilize the Study Area.

The objective of the ESP is to collect data and information to fill these data gaps, so that an accurate assessment of ecological risks can be made for the Study Area.

3. Problem Formulation

The purpose of the ERA is to present an accurate evaluation of the risks to fish and wildlife from multiple chemicals that are present in sediment and aquatic organisms in the Study Area. Risks will be evaluated based on available measures of adverse effects on fish and wildlife populations, and on estimates of the organisms' exposure to chemicals in the Study Area, in conjunction with the known toxicity of these chemicals. The focus of the ERA will be on addressing the assessment endpoints, and more specifically answering the risk questions that are formulated in Section 3.4 of this Problem Formulation. The ESP contains the specifications for collection of the data upon which the risk hypotheses will be addressed and risk questions answered. At present, a plan to collect surface water samples is being considered to address the data gap related to health and ecological receptors' exposure to contaminants in surface water.

The problem formulation (Step 3 of the ERAGS process) establishes the goals, breadth, and focus of the ERA (U.S. EPA 1997), and provides a systematic approach for organizing and evaluating available information on ecological stressors and possible effects (U.S. EPA 1998). The following components of problem formulation are the planning tools that focus the baseline ecological risk assessment and provide a basis for defining ecological risk:

- Site characterization
- Development of the conceptual site model
- Selection of chemicals of potential concern (COPC)
- Selection of assessment endpoints (including representative receptors and exposure pathways)
- Development of risk hypotheses and questions.

Each of these components is described for the Study Area in the following subsections.

3.1 Site Characterization

The Study Area is located on the lower portion of the Passaic River, one of the tributaries to Newark Bay, in the Greater New York City Metropolitan Area (Figure 3). The Study Area is defined as that portion of the Passaic River extending from the abandoned ConRail Bridge (located approximately 4,000 feet upriver from the red channel junction marker at the confluence of the Hackensack and Passaic Rivers with Newark Bay) to a transect six miles (31,680 feet) upriver of this bridge. It is within the tidal estuarine portion of the Passaic River, and is characterized by a relatively wide range in salinity (about 5 to 20 ppth).

The Newark metropolitan area has been one of the largest manufacturing centers in the eastern United States since the mid 19th century. The land use surrounding the Study Area has been primarily industrial for most of this time. Development along the River has been spurred by extensive dredging, massive bridge construction, and heavy commercial shipping. As a result, the aquatic habitats of this system have been substantially altered, and most of its adjacent wetlands and natural shorelines have been "reclaimed" to increase available land for urban/industrial development. In addition, municipal and industrial waste disposal, atmospheric deposition, and accidental oil and chemical spills have contaminated the Passaic's water and sediment with sewage and toxic chemicals since the mid 1800s. These cumulative effects have resulted in the loss of breeding and foraging habitat for fish, shellfish, and birds, degraded water quality, and chemical pollution of sediments. As a result, every aspect of the Study Area's ecosystem has been degraded substantially. Populations of fish, shellfish, and benthic invertebrates are relatively low in terms of diversity and abundance compared to other waterways in the NY/NJ Harbor Estuary. The current status of the Study Area ecology should be properly viewed as the result of more than 150 years of anthropogenic impacts, many of them irreversible.

Detailed habitat surveys conducted in the Study Area in the late summer/early fall 1999 and again in spring 2000 (as part of the ESP), suggest that the Study Area is fairly unique in that it is so urbanized that there are virtually no sizeable wetland or terrestrial habitats associated with the river within the 6 mile reach. For this reason, the ecology of the system is limited. The only substantial habitats that are present are intertidal mudflats. These mudflats occur fairly uniformly along the banks of the 6-mile reach, with those in the lower 3 miles being larger than those in the upper 3 miles.

A detailed breakdown of the shoreline characteristics within the Study Area is presented in Table 1. The shoreline characteristics were quantified using Geographic Information System (GIS) analyses of detailed digital maps of the Study Area, and were verified based on the results of detailed photographic/video surveys. The results shows that rip-rap and bulkheads account for more than 80 percent of the linear shoreline in the Study Area. Mudflats are the key habitats for aquatic organisms and piscivorous birds in the Study Area. This is due primarily to the fact that the benthic invertebrates and forage fish that make up the primary food source for higher trophic-level fish, shellfish, and piscivorous birds inhabit mudflats almost exclusively.

3.2 Selection of Chemicals of Potential Concern (COPC)

For this Problem Formulation, analytical chemistry data that were collected and validated as part of (or during the same period as) the RI/FS and ESP field sampling activities (1995 through 2000) were compiled and reviewed. The

objective of this review was to determine the types and numbers of chemicals that were detected in surface sediments and aquatic organisms collected from the Study Area. Sediment data under consideration were limited to samples collected from the surficial layer (approximately zero to 15 cm depth) since this represents the biologically active zone (BAZ) in which aquatic organisms may be exposed to contaminants. The following analytical datasets were compiled for this analysis:

- 1995 RI sediment sampling program
- 1995 biological sampling program
- Fall 1999 ESP sampling program
- Spring 2000 ESP sampling program.

Data were broken down by matrix, organism, and chemical class. Data for aquatic organisms were divided into three categories: fish, blue crab, and transplanted bivalves that were collected from the caged bivalve study conducted under the ESP. Because surface water data have not yet been collected from the Study Area, the results are reported as "not analyzed." As discussed in Section 3 above, surface water data remain a data gap that needs to be filled for the ecological risk assessment.

A list of the chemicals that were detected in each matrix category is provided in Table 2. These chemicals, which were detected in samples of one or more matrix in the 1995 – 2000 datasets, comprise the preliminary list of chemicals of potential concern (COPC) for the ERA. The final list of COPC will be determined from the formal COPC screening process that will be performed during the implementation of the ERA. A summary of the preliminary COPC follows.

