National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Northeast Coastal and Barrier Network Assessment of Contaminant Threats

Colonial National Historical Park

Natural Resource Report NPS/NCBN/NRTR—2010/355



ON THE COVER
Wormley Creek at the pond dam, Yorktown Tour Road
Photographed by Dorothy Geyer

Northeast Coastal and Barrier Network Assessment of Contaminant Threats

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July 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Cooper, K. R., M. Borjan. 2010. Northeast Coastal and Barrier Network assessment of contaminant threats: Colonial Historical National Park. Natural Resource Technical Report NPS/NCBN/NRTR—2010/355. National Park Service, Fort Collins, Colorado.

NPS 333/105048, July 2010

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List of Abbreviations

COLO	Colonial National Historical Park
COC	Chemical of Concern
DDE	Primary persistent metabolite of DDT
DDT	Broad spectrum pesticide
EPA	Environmental Protection Agency
ERL	Expected Response Low
ERM	Expected Response Moderate/Medium
NPL	National Priority List (Superfund)
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
ppb	Parts per billion (ug/Kg or ug/L)
ppm	Parts per million (mg/Kg or mg/L or atmospheric # atoms/cubic meter air)
TEL	Threshold Effects Level
TBT	Tributyltin
TOC	Total Organic Carbon
TRI	Toxic Reporting Inventory
USEPA	U. S. Environmental Protection Agency
VIMS	Virginia Institute of Marine Sciences
VOC	Volatile Organic Compounds

Introduction

This report deals with the chemicals of concern (COC) for two units of the Colonial National Historical Park (COLO), Jamestown and Yorktown. The chemical contributions present in the James and York River are also discussed as they relate to potential impacts on wildlife populations. Sampling recommendations are based on the ecosystems within the park and the specific baseline inventory of COCs both within and outside the boundaries of the park units. Contaminant data has been reviewed from State, County, U.S. Environmental Protection Agency (USEPA), National Park Service (NPS), Virginia Institute of Marine Sciences (VIMS), U.S. Navy and National Oceanographic and Atmospheric Administration (NOAA) to prepare the data synthesis for this park. Within the Appendix are the NOAA raw data tables along with EPA REMAP data, Virginia Department of Environmental Quality Data, and data from VIMS that have been formatted to simplify examining the chemicals analyzed and their corresponding concentrations. Telephone and survey interviews, along with site visits, were conducted with NPS staff. Based on the recommended monitoring plans, the NPS staff will be able to assess threats to natural resources and whether the "vital signs" are improving or declining within the park boundaries over time as it relates to COCs.

Detailed Standard Operating Procedures (SOPs) for the methods of collection for different matrices, specific analytical methods for different analytes, holding times and decontamination approaches are described in a separate portion of this document (Appendix 1). A detailed description of how to use a simple Hazard Quotient (HQ) approach and a more sophisticated foodweb model for ecological based risk assessment (Sample 1996) is also presented in Appendix 1.

General Physical Characteristics

COLO encompasses Yorktown and Jamestown, Virginia. The final major battle of the American Revolutionary War occurred in Yorktown. The British army under General Charles Lord Cornwallis had to surrender to General Washington's combined American and French army to secure independence for the United States. Jamestown is where the first permanent English colony began in North America. (USNPS 2007)

COLO is located approximately sixty miles East from Richmond, Virginia. Jamestown and Yorktown are situated in the Atlantic Coastal Plane in the southern tidewater region of Virginia, positioned on the James and York Rivers, respectively (Figure 1). The park was established in 1936 from the Colonial National Monument Act. The number of recreational visits in 2005 was over 3 million and the forecasted visits for 2006 and 2007 were estimated to be slightly over 3 million as well (USNPS, 2006).

COLO encompasses 10,221-acres in a number of different locations. This report will concentrate on Jamestown Island (1,561 acres) and Yorktown (4,302 acres) Figures 2 and 3, respectively. The 23-mile Colonial Parkway (3,596 acres) connects these and other colonial sites, including Colonial Williamsburg (Figure 1). In addition to the three major areas noted above, the park is also responsible for several detached areas: the 312-acre Green Spring 17th century plantation site of Sir William Berkeley; the 0.23-acre Cape Henry memorial, which marks the approximate site of the first landing of the Jamestown colonists (Cape Henry Memorial is 63 miles southeast of Jamestown Island near Virginia Beach); the 414-acre Swann's Point (Southwest of Jamestown

Island, across the James River); and Tindall's Point (a site which contains various Civil War fortifications) (USNPS, 2005). These areas were not included in this report.

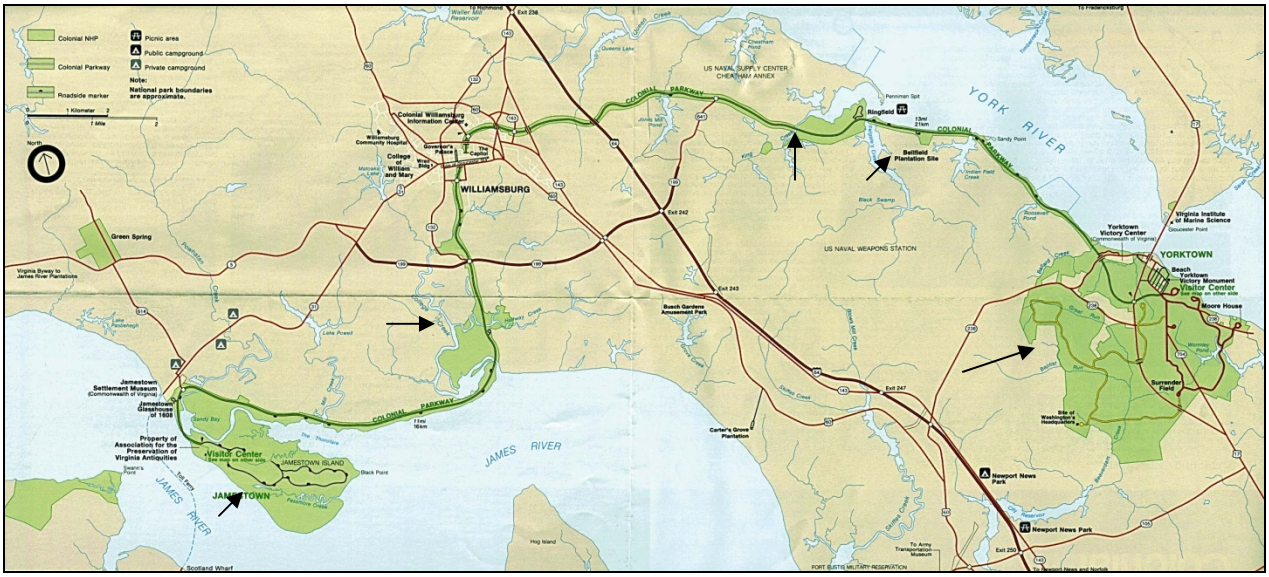


Figure 1.Colonial National Historical Park (COLO). (green shaded areas and arrows indicate areas to be sampled).



Figure 2. Map of COLO and U.S. Naval Stations at Yorktown.

Jamestown Island is surrounded by Sandy Bay and Back River/The Thorofare to the north and the James River to the east and south (Figure 3). There is a small inlet leading from Sandy Bay to the James River over which the Colonial Historical National Parkway passes and which separates Jamestown from the mainland. There are several small residential communities on Powtatan Creek that drains into Sandy Bay and Lake Powell that drains into The Thorofare on the north side of the island. Located on the grounds of Jamestown are a newly constructed visitor center along with the former visitor center, as well as a museum shop, maintenance areas and historic buildings. An archeological museum and ruins are part of Jamestown. There is also a working Glasshouse as you enter the park with a working kiln. There are no residential areas within the park boundaries. There are also a series of roads that allow visitors to view various biological habitats on the middle and eastern end of the island (Figure 3). The island has extensive swamp and marsh areas that drain into the James River and The Thorofare. The shoreline area nearest the ruins and visitor center along the James River has been armored with large boulders to prevent shoreline erosion. The remainder of the shoreline is predominately marsh area.



Figure 3. Map of Jamestown National Historical Park, Jamestown Island.

The Colonial National Historical Parkway (23 miles) connects Jamestown to Williamsburg to Yorktown. This is a multilane highway that is used both by visitors to the park and local residents. Due to increased visitors to the park during the summer months, traffic on the Parkway is heavier during this time. Along the parkway are a number of small pullover areas that have picnic or small trails for hiking. Three of these areas along the parkway have been identified as potential sampling sites to assess the roads impact on soils adjacent to the parkway. The three areas are as follows: Kingsmill Area (bordered by Halfway Creek and College Creek), COLO

(north of Cheatham Annex and south of Queen Creek), and Ringfield Picnic Area (south of Cheatham Annex and King Creek) (Figure 1). Each of these areas are bounded by the parkway and are areas with large mixed pine forested areas and open grassy fields that lead down to swamp or tidal creek areas. These areas are devoid of permanent structures.

The COLO at Yorktown is situated along the lower York River (Figure 2). The Yorktown Unit (YTU) is sandwiched between the U.S. Naval Weapons Station to the north and the Naval Supply Center and Coast Guard Yorktown Reserve Training Center to the south. Within the park boundaries are located the Colonial National Monument Yorktown Battlefield, City of Yorktown, and several smaller residential communities (Hickory Hill). Yorktown Battlefield is administered by the National Park Service as part of the COLO. The Information Center has visitor parking areas near the eastern portion of the park. Yorktown has both the historical buildings refurbished by the Park Service and private homes and municipal buildings. Adjacent to the Cole Memorial Bridge that connects Yorktown to Gloucester Point are privately owned shops, restaurants and a small public bathing beach. There is also a small marina at this location. Naval ships pass by this area to the U.S. Naval facilities just north of Yorktown. Commercial ships move up and down the York River. Located adjacent to the park is a rapidly developing suburban/urban area that will potentially impact the wildlife living within the park both from physical, as well as chemical inputs.

In addition, to adjoining residential development, other key park neighbors include several major military installations: Yorktown Reserve Training Center (Coast Guard), and three Navy facilities: the Yorktown Naval Weapons Station, Cheatham Annex/Naval Supply Center, and Yorktown Navy Fuel Farm. Two of the installations are currently involved in major hazardous materials or fuel spill cleanup projects in areas immediately adjacent to the park. The BP/Amoco Giant Yorktown Refinery is located on the York River and just south of Wormley Creek that is the boundary between the park and the facility. A fully executed RCRA Administrative Consent Order has been executed for both the refinery and the contiguous 85 acre parcel of land owned by BP. The facility is working with the USEPA to finalize the remedial design and begin construction in 2007. (USEPA 2007b)

Their proximity to the park and the known surface water and groundwater contamination poses a threat to wildlife living in the park. There is likely movement of contaminants onto park properties. The species with home ranges that would include both park and nearby properties would also be exposed to COCs originating from these facilities.

Biological Habitats

Besides these significant cultural resources, COLO possesses a variety of significant natural resources. Three types of forests can be found in the park, including pine, mixed pine, and hardwood. Forested wetlands occur on 730 of those acres. There are 448 species of animals and 1,017 species of vascular flora. Studies by the Virginia Department of Conservation and Recreation, the Division of Natural Heritage, and the park itself indicate that COLO has the second highest amount of rare, threatened and endangered (RTE) species of all NPS units in Virginia. Three of these species include the Bald Eagle, Great Blue Heron, and Great Egret. The Division of Natural Heritage has created a management plan for these species and associated habitats. Studies and inventories have also been conducted, and extensive GIS databases have

been developed on invasive plant species, fish, reptiles and amphibians, macro-benthos, water quality, air quality, and hydrology. (Monz, 2003)

Wetlands cover 2,200 acres of the park. The park properties are bordered by the York River and the James River, with a total of 30 miles of shoreline with numerous beaches (Figure 1-3). Both of these rivers are tidal and drain into the Chesapeake Bay. Complex networks of streams with substantial acreage of salt and freshwater marshes are located on the park lands. These areas serve as important nursery grounds for juvenile fishes and nesting areas for several avian species found within the Chesapeake Bay. Twenty-four miles of perennial streams and 30 miles of intermittent streams flow throughout the park, which has a direct hydrological link to the Chesapeake Bay.

COLO is part of two major watersheds, the James River Watershed (Lower James HUC# 02080206) and the York River Watershed (HUC# 02080107). Both are sub-watersheds of the Chesapeake Bay watershed, which stretches from Pennsylvania to Virginia. Within the James River and York watersheds are eleven sub-watersheds - Diascund Creek, Ware Creek, Yarmouth Creek, Gordon Creek, Powhatan Creek, Mill Creek, College Creek, James River, York River, Skiffe's Creek and Chickahominy River. (Horne, 2006)

The James River watershed is about 10,432 square miles (6.5 million acres) and The James River is 450 miles long. The watershed starts in the mountains of Bath and Highland Counties and eventually empties into the Chesapeake Bay at Hampton Roads and Newport News. The river itself is 340 miles long, and its watershed comprises about 24 percent of Virginia, 42 percent of the Virginia Chesapeake Bay watershed, and about 15 percent of the entire Chesapeake Bay basin. It is the third largest tributary of the Chesapeake Bay. The James River watershed is predominantly forested. About 71 percent of the watershed is forested, 23 percent is agricultural (2.6 million acres in 1997), and 6 percent is urban. Nearly 15 percent of the watershed is protected by designated wildlife areas, parks, and national forests. Both Richmond and Petersburg are large urban areas in the northern headwaters of the James River. Land use within the rivers basin varies considerably from headwaters to its mouth. The Lower James River – Middle Tidal watershed covers 142 square miles and includes Colonial Williamsburg, James City County, and Surry. Cover within the watershed consists mainly of forested area and approximately 7 percent is impervious. The major impact on Jamestown from the James River comes from upriver contamination south of Richmond and Petersburg. The mouth of the James River empties into the Chesapeake Bay at Newport News, Hampton Roads and Norfolk. The river is tidal up past Jamestown and there is a potential for contaminated sediments and suspended sediments to move up into the James River from Hampton Roads, Newport News and Norfolk.

The York River watershed is approximately 2,670 square miles. Its 2000 population was estimated at 372,488, and the watershed is one of the bay's fastest growing tributary basins. Williamsburg, West Point, Ashland and Mechanicsville are among the largest urban areas in the watershed. The York's headwaters are in Orange and Louisa counties, and the river empties into the Chesapeake Bay at Yorktown and Gloucester Point. The watershed comprises about 12 percent of Virginia's entire bay basin. Land use is predominantly rural. About 73 percent of the watershed is forested, 19 percent is agricultural and 8 percent is urban. The river has historic, scenic and wildlife value. The upper reaches of the river make up the most pristine freshwater

complex on the East Coast. In fact, four sites in the basin were selected as the first components of the Chesapeake Bay Natural Estuarine Research Reserve System. Unlike the James River to the south and the Rappahannock River to the north, the York River's tributaries remain free flowing. Because habitat and water quality there are excellent, largemouth bass, bream, pickerel and white perch are abundant. As the rivers join, the York's 34-mile tidal zone hosts plentiful drum, menhaden, bluefish, flounder and blue crabs. Oyster harvests, however, have fallen dramatically, mainly because of disease (MSX and Dermocystidium) over fishing and chemical/biological contamination. The City of Hopewell is located north of Jamestown, and is heavily industrialized which has contributed historical (Kepone) and present day downstream contamination.

COCs Source Inputs

Based on review of off-site activities and activities that are on going at the park locations, the greatest risk to wildlife coming into contact with COCs would appear to be from off-site activities. Wildlife that has a home range larger than the park area could be exposed to COCs from surrounding industries. On site deposition from atmospheric sources likely have occurred and continue today (Clear Air Status and Trends Network). Movement of contaminants from the soil into the sediment and surface waters also allow for COCs to move onto park properties.

COC Sources for the Colonial National Historical Parkway

The areas along the Colonial National Historical Parkway (CHP) are non-developed and have few if any structures that are not related directly to the parkway infrastructure. The vegetation and pull-off areas vary in the amount of maintenance that is done on maintaining the vegetation. The areas include mowed lawns, pine-oak forest, wetland areas leading into marsh and open river areas. Other than the runoff from the parkway there are no other likely sources of COCs.

COC Sources Potentially Impacting Jamestown

On-site activities at Jamestown Island produce few if any sources of COCs that would affect park wildlife. The new visitor center is located directly next to the parking area and the bridge connecting to the island is constructed of non-CCA treated material. The older visitor center buildings are clustered in a small area over the Pitch Tar Swamp. There is no incinerator or other commercial operations at this location. The small kiln used in the glass blowing may contribute some minor metal or hydrocarbons. The buildings are on city sewerage so there would be no contamination from septic fields. The main parking area may be the major contributor to COCs primarily polyaromatic hydrocarbons (PAHs) and metals entering into nearby areas. The maintenance area might also contribute some minor petroleum hydrocarbons and (volitile organic compounds)VOCs, but these compounds would be restricted to this area. The proposed samples to be collected at Jamestown would resolve if there are any COCs present and at what levels.

Surface Water Inputs - James River

It is estimated that about 1/3 of Virginia's total population lives in the James River watershed (approximately 2.5 million people). The James River receives the highest nutrient inputs of any river in Virginia, mostly from sewage treatment plants (STPs) and industrial discharges, but also in lesser amounts from agricultural and urban runoff. With 21 significant municipal dischargers and 28 major industrial dischargers, the James River is stressed by a combination of pollutants, including nutrients, toxics and bacteria. Over the years, the productivity of its fisheries, such as shad and striped bass, declined dramatically, rebounding only recently due to habitat enhancement, restocking efforts, fishing restrictions and the provision of fish passages through five dams in Richmond VDCR 2003a). Jamestown Island lies within two watersheds: the Lower James River –that is tidal and the Powhatan Creek. Because of the tidal nature contaminants from below, as well as, contamination from upstream can impact the Jamestown wildlife.

Virginia's DEQ 2000 Water Quality Assessment Report designated 379 miles of the James River and its tributaries as impaired, because they do not meet state water quality standards. In addition, 29 square miles of its tidal estuaries are impaired (VDCR 2003a).

However, more than 53,000 acres of once productive shellfish beds are now closed. Approximately 72 percent of the phosphorus and 62 percent of the nitrogen reaching the waters of the James River are reported to originate from non-point sources.

Powhatan Creek that drains into Sandy Bay on the western end of Jamestown Island have nitrogen (0.55-1.25 mg/L) and phosphorous (<0.1 mg/L) levels that are at or below levels of concern, nitrogen (2.0 mg/L) and phosphorous (0.1 mg/L). Copper levels collected from 1992-1998 ranged from 20 -30 ug/L in the tidal and non-tidal reaches of the Creek, which are above the criteria maximum concentration for freshwater 13 ug/L and for marine at 4.8 ug/L (NOAA Squirt 1999). This creek is also impacted by high concentrations of fecal coliform. These elevated levels may be a result of the local marina, development and the storm water run off from the impervious cover and storm drains. Copper would be considered a COC for waters near Jamestown.

The James River receives the highest combined point and non-point nutrient inputs of any of the major Chesapeake Bay tributaries. Around 53 percent of the controllable nitrogen and 58 percent of the phosphorous entering the river originate from point sources (Sprague, L.A., 2001). Overflow of combined sewers and chemical pollution also pose serious problems, especially during periods of heavy rainfall. Landings of freshwater spawners, such as shad and striped bass, and commercial harvests of market oysters have significantly declined within the area. Over 53,000 acres of once productive shellfish beds are now closed due to fecal coliforms (VDCR 2003a).

In Table 1 are the active industrial sources for discharge into the James-Mid and Tidal River. The permitted discharges in Chester, Charles City are above Hopewell and would contribute few if any COCs reaching Jamestown. The dischargers at Hopewell are also up river of Jamestown and would likely have little impact on Jamestown wildlife. The Colonial Pipeline at Surry and Lee Hall are inland and would likely not contribute to COCs unless there was a major spill. The water supply and treatment facilities would contribute low level VOCs, but would not impact wildlife at Jamestown. The BASF plant in Williamsburg is being remediated and would not pose any risk to Jamestown wildlife (Table 2).

