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REVISED WORK PLAN FOR WORK ASSIGNMENT NUMBER 0-071 FOR SITE-SPECIFIC
ECOLOGICAL AND CONTAMINANT DATA FOR OPERABLE UNIT 3 (OU 3) NSY
PORTSMOUTH VA
5/22/2000
LOCKHEED MARTIN

REC'D 6/1/00

REVISED WORK PLAN

FOR

WORK ASSIGNMENT NO. 0-071

**ATLANTIC WOOD INDUSTRIES, INC.
ECOLOGICAL RISK ASSESSMENT**

May 22, 2000

DRAFT

**REVISED WORK PLAN
ATLANTIC WOOD INDUSTRIES, INC
ECOLOGICAL RISK ASSESSMENT**

**Prepared for
U.S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESPONSE TEAM CENTER (ERTC)**

Date: May 22, 2000
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REAC Program Manager _____ Date: _____

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RESUBMITTAL

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Work Assignment Number: 0-071
Work Assignment Title: Atlantic Wood Industries, Inc. Ecological Risk Assessment
Work Assignment Manager: David Charters, Ph.D.
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Duration: June 15, 1999 thru May 31, 2000
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INTRODUCTION

Purpose

The purpose of this work assignment (WA) is to generate site-specific ecological and contaminant data for the Atlantic Wood Industries, Inc. (AWII), Operable Unit 3 (Elizabeth River sediments), Portsmouth, Virginia (VA), and generate an ecological risk assessment for the aquatic and terrestrial components of the site.

Background

Ecological Setting The AWII site is located on 19.2 hectares (ha) of land on the west bank of the southern branch of the Elizabeth River in Portsmouth, VA (Figure 1). Surface runoff from the site drains into the Elizabeth River, which is the primary aquatic habitat impacted by the site. The peripheral habitats along the southern branch of the river include intertidal mudflats, associated benthic habitats, shallow waters directly offshore from the site, and the waters and sediment of the Elizabeth River, both upstream and downstream from the site (Keystone Environmental Resources 1990). These areas provide habitats for a number of aquatic species, including benthic macroinvertebrates and anadromous, catadromous and estuarine fish species. The Norfolk Naval Ship Yard (NNSY) site, which surrounds the AWII site, potentially impacts both the Elizabeth River and Paradise Creek. The terrestrial areas associated with the NNSY site, and subsequently the AWII site, are comprised of prior landfill areas that are maintained as grassy fields and hedgerows (CH2M Hill 1998). The landfills are associated with wetland areas that convey surface runoff from the terrestrial areas into the wetlands, Paradise Creek and the Elizabeth River. Since the soils associated with these terrestrial areas are highly contaminated with polycyclic aromatic hydrocarbon (PAH), it is likely that this may be the greatest source of contaminated runoff into the peripheral wetland and aquatic habitats (NOAA 1992). The grassy, wooded, and hedgerow areas of the landfills provide habitat for birds, mammals and other wildlife (CH2M Hill 1998).

Paradise Creek is a tributary connected to the AWII site via a drainage ditch. It flows into the southern branch of the Elizabeth River and contains the largest marsh creek complex in Portsmouth (Keystone Environmental Resources 1990). The presence of reed grass is indicative of a disturbed wetland area, however, these marsh areas are mostly comprised of saltmarsh cordgrass. The two types of wetlands (reed grass and saltmarsh cordgrass communities) located in five different areas on the AWII site were identified as disturbed wetlands with little to moderate habitat value (NOAA 1992). Additional riparian habitat located off-site include six tidal tributaries that are associated with estuarine emergent marshes and stream banks (NOAA 1992). While these areas do not provide high value habitat, they do support small populations of wildlife (NOAA 1992).

The Elizabeth River consists of one main stem with three major branches. The eastern and southern branches of the river are lined by industry and shipyards while the western branch has few industries, relatively shallow channels and abundant natural marsh areas. The drainage area of the Elizabeth River is approximately 777 square kilometers (km²). The river has poor flushing characteristics resulting from a relatively flat topography and canal locks on the upper river, which limit freshwater input. The result is that sediment and pollutants tend to stay trapped within the river system (Elizabeth River Project 1996).

There are a variety of habitats located within the Elizabeth River watershed, which can be classified based on water depth and salinity. These habitat zones can be generally categorized as: upland zones; intertidal and littoral zones; shallow water zones; deep water zones; wetlands; tidal wetlands and areas of submerged aquatic vegetation (SAV) (Elizabeth River Project 1996). A variety of fish and wildlife species utilize these habitats with fisheries providing an important commercial component of the area. Blue crab (*Callinectes sapidus*) and eastern oyster (*Crassostrea virginica*) are two commercially and recreationally important species harvested in various areas of the river (NOAA 1992). However, because of contamination, a shellfish advisory issued in 1982, prohibits the collection of shellfish with the exclusion of blue crab, and is still in effect. Other important fish species are listed below.

The benthic community in the river consists of a variety of invertebrates including insects, annelids, molluscs and crustaceans. In addition to the benthic community, a variety of terrestrial and aquatic species are also known or expected to inhabit the site and the associated habitats (NOAA 1992). Some of the species that are expected to use the areas for food or habitat are listed below:

FISHERIES:

Blueback herring (<i>Alosa aestivalis</i>)	Atlantic silverside (<i>Menidia menidia</i>)
Alewife (<i>Alosa pseudoharengus</i>)	Hogchoker (<i>Trinectes maculatus</i>)
American shad (<i>Alosa sapidissima</i>)	Oyster toadfish (<i>Opsanus tau</i>)
Striped bass (<i>Morone saxatilis</i>)	Atlantic menhaden (<i>Brevoortia tyrannus</i>)
American eel (<i>Anguilla rostrata</i>)	Spot (<i>Leiostomus xanthurus</i>)
Bay anchovy (<i>Anchoa mitchilli</i>)	Atlantic croaker (<i>Micropogonias undulatus</i>)
Weakfish (<i>Cynoscion regalis</i>)	Spotted hake (<i>Urophycis regia</i>)
Mummichog (<i>Fundulus heteroclitus</i>)	Blue crab (<i>Callinectes sapidus</i>)
Striped killifish (<i>Fundulus majalis</i>)	Eastern oyster (<i>Crassostrea virginica</i>)

BIRDS:

Great blue heron (<i>Ardea herodias</i>)	American kestrel (<i>Falco sparverius</i>)
English sparrow (<i>Passer domesticus</i>)	Belted kingfisher (<i>Ceryle alcyon</i>)
Herring gull (<i>Larus argentatus</i>)	Snowy egret (<i>Egretta thula</i>)
Marsh wren (<i>Cistothorus palustris</i>)	Mockingbird (<i>Mimus polyglottos</i>)
Red-winged blackbird (<i>Agelaius phoeniceus</i>)	
Black-crowned night heron (<i>Nycticorax nycticorax</i>)	

MAMMALS:

Muskrat (<i>Ondatra zibethica</i>)	Meadow vole (<i>Microtus pennsylvanicus</i>)
Mink (<i>Mustela vison</i>)	Marsh rabbit (<i>Sylvilagus palustris</i>)
Norway rat (<i>Rattus norvegicus</i>)	Opossum (<i>Didelphis marsupialis</i>)
Rice rat (<i>Oryzomys palustris</i>)	Raccoon (<i>Procyon lotor</i>)

Site History The AWII site is located on the west bank of the highly industrialized southern branch of the Elizabeth River, in Portsmouth, VA (Figure 1). The site occupies 19.2 ha of relatively flat land, ranging in elevation from mean sea level (MSL) to 3 meters (m) above MSL. Some industrial activities still occur within the western half of the site, where treated and untreated wood is stored and concrete products are manufactured. Prior to the late 1980s, wood was processed and stored within the eastern portion of the site. These operations were terminated as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-related activities progressed, although structures from the former wood treatment facility still remain on site.

The area surrounding the site is highly industrialized, and the Elizabeth River has a long history of industrial use dating back to the 1600s (Nichols and Howard-Strobel 1991). Although the AWII site was the last active wood treating facility in the region, other wood treatment facilities operated along the Elizabeth River, both upstream and downstream of the site (NOAA 1992). Fires at the Eppinger and Russell wood treating facility upstream of the site led to releases of creosote and severe contamination of the river during at least two episodes in 1963 and 1967 (Bieri et al. 1983; Merrill and Wade 1985). Releases also occurred at AWII from creosote storage tanks along Elm Avenue (Worsham, personal communication). These tanks were removed in the mid-1980s. The Elizabeth River has been documented to have some of the highest sediment PAH contamination in the world (Bieri et al. 1983). The wood treatment facilities located along the river have been a suspected major source of this contamination.

The AWII facility operated from 1926 to 1991. Wood was treated with creosote and pentachlorophenol (PCP) under pressure in retort chambers. Wood treated with chromium copper arsenate (CCA) at another AWII facility was also stored on site. The U.S. Navy (USN) used portions of the site from 1943 to 1948 under a lease agreement with AWII.

Until 1972, waste preservative from the wood treatment process was stored at the southwest corner of the site in an unlined waste lagoon. The lagoon was 17 meters (m) wide, 45 meters long, 1.5 meters deep, and it held approximately 1,200 cubic meters of waste material. From 1972 to 1983 the lagoon was used to hold cuttings from the processed wood. A total of 560 cubic meters of contaminated wood chips were disposed of in the waste pit. The lagoon was backfilled in 1983 (ESC 1988).

Surface runoff from the site drains to the Elizabeth River via three National Pollutant Discharge Elimination System (NPDES)-permitted storm water outfalls (Outfalls 001 to 003) and the Elm Avenue storm sewer outfall. Runoff from the northeast portion of the site drains via the storm sewer outfall and Outfall 002 to a small drainage ditch inlet of the Elizabeth River between the site and the Jordan Bridge. Outfall 001 receives runoff flowing east across the southeast storage area. Outfall 003, located in the northwestern corner of the property, discharges runoff from the western portion of the site into an open ditch that leads to Paradise Creek and eventually discharges to the river (ESC 1988). The drainage ditch inlet from the Elizabeth River that runs along the northern boundary of the site also receives direct surface water runoff from the site.

Two groundwater-bearing zones identified beneath the AWII are the Upper Columbia aquifer, ranging between 5.5 m and 7.5 m and the Lower Yorktown-Eastover aquifer. A semi-confining unit of clay is located beneath the Columbia aquifer. The Columbia aquifer is considered a water-table aquifer recharged predominantly from precipitation (KER 1990). Within the eastern portion of the site, groundwater flows east towards the Elizabeth River. Average linear velocity calculated for flow beneath the eastern portion of the site is 27.5 m per year (KER 1990). Flow velocity information is not available for the western portion of the site.

Freshwater input to the Elizabeth River system is limited to storm water runoff and drainage from Lake Drummond, which is located in the Great Dismal Swamp. This flow is regulated through a series of locks and canals as part of the Intercoastal Waterway. Flows vary seasonally, but average winter peak and summer low discharges are only 10.2 and 0.7 cubic meters per second, respectively. Flow characteristics of the river are heavily influenced by tides.

Sources of Contaminants and Contaminants of Concern The primary sources of contaminants at the AWII site are associated with past activities and the raw materials used in the wood treatment process. Creosote and PCP are the major raw materials from which on-site contaminants originated. A special formulation of creosote and PCP (“creo-penta”) was used from the late 1950s to the early 1960s. PCP was also used at the site from 1972 to 1985, and its use was briefly resumed in spring 1991. Creosote had been used at the site since the 1950s. All wood treatment operations were suspended on 6 August 1991. Although timber treated with CCA continues to be stored at the site, this compound was never used in wood treatment operations at this facility (ESC 1988).

Creosote was originally stored in four above-ground storage tanks located along the south side of Elm Avenue. Tank 1 held 3.3 million liters (L) and the remaining three each held 1.7 million L. Before they were removed during 1985 and 1986, these tanks contained creosote and PCP, plus contaminated process water. They leaked into the storm sewer system that led into the inlet near Outfall 002. Beginning in 1975, creosote used for treatment was stored in smaller tanks located in the central portion of the site (ESC 1988).

Prior to 1972, the waste preservative left from the wood treatment process was stored at the southwest corner of the property in the “historic disposal area”. From 1972 to 1983, this area was used to hold cuttings from the processed wood. The area was backfilled in 1983 (ESC 1988). Additional information regarding past waste management practices is discussed in the Remedial Investigation (RI) (ESC 1988, KER 1990).

Based on the results of sampling conducted during the RI, it was determined that areas surrounding the treatment buildings contain the most heavily PAH-contaminated soils. Since these areas are near the river, they represent a potential source of contaminated runoff to the drainage ditch, inlet, and Elizabeth River. Sampling of sediments from these areas have documented extensive PAH contamination (KER 1990) and confirmed transport of contaminants to habitats of concern. Samples from five stations in the inlet indicated a decreasing gradient of PAH content. The head of the inlet is dominated by sand and gravel with 100 percent product (creosote) saturation of sediment pore water spaces (KER 1990). At sampling sites near the mouth of the inlet, the sediment texture changes from clayey sand to sandy clay, and concentrations ranged from residual to heavy product saturation of pore spaces. However, the finer-grained sediments allow more surface area for adsorption of PAHs, and therefore, greater apparent concentrations than gravel samples. In 1996, a removal action was conducted in the inlet, from the vicinity of the outfall to the low water line.

Soil Contaminants Of Potential Concern (COPCs)

The following BNAs were retained as COPCs because they had HQs greater than one when compared to the Dutch Soil Cleanup (Interim) Act threshold values: 1,2,4-trichlorobenzene, 1,4 dichlorobenzene, 2-methylphenol, 2,4-dimethylphenol, 3,3'-dichlorobenzidine, 4-methylphenol, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carbazole, dibenzofuran, diethylphthalate, di-n-butylphthalate, pentachlorophenol and phenol. Volatile organic compounds were also detected in several soil samples and include: 1,1-dichloroethene, 2-butanone, acetone, benzene, carbon disulfide, chlorobenzene, ethylbenzene, methylene

chloride, styrene, toluene, trichloroethene and total xylenes.

Several pesticides, PCBs, dioxin/furans and metals also had HQs greater than one when compared to the Dutch Soil Cleanup (Interim) Act threshold values. The following pesticides and PCBs had HQs greater than one or had no available benchmarks: 4,4'-DDD, 4,4'-DDE, 4,4'- DDT, alpha-chlordane, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, gamma-BHC (lindane), gamma-chlordane, PCB-1016, PCB-1248, PCB-1254 and PCB-1260. The following dioxins/furans were retained as COPC as no benchmarks were available for these contaminants: 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, 1,2,3,4,7,8-HxCDD, 1,2,3,4,7,8-HxCDF, 1,2,3,7,8,9-HxCDD, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 2,3,7,8-TCDF, OCDD and OCDF. All metals were retained as COPC with the exception of barium, chromium and cobalt.

Sediment COPCs

When compared to the U.S. EPA Region III benchmark values for the protection of flora and fauna, each of the low and high molecular weight PAHs, excluding 2-methylnaphthalene, was retained as a COPC for one of two reasons: 1) because a PAH had maximum concentration that exceeded the benchmark value or 2) because no benchmark was available for the contaminant. The following BNAs had maximum concentrations that exceeded the benchmark values: 2,4'-dimethylphenol, bis(2-ethylhexyl)phthalate, dibenzofuran, pentachlorophenol and phenol. The following BNA compounds were retained as COPC as they were detected but did not have benchmarks: 2,4-dinitrotoluene, carbazole and 4-nitrophenol. As 1,2-dichlorobenzene, 1,4-dichlorobenzene and butylbenzylphthalate had detection limits greater than the benchmark for sediments, these compounds must also be retained as COPC. The following VOCs were retained as COPC: acetone and chloroform.

The following pesticides had HQs greater than one: 4,4'-DDD, 4,4'-DDE, 4,4'- DDT, alpha-chlordane, dieldrin and gamma-chlordane. All TAL metals were retained as COPC with the exception of antimony, manganese, silver and thallium.

Water COPCs

Samples (surface water and sediment) were not analyzed for tributyltin (TBT) during remedial investigations previously conducted at the AWII site or the Norfolk Naval Shipyard. As a result, TBT was not included as a contaminant of potential concern in the screening-level ERA. However, substantial evidence exists indicating that TBT is present in the Elizabeth River and is bioavailable.

Only one semi-volatile compound, di-n-butylphthalate, had maximum concentrations that resulted in an HQ greater than one. No other PAHs, BNAs or VOCs were detected or had maximum concentrations that exceeded the benchmark values in water samples.

No pesticides or PCBs had HQs greater than one when compared to the U.S. EPA Region III benchmark values for the protection of flora and fauna. The following TAL metals had HQs greater than one and thus will be retained as COPCs: aluminum, calcium, copper, cyanide, iron, lead, magnesium, manganese, mercury, potassium, sodium and zinc.