A total of 192 chemicals were detected in samples collected from the Study Area between 1995 and 2000. These include 169 in surface sediments, 174 in fish, 159 in blue crab, and 110 in bivalves.

In the 1995 RI surface sediment data there were 119 chemicals detected from 7 classes, including 25 polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), 23 inorganic chemicals, 17 polycyclic aromatic hydrocarbons (PAHs), 21 polychlorinated biphenyl (PCB) congeners, 21 pesticides/PCB Aroclors®, 10 semivolatile compounds, and 2 miscellaneous organic compounds. In the 1995 biological data there were 94 chemicals detected in fish from 6 classes, including 17 PCDD/Fs, 18 inorganic chemicals, 19 PAHs, 20 PCB congeners, 18 pesticides/PCB Aroclors, and 2 miscellaneous organic compounds. Blue crab samples contained 81 chemicals from 7 classes, including 22 PCDD/PCDFs, 17 inorganic compounds, 2 miscellaneous chemicals, 19 PAHs, 11 PCB congeners, 8 pesticides/PCB Aroclors and 2 semivolatile compounds.

In the 1999-2000 ESP sediment data there were 143 chemicals detected from 10 classes of chemicals, including 17 PCDD/PCDFs, 2 herbicides, 23 inorganic compounds, 4 organotins, 25 PAHs, 35 PCB congeners, 9 PCB homologue groups, 8 pesticides/PCB Aroclors, 18 semivolatile compounds, and 2 miscellaneous organic compounds. In bivalves there were 110 chemicals detected in 8 classes of chemicals including 14 PCDD/PCDFs, 21 inorganic compounds, 1 organotin, 19 PAHs, 31 PCB congeners, 8 PCB homologue groups, 10 pesticides/PCB Aroclors and 6 semivolatile compounds. There were 143 chemicals detected in blue crab from 9 classes of chemicals including 15 PCDD/PCDFs, 4 herbicides, 22 inorganic compounds, 4 organotins, 25 PAHs, 35 PCB congeners, 8 PCB homologue groups, 9 pesticides/PCB Aroclors and 21 semivolatile compounds. Fish contained 153 chemicals in 9 classes of chemicals including 17 PCDD/Fs, 4 herbicides, 23 inorganic compounds, 3 organotins, 25 PAHs, 37 PCB congeners, 9 PCB homologue groups, 9 pesticides/PCB Aroclors and 26 semivolatile compounds.

The results indicate that there are a large number of preliminary COPC from a variety of chemical classes. The ERA will focus on determining the direct toxicity of these compounds to organisms that are exposed to sediments, and the indirect toxicity from bioaccumulation and trophic transfer of chemicals through the food web, as discussed in Section 3.4.

3.3 Conceptual Site (Food Web) Model

The conceptual site model is a simplified diagram that demonstrates the hypothetical links between the contaminants in sediments and biota, and helps to formulate risk hypotheses. It is used as a planning tool to identify the exposure pathways, ecological receptors, and potential effects on which to focus the ecological risk assessment. The conceptual site food web model shown in Figure 4 illustrates the potential exposure pathways for chemicals in sediments of the Study Area. Because many of these chemicals biomagnify in the food web, the most significant route of exposure is ingestion of contaminated prey. This exposure pathway is complete for organisms that obtain their food (e.g., fish and invertebrates) from the Study Area.

The SLHERA contained a simplified conceptual food web for the Study Area that was developed based on the limited amount of information on the biology and ecology of the Study Area that was available in 1995. The organisms in this food web were limited to benthic invertebrates, mummichog (forage fish), blue crab, and striped bass (predatory fish). Since that time, more biological/ecological information has been gathered for the Study Area, and the U.S. EPA provided their input to CLH as to what additional organisms they want added to the food web for the HERA. This input came in two forms: comments on the SLHERA, and comments provided iteratively to CLH during the development of the ESP from December 1995 through March 1999.

From July 1999 through June 2000 a substantial amount of information regarding the ecology and biology of the Study Area was gathered as part of the implementation of the ESP. The ESP data (including biological and habitat survey information as well as physical and chemical data) will be described in detail in the ERA. Figure 4 is a revised conceptual food web for the ERA that has been developed based on the data and information collected since the SLHERA (including a preliminary review of the ESP data), and in consideration of U.S. EPA's comments as described above.

The revised food web contains six new organisms: grass shrimp, one new forage fish (Atlantic silverside), two new predatory fish (American eel and white perch), and two categories of fish-eating birds; herons and egrets (migratory wading birds), and the year-round resident Kingfisher. The conceptual food web illustrates the potential link between these organisms in the Study Area. Data have been collected under the ESP and RI to assess chemical risks to these organisms. This food web will also be linked mathematically in the revised food web model that is being developed for the feasibility study (FS) to describe and quantify the flow of chemicals from sediments through organisms within the Study Area. The ESP data will be used to calibrate the FS food web model.

While biological surveys of any aquatic ecosystem, including the Study Area, typically indicate that a variety of fish and wildlife exist in the system, a risk assessment cannot be performed for each organism. Instead, U.S. EPA guidelines call for the selection of representative receptors from each group of organisms that may be exposed to chemicals at a site (U.S. EPA 1997; 1998). These are termed indicator organisms. They are species that are selected to represent their trophic level or feeding guild in the food web at a site. The criteria for their selection include:

- They are abundant at the site;
- They are considered essential to, or indicative of, the normal functioning of the habitat or system;
- They are likely exposed to chemicals in a manner that is typical for their trophic level or feeding guild; and
- They are known to be sensitive to the effects of one or more COPC (often the most sensitive species from a group is selected for risk assessment).