Two sewage treatment facilities are located near Jamestown Island on the James River. The Williamsburg Sewage Treatment Plant serves about 50,000 people. The treatment facility has a design flow of 22.5 MGD. It is an activated sludge plant with tertiary clarifiers. Discharge of final effluent is into the James River. Sludge is dried and incinerated on site and the incinerator ash is disposed of in an approved landfill.

The James River Sewage Treatment Plant located in Newport News, VA has a design flow of 20 MGD. The facility consists of screening grit removal; primary and secondary sedimentation; chlorination; and dechlorination. Discharge is into the James River. Both of these facilities would contribute to the load of nutrients and trace metals entering into this water body along with lower concentrations of pharmaceuticals, VOCs and other personal care products. The COCs from these facilities are primarily from household waste. These facilities would contribute to contamination in and around Jamestown.

Table 1. Active Industrial Sources of Discharge into the James River (VPDES Permitted Discharges).

Facility Name	Location	Permit #
Mt Zion Rustic WTP	Charles City	VA0085936
Honeywell Resins and Chemicals LLC - Chesterfield	Chester	VA0005312
Dominion Virginia Power - Chesterfield	Chester	VA0004146
Philip Morris USA Incorporated - Park 500	Chester	VA0026557
Trans Ind Incorporated	Chester	VA0088153
DuPont Teijin Films	Hopewell	VA0003077
RJ Reynolds Tobacco Company - Hamner Division	Chester	VA0002780
Colonial Pipeline Company - Yorktown	Lee Hall	VA0051870
Lawnes Point Water Suppy System	Rushmere	VA0091731
Dominion - Gravel Neck CT Station	Surry	VA0004090
Colonial Pipeline Surry	Surry	VA0085481
Smurfit Stone Container Enterprises Inc - Hopewell	Hopewell	VA0004642
Dominion - Hopewell Power Station	Hopewell	VA0082783
Honeywell International Incorporated - Hopewell	Hopewell	VA0005291
Hopewell Cogeneration Limited Partnership	Hopewell	VA0079502
James River Cogeneration Company	Hopewell	VA0073300
Nalco Company	Hopewell	VA0077089
BASF Corporation - Williamsburg	Williamsburg	VA0003654
JCSA - Five Forks Water Treatment Facility	Williamsburg	VA0091111

Table 2 lists additional industrial or military facilities which are in the vicinity of Jamestown. The James River Reserve Fleet at Fort Eustis is a fleet of 71 “mothballed” ships that are held in reserve in case of a national or international emergency. The military base at Fort Eustis is an active training and support facility. The potential impact of this fleet is discussed in greater detail in the surface water section. The Williamsburg airport is a single runway small facility which services small corporate and private aircraft. The airport is north of Jamestown and adjacent to College Creek and would likely not impact wildlife at Jamestown. The other two operations (VA Natural Gas and Cook’s Landscaping), also pose little risk to the wildlife at Jamestown.

There is a VDH fish advisory for the James River at the interstate 95 James River Bridge crossing in Richmond downstream (~110 miles) to the Hampton-Norfolk Bridge Tunnel (mouth of James River) for both polychlorinated biphenyl (PCBs) and Kepone.

The T&S Disposal/Waltrip Recycling Facility is located in Williamsburg, VA. The site is a 5 acre landfill (construction and site preparation waste only) and mulch manufacture and distribution facility. This facility would not appear to contribute to COCs for Jamestown Island wildlife.

Table 2. Industrial and Military Facilities in the Vicinity of Jamestown.

Occupant	Site Description
James River Reserve Fleet, Fort Eustis Owner: US Maritime Commission, USDOT	Military support installation 80 persons On-shore: 1 X 1,000 gallon above ground storage tank (empty); 2 X 500 gallon above ground storage tank with gasoline (all coffer dammed); (2) oil/water separators for treatment of bilge water Off-shore: (71) "mothballed" ships, source of numerous small fuel oil leaks from leaking hulls and may worsen with age Reserve fleet down-sized to 16 ships Outfitted with portable toilet that is pumped on routine basis (1) storm water discharge
US Transportation Center, Fort Eustis Owner: USDOD	Military installation ~25,000 persons (81) above ground storage tanks over 500 gallons capacity with total capacity of 148,900 gallons storing fuels, lubricants, solvents, oily waste water (27) superfund sites located within present survey boundary: retired landfills (unlined); tank areas; dredge/sludge areas; pesticide storage areas; firefighting training areas; maintenance shops; artillery range and impact areas- most commonly contaminated with PCBs, petroleum distillates, metals, VOCs Base has (81) outfalls, (79) of which are storm water
Virginia Natural Gas, Williamsburg Owner: AGL Resources	Natural gas pipeline peak shaving facility
Mann Industries, Inc., Williamsburg Owner: BASF	Former acrylic fiber manufacturing plant now permanently closed Soils contaminated with number of organic compounds and is being remediated by underground air injection Plants private STF has been demolished Storm water discharge to Wood Creek, Grices Run, James River
Williamsburg/Jamestown Airport, Williamsburg	Observed on-site (2) above ground storage tanks over 500 gallons in capacity for fuel
Cook's Landscaping, Williamsburg Owner: Jeff Schell	Corrugated fiberglass paneled 1 story garden shop ~10 employees Observed on-site (2) above ground storage tanks over 500 gallons in capacity for fuels

(VDH 2005)

Hopewell, Virginia is north of Jamestown Island, and over the years has been the home to a number of large industries that have contributed to down river contamination. The Allied Signal Companies release of Kepone in the early 1970s into the James resulted in closure of the river for fishing and shellfishing until 1980s. Today there is still a fish-eating advisory the lower tidal rach of the James River. The Exeter (EPA VAD988222972) site is listed as a former Superfund site, but it is being proposed to be developed following removal of PCB transformers and other contaminants from the site. The sites within Hopewell do not appear to pose a threat to wildlife at Jamestown Island.

In Table 3 is a list of marinas and or docking facilities in the immediate areas of the parks. The National Defense Reserve Fleet that is anchored off of Ft. Eustis in the James River poses both a chronic risk from small oil releases, but also a more catastrophic spill could occur that would dramatically impact wildlife within the region. A larger spill could result from the moving of the fleet for decommission or from storm events. A spill at that location could also severely damage the sediments in the creeks and rivers adjacent to Jamestown. The amphibious training area at Skiffes Creek Harbor is associated with the Department of Army. This is a restricted area and is used for training and small cargo vessels. Petroleum hydrocarbon spills are likely the greatest threat. The remainder of the marinas likely poses local concerns, but would not pose a serious risk to wildlife on or near park properties. The area waters adjacent to Jamestown do have considerable boat traffic and hydrocarbon levels are likely elevated in this reach of the river due to current use and historical activities at Newport News, Hampton Roads and Norfolk. The COCs would include light and heavy petroleum products, tributyltin (TBT), copper and lead.

The primary concern to park resources is the threat of an oil spill or significant hydrocarbon release. Impairments to park resources can arise from the accumulated affects of small spills, and possibly from larger spills from facility releases, intentional releases, or a major tank spill. Small spills occur on a regular basis in all of the marinas and are likely to go unreported, but their cumulative effect is the overall degradation of the benthic environment and elevated water soluble fractions that could affect pelagic organisms.

Several other industrial facilities in the area have reported in their toxic reporting inventory (TRI) reports supplied to the USEPA air releases (USEPA 2004). The Anheuser Busch Inc. facility has reported releasing ammonia (21,393 lbs/yr) and chlorine (183 lbs/yr). They also report releasing 0.123 grams of dioxin-like compounds. The congeners released are pentachlorinated congeners and higher. These levels pose no threat to wildlife on Jamestown. The second facility is the Bell Metal Beverage Container Corporation which releases 329,000 (lbs/yr) of glycol ethers and 239,000 lbs/yr of n-butyl alcohol. Since these are dispersed over a wide area and both compounds are highly volatile, they would not impact Jamestown wildlife.

Table 3. Local Marinas and Boating Activity**.**

Marina	Site Description
James River Reserve Fleet off Ft. Eustis Owner: US Maritime Commission, USDOT	Military support installation 80 persons Off-shore: 98 “mothballed” ships- source of numerous small fuel leaks from leaking hulls with potential to worsen with age Reserve Fleet being down-sized to 16 Has on-shore sanitary facility and solid waste receptacle
Skiffes Creek Harbor, US Transportation Center, Dept. of the Army Owner: USDOD	Military installation ~25,000 persons Training harbor: ~35 amphibious and small cargo vessels On-shore sanitary facility and solid waste receptacles
Kings Mill Marina, Williamsburg Owner: Kings Mill Property Owners Assoc. (Private marina)	3 employees 75 slips available Boating services available: fuel, water, electricity, in-out ramp Containers available for solid waste disposal Sanitary facilities: commodes, urinals, lavatories, showers. Sewage disposal by connection to Hampton Roads Sanitation District Boat holding tank pump-out facilities and dump station facilities provided
Jamestown Marina, Williamsburg Owner: Commercial marina	3 employees 14 slips and 9 dry storage spaces available Present at survey: (1) pleasure boat at 26’; (4) pleasure boats over 26’; dry storage had (4) pleasure boats under 26’ Boating services provided: fuel, water, electricity, repair services, and in-out ramp Containers available for solid waste disposal Sanitary facilities provided: commodes, lavatories Sewage disposal by connection to Hampton Roads Sanitation District Dump station facilities provided Has exemption to requirement to provide boat holding tank pump-out facilities
Jamestown Yacht Basin, Williamsburg Owner: Commercial marina	3 employees 88 slips, 30 dry storage spaces available Present at survey time: (9) pleasure boats under 26’; (49) pleasure boats over 26’; dry storage had (20) pleasure boats under 26’ Boating services provided: fuel, water, electricity, repair services, and in-out ramp Sanitary facilities provided: commodes, lavatories, showers Sewage disposal by on-site septic tank Boat holding tank pump-out facilities and dump station facilities provided
Kings Point, Williamsburg Owner: Kings Point Club, Inc., private country club	8 slips available Boating services provided: in-out ramp Sanitary facilities provided: commodes, lavatories, showers Sewage disposal by connection to Hampton Roads Sanitation District Has exemption to requirement to provide boat holding tank pump-out facilities

(VDH 2005)

Sediment COCs-James River

Between 1985 and 1996, cropland and pastureland held steady as the heaviest contributors of sediment loading to the James River watershed. Corn field s adjacent to Powaton Creek likely contribute nutrient loading and pesticide inputs into this small watershed. According to the Virginia Department of Forestry, the implementation of forestry Best Management Practices (BMP) has decreased sedimentation and runoff. Shoreline stabilization along the tidal portion of the James River increased nearly 13 percent between 1985 and 1990. Shoreline hardening changes the natural interface between land and water, resulting in habitat and hydrologic changes along the river.

Allied Chemical Corporation, located in Hopewell, VA, produced the insecticide Kepone, which the USEPA had discovered was contaminating the James River. It was estimated that around 90,720 kg of Kepone had been released into the environment through atmospheric emissions, wastewater, or disposal of bad batches (Lunsford et al. 1980 & Battelle 1978). According to a study by Luellen et al. (2005), Kepone can still be detected in a large number of fish in the James River. The concentration of Kepone has remained steady since the 1990s. Luellen noted that only 6% of the samples fell below the detection limit since 1987, possibly due to resuspension of contaminated sediments (Luellen et al 2005).

COC Sources for COLO -Yorktown

The Naval Weapons Station at Yorktown (EPA ID VA8170024170) and the Naval Weapons Station Yorktown – Cheatham Annex (EPA ID VA3170024605) are two USEPA national priority list (NPL) sites that are close in proximity to the COLO and may contribute to COCs for wildlife on NPS properties. The contaminants may make there way onto park properties from movement of sediment or contaminated surface water into adjoining marsh areas and the York River.

The US Naval Weapons Station (WPNSTA) in Yorktown borders COLO and the York River (Figure 2 and 4). The facility is 10,624 acres and is located in York and James City Counties and in the City of Newport News. According to the USEPA, WPNSTA, was placed on the NPL in 1992 due to 19 sites being identified as past disposal or storage areas for hazardous materials such as acids, asbestos, explosives, cadmium, lead, mercury, nickel, paint thinners, solvents, varnishes, waste oil, and PCBs, along with some of the Navy's nuclear arsenal that was stored and maintained at WPNSTA such as RDX (cyclotrimethylenenitramine), HMX (cyclotetramethylenetetranitramine), and TNT (2,4,6- trinitrotoluene) (Figure 4 and Table 4). The site is located near two major tributaries of the Chesapeake Bay and migration of contaminants to both the James and York River has been of concern (USEPA 2006b).

Located on the same Virginia Peninsula is the Naval Weapons Station Yorktown- Cheatham Annex, which is just outside of Williamsburg, VA in York County (Figure 2 and 5). The Cheatham Annex lies on the York River about 15 miles upstream of the Chesapeake Bay. This facility was added to the NPL in 2000. Five sites, four areas of concern, and one preliminary screening area for ongoing remedial activity were established. This 1,579 acre federal facility was used for receiving, storing, packing, and shipping of materials to federal facilities on the east coast and to European distribution centers. DuPont operated a large powder and shell-loading plant for about three years and then was privately owned and used for farming or left idle (USEPA 2006c).

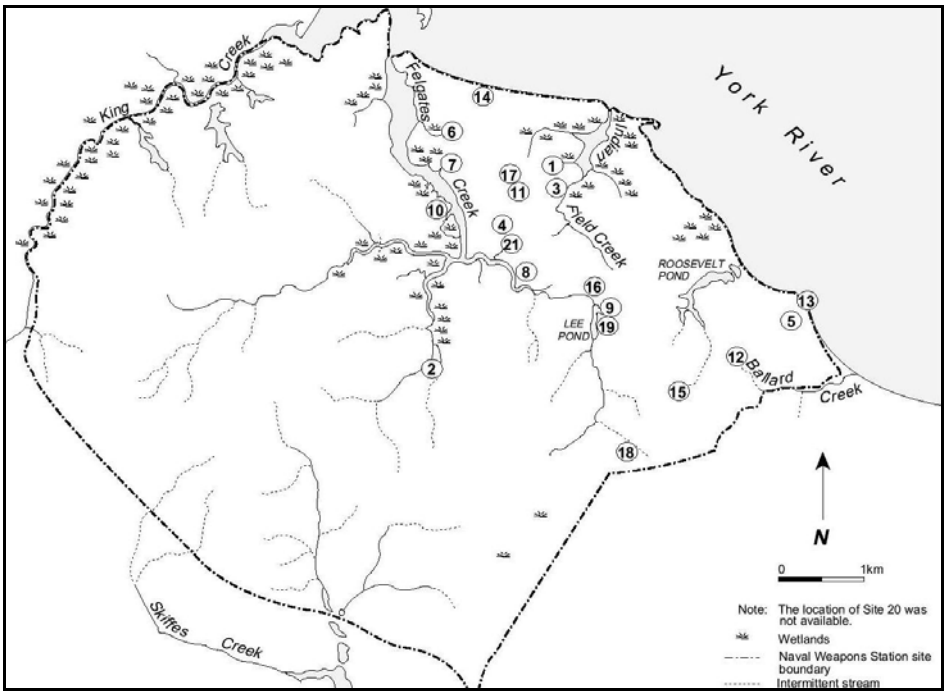


Figure 4. Naval Weapons Station Yorktown and Station Locations. (NOAA Office of Response and Restoration 2006)

Within Table 5 is a list of dates of operation for activities at each of the sites and the main COCs. Table 6 lists the maximum concentrations of primary COCs detected at several locations at the Cheatham Annex. There is little question that COCs from these military installations would have an impact on wildlife in the immediate receiving waters. What is not as clear is the impact on wildlife on the NPS adjacent properties.

For more detailed data on the Naval Weapons Station Yorktown (Cheatham Annex) refer to the USEPA Hazard Ranking System (HRS) Documentation Record at http://epa.gov/reg3hwmd/super/sites/VA3170024605/index.htm. The data presented in Table 6 will be discussed further by matrix type (page 31).

The BP/Amoco Giant Yorktown Refinery is located on the York River and just south of the boundary for the park. The facility is bounded by the York River on the north and east, by Back Creek on the south and by the Dominion Power Station on the west. The main contaminants of concern in the soil, surface water and groundwater are petroleum hydrocarbons such as benzene, toluene, xylenes, polycyclic aromatic hydrocarbons, phenols and heavy metals such as arsenic, chromium and cadmium. A fully executed RCRA Administrative Consent Order has been executed for both the refinery and the contiguous 85 acre parcel of land owned by BP. The facility is working with the USEPA to finalize the remedial design and begin construction in 2007. A spill at this location would impact the wildlife within the park and a spill response plan should be developed.

Dominion Yorktown Power Station is located adjacent to the BP/Amoco Giant Yorktown Refinery. There are three generating units that can produce 1,150 megawatts of energy. Two of

the units are coal fired (355 megawatts), while the third (875 megawatts) burns oil that is cleaner burning than coal. Based on the USEPA's TRI data for 2002 the facility released 1,621,790 lbs of compounds into the air. The facility also reported releasing 4.74 grams of dioxins, but no congener specific information was reported. The facility land applies the recovered fly ash and incinerator ash on-site.

The U.S. Coast Guard Training Center has reported in their TRI report on-site disposal of 250 lbs/yr of lead. Unless this was mobilized into surface or groundwater it would pose little or no threat to wildlife at Yorktown.

Table 4. Site names, periods of operation and type of waste disposed or spilled.