General Assumption

The objective of this project is to provide technical support to the U.S. Environmental Protection Agency/Environmental Response Team Center (U.S. EPA/ERTC) and U.S. EPA Region III with evaluating the ecological risks associated with the AWII site, Portsmouth, VA. This document reiterates identified data gaps to be filled to evaluate current ecological risk issues associated with the site. This document encompasses Steps 3 and 4 of the 8 Step EPA risk assessment guidance (U.S. EPA 1997). The field investigation to be conducted under this work plan (WP) is directed at both the aquatic and terrestrial aspects of the full ecological risk assessment (ERA). The work assignment manager (WAM) will be the liaison to the public during all field activities. To the extent possible, specific details of the sampling design are presented below. Should field conditions require a modification of the WP, the changes in scope will be documented in field log books or field change forms, signed by the Task Leader (TL) and WAM. The change in scope will be reflected in an amendment to the work assignment (WA) and a revision in this WP. The schedule for this project, as well as other ongoing projects, may be modified to accommodate the changes in scope. Similarly, the costs (including labor and materials) required to complete this project are likely to change and will be reflected in the revised WP. Any alterations will be documented in the final report and will be made in a manner consistent with Step 5 of the EPA guidance (U.S. EPA 1997).

TECHNICAL APPROACH

Scope of Work

The scope of work for this project includes the collection and evaluation of both aquatic and terrestrial environmental samples. A list of tasks for the project are presented below. All data collected and evaluated are to be used in the preparation of a baseline ecological risk assessment (ERA).

- Task 1: Collect the existing information to determine data gaps which remain for the Elizabeth River system and associated areas.
- Task 2: Collect aquatic field samples to include: surface water, sediment, sediment profile imagery, fish, benthic macroinvertebrates.
- Task 3: Collect terrestrial field samples to include: soil, plants, small mammals.
- Task 4: Evaluate toxicity/bioavailability of sediment and soil contaminants with toxicity/bioaccumulation tests.
- Task 5: Evaluate benthic macroinvertebrate community with sediment profile imagery (SPI).
- Task 6: Evaluate concentrations of contaminants in abiotic and biotic matrices of samples collected.
- Task 7: Generate a baseline ecological risk assessment.
- Task 8: Prepare technical presentations.

Investigative Strategy

Screening Risk Assessment and Preliminary Problem Formulation A screening ecological risk assessment was conducted to determine the risk associated with the exposure of biota to site-related contaminants. The following steps were completed for this risk assessment:

- (1) A literature search was conducted to locate life history information for selected indicator species, to determine ecotoxicological effects of the site contaminants, and to locate bioconcentration factors for site contaminants.
- (2) A preliminary problem formulation was prepared to evaluate the potential risk to ecological receptors. This assessment consisted of the following steps:
 - Exposure scenarios were determined based on site contaminant levels, the extent and magnitude of contamination, and the toxicological mechanisms of the contaminants.
 - Indicator species were selected based on species present and/or potentially present on site, the availability of toxicity information from the literature, and the potential for exposure to site contaminants based on habitat use or behavior.
 - Exposure pathway(s) were determined for each indicator species.
 - Exposure and effect profiles were written for each indicator species and each site contaminant.

In addition, a desktop risk evaluation was performed utilizing the parameters outlined in the preliminary problem formulation and enhanced by gathering the following information:

- A risk characterization was conducted which will involve the calculation of hazard quotients for each species for a range of exposure scenarios.

Based on the results of the screening ecological risk assessment, the contaminants of potential concern identified were associated with the terrestrial and aquatic ecosystem. In addition, a set of data requirements were established for each of the assessment endpoints. These data requirements comprise the additional data necessary to complete a baseline risk assessment. The sections below describe each assessment endpoint and the potential data requirements necessary to evaluate the assessment endpoint.

Data Requirements

Listed below are the refined assessment endpoints developed for this site. These assessment endpoints were identified based on the habitat types present, the type of contaminants, and the potentially present species. Following the assessment endpoint are the testable hypotheses and measurement endpoint(s) (measures of exposure and effects) (Table 1). The assessment endpoints may have more than one measurement endpoint. For those assessment endpoints having multiple measurement endpoints, a weight-of-evidence approach will be used in the risk assessment which allows the results of the measurement endpoints to be integrated into a single conclusion. A weight-of-evidence evaluation implies that there are multiple lines of evidence, but

not all lines of evidence have equal strength. When multiple lines of evidence for a particular assessment endpoint lead to the same conclusion, there is an implied weighing and the level of confidence increases in the risk estimate. If multiple lines generate apparent conflicts, then the weights relative to the mechanisms of toxicity will be used in evaluating the level of confidence in the risk estimate. A discussion of the relative weighting of the measurement endpoints will be presented in the final ecological risk assessment. Similarly, some measurement endpoints will be utilized for multiple assessment endpoints (i.e. concentration of COCs in soil, sediment, and surface water).

Assessment Endpoint #1: Viability of the benthic invertebrate community A viable benthic invertebrate community (where viable may imply a normally distributed, species rich community) is imperative for the maintenance of successful aquatic and terrestrial community. Benthic invertebrates are especially susceptible to exposure to chemical contamination in the Elizabeth River and Paradise Creek because they live and feed directly in the sediment, where most contaminants are concentrated. Benthic invertebrate communities are heterogeneous assemblages of organisms that inhabit the bottom substrate of freshwater, estuarine, and marine water bodies. Benthic organisms range in size from microscopic to relatively large macroscopic individuals and, based on size, may be artificially divided into two major groups. Macrobenthos consist of organisms retained by a number 500 sieve (0.5 millimeter mesh) and microbenthos consist of individuals that pass through the sieve. The taxa that comprise the macro- and microbenthos may be similar and/or consist of different sized individuals of the same taxa. The major invertebrate groups found within benthic habitats such as that of the study area include annelids, molluscs and crustaceans.

The benthic community may inhabit sediment, rock, submerged debris, aquatic vegetation, and root masses, and the composition of the community is strongly related to the nature of the substrate. However, while substrate may dictate the distribution and abundance of benthic infauna, benthic epifauna (e.g., eastern oyster) are primarily limited by space. The composition and community structure of the benthic infaunal community are largely dictated by the nature of the substrate. Particle size distribution, organic matter content, and sediment thickness are sediment characteristics that determine the species that will inhabit a particular environment. The community of a fine textured, soft deep sediment is largely infaunal and exists within the deposits whereas the community of a coarse-textured, shallow sediment inhabits the surface of the substrate. Within the sediment are layers that relate to oxidation-reduction reactions that also affect the community. Other abiotic habitat characteristics such as water depth, nutrient availability and salinity as well as biotic characteristics such as primary production, predation, and competition are also significant.

Within the benthic community, it is important to distinguish between the ecological roles of epifauna, organisms that live on the bottom, and infauna, organisms that live in the sediment. Typical estuarine epifaunal communities consist of sessile organisms such as barnacles, oysters, sponges and tube building animals. Typical infaunal communities are comprised of polychaete worms, nemertean worms, bivalve molluscs, and echinoderms such as sea cucumbers. Most epifauna are suspension feeders, which involves pumping large quantities of water across the gills to obtain food. Suspension feeding may lead to the concentration of contaminants in the tissue, potentially affecting the health of the organisms while creating an exposure pathway for predators utilizing epifauna for food. Some infauna are also suspension feeders and feed by pumping water through their burrows or by extending a feeding apparatus above the surface of the sediment. Infauna may also be deposit feeders who actively burrow into organic rich sediment to feed. The burrowing activity (known as bioturbation) of both deposit and suspension feeders aerates and destabilizes the sediment and regenerates inorganic nutrients. Disturbance of sediment is of special concern in contaminated habitats, as burrowing may potentially mobilize contaminants that are adsorbed to the sediment.

It is interesting to note that suspension and deposit feeders are seldom observed living together in an estuarine system. The trophic commensalism hypothesis suggests that the turbidity created by deposit feeders results in increased sediment suspension which in turn clogs the feeding apparatus of the suspension feeders (Day et al. 1989). This hypothesis serves to illustrate the complex dynamics and interactions of the benthic invertebrate community. Such interactions are not limited to those only within the benthos itself. Benthic invertebrates are important links in the trophic sequence of aquatic communities and they consume bacteria that inhabit the benthic environment. Benthic invertebrates then serve as food for bottom-feeding fish and other benthic invertebrates, such as carnivorous epifauna (e.g., some polychaetes, decapods). Carnivorous epifauna in turn also serve as food items for bottom-feeding fish. Therefore, benthic invertebrates are an important link in the aquatic food chain and a decline in benthic invertebrate populations could result in population declines of fish that feed upon them and population explosions of bacteria.

Benthic organisms play several other important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the open water or transported from external sources. In doing so, benthic invertebrates play an integral role in nutrient and energy cycling in aquatic environments. Since the number of organisms supported at any position in a food chain depends on the limits of the energy supply available, the role of energy transfer played by benthic invertebrates is integral to the productivity of an aquatic ecosystem. Furthermore, since the energy and nutrient cycles are delicately balanced, a depauperate benthic invertebrate community would have detrimental impacts on the balance of energy within that ecosystem.

Several benthic taxa are also important commercial and recreational species. A decline in the population of these benthic invertebrate species can adversely impact certain commercial and recreational industries, such as clamming. This can have a detrimental effect on the economy of certain localities that rely on such industries for revenue and tourism.

Due to the ecological roles played by benthic invertebrates and their high potential for exposure to contaminants in the sediment, as well as their potential economic value, benthic invertebrates are of particular concern at the AWII site. Because aquatic ecosystems typically exhibit a fairly high resilience (i.e., the speed with which a perturbed system returns to equilibrium), protection of benthic species richness and diversity ultimately ensures the stability of not only the benthic community but also the stability of the wetland ecosystem as a whole.

Testable Hypotheses:

- The diversity and abundance macroinvertebrate community on-site is not significantly less than the numbers at the proposed reference locations.
- The toxicity of COCs in sediment on-site is not significantly greater than at the reference locations.
- The concentration of bioaccumulated COCs are not greater than toxicity effects levels.
- The concentration of COCs in sediment and surface water on-site are not greater than benchmark values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in sediment and surface water.
- Field survey the benthos qualitatively using sediment profile imaging.
- Evaluate benthic macroinvertebrate quantitatively with ponar grab samples.
- Determine the bioavailability of COCs by conducting *in situ* caged bivalve bioaccumulation studies.
- Evaluate the toxicity of COCs in sediment through toxicity testing with amphipods (*Leptocheirus plumulosus*) and polychaetes (*Neries virens*).

Assessment Endpoint #2: Viability of the fish community The second assessment endpoint is aimed at the viability of the fish populations in the Elizabeth River. Fish serve a vital role in aquatic ecosystems because they function in nutrient and energy transfer within the river. Specifically, fish act as a link between aquatic and terrestrial ecosystems and between the benthic and pelagic environments within aquatic systems. Fish that consume benthic organisms are consumed by other fish, which are in turn consumed by terrestrial organisms such as mammals and birds. These predator-prey interactions represent a transfer of energy from and within the aquatic ecosystem. Since the number of organisms supported at any position in a food chain depends on the limits of the energy supply available, the role of energy transfer played by fish is integral to the productivity of an aquatic ecosystem. Furthermore, since the energy and nutrient cycles are delicately balanced, even a small decline in the fish population of an aquatic ecosystem has detrimental impacts on the balance of energy within that ecosystem.

Fish typically comprise a large proportion of the biomass of an aquatic ecosystem and are in a wide range of trophic positions (e.g., primary consumers/carnivores, herbivores, planktivores). Fish serve as predators at various trophic levels, thereby exerting some control over energy and material flows. For example, top consumers/carnivores may prey on mid-level carnivores, which in turn prey on herbivores, etc. Common prey items for fish include zooplankton, periphyton, benthic invertebrates, and other fish. In addition, fish serve as links between lower trophic levels and higher ones where the top predators are mammals, birds and humans. A viable fish population (where viable may imply a normally distributed, species rich community) is therefore imperative for the maintenance of successful aquatic and terrestrial community. Mummichugs (*Fundulus heteroclitus*) represent a large proportion of the biomass of tidally influenced rivers and creeks, and provide ample numbers for collection and statistical power of accumulation data analyses.

Fish are also important recreationally and commercially. It has been shown that declines in fish populations resulting from chemical contamination have adversely impacted commercial and recreational fishing industries in many areas of the country. In some areas, this has had a major impact on local economies due to losses from decreased tourism and decreased revenues from the sale of fish.

Testable Hypotheses:

- The toxicity of COCs in sediment on-site is not significantly greater than at the reference locations.
- The concentration of COCs in sediment and surface water on-site are not greater than benchmark values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in sediment and surface water.
- Determine the concentration of COCs in benthic invertebrate tissues (*Crassostrea virginica*).
- Determine the concentration of COCs in fish tissues (*F. heteroclitus*).
- Evaluate the toxicity of COCs in surface water and sediment through toxicity testing with the silverside (*Menidia beryllina*).

Assessment Endpoint #3: Viability of the soil invertebrate community Terrestrial soil ecosystems are populated by high numbers of species, individuals, and trophic levels. The soil community has an important influence on the terrestrial environment because of the abundance of individuals, taxa, feeding habits, and ecological functions. Although the soil community is typically considered a separate ecosystem it is intimately connected to the terrestrial ecosystem through a common energy source that includes living and dead vegetation, animal biomass, and feces.

The most outstanding characteristic of the soil as a habitat is the relatively stable chemical and structural environment it provides. Until the moisture drops below a critical point, the soil atmosphere remains at or near saturation, and the soil temperature remains within a relatively narrow range. The low penetrability of soil restricts movement to most taxa except to burrowing species such as earthworms. In addition, soil pore space is a critical factor that determines the nature of the living space, humidity, and gaseous condition of the environment. Spaces between surface litter, cavities walled off by soil aggregates, pore spaces between individual soil particles, root channels, and fissures provide potential habitats for soil invertebrates. Such variability of conditions creates a variety of habitats, which is reflected by the high taxonomic diversity of the soil community.

The distribution of taxa in different soils is determined by soil characteristics, and there is a relationship between the average size of soil spaces and the fauna inhabiting them. Most soil fauna are limited to pores and cavities larger than themselves. Large species of mites inhabit loose soils with crumb structure, whereas smaller forms inhabit more compact soils. Larger soil species are confined to upper layers where soil interstices are the largest. Water in pore spaces is essential because the majority of soil fauna are active only in the aqueous microhabitat. Soil water is usually present as a thin film lining the surface of soil particles that contains bacteria, unicellular algae, protozoa, rotifers, and nematodes. Most of these organisms are restricted in their movement by the thickness and shape of the water film. Many small species and immature stages of larger species may be completely immobilized by a film of water. Nematodes are less restricted because they can distort the water film by muscular movements. Additionally, if the water film dries up, some nematode species encyst or enter a dormant state. Other species are highly susceptible to desiccation and avoid it by burrowing deeper into the soil. In contrast, excess water and lack of aeration are detrimental to many soil taxa animals, particularly when air spaces become flooded with deoxygenated water and produce a zone of oxygen shortage. Soil acidity is also an important habitat parameter for soil taxa. For example, in northern hardwood forests, earthworms are most abundant both in species and in numbers when the pH is between 4.1 and 5.5 units, whereas mites and springtails can exist in very acidic conditions.

The interrelations of soil organisms are complex, and within the upper layers of the soil, energy flows through a series of trophic levels similar to those of surface communities. The Oligochaetes are the most prominent soil taxa and include two common families, the *Lumbricidae* (earthworms) and the *Enchytraeidae* (white or pot worms). Earthworm activity consists mainly of burrowing, ingestion and partial breakdown

of organic matter, and the egestion of surface or subsurface casts. Soil is ingested during burrow construction, mixed with intestinal secretions, and passed out either as aggregated castings on or near the surface or as a semiliquid in intersoil spaces along the burrow. Casts contain a larger proportion of fine soil particles than uningested soil as well as higher total nitrogen, organic carbon, exchangeable calcium and magnesium, available phosphorus, and pH. Subsurface soil is brought to the top and organic matter is pulled down and incorporated into the subsoil to form soil aggregates. These aggregates result in a more open structure in heavy soil and bind particles of light soil together.

Testable Hypotheses:

- The toxicity of COCs to invertebrates in soil on-site is not significantly greater than the reference locations.
- The concentration of COCs in soil on-site are not greater than the benchmark values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil collected from on-site and at reference locations.
- Evaluate the toxicity and accumulation of COCs in soil through solid-phase testing using earthworms (*Eisenia foetida*).
- Evaluate the toxicity of COCs in soil through comparison with toxicity reference values.

Assessment Endpoint #4: Viability of the insectivorous small mammal community The fourth assessment endpoint is aimed at viable insectivorous mammal populations along the Elizabeth River. Insectivorous mammals are mid-trophic level organisms that rely primarily on insects as forage. The foraging behavior of insectivorous mammals may represent a pathway by which nutrients and energy are transferred from lower to higher links in the food chain. For example, insects are consumed by mid-level insectivores (shrews, *Soricidae*) which are in turn consumed by an upper level consumer (northern harrier, *Circus cyaneus*). Insectivores may also transfer energy from the detrital food chain to the grazing food chain in that insectivores may consume detritivores (e.g., millipedes) thereby providing a link between the two chains.

In addition to contributing to terrestrial energy pathways in an estuarine system, the predation of insects regulates insect population size, and species abundance and diversity. Conversely, insectivorous mammals also serve as prey items for upper trophic level predators. Predation by and of insectivorous mammals therefore contributes to balanced populations of insects and other terrestrial organisms, a balance that is essential for normal ecosystem functioning.