In addition, any rare, threatened, or endangered species that occur at a site are typically evaluated in the risk assessment. This does not apply to the Study Area as such organisms are not known to occur in or utilize the Study Area.

The most significant change in the conceptual food web model to date is the addition of piscivorous birds to the food web. Again, this change is in response to both U.S. EPA comments and the ecological investigations that have been performed in the Study Area since the SLHERA. The two birds that were added are indicator organisms for a single

trophic level in the model: piscivorous birds. These are birds that forage in the Study area, and are known to feed only on fish or other aquatic organisms.

Two bird species were chosen to represent very different levels of potential exposure in the Study Area. The heron/egret family was chosen as a group representative of highly migratory birds that only utilize the Study Area for a fraction of the year. The kingfisher was chosen as a non-migratory species that often spends the entire year in one system. Together, the herons/egrets and kingfisher will represent the range of fish-eating bird exposure that may occur in the Study Area.

3.4 Assessment Endpoints

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes" (U.S. EPA 1998). The assessment endpoints for the Study Area were previously defined by U.S EPA, and included in the ESP. The following discussion expands on the presentation of assessment endpoints included in the ESP.

In the Study Area there are two critical concerns around which assessment endpoints were formulated: direct toxicity to animals from exposure to chemicals in sediments, and indirect toxicity of bioaccumulative chemicals via trophic transfer (i.e., animals eating other contaminated animals) through the food web. For bioaccumulative chemicals (e.g., pesticides, PCBs, PCDD/Fs, mercury), the assessment endpoints for risk assessment should focus on fish and wildlife at middle to high trophic levels in the food web (e.g., crabs, fish, and piscivorous birds). These consumer organisms tend to have the greatest susceptibility to adverse effects from exposure to such compounds because theoretically they can accumulate relatively large concentrations of chemicals from the variety of animals they eat. This phenomenon of increasing bioaccumulation with increasing trophic level in a food web is termed biomagnification. The level of biomagnification that occurs at a given site is highly site-specific, and depends on the range of factors that control the bioavailability of chemicals from sediments into the food web, and exposure.

The selected assessment endpoints for the Study Area, as defined in the ESP and refined in this protocol, are:

- Survival and maintenance of a normally functioning benthic invertebrate community
- Survival and maintenance of healthy, reproducing populations of blue crab
- Survival and maintenance of healthy, reproducing populations of fish
- Survival and maintenance of healthy, reproducing populations of piscivorous birds.

If the outcome of the assessment suggests that these assessment endpoints are threatened by the presence of one or more groups of chemicals within the Study Area, then they are considered "at risk." U.S. EPA (1997) suggests formulating risk hypotheses and risk questions to be addressed by the risk assessment process. For the Study Area ERA, the risk hypotheses/questions can be stated as:

- *Benthic invertebrates are directly exposed to multiple chemicals in sediments of the Study Area. Toxicity from these chemicals can depress the diversity and abundance of organisms that make up the benthic community. Do the available data suggest that acute and/or chronic toxicity to benthic invertebrates from one or more chemicals is occurring? If so, where are these risks occurring and at what magnitude?*

- *Fish and crabs utilizing the Study Area are bioaccumulating chemicals from sediment and/or food sources. Exposure occurs primarily through consumption of contaminated food (prey). Do the available data suggest that Study Area-related chemicals are being accumulated in fish and crabs to concentrations where adverse reproductive effects can occur? If so, where within the Study Area are these risks likely to occur, and are these risks significant from a population perspective?*

- *Piscivorous birds from colonies within the Hackensack Meadowlands and/or other habitats near the Study Area are bioaccumulating chemicals from food (prey) sources in the Study Area. Do the available data suggest that Study Area-related chemicals are being accumulated in piscivorous birds to concentrations where adverse reproductive effects can occur? If so, where within the Study Area are these risks likely to occur, and are these risks significant from a population perspective?*

These risk hypotheses and questions formed the basis for the design and implementation of the ESP for the Study Area, and the subsequent conduct of the risk assessment (including exposure assessment, effects assessment, and risk characterization).

4. References

U.S. EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. EPA/540/R-97/006. U.S. Environmental Protection Agency, Solid Waste and Emergency Response, Washington, DC.

U.S. EPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1999. Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites.

Table 1. Shoreline Habitat Characterization for the Passaic River Study Area

	Point-No-Point Reach				Harrison Reach				Newark Reach			
	Right Bank (a)		Left Bank (b)		Right Bank		Left Bank		Right Bank		Left Bank	
Shoreline Habitat Type	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total
Bulkhead	1219	16%	4994	63%	4524	39%	3131	25%	6860	81%	5973	77%
Riprap	4128	54%	2873	37%	4508	38%	4037	32%	1562	19%	1796	23%
Mixed Vegetation (c)	883	12%	0	0%	2171	19%	3409	27%	0	0%	0	0%
Aquatic Vegetation	1407	18%	0	0%	519	4%	1917	15%	0	0%	0	0%
Total Shoreline (feet)	**7637**		**7867**		**11722**		**12494**		**8422**		**7769**	

	Kearny Reach				Arlington Reach				Cumulative Total for Study Area					
	Right Bank (a)		Left Bank (b)		Right Bank		Left Bank		Right Bank		Left Bank		Total Shoreline	
Shoreline Habitat Type	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total	Linear Feet	Percent of Total
Bulkhead	4802	90%	3214	62%	573	89%	0	0%	17978	53%	17312	51%	35290	52%
Riprap	526	10%	800	15%	70	11%	30	4%	10794	32%	9536	28%	20330	30%
Mixed Vegetation (c)	0	0%	1189	23%	0	0%	655	96%	3054	9%	5253	15%	8307	12%
Aquatic Vegetation	0	0%	0	0%	0	0%	0	0%	1926	6%	1917	6%	3843	6%
Total Shoreline (feet)	**5328**		**5203**		**643**		**685**		**33752**		**34018**		**67770**	

(a) Right bank facing downstreem (e.g., western shoreline)

(b) Left bank facing downstream (e.g., eastern shoreline)

(c) Mixed vegetation refers to areas of aquatic vegetation interspersed with riprap or bulkhead and areas of riprap shoreline with significant overhanging riparian vegetation.