Site of Concern	Period of Operation	Types of Wastes Disposed or Spilled
LEE POND WATERSHED		
Site 9: Explosive Contaminated Wastewater Discharge Drainage Area	Late 1930s	trichloroethylene, TNT, RDX, HMX
Site 16: West Road Landfill	1950s-1960s	batteries, banding material, PCB-contaminated pressure transmitting fluid, chemicals
Site 18: Building 476 Discharges	1940s-1960s	mercury, nickel, cadmium, lead
Site 19: Conveyor Belt Soils at Building 10	1940-1970s	TNT, RDX
ROOSEVELT POND WATERSHED		
Site 15: Electrical Shop Disposal Area	1973	copper and other wires, concrete, telephone poles, metals
FELGATES CREEK WATERSHED		
Site 2: Turkey Road Landfill	1940-1981	mercury and zinc-carbon batteries, construction rubble, missile hardware, electrical devices, empty oil drums
Site 4: Burning Pad Residue Landfill	1940-1975	burning pad residues (e.g., TNT, RDX, 2,4-DNT), weapon batteries, fly ash, mine casings, electrical equipment, PCBs
Site 6: Explosive Contaminated Wastewater Impoundment	1942-1975	solvents (e.g., trichloroethylene, trichloroethane, cyclohexanone), explosive residues (e.g., TNT, RDX, 2,4-DNT)
Site 7: Plant 3 Explosive Contaminated Waste-water Discharge Area	1945-1975	explosive residues (e.g., TNT, RDX), trichloroethylene, cyclohexane
Site 8: NEDED Explosive Contaminated Waste-water Discharge Area	1940-1975	spent/neutralized acids, trichloroethylene, acetone, cyclohexane, explosive residues (e.g., TNT, RDX, 2,4-DNT, HMX)
Site 10: Felgate Crossing Fill Area	1940s	plaster-filled mines, ordnance steel, inactive military hardware
Site 21: Battery and Drum Disposal Area	Unknown	VOCs, trace elements, pesticides, BNAs, PCBs
INDIAN FIELD CREEK WATERSHED		
Site 1: Dudley Road Landfill	1965-1981	asbestos, oil, grease, paint, solvents, explosive contaminated carbon, appliances, scrap metal, plastics, lumber, packaging wastes, waste oil
Site 3: Group 16 Magazines Landfill	1940-1970	grease trap wastes, sludge from boiler cleaning operation, solvents (e.g., trichloroethylene, methylene chloride), Imhoff tank skimmings (oils)
Site 11: Aberdeen. Explosives Pits	1930-1950	TNT, RDX, HMX
Site 17: Holm Road Landfill	1950s-1960s	PCB-contaminated hydraulic fluids, batteries from underwater weapons, scrap metals
BALLARD CREEK WATERSHED		
Site 12: Barracks Road Landfill	1925-mid-1960s	garbage, scrap wood, explosive contaminated packaging, solvents
YORK RIVER WATERSHED		
Site 5: Surplus Transformer Storage Area	1940-1981	PCBs
Site 13: Building Rubble Disposal Site	Demolished in 1977	asbestos
Site 14: Aviation Field	1930s	munitions

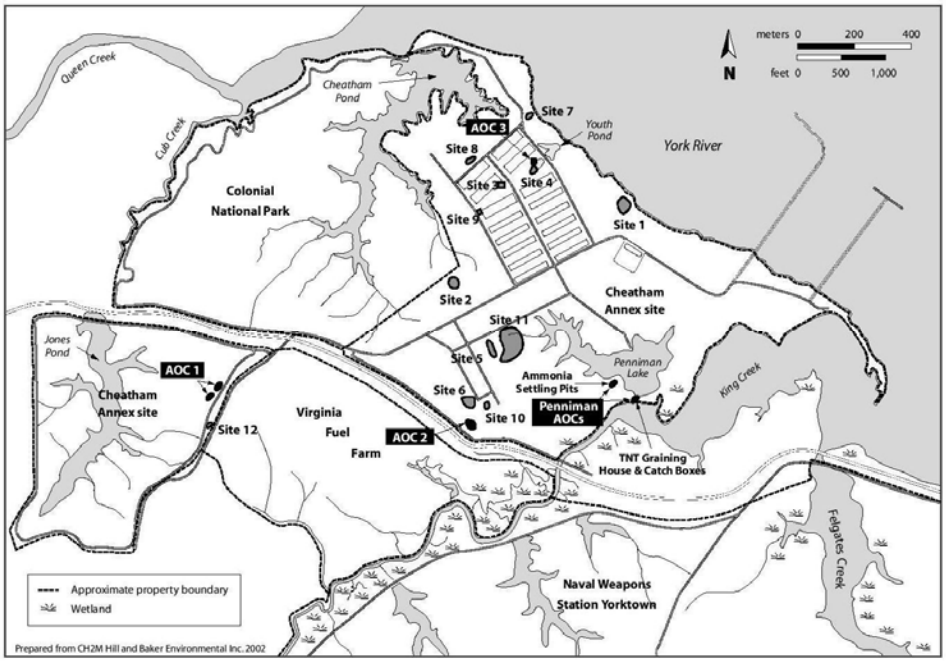


Figure 5. Map of the Naval Weapons Station Yorktown Cheatham Annex site and location of specific sites analyzed for contamination. (NOAA Office of Response and Restoration 2006)

Soil and Sediment

At the Naval Weapons Station at Yorktown (CERCLIS #VA8170024170) a number of trace metals and ordinance compounds were detected from soil and sediment samples collected at four watersheds at the site (Lee Pond, Felgates Creek, Indian Filed Creek, Ballard Creek). The values in bold for the soil are at concentrations above reference levels (USEPA 1986), while the bolded sediment values are above reference levels are based on Buchman (1999). Soil samples were not taken from Ballard Creek or Indian field Creek. The following concentrations ranges in mg/kg were detected in soil: arsenic 11, cadmium 2.6-ND, chromium 38-8, copper 47, lead 92-14, mercury 3.3, nickel 15-ND, silver ND, zinc 1,000-56, 2.,4-DNT 3.1- ND, HXM ND, RDX 850-2.7, and TNT 1430-3400. The following concentrations ranges in mg/kg were detected in sediment: arsenic 13-7.4, cadmium 7.2-1.3, chromium 110-28, copper 570-10, lead 250-32, mercury 0.68-ND, nickel 24-14, silver 7.3-0.3, zinc 730-110, 2.,4-DNT 17- ND, HXM 44-ND, RDX 1.1-ND, and TNT 1240-2.7. There are no reference levels for the munitions, but there presence indicates potential for continued release into the environment and exposure to wildlife.

Sediments from Ballard Creek also contained elevated concentrations of total PAHs (23 mg/kg), BHC (0.084 mg/kg), DDT (0.084 mg/kg) and chlordane (2.8 mg/kg). Since Ballard Creek is the northern boundary for the park, it is likely that these and other contaminants have migrated onto park property.

Within Table 6 is shown the maximum concentrations for primary COCs detected at several sites located at the Cheatham Annex location (Figure 5). The metals that are greater than the Region III Biological Technical Assistance Group (BTAG) levels for fauna in soils are the following: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc. The PAHs

present in the soil at Site 1 would indicate high level of petroleum based hydrocarbons. These levels are well above screening levels. The pesticides which were elevated included 4,4-DDE, 4,4-DDT and heptachlor epoxide. The total PCBs at Site 1 was 5.4 mg/kg.

The sediment values for Site 1 (Table 5) reflect elevated levels (mg/kg) of metals, PAHs, pesticides and PAHs. The metals that were above sediment criteria levels included the following: arsenic, cadmium, copper, lead, mercury, nickel, silver and zinc. Similar to the soil contamination the sediment contained a number of PAHs that were well above sediment criteria. The pesticides that were above sediment criteria included: 4,4-DDE, 4,4-DDT, dieldrin and lindane (Gamma BHC). The total PCBs were also above the sediment criteria.

The Commonwealth of Virginia currently owns a 435-acre fuel storage facility located in western York County adjacent to the Colonial Parkway. The site, known as Commonwealth of Virginia Emergency Fuel Storage Facility (CVEFSF), was formerly owned and operated by the U.S. Navy. This site lies within the Kings Creek sub-basin, which drains through the park into the York River. This facility contained (23) two million-gallon underground storage tanks, which stored various petroleum products including No. 2 fuel oil, kerosene, gasoline, oil and various special Navy and aviation fuels. A site investigation has been conducted over the site. While the site is neither on the Superfund list nor the NPL, the Commonwealth of Virginia is negotiating with USEPA and the U.S. Army Corps of Engineers regarding final site remediation. Remediation activities to date have included removal of all known PCB materials, equipment and numerous small PCB stains from the soil and concrete pads. As well, contracts have been initiated to remove petroleum sludge from pits and contaminated water and soil from the site. Cleaning of contaminants from the storage tanks and underground piping is for the most part complete. The Virginia Emergency Fuel Storage Facility has resulted in heavy petroleum contamination of soil and sediment at Hipps Pond and along two influent ravines. The contamination is primarily polycyclic aromatic hydrocarbons. The surface waters near the facility show low surface water contamination, which likely reflects the slow release from reservoirs (sediment and groundwater) and natural flushing of the system into the York River.

Table 5. Yorktown Naval Weapons Station (Cheatham Annex) Site Description.

Site	Description
Site 1- Landfill Near Incinerator	located along the York River, 1.3 acres 1942-1951: used as disposal area for burn residues 1951-1972: used as general landfill Wastes including empty paint and paint thinner cans, cartons of ether and other unspecified drugs, railroad ties, tar paper, sawdust, rags, concrete, and lumber were burned and disposed until 1981 ~15,500 tons solid waste buried Debris exposed along the western side along the edge of marsh associated with unnamed tributary to the York River COCs; metals, SVOCs (primary PAHs), and PCBs
Site 2- Contaminated Food Disposal Area	Pit is ~50 ft in diameter and was 12-15 ft deep Not considered significant source of contamination
Site 3- Submarine Dye Disposal Area	Dye stored in 55gal drums on 2 or 3 pallets between the warehouses Drums corroded, dyes leaked onto ground and into storm sewer system, which leads to the York River Drums removed in early 1970s and area presently used as storage lot
Site 4- Medical Supplies Storage Area	1968 or 1969: out-of-date medical supplies unloaded down bank and covered with soil ~7,000 cubic yards of material was reported to be disposed of at this site
Site 5- Photographic Chemicals Disposal Area	1967 or 1968: outdated photographic chemicals (developers and fixers) disposed in pit Quantity: 20-40 gal, or one pallet full (~6 months accumulation)
Site 6- Spoiled Food Disposal Area	1970: ~750 cubic yards of food spoiled in cold storage was buried in 12-15 ft deep pits Food had no hazardous properties
Site 7- Old DuPont Disposal Area	Waste was reported to be non-hazardous and/or inert No specific information on quantity and type of waste is available COCs: PCBs and Silver sediment exceeded ERL (expected response low)

Table 5. Yorktown Naval Weapons Station (Cheatham Annex) Site Description. (continued)

Site	Description
Site 8- Landfill near Building CAD 14	Less than ¼ of acre in size Trenches with surface areas of 2,000 feet and depths of 10 ft Used for waste disposal as recently as 1980 Reported that non-hazardous materials like spoiled meat and clothing are disposed of at the site
Site 9- Transformer Storage Area	~7,000 square feet 1973-1980: electrical transformers, some containing PCBs, were stored either waiting repair or disposal 6-30 transformers stored at a time Storage area surface was exposed soil enclosed by an earthen containment wall Transformers no longer stored after 1980, area graded and covered with gravel COCs: PCBs
Site 10- Decontamination Agent Disposal Area Near First St.	~75-100 gal of decontamination agent (DS-2) reported buried at site DS-2: toxic to humans; decontaminates equipment contaminated with nerve or blister agent; 70% diethylene triamine, 28% ethylene glycol monomethyl ether, 2% sodium hydroxide VOCs were detected in soil samples
Site 11- Bone Yard	8 acres, used between 1940-1978 Wasted deposited include oil, asphalt, and gasoline Submarine net coating, tar, operation once occurred 15 barrels of 500 gal above ground tanks (10) 5 gal containers of concrete sealant (paraplastic) Numerous barrels of petroleum products Several 500 gal square tanks containing asphalt or oil to make asphalt Site investigation detected: toluene, 111-TCE, PAHs, leachable lead, cadmium, barium, methylene-chloride, 1,1,1-trichloroethane (TCA), xylene, toluene Impact on shallow soils, marsh sediment, and lake sediment; no impact on ground and surface water
Site 12- Disposal Site Near Water Tower	Surface disposal of scrap metal- old automobile parts and iron pipes ~10-110 cubic feet of material disposed of at site Not considered significant source of contamination

Table 5. Yorktown Naval Weapons Station (Cheatham Annex) Site Description. (continued)

Site	Description
Area of Concern 1- Scrap Metal Dump	Wood and metal debris outcrop the banks of ravine Orange staining in unnamed tributary VOCs, SVOCs, pesticides, PCBs, inorganics, and cyanide detected in surface soil and sediment samples
Area of Concern 2- Dextrose Dump	Foundation piers left from the Penniman Shell Loading Plant 470 bottles removed from site: ~5% randomly selected and analyzed; each contained 2,000 ppm glucose COCs in soil: cadmium, silver, copper, lead, arsenic, chromium, zinc, PCBs, DDT, DDE and dieldrin.
Area of Concern 3- CAD 11/12 Pond Bank	20 ft by 20 ft by 10 ft high pile of metal banding along the north bank of the unnamed pond
Penniman Area of Concern	*Ammonia settling pits*: Consists of earthen earthen ammonia settling pits part of former shell loading area; wastewater from ammonia finishing building discharged *TNT Graining House Sump & TNT Catch Box Ruins*: Concrete-lined open top pit that may be sump pit for TNT graining house *Waste Slag Material*: Consists of waste metal slag material along railroad tracks *1918 Drum Storage*: Storage of 55 gal drums when shell loading area was active; currently a yard area These 5 sub-areas have not been investigated

(VADEQ 2006)

Ground Water Inputs

The York-James Peninsula is comprised of 6 confined aquifers, or significant water-bearing geologic layers, and an overlying water table aquifer. These aquifers include: Columbia, Yorktown-Eastover, Chickahominy-Piney Point, Aquia, Upper Potomac, Middle Potomac, and Lower Potomac. The aquifers are primarily sand and the confining layers are mostly silt and clay. The USGS classifies the Jamestown/Yorktown area as poorly drained lowlands. Groundwater quality is normally good; however some water contains high levels of iron and hydrogen sulfide (USGS 2006).

The York County Health Department is currently monitoring off-site wells located to the west of the Commonwealth of Virginia Emergency Fuel Storage Facility (CVEFSF). Five discrete groundwater plumes contaminated with petroleum hydrocarbons were identified at the site (USEPA Region 3 2007). The COCs include benzene, toluene, xylenes and ethylbenzene. In the most recent collections 3 of the 5 study areas have reached drinking water standards. Continued monitoring will indicate if the groundwater remains at these levels since groundwater contamination can vary depending on the type of plume (continuous or pancaked) and number of incidents. Groundwater from off-site wells has not indicated petroleum hydrocarbon contamination moving off-site.

At the Naval Weapons Station at Yorktown a number of trace metals and ordinance compounds were detected from groundwater samples in the four watersheds. The following concentrations

ranges in ug/l were detected: arsenic 83-ND, cadmium 85-ND, chromium 260-ND, copper 82-ND, lead 110-ND, mercury 0.33-ND, nickel 75-11, silver 15-ND, zinc 19.000-16, 2.,4-DNT ND, HXM 0.72-ND, RDX 9.0-ND, and TNT 0.13-ND. The values in bold are at concentrations above reference levels (USEPA 1986). There are no reference levels for the munitions, but their presence indicates movement into the groundwater. The munitions levels in the groundwater are very low and likely pose little risk to wildlife.

At the Cheatham Annex site 1 there were no pesticides, PAHs or PCBs detected above detection limits (Table 6). Arsenic, cadmium, chromium and mercury were detected, but were below levels of concern. Copper, lead, nickel, selenium, and silver were below detection limits. Zinc was the only metal that was above the concentration of concern.

Surface Water Inputs

The main stem of the York River begins at West Point, Virginia with few towns on the eastern shore of the river until north of Gloucester Point. Along the western peninsula there are a number of military installations: Camp Perry Naval Reservations Armed forces Experimental Activity, U.S. Naval Supply Center Cheatham Annex, U.S. Naval Weapons Station, and the U.S. naval Supply Center. These installations have large expanses of woodland and fresh and salt water marsh areas. There are also areas of extensive manufacturing and industrial development for carrying out activities at the bases. As previously discussed a number of terrestrial COCs likely move off-site into adjacent surface waters.

At the Naval Weapons Station at Yorktown a number of trace metals and ordinance compounds were detected from surface water samples collected at four watersheds at the site. The following concentrations ranges in ug/l were detected: arsenic 9.4-ND, cadmium 4-ND, chromium14-6, copper 13-4, lead 85-ND, mercury 0.26-0.2, nickel 15-ND, silver 18-ND, zinc 110-31, 2.,4-DNT ND, HXM 1.7-ND, RDX 23-ND, and TNT 19-0.55. The values in bold are at concentrations above reference levels (USEPA 1986). There are no reference levels for the munitions, but there presence indicates movement into the surface water from groundwater or runoff from contaminated soil. The surface water at Site 1 at the Cheatham Annex location had elevated levels of metals that would adversely impact wildlife. The following metals were above the ambient water criteria for the protection of aquatic organisms (USEPA 2002): arsenic and copper. Cadmium, chromium, mercury, and zinc were detected, but were below concentrations of concern (Table 6). No PAHs or pesticides were detected in the surface waters (Table 6).

The St. Laurent Corp. manufactures container board at the West Point, Virginia facility. The Mattaponi and Pamunkey rivers converge to form the York River at West Point. This facility uses recycled material to manufacture container board. There is no bleaching in the process, and there are limited inputs into the York River. The major inputs are nitrogen, phosphorous and suspended solids. This COCs from this facility would not impact COLO wildlife.

Overall phosphorus levels in the York River meet USEPA and state criteria. Both nitrogen and phosphorus levels are below the state median, but phosphorus levels are increasing in the middle section and nitrogen levels are rising throughout the river. Approximately 57 percent of the nitrogen and 47 percent of the phosphorus reaching the York River originate from non-point sources. The river is similar to its northern neighbor, the Rappahannock River; in that most of its dissolved oxygen problems occur at its mouth. Water quality at the mouth of the river is

sometimes too poor to support the growth of submerged aquatic vegetation (or underwater grasses) needed by organisms for habitat, and benthic organisms. Conditions are marginal for fish in the lower portion of the river. (VDCR 2003b)

Table 6. Maximum Concentrations of Primary COCs Detected at Site 1, Site 7 and AOC2 at the Cheatham Annex location. Values in bold exceed screening guidelines.

	Soil (mg/kg)			Water (µg/L)			Sediment (mg/kg)		
	Site Soil		BTAG[a] Screening	Ground-water	Surface Water		Sediment		
Contaminant	Site 1	AOC 2	Level	Site 1	Site 1	AWQC[b]	Site 1	Site 7	ERL[c]
METALS/INORGANICS									
Arsenic	**40**	**37**	5.2[d]	35	14	36	**12**	5.9	8.2
Cadmium	**31**	**12**	0.06[d]	2.8	0.21	8.8	**3.3**	<0.09	1.2
Chromiume	**70**	**95**	37[d]	7.7	1.7	50	30	22	81
Copper	**4300**	**320**	17[d]	ND	**11**	3.1	**90**	7.4	34
Lead	**2700**	**220**	0.01	ND	6.9	8.1	**89**	21	46.7
Mercury	**1.6**	**0.06**	0.058[d]	0.05	0.17	0.94[f]	**1.4**	0.11	0.15
Nickel	**500**	**24**	13[d]	ND	ND	8.2	**25**	4.8	20.9
Selenium	**7.9**	<1.1	1.8	ND	ND	71	0.54	<0.81	1.0[g]
Silver	**14**	**23**	0.05[d]	ND	ND	1.9[h]	**2.4**	**8**	1
Zinc	**8700**	**130**	48[d]	**130**	64	81	**340**	33	150
PAHs									
Acenaphthene	**41**	**<0.4**	0.1	ND	ND	710[i]	ND	**<0.47**	0.016
Acenaphthylene	0.069	**<0.4**	0.1	ND	ND	300[h,i,j]	**0.13**	**<0.47**	0.044
Anthracene	**77**	**<0.4**	0.1	ND	ND	300[h,i,j]	**0.39**	**<0.47**	0.0853
Benz(a)anthracene	**120**	**<0.4**	0.1	ND	ND	300[h,i,j]	**3.3**	**<0.47**	0.261
Chrysene	**120**	**<0.4**	0.1	ND	ND	300[h,i,j]	**5.6**	**<0.47**	0.384
Dibenz(a,h)anthracene	**17**	**<0.4**	0.1	ND	ND	300[h,i,j]	**0.57**	**<0.47**	0.0634
Fluoranthene	**240**	**<0.4**	0.1	ND	ND	16[i]	**7.6**	<0.47	0.6
Fluorene	**48**	**<0.4**	0.1	ND	ND	300[h,i,j]	ND	**<0.47**	0.019
2-Methylnaphthalene	9.6	<0.4	NA	ND	ND	300[h,i,j]	ND	**<0.47**	0.07
Naphthalene	**17**	**<0.4**	0.1	ND	ND	2350[h,i]	ND	**<0.47**	0.16
Phenanthrene	**260**	**<0.4**	0.1	ND	ND	NA	ND	**<0.47**	0.24
Pyrene	**200**	**<0.4**	0.1	ND	ND	300[h,i,j]	**8.8**	<0.47	0.665
Other SVOCs									
Pentachlorophenol	ND	**<1.0**	0.1	ND	ND	7.9	ND	<1200	NA
PESTICIDES/PCBs									
Aldrin	0.029	ND	0.1	ND	ND	1.3[h]	ND	<0.0024	0.0095[k]
Chlordane	ND	ND	0.1	ND	ND	0.004	ND	<0.0048	0.0005
4,4-DDE	**1.5**	0.0054	0.1	ND	ND	14[h,i]	**0.047**	**<0.0047**	0.0022
4,4-DDT	**2.2**	0.0041	0.1	ND	ND	0.001	**0.024**	**<0.0047**	0.00158[l]
Dieldrin	ND	0.0096	0.1	ND	ND	0.0019	**0.0049**	**<0.0047**	0.00002
Endosulfan (alpha + beta)	0.0022	<0.0067	NA	ND	ND	0.0087	ND	<0.0071	NA
Endrin	ND	<0.004	0.1	ND	ND	0.0023	ND	<0.0047	NA
Lindane (Gamma-BHC)	ND	<0.002	0.1	ND	ND	0.16[h]	**0.011**	**<0.0024**	0.00032[m]
Heptachlor	ND	<0.002	NA	ND	ND	0.0036	ND	**<0.0024**	0.0003[n]
Heptachlor Epoxide	**0.16**	<0.002	0.1	ND	ND	0.0036	0.039	<0.0024	NA
Total PCBs	5.4	0.35	NA	ND	ND	0.03	**0.81**	**0.54**	0.0227
Toxaphene	ND	<0.2	NA	ND	ND	0.0002	ND	<0.240	NA

Table 6. (continued) Maximum Concentrations of Primary COCs Detected at Site 1, Site 7 and AOC2 at the Cheatham Annex location. Values in bold exceed screening guidelines.

a: Region III Biological Technical Assistance Group (BTAG) screening levels for fauna (USEPA 1995).
b: Ambient water quality criteria (AWQC) for the protection of aquatic organisms (USEPA 2002). Marine chronic criteria presented.
c: Effects Range-Low represents the 10th percentile for the dataset in which effects were observed or predicted in studies compiled by Long et al. (1998).
d: Shacklette and Boerngen (1984), except for cadmium and silver, which represent average concentrations in the Earth's crust from Lindsay (1979).
e: Screening guidelines represent concentrations for $Cr.^{+6}$
f: Derived from inorganic mercury data, but is applied to total mercury.
g: Marine apparent effects threshold (AET) for amphipod bioassay. The AET represents the concentration above which adverse biological impacts would be expected.
h: Chronic criterion not available; acute criterion presented.
i: Lowest Observable Effect Level (LOEL) (USEPA 1986).
j: Value for chemical class.
k: Marine apparent effects threshold (AET) for amphipod and echinoderm larvae bioassays. The AET represents the concentration above which adverse biological impacts would be expected.
l: Expressed as Total DDT.
m: Threshold effects level (TEL).
n: Marine apparent effects threshold (AET) for bivalve bioassay. The AET represents the concentration above which adverse biological impacts would be expected.
NA: Screening guidelines not available.
ND: Not detected

(NOAA Office of Response and Restoration 2006)

Table 7. Active Industrial Sources of Discharge into the York River Watershed in the Vicinity of the Yorktown Unit.