Since insectivorous mammals are mid-level predators, they are especially susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed. The higher the trophic level of the food chain, the more concentrated the contaminants in the tissues become due to a process known as biomagnification. In a terrestrial system, small mammals, such as moles, are common predators of insects. Insects have been shown to accumulate contaminants that are present in terrestrial ecosystems. Therefore, mammals that consume insects have the potential to accumulate large concentrations of contaminants in their tissues.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The body burden of COCs in small mammal species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil collected from locations on-site.
- Determine the concentration of COCs in selected food items of modeled receptors collected from locations on-site.
- Determine the concentration of COCs in small mammals collected from locations on-site.
- Through a food chain exposure model for the shrew, evaluate the toxicity of COCs on-site via dietary exposure by comparison to toxicity reference values.

Assessment Endpoint #5: Viability of the aquatic feeding small mammal community The fifth assessment endpoint is aimed at viable aquatic feeding mammal populations along the Elizabeth River. Aquatic feeding mammals are upper trophic level organisms that rely primarily on fish as forage. Foraging behavior of piscivorous mammals represents a pathway by which nutrients and energy are transferred from aquatic to terrestrial ecosystems. There is a close relationship between terrestrial and aquatic systems due to the nutrient and energy flow between these systems. Nutrients enter aquatic ecosystems via surface water runoff, input via streams, and water infiltration through the soil. Energy enters aquatic ecosystems via sunlight and other biological inputs such as detritus and leaves. Nutrients and energy are transferred from aquatic to terrestrial ecosystems via biological outputs. An example of a biological output is the act of a piscivorous mammal consuming fish. Nutrient and energy cycles between aquatic and terrestrial systems are delicately balanced. Since nutrients and energy are limiting factors in the production of an ecosystem, the transfer of energy from an aquatic to a terrestrial system is essential. Piscivorous mammals provide one mechanism by which nutrients and energy are transferred from aquatic to terrestrial ecosystems and are therefore important in the maintenance of balanced nutrient and energy cycles.

In addition to contributing to aquatic and terrestrial energy pathways in an estuarine system, the predation of fish regulates fish population size and species abundance and diversity. Conversely, aquatic feeding mammals also serve as prey items for upper trophic level predators. Predation by and of aquatic feeding mammals therefore contributes to balanced populations of fish and other aquatic and terrestrial organisms, a balance that is essential for normal ecosystem functioning.

Since aquatic feeding mammals are upper trophic level predators, they are especially susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed. The higher the trophic level of the food chain, the more concentrated the contaminants in the tissues become due to a process known as biomagnification. In a freshwater system, mammals are common predators of fish. Fish have been shown to accumulate contaminants that are present in aquatic ecosystems. Therefore,

mammals that consume fish have the potential to accumulate large concentrations of contaminants in their tissues.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of model receptors to COCs on-site is not greater than toxicity reference values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil, sediment, and surface water on-site.
- Determine the concentration of COCs in selected food items (*F. heteroclitus*) of modeled receptors collected from locations on-site.
- Through food chain models for the mink (*Mustela vison*) and raccoon (*Procyon lotor*), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Assessment Endpoint #6: Viability of the herbivorous small mammal community The sixth assessment endpoint is aimed at viable herbivorous mammal populations along the Elizabeth River. Herbivorous mammals are organisms that rely primarily on vegetation as forage. The role of herbivores is essential to an ecosystem as they transfer the energy available in plant tissue (primary producers) to animal tissue, thereby supporting upper trophic levels.

In addition to contributing to terrestrial energy pathways in an estuarine system, the foraging by herbivores on vegetation regulates vegetation density, and species abundance and diversity. Conversely, herbivorous mammals also serve as prey items for upper trophic level predators. Predation by and of herbivorous mammals therefore contributes to a balanced vegetative community, in terms of species diversity and abundance, while regulating upper trophic level terrestrial organisms. This balance is essential for normal ecosystem functioning.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of model receptors to COCs on-site is not greater than toxicity reference values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil, sediment, and surface water on-site.
- Determine the concentration of COCs in selected food items of modeled receptors on-site.

- Through food chain exposure models for the meadow vole (*Microtus pennsylvanicus*), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Assessment Endpoint #7: Viability of the insectivorous avian community The seventh assessment endpoint is aimed at viable insectivorous bird populations along the Elizabeth River. Insectivorous birds are mid-trophic level organisms that rely primarily on insects as forage. The foraging behavior of insectivorous birds may represent a pathway by which nutrients and energy are transferred from lower to higher links in the food chain. For example, insects are consumed by mid-level insectivores which are in turn consumed by an upper level consumer. Insectivores may also transfer energy from the detrital food chain to the grazing food chain in that insectivores may consume detritivores (e.g., millipedes) thereby providing a link between the two chains.

In addition to contributing to terrestrial energy pathways in an estuarine system, the predation of insects regulates insect population size, and species abundance and diversity. Conversely, insectivorous birds also serve as prey items for upper trophic level predators. Predation by and of insectivorous birds therefore contributes to balanced populations of insects and other terrestrial organisms, a balance that is essential for normal ecosystem functioning.

Since insectivorous birds are mid-trophic level predators, they are susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed. The higher the trophic level of the food chain, the more concentrated the contaminants in the tissues become due to a process known as biomagnification. In a terrestrial system, birds are common predators of insects. Insects have been shown to accumulate contaminants that are present in terrestrial ecosystems. Therefore, birds that consume insects have the potential to accumulate large concentrations of contaminants in their tissues.

Some birds are resident year-round and some are migratory. The variable mobility of potential avian receptors, relatively large home range, variable diet, and often seasonal residency, suggest that the potential for exposure and the identification of specific exposure routes and concentrations are associated with some uncertainty. Nonetheless, the avian insectivorous community is of particular concern due to the potential for exposure and adverse effects in a higher trophic level organism, their role in regulating populations, and their role in energy transfer.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of model receptors to COCs on-site is not greater than benchmark values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil, sediment, and surface water on-site.
- Determine the concentration of COCs in selected food items (earthworms and *Neries virens*) of modeled receptors on-site.
- Through food chain exposure models for the American robin (*Turdus migratorius*), English

sparrow (*Passer domesticus*), Mockingbird (*Mimus polyglottos*), red-winged blackbird (*Agelaius phoeniceus*), and marsh wren (*Cistothorus palustris*), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Assessment Endpoint #8: Viability of the aquatic feeding avian community The eighth assessment endpoint is aimed at viable aquatic feeding bird populations along the Elizabeth River. Aquatic feeding birds are upper trophic level organisms that rely primarily on fish as forage. Foraging behavior of aquatic feeding birds represents a pathway by which nutrients and energy are transferred from aquatic to terrestrial ecosystems. There is a close relationship between terrestrial and aquatic systems due to the nutrient and energy flow between these systems. Nutrients enter aquatic ecosystems via surface water runoff, input via streams, and water infiltration through the soil. Energy enters aquatic ecosystems via sunlight and other biological inputs such as detritus and leaves. Nutrients and energy are transferred from aquatic to terrestrial ecosystems via biological outputs. An example of a biological output is the act of an aquatic feeding bird consuming fish and/or benthic invertebrates. Nutrient and energy cycles between aquatic and terrestrial systems are delicately balanced. Since nutrients and energy are limiting factors in the production of an ecosystem, the transfer of energy from an aquatic to a terrestrial system is essential. Aquatic feeding birds provide one mechanism by which nutrients and energy are transferred from aquatic to terrestrial ecosystems and are therefore important in the maintenance of balanced nutrient and energy cycles.

In addition to contributing to aquatic and terrestrial energy pathways in an estuarine system, the predation of fish and benthic invertebrates regulates fish and invertebrate population size, and species abundance and diversity. Conversely, aquatic feeding birds also serve as prey items for upper trophic level predators. Predation by and of aquatic feeding birds therefore contributes to balanced populations of fish and other aquatic and terrestrial organisms, a balance which is essential for normal ecosystem functioning.

Since aquatic feeding birds are upper trophic level predators, they are especially susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed. The higher the trophic level of the food chain, the more concentrated the contaminants in the tissues become due to a process known as biomagnification. In a freshwater system, birds are common predators of fish. Fish have been shown to accumulate contaminants that are present in aquatic ecosystems. Therefore, birds that consume fish have the potential to accumulate large concentrations of contaminants in their tissues.

Some birds are resident year-round and some are migratory. The variable mobility of potential avian receptors, relatively large home range, variable diet, and often seasonal residency, suggest that the potential for exposure and the identification of specific exposure routes and concentrations are associated with some uncertainty. Nonetheless, the avian aquatic feeding community is of particular concern due to the potential for exposure and adverse effects in a higher trophic level organism, their role in regulating populations, and their role in energy transfer.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of model receptors to COCs on-site is not greater than toxicity reference values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in sediment and surface water collected on-site.
- Determine the concentration of COCs in selected food items (*F. heteroclitus*) of modeled receptors on-site.
- Through food chain exposure models for the black-crowned night heron (*Nycticorax nycticorax*), herring gull (*Larus argentatus*), great blue heron (*Ardea herodias*), belted kingfisher (*Megasceryle alcyon*), and Snowy egret (*Egretta thula*), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Assessment Endpoint #9: Viability of the carnivorous avian community The ninth assessment endpoint is aimed at viable carnivorous bird populations along the Elizabeth River. Carnivorous birds are upper trophic level organisms that rely primarily on animal tissue, such as small mammals, as forage. The foraging behavior of carnivorous birds may represent a pathway by which nutrients and energy are transferred from lower to higher links in the food chain. For example, a carnivorous bird (upper trophic level) may feed on an herbivorous small mammal (mid-level) which in turn feeds on vegetation (primary producer).

In addition to contributing to terrestrial energy pathways in an estuarine system, the predation of small mammals regulates mammal population size, and species abundance and diversity. Conversely, carnivorous birds may also serve as prey items for upper trophic level predators. Predation by and of carnivorous birds therefore contributes to balanced populations of small mammals and terrestrial organisms, a balance that is essential for normal ecosystem functioning.

Since carnivorous birds are upper trophic level predators, they are especially susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed. The higher the trophic level of the food chain, the more concentrated the contaminants in the tissues become due to a process known as biomagnification. In a terrestrial system, birds are common predators of small mammals. Small mammals have been shown to accumulate contaminants that are present in terrestrial ecosystems. Therefore, birds that consume small mammals have the potential to accumulate large concentrations of contaminants in their tissues.

Some birds are resident year-round and some are migratory. The variable mobility of potential avian receptors, relatively large home range, variable diet, and often seasonal residency, suggest that the potential for exposure and the identification of specific exposure routes and concentrations are associated with some uncertainty. Nonetheless, the carnivorous avian community is of particular concern due to the potential for exposure and adverse effects in a higher trophic level organism, their role in regulating populations, and their role in energy transfer.

Testable Hypotheses:

- The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.
- The dietary exposure of model receptors to COCs on-site is not greater than toxicity reference values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil collected from locations on-site.
- Determine the concentration of COCs in selected food items (small mammals) of modeled receptors on-site.
- Through food chain exposure models for the northern harrier (*C. cyaneus*), American kestrel (*Falco sparverius*) and great horned owl (*Bubo virginianus*), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Assessment Endpoint #10: Viability of the vegetative community Wetland plants are central to the structure and function of the wetland. They are a primary food source for many wetland animal species, including developing fish and amphibian larvae. These plants provide habitat and cover for wetland animals, help control the hydrology of the wetland, promote nutrient cycling and stabilization, are a source of oxygen, and help hold the wetland soils during floods. The intimate association between the physical aspects of the wetland and plant biology illustrates the integrated nature of the wetland system. Cover plants usually provide some food directly for the invertebrate life they harbor. Except for submergent vegetation and associated invertebrates, food is generally distributed in zones or patches determined by cover plant distribution. Vegetation is also critical in providing isolation between nesting pairs of waterfowl, thus often determining breeding density and production. Finally, it satisfies requirements of songbirds for nest sites, nesting materials and songposts.

Life-form or physiognomy is more suitable than species composition as a descriptor of the vegetation component of wildlife habitat. It has been demonstrated that bird species diversity can be explained as a function of foliage height diversity and that plant species are relatively unimportant except for birds with extremely specialized habits like crossbills. Life-form is also a key determinant of waterfowl habitat; waterfowl place nests in vegetation consisting of different plant species but rarely of different physiognomy.

Testable Hypotheses:

- The concentration of COCs in soil on-site are not greater than the benchmark values.

Measurement Endpoints (Exposure and Effects):

- Determine the concentration of COCs in soil.
- Evaluate the toxicity (seed germination, biomass, and root elongation) and accumulation of COCs in soil through solid-phase testing using plants (*Brassica*).
- Evaluate the toxicity of COCs in soil, sediment, and surface water through comparison with toxicity reference values.

Terrestrial Sampling

A field investigation is necessary to collect the information described above for use in a baseline risk assessment. This investigation will involve the collection of soil, sediment, water, and biota (Table 2). A

total of 24 sampling locations have been selected (3-terrestrial and 21-aquatic) (Figure 2). In addition to chemical analyses, some physical samples will be analyzed using toxicity testing. A description of each task is described in detail below.

Habitat Evaluation A qualitative survey of the habitat will be conducted. Dominant taxa and broad community types will be identified describing the general extent of the communities present.

Sampling Locations The study area includes the AWII property. There will be three sites chosen for small mammal trapping, including the reference site. Other terrestrial monitoring samples such as soil and vegetation are to be co-located with the small mammal collection, in addition to other selected sites.

Soil Sampling Surficial soil (0 to 15 centimeters, (cm), below ground surface) will be collected from sites coinciding with the small mammal grid and vascular plant collections using a dedicated disposable plastic trowel or appropriately decontaminated stainless steel trowel per ERTC/REAC SOP #2012, *Soil Sampling*. Individual grabs will be placed into a 56.8 (L) stainless-steel bucket and homogenized. Aliquots for laboratory analyses will be dispensed into appropriate sample containers and all unused sample material will be returned to the site.

The number of soil samples to be collected for this project are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Terrestrial Plant Sampling

Vascular Plant Survey Aerial photographs of the study area will be obtained and used to determine current status in major vascular plant types. Vegetation cover mapping of the site will be conducted with the objective of providing qualitative information on the composition and spatial orientation of the plant communities on the site, for correlation with exposure pathway evaluation. Plant communities will be delineated visually, estimating distances from landmarks. Dominant cover will be marked on an aerial photo and field verification will be documented through sketches made in personal logbooks. Visual estimates will also be made on the amount of bare areas. The relative species composition of vascular plant community will be made during the terrestrial portion of the investigation.

Plant Tissue Residue Analysis Vegetation will be collected by hand for residue analysis per ERTC/REAC SOP #2038 *Vegetation Assessment Field Protocol*. The most abundant taxa, or taxa otherwise important in the food web, observed at all sampling locations will be targeted for residue analysis. Three samples will be collected from within each area and each sample will consist of vegetation collected from grabs secured from the areas selected for soil sampling, from within the small mammal grid. The above ground portion of plants from the soil sampling area will be collected by cutting the stems at the soil surface with a decontaminated knife or shears. The plants will be cut into 15 cm lengths and packaged in appropriate sample containers.

The number of vegetation samples to be collected for this project are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Small Mammal Trapping

Small Mammal Survey A small mammal community survey will be conducted using trapping techniques per ERTC/REAC SOP #2029, *Small Mammal Sampling*, and ERTC/REAC SOP # 3021, *Procedure for Personal Protection against Hantavirus Infection while Trapping, Handling, and Processing Small Mammals*. Trap locations will be guided by the results of the previous investigation and the physical habitat available.

A combination of traps (e.g., Museum Special and Sherman Live Traps) will be set in high grass or bushy areas and along edge habitat within each of the sampling areas. The traps will be set in grids, with each line consisting of a mix of trap types. The number of lines per grid and the grid orientation will be dependent on available habitat. Individual traps will be set in locations that offer the optimal chance for trap success and will be baited with a rolled oat and peanut butter mixture. The number of traps set and the duration of the effort will be determined by the availability of existing habitat and trap success. Initially, 100 traps will be set in each area for three nights, resulting in approximately 900 trap-nights.

All traps will be baited and checked for success following an appropriate duration of time. Traps will be checked in the early morning and afternoon and reset. Successful traps containing animals will be pulled from the line and replaced with a newly set trap. Each animal captured will be assigned an individual identification number associated with a specimen data sheet. The identification number will contain the area trapped, transect line, and trap number. All specimens captured in Sherman Live Traps will be identified and, if not retained as a voucher specimen, will be released at the point of capture.

Small Mammal Tissue Residue Analysis Small mammals will be collected for residue analysis using trapping techniques per ERTC/REAC SOP #2029, *Small Mammal Sampling* and ERTC/REAC SOP #3021, *Procedure for Personal Protection against Hantavirus Infection while Trapping, Handling, and Processing Small Mammals*. The most abundant species collected, or that species important in the exposure pathway, from all locations will be targeted for residue analysis and it is anticipated that approximately 24 specimens (eight per area) will be collected. Animals collected in excess of this goal will be kept to a minimum so that discrete populations will not be depleted and to minimize immigration from surrounding areas. Trap locations will be guided by the results of the previous investigation and the physical habitat available.