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Table 2. Chemicals Detected in Surface Sediments and Aquatic Organisms from the Passaic River Study Area

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	Chemical	Crabs	Fish	Surface Sediment	Surface Water	Bivalve[4]	Crabs	Fish	Surface Sediment	Surface Water
2,3,7,8-PCDD/Fs	2,3,7,8-TCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	2,3,7,8-TCDD	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	2,3,4,7,8-PeCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	2,3,4,6,7,8-HxCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,7,8-PeCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,7,8-PeCDD	x		x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,7,8,9-HxCDF			x	NA			x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,7,8,9-HxCDD	x		x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,6,7,8-HxCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,6,7,8-HxCDD	x		x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,7,8-HxCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,7,8-HxCDD	x		x	NA		x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,7,8,9-HpCDF			x	NA			x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,6,7,8-HpCDF	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,6,7,8-HpCDD	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,5,6,7,8-OCDF		x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	1,2,3,4,5,6,7,8-OCDD	x	x	x	NA	x	x	x	x	NA
2,3,7,8-PCDD/Fs	Total HpCDD	x	x	x	NA					NA
2,3,7,8-PCDD/Fs	Total HpCDF	x	x	x	NA					NA
2,3,7,8-PCDD/Fs	Total HxCDD	x		x	NA					NA
2,3,7,8-PCDD/Fs	Total HxCDF	x	x	x	NA					NA
2,3,7,8-PCDD/Fs	Total PeCDD	x		x	NA					NA
2,3,7,8-PCDD/Fs	Total PeCDF	x	x	x	NA					NA
2,3,7,8-PCDD/Fs	Total TCDD	x	x	x	NA					NA
2,3,7,8-PCDD/Fs	Total TCDF	x	x	x	NA					NA
Herbicides	2,4,5-T				NA		x	x		NA
Herbicides	2,4,5-TP (Silvex)				NA		x	x	x	NA
Herbicides	2,4-D				NA		x	x		NA
Herbicides	2,4-DB				NA		x	x	x	NA
Inorganic Compounds	Aluminum	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Antimony			x	NA	x	x	x	x	NA
Inorganic Compounds	Arsenic	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Barium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Beryllium			x	NA	x	x	x	x	NA
Inorganic Compounds	Cadmium	x	x	x	NA	x	x	x	x	NA

Table 2. (cont.)

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	**Chemical**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**	**Bivalve[4]**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**
Inorganic Compounds	Calcium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Chromium		x	x	NA	x	x	x	x	NA
Inorganic Compounds	Cobalt			x	NA		x	x	x	NA
Inorganic Compounds	Copper	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Iron	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Lead	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Magnesium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Manganese	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Mercury	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Nickel			x	NA	x	x	x	x	NA
Inorganic Compounds	Potassium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Selenium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Silver	x		x	NA		x	x	x	NA
Inorganic Compounds	Sodium	x	x	x	NA	x	x	x	x	NA
Inorganic Compounds	Thallium		x		NA	x		x	x	NA
Inorganic Compounds	Titanium	x	x	x	NA					NA
Inorganic Compounds	Vanadium			x	NA	x	x	x	x	NA
Inorganic Compounds	Zinc	x	x	x	NA	x	x	x	x	NA
Miscellaneous Chemical Data	Methyl Mercury	x	x		NA					NA
Miscellaneous Chemical Data	Petroleum Hydrocarbons	x	x	x	NA				x	NA
Miscellaneous Chemical Data	Total Cyanide			x	NA				x	NA
Organotins	Dibutyltin				NA		x	x	x	NA
Organotins	Monobutyltin				NA		x	x	x	NA
Organotins	Tetrabutyltin				NA		x		x	NA
Organotins	Tributyltin				NA	x	x	x	x	NA
PAHs	1,6,7-Trimethylnaphthalene				NA		x	x	x	NA
PAHs	1-Methylnaphthalene				NA	x	x	x	x	NA
PAHs	1-Methylphenanthrene				NA	x	x	x	x	NA
PAHs	2,6-Dimethylnaphthalene				NA		x	x	x	NA
PAHs	2-Methylnaphthalene	x	x	x	NA	x	x	x	x	NA
PAHs	Acenaphthene	x	x	x	NA	x	x	x	x	NA
PAHs	Acenaphthylene	x	x	x	NA		x	x	x	NA
PAHs	Anthracene	x	x	x	NA	x	x	x	x	NA
PAHs	Benzo(a)anthracene	x	x	x	NA	x	x	x	x	NA
PAHs	Benzo(a)pyrene	x	x	x	NA	x	x	x	x	NA

Table 2. (cont.)