Facility Name	Location	Permit #
Giant Yorktown Refinery	Grafton	VA0003018
Williamsburg Water Filter Plant	Williamsburg	VA0056537
Dominion - Yorktown Power Station	Yorktown	VA0004103
Water Country USA	Williamsburg	VA0089826
Augusta Wood Products LC - Sawmill	West Point	VA0090433
Smurfit Stone Container Corporation - West Point	West Point	VA0003115

Based on the TRI data from the Giant Yorktown Refinery nitrate compounds (160,469 lbs/yr) comprise the largest amount of compounds released followed by ammonia (15,150 lbs/yr), phenol (931 lbs/yr), nickel compounds (451 lbs/yr), lead (443.2 lbs/yr) with various other mono and polycyclic hydrocarbons.

Neither the Williamsburg Water Filter Plant nor Water Country USA is releasing COCs that would pose a risk to wildlife at the Yorktown unit. Neither the Augusta Wood Products LC – Sawmill or the Smurfit Stone Container Corporation located in West Point pose any threat to wildlife at the Yorktown unit.

The Dominion – Yorktown Power Station is located south of the Yorktown unit. In 2002 the plant reported that it released 178,507 lbs of contaminants into its effluent. The major metals reported to be released include barium, manganese, nickel and copper. The plant is likely a major source of atmospheric deposition into the park.

COCs in Different Matrixes

The primary data sources for COCs were the USEPA- EMAP, REMAP, and National Coastal Assessment database from the Mid-Atlantic Region and the NOAA National Status and Trends Mussel Watch database. Summarized below are the major findings from sediment and tissues collected from the James and York Rivers. The data sets for both the James and York Rivers are not extensive and give only an indication for the levels of contaminants present in wildlife living in or around Jamestown and Yorktown.

USEPA REMAP Data - Sediment

The USEPA had collected sediment samples from points along the James River from 1990 to 1993. These stations are up river from Jamestown. Arsenic, chromium, copper, mercury, nickel, lead, and zinc remained persistent in all sampling years with some stations showing concentrations above screening values. PAHs were detected from 1990 to 1993 and were above threshold effects level (TEL) and ERL values. Samples showed the presence of PCBs starting in the 1991 samples and concentrations were above TEL and ERL values in 1992 and 1993 samples (Appendix 3). These results reflect the impact of the more heavily industrialized areas at Hopewell and below Richmond.

NOAA National Status and Trends Data - Sediment

The NOAA Mussel Watch program, under the NOAA National Status and Trends Program, analyzes chemical and biological contaminant trends in sediment and bivalve tissue collected at over 280 coastal sites from 1986 to present. Only one station is located on the James River: Chesapeake Bay, James River (CBJR) (Figure 6). More data can be obtained from the NOAA Mussel Watch database at http://www8.nos.noaa.gov/cit/nsandt/download/mw_monitoring.aspx for other sites within the Chesapeake Bay. The data from CBJR is presented in tabular form in Appendix 2, and is the most extensive data set for this reach of the James River near Jamestown.

Sediment samples in the James River were taken in 1989 and 1997. Metals of concern in the James River include arsenic (5.9, 10.1 ug/dry g), chromium (58, 61 ug/dry g), copper (23.3, 19.8), lead (39, 32.7 ug/dry g), nickel (28.7, 28.4 ug/dry g), and zinc (156.6, 168 ug/dry g). These metals were detected in both sampling years. Arsenic, nickel, and zinc exceeded both TEL and ERL values. Chromium, copper, and lead exceeded TEL values. Arsenic was detected in 1989 but did not exceed the TEL or ERL values as it did in 1997. Other COCs in the James River sediment samples include 2-methylnaphthalene (23.3ng/dry g), acenaphthylene (4.1,4.1 ng/dry g), dibenzo[a,h]Anthracene (6.8, 11.3 ng/dry g), and dieldrin (0.14 ng/ dry g). All exceeded TEL values except dieldrin, which exceeded ERL values. 2-Methylnaphthalene was above the TEL only in the 1989 sample and dieldrin occurred in 1997, while the others were present in both sampling years (Appendix 4).

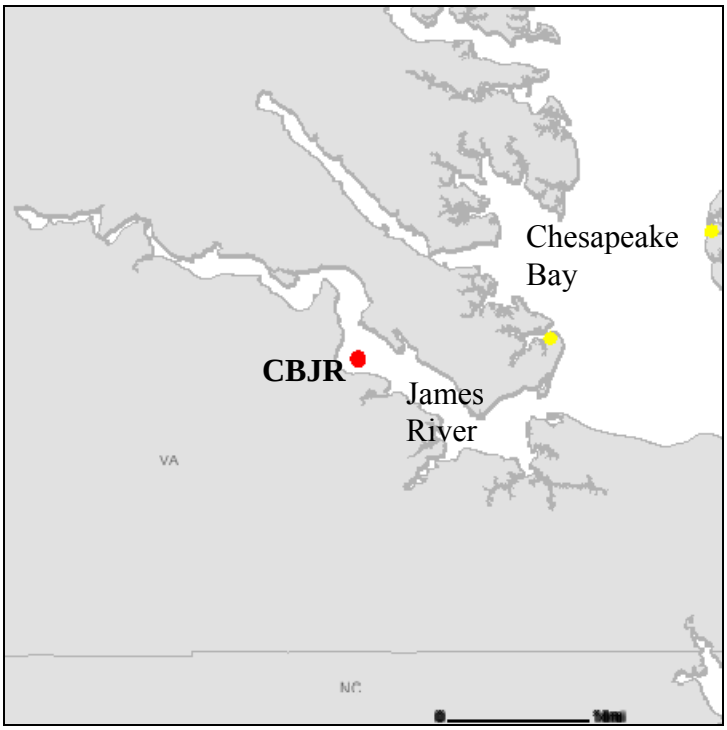


Figure 6. COLO- NOAA Mussel Watch Site (CBJR). (NOAA 2006**)**

Virginia Department Of Environmental Quality Data (VADEQ)- Sediment

At least one sediment sample is collected at each station where fish tissue are sampled and analyzed for a suite of chemical contaminants known to bioaccumulate. These include selected heavy metals, selected non-halogenated organic compounds (PAHs) and halogenated organic compounds (DDT, Chlordane, PCBs, etc.)

The VADEQ obtained samples mostly from the James River. Based on the sediment data that has been collected from James River (north and south of Jamestown Island) from a number of locations both by USEPA and NOAA the following COCs have been reported multiple times at levels above ERL or TEL values. All other analytes were below the level of concern.

The release of Kepone (Clordecone) into the James River historically has been a COC for oyster and finfish (United Nations 2006). Based on conversations with scientist at VIMS and examining recent data sets for biota and sediments, it would appear that the levels are below levels of concern in the biota in the James River, and is no longer a COC for the Jamestown Island wildlife.

Sediment samples collected by VIMS researchers both in the main branch of the York River and small tributaries are presented in Appendix5 and 6. The sediments in the main branch of the York River were found to be below any sediment levels of concern (Appendix 5 Table 6). It is likely that because of the size of the York River that these contaminated sediments are rapidly diluted from cleaner sediments from upstream areas. However, small creeks associated with the military installations did have levels of metals and PAHs that were above threshold levels (Table

6). Arsenic in Penniman Lake was greater than the ERL. Copper and zinc were above the ERL at all the sites examined (Appendix 5 Table 6). Sediment samples were taken in the York River from Bowie Pond (Campbell Creek) in 2005 had levels of mercury and arsenic above ERL screening values. Mercury was below the TEL. DDT and metabolites were at non-detect levels. The PCBs (0.48-7.34 ng/g dry) were detected, but these are low levels.

Tissue Data

There are three sources of tissue level data that related to the James and York River. The Virginia Department of Environmental Quality collected fish samples from across the state and there are few samples collected in the immediate vicinity of either Jamestown or Yorktown (Appendix 1). The second set of data is in the Eastern oyster collected from the Mussel Watch Station at CBJR (Figure 6) since 1989 (Appendix 4). The third set of data was collected by researchers at VIMS (Appendix 5 and 6). The VIMS data primarily examines PCBs and PAHs in tissue samples from a variety of organisms.

Virginia Department Of Environmental Quality Data (VADEQ) – Tissue

The VADEQ Office of Water Quality Programs' Fish Tissue and Sediment Contaminants Monitoring Program conduct routine studies of fish tissue and sediment samples in state waters. The program fulfills the Clean Water Act 106 United States Environmental Protection Agency grant requirements and the code of Virginia: Article 1. Section 62.1-44.19:5 which direct Department of Environmental Quality to implement the collection of fish tissue and sediment as part of a multi-phase approach to systematically assess, manage, and communicate the associated risks of contaminants in the aquatic environment.

Table 8. COCs Detected in James River Sediment.

COC	USEPA 1990	USEPA 1991	USEPA 1992	NOAA GBJR
Arsenic	+	+	+	+
Chromium	+	+	+	+
Copper	+	+	+	+
Nickel	+	+	+	+
Zinc	+	+	+	+
Dieldrin				+
HMW PAHs	+	+	+	+
LMW PAHs		+	+	+
Msc.PAHs		+	+	+

Tissue samples taken from fish in the Upper James River indicate concentrations of arsenic to be above VADEQ screening values (Table 18). For more detailed information on the VADEQ screening values for fish tissue go to: http://www.deq.state.va.us/fishtissue/background.html. Mercury concentrations in Small Mouth Bass were found to exceed VADQE and Virginia Department of Health screening values. Arsenic and mercury were also found to exceed screening values in the Upper James River Basin- Maury River Watershed and the Middle James River Basin. High lead levels were also observed in some of the tissue samples from each site (Appendix 5).

PAHs remained below screening values or were not detected. In the Middle James River Basin, PCB concentrations from Redhorse Sucker fish exceeded screening values. Based on these limited results, fish in the mainstream area of the James River near Jamestown would pose little hazard to wildlife within the park.

VIMS Data - Tissue

All VIMS data has been organized by area sampled and by aquatic species sampled within the Appendix 5 and 6. Total PCB and PAH values have been summarized from these data and can also be found within the Appendix.

In the upper reach of the York River As, Cd, Cr, Pb, and Se were at detection limits for a wide variety of fish species. Mercury was detected in the upper reaches near West Point and Purtan Island ranging from (0.04-8.22 ug/g dry) in blue crabs and several fish species. In Queens Creek near Camp Perry mercury (0.01-6.12 ug/g dry) was also detected in a number of fish species. A similar pattern was seen in Kings Creek (ND-2.53 ug/g dry). In Wormley Creek As, Cd, Cr, Hg, Pb, and Se were at non detectable levels. In the 2000 collection Gizzard Shad had elevated PCB levels from Carter Creek (712.6 ng/g dry), King Creek (1,041.38 and 1324.6 ng/g dry), and West Point (538.3 ng/g dry). Other fish and blue crabs were in the 100 ng/g dry range. DDT and its metabolites were detected in fish and shellfish collected from Kings Creek, Carter Creek and Wormley Creek, but were just above the detection limits. In the 2003 sample collections from the same locations PCBs were still elevated, but DDT and its metabolites were at non-detectable levels. Clordane (8.9-126.9 ng g dry) was detected in a number of fish species and blue crabs from King Creek.

In the James River in the vicinity of Jamestown Island Shiffles Creek had very low levels of As, Cd, Cr, Hg, Pb, and Se in several fish species. Fish from this same creek had elevated levels of PCBs. The highest level of Total PCBs was in the catfish (2,016 ng/dry g) and common carp (8,520 ng/dry g). Therefore, the southern reach of the James River has elevated PCB levels at Chippokes Point and Skiffles Creek. The VIMS data also provides concentrations of specific congeners present within the tissue.

NOAA National Status and Trends Data - Tissue

As stated above only one station is located on the James River: Chesapeake Bay, James River (CBJR) (Figure 6). There is no station located on the York River. The data from CBJR is presented in tabular form in Appendix 2, and is the most extensive data set for this reach of the James River near Jamestown. *Crassostrea virginica* were collected from this location since 1989. The results are presented on a dry weight basis and can be converted to wet weight by using a conversion factor of 12.4 %.

Arsenic (range 4.96-7.4 ug/g dry), chromium (range ND-0.883 ug/g dry), and nickel ((3.2-5.287 ug/g dry) have remained relatively constant. Copper (443-1724 ug/g dry) is very high in oysters from this location. This could be a result of the large number of military ships located in the area and the fact that oysters will readily accumulate copper. Zinc (4300 – 7497 ug/g dry) is also very high and is likely due to human inputs. Tributyltin (97.51-365 ng Sn/ g dry) has decreased over the years and likely reflects the banned use on ship bottoms.

DDT and its metabolites are currently in the low ng/g dry reange and have steadily decreased since the late 1980s. Total DDT in 1989 was 71.133 ng/ g dry and in 2003 the value was 24.972 ng/g dry. Chlordanes have also shown a dramatic decrease since the late 1980s. High and low molecular weight PAHs have remained relatively constant except for peaks, which likely indicate a recent small spill event or release from terrestrial sources. PCBs (99.724-303.99 ng/ g dry) have remained in the 100 ppb range and may pose some impact to wildlife that is chronically exposed.

Recommended Sampling Strategies For Monitoring Purposes

For both Jamestown Island and Yorktown the COCs would appear to be from off-site sources. The Colonial Parkway and associated motorvehicles would be a source of contamination that could impact terrestrial and aquatic wildlife. In surrounding areas at both locations metals and PAHs (Tables 5, 6, 8 and Appendixes) are above threshold levels in sediments. PCBs are also compounds that could impact wildlife in this area primarily at Yorktown. The munitions present primarily in the Yorktown vicinity do not have wildlife criteria values, and were at fairly low levels and likely would not impact wildlife. The sampling plan proposed below is to fill in data gaps concerning these COCs on park properties. The selection of specific locations for sampling does overlap where possible with the identified conservation areas within the parks (USNPS 2005). The information obtained on the COCs within these areas will help guide the protection and stewardship of the natural heritage resources.

Within Table 9 are the recommendations for sampling to be carried out at Jamestown Island, Virginia. The first sample (JTU-1) is a composite sediment sample to be collected from Sandy Bay Cove, Back River near Pyping Point and at the mouth of King Mill Creek. These three composite sediment samples will allow for an evaluation to be made from historically deposited contaminants on sediments and the impact of current boat traffic in these waters. Because these are drainage areas from nearby farms, a pesticide scan should be included. At the same locations (JTU-2) it is being recommended that *Fundulus heteroclitus* (9 composites at each location) be collected and the same series of chemicals be analyzed for in the whole fish. These sample locations should be revisited periodically, on a 3 year cycle, to determine if there are any changes in the chemical levels in the sediment or biota.

Sediment (JTU-3) and biota (JTU-4) samples should be collected along the James River side of Jamestown Island. The first location would be near Glass House Point, the second would be at the mouth of Passmore Creek and the third investigative sample should be at Lower Point. Both the biota and sediment samples should examine the full suite of compounds. *Fundulus heteroclitus* should be the fish that is collected from these locations.

The sediment samples (JTU-5) being proposed are investigative samples to establish current levels of contaminants on the island proper. The first sample should be a composite sample near the Visitor Center walkway. The second should be along Kingmill Creek which is in a pitch/tar swamp. The third site should be adjacent to the overlook at Passmore Creek. The fourth sediment sample should be from the small pond (0.3 acre) adjacent to the bus parking area. These samples will allow for the determination of what compounds are present in sediment from small drainage areas on the island.

The soil samples (JTU-6) being proposed to be examined are at four locations on Jamestown Island. The first is next to the Glass Blowing operation. This is to assess if the kiln and activities result in an elevated level of contaminants. The second is next to the visitor parking lot to assess the impact of vehicles parked in this area. The third is on the eastern tip of the island at Travis Cemetery. It is likely that the third sample will have the lowest concentrations of anthropogenic (man made) chemicals. The fourth is the shop maintenance area.

Table 9. Recommendations for Sampling to Examine COCs in Different Matrix in Jamestown Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals.

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Sediment (JTU-1)	Heavy Metals	(7000, 7010, 6010B, 6020A)	3	Composite	1-3/ Ponar Grab	Sandy Bay cove area Jamestown Island
	Imw & hmw PAHs	(8100, 8275A)				Back River near Pyping Point
	PCBs	(8260B, 8021B)				King Mill Creek at the mouth
	VOCs	(8240)				
	Pesticides	(8270D)				
Biota (JTU-2)	Heavy Metals	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ Fundulus sp. trap	Sandy Bay cove area Jamestown Island
	Imw PAHs	(8100, 8275A)			Eastern Oyster hand	Back River near Pyping Point
	hmw PAHs	(8100, 8275A)			Blue Crab trap	King Mill Creek at the mouth
	VOCs	(8240)				
	Pesticides	(8270D)				
Sediment (JTU-3))	Heavy Metals	(7000B, 7010, 6010B, 6020A)	3	Composite	Investigative sampling 1 / Ponar Grab	James River Glass House Point
	Imw PAHs	(8100, 8275A)				James River mouth Passmore Creek
	hmw PAHs	(8100, 8275A)				James River Lower Point
	VOCs	(8240)				
	Pesticides	(8270D)				

Table 9. Recommendations for Sampling to Examine COCs in Different Matrix in Jamestown Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals. (continued)

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Biota (JTU-4)	Heavy Metals	(7000, 7010, 6010B, 6020A)	3	Composite	1-3/ Fundulus sp. trap Investigative sampling	James River Glass House Point James River mouth Passmore Creek James River Lower Point
	Imw PAHs	(8100, 8275A)				
	hmw PAHs	(8100, 8275A)				
	VOCs	(8240)				
	Pesticides	(8270D)				
Sediment (JTU-5))	Heavy Metals	(7000B, 7010, 6010B, 6020A)	4	Composite	Investigative sampling 1 / Ponar Grab	Swamp near Visitor Center walkway Kingmill Creek Pitch/Tar Swamp Passmore Creek near overlook Pond adjacent to bus parking area
	Imw PAHs	(8100, 8275A)				
	hmw PAHs	(8100, 8275A)				
	VOCs	(8240)				
	Pesticides	(8270D)				
Soil (JTU-6)	Heavy Metals	(7000, 7010, 6010B, 6020A)	4	Composite	1-3/ split spoon	Next to Glass Blowing operation
	Imw & hmw PAHs	(8100, 8275A)				Visitor Center Parking lot
	VOCs	(8240)				Eastern tip Travis Cemetery
	Pesticides	(8270D)				NPS Maintenance Shop

To assess the levels of compounds that may be associated with traffic along the Colonial Historical Parkway (CHP) three locations along the route are being recommended to be sampled (Table 10). The first sets of samples (CHP-1) are soil samples at the three locations. The three locations are at half Creek Bridge, adjacent to the Cheatham National Park Area and at the Ringfield Picnic Areas south of Cheatham Annex (Figure 1). At each of these locations three composite samples along a transect (adjacent, 10 and 100 yards) should be taken. The results from these samples will allow for comparison between each of the locations and at distances away from the Colonial Historical Parkway.