Successful traps containing animals will be pulled from the line and replaced with a newly set trap. An aluminum tag bearing the identification number will be affixed to the trap and captured animals retained for analysis will be brought back to a central staging area, sacrificed by cervical dislocation or asphyxiation using dry ice, and partially processed per ERTC/REAC SOP #2039, *Small Mammal Dissection and Processing* and ERTC/REAC SOP #3021, *Procedure for Personal Protection against Hantavirus Infection while Trapping, Handling, and Processing Small Mammals*. The location of capture, habitat conditions, species, and any other pertinent information will be recorded on the specimen data sheet. Animals will be placed in resealable plastic bags labeled with the identification number, site name, date, location of capture, species name and placed on wet ice for shipment to the ERTC/REAC Biology Laboratory where processing will be completed, and will include species determination, total weight, total tail and hind foot lengths, and notable physical conditions. Partial necropsies will be performed to obtain kidney and liver weights, and to remove the embryos (if present) and colon. The stomach contents will be removed, the stomach rinsed in distilled water, and then placed back into the body cavity.

The analytical determinations for each carcass (minus embryos and colon) are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Toxicity Evaluations

Five-day seed germination and 28-day plant growth evaluations will be conducted on the site soil using the plant Rape (*Brassica napus*, family Cruciferae) to provide insight concerning the availability and toxicity of contaminants that may be present in the soil. These evaluations will be conducted per published methods and will determine the range of biological response to differing metal concentrations. *Brassica* seeds will be obtained from a commercial weed seed supplier (Valley Seed Service, Fresno, California). Size-grading will be conducted to minimize the variation in germination rates and success among differently sized seeds. The seeds will be size-graded using four nested American Standard Testing Materials (ASTM) soil sieves of decreasing mesh size (No. 8, 10, 18, 20). Seeds will be loaded into the top sieve (No. 8), and the nested sieves agitated for 60 seconds. The sieves will be disassembled and the largest fraction of seeds will be used for the experiments.

Seed Germination Soil from each location (composite from each small mammal grid, $n = 3$) selected plus one control will be dried in a laboratory oven at 100 degrees centigrade ($^{\circ}\text{C}$) for 24 hours. The soil will be homogenized and re-hydrated to an approximate 80 percent (%) moisture level. The moisture level will be determined using a field soil moisture probe. Soil from each location will be spread evenly along the bottom of commercially available plastic nursery trays measuring 16 cm by 12 cm by 5 cm deep, resulting in a layer of soil approximately 1.5 cm deep. Three replicates per treatment (including the control) will be prepared in this manner and arranged in a randomized block pattern.

Each replicate will consist of four lines of ten seeds, planted 0.25 cm deep. A 0.3 cm layer of horticultural vermiculite will be spread on the soil surface and wet with a fine mist of water. Plastic sheeting will be secured over the trays to retain moisture. The trays will be maintained at $24\pm 4^{\circ}\text{C}$ for 5 days following germination, upon which all seedlings and emerging cotyledons at the soil surface will be enumerated.

Shoot Height and Biomass Soil from each location (composite from each small mammal grid, $n = 3$) selected plus one control will be dried in a laboratory oven at 100°C for 24 hours. The soil will be homogenized and rehydrated to an approximate 80 % moisture level. The moisture level will be determined using a field soil moisture probe. The soil from each location will be placed in 250 milliliter (mL) Styrofoam containers. Three size-graded seeds will be planted 0.3 cm deep per container. Ten replicates per treatment will be prepared in this manner and arranged in a randomized block pattern. All replicates will be covered with plastic sheeting to retain moisture until germination. Upon germination, the plastic sheeting will be removed and the replicates thinned to one individual per container. The containers will be maintained at an approximate 70 % moisture level at $24\pm 4^{\circ}\text{C}$ for 28 days.

After 28 days, the height of the aboveground portion of each plant (hereafter referred to as the shoot) will be removed from the below ground portion of the plant (hereafter referred to as the root), measured to the nearest 1 mm, and dried in a laboratory oven at 100°C for 24 hours. The dried shoot will be then weighed to the nearest 0.001 grams (g) per ERTC/REAC SOP #2034, *Plant Biomass Determinations*.

The number of samples to be collected for the toxicity evaluation are summarized in Table 5, Summary

of Toxicity Test Information. This table identifies analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Earthworm (*Eisenia foetida*) Soil Toxicity/Accumulation Acute soil toxicity evaluations using *E. foetida* will be employed to provide data concerning the availability and toxicity of contaminants present in the soil (U.S. EPA 1989). If samples are found to be acutely toxic, then tests may only last 14 days rather than the 28 days as outlined in the accumulation test procedures. The earthworm *E. foetida* is widely distributed in soil including those of the site area and this organism is an important component of the terrestrial invertebrate community and often comprises a significant proportion of the soil biomass. In addition to being in intimate physical contact with the substrate, *E. foetida* feeds on detrital matter and vegetative debris incorporated into the soil.

Each soil toxicity test will consist of three replicates per sample location, and a control and standard reference toxicant will be used. Control mortality should not exceed ten percent. Preparation of soil will include screening and mixing and the moisture content and water holding capacity will be determined. The test soil will be hydrated to 75 % of the water holding capacity with reverse osmosis water and the pH values will be recorded. Each replicate will contain 220 g of soil dry weight and ten weighed worms will be introduced into each test chamber. Adult clitellate worms with a wet range of 300 - 600 milligrams (mg) each will be used. The organisms may be fed throughout the duration of the exposure, if deemed necessary to allow survival and growth for the duration of the test. Following toxicity testing, the earthworms which had also survived the exposure will be purged of gut contents for 24 hours and then frozen for residue analysis.

The number of samples to be collected for the toxicity evaluation are summarized in Table 5, Summary of Toxicity Test Information. This table identifies analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Aquatic Sampling

Sampling Locations To the maximum extent possible, sampling locations will be co-located to decrease costs and increase interpretive powers. The locations are situated in areas exhibiting similar habitat characteristics including substrate composition, riparian vegetation, topographic relief, channel morphology, flow velocity, watershed features, and land use. Where possible, sample locations will represent a gradient of concentrations of COCs. Additional locations may be necessary to adequately evaluate impacts to the Elizabeth River and Paradise Creek. A total of 21 locations have been established and were used to develop the budget and schedule (See Figure 2). Should more locations be necessary, the changes in scope will be documented in field log books or field change forms, signed by the Task Leader (TL) and WAM. The change in scope will be reflected in an amendment to the work assignment (WA) and a revision in this WP.

- AWII-01 Atlantic Wood Industries, Inc. Cove: Located in the small cove north of Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.
- AWII-02 Atlantic Wood Industries, Inc. Cove: Located in the small cove north of Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.

- AWII-03 Atlantic Wood Industries, Inc. Cove: Located in the small cove north of Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.
- AWII-04 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.
- AWII-05 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.
- AWII-06 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and Jordan Bridge, on the west side of the Southern Branch of the Elizabeth River.
- AWII-07 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and U.S. Naval Reserve pier, on the west side of the Southern Branch of the Elizabeth River.
- AWII-08 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and U.S. Naval Reserve pier, on the west side of the Southern Branch of the Elizabeth River.
- AWII-09 Atlantic Wood Industries, Inc. Cove: Located in the small cove between AWII pier and U.S. Naval Reserve pier, on the west side of the Southern Branch of the Elizabeth River.
- ER-10 Elizabeth River: Located on the east side of the main channel of the Southern Branch of the Elizabeth River, approximately half way between the confluences with Paradise Creek and Julian Creek.
- ER-11 Elizabeth River: Located on the west side of the main channel of the Southern Branch of the Elizabeth River, just downstream of the confluence with Paradise Creek.
- ER-12 Elizabeth River: Located on the west side of the main channel of the Southern Branch of the Elizabeth River, across from the cove between the AWII pier and Jordan Bridge.
- ER-13 Elizabeth River: Located in the main channel of the Southern Branch of the Elizabeth River, across from the cove between the AWII pier and Jordan Bridge.
- ER-14 Elizabeth River: Located on the east side of the main channel of the Southern Branch of the Elizabeth River, across from the cove between the AWII pier and Jordan Bridge.
- PC-15 Paradise Creek: Located at the outfall from the landfill, on the north side of Paradise Creek.

- PC-16 Paradise Creek: Located upstream of the Victory Boulevard bridge, on Paradise Creek.
- PC-17 Paradise Creek: Located on the north side of Paradise Creek, approximately 0.4 km upstream of the Victory Boulevard bridge.
- SC-18 Scuffeltown Creek: Located in the mouth of Scuffeltown Creek, at the confluence with the Southern Branch of the Elizabeth River.
- SC-19 Scuffeltown Creek: Located approximately 0.4 km upstream of the confluence of Scuffeltown Creek and the Southern Branch of the Elizabeth River.
- YR-20 York River: Located on the York River. Deep water reference, mid-channel (3 replicates).
- YR-21 York River: Located on the York River. Queen Creek, shallow water reference (3 replicates).

Surface Water Sampling Surface water will be collected all sampling locations per ERTC/REAC SOP #2013, *Surface Water Sampling*. If necessary, a Kemmerer bottle will be used to collect the water samples. To avoid the incidental incorporation of suspended sediment into the sample, water will be collected prior to other sampling activities that may disturb the sediment. Water samples will be collected at half the maximum depth at each sampling location, with tidal stage noted.

The number of surface water samples to be collected for this project are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Water Quality Measurements Water quality parameters will be measured using an Hydrolab Surveyor II Water Quality Management System. The Hydrolab will be used to measure temperature (°C), pH, dissolved oxygen (DO, mg/L), salinity, conductivity (microohms, $\mu\text{mhos}/\mu\text{S}$), oxidation-reduction potential (volts, V), and turbidity (Nephelometric Turbidity Units, NTU). The Hydrolab will be calibrated prior to data collection and after data collection is complete. The Hydrolab will be used in accordance with the manufacturer's operating manual.

Sediment Sampling Sediment will be collected per ERTC/REAC SOP #2016, *Sediment Sampling*. Sediment samples will be collected using a decontaminated ponar or eckman dredge. Samples will be collected from representative depositional areas at each location. Overlying water depth will be noted at the time of collection. A volume of sediment sufficient to fulfill the analytical requirements will be collected from several co-located grabs, placed into a 56.8 L stainless-steel bucket. Prior to homogenization, any aliquots required for volatile organic compounds (VOCs) will be dispensed. The bulk sample will then be covered and returned to the staging area and homogenized. After the sample is thoroughly mixed, aliquots for laboratory analyses will be dispensed into appropriate sample containers. All unused sample material will be returned to the site of collection.

The number of sediment samples to be collected for this project are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Sediment Profile Imaging (SPI) Sediment profile images are photographs of vertical sections of sediment extending from the surface of the sediment to approximately 20 cm below. Images are obtained using a camera-mounted frame which forces a specially-designed structure into the sediment. One side of the structure is clear and vertical. Forming a lower vertex with the clear wall is a mirrored wall angled at 45 degrees to the clear wall. The camera views the vertical sediment profile by its reflection off the mirror. The apparatus includes a powerful light source.

SPI images will be obtained at 21 locations or fewer, at the discretion of the WAM. The camera system will be deployed and retrieved by two field scientists/technicians while the vessel operator controls the hydrowire winch. The general procedure for collecting SPI images is as follows:

- Make logbook entries as necessary throughout the sampling process to ensure thorough recordkeeping.
- Load the camera with 100 ISO color slide film, close the camera housing, and secure it to the SPI camera frame.
- With the camera system on deck, take two successive photographs of the Kodak Color Separation camera system Guide and Grey Scale (Small), which is Publication No. Q-13, catalog No. 152 7654, 1994 from Eastman Kodak, Co., Rochester, NY.
- Maneuver the sampling vessel to the proposed sampling location.
- Signal the winch operator to lift the camera system.
- Guide the camera system overboard until it is clear of the vessel.
- Lower the camera system through the water column to the bottom at approximately 0.3 m/s.
- Record the location on the DGPS when the camera system contacts the bottom.
- Trigger the camera system to take a photograph.
- Signal the winch operator to begin retrieving the camera system and raise approximately 2 m off the bottom.
- Lower camera for the next replicate image. Repeat steps 10 and 11 until 2 images are obtained at each station.
- Guide the camera system aboard the vessel and place it securely on the deck.
- Check the frame counter to make sure that the requisite number of replicates has been taken.

- Check the prism penetration depth indicator on the camera frame to see that the optical prism has actually penetrated the bottom to a sufficient depth to acquire a profile image.
- If images have been missed (frame counter indicator) or the penetration depth is insufficient (penetration indicator), take additional replicates.
- Ensure that all logbook entries are complete.
- Proceed to the next proposed SPI location.

Field quality assurance/quality control (QA/QC) procedures will be an integral part of the SPI survey. At the beginning of each survey day, the time on the data logger mounted inside the SPI camera will be synchronized with that of the internal clock on the computerized navigation system being used to conduct the survey. Each SPI station replicate will be identified by the time recorded on the film and on disk along with vessel position. Test shots will be fired on deck at the beginning and end of each roll of film to verify that all internal electronic systems are working to design specifications. Spare charged batteries will be carried in the field at all times to insure uninterrupted sample acquisition.

At a minimum a 0.3 m section of the exposed roll of bulk film will be developed in the field or commercially, at the end of every survey day to verify successful camera operation; strict controls will be maintained for development temperatures, times, and chemicals to insure consistent density on the film emulsion so as to minimize interpretive error by the computer-image analysis system. The film then will be visually inspected under magnification. Any problems detected will be used to diagnose potential malfunctions in the camera; if necessary, all film from that particular survey day will be developed to diagnose equipment problems before continuing any field operations. Once any required repairs or corrective actions are taken, field operations will continue, and any missed stations can be re-occupied the next survey day.

SPI images will be analyzed using a full-color computer-image analysis system. Typical parameters measured include the following:

- Presence and thickness of any depositional layers
- Presence of subsurface methane gas pockets (evidence of excess organic loading)
- Grain-size major mode and range (phi scale)
- Small-scale surface boundary roughness
- Depth of the apparent redox potential discontinuity
- Evidence of erosional and depositional events, such as bedforms, mudclasts, and recently deposited sedimentary intervals, allowing identification of high- and low-energy areas
- Infaunal successional stage

- Calculation of the organism-sediment index, which allows rapid identification and mapping of disturbance gradients in surveyed areas

All data collected during the computer-image analysis will be stored on diskette and printed out on data sheets for editing and as a hard-copy backup; a separate data sheet will be generated for each SPI image. All data sheets will be edited and verified by a senior scientist before being approved for final data synthesis, statistical analyses, and interpretation.

Data extracted from the SPI image analysis will be tabulated and examined for general characteristics and possible spatial distribution patterns. These data will be used to provide baseline information about the physical, chemical, and biological conditions. SPI images will be stored in project files.

An additional bulk-sediment sample (only one replicate) will be collected with a petite ponar at all 21 sediment sampling locations and archived for potential qualitative benthic community analyses. Should analysis be required, the changes in scope will be documented in field log books or field change forms, signed by the Task Leader (TL) and WAM. The change in scope will be reflected in an amendment to the work assignment (WA) and a revision in this WP. The schedule for this project, as well as other ongoing projects, may be modified to accommodate the changes in scope. Similarly, the costs (including labor and materials) required to complete this project are likely to change and will be reflected in the revised WP.

Caged-Bivalve (Oyster) Accumulation Study

Oysters (*Crassostrea virginica*) will be provided by Middle Peninsula Aquaculture (North VA). Culture conditions of the organisms will be described in detail in the final report. Organisms will be transported to the site in aerated culture water.

Whole-animal wet-weight will be the criterion used to select oysters for this baseline monitoring study. Detailed attention will be given to the care and handling of the oysters throughout the process to minimize stress to the animals and to ensure that all test animals are of high quality. Only live oysters that fully close, or those that close immediately upon light physical stimulation, will be used. Following an initial assessment of the available size range, the oysters will be distributed to the mesh tubes as described below. Oysters weighing approximately 10-15.0 grams (g, wet weight with shell) will be selected for use in this study. Unsorted oysters will be held in a flow-through system until needed. During the distribution process, the oysters will be maintained within their acclimated temperature range by placing them in tubs of water taken directly from the flow-through tanks and changed frequently to maintain oxygen levels and eliminate the potential for the buildup of waste products.

Immediately prior to placement in the mesh tube, individual oysters will be measured for its whole-animal wet-weight to the nearest 0.01 g with an electronic balance. The oyster will be then placed into a pre-labeled mesh tube (approximately 10 centimeters, cm, in diameter and 2 m long; 1.9 cm mesh size). Nylon cable ties will be used to separate individual oysters within the mesh tube. Each tube will contain approximately 10 oysters and five tubes will be prepared for each cage. After all oysters are placed in the mesh tubes, they will be returned to the flow-through holding tanks until deployment.

At the time of deployment, all of the oysters will be taken from the holding tanks, placed into ice chests, and transported to a staging area near the site. At this time, mesh tubes containing oysters will be removed from the holding tanks and affixed to cages (approximately 0.5 m wide by 1 m high, and constructed of 2.5 cm

diameter polyvinyl chloride pipe material). Three cages will be prepared for each location. For each cage, the five mesh tubes containing oysters labeled as Bag-1, Bag-2, Bag-3, Bag-4, and Bag-5 for that cage will be secured to the PVC frame with large nylon cable ties. The cages will be then wrapped with heavy-duty plastic screen (approximately 2.5 cm mesh size) to discourage predators. All cages will be deployed on the same day.