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	**Chemical**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**	**Bivalve[4]**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**
PAHs	Benzo(b)fluoranthene	x	x	x	NA	x	x	x	x	NA
PAHs	Benzo(e)pyrene	x	x		NA	x	x	x	x	NA
PAHs	Benzo(g,h,i)perylene	x	x	x	NA	x	x	x	x	NA
PAHs	Benzo(k)fluoranthene	x	x	x	NA	x	x	x	x	NA
PAHs	Biphenyl				NA		x	x	x	NA
PAHs	Chrysene	x	x	x	NA	x	x	x	x	NA
PAHs	Dibenzo(a,h)anthracene	x	x	x	NA	x	x	x	x	NA
PAHs	Dibenzothiophene				NA		x	x	x	NA
PAHs	Fluoranthene	x	x	x	NA	x	x	x	x	NA
PAHs	Fluorene	x	x	x	NA		x	x	x	NA
PAHs	Indeno(1,2,3-cd)pyrene	x	x	x	NA	x	x	x	x	NA
PAHs	Naphthalene	x	x	x	NA	x	x	x	x	NA
PAHs	Perylene	x	x		NA	x	x	x	x	NA
PAHs	Phenanthrene	x	x	x	NA	x	x	x	x	NA
PAHs	Pyrene	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-1			x	NA			x	x	NA
PCB Congeners	PCB-3				NA			x	x	NA
PCB Congeners	PCB-5		x	x	NA					NA
PCB Congeners	PCB-8				NA	x	x	x	x	NA
PCB Congeners	PCB-15				NA	x	x	x	x	NA
PCB Congeners	PCB-18				NA	x	x	x	x	NA
PCB Congeners	PCB-28		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-44		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-52				NA	x	x	x	x	NA
PCB Congeners	PCB-66		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-77	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-81				NA	x	x	x	x	NA
PCB Congeners	PCB-87				NA	x	x	x	x	NA
PCB Congeners	PCB-90/101				NA	x	x	x	x	NA
PCB Congeners	PCB-105	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-110		x	x	NA					NA
PCB Congeners	PCB-114	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-118	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-123	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-126	x	x	x	NA	x	x	x	x	NA

Table 2. (cont.)

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	**Chemical**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**	**Bivalve[4]**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**
PCB Congeners	PCB-128				NA	x	x	x	x	NA
PCB Congeners	PCB-138		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-153		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-156	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-157	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-167	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-169	x	x	x	NA		x	x		NA
PCB Congeners	PCB-170		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-180		x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-183				NA	x	x	x	x	NA
PCB Congeners	PCB-184				NA		x	x		NA
PCB Congeners	PCB-187				NA	x	x	x	x	NA
PCB Congeners	PCB-189	x	x	x	NA	x	x	x	x	NA
PCB Congeners	PCB-194				NA	x	x	x	x	NA
PCB Congeners	PCB-195				NA	x	x	x	x	NA
PCB Congeners	PCB-202				NA	x	x	x	x	NA
PCB Congeners	PCB-206				NA	x	x	x	x	NA
PCB Congeners	PCB-207				NA		x	x	x	NA
PCB Congeners	PCB-209				NA		x	x	x	NA
PCB Homologue Groups	Total Dichlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Heptachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Hexachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Monochlorobiphenyl				NA			x	x	NA
PCB Homologue Groups	Total Nonachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Octachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Pentachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Tetrachlorobiphenyl				NA	x	x	x	x	NA
PCB Homologue Groups	Total Trichlorobiphenyl				NA	x	x	x	x	NA
Pesticides/PCB Aroclors	4,4'-DDD	x	x	x	NA	x	x	x	x	NA
Pesticides/PCB Aroclors	4,4'-DDE	x	x	x	NA	x	x	x	x	NA
Pesticides/PCB Aroclors	4,4'-DDT		x	x	NA		x	x	x	NA
Pesticides/PCB Aroclors	Aldrin		x		NA					NA
Pesticides/PCB Aroclors	Alpha-BHC		x	x	NA	x	x			NA
Pesticides/PCB Aroclors	Alpha-Chlordane	x	x	x	NA	x	x	x		NA
Pesticides/PCB Aroclors	Aroclor-1242			x	NA					NA

Table 2. (cont.)

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	**Chemical**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**	**Bivalve[4]**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**
Pesticides/PCB Aroclors	Aroclor-1248		x	x	NA		x	x	x	NA
Pesticides/PCB Aroclors	Aroclor-1254			x	NA		x	x	x	NA
Pesticides/PCB Aroclors	Aroclor-1260		x	x	NA		x	x	x	NA
Pesticides/PCB Aroclors	Beta-BHC			x	NA					NA
Pesticides/PCB Aroclors	Delta-BHC	x	x	x	NA	x				NA
Pesticides/PCB Aroclors	Dieldrin		x	x	NA	x				NA
Pesticides/PCB Aroclors	Endosulfan I	x			NA	x				NA
Pesticides/PCB Aroclors	Endosulfan II		x	x	NA				x	NA
Pesticides/PCB Aroclors	Endrin		x	x	NA					NA
Pesticides/PCB Aroclors	Endrin Aldehyde		x	x	NA			x		NA
Pesticides/PCB Aroclors	Endrin Ketone	x	x	x	NA					NA
Pesticides/PCB Aroclors	Gamma BHC	x		x	NA					NA
Pesticides/PCB Aroclors	Gamma Chlordane		x	x	NA	x				NA
Pesticides/PCB Aroclors	Heptachlor Epoxide	x	x	x	NA	x				NA
Pesticides/PCB Aroclors	Methoxychlor		x	x	NA	x				NA
Pesticides/PCB Aroclors	Total PCBs		x	x	NA		x	x	x	NA
Semivolatile Compounds	1,2,4-Trichlorobenzene	x			NA	x	x	x	x	NA
Semivolatile Compounds	1,2-Dichlorobenzene				NA	x	x	x	x	NA
Semivolatile Compounds	1,3-Dichlorobenzene				NA		x	x	x	NA
Semivolatile Compounds	1,4-Dichlorobenzene				NA		x	x	x	NA
Semivolatile Compounds	2,4,5-Trichlorophenol			x	NA			x	x	NA
Semivolatile Compounds	2,4,6-Trichlorophenol			x	NA			x		NA
Semivolatile Compounds	2,4-Dichlorophenol			x	NA		x	x	x	NA
Semivolatile Compounds	2,4-Dimethylphenol				NA			x		NA
Semivolatile Compounds	2,4-Dinitrotoluene				NA		x	x		NA
Semivolatile Compounds	2,6-Dinitrotoluene				NA		x	x		NA
Semivolatile Compounds	2-Chloronaphthalene				NA		x			NA
Semivolatile Compounds	2-Chlorophenol				NA		x	x	x	NA
Semivolatile Compounds	2-Methylphenol				NA				x	NA
Semivolatile Compounds	2-Nitrophenol				NA			x		NA
Semivolatile Compounds	3-Nitroaniline				NA			x		NA
Semivolatile Compounds	4-Chloro-3-methylphenol				NA			x		NA
Semivolatile Compounds	4-Chloroaniline			x	NA					NA
Semivolatile Compounds	4-Methylphenol				NA		x	x	x	NA
Semivolatile Compounds	4-Nitrophenol				NA			x		NA