Sediment samples (CHP-2) are being proposed to be sampled in water bodies that are adjacent to the Colonial Historical Parkway. The first is at the confluence of College and Halfway Creek. This sample will allow for evaluating contributions not only from the parkway, but also from upstream inputs from Colonial Williamsburg, the regional airport and surrounding drainage. The second set of sediment samples should be collected at Cheatham Pond. The samples should be collected at the southeastern area nearest the parkway, in the middle and at the eastern end. The third set of 3 composite samples would be at King Creek near the Ringfield Picnic area. This area is directly across from the U.S. Naval Supply Center Cheatam Annex. The location is also directly across from the militaries gulf course, which may contribute to pesticide levels at this location. The collection of 3 composite samples will allow for comparisons between these locations and others collected at Jamestown Island and Yorktown. These are investigative samples and the frequency of collection can be assessed after obtaining the results.

The samples to be collected at the Yorktown unit (YTU) are summarized in Table 11. The sediment samples (YTU-1) to be collected at Beaverdam Creek, Baptist Run and Great Run should be collected in depositional areas along these small creeks. This set of samples will allow for determining the chemicals collected in the surface sediments from drainage areas in the western portion of the COLO. This area is primarily forested and open grassy fields with little or no development. Aquatic biota (YTU-2) should also be collected from these same areas to determine if there is any COC that may be being accumulated. The specific species to be collected will depend on the species present in these small creeks. It is recommended that some type of small freshwater finfish or turtles be sampled in these areas. This would be an investigative sample.

Sediment samples along Yorktown Creek (YTU-3) should be collected for investigative samples. The first composite sample should be collected in depositional areas near the headwaters of the creek. The second sample should be at the route 17 Bridge and the third should be at the confluence of the York River. This series of sediment samples will indicate what impact the town of Yorktown and other human activities has on this small creek.

Sediment samples (YTU-4) should be collected from three depositional areas in Wormley Pond. The location in the southern area of the park and adjacent to the Naval Supply Center and other nearby incineration and refinery operations could indicate impacts from these operations from atmospheric deposition, and through groundwater or surface water contributions. *Fundulus heteroclitus* (YTU-5) and blue crabs from this location should be collected, and body burdens determined. These are investigative samples, and the results will determine whether additional sampling is warranted.

Table 10. Recommendations for Sampling to Examine COCs in Different Matrix along the Colonial Historical Parkway. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals.

Matrix	Analyte (1)		Number of Samples/Type (2)		Frequency/Method	Location on Site
(Number)	(Method #)					
Soil (CHP-1)	Heavy Metals	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ split spoon	Halfway Creek Bridge
	Imw & hmw PAHs	(8100, 8275A)			Investigative	Cheatham National Park Areas
	PCBs	(8260B, 8021B)				Ringfield Picnic Area south of Cheatham Annex
	VOCs	(8240)				
Sediment (CHP-2)	Heavy Metals	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ Ponar Grab	Confluence College & Halfway Creek
	Imw & hmw PAHs	(8100, 8275A)			Investigative	Cheatham Pond
	PCBs	(8260B, 8021B)				Ringfield Picnic King Creek
	VOCs	(8240)				
	Pesticides	(8270D)				

Table 11. Recommendations for Sampling to Examine COCs in Different Matrix in Colonia National Historical Park, Yorktown, Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals.

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Sediment (YTU-1)	Heavy Metals	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ Ponar Grab	Beaverdam Creek
	Imw & hmw PAHs	(8100, 8275A)			Depositional areas	Baptist Run
	PCBs	(8260B, 8021B)				Great Run
	VOCs	(8240)				
	Pesticides	(8270D)				
Biota (YTU-2)	Heavy Metals	(7000, 7010, 6010B, 6020A)	3	Composite	1/ Fundulus sp or small freshwater species i.e. catfish or turtles Investigative sampling	Beaverdam Creek
	Imw & hmw PAHs	(8100, 8275A)				Baptist Run
	PCBs	(8260B, 8021B)				Great Run
	VOCs	(8240)				
	Pesticides	(8270D)				
Sediment (JTU-3))	Heavy Metals	(7000B, 7010, 6010B, 6020A)	9	Composite	Investigative sampling 1 / Ponar Grab	Yorktown Creek headwaters
	Imw PAHs	(8100, 8275A)				Rt. 17 Bridge
	hmw PAHs	(8100, 8275A)				Confluence with York River
	VOCs	(8240)				
	Pesticides	(8270D)				

Table 11. Recommendations for Sampling to Examine COCs in Different Matrix in Colonia National Historical Park, Yorktown, Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals. (continued)

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Sediment (YTU-4)	Heavy Metals Imw & hmw	(7000, 7010, 6010B, 6020A)	6	Composite	1-3/ Ponar Grab	Wormley Pond
	PAHs	(8100, 8275A)			Depositional areas	Wormley Creek
	PCBs	(8260B, 8021B)				
	VOCs	(8240)				
	Pesticides	(8270D)				
Biota (YTU-5)	Heavy Metals Imw & hmw	(7000, 7010, 6010B, 6020A)	6	Composite	1/ Fundulus sp. and blue crab	Wormley Pond
	PAHs	(8100, 8275A)			Investigative sampling	Wormley Creek
	PCBs	(8260B, 8021B)				
	VOCs	(8240)				
	Pesticides	(8270D)				
Sediment (YTU-6)	Heavy Metals Imw & hmw	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ Ponar Grab	Ballard Creek 3 locations along the
	PAHs	(8100, 8275A)			Depositional areas	creek.
	PCBs	(8260B, 8021B)				
	VOCs & Munitions	(8240)				
	Pesticides	(8270D)				

Table 11. Recommendations for Sampling to Examine COCs in Different Matrix in Colonia National Historical Park, Yorktown, Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals. (continued)

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Biota (YTU-7)	Heavy Metals	(7000, 7010, 6010B, 6020A)	9	Composite	1-3/ traps Fundulus	Ballard Creek 3 locations along the Creek 1 composite at each location for each species
	Imw & hmw PAHs	(8100, 8275A)			sp. and Blue	
	PCBs	(8260B, 8021B)			Crab and Eastern	
	VOCs & Munitions	(8240)			oyster	
	Pesticides	(8270D)				
Sediment (JTU-8))	Heavy Metals	(7000B, 7010, 6010B, 6020A)	9	Composite	Investigative sampling 1-3 / Ponar Grab	York River near Moore House (south) York River Yorktown marina/beach York River confluence of Roosevelt Pond.
	Imw PAHs	(8100, 8275A)				
	hmw PAHs	(8100, 8275A)				
	VOCs	(8240)				
	Pesticides	(8270D)				
Biota (YTU-9)	Heavy Metals	(7000, 7010, 6010B, 6020A)	27	Composite	1-3/ traps Fundulus	York River near Moore House (south) York River Yorktown marina/beach York River confluence of Roosevelt Pond.
	Imw & hmw PAHs	(8100, 8275A)			sp. and Blue	
	PCBs	(8260B, 8021B)			Crab and Eastern	
	VOCs	(8240)			oyster	
	Pesticides	(8270D)				

Table 11. Recommendations for Sampling to Examine COCs in Different Matrix in Colonia National Historical Park, Yorktown, Virginia. The method numbers refer to EPA SW-846 (2) 1 -3 Means sample in the first year then at 3 yr intervals. (continued)

Matrix (Number)	Analyte (1) (Method #)		Number of Samples/Type (2)		Frequency/Method	Location on Site
Soil (YTU-10)	Heavy Metals Imw & hmw	(7000, 7010, 6010B, 6020A)	18	Composite	1-3/ split spoon	3 locations N/E/S Wormley Pond
	PAHs	(8100, 8275A)			Investigative sampling	3 locations west of Rt. 17
	PCBs	(8260B, 8021B)				3 locations between Ballard and Yorktown Creeks
	VOCs	(8240)				3 locations in drainage area of visitor parking area
	Pesticides	(8270D)				3 locations in restored Yorktown historic area
	Dioxins	(8290)				3 locations at the main maintenance and shop area

Both sediment (YTU-6) and biota (YTU-7) samples should be collected from Ballard Creek. This creek runs along the northern border of park and is the dividing line between the park and U.S. Naval Weapons Station. As describe above there are numerous hazardous sites located at the U.S. Naval Weapons Station that are in various stages of cleanup and or are still in use. The sediment samples should be at depositional areas along the creek. Both blue crabs (*Calinectes sapidus*) and *Fundulus heteroclitus* or *Fundulus diaphanus diaphanus* should be collected to determine what compounds are present in their tissues. Male blue crabs would be preferred due to their limited migration. Because of the known contamination sources this creek should be continually monitored.

Three locations are recommended to be collected along the York River for sediment (YTU-8) and biota (YTU-9). At each location 3 composite sediment samples should be collected. The first location is along the York River near the Moore House. This location is near the Naval Supply Center and other point source contamination. The second location is at the Yorktown marina/beach. The third location is at the confluence of the York River and Roosevelt Pond. This is a drainage area coming off of the U.S. Naval Weapons Station. These samples should be collected on at least a three year cycle. For the biota three species are recommended: *Fundulus sp*., *Crassostrea virginica* Eastern Oyster, and *Calinectes sapidus* Blue Crab.

The soil (YTU-10) samples being recommended to be collected will allow for an overview of the current levels of contaminants throughout the park. These samples will compliment the sediment samples collected in the creeks and rivers on or near the park. The first set of samples should be collected in the drainage area of Wormley pond. The second set should be collected from areas west of Rt. 17 in the drainage areas of Beaverdam Creek, Baptist Run, and Great Run. The third set of soil samples should be in drainage areas of the visitor parking lot. Three locations in the restored historic area of Yorktown should be collected. Three locations at the main maintenance and shop area should be sampled.

Management Recommendations

- Develop comprehensive land use planning and work with the appropriate government officials in those jurisdictions to limit potential impacts on the park resources.

- Continue to foster joint studies with the U.S. Navy, USEPA, VADEQ and other nearby industrial complexes that could impact wildlife on park properties. There is a need to expand the data base to better ascertain potential impacts to natural resources in the immediate areas.

- If not already in existence, establish an environmental and natural resource working group using both park personnel, state and academic researchers from VIMS to discuss COCs impacts and collection protocols.

- In all new construction of buildings or parking areas construct water catchments that can hold contaminated water from freely running into nearby creeks prior to remedial treatment. It is important that the receiving waters still collect similar flows that were present prior to building of these facilities.

- Establish a permanent collection site for *Crassostrea virginica* and sediment on the York River adjacent to the park that can be compared to the Status and Trends location on the James River. Possibly one of the YTU 8 or 9 sites (Table 11).

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Appendix 1: Hazard Quotient Approaches and Sampling Protocols for Screening Level Evaluations for Chemicals of Concern at National Parks

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1.0 Introduction

Appendix 1 gives a brief overview of ecological risk assessment approaches and standard sample collection methods that can be employed at the National Parks for various matrixes and compounds. It is not our intention to recreate the wheel, but to incorporate methods that are generally accepted by the scientific community. Many of the sampling protocols cited are from a number of different agencies (USEPA Emergency Response Team website, NOAA Status and Trends, and the New Jersey Department of Environmental Protection). The methods described in these documents are standard methods and would be appropriate for use by the National Park Service. The standard operating procedures (SOPs) are slightly different for each agency, but the basic approaches and quality assurance and quality controls (QA/QC) are comparable. Appendix 1 is not exhaustive, but attempts to bring together in a single location, SOPs that can be used by park personnel involved in chemical of concern (COC) evaluations. In some instances, the recommendation of one protocol over another is based on our own experience or bias, and is only a recommendation. The detailed protocols are presented in Appendix 2.

The National Park Service (NPS) has a website wherein a number of commonly occurring compounds are discussed, from a broad basis incorporating human and rodent information, and where available, wildlife and plant toxicity data (Environmental Contaminants Encyclopedia, Ed. Roy Irwin (www.nature.nps.gov/hazardssafety/toxic/). The general mechanism of toxicity is also presented and can be applied to a wide variety of wildlife. In many instances the mechanism of action of a COC will result in similar effects across a wide variety of flora and fauna due to similar biochemical pathways. The ECOTOX database (http://cfpub.epa.gov/ecotox/) released in 2000 by the USEPA and managed by the USEPA Duluth Laboratory has extensive ecological data both for terrestrial and aquatic species, as well as greater detail than what is described in this appendix. For chemical, physical, and fate data on specific compound the CHEMFATE database (http://www.syrres.com/eSc/chemfate.htm), maintained by Syracuse Research Corporation, is also a reference source. Another valuable resource for using screening benchmarks is available from Oak Ridge National Laboratory, which describes ecological risk analysis including guidance, tools, and applications (www.esd.ornl.gov/programs/ ecorisk/ecorisk.html). The Agency for Toxic Substances and Disease Registry provides individual chemical Toxicological Profiles (www.atsdr.cdc.gov/). The USEPA ECOTOX Database provides toxicology data on individual compounds for aquatic and terrestrial life (www.epa.gov/med/Prods_Pubs/ecotox.htm).

2.0 Routes of Entry of Pollutants into Ecosystems

This is a simple overview of the fate and transport of COCs (Suter 1993). It is important for any ecological based assessments to realize that COCs can enter an ecosystem by many routes (transport through air, water, or soil/sediments) from point and non-point sources. The fate of the COC can be impacted by a number of physical parameters of the receiving area. Any park, whether small or large, is part of a larger watershed and airshed, with many different inputs. Therefore, it is essential that the park lands properties be examined in relationship to their surrounding environs. Establishing a baseline level of chemicals present on the park lands and waters is important to be able to determine increases or decreases in a particular chemical. Because a number of chemicals occur naturally, it is important to understand the naturally occurring levels. The plants and animals that are present at the parks and surrounding areas are important in assessing the potential impact of specific COCs on the organisms. Because of the diversity of the plant and animals (ecological receptors), it is impossible to assess each species independently. It is vital, therefore, to identify representative or surrogate species that can be used to assess potential impacts on larger groups of organisms. This is one of the underlying principles for historical and continued collection of Mussel Watch Data (oysters, mussels, and clams). The use of a surrogate species may not always be the most sensitive organisms, but they do allow for evaluation of a single species over multiple years as an indicator of improvement, constantcy, or deterioration of the organisms' exposure and possible health. If such a species is identified, it should be used as an indicator species for that park. For example, there are specific plant species that are very sensitive to ozone, while other plants show no toxicity at much higher atmospheric concentrations. In that particular case, the most sensitive species would become the plant species that sets the lowest observable adverse effects level (LOAEL) in the atmosphere. If this sensitive species approach is taken then it will protect other more resistant species in the park. The natural resource surveys and inventories at the park can give information on population level changes and the trends can be compared with chemical level exposures.

In the above paragraph, COCs were discussed, but it also must be realized that individual species can be impacted by non-chemical stressors that can have deleterious effects. Physical parameters such as pH, alkalinity, salinity, dissolved oxygen, water transparency, and temperature can result in the loss of species and be important stressors affecting an organisms response. It should be recognized that physical parameters often limit distributions of organisms. Therefore, plants and animals living in an ecosystem can be impacted both by physical parameters, as well as COCs. Because of this fact, the USEPA's (1992) Framework for Ecological Risk Assessment includes "stressor response" which would include physical parameters as do later EPA documents (USEPA 1993, 1997a, 1998). A classic example is the effect of pH in freshwater systems and the loss of species dependent on pH tolerances. These physical parameters are easily measured and should be incorporated into any monitoring plan since they have profound effects on bioavailability and uptake (Rand and Petrocelli 1985; Schwarzenbach et al. 2003).

The selection of the animals and plants to be used in the risk assessment will be in some cases site specific because of the unique species present at the park or the surrounding area. Generally, there will be both terrestrial and aquatic species and associated toxicity data used for determining which if any COCs pose a hazard. The selected species may also be used as indicator species that

can be collected and analyzed for COCs. The sampling may be done to determine if COCs are reaching elevated levels. This will also allow for COC trends to be developed. Samples of water, soil, sediment and air may be conducted in concert or as independent samples to establish reference or baseline levels. In many parks, there is no plan in place. High volume air samples and semi-permeable membrane water and soil samples could be added if grab samples would not be able to detect COCs (Huckins et. al. 1990; Petty et. al. 2000; Sun et al. 2008).

2.1 Fate and Transport

Pollutants can enter an ecosystem through both human activities, and naturally occurring processes (weathering of rocks, volcanic activity, and others). While knowledge of sources will give you important information on the type of contaminants your environment might be exposed to, the concentration or dose of a compound will dictate the response observed in the wild. As all toxicologists know "the dose makes the poison," and once this level has been exceeded, toxicity may be observed. In all of the different matrices (surface and groundwater, sediments, and terrestrial soil), there are both point and non-point sources of contamination. Ecosystems are impacted from contamination contributed from atmospheric, terrestrial and aquatic sources. Below is a brief description of sources of contaminants entering into the different media, also shown in Figure 1.

The conceptual diagram shown in Figure 2 illustrates the requirement that the chemical can be bound or in a free state during exposure. Generally, if the compound is sequestered in a particle it is not available to be taken up by an organism since the compound must be free to be able to be transported across a biological membrane. A number of factors, such as charge and size, can determine whether a compound will be taken up by an organism. Once inside the cell, the compound can be metabolized, stored or excreted. If the compound reaches a target tissue where it causes toxicity at sufficient concentration then sublethal or lethal effects may be observed (Klassen and Rozman 1991). The physical chemical environments in which they exist can dramatically alter the chemical species that is available for accumulation (Spacie and Hamelink 1985). These general principles apply to organic compounds as well as metallic compounds.

Atmospheric contamination can enter the terrestrial soil and surface waters through precipitation (wet deposition) or from suspended particulates (dry deposition). There can be a contribution from both the terrestrial soil compartment and the surface water compartment into the atmosphere via particle suspension and volatilization processes. The contamination of the terrestrial soil from atmospheric deposition or from crustal compounds (background) can flow into the surface waters and end up in suspension or depositing on the bottom as sediment. Groundwater can become contaminated from compounds leaching into the groundwater. Surface waters can also contaminate groundwater when they are in direct contact (e.g., saltwater intrusion) or as the groundwater is being recharged. Groundwater contamination can reach surface waters in the basal flow of rivers and through seeps. The ability of a compound to move between these different compartments is determined by the physical chemical properties of the individual compound. Biotic factors can result in modifying the amount of a COC that could be releases from any of these compartments. Regional point sources of contamination can result in contamination spreading into several of these compartments.