One continuously recording temperature monitoring device will be attached to one of the three cages prepared for each location and set to collect temperature data at 12 minute intervals over the deployment period.

During the project design stage, a random number table will be used to assign cages to stations. The cages, numbered from 1 to 30 will be assigned station numbers.

An Analysis of Variance (ANOVA) will be used to confirm statistically similar sizes among cages and stations ($\alpha = 0.05$). At the beginning of the test, the mean oyster weight will be statistically similar among all cages.

The cages containing oysters will be deployed at all reference and test stations in a linear fashion. The three oyster cages assigned to a particular station will be placed approximately 5 m apart along a transect at the center of each station. Cement blocks will be used to secure the cages and prevent movement with tidal exchange. Stakes, surface markers, and flags will be used to mark each station. A warning sign to discourage vandalism or removal by trespassers will be attached to each station marker. Station position coordinates will be obtained using GPS.

An additional 150 oysters (i.e., three groups of 50 oysters each) will be used for initial tissue weight determinations and chemical analyses to obtain background (T_0) concentrations of contaminants.

All equipment (i.e., shucking knives and the aluminum foil covering the cutting boards) used during tissue extraction will be thoroughly cleaned before processing a new batch (i.e., replicate) according to the decontamination procedure outlined later in this WP. Prior to tissue removal, all staff will thoroughly wash their hands with Liquinox. Gloves will be worn during the shucking process to reduce the potential for contamination. The shucking process involves separating, or popping, the oyster shells with a special shucking tool. Once separated, a thin-bladed stainless steel knife will be used to separate the oyster soft tissues from the shell. The severed tissue will be held in such a position that the excess liquid will be allowed to drain. The soft tissues will be kept on the shell during extraction and after complete separation. The shell will be used as a "holding dish" until tissue weights will be made. A weighing pan will be made from decontaminated aluminum foil. The soft tissues will be placed on the weigh pan using the original shucking knife.

When all tissues of a "replicate" ($n = 50$) are weighed, the tissues will be transferred from the weigh pan to certified clean sample jars. The sample jar will be tightly capped, affixed with a prepared label, and placed in the freezer.

All oyster cages will be located and retrieved at the end of a 30 day exposure period. After removal from the field stations, the caged oysters will be transported to the holding tanks for an overnight depuration period.

End-of-test measurements will include whole-animal wet-weights and soft tissue weights for each live individual. The oysters will be processed one cage at a time. Prior to taking these measurements, the oysters will be assessed for overall condition, and the number of dead and/or missing animals will be recorded for each location. The oysters will be removed from the mesh tubes and placed, in sequence starting with the number one oyster in Bag 1, into compartmentalized holding trays. If a dead oyster is encountered, the empty shells will be placed into the compartmentalized holding tray as a marker. These holding trays will be then placed into tubs containing clean river water to eliminate air bubbles between the oyster shells. Starting with oyster number one, the oyster will be taken from the holding tray, blotted dry, and the whole-animal wet-weight measurement will be made using an electronic balance. The weighed oyster will then put into a second compartmentalized tray to maintain proper sequence. The weight data will be recorded manually on to laboratory data sheets and electronically to a computer file. The process will be repeated until all individuals of a given cage will be measured.

For each cage, tissues from all live oysters will be removed from the shells as described above and composited for chemical analyses. The sample jar will be tightly capped, affixed with a prepared label, and placed in the freezer. The frozen oyster tissue samples will transported on dry ice overnight for chemical analyses.

The number of samples to be collected for the evaluation are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Fish Collection Fish will be collected from the Elizabeth River, Paradise Creek, and York Creek using common fisheries management techniques (i.e. minnow traps, seines, electrofishing, etc.), as appropriate to the site. The sampling crew will taxonomically identify the fish and record the weight of the fish (ERTC/REAC SOP # 2039, *Fish Handling and Processing*). Because of the need for tissue analysis to evaluate the potential transfer of COCs to piscivorous birds (i.e. black-crowned night heron, *Nycticorax nycticorax*; herring gull, *Larus argentatus*; great blue heron, *Ardea herodias*; belted kingfisher, *Megasceryle alcyon*; and Snowy egret *Egretta thula*), whole fish will be wrapped in aluminum foil, placed in a plastic bag, and placed on wet ice. It is anticipated that a species representative of the site (i.e. dominant taxa, high percentage of total biomass, ect.) will be targeted for analyses. Fish will be collected from the 7 locations identified in Table 2. It is anticipated that three composite samples (of same species and biomass necessary to meet analytical requirements) will be collected from each location (21 total samples). Fish will be shipped via overnight delivery to the subcontracted analytical lab. Fish tissue will be analyzed for TAL metals, BNA, pesticides/PCBs, TBT, percent lipids, and percent moisture.

The number of samples to be collected for the evaluation are summarized in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

Toxicity Evaluations Laboratory toxicity tests will be conducted using site sediment with the following species: silversides (*Menidia beryllina*) and amphipods (*Leptocheirus plumulosus*).

The number of samples to be collected for the toxicity evaluation are summarized in Table 5, Summary of Toxicity Test Information. This table identifies analytical parameters desired; type, volume and number

of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples.

STANDARD OPERATING PROCEDURES

Sampling Equipment Decontamination The following sampling equipment decontamination procedure will be employed prior and subsequent to sampling each location (unless otherwise documented in the field) in the following numerical sequence:

- 1 physical removal
- 2 nonphosphate detergent wash (Liquinox)
- 3 potable water rinse
- 4 distilled/deionized water rinse
- 5 10% nitric acid rinse
- 6 solvent rinse (Acetone)
- 7 distilled water rinse
- 8 air dry

Sample Documentation Sample documentation will be completed per the following Environmental Response Team (ERTC)/Response Engineering and Analytical Contract (REAC) Standard Operating Procedures (SOPs):

- ERTC/REAC SOP #2002, *Sample Documentation*
- ERTC/REAC SOP #4005, *Chain of Custody Procedures*

Sample Packaging and Shipment Sample packaging and shipment will be conducted in accordance with the following ERTC/REAC SOP:

- ERTC/REAC SOP #2004, *Sample Packaging and Shipment*

Sampling Techniques Field activities will be conducted in accordance with the following SOPs:

- ERTC/REAC SOP #2012, *Soil Sampling*
- ERTC/REAC SOP #2013, *Surface Water Sampling*
- ERTC/REAC SOP #2016, *Sediment Sampling*
- ERTC/REAC SOP #2029, *Small Mammal Sampling and Processing*
- ERTC/REAC SOP #2037, *Terrestrial Plant Community Sampling*
- ERTC/REAC SOP #2038, *Vegetation Assessment Field Protocol*
- ERTC/REAC SOP #2039, *Fish Handling and Processing*
- ERTC/REAC SOP #2056, *Methods for Conducting 14-Day Acute Soil Toxicity Tests with the Earthworm, Eisenia foetida*
- ERTC/REAC SOP#2139, *Operation of the Hydrolab Surveyor II Water Quality Management System*
- ERTC/REAC SOP #3021, *Procedure for Personal Protection Against Hantavirus Infection While Trapping, Handling, and Processing Small Mammals*

Waste Disposal Investigative derived waste (i.e. PPE) will be disposed of in accordance with all state and federal regulations. All of the treated and untreated samples will be maintained for 60 days after the issuance of the final report. If no additional testing has been requested at the end of the 60 days, with the approval and concurrence of the Task Leader, arrangements will be made for disposal.

STAFFING PLAN AND SCHEDULE

Staffing Plan The REAC TL/Quality Control (QC) Coordinator is the primary REAC point of contact with the U.S. EPA WAM. The TL is responsible for the development and completion of the WP, project team organization, and supervision of all project tasks, including reports and deliverables. In addition, the QC Coordinator is responsible for ensuring field adherence to the WP and recording any deviations from the WP.

The following REAC field sampling personnel will work on this project:

<u>Personnel</u>	<u>Responsibilities</u>	<u>Level of Responsibility</u>
Environmental Toxicologist	Task Leader, Sample Management, Report(s) Preparation	P3
Geologist	Boat Operator	T3
Aquatic Toxicologist	Field Collection, Report(s) Evaluation	P4
Aquatic Ecologist	Field Collection	P3
Field Biologist	Field Collection	P3
Field Biologist	Field Collection	T3
Biology Technician	Field Collection	T1
Aquatic Ecologist	Field Collection, Statistical Support	P2
Field Biologist	Field Collection, Sample Management	T3
Administrative Support	Subcontracting Support	P3
Chemistry Technician	Inorganic and organic Analyses	T3

Other REAC personnel may work on this project as needs dictate.

The REAC QA Officer, the acting Health and Safety Officer, the Operations Section Leader, and the Analytical Section Leader, are responsible for auditing and guiding the project team, reviewing/auditing the deliverables and proposing corrective action, if necessary, for nonconformity to the QAWP or Health and Safety Plan (HASP).

While not specifically identified, activities such as electronic technical data documentation, video documentation, photodocumentation, computer graphics and support, statistics, word processing, report preparation, and purchasing support may be required in order to accomplish the objectives of this project.

The following identified laboratories are expected to provide the listed on-site analyses:

<u>Lab Name</u>	<u>Location</u>	<u>Parameters</u>
Striplin Environmental	Olympia, WA	Sediment Profile Imaging
Landau Associates	Edmonds, WA	Oyster Bioaccumulation Study
		Training

The following laboratories/vendors are expected to provide these off-site analyses/treatability tests:

<u>Lab Name</u>	<u>Location</u>	<u>Parameters</u>
To be determined	NA	TAL metals
To be determined	NA	BNA, Oil Fingerprinting
To be determined	NA	Pesticides/PCBs
To be determined	NA	VOAs
Sewern Trent Laboratories	Savannah, GA	TBT
Sewern Trent Laboratories	Savannah, GA	Total organic carbon
Sewern Trent Laboratories	Savannah, GA	Dissolved organic carbon
Sewern Trent Laboratories	Savannah, GA	Grain size
To be determined	NA	Percent moisture and lipids
To be determined	NA	Sediment toxicity tests
To be determined	NA	Earthworm/Plant toxicity tests

Cost Estimate The estimated costs (including labor, travel and equipment, subcontractor and analytical) to complete this project are depicted in the attached cost summary sheet. Since the U.S. EPA/ERTC budget was estimated prior to the development of the scope of work (including the number of samples, type of analyses, subcontractor involvement, etc.), the cost required to complete the specific tasks outlined in this WP may change as the project develops.

Schedule of Activities and Deliverables The original QAWP was initiated in April 1999. The field work outlined in this WP is expected to be conducted in Spring 2000 and the overall project is expected to close out with the issuance of a baseline ecological risk assessment.

TASK/MEASUREMENT ENDPOINT	ESTIMATED PERFORMANCE PERIOD
1. Sediment Profile Imaging	June 2000
2. Fish sampling	June 2000
3. Sediment and surface water sampling	April 2000
4. Caged Bivalve <i>In situ</i> Study	June - July 2000
5. Soil sampling	June 2000
6. Small mammal trapping	June 2000
7. Vegetation survey and sampling	June 2000

The following deliverables will be provided under this project:

<u>Item</u>	<u>Date</u>
Work Plan	August 1999
Final Analytical Report	August 2000
Problem Formulation	October 2000
Final Baseline Risk Assessment	February 2001

All project deliverable and task dates are estimates based on the information available at the time of field sampling WP completion. New information, additional tasks, and changes in scope may result in revisions to these dates.

QUALITY ASSURANCE

QA objectives and protocols are summarized in Tables 3 and 4 and they are based on those outlined in U.S. EPA (1990). In addition, these tables list the total numbers of samples from each matrix that will be collected and analyzed for this project. Below is a description of the protocols necessary to satisfy QA1 and QA2 level data. Data will not be analyzed following QA3 criteria. Once samples are collected and analyzed, the results will be validated following ERTC/REAC SOP 1016, *Data Validation Procedures for Routine Organic Analyses* and SOP 1017, *Data Validation Procedures for Routine Inorganic Analyses*.

The following QA Protocols for QA1 data are applicable to all sample matrices:

1. Sample documentation in the form of field logbooks, the appropriate field data sheets, and chain-of-custody forms will be provided.
2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.
3. Detection limit(s) will be determined and recorded, along with the data, where appropriate.

The following QA Protocols for QA2 data are applicable to all sample matrices:

1. Sample documentation in the form of field logbooks, the appropriate field data sheets, and chain of custody forms will be provided. Chain-of-custody sheets are optional for field screening locations.
2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.
3. Detection limit(s) will be determined and recorded, along with the data, where appropriate.
4. Sample holding times will be documented; this includes documentation of sample collection and analysis dates.
5. Initial and continuing instrument calibration data will be provided.
6. For **soil, sediment and water samples**, rinsate blanks, field blanks, and trip blanks will be included at the rate specified in Table 3, footnotes 2 and 3.
7. Performance Evaluation (PE) samples are optional, if available.
8. **Definitive Identification** - analyte identification on 10 percent of the screened (field or lab) or 100 percent of the unscreened samples will be confirmed using a U.S. EPA-approved method; documentation such as chromatograms, mass spectra, etc. will be provided.
9. **Quantitation** - documentation for quantitative results from screening and U.S. EPA-approved verification methods (for screened samples) or quantitative results (in the case of unscreened samples) will be provided.

The number of samples to be collected for this project/event are presented in Table 3, Field Sampling Summary, and Table 4, QA/QC Analysis and Objectives Summary. These tables identify analytical parameters desired; type, volume and number of containers needed; preservation requirements; number of samples to be collected; and associated number and type of QA/QC samples based on the QA level. In addition, the number of samples to be analyzed for toxicity tests are presented in Table 5. Based on the above sampling objectives, the detection limits for sediment, water, and tissue are presented in Table 6.

The detection limits for tissue are the same as those listed for sediment.

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Table 1. Assessment Endpoints and the Associated Testable Hypotheses and Measurement Endpoints
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint
1. Viability of Benthic Community	The concentrations of COCs in sediment and surface water on-site are not greater than benchmark values.	Determine the concentrations of COCs in sediment and surface water.
	The concentration of bioaccumulated COCs are not greater than toxicity effects levels.	Determine the bioavailability of COCs by conducting <i>in situ</i> caged bivalve bioaccumulation studies. Determine the bioavailability of COCs by conducting laboratory benthic invertebrate (<i>Neries virens</i>) bioaccumulation studies.
	The toxicity of COCs in sediment on-site is not significant.	Evaluate the toxicity (growth/survival) of COCs in sediment through toxicity testing with amphipods (<i>Leptoichirus plumulosus</i>).
	The macroinvertebrate community on-site is not significantly impacted.	Conduct qualitative survey of benthos using sediment profile imaging. Evaluate benthic macroinvertebrate quantitatively with ponar grab samples.
2. Viability of the fish community	The concentrations of COCs in sediment and surface water on-site are not greater than benchmark values.	Determine the concentration of COCs in sediment and surface water. Determine the concentration of COCs in benthic invertebrate tissues (<i>Crassostrea virginica</i>). Determine the concentration of COCs in fish tissues (<i>Fundulus heteroclitus</i>).
	The toxicity of COCs in sediment on-site is not significant.	Evaluate the toxicity of COCs in sediment through toxicity testing with the silverside (<i>Menidia beryllina</i>) elutriate test.
	The toxicity of COCs in surface water on-site is not significant.	Evaluate the toxicity of COCs in surface water through toxicity testing with the silverside (<i>Menidia beryllina</i>).
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through a food chain exposure model, evaluate the toxicity of COCs on-site via dietary exposure by comparison to toxicity reference values.