Table 2. (cont.)

		1995[1,2]				Fall 1999/Spring 2000[3]				
Process Class	**Chemical**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**	**Bivalve[4]**	**Crabs**	**Fish**	**Surface Sediment**	**Surface Water**
Semivolatile Compounds	bis(2-Chloroethoxy)methane				NA		x			NA
Semivolatile Compounds	bis(2-Chloroethyl)ether				NA		x			NA
Semivolatile Compounds	bis(2-Ethylhexyl)phthalate	x		x	NA	x	x	x	x	NA
Semivolatile Compounds	Butyl benzyl phthalate			x	NA			x	x	NA
Semivolatile Compounds	Carbazole			x	NA				x	NA
Semivolatile Compounds	Dibenzofuran			x	NA			x	x	NA
Semivolatile Compounds	Diethyl phthalate				NA	x	x	x		NA
Semivolatile Compounds	Di-n-butylphthalate				NA	x	x	x	x	NA
Semivolatile Compounds	Di-n-octylphthalate			x	NA		x	x	x	NA
Semivolatile Compounds	Hexachlorobenzene				NA				x	NA
Semivolatile Compounds	Hexachlorobutadiene				NA		x			NA
Semivolatile Compounds	Hexachloroethane				NA		x	x		NA
Semivolatile Compounds	Isophorone				NA		x	x		NA
Semivolatile Compounds	Nitrobenzene				NA		x			NA
Semivolatile Compounds	N-Nitrosodiphenylamine			x	NA				x	NA
Semivolatile Compounds	Pentachlorophenol				NA			x		NA
Semivolatile Compounds	Phenol				NA	x	x	x	x	NA

Notes:

[1] Sediment data collected during the 1995 Remedial Investigation sampling event. Fish and crab data collected by CLH in September 1995.

[2] *Ten volatile organic compounds (VOCs) were also detected in surface sediments collected in 1995. Because the frequency of detection of these compounds* was extremely low, EPA and CLH decided to eliminate VOCs as chemicals of interest.

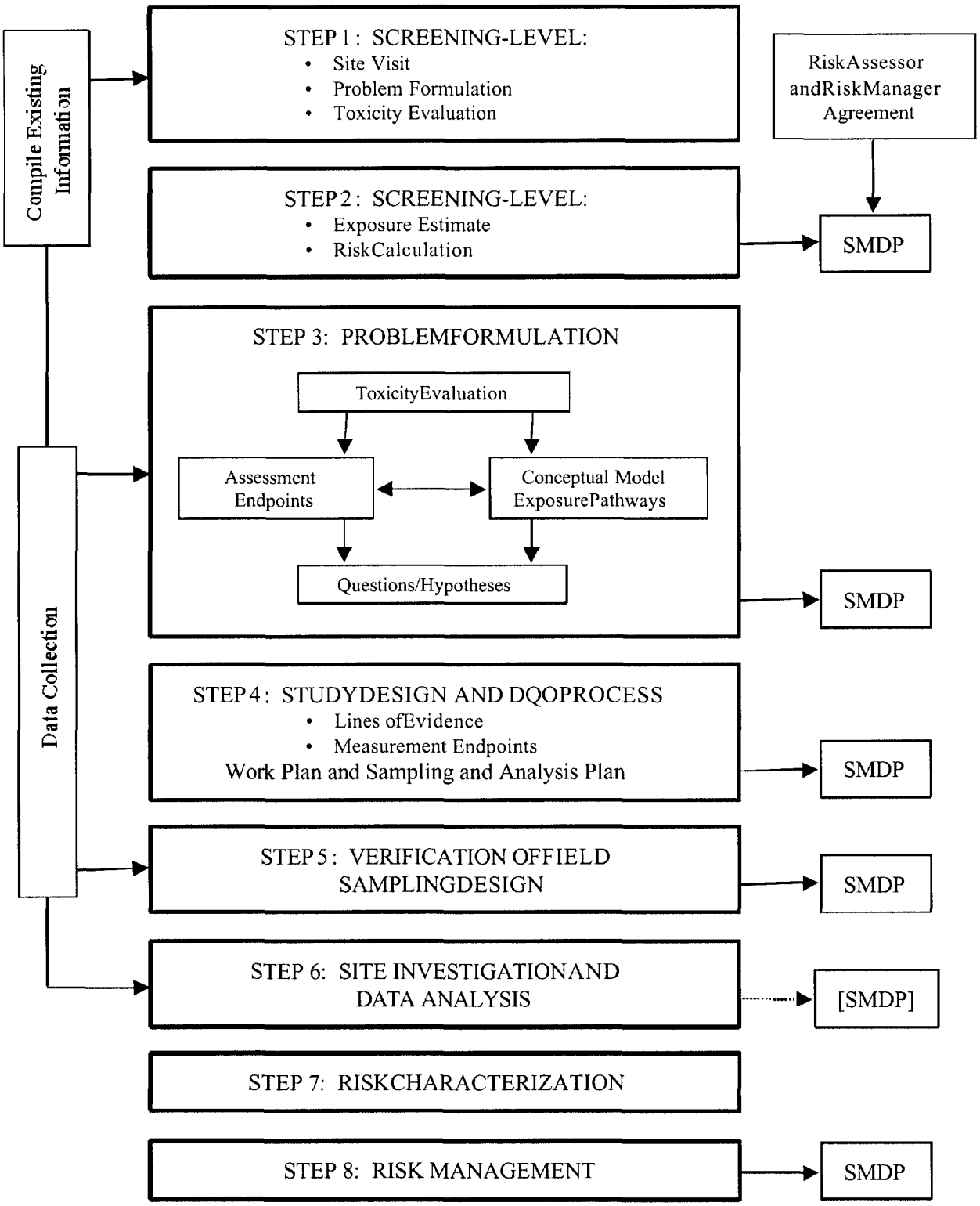
[3] Data collected during the implementation of the Ecological Sampling Plan (ESP).