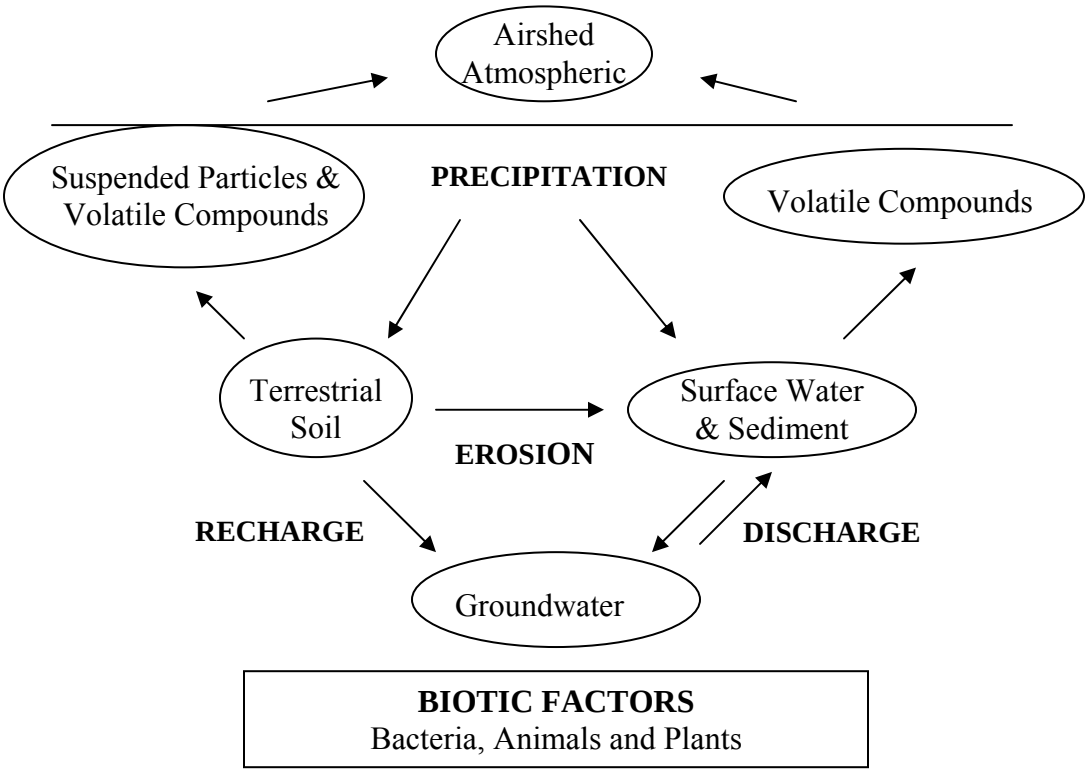


Figure 1. Pathways for Contaminant Movement (Arrows) Between the Different Matrixes Comprising the Ecosystem. Biotic factors can modify fate and transport of contaminants within an ecosystem by increasing or decreasing bioavailability.

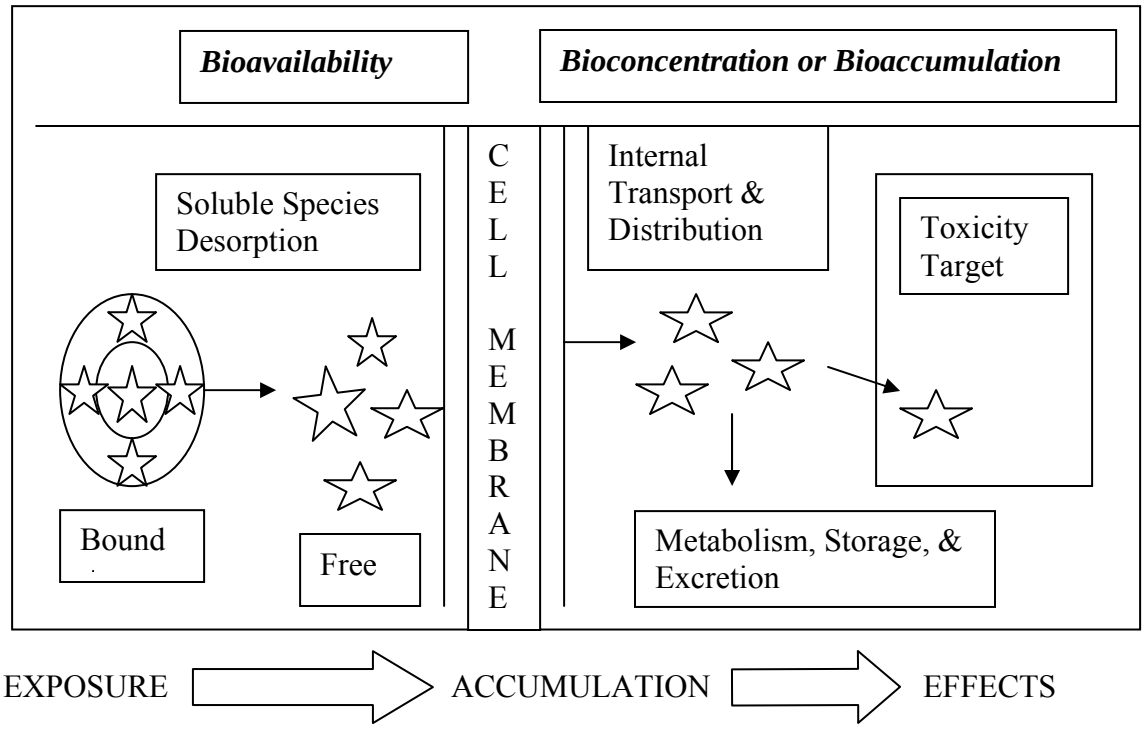


Figure 2. Conceptual Diagram for Evaluating Bioavailability to Organisms from a Compound (Stars) Present in the Environment in a Bound (NOT BIOAVAILABLE) and Free State (BIOAVAILABLE) for Exposure, Uptake across the Biological Membrane Resulting in Bioaccumulation within the Organism, and Subsequent Internal Transport and Distribution. The compound can undergo metabolism, storage and excretion. A metabolite or the parent compound could interact at the toxicity target site resulting in sublethal or lethal effects.

The movement of contaminants through the different matrices and ultimately into plants and animals (environmental fate) is determined by the physical characteristics of the compound and the environmental compartment it is entering (Figure 2). Bioavailability is an important concept that determines what levels of specific compounds will be present in the biota inhabiting contaminated and non-contaminated environments. Bioavailability is determined by many factors that determine how much of the compound or metal is in a free state that can be taken up by an organism or plant. Physical-chemical properties of the matrix into which a compound is associated and the properties of the surrounding medium will affect the level of compound that is free to be taken up by the organism. Factors such as pH, total organic carbon, and acid volatile sulfides can dramatically affect the uptake of a compound. A full discussion of release from a specific matrix and the uptake mechanisms based on characteristics of a metal or organic compound are too complicated for this appendix (Casarett and Doull 1991, 1996, 2008; Jorgensen et al. 1991; Schwarzenbach et al. 2003).

A critical physical characteristic of a compound is polarity, which will determine the compound's affinity for polar (water) and non-polar (lipids and non-polar materials) matrixes. In the case of water, oxygen draws electrons away from the two hydrogen atoms, which creates a partial negative charge on the oxygen and a partial positive charge on the hydrogen atoms. Because of the polar nature of water, cations and anions (i.e., positively and negatively charged compounds) are attracted to water and are soluble. These include inorganic salts (alkali earth metals) and polar organic compounds containing polar groups (e.g., alcohols, acids, and amines). Compounds that are not polar generally will partition into non-polar compartments that contain lipids (such as living organisms) and organic carbon (organic enriched particles). An important property of chemicals, which is used in estimating the potential to accumulate into living organisms is the octanol/water partitioning coefficient (K_{ow}). As the name implies, it is the concentration of a compound in octanol divided by the concentration of the compound in the water phase at equilibrium. This is a measure of the hydrophobicity of the compound. This value can be used to estimate the bioconcentration of compounds into organisms. In a similar fashion, compounds will partition between the different compartments described in Figure 1 based on physical chemical properties of the compound (e.g., Henry's constant relating distribution of volatile compounds between air and water and soil).

The residence time of the parent compound and its metabolites are determined by the compound's molecular stability. There are many methods by which a compound can be broken down in the environment (e.g., hydrolysis, auto-oxidation, photolysis, and enzymatic biotransformation). The rate of breakdown of a compound will determine the half-life in any particular medium. Persistent organic pollutants are generally recalcitrant to physical, chemical, and biochemical transformation (e.g., DDT/DDE, PCBs, and dioxins). However, in some instances metabolism (e.g., Benzo(a)pyrene, dieldrin) and photolysis (e.g., petroleum hydrocarbons) can result in activation of a compound to reactive chemical species that can result in cellular transformation leading to cancer, developmental effect, or acute toxicity.

Metals are non-biodegradable and do not breakdown in a similar fashion to organic compounds in the environment. Metals can exist as multiple converting species that are determined by the environmental chemistry of the medium they are located in. In the case of metal contaminants, they also are persistent and their ionization state will affect their residence time and transport

within the environment (USEPA 2007). USEPA's Framework for Metal Risk Assessment (http://www.epa.gov/osa/metalsframework) is a document that discusses in great detail each of these issues, and should be referred to when dealing with metal risk assessments (USEPA 2007). In the case of mercury, the metabolism to methyl mercury results in at least one bioavailable and toxic form of the metal. Metals that are deposited onto the soil or into sediment can have very long residence times and may become mineralized. It is important to note that geological deposit and the earth's crust are comprised of a number of metals that contribute to the general background concentrations for a specific region even without anthropogenic contributions. Background levels of metals in Northeast soils and in the earth's crust are summarized in Table 1. Background metal concentrations can vary over several orders of magnitude based on the soil type, geography and other factors. Additional sources of regional and state soil metal levels can be obtained from USEPA ecological soil screening levels document (USEPA 2003). The site-specific assessments proposed for the parks will involve only a single geographic area of concern and the regional values can be used for comparison to values obtained within the park. There are also "ambient concentrations" provided on a state-by-state basis (Sanders 2003).

2.1.1 Atmospheric

The airshed that overlies a watershed can contribute large quantities of contaminants that are associated with particle deposition, gases or dissolved in rain or snow. The sources of contamination can be from both local, as well as long distance transport. Incineration of waste and production of energy using coal and other sources can contribute to atmospheric contamination. Other sources include internal combustion engines, pesticide use on production agriculture, and volatile organic compounds that are used in refrigerants, solvents, and industrial processes. The magnitude of toxic chemical releases that may occur on a yearly basis into the atmosphere is often not appreciated, nor the resident time that these contaminants have in the atmosphere (Loganathan and Kannan 1994; Kannan et al. 2007). From anthropogenic sources it is estimated that 5.4 billion metric tons of CO_2, 89.3 million metric tons of SO_x, 60.7 million metric tons of NO_x, and 0.98 million metric tons of chlorofluorocarbons (CFCs). Regional and local sources often contribute to higher local concentrations and corresponding higher concentrations entering surface water, soils, and biota.

2.1.2 Soil

Contamination of soil can occur through deliberate contamination from dumping of industrial and municipal wastes (metals, organic compound radioactive material), direct application of pesticides or herbicides, application of sewage sludge (heavy metals, nitrates, phosphates, detergents), and other soil amendments, and atmospheric deposition of long and short range contaminants (metals, sulfur dioxide, nitrogen oxides, dioxins and furans and other organic compounds). The soil characteristics (organic content, buffering capacity) can affect the fate of the contaminants deposited on the soil and their impact on flora and fauna. Erosion of soils is one of the major means by which contaminated soils can reach surface waters and also contribute to sediment contamination. Because watersheds represent large drainage basins, upstream soil contamination can impact downstream water and sediment quality as it is deposited at the mouth of the rivers and bays or simply deposited in a slow moving portion of a stream. In many instances, acceptable levels of soil contamination are based on human and terrestrial wildlife

Table 1. Levels Reported in the Earth's Crust (parts per million).[1]

Atomic Number	Element	Crustal Average	Atomic Number	Element	Crustal Average
1	H	1,400	45	Rh	0.005
3	Li	20	46	Pd	0.01
4	Be	2.8	47	Ag	0.07
5	B	10	48	Cd[2]	0.2
6	C	200	49	In	0.1
7	N	20	50	Sn	2
8	O	466,000	51	Sb	0.2
9	F	625	52	Te	0.01
11	Na	28,300	53	I	0.5
12	Mg	20,900	55	Cs	3
13	Al	81,300	56	Ba	425
14	Si	277,200	57	La	30
15	P	1,050	58	Ce	60
16	S	260	59	Pr	8.2
17	Cl	130	60	Nd	28
19	K	25,900	62	Sm	6.0
20	Ca	36,300	63	Eu	1.2
21	Sc	22	64	Gd	5.4
22	Ti	4,400	65	Tb	0.9
23	V	135	66	Dy	3.0
24	Cr	100	67	Ho	1.2
25	Mn	950	68	Er	2.8
26	Fe	50,000	69	Tm	0.5
27	Co	25	70	Yb	3.4
28	Ni[2]	75	71	Lu	0.5
29	Cu[2]	55	72	Hf	3
30	Zn[2]	70	73	Ta	2
31	Ga	15	74	W	1.5
32	Ge	1.5	75	Re	0.001
33	As	1.8	76	Os	0.005
34	Se	0.05	77	Ir	0.001
35	Br	2.5	78	Pr	0.01
37	Rb	90	79	Au	0.004
38	Sr	375	80	Hg	0.08
39	Y	33	82	Pb[2]	13
40	Zr	165	83	Bi	0.2
41	Nb	20	90	Th	7.2
42	Mo	7	92	U	1.8
44	Ru	0.01			

[1]Values taken from Mason B. Principals of Geochemistry, Third Edition.
[2]Values are ppm mg/kg and the source is from NE-1001 Application of sewage biosolids to agricultural soils in the Northeast: long-term impacts and benefit uses.
http://www.lgu.umd.edu/lgu_v2/homepages/pub.cfm?trackID=31
Ranges determined from ME (n=27),NJ (n=114),NY (n=74) and PA (n=40): Ni 8.4-41.2, Cu 11-64.8,Zn 29.2-83.8, Cd 0.09-0.173 and Pb 12.6-19.6.

risk assessments, and exposure is assessed differently for terrestrial pathways. However, those same concentrations in soils, when deposited into aquatic systems can cause a different response to aquatic organisms. In some instances, studies indicate aquatic organisms are more sensitive to certain compounds in sediments, when the same level in soils would not elicit a response in terrestrial organisms.

For metals, it must be recognized that they naturally occur in the earth's crust and represent non-anthropogenic background levels. Listed in Table 1 are typical background soil metal concentrations reported for the earth's crust and in the footnote values for the Northeastern states. The footnote values represent the range of these metals from samples collected throughout the Northeast. The values in this table allow for a quick reference benchmark for comparison to soil samples collected at a park site. It should be emphasized that these are just general numbers and regional background levels should be consulted if park land values appear to be elevated. Background levels can be directly compared to samples to determine if the samples are significantly higher, and could indicate a local source. The actual concentrations would then have to be examined to see if the levels are at a toxic threshold level or higher, and determine what actions might be taken. Another approach to obtain reference background soil data is to use the Natural Resource Conservation Surface's County Soils Publication and Maps to identify similar soil type in an unaltered location and collect a reference sample from this location.

2.1.3 Surface Water

Surface waters receive anthropogenic (man-made) inputs from atmospheric deposition, non-point source runoff from terrestrial sources (petroleum products from automobiles, road salt, etc.), and point source discharges (sewage treatment plants, industrial discharge, landfill leachate, etc.). There are also natural sources of contaminants such as the earth's crust and natural processes (petroleum seeps, volcanism) that release compounds and metals into water and into the atmosphere. Transport in water can occur either by being in solution or in suspension as a micelle, an electrically charged particle formed by an aggregate of molecule, or associated with particulate matter. Compounds and metals can absorb onto particulate matter in suspension and some of these contaminant-enriched particles will eventually settle out in bottom sediment. In rivers, pollutants can be transported over great distances where they can enter into estuaries and ultimately the oceans. Contaminants associated with eroding soil can be a major source of chemicals entering into surface waters. Release of pollutants into moving surface water is followed by dilution and in some cases degradation. The point of entrance will normally represent the area where the highest concentration is observed, followed by a concentration gradient downstream. The stream flow and physical characteristics may result in depositional areas that should be sampled. In some instances, such as sewage outfalls, there may be a change in the biota upstream from the outfall when compared to biota present downstream from the outfall. The difference from upstream to downstream biota may reflect a contaminant or physico-chemical parameters that impact the biota. In the case of small lakes and ponds, where there is no major outlet, chemicals may buildup in these waters. It is also important to understand that freshwater and saltwater organisms may respond differently to the same compound, and because of this the no observed adverse effect levels (NOAELs) are often different. The surface waters and the associated particulate fractions are sinks for accumulating contaminants as they move

from upland into estuaries and into the oceans. Surface waters can be contaminated from many different sources resulting in many anthropogenic compounds being present.

2.1.4 Sediment

Sediment can be either suspended in the water column and or deposited along the bottoms of rivers, estuaries, and depositional areas in the ocean. Sediment originates from the contribution of soil washing into the surface waters and from breakdown of organic matter in the receiving waters. Sediment can become contaminated from land sources, as well as from contaminants that accumulate in organisms and adhere to the sediment from the water column. The physical and chemical characteristics of the sediment will influence the amount of contamination associated with it. Sediments with high organic content and charge will have elevated levels of organic and metals, respectively. The smaller the particle size the greater the surface area to volume ratio and the higher the contaminant enrichment. Therefore, sediments with large grain size containing mainly sand will have little or no metals or organic contaminants associated with them. Sediment particle size also influences contaminant bioavailability. Bioavailability can be reduced in clay and silt sediments compared to coarser sediments. Thus, when conducting sediment analyses, it is important to evaluate both grain size and total organic carbon (TOC).

2.1.5 Groundwater

Groundwater is water located below the surface of the soil and can be found in soil pores (sometimes called pore water) or fractures in the geological deposited soils. An aquifer is a saturated zone where usable quantities of water can be withdrawn. Groundwater is recharged from rainwater leaching into the subsurface areas. Groundwater, unlike surface water, flows very slowly and discharges into seeps or springs that feed into surface waters, sometimes over decades. Therefore, contamination that reached the aquifer decades ago may only now be discharged into rivers and springs. In any one area, there can be several aquifers that are confined to different depths by geological formations. Generally, the shallow aquifers are at greatest risk of contamination. Contamination of groundwater can occur from pollutants seeping into the soil and leaching into the groundwater. Contamination can flow from septic fields, underground storage tanks, direct injection into deep wells, or leaching from surface soil applications. The rate at which a contaminant leaches into an aquifer is determined by the soil characteristics. A general rule is that sandy soil allows for easier penetration of contaminants than higher organic containing soils. Aquifers that are below bedrock areas can become contaminated through cracks and fissures in the rock or contamination on abandoned wells. Contaminants entering the groundwater can include metals, volatile organic compounds, petroleum products, and leachable pesticides. Once contamination of an aquifer occurs it is very difficult to remediate the contaminants. Degradation and mineralization of contaminants in aquifers occurs very slowly because of the lack of bacteria, light, and oxygen tension. Because of the slow recharge of aquifers, dilution of the contamination is minimal. Movement within the aquifer is determined in part by the polarity of the compound.