Table 1 (cont'd). Assessment Endpoints and the Associated Testable Hypotheses and Measurement Endpoints
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint
3. Viability of the soil invertebrate community	The concentration of COCs in soil on-site are not greater than the benchmark values.	Determine the concentration of COCs in soil collected from on-site and at a reference locations.
	The toxicity of COCs to invertebrates in soil on-site is not significantly greater than the reference locations.	Evaluate the toxicity of COCs in soil through comparison with toxicity reference values. Evaluate the toxicity (growth/survival) of COCs in soil through solid-phase testing using earthworms (<i>Eisenia foetida</i>). Evaluate the bioaccumulation of COCs in soil with laboratory testing using earthworms (<i>Eisenia foetida</i>).
4. Viability of the insectivorous small mammal community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentration of COCs in soil collected from locations on-site. Determine the concentration of COCs in selected food items of modeled receptors collected from locations on-site.
	The body burden of COCs in small mammal species at locations on-site do not result in HQ values greater than one.	Determine the concentration of COCs in small mammals collected from locations on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through a food chain exposure model for the shrew, evaluate the toxicity of COCs on-site via dietary exposure by comparison to toxicity reference values.
5. Viability of the aquatic feeding small mammal community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentrations of COCs in soil, sediment, and surface water on-site Determine the concentrations of COCs in selected food items (<i>F. heteroclitus</i>) of modeled receptors on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through food chain exposure models for the mink (<i>Mustela vison</i>) and racoon (<i>Procyon lotor</i>), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Table 1 (cont'd). Assessment Endpoints and the Associated Testable Hypotheses and Measurement Endpoints
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint
6. Viability of the herbivorous small mammal community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentrations of COCs in soil, sediment, and surface water on-site. Determine the concentrations of COCs in selected food items of modeled receptors on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through food chain exposure models for the meadow vole (<i>Microtus pennsylvanicus</i>) evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.
7. Viability of the insectivorous avian community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentrations of COCs in soil, sediment, and surface water on-site. Determine the concentrations of COCs in selected food items (earthworms and benthic invertebrates) of modeled receptors on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through food chain exposure models for the American robin (<i>Turdus migratorius</i>), English sparrow (<i>Passer domesticus</i>), mockingbird (<i>Mimus polyglottos</i>), red-winged blackbird (<i>Agelaius phoeniceus</i>) and marsh wren (<i>Cistothorus palustris</i>) evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.
8. Viability of the aquatic feeding avian community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentrations of COCs in sediment and surface water collected on-site. Determine the concentrations of COCs in selected food items (<i>F. heteroclitus</i>) of modeled receptors on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through food chain exposure models for the black-crowned night heron (<i>Nycticorax nycticorax</i>), herring gull (<i>Larus argentatus</i>), great blue heron (<i>Ardea herodias</i>) belted kingfisher (<i>Megaceryle alcyon</i>), osprey (<i>Pandion haliaetus</i>), and snowy egret (<i>Egretta thula</i>), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.

Table 1 (cont'd). Assessment Endpoints and the Associated Testable Hypotheses and Measurement Endpoints
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint
9. Viability of the carnivorous avian community	The concentration of COCs in food items of modeled receptor species at locations on-site do not result in HQ values greater than one.	Determine the concentrations of COCs in soil collected on-site. Determine the concentrations of COCs in selected food items (small mammals) of modeled receptors on-site.
	The dietary exposure of selected receptors to COCs on-site is not greater than toxicity reference values.	Through food chain exposure models for the American kestrel (<i>Falco sparverius</i>) and great horned owl (<i>Bubo virginianus</i>), evaluate the toxicity of the dietary exposure to COCs on-site by comparison to toxicity reference values.
10. Viability of the vegetative community	The concentration of COCs in soil on-site are not greater than the benchmark values.	Determine the concentrations of COCs in soil. Evaluate the toxicity (seed germination, biomass, and root elongation) and accumulation of COCs in soil through solid-phase testing using plants (<i>Brassica</i>). Evaluate the toxicity of COCs in soil, sediment, and surface water through comparison with toxicity reference values.

Table 2. Breakdown of Samples and Analyses by Sample Location
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Location	TAL Metals	BNAs	Pest./PCBs	VOAs	TBT	Oil Finger-printing	TOC	Grain Size	Oysters	Fundulus	<i>Leptochirus plumulosus</i>	<i>Menidia Beryllina</i>	<i>Nereis virulens</i>	SPI
ER01	•	•	•		•	•	•	•		•	•	•	•	•
ER02	•	•	•		•	•	•	•	•		•	•	•	•
ER03	•	•	•		•	•	•	•			•	•	•	•
ER04	•	•	•		•	•	•	•		•	•	•	•	•
ER05	•	•	•		•	•	•	•	•		•	•	•	•
ER06	•	•	•		•	•	•	•			•	•	•	•
ER07	•	•	•		•	•	•	•		•	•	•	•	•
ER08	•	•	•		•	•	•	•	•		•	•	•	•
ER09	•	•	•		•	•	•	•			•	•	•	•
ER10	•	•	•		•	•	•	•						•
ER11	•	•	•		•	•	•	•	•					•
ER12	•	•	•		•	•	•	•						•
ER13	•	•	•		•	•	•	•						•
ER14	•	•	•		•	•	•	•	•					•
PC15	•	•	•	•	•	•	•	•	•		•	•	•	•
PC16	•	•	•	•	•	•	•	•	•	•	•	•	•	•
PC17	•	•	•	•	•	•	•	•	•	•	•	•	•	•
SC18	•	•	•		•	•	•	•	•	•	•	•	•	•
SC19	•	•	•		•	•	•	•						•
YR20A,B,C (3 replicates)	•	•	•		•	•	•	•			•	•	•	•
YR21A,B,C (3 replicates)	•	•	•		•	•	•	•	•	•	•	•	•	•

Table 2 (cont'd). Breakdown of Samples and Analyses by Sample Location
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Location	TAL Metals	BNAs	Pest./PCBs	VOAs	Oil Finger-printing	TOC	Grain Size	Earthworms	Mammals	Plants
SiteSoil 1-a	•	•	•	•	•	•	•	•	•	•
SiteSoil 1-b	•	•	•	•	•	•	•	•		•
SiteSoil 1-c	•	•	•	•	•	•	•	•		•
SiteSoil 2-a	•	•	•	•	•	•	•	•	•	•
SiteSoil 2-b	•	•	•	•	•	•	•	•		•
SiteSoil 2-c	•	•	•	•	•	•	•	•		•
SiteSoil 3-a	•	•	•	•	•	•	•	•	•	•
SiteSoil 3-b	•	•	•	•	•	•	•	•		•
SiteSoil 3-c	•	•	•	•	•	•	•	•		•

Table 2 (cont'd). Breakdown of Samples and Analyses by Sample Location
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Location	Oysters						Fundulus						Nereis					Small Mammals, Plants, Earthworms			
	Pest./PCBs	TBT	TPH	BNAs	TAL Metals	Lipid	Pest./PCBs	TBT	TPH	BNAs	TAL Metals	Lipid	Pest./PCBs	TBT	BNAs	TAL Metals	Lipid	Pest./PCBs	BNA	TAL Metals	Lipid
ER01	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
ER02													•	•	•	•	•				
ER03													•	•	•	•	•				
ER04	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
ER05													•	•	•	•	•				
ER06													•	•	•	•	•				
ER07	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
ER08													•	•	•	•	•				
ER09													•	•	•	•	•				
ER10																					
ER11																					
ER12	•	•	•	•	•	•							•	•	•	•	•				
ER13																					
ER14																					
PC15	•	•	•	•	•	•															
PC16	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
PC17	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
SC18	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
SC19																					
YR20A,B,C													•	•	•	•	•				
YR21A,B,C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
Site Soil 1																		•	•	•	•
Site Soil 2																		•	•	•	•
Site Soil 3																		•	•	•	•

TABLE 3. Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level ¹	Matrix *	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples ⁶
							Rinsate Blanks ²	Field/Trip Blanks ³	PE Samples ⁴	Total Matrix Spikes ⁵	
Pesticides/PCBs	To be determined	X	8 oz glass (1)	4°C	7/40 days	183	NA	NA/NA	NA	19	183
Pesticides/PCBs	To be determined	SD	8 oz glass (1)	4°C	7/40 days	25	2	2/NA	NA	3	29
Pesticides/PCBs	To be determined	S	8 oz glass (1)	4°C	7/40 days	9	1	1/NA	NA	2	11
Pesticides/PCBs	To be determined	SW	32 oz amber glass (2)	4°C**	7/40 days	25	2	2/NA	NA	3	29

* Matrix: S-Soil, SW-Surface Water, X-Tissue, SD-Sediment

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₃.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are used, rinsate blanks are not required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank is required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 3 (cont'd). Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level ¹	Matrix *	Container Type and Volume (# Containers req'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples ⁶
							Rinsate Blanks ²	Field/ Trip Blanks ³	PE Samples ⁴	Total Matrix Spikes ⁵	
VOAs	To be determined	SD	4 oz glass, septum (1)	4°C	7/40 days	3	1	1/NA	NA	1	5
VOAs	To be determined	S	4 oz glass, septum (1)	4°C	7/40 days	9	1	1/NA	NA	2	11
BNA	To be determined	X	8 oz glass (1)	4°C	7/40 days	183	NA	NA/NA	NA	19	183
BNA	To be determined	SD	8 oz glass (1)	4°C	7/40 days	25	2	2/NA	NA	3	29
BNA	To be determined	S	8 oz glass (1)	4°C	7/40 days	9	1	1/NA	NA	2	11
BNA	To be determined	SW	32 oz amber glass (2)	4°C**	7/40 days	25	2	2/NA	0	3	29

* Matrix: S-Soil, SW-Surface Water, X-Tissue, SD-Sediment

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₃.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are used, rinsate blanks are not required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank is required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 3 (cont'd). Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

							QC Extra's				
TAL Metals (Filtered)	To be determined	SW	1 1 L HDPE (1)	HNO ₃ to pH < 2 4°C	6 months	25	2	2/NA	0	3	29
TAL Metals (Total)	To be determined	SW	1 L HDPE (1)	HNO ₃ to pH < 2 4°C	6 months	25	2	2/NA	0	3	29
TAL Metals	To be determined	X	aluminum foil/plastic bag (1)	0°C	6 months	183	NA	NA/NA	NA	19	183
TAL Metals	To be determined	SD	8 oz glass (1)	4°C	6 months	25	2	2/NA	NA	3	29
TAL Metals	To be determined	S	8 oz glass (1)	4°C	6 months	9	1	1/NA	NA	2	11

* Matrix: S-Soil, SW-Surface Water, X-Tissue, SD-Sediment

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₃.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are used, rinsate blanks are not required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one blank is required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 3 (cont'd). Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level ¹	Matrix *	Container Type and Volume (# Containers req'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples ⁶
							Rinsate Blanks ²	Field/Trip Blanks ³	PE Samples ⁴	Total Matrix Spikes ⁵	
TBT	To be determined	SW	1 liter glass or polyethylene (1)	4°C	7/40d	25	2	2/NA	0	3	29
TBT	To be determined	SD	8 oz glass (1)	4°C	7/40d	25	2	2/NA	0	3	29
TBT	To be determined	X	aluminum foil/plastic bag (1)	4°C	7/40d	99	NA	NA/NA	0	10	99
Oil Fingerprinting	To be determined	SW	1 liter glass or polyethylene (1)	4°C	7/40d	25	2	2/NA	0	3	29
Oil Fingerprinting	To be determined	SD	8 oz glass (1)	4°C	7/40d	25	2	2/NA	0	3	29
Oil Fingerprinting	To be determined	S	8 oz glass (1)	4°C	7/40d	9	1	1/NA	0	2	11

* Matrix: S-Soil, SW-Surface Water, SD-Sediment, X-Tissue

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₃.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 3 (cont'd). Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level ¹	Matrix *	Container Type and Volume (# Containers rq'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples ⁶
							Rinsate Blanks ²	Field/Trip Blanks ³	PE Samples ⁴	Total Matrix Spikes ⁵	
Percent moisture	To be determined	X	8 or 32 oz glass (1)	4°C	7 days	183	NA	0/NA	NA	NA	183
Hardness	To be determined	SW	1 L HDPE (1)	4°C	48 hours	25	NA	0/NA	NA	NA	25
Alkalinity	To be determined	SW	1 L HDPE (1)	4°C	48 hours	25	0	NA/NA	0	0	25
TSS	To be determined	SW	1 L HDPE (1)	4°C	48 hours	25	0	NA/NA	0	0	25
DOC	To be determined	SW	1 L HDPE (1)	4°C; pH < 2 (H ₂ SO ₄)	48 hours	25	0	NA/NA	0	0	25

* Matrix: S-Soil, SD-Sediment, SW-Surface Water, X-Tissue

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₃.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 3 (cont'd). Sediment, Water, and Tissue Summary
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level ¹	Matrix *	Container Type and Volume (# Containers req'd)	Preservative	Holding Times	Subtotal Samples	QC Extra's				Total Field Samples ⁶
							Rinsate Blanks ²	Field/Trip Blanks ³	PE Samples ⁴	Total Matrix Spikes ⁵	
Grain Size	To be determined	SD	32 oz glass (1)	N/A	N/A	25	0	0/NA	0	0	25
Grain Size	To be determined	S	32 oz glass (1)	N/A	N/A	9	0	0/NA	0	0	9
Total Organic Carbon (Loss on Ignition)	To be determined	SD	4 oz glass (1)	4°C	28 days	25	0	0/NA	0	0	25
Total Organic Carbon (Loss on Ignition)	To be determined	S	4 oz glass (1)	4°C	28 days	9	0	0/NA	0	0	9

* Matrix: S-Soil, SD-Sediment, SW-Surface Water, X-Tissue

** If residual chlorine is present, preserve with 0.008% Na₂S₂O₅.

1. The concentration level, specific or generic, that is needed in order to make an evaluation. This level will provide a basis for determining the analytical method to be used.
2. If dedicated sampling tools are not used, rinsate blanks are required for the aqueous matrix. They are optional for the soil matrix. For QA2 and QA3, a minimum of one or one blank required per type of sampling device per day. For QA1, enter "N/A".
3. Field blanks are required for aqueous and non-aqueous matrices. Aqueous field blanks are prepared with distilled/deionized water and non-aqueous field blanks are prepared with clean sand or soil. For QA2 and QA3, one blank required per day. For QA1, enter "N/A". For QA2 and QA3, one trip blank required per cooler used to transport VOA samples. For QA1, enter "N/A". Each aqueous trip blank consists of two 40ml vials filled with distilled/deionized water. Each non-aqueous trip blank consists of two 40 ml vials filled with clean sand or soil.
4. Performance evaluation samples are optional for QA2 and mandatory for QA3 at one per parameter per matrix. For QA1, enter "N/A".
5. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq 10\%$ total samples, regardless of QA Objective. In addition, for QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes.
6. Add the numbers of rinsate blanks, field blanks, trip blanks, and PE samples to the subtotal number of samples to determine this.

TABLE 4. QA/QC Requirements for Sediment, Water, and Tissue Samples
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

Analytical Parameter	Matrix *	Analytical Method Ref.	Matrix Spikes		QA/QC	
			Lab ¹	Additional ²	Detection Limits ³	QA Objective ⁴
PEST/PCB	SD, SW, S, X	8080/SW-846/EPA-608	SD,SW - 3 ea. S - 2 X - 17	0		2
TAL Metals	SD, SW, S, X	SW-846/EPA-600	SD,SW - 3 ea. S - 2 X - 17	0		2
BNA	SD, SW, S, X		SD,SW - 3 ea. S - 2 X - 17	0		2
VOAs	SD, S	8240	SD - 1 S - 2	0		2
TBT	SD, SW, X		SD,SW - 3 ea. X - 10	0		2
Oil Fingerprinting	SD, SW, S,		SD,SW - 3 ea. S - 2	0		2

* Matrix: S-Soil, SD-Sediment, SW-Surface Water, X-Tissue

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of >10% total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

TABLE 4 (cont'd). QA/QC Requirements for Sediment, Water, and Tissue Samples
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

			Matrix Spikes		QA/QC	
Alkalinity	SW	EPA 310.1	NA	NA		1
Hardness	SW	EPA 130	NA	NA		1
Dissolved Organic Carbon	SW	To be determined	NA	NA		1
Moisture	X	EPA 160.3	NA	NA		1
Lipids	X	To be determined	NA	NA		1
Grain Size	SD, S	ASTM D422-63	NA	NA		1
Total Organic Carbon	SD, S	SW 846-9060	NA	NA		1

* Matrix: S-Soil, SD-Sediment, SW-Surface Water, X-Tissue

1. Ensure that sufficient volume of environmental sample is collected for lab spiking. All analyses conducted at the REAC laboratories require matrix spike samples at a frequency of $\geq 10\%$ total samples, regardless of QA Objective.
2. For QA2 (optional) and for QA3 (mandatory): Determine bias (% recovery) using a minimum of 2 matrix spikes. Determine precision using a minimum of 8 matrix spikes. Laboratory matrix spikes may be utilized to fulfill these additional QA requirements.
3. To be determined by the person arranging the analysis. Should be equal to or less than the action level.
4. Enter QA Objective desired: QA1, QA2, or QA3.

TABLE 5. Summary of Toxicity Test Information
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

Analytical Parameter	Action Level	Matrix *	Container Type and Volume (# Containers req'd)	Preservative	Holding Times	Subtotal Samples	QC Extras **			Total Samples
							Controls (100% Diluent Water or Clean Sediment)	Reference Toxicants	Replicates	
<i>Neries virens</i>	Mortality/Growth Bioaccumulation	SD	32 oz glass (3)	4°C	4 days	15	1	1	3	15
Silverside elutriate test (<i>Menidia beryllina</i>)	Mortality/Growth	SD	32 oz glass (3)	4°C	4 days	15	1	1	3	15
<i>Leptoichirus plumulosus</i>	Mortality/Growth	SD	32 oz glass (6)	4°C	4 days	15	1	1	3	15
<i>Brassica</i> 14 and 28 day Toxicity	Mortality/Growth	S	32 oz glass (3)	4°C	4 days	3	1	1	3	3
28-day <i>Eisenia foetida</i> Toxicity Test	Mortality/Growth Bioaccumulation	S	5 gal. plastic (1)	4°C	4 days	3	1	1	3	3

* Matrix: S-Soil,SD-Sediment, SW-Surface Water

** 3 replicates per sample location and for each control

Table 6. Detection Limits for the Target Compound List and Target Analyte List
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

TARGET COMPOUND LIST AND QUANTITATION LIMITS⁽¹⁾

Volatiles	CAS Number	Quantitation Limits ⁽²⁾	
		Water µg/L	Low Soil/Sediment ⁽³⁾ µg/kg
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethane	75-35-4	5	5
1,1-Dichloroethene (DCE)	75-34-3	5	5
1,2-Dichloroethane (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Bromodichloromethane	75-27-4	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene (TCE)	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	75-25-2	5	5
4-Methyl-2-pentanone	108-10-1	10	10
2-Hexanone	591-78-6	10	10
Tetrachloroethene (PCE)	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (total)	1330-20-7	5	5

⁽¹⁾ Specific quantitation limits (QLs) are highly matrix dependent. The QLs listed herein are provided for guidance and may not always be achievable.