[4] Based on chemical analyses of transplanted bivalves from caged bivalve investigation conducted under the ESP in Fall 1999.

2,3,7,8-PCDD/Fs - 2,3,7,8-substituted polychlorinated dibenzo-*p*- dioxins and dibenzofurans.
PAH - Polycyclic aromatic hydrocarbons.
PCB - Polychlorinated biphenyls.

NA - Data not available.

Figure 1. Ecological Risk Assessment Guidance for Superfund (ERAGS)



As depicted on pg.I-9ofU.S.EPA's1999EcologicalRiskAssessment Guidancefor Superfund: ProcessofDesigning and Conducting EcologicalRisk Assessments.

Figure 2. ERAGS Scientific Management Decision Points

U.S. EPA 1997 Steps in the Ecological Risk Assessment Process and Corresponding Decision Points in the Superfund Process

Steps andScientific/ManagementDecision Points(SMDPs):

1.	Screening-Level ProblemFormulation andEcological Effects Evaluation	
2.	Screening-Level PreliminaryExposure Estimate and Risk Calculation	SMDP(a)
3.	Baseline RiskAssessment Problem Formulation	SMDP(b)
4.	StudyDesignandDataQualityObjectives	SMDP(c)
5.	Field Verification of SamplingDesign	SMDP(d)
6.	Site Investigation andAnalysis of Exposure andEffects	[SMDP]
7.	Risk Characterization	
8.	Risk Management	SMDP(e)

CorrespondingDecisionPointsinthe Superfund Process:

(a) Decision about whether a fullecologicalriskassessmentis necessary.

(b) Agreement among the risk assessors, risk manager, and other involved parties on the conceptual model,including assessment endpoints, exposure pathways, and questions or riskhypotheses.

(c) Agreement among the risk assessors and risk manager on the measurement endpoints, studydesign,anddatainterpretationandanalysis.

(d) Signing approval of the work plan and sampling and analysis plan for the ecological risk assessment.

(e) Signing the RecordofDecision.

[SMDP] only ifchangetothesampling and analysis planisnecessary.

As depicted on pg.I-10 of U.S. EPA's 1999Ecological Risk Assessment Guidance for Superfund: Process of Designing and Conducting Ecological Risk Assessments.