3.0 Ecological Risk Assessment

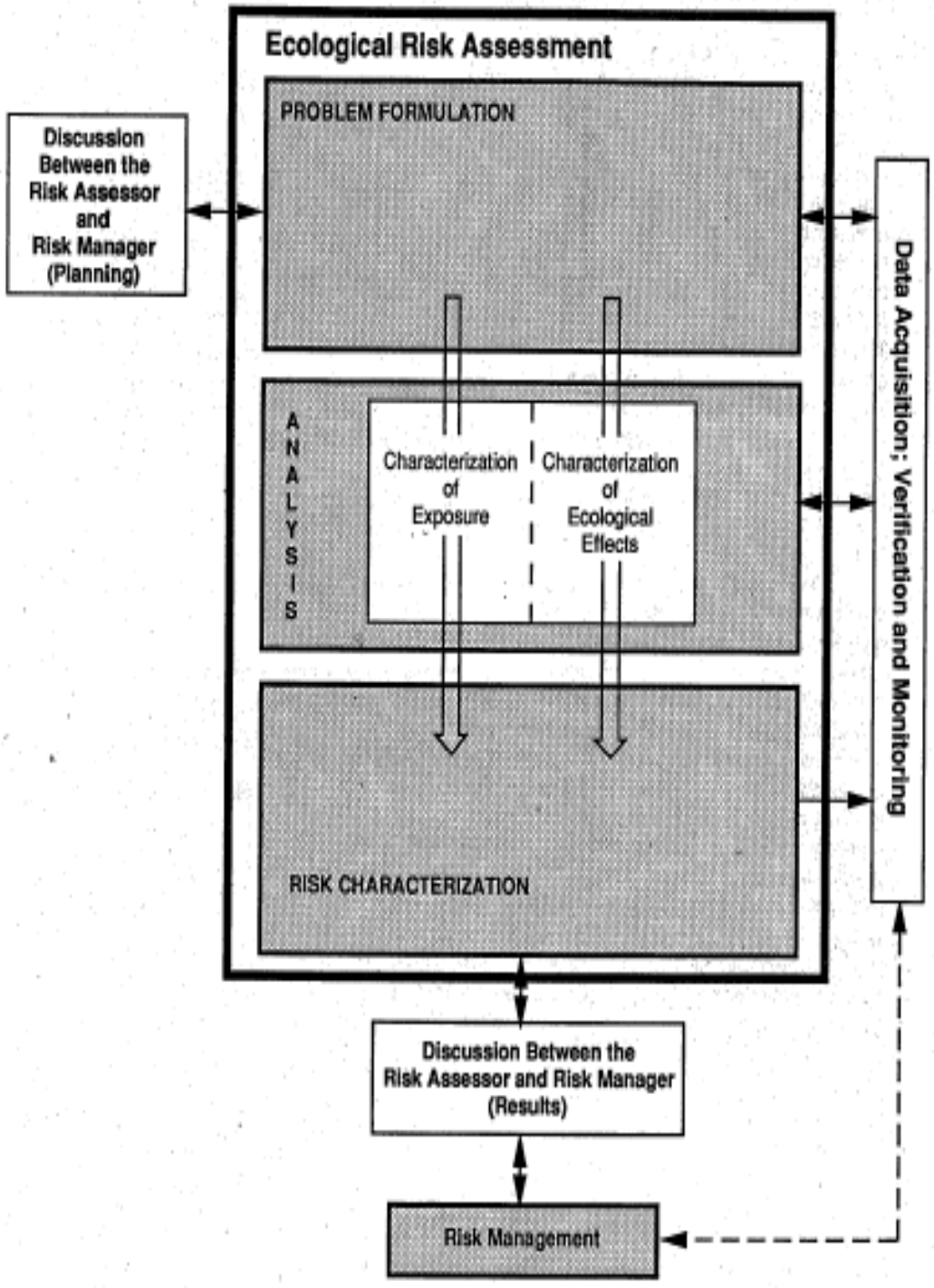
The basic underlying principle of an ecological risk assessment is based on the USEPA Guidelines for Ecological Risk Assessment (USEPA 1998). For each park it is necessary to follow a step-wise approach to evaluating potential hazards from COCs to the terrestrial and aquatic wildlife and flora. The general approach has been adopted by USEPA (1998) where there is the problem formulation where integration of available information on each park's potential COCs is carried out (Figure 3). Because each park is unique in its location and its surroundings, each require an inventory of existing threats. This can take the form of a general information questionnaire (see Appendix 2, Survey Instrument) and gathering general information about the park from literature, databases, and the internet. The analysis phase will attempt to obtain measurement for COCs (exposure analysis) or unusual abiotic conditions (stressor response profile) that exist either on or adjacent to the parks. The last phase is the risk characterization (risk estimation). The final approach is to make scientific based management recommendations that may include the following: 1) no action necessary as COCs fall below any level of concern; 2) identify specific targeted baseline sampling for historical reference for any future incident; 3) specific targeted sampling approaches for confirming elevated COCs; and 4) remediation of contaminated sites or engineering modifications to reduce impact. The amount of available information on COCs present in the biota and the different environmental matrices the parks and offsite (problem formulation and analysis phase) will affect the extent and uncertainty of the risk characterization that can be made and what management options are available. There is a need to follow up on any action that is taken to determine if the species at risk are remaining the same, increasing or decreasing. Population surveys can be a valuable long-term monitoring tool when coupled with analysis of chemical and non-chemical stressors.

3.1 Screening Level for Ecological Risk Assessment

It must be realized that a "hazard" in toxicology is determined by the risk of a compound causing an adverse effect and actual exposure to that compound (Risk×Exposure=Hazard). The risk component incorporates a specified exposure dose under specific conditions. Therefore, there is no hazard if a COC has no adverse effect at a specific dose/concentration (risk component). If the organism does not come into contact with the chemical (exposure component) than there is no hazard and the compound is not a COC. In either event, there will be no adverse effect to wildlife or plants. Although there are many approaches to estimating hazards including estimating the movement through fate and transport models and food webs, those methods are beyond the scope of this appendix and project. If the concentration of a COC in an organism is greater than the environmental media (soil, water, or sediment) it is living in, then the COC is said to bioconcentrate. When the organisms COC burden is from both environmental media and food intake, then the COC is said to bioaccumulate. Biomagnification of a COC occurs when each trophic level in the food web has a higher amount of COC than the trophic level below (Newman and Unger. 2003).

Bioconcentration (BCF) and bioaccumulation (BAF) factors are two parameters that are important in both terrestrial and aquatic organisms for assessing the hazard based on steady state

Figure 3. Proposed Guidelines for Ecological Risk Assessment.



(USEPA 1992, 1997a)

body burden. The steady state tissue concentrations represent the maximum levels that are expected based on a particular level of exposure. The steady state level is achieved by the accumulation, distribution, metabolism, and elimination of a compound within an organism (Figure 2).

BCF = concentration in organism / concentration in ambient medium *Eq. 1*

BAF = concentration in organism / concentration in food and external media X(ingested prey/water/soil/sediment) *Eq.2*

In aquatic ecosystems where the main route of exposure is through the water column, the BCF is an appropriate means to estimate body burdens. If food, abiotic, media and ambient water concentrations are important exposure routes then Eq 2 should be used to calculate the BAF. In the case of terrestrial organisms, BCFs and BAFs can also be calculated. Although not dealt with in this report, atmospheric exposure to terrestrial wildlife can result in a steady state BCF from airborne exposure. In the majority of cases, the BAF (Eq 2) is the appropriate value to be calculated for terrestrial wildlife.

Most wildlife do not remain on a contaminated site or consume only contaminated food, which would result in an area use factor (AUF) of less than one. In order to be conservative, an AUF equal to one is used for all calculations. An AUF of one assumes that the organism ingests contaminated food or water for their entire life. While this assumption simplifies the assessment, due to the mobility and the diverse diets of most wildlife it is likely to overestimate the actual exposure experienced. It should be remembered, however, that the purpose of the screening assessment is to identify potential risks and data gaps to be filled. As more data are collected these assumptions can be modified to reflect the actual amount of time that a species spends within a specified area or park.

Our analysis involved an evaluation of the ecological risks of environmental contaminants based on a two-tiered approach. This approach follows closely with that reported by Sample (1996). In the hazard quotient (HQ) approach discussed below, the concentrations of the contaminants in the environments are compared to the NOAEL. These screening ecotoxicity values are based on literature surveys for values that have been reported to cause no adverse effect NOAEL or the LOAEL in different media.

The second approach incorporates the exposure of oral ingestion of contaminated media to reach a dose. This approach gives a benchmark that is either exceeded or not, based on known adverse effects in organisms compared to their determined dose. This approach is simple yet allows new information to be incorporated as new studies are carried out that better define the NOAEL or LOAEL values (Crane and Newman 2000). When these values are less than the toxicological benchmarks, the contaminant should be excluded from any further consideration. This process assumes there are no contributions from other compounds to increase the mixture toxicity.

3.2 Hazard Quotient Approach (HQ)

Ecological risks of environmental contaminants at the parks and evaluated with a two-tiered process. This approach follows closely that proposed by Sutter (1996). In the first tier, a screening assessment is performed where concentrations of contaminants in the environment are compared to NOAEL-based toxicological benchmarks. These benchmarks represent concentrations of chemicals (i.e., concentrations presumed to be non-hazardous to the biota) in environmental media (water, sediment, soil, food, etc.) that should not result in an adverse effect. One of the principal sources for the values that are used for this calculation is the NOAA Screening Quick Reference Tables (SQuiRT), which are available online at http://www.response.restoration.noaa.gov/book_shelf/122_squirt_cards.pdf for reference. If site-specific values or more recent literature-based information is available then these values can be used for screening purposes. Within the NOAA SQuiRT tables are background levels for inorganic and organic compounds in freshwater and marine sediments, fresh and saline surface water and groundwater. These tables also give different effect levels: threshold effects levels (TEL), probable effects level (PEL), and effect range medium (ERM. The NOAA document also contains two tables summarizing specific extraction and detection methods for inorganic trace elements and organic compounds and a summary table listing appropriate containers for each analyte, preservation methods, maximum holding times, and required sample size.

In practice, when contaminant concentrations in food, water, soil, and sediment resources are less than the threshold toxicological benchmarks, the contaminants may be excluded from further consideration. As stated above, this assumes no additive or synergistic effects from similar contaminants. The PEL and ERM values allow for comparison to the increasing likelihood of an effect on the biota. In the case of sediment values, the levels are provided both for freshwater and marine sediments for inorganic and organic compounds sampled by NOAA. Another source for freshwater sediment screening values is MacDonald et al. (2000). To determine which contaminants pose a risk, an HQ is calculated, where HQ=media concentration/benchmark. If the HQ≥1, contaminant concentrations are sufficiently high that they may produce adverse effects. This basically means that the concentration observed in the environment is greater than or equal to a threshold or known effects level (i.e., PEL or ERM) and there is an increased likelihood that the compound may have an adverse effect on the organism and warrant further investigation. An HQ<1 means there is no risk based on the laboratory derived values.

EXAMPLE CALCULATION: Values in ppb (ug/Kg) dry weight.

	Threshold Effects Level (TEL)	Probable Effects Level (PEL)	Effects Range Medium (ERM)	Source
Arsenic	7,240	41,600	70,000	NOAA SQUIRT
Arsenic sample value sediment 40,000 ppb	40,000/7240 = 5.5 TEL HQ > 1	40000/41600=0.96 PEL HQ < 1	40000/70000=0.57 ERM HQ < 1	

In this example arsenic would be considered a chemical of concern since it was above the TEL value. If the PEL and ERM had HQ>1 the detected concentration would indicate a probability of increasing toxic responses to benthic organisms. Scientific judgment needs to be exercised when multiple compounds of similar mechanisms of toxicity may be present in a sample or another factor may result in greater sensitivity of the organism to a contaminant.

Therefore, if the concentration of a contaminant exceeds a benchmark, HQ≥1 that contaminant should be retained as a COC. Conversely, if the HQ<1, the contaminant would not be retained as a COC.

3.3 Estimating Body Burdens for Comparison to NOAELs for Wildlife

Calculations can be made to determine on a daily basis the amount of a contaminant that an organism is being exposed to from its food, water or other ingestion exposure routes (e.g., sediment or soil). In this approach, both inhalation exposure and dermal adsorption are not included in the daily intake which can underestimate exposure, but normally the conservative assumptions made in estimating the other major exposure routes may negate the need to be concerned with other routes of exposure. Dermal exposure needs to be included when amphibians and reptiles are the organisms of concern. The daily exposure estimations based on known or estimated levels of a contaminant can be calculated using standard calculations and based on literature-derived life history data.

The total body burden can then be compared to LOAELs from literature studies or estimated from other reported endpoints (LOAEL, or a dose resulting in 50% death (LD_{50}). One approach to estimate a LOAEL from a NOAEL is to apply an uncertainty factor of 10 to the values.

LOAEL = NOAEL multiplied by an uncertainty factor of 10 *Eq.3*

In the case where there is only LD_{50} data, either examine the slope of the line and extrapolate to the x-axis, or apply a larger uncertainty factor (100 or 1000) to estimate the total body burden. The difficulty with extrapolating from these values is that the degree of uncertainty is greatly increased, but if no other value exists it may be the only alternative to estimate whether a contaminant potentially poses a risk.

The presentation of toxicity data on an mg/kg body weight (BW)/day basis allows comparisons to the calculated levels for a particular species of interest. If the levels that are calculated exceed the LOAEL then the levels in these matrices would pose a hazard to that particular species, and be considered a COC. When calculating these values care must be taken to convert any dry weight concentrations to wet weight by applying the appropriate water content values for specific prey species (see Table 6) or the value determined by the analytical laboratory at the time of analysis.

4.0 Trophic Level Evaluation

Trophic level evaluation is not required for all compounds, because there are certain characteristics which preclude biomagnification up the food web. Compounds that are rapidly metabolized, poorly absorbed from the gastrointestinal track or epidermis, or rapidly eliminated generally need not be examined in a trophic model. In these cases, the compound can be compared to the LOAEL for determining if the concentrations are above a threshold of concern (as described in the previous section). In the case of trophic level evaluations, the organism impacted is studied through direct contact with environmental matrixes and through their food sources (bioaccumulation). Therefore, when calculating the daily intake of a compound, the sources of the contaminants include water, sediment/soil, and food. Airborne exposure is not included in these calculations. In this way, representative organisms at different trophic levels can be selected, and their daily intake calculated and compared to effects levels. By using this approach, the total daily intake can be calculated using both empirical data from organisms collected on or offsite, or through estimated prey body burdens or matrix values. When the total daily intake of a compound (TDI) from all the sources is calculated, these values can be compared to the LOAEL value derived from the literature. When the TDI exceeds this benchmark effects value, the compound should be considered a COC. This is a highly conservative approach because it assumes that all of the food consumed is contaminated at a set level and that there is 100% uptake and retention. In the real world, it is unlikely that an organism will be exposed continuously to contaminated sediment/soil and prey at a constant level; there is never 100% uptake due to metabolism and elimination pathways. This conservative approach will help protect wildlife especially when tissue dose data for specific organisms is lacking.

In some instances where there are virtually no data on a chemical, the approach undertaken may have to be very simplistic. The aquatic food chain multiplier (FCM) described below is such an approach. If a large amount of data is available on emperical matrix values (i.e., water, sediment, or soil contaminant concentrations) and lower trophic level prey dose, then a better estimate of the predator dose can be calculated using the estimated dose from all source inputs. Because of the complexity of food webs even in the simplest of ecosystems, there is a need to select sentinel organisms that can represent large classes of organisms and reflect the ecosystems being evaluated when evaluating compounds that have a potential to bioaccumulate.

4.1 Estimating Aquatic Organisms' Body Burdens

If the BCF is not available for a specific compound then the following relationship developed by Lyman et al. (1982) can be used based on the octanol-water partitioning equation (P_{oct} is the partitioning coefficient for octanol-water).

$$Log_{10}\, BCF = 0.76\, Log_{10}\, P_{oct} - 0.23 \qquad Eq.\ 4$$

In a similar fashion the BCF can be calculated from the water solubility of a compound as reported by Lyman et al. (1982).

$$Log_{10}\ BCF = 2.791 - 0.564\ Log_{10}\ Water\ Solubility\ (mg/L) \qquad Eq.\ 5$$

Equation 4 and 5 will estimate BCF values, but tissue and matrix concentrations are more accurate for empirical BCF determinations.

4.2. Aquatic Food Chain Multiplier (FCM)

The FCM is a very simplistic approach where the concentration in a matrix is used to estimate the level in biota at different trophic levels. This approach does not differentiate between a BCF and a BAF. The differences between a BCF and BAF have been previously discussed (Screening Level for Ecological Risk Assessment).

To estimate the tissue concentration in different trophic levels the only information needed is the Log_{10} K_{ow} for a chemical of interest (Sample et al. 1996). Although the FCM is a very simple approach, it is based on the assumption that the primary uptake route of these compounds is through passive diffusion, which is controlled by the lipophilicity of the compound. It is a conservative estimate since it assumes 100% uptake and does not take into account factors affecting absorption, metabolism or elimination for different species. Estimates can be made for concentrations in zooplankton (trophic level 2), small fish (trophic level 3), and piscivorous fish and top predators (trophic level 4). Table 2 shows the multipliers for estimating the amount of a compound that will accumulate in each of the higher trophic level organisms based on the Log_{10} K_{ow}. The FCM approach may be applicable for some metals if the organo-metallic forms (i.e., methylmercury) are known to be biomagnified in higher trophic levels based on Log_{10} K_{ow} (USEPA 1995).

Table 1, located in Appendix 2, is a compilation of the Log_{10} K_{ow} values and calculated concentration factors for each trophic level for the compounds that are routinely analyzed for by NOAA and USEPA. The FCM approach is useful when there is a new compound that is identified and there is very little data on levels in higher trophic level organisms. By obtaining the Log_{10} K_{ow} from the literature or even doing a simple partitioning experiment one can obtain this value. It must be realized that depending on the method from which it was derived there can be differences in the actual K_{ow} values; however, they are generally similar. This value is then used to determine what multipliers (Table 2) are to be used for each trophic level. This is an approach that does not take into consideration any elimination pathways, and will overestimate tissue levels when metabolism does play a major role. The estimated FCM tissue value can then be compared to the LOAEL value determined from literature values.

For example, if a new compound has a Log_{10} K_{ow}=6.0 (see Table 2 for multipliers for each trophic level) and is detected at 10 mg/L in water, then it is assumed that zooplankton (level 2) will have 10 mg/kg body levels (1 x 10 mg/kg since one liter equals one kilogram). Trophic level 3 organisms would have 105.56 mg/kg and level 4 would have 159.96 mg/kg. Based on the estimated total dose these values can then be compared to LOAEL and or NOAEL values for representative species.

If for some reason there is no known $K_{ow,}$ then an alternative would be to find a compound with a

Table 2. Aquatic Food Chain Multipliers (Taken from Sample et al., 1997 which was modified from EPA 1993).

Trophic level 2=zooplankton;
Trophic level 3=small fish;
Trophic level 4=piscivorous fish, including top predators.

Log K_{ow}	Prey Trophic Level 2	Prey Trophic Level 3	Prey Trophic Level 4
2.0	1	1.005	1.000
2.5	1	1.010	1.002
3.0	1	1.028	1.007
3.1	1	1.034	1.007
3.2	1	1.042	1.009
3.3	1	1.053	1.012
3.4	1	1.067	1.014
3.5	1	1.083	1.019
3.6	1	1.103	1.023
3.7	1	1.128	1.033
3.8	1	1.161	1.042
3.9	1	1.202	1.054
4.0	1	1.253	1.072
4.1	1	1.315	1.096
4.2	1	1.380	1.130
4.3	1	1.491	1.178
4.4	1	1.614	1.242
4.5	1	1.766	1.334
4.6	1	1.950	1.459
4.7	1	2.175	1.633
4.8	1	2.452	1.871
4.9	1	2.780	2.193
5.0	1	3.181	2.612
5.1	1	3.643	3.162
5.2	1	4.188	3.873
5.3	1	4.803	4.742
5.4	1	5.502	5.821
5.5	1	6.266	7.079
5.6	1	7.096	8.551
5.7	1	7.962	10.209
5.8	1	8.841	12.050
5.9	1	9.716	13.964
6.0	1	10.556	15.996
6.1	1	11.337	17.783
6.2	1	12.064	19.907
6.3	1	12.691	21.677

Table 2. Aquatic Food Chain Multipliers (Taken from Sample et al., 1997 which was modified from EPA 1993) (continued).

Trophic level 2=zooplankton;
Trophic level 3=small fish;
Trophic level 4=piscivorous fish, including top predators.