⁽²⁾ QLs listed for soil/sediment are based on wet weight. The QLs calculated by the laboratory for soil/sediment, on a dry weight basis will be higher.

⁽³⁾ Medium soil/sediment QLs for Volatile Target Compound List (TCL) compounds are 125 times the individual low soil/sediment QL.

Table 6 (cont'd.). Detection Limits for the Target Compound List and Target Analyte List
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

TARGET COMPOUND LIST AND QUANTITATION LIMITS⁽¹⁾

Volatiles (Cont'd)	CAS Number	Quantitation Limits ⁽²⁾	
		Water µg/L	Low Soil/Sediment ⁽³⁾ µg/kg
Dichlorofluoromethane	75-43-4	10	10
Trichlorofluoromethane	75-69-4	5	5
trans-1,2-Dichloroethene	156-60-5	5	5
2,2-Dichloropropane	594-20-7	5	5
cis-1,2-Dichloroethene	156-59-2	5	5
1,1-Dichloropropene	563-58-6	5	5
1,2-Dichloropropane	78-87-5	5	5
Dibromomethane	74-95-3	10	10
1,3-Dichloropropane	142-28-9	5	5
1,2-Dibromomethane	106-93-4	5	5
1,1,1,2-Tetrachloroethane	630-20-6	5	5
p-Xylene	106-42-3	5	5
m-Xylene	108-38-3	5	5
o-Xylene	95-47-6	5	5
Isopropylbenzene	98-82-8	5	5
1,2,3-Trichloropropane	96-18-4	5	5
Bromobenzene	108-86-1	5	5
n-Propylbenzene	103-65-1	5	5
2-Chlorotoluene	95-49-8	5	5
4-Chlorotoluene	106-43-4	5	5
1,3,5-Trimethylbenzene	25551-13-7	5	5
tert-Butylbenzene	98-06-6	5	5
1,2,4-Trimethylbenzene	25551-13-7	5	5
sec-Butylbenzene	135-98-8	5	5
1,3-Dichlorobenzene	541-73-1	5	5
p-Isopropyltoluene	99-87-6	5	5
1,4-Dichlorobenzene	106-46-7	5	5
1,2-Dichlorobenzene	95-50-1	5	5
n-Butylbenzene	104-51-8	5	5
1,2-Dibromo-3-Chloropropane	96-12-8	5	5
1,2,4-Trichlorobenzene	120-82-1	5	5
Naphthalene	91-20-3	5	5
Hexachlorobutadiene	87-68-3	10	10
1,2,3-Trichlorobenzene	12002-48-1	10	10

- (1) Specific quantitation limits (QLs) are highly matrix dependent. The QLs listed herein are provided for guidance and may not always be achievable.
- (2) QLs listed for soil/sediment are based on wet weight. The QLs calculated by the laboratory for soil/sediment, on a dry weight basis will be higher.
- (3) Medium soil/sediment QLs for Volatile Target Compound List (TCL) compounds are 125 times the individual low soil/sediment QL.

Table 6(cont'd.). Detection Limits for the Target Compound List and Target Analyte List
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

TARGET COMPOUND LIST AND QUANTITATION LIMITS⁽¹⁾

Semivolatile	CAS Number	Quantitation Limits ⁽²⁾	
		Water µg/L	Low Soil/Sediment ⁽³⁾ µg/kg
Phenol	108-95-2	10	330
bis (2-Chloroethyl) ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis (2-Chloroisopropyl) ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-di-n-propylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
bis (2-Chloroethoxy) methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1,700
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1,700
Dimethylphthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330

⁽¹⁾ Specific quantitation limits (QLs) are highly matrix dependent. The QLs listed herein are provided for guidance and may not always be achievable.

⁽²⁾ QLs listed for soil/sediment are based on wet weight. The QLs calculated by the laboratory for soil/sediment, on a dry weight basis will be higher.

⁽³⁾ Medium soil/sediment QLs for Volatile Target Compound List (TCL) compounds are 125 times the individual low soil/sediment QL.

Table 6 (cont'd.). Detection Limits for the Target Compound List and Target Analyte List
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

TARGET COMPOUND LIST AND QUANTITATION LIMITS⁽¹⁾

Semivolatile (Cont'd)	CAS Number	Quantitation Limits ⁽²⁾	
		Water µg/L	Low Soil/Sediment ⁽³⁾ µg/kg
3-Nitroaniline	99-09-2	50	1,700
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1,700
4-Nitrophenol	100-02-7	50	1,700
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl-phenyl ether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1,700
4,6-Dinitro-2-methylphenol	534-52-1	50	1,700
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1,700
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Carbazole	86-74-8	10	330
Di-n-butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	6,700
Benzo (a) anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis (2-Ethylhexyl) phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo (b) fluoranthene	205-99-2	10	330
Benzo (k) fluoranthene	207-08-9	10	330
Benzo (a) pyrene	50-32-8	10	330
Indeno (1,2,3-cd) pyrene	193-39-5	10	330
Dibenzo (a,h) anthracene	53-70-3	10	330
Benzo (g,h,i) perylene	191-24-2	10	330

(1) Specific quantitation limits (QLs) are highly matrix dependent. The QLs listed herein are provided for guidance and may not always be achievable.

(2) QLs listed for soil/sediment are based on wet weight. The QLs calculated by the laboratory for soil/sediment on a dry weight basis will be higher.

(3) Medium soil/sediment QLs for Semivolatile Target Compound List (TCL) compounds are 60 times the individual Low soil/sediment QL.

Table 6 (cont'd.). Detection Limits for the Target Compound List and Target Analyte List
Atlantic Wood Industries, Inc.
Portsmouth, Virginia

May 2000

TARGET COMPOUND LIST AND QUANTITATION LIMITS⁽¹⁾

Pesticides/PCBs	CAS Number	Quantitation Limits ⁽²⁾	
		Water µg/L	Low Soil/Sediment ⁽³⁾ µg/kg
alpha-BHC	319-84-6	0.02	3.3
beta-BHC	319-85-7	0.02	3.3
delta-BHC	319-86-8	0.02	3.3
gamma-BHC (Lindane)	58-89-9	0.02	3.3
Heptachlor	76-44-8	0.02	3.3
Aldrin	309-00-2	0.02	3.3
Heptachlor epoxide	1024-57-3	0.02	3.3
Endosulfan I	959-98-8	0.02	3.3
Dieldrin	60-57-1	0.02	3.3
4,4'-DDE	72-55-9	0.02	3.3
Endrin	72-20-8	0.02	3.3
Endrin aldehyde	7421-93-4	0.02	3.3
Endosulfan II	33213-65-9	0.02	3.3
4,4'-DDD	72-54-8	0.02	3.3
Endosulfan sulfate	1031-07-8	0.02	3.3
4,4'-DDT	50-29-3	0.02	3.3
Methoxychlor	72-43-5	0.02	3.3
Endrin ketone	53494-70-5	0.02	3.3
alpha-Chlordane	5103-71-9	0.02	3.3
gamma-Chlordane	5103-74-2	0.02	3.3
Toxaphene	8001-35-2	0.50	83
Aroclor-1016	12674-11-2	0.25	42
Aroclor-1221	11104-28-2	0.50	83
Aroclor-1232	11141-16-5	0.25	42
Aroclor-1242	53469-29-6	0.25	42
Aroclor-1248	12672-29-6	0.25	42
Aroclor-1254	11097-69-1	0.25	42
Aroclor-1260	11096-82-5	0.25	42

- (1) Specific quantitation limits (QLs) are highly matrix dependent. The QLs listed herein are provided for guidance and may not always be achievable.
- (2) QLs listed for soil/sediment are based on wet weight. The QLs calculated by the laboratory for soil/sediment on a dry weight basis will be higher.
- (3) Medium soil/sediment QLs for Pesticides/Polychlorinated biphenyls (PCBs) Target Compound List (TCL) compounds are 15 times the individual low soil/sediment QL.

Table 6 (cont'd.). Detection Limits for the Target Compound List and Target Analyte List
 Atlantic Wood Industries, Inc.
 Portsmouth, Virginia

May 2000

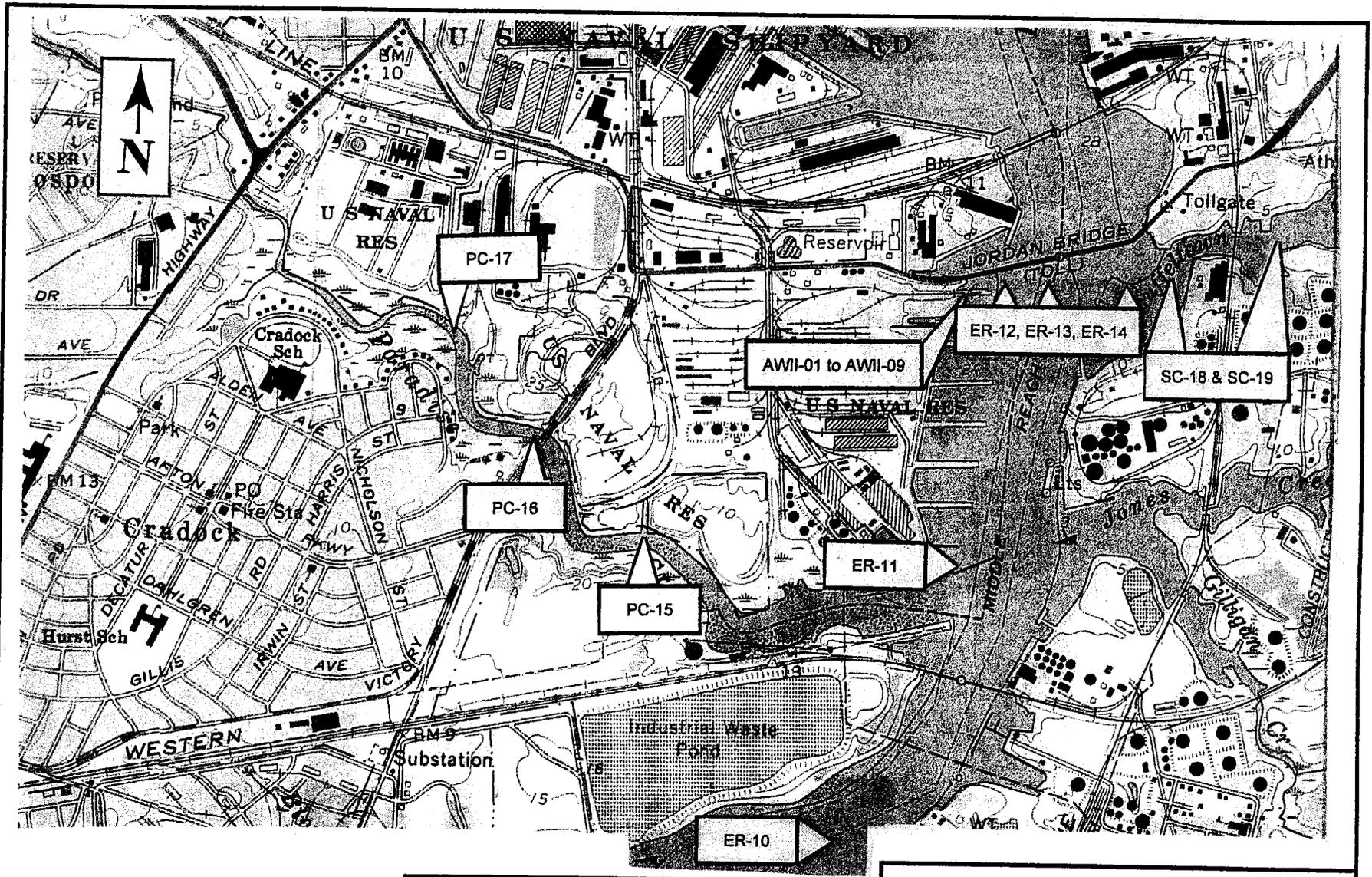
INORGANIC TARGET ANALYTE LIST

Analyte	Range of Detection Limits	
	Water µg/L	Soil mg/kg
Aluminum	100	20
Antimony	10	6
Arsenic	5	1
Barium	5	5
Beryllium	2	0.5
Cadmium	5	1
Calcium	500	50
Chromium	5	1
Cobalt	10	1.5
Copper	10	1
Iron	50	10
Lead	5	5
Magnesium	500	50
Manganese	5	2
Mercury	0.2	0.04
Nickel	10	2
Potassium	2,000	200
Selenium	5	1
Silver	5	1
Sodium	500	50
Thallium	5	1
Vanadium	10	2
Zinc	5	2



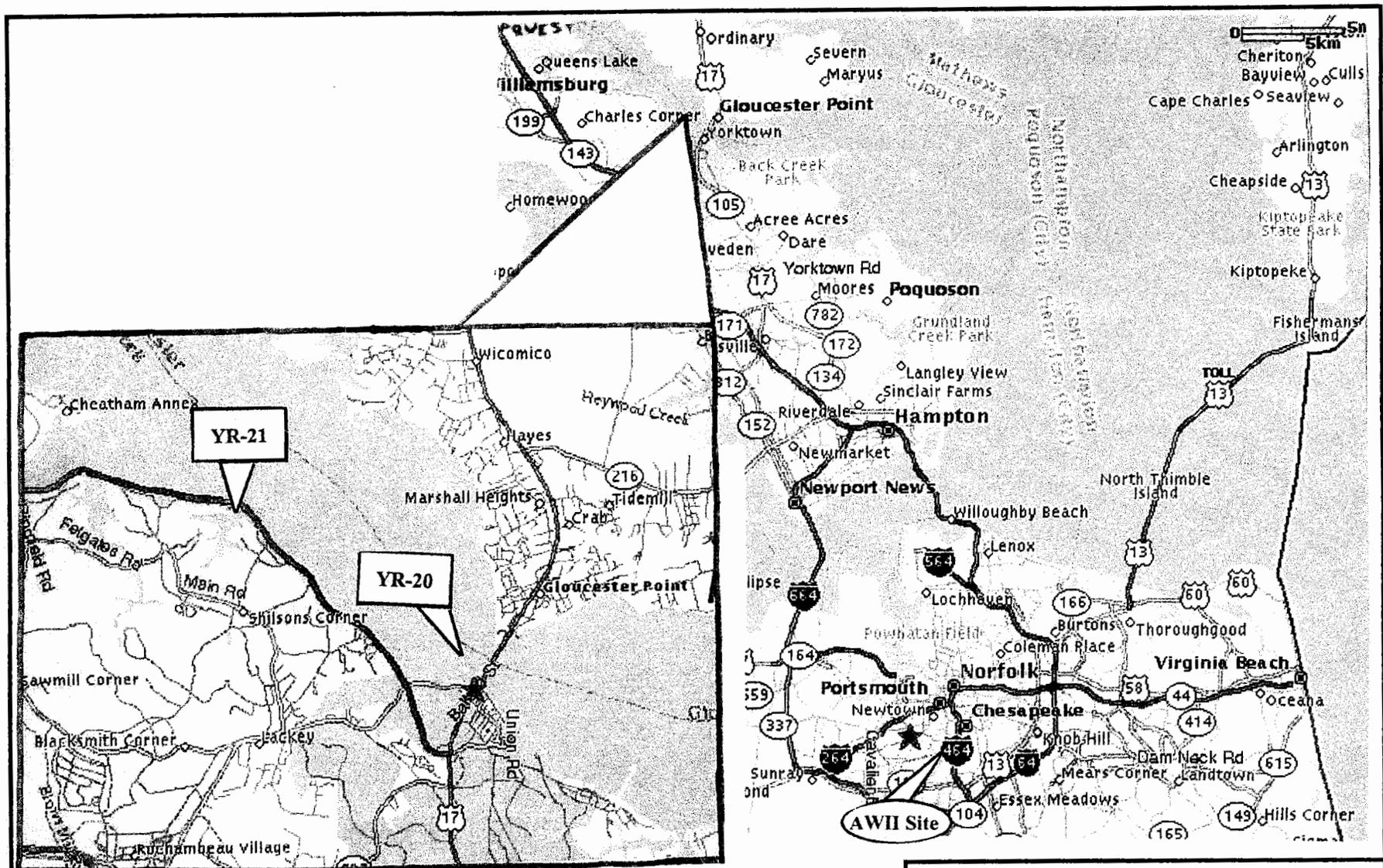
U.S. ENVIRONMENTAL RESPONSE TEAM CENTER
 RESPONSE ENGINEERING AND ANALYTICAL
 CONTRACT
 68-C99-223
 W.A. # R1A00071

Figure 1
 SITE LOCATION MAP
 ATLANTIC WOOD INDUSTRIES, INC.
 PORTSMOUTH VA
 MAY 2000



U.S. ENVIRONMENTAL RESPONSE TEAM CENTER
 RESPONSE ENGINEERING AND ANALYTICAL
 CONTRACT
 68-C99-223
 W.A. # R1A00071

FIGURE 2
SAMPLING LOCATIONS
 ATLANTIC WOOD INDUSTRIES, INC. SITE
 PORTSMOUTH VA
 MAY 2000



U.S. ENVIRONMENTAL RESPONSE TEAM CENTER
 RESPONSE ENGINEERING AND ANALYTICAL
 CONTRACT
 68-C99-223
 W.A. # R1A00071

FIGURE 3
REFERENCE SAMPLING LOCATIONS
ATLANTIC WOOD INDUSTRIES, INC. SITE
PORTSMOUTH VA
MAY 2000

Appendix A

Data Quality Objectives (DQO)

Atlantic Wood Industries, Inc.
Ecological Risk Assessment

May 2000

DRAFT

1.1 Data Quality Objectives

The Data Quality Objective (DQO) Process is a seven-step process designed to ensure that the data used in decision-making are of the type, quantity, and quality necessary for the intended purpose. The seven steps in the DQO process include:

- Step 1: State the problem
- Step 2: Identify the decision
- Step 3: Identify inputs to the decision
- Step 4: Define the study boundaries
- Step 5: Develop a decision rule
- Step 6: Specify tolerable limits on decision errors
- Step 7: Optimize the design

The scoping team has decided to employ the DQO process to help determine if there are any areas of the Atlantic Wood Industries, Inc. Site that pose an unacceptable risk to the environment and thus require any further action. Utilization of the DQO process allows the team to plan the generation of a statistically valid sampling plan, data with known confidence, make defensible decisions, and save time and resources. The application of these steps in the AWII ERA are discussed below.