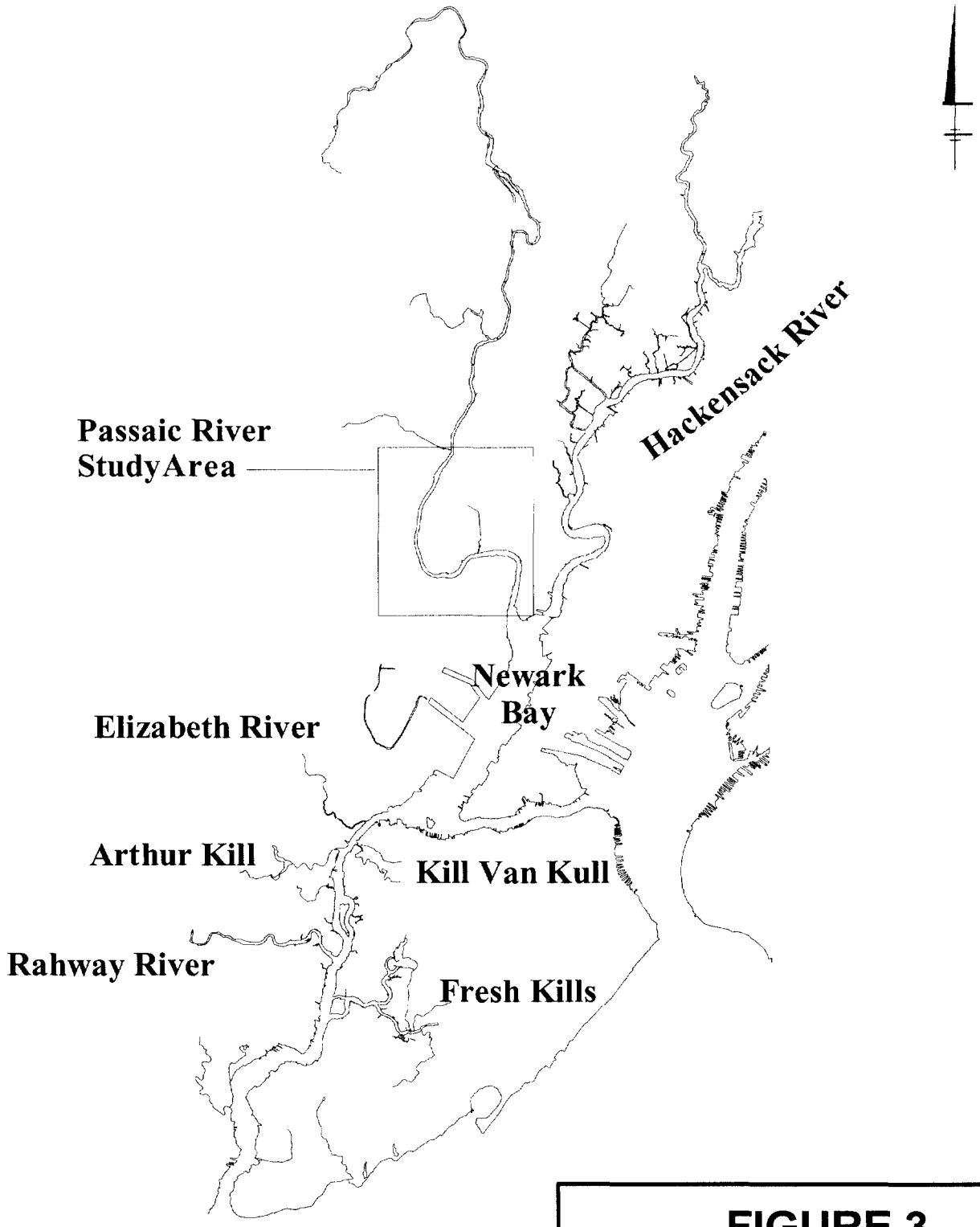


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FIGURE 3

Passaic River Study Area

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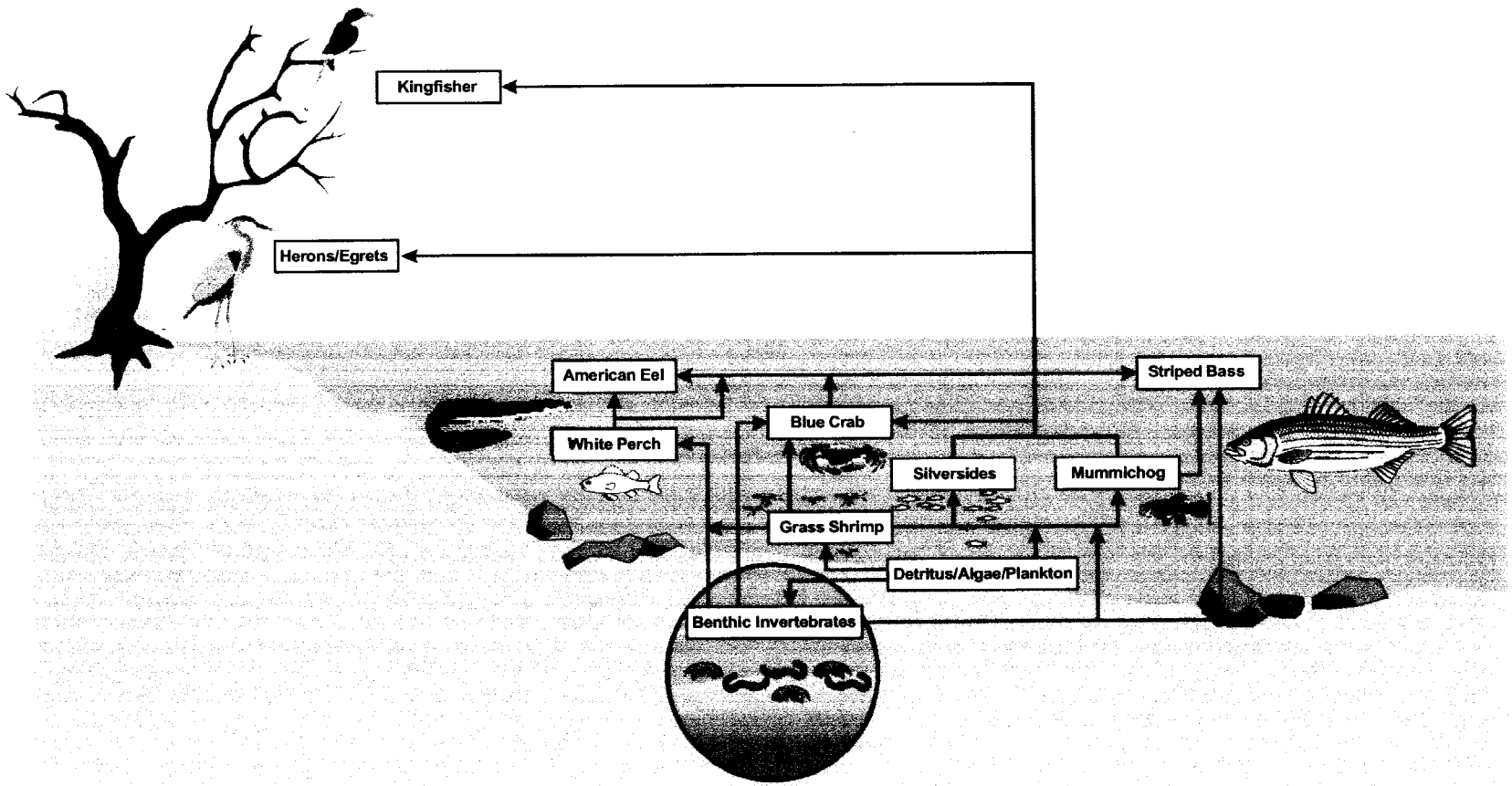

CONTAMINANT EXPOSURE PATHWAYS:

- Water
- Surface Sediments
- Food Web Interactions

CHEMICAL LAND HOLDINGS, INC.

PASSAIC RIVER STUDY AREA
ECOLOGICAL RISK ASSESSMENT PROTOCOL

CONCEPTUAL FOOD WEB FOR THE PASSAIC RIVER STUDY AREA

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 4

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