1.2 DQO Development

Step 1: State the Problem — a description of the problem(s) and specifications of available resources and relevant deadlines for the study.

- Identify the members of the DQO scoping team — The members of the DQO scoping team include Regional and ERT ecological risk assessors, the remedial project manager (RPM), a field sampling expert, a risk assessor, a statistician, and stakeholders. The RPM is the ultimate decision maker.
- Define/refine the conceptual site model — The primary sources of contaminants at the AWII site are associated with past activities and the raw materials used in the wood treatment process. Creosote and PCP are the major raw materials from which on-site contaminants originated. A special formulation of creosote and PCP (“creo-penta”) was used from the late 1950s to the early 1960s. PCP was also used at the site from 1972 to 1985, and its use was briefly resumed in spring 1991. Creosote had been used at the site since the 1950s. All wood treatment operations were suspended on 6 August 1991. Although timber treated with CCA continues to be stored at the site, this compound was never used in wood treatment operations at this facility (ESC 1988). A screening ecological risk assessment was conducted to determine the risk associated with the exposure of biota to site-related contaminants (U.S. EPA 1999). Analyses of site abiotic matrices indicate possible risk associated with exposure to surface water, sediment of the Elizabeth River and soils at the AWII site.
- Define exposure scenario — A screening level ecological risk assessment (SLERA) conducted by USEPA’s Environmental Response Team (ERT) in April 1999 found that contamination in the soil, sediment, and water at or in the vicinity of the site may pose risks to ecological receptors. In soils, risks may be posed by PAHs, BNAs, VOCs, pesticides, PCBs, dioxins/furans, and metals. In sediments, PAHs, BNAs, VOCs, pesticides, and metals may pose risks to ecological receptors. In water, one SVOC, several metals, and tributyltin may be risk factors for ecological receptors.

Because of the mix of contaminants found at or near the site, ecological risks posed by contaminants in soil, sediment, and water would be expected to be posed through either direct contact with contaminated media or via bioaccumulation of contaminants up the food chain.

This current ecological risk assessment is for Operable Unit (OU) 3 of the AWII site which includes sediments in the Elizabeth River. However, risks posed by on-site soil contamination are also considered in this ERA for the following reasons:

- Soil contamination at the site occurs in close proximity to the Elizabeth River as well as to a ditch and inlet that drain to the Elizabeth River. As a result, soil may act as a continuing source of contamination to these areas.
- Direct contact with soil contamination at the site may pose risks to populations of lower trophic level terrestrial organisms at the base of the food chain (e.g., plants, soil invertebrates, small mammals, etc.). This could result in an alteration of the food supply to higher trophic level organisms whose feeding habits encompass both aquatic and terrestrial areas.
- Many contaminants found in the soils at the site have the potential to bioaccumulate up the food chain. Thus, organisms at higher trophic levels that feed in both aquatic and terrestrial areas could receive a significant portion of their total body burdens of contaminants indirectly from soil exposure.
- Specify the available resources Cost effectiveness and data validity are a high priority of the U.S. EPA for this study. Funds have been made available for 3 sampling trips, each of which will consist of a maximum of 8 crew members.
- *Time.* Scientific and logistic considerations have made it necessary for there to be 3 sampling trips. The first of these trips will occur in the late spring of 2000 and will include the collection of sediment and surface water for chemical and toxicological evaluation. In addition, locations will be selected for collection of small mammals, macrophytes, and fish for tissue residue analysis. All validated data is expected to be made available by late May or early June 2000. A second sampling trip will occur approximately 30 days after the first trip. During this second trip, sediment profile imaging will be conducted to determine the type and quality of aquatic habitat available to benthic communities in the vicinity of the site. Caged bivalves will also be placed in the river at selected locations. During third sampling trip, bivalve cages will be retrieved from the river and tissue samples will be obtained. Also, soil, plants, and small mammals will be collected for evaluation.
- *Identify project constraints.* Collection of samples may be limited by weather conditions.
- Write a brief summary of the contamination problem — The primary sources of contaminants at the AWII site are associated with past activities and the raw materials used in the wood treatment process. Creosote and PCP are the major raw materials from which on-site contaminants originated. A special formulation of creosote and PCP ("creo-penta") was used from the late 1950s to the early 1960s. PCP was also used at the site from 1972 to 1985, and its use was briefly resumed in spring 1991. Creosote had been used at the site since the 1950s. All wood treatment operations were suspended on 6 August 1991. Although timber treated with CCA continues to be stored at the site, this compound was never used in wood treatment operations at this facility (ESC 1988).

Creosote was originally stored in four above-ground storage tanks located along the south side of Elm Avenue. Tank 1 held 3.3 million liters (L) and the remaining three each held 1.7 million L. Before they were removed during 1985 and 1986, these tanks contained creosote and PCP, plus contaminated process water. They were known to leak into the storm sewer system that led into the inlet near Outfall 002. Beginning in 1975, creosote used for treatment was stored in smaller tanks located in the central portion of the site (ESC 1988).

Prior to 1972, the waste preservative left from the wood treatment process was stored at the southwest corner of the property in the "historic disposal area". From 1972 to 1983, this area was used to hold cuttings from the processed wood. The area was backfilled in 1983 (ESC 1988). Additional information regarding past waste management practices is discussed in the Remedial Investigation (RI) (ESC 1988, KER 1990).

Based on the results of sampling conducted during the RI, it was determined that areas surrounding the treatment buildings contain the most heavily PAH-contaminated soils. Since these areas are near the river, they represent a potential source of contaminated runoff to the drainage ditch, inlet, and Elizabeth River. Sampling of sediments from these areas have documented extensive PAH contamination (KER 1990) and confirmed transport of contaminants to habitats of concern. When grain size is accounted for, samples from five stations in the inlet indicated a decreasing gradient of PAH content where decreasing grain size was correlated with higher PAH content. The head of the inlet is dominated by sand and gravel with 100 percent product (creosote) saturation of sediment pore water spaces (KER 1990). At sampling sites near the mouth of the inlet, the sediment texture changes to clayey sand and then sandy clay, and concentrations ranged from residual to heavy product saturation of pore spaces. However, the finer-grained sediments allow more surface area for adsorption of PAHs, and therefore, greater apparent concentrations than gravel samples. In 1996 a removal action was conducted in the inlet, from the vicinity of the outfall to the low water line.

Step 2: Identify the Decision — a statement of the decision that will use environmental data and the actions that could result from this decision.

- State the decision — The decision to be made is whether unacceptable risks are posed to ecological receptors by contaminants associated with the AWII Site.
- State the actions that could result from the decision —
 - (A) If no unacceptable risks are identified, then no additional assessment or remedial activities would be warranted.
 - (B) If unacceptable risks are identified, either additional risk assessment activities can occur (e.g., to reduce any uncertainty associated with risk predictions) or risk management decisions can be made.

Step 3: Identify the Inputs to the Decision — a list of the environmental variables or characteristics that will be measured and other information needed to make the decision.

- Identify the information inputs needed to resolve the decision — The data required to resolve the decision are outlined in the WP (July 1999).
- Identify sources for each informational input — As outlined in the WP (July 1999) the sources of information inputs for resolving the decision will include the following:
 - field-collected data on contaminant concentrations in all pertinent abiotic media surface water, soil, and sediment)
 - field-collected data on tissue burdens of contaminants in biota native to the site or biota exposed to contaminated media at the site as part of this investigation (e.g., caged bivalves)
 - results of laboratory bioassays conducted to assess the toxicity of various abiotic media at the site
 - results of laboratory tests conducted to assess the bioavailability of various contaminants of concern at the site, and the degree to which these contaminants may be accumulated by potential ecological receptors at the site

- qualitative or semi-quantitative evaluations of habitat types available at the site
- literature-derived information on the toxicity of site-related contaminants of concern
- Define the basis for establishing contaminant-specific action levels — For those assessment endpoints having multiple measurement endpoints, a weight-of-evidence approach using the types of data described above will be used in the risk assessment. This will allow the results of the measurement endpoints to be integrated into a single conclusion. A weight-of-evidence evaluation implies that there are multiple lines of evidence, but not all lines of evidence have equal strength. When multiple lines of evidence for a particular assessment endpoint lead to the same conclusion, there is an implied weighing and the level of confidence increases in the risk estimate. If multiple lines generate apparent conflicts, then the weights relative to the mechanisms of toxicity will be used in evaluating the level of confidence in the risk estimate. Absolute weight values are not applied *a priori* as field data robustness is unable to be predicted.
- Identify potential sampling techniques and appropriate analytical methods — Sampling techniques and analysis methods are outlined in the WP (July 1999).

Step 4: Define the Boundaries of the Study— a detailed description of the spatial and temporal boundaries of the decision; characteristics that define the environmental media, objects, or people of interests; and any practical considerations for the study.

- Define the spatial boundaries — The spatial boundaries of the study are to include all necessary locations to effectively establish an exposure gradient that will produce data that can be extrapolated within the system.
- Define the temporal boundaries — Temporal boundaries for sample collection have been selected based on primarily on ecological concerns (i.e., the need to ensure biological communities are present at the time of sampling), but also on logistical appropriateness and comparative value with previous investigations. See the WP (July 1999) for an estimated time line of sample collections.
- Identify practical considerations that may interfere with the study — Extreme weather fluctuations pose possible interferences with the study. Seasonal differences in biota abundance may also pose difficulties to sampling.

Step 5: Develop a Decision Rule — an “if...then...” statement that defines the conditions that would cause the decision maker to choose among alternative actions.

- Specify the parameter of interest — The parameters of interest are outlined in WP (July 1999).
- Specify the action level for the study — The action levels will vary depending on the assessment endpoint being considered and any one particular contaminant of interest. Some of the contaminants have guidelines or criteria for protection of human and/or ecological health, as set by legal statutes. In addition, site derived no observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) will be compared with benchmark values from peer reviewed literature. For those assessment endpoints having multiple measurement endpoints, a weight-of-evidence approach will be used, as described above. A weight-of-evidence evaluation implies that there are multiple lines of evidence, but not all lines of evidence have equal strength. When multiple lines of evidence for a particular assessment endpoint lead to the same conclusion, there is an implied weighing and the level of confidence increases in the risk estimate. If multiple lines generate apparent conflicts, then the weights relative to the mechanisms of toxicity will be used in evaluating the level of confidence in the risk estimate. A discussion of the relative weighting of the measurement endpoints will be presented in the final ecological risk assessment. Similarly, some measurement endpoints will be utilized for multiple assessment endpoints (i.e. concentration of COCs in soil, sediment, and surface water).

- Develop a decision rule (an “if...then...” statement) — If no risks are posed by existing conditions at Atlantic Wood Industries, Inc., then no further evaluation or remediation would be necessary. However, if the decision is that possible risks do exist by conditions at Atlantic Wood Industries, Inc., then additional risk evaluations or remediation may be warranted.

Step 6: Specify Limits on Decision Errors — the acceptable decision error rates based on consideration of the consequences of making an incorrect decision.

- Determine the possible range of the parameter of interest — The design of the input parameters is such that a decision error of concluding a lack of risk when in fact risk does exist is unlikely.
- Define both types of decision errors and identify the potential consequences of each — Define both types of decision errors and establish which decision error has the more severe consequences. The two decision errors are:

Decision Error ‘a’: The decision that risk does exist, when in fact it does not (“false positive”).

Decision Error ‘b’: The decision that risk does not exist, when in fact it does (“false negative”).

Of the two types of error described above, type “b” decision errors would have the most severe consequences at the AWII site. The consequences of committing a type “a” error at this site would not be too substantial. Such an error would lead to either additional assessment activities, which increase costs but would not result in long-term or permanent ecological damage, or to implementation of a remedy. Implementation of an unnecessary remedy would increase costs and could also result in habitat destruction. However, since no highly valuable or unique habitat is present at or near the site, the consequences of implementing an unnecessary remedy to ecological resources would not be too severe. Thus, the ERA for AWII has been designed to maximize protectiveness to ecological receptors by ensuring that type “b” errors do not occur.

- Identify Acceptable Decision Error Rates —

False Positive Error: A decision that risk exists, when in fact it does not requires further evaluation. The further evaluation could be in the form of additional data collection or re-evaluation of current data and associated decisions. The SAM desires to have at least a 95 percent chance of detecting if risk exists (5% probability of false positive error).

False Negative Error: A decision that no risk exists, when in fact it does, is an unacceptable error. Therefore, very conservative assumptions are made throughout the process so as to eliminate, or at least minimize, the chance of such a decision (5% probability of false negative error).

Step 7: Optimize the Design — the decision maker will analyze existing data and select the lowest cost sampling design that is expected to achieve the DQOs.

- Develop general sampling and analysis design alternatives — The study is a direct result of data gaps outlined in the screening level risk assessment, SLRA (U.S. EPA 1999). The WP (July 1999) outlines the data required and the collection methods to be employed.

Sample Size -- An important factor in designing a field sampling plan that adequately addresses testable hypotheses is sample size. Standard error of a data set is an estimate of precision. There are four factors involved in the determination of standard error: 1) inherent variability, 2) sample size, 3) sampling design, and 4) the data analysis method. Sample size can be determined *a priori* by making decisions regarding required precision and the known relationships between standard error, sample size, population distribution, and analysis method. These relationships are typically complex and may be dependent upon unknown factors such as population variance. Commonly, the standard error will approximately

inversely proportional to the square root of the sample size. Therefore, increasing the sample size by a factor of four will double the precision or halve the uncertainty. This gain in precision is more pronounced in small sample sizes.

One must also consider the balance between Type I errors (rejecting a true null hypothesis) and Type II errors (accepting a false null hypothesis) when calculating sample size. The probability of falsely accepting the null hypothesis (Type II error) is expressed as the power of a test. Power is affected by the test method, the significance level, the sample size, the sampling method, and the population variance. In ecological risk assessment power is possibly more important than the significance level. Acceptance of the null hypothesis (no effect) when in fact an adverse effect may exist could have profound legal and environmental consequences.

Most environmental assessments involve the comparison of two sample means: one from the site and one from a reference site. The test method, the power, the significance level, and the magnitude of the difference to be detected must be set before appropriate sample size can be determined. Many times the standard deviation of a sample must be estimated. There then is a two step process in determining the sample size (n). The following formula would be used to determine an initial sample size:

$$n = 2(Z_a + Z_b)^2(s/d)^2$$

where:

n = sample size

Z_a = normal score corresponding to the significance level

Z_b = normal score corresponding to the Type II error

d = size of the difference to be detected

s = population standard deviation

If the standard deviation is estimated, the sample size should be increased. After completing the above calculation, multiply the resulting sample size by a factor of $(n + 3)/(n + 1)$ (U.S. EPA 1989c).

For the purposes of this particular investigation, replication in toxicity tests were predicated by standard methods set forth by ASTM and U.S. EPA. Replication of the tissues for residue analyses was calculated as stated above, with the significance level set at 0.05 and the power set at 0.95. Standard deviation was estimated and the resulting sample size was selected per location. This number is set as a goal.

- Select the most resource-effective design that satisfies all of the DQOs — The basis for the selection of sampling techniques can be found in the WP (July 1999). The WP (July 1999) gives details of the collection techniques to be employed.
- Document the details and assumptions of the selected design — The design of the study and all data evaluation is based on conservative assumptions that minimize the chance that a decision of “no risk” is made when in fact an ecological risk exists.