Log K_{ow}	Prey Trophic Level 2	Prey Trophic Level 3	Prey Trophic Level 4
6.4	1	13.228	23.281
6.5	1	13.662	24.604
6.6	1	13.980	25.645
6.7	1	14.223	26.363
6.8	1	14.355	26.669
6.9	1	14.388	26.669
7.0	1	14.305	26.242
7.1	1	14.142	25.468
7.2	1	13.852	24.322
7.3	1	13.474	22.856
7.4	1	12.987	21.038
7.5	1	21.517	18.967
7.6	1	11.708	16.749
7.7	1	10.914	14.388
7.8	1	10.069	12.050
7.9	1	9.162	9.840
8.0	1	8.222	7.798
8.1	1	7.278	6.012
8.2	1	6.361	4.519
8.3	1	5.489	3.311
8.4	1	4.683	2.371
8.5	1	3.949	1.663
8.6	1	3.296	1.146
8.7	1	2.732	0.778
8.8	1	2.246	0.521
8.9	1	1.837	0.345
9.0	1	1.493	0.226

similar structure and use that compound's K_{ow} for the estimation. These estimates can also be used for calculating levels in higher trophic level organism as described. It is important to realize that the more assumptions that are made, the less reliable the calculated body burdens. That is why it is critical to not rely solely on these estimates without empirically determined tissue levels from field samples.

Table 3 shows examples of calculated values for chemical BAF values for trophic level 3 and 4 organisms. These calculations are based on Eq. 4 and the FCM values presented in Table 2. The full list of compounds sampled by NOAA and USEPA are presented in Appendix 2, Table 1.

As shown in Table 3, acetone would not be expected to bioaccumulate into higher trophic levels. Both aldrin and benzo(a)pyrene would be assumed to accumulate into the higher trophic level organisms. This model assumes that for most trace metals that there is no bioaccumulation in higher trophic levels. Care should be exercised when there is evidence for specific metal bioaccumulation from prey species or where the metal may not be bioavailable such as with Cd (DiToro et al. 1992). In the case of organo-metals, there can be bioaccumulation in higher organisms, as seen with methyl mercury (USEPA 1997b). Selenium is also accumulated due to its similarity to calcium and using transporters and sequestration areas within the cell (Peterson and Nebeker 1992). Using this method, the calculation of tissue concentrations can be used in estimating body burdens in these trophic level organisms for comparison to LOAELs to calculate a HQ. These values can also be used to estimate concentrations in prey species for terrestrial mammals and piscivorous birds.

4.3 Terrestrial Organisms (Wildlife and Plants)

Wildlife is exposed to contaminants through the ingestion of food, the drinking of water, the breathing of air, and direct contact with the skin. In the evaluations being carried out for this project, both dermal absorption and inhalation will not be considered as major exposure pathways of terrestrial organisms to metals or organic compounds. Therefore, the major routes of exposure are through the oral route, which would include food, water, and ingested soil and sediment (Table 4). All values are expressed in terms of a body weight-normalized daily dose or mg/kg body weight per day (mg/kgBW/d). An estimated food intake rate (FIR) would be calculated as shown below.

$$FIR = \frac{(C_f \times IR) + (C_w \times IR) + (C_s \times IR)}{BW} \qquad Eq.6$$

FIR = food intake rate - estimated (mg/kg/d)
C_f = concentration in food -wet weight basis (mg/kg)
C_w = concentration in water (mg/L)
C_s = concentration in soil or sediment (mg/kg)
IR = ingestion rate (kg/d)
BW = body weight (kg)

Table 3. Selected Compounds for Determining Trophic Level BAFs.

Chemical	Log_{10} K_{ow}	BCF[1]	Trophic Level 3[2] FCM	Trophic Level 3 BAF	Trophic Level 4 FCM	Trophic Level 4 BAF
Acetone	-0.24	0.39	1	0.39	1	0.39
Aldrin	6.5	51286.14	13.66	7000000[5]	24.604	13000000[5]
Benzo(a)pyrene	6.11	25917.91	11.34	294000[5]	17.783	461000[5]
Mercury (Methyl Mercury)[3]				27900.00		140000.00
Selenium[4]				2600.00		6800.00

1. BCF calculated using Eq. 4.
2. Level 3=small fish, Level 4=piscivorous fish, including top predators.
3. Literature citation EPA 1995.
4. Peterson and Nebeker 1992.
5. Rounded off values

Table 4. Reference Values for Representative Terrestrial Mammalian Species.

Species	Body Weight (kg)	Food Intake (kg/day)	Water Intake (L/day)	Soil Consumption Rate (kg/day)
White-footed mouse	0.022	0.0034	0.0066	0.000068
Eastern cottontail	1.2	0.237	0.116	0.015
Mink	1.0	0.137	0.099	Negligible
Red fox	4.5	0.45	0.38	0.0126
Whitetail deer	56.5	1.74	3.7	0.0348

(Modified from Sample et al. 1996)

Because wildlife does not consume dry food, these estimates must be adjusted to account for the water content of food. Water content of selected wildlife foods are given in the Wildlife Exposures Factors Handbook (USEPA 1993), and in Table 5. This adjustment is important because most analytical data generated today are on a dry-weight basis. Therefore, the concentrations used for the calculations must be decreased by the percentage of water content. When calculating the food that is consumed it must be realized that most organisms consume a variety of organisms and plant species, and this will affect their estimated daily intake. It is unlikely that there will be data on each of these food types, but when estimating the daily intake, assumptions will have to be made based on best available data. This also would indicate data gaps that if resolved would be helpful in estimating exposure and whether the tissue does approach levels of concern.

Water consumption rates are available for some species of mammalian wildlife (Table 5). Water ingestion in the equation is included when water is a route of exposure for a primary contaminant of concern. Since this is a conservative approach, if a range of data is available, either use the highest value observed or use a mean for the values.

For the terrestrial environment, the animals that were selected are listed in Table 6 and their food sources in Table 6-8. Sample et al. (1996) list data for a much larger number of animals than are presented in this appendix. The terrestrial mammals selected for discussion in this report were selected on the basis that they are commonly present at the parks and represent species that are exposed to compounds through different routes: white-footed mouse (*Peromyscus leucopus*), Eastern cottontail (*Sylvilagus floridanus*), mink (*Mustela vison*), red fox (*Vulpes vulpes*), and white-tailed deer (*Odocoiles virginianus*).

The food intake rates in Table 4 are based on dry weight and must be converted to a wet weight basis. The amount of water present in various classes of organisms was modified from Sample (1994) and represent averages within a group. In order to simplify the calculation, a single recommended value is shown in Table 5 along with the range of reported values.

EXAMPLE CALCULATION: For example if the mink consumed 0.137 kg/day (Table 4) of aquatic invertebrates then the wet weight value would be 0.685 kg/day. The dry mass equals one fifth of the total weight (wet weight consumed=0.137 kg x 5) Table 6. The same approach is used when multiple species comprise the diet of the animal of interest and requires that the total diet be proportioned to the type of prey consumed and corrected for water content.

Prey (0.137 kg/day) [Table 4]	Mink Diet [Table 6]	Water Content [Table 5]	Dry Wt (kg/day)	Wet Wt kg/day
Mammals	46%	68%	0.063	0.197
Fish & Invertebrates	31%	75% (70-80%)	0.042	0.168
Amphibians	13%	85%	0.018	0.120
Birds	10%	68%`	0.014	0.044
Total	100%	-------	0.137	0.529

Table 5. Estimated Water Content for Various Types of Food Types. Recommended values were based on professional judgment and values reported by sample (1994).

Food Type	Recommended Water Content (%)	Ranges (%)
Aquatic invertebrates	80	71-87
Aquatic vertebrates	70	68-75
Aquatic plants	85	84-87
Terrestrial invertebrates	70	61-84
Mammals	68	NR
Birds	68	67-68
Reptiles	66	NR
Amphibians	85	NR
Terrestrial plants leaves	80	70-88
Terrestrial seeds/dry grass	9	7-10

NR = not reported

Table 6. Diet Composition of Representative Terrestrial Mammals Likely to be Encountered at Park Locations.

Species	Diet Composition	Percentage (%)
White-footed mouse	Seeds, fruit, vegetation	34-67
	Arthropods	30-57
Eastern cottontail	Herbaceous plants	100
Mink	Mammals	46
	Fish & invertebrates	31
	Amphibians	13
	Birds	10
Red fox	Mammals	70
	Birds	12
	Plants	10
	Insects	1
	Msc.	remainder
White-tailed deer	Herbaceous plants	100

Table 7. Avian Species That Are Recommended for Estimating Exposure Concentrations.

Species	Body weight (kg)	Food Intake (kg/day)	Water Intake (L/day)	Soil/Sediment Consumption (kg/day)
American robin	0.077	0.093	0.0106	0.0019
American woodcock	0.198	0.15	0.02	0.0156
Belted kingfisher	0.148	0.075	0.016	Negligible[1]
Great blue heron	2.39	0.42	0.1058	Negligible[1]
Red-tailed hawk	1.126	0.109	0.064	Negligible[1]
Osprey	1.5	0.3	0.077	Negligible[1]

1. Piscivorous birds assumed to be negligible and red-tailed hawk consuming mammalian prey. Piscivorous birds may be exposed to entrained sediments in the prey item.

Table 8. Diet Composition of Representative Avian Species Likely to be Encountered at Park Locations.

Species	Diet Composition	Percentage (%)
American robin	Fruit (seasonal)	7-83
	Invertebrates	8-93
American woodcock	Primarily earthworms	58-98
Belted kingfisher	Cyprinids & other fish	86.6
	Crayfish	13.3
Great blue heron	Fish (Predominantly)	100
	Other invertebrates, birds, and small mammals	
Red-tailed hawk	Small mammals	78.5
	Bird	8.5
	Snake	13.0
Osprey	Fish (Predominantly)	100

If there is no food ingestion rate (IR) data available for birds or mammals, then another approach employing (Eq. 8-12) allometric regression models based on metabolic rate is used (Nagy 1987). The BW is on a kg wet or live weight basis.

$IR = 0.0687\ (BW)^{0.022}$	*Placental mammals*	*Eq. 7*
$IR = 0.0306\ (BW)^{0.564}$	*Rodents*	*Eq. 8*
$IR = 0.0875(BW)^{0.727}$	*Herbivores*	*Eq. 9*
$IR = 0.0582(BW)^{0.651}$	*Birds*	*Eq. 10*
$IR = 0.141(BW)^{0.850}$	*Passerine birds*	*Eq.11*

Because this is a screening exercise, in many instances contamination concentrations in the food is not available, and in these circumstances estimates must be generated from existing abiotic data or regional concentrations. In these cases, uptake factors can be used to estimate the values in the food or water (Eq. 2 & 4). The same can be done from organism data by back calculating to media concentrations (Eq. 2). As seen in Table 2, tissue concentrations for aquatic species can be estimated from the Log_{10} K_{ow} for any compound. These estimated concentrations can be used for evaluating the daily intake by specific organisms that consume these food organisms.

In the case of the American robin, there is seasonal variation in the foods that are consumed. However, when available, the earthworm is their primary food source. For a detailed approach to estimate earthworm concentrations, refer to Appendix 2. The same is true for the American woodcock with the earthworm being a major food item. Also, in the case of the great blue heron, osprey, and belted kingfisher, an assumption that can be made is that 100% of their prey consists of trophic level 3 and 4 fish. If there are data available on the proportion of the diet from a number of different organisms, these percentages can be used to approximate the contribution of the COC by the different prey items.

4.4 Terrestrial Plant Contamination

Estimating the amount of chemical uptake and adherence to plant material is a very complicated exercise, due in part to the variety of plants and the diversity of chemicals being applied and present in the atmosphere (Appendix 2, Calculating Uptake into Terrestrial Vegetation). In the case of direct application of a chemical (e.g., pesticide), the estimated chemical concentration can be calculated and this value used as the worst case scenario for foliar concentrations. These values can be used for estimating exposure to herbivores and omnivores. If there is concern of a compound on plant material that is being consumed, then it is recommended that the plant material be sampled directly. This will allow for “site specific” determinations that will be directly applicable to the parks.

5.0 Sample Collection and Analytical Techniques

COCs can be divided into general categories that include radionuclide, inorganic, and organic compounds. Within each of these categories there are many subgroups that may have specific common characteristics. The techniques for quantification of these compounds are generally specific and have been approved by national organizations (USEPA, NOAA, ASTM) and are rigorously followed. Any specific technique will establish which analytes will be analyzed and at what detection limit. There are also specific matrix protocols because the specific matrix will change the extractability, recovery and limit of detection of the analyte (Appendix 2,Table 4). It is critical to determine which analytes are to be tested and what is the level of detection needed.

Just as important as the analytical technique (federal or state agency approved protocols) and lab selection (state and federal certified for analytic technique) is the field collection method (Table 9 & 10, Appendix 2 - General Field Sampling Guidelines). The protocols contained in Appendix 2 have been taken directly from the USEPA Emergency Response Team website and the individual SOPs are listed http://www.ert.org/mainContent.asp?section=Products&subsection=List. Because many compounds are ubiquitous, it is essential that the method of collection not introduce the analyte of interest into the sample from a spurious source. Cross contamination of samples will result in artifacts due to handling and not due to the presence of a COC (Appendix 2 - Sampling Equipment Decontamination). It is important to follow the recommended decontamination procedures, highest purity of solvents and appropriate field sample controls. Another important factor is the dissimilar holding times that are acceptable for the different COCs (Table 10). If a sample is analyzed after an unacceptable holding time (determined by analytical protocol), the results are suspect because of potential loss of analyte or parent chemical alteration.

5.1 Sampling Design

The goals of the sampling design include (1) support a decision whether a contaminant level exceeds a threshold of unacceptable hazard, (2) identify the location of “hot spots” (3) characterize the nature and extent of the contamination, and (4) determine trends in contamination levels. Prior to conducting any sample collections, a full SOP for the sampling procedures, QA/QC samples, sample storage, analytical method, and data analysis (statistics and data usage) should be outlined in detail. Any deviation from the SOP should be noted in a bound sample log. All notes and information collected while sampling should be written in the log book, and signed and dated at the bottom of each page by the person entering the information. If a misstatement or an incorrect entry is entered it should be crossed out with a single line and then initialed by the person changing the entry. All entries need to be in waterproof pen. All personnel involved in the sampling protocol need to have read the protocol and understand the procedures being carried out.

The sampling design is critical to evaluate how representative a sampling strategy is to determining the extent of a given COC at any location (USEPA 2002a). Probability-based sampling involves collection of samples in a nonsystematic fashion from the entire park. Systematic sampling involves collection of samples based on a grid or a pattern, which has been

previously statistically established. If possible, the number of samples to be collected can be determined from preliminary sampling and statistics. When judgmental sampling is performed, samples are collected only from portions of the park that are most likely to be contaminated based on expert knowledge or professional judgment and from a reference site. A grid design can be used for judgmental sampling as well. This latter approach is the one that will likely be used at most parks if for no other reason than decreased number and cost of sample analysis. Under some circumstances a combination of approaches may be used. There is no absolute number of samples that is required to establish the level of a COC at any location. It is important for comparative purposes that a minimum of three discrete independent samples with a subset of duplicates be collected at the designated site location. This will allow for, at a minimum, a mean and standard deviation to be determined, as well as for a statistical analysis to be performed (Student t-test). To prevent sample loss or the influence of outlier values, it is suggested that four to six discrete samples be collected. Increased sample number size will generally reduce the influence of any one outlier; however, sample analysis may limit the number of samples (dioxin like compounds and PCBs cost ~$1,500 per sample) that can be analyzed. For a detailed description of sampling design and statistical interpretation refer to USEPA (2002).

Collection of duplicate or split samples can be used in place of samples that may be lost or damaged. The cost of the sampling campaign is quite high and it is often cheaper to collect the duplicate samples at the time of initial sampling than having to resample the site. For this program, it is being recommended that specific sites within the park be sampled based on suspected introduction of COCs or for the protection of an important natural resource in case of a spill (judgmental sampling). In the case of a spill situation, the samples should include reference samples outside of the spill area, samples at the point of the spill, and samples along the expected concentration gradient of the spill. There is no set number of sample sites, but an adequate number of sites should be sampled to delineate the extent of the spill.

5.2 Discrete or Composite Samples

The two most common types of sample collection are either discrete grab samples or composites of samples collected over an area or a specified time period. The matrix being sampled along with the sampling design strategy will influence the type of sample collected. As the name implies grab samples are taken at a single point in time from the matrix being sampled. This is a discrete sample that will relay the concentration within the matrix at this single point in time and location. A composite sample is a mixture of numerous individual samples that are well mixed and then sampled for analysis. The rational for using a composite sample is that there can be variability in field samples and a composite would give an averaged concentration in the matrix. A composite sample can dilute contaminant result, so it should be noted that if you have an elevated composite sample you may wish to resample with a discrete sampling design to better understand contaminant distribution. This can be achieved if individual samples that comprise the composite can be stored until it is determined whether a point estimate is needed. Chain of custody for any sample is a critical requirement when collecting any sample. It is also important to understand for different statistics are required when comparing individual discrete samples versus composite samples (Newman and Unger 2003; USEPA 2002a).

Atmospheric sampling composite samples are usually collected because of the traditionally low levels of contaminants. There are many different types of samplers from passive designed units (wet and dry samplers, semi permeable membranes) to low volume (carbon filter mini-pumps) and high volume throughput samplers (different filter materials depending on COC). Again, the specific COC will determine the material used to trap the COC or the specific type of sampler (see Appendix 2).

As with air sampling, water sampling (surface and groundwater) can be done either using a single grab type sample or a composite sampler that collects discrete samples for a designated period of time. The composite gives an average of the COC over the time period and results in an average concentration (smoothing out highs and lows). A 24 hour composite sampler is commonly used at sewage treatment or effluent sampling to establish the average concentration over a 24 hour period. Composite sampling allows for a larger volume of sample to be collected that can be used for either analytical or biological toxicity testing. General methods for collection of surface and groundwater samples are summarized in Appendix 2 Surface Water Sampling and Groundwater Well Sampling.

In the case of soil samples, vegetation is removed and surface or core samples at various depths can be obtained. Because of spatial variability of contaminates it is important to composite samples from a specific area. A recommended protocol is to use discrete sampling from a square meter and combining five sub-samples taken from the four corners and the center of the square meter. In the case of sediment sampling, three or more cores or benthic grab samples from each location should comprise the composite. One approach in a small boat using a ponar is to sample from three locations within the boat. In larger vessels and or using larger sampling devices multiple samples from the stern of the boat can be used to make a composite sample. Another advantage to the composite sample is that there is a sufficient amount to collect duplicate samples that may be used (if needed) or as QA/QC samples. Within Appendix 2 are extensive protocols for sediment and soil sampling.

Within Table 9 are summarized the analytical methods for each of the different matrices. Table 10 summarizes for each class of analytes being examined in a specific matrix the required container, preservation method and recommended holding times. Prior to any sampling campaign contact should be made to the analytical laboratory and to determine if they have any specific requirements. What are shown in Table 10 are the generally accepted parameters. To have sufficient material for laboratory “spiking” for determining recoveries (two matrix spikes and one travel blank) and precision (eight matrix spikes) additional samples should be collected at the time of sampling. Sample size can be established following discussions with the laboratory conducting the analysis. In preparation of a spill incident, containers should be onsite along with appropriate collecting devices and identified certified laboratories that can conduct the analysis.

Breaches of protocol for analytical techniques, holding times, cross contamination, individual sample identity, and integrity (chain of custody) can result in the data being suspect and unusable for general monitoring, publication and or litigation purposes. Quality Control and Quality

Assurance Work Plan must be followed for the entire project from planning of sample collection, to analysis and interpretation.

Table 9. Recommended Analytical Methods by Matrix Being Analyzed.

Analyte	Method Number	Instrument	Matrix
PAHs	8270D	GC/MS	S, SD, X
PCBs	8270D	GC/MS	S, SD, X
Total petroleum hydrocarbon	8015B 418.1	GC/MS GC/FID	S, SD, X
Pest/PCB	8080/SW-846 608	GC/MS	S, SD, X W
Oil + grease	5520A+F	IR & Fluorescence	W
Dioxins/furans	8280B 8290A	GC/MS	S, SD, X
Metals	EPA-600/CFR40 7000B 7010 6010B SW-846	Flame AA ICP	W S, SD, X
VOA	8240/SW-846 624/CLP	GC/MS	S, SD W
Grain size	ASTM D422-63	NA	S, SD
Total organic carbon	SW 846-9060	NA	S, SD

S=soil, SD=sediment, W=water, X=tissue, NA=not applicable, VOA=volatile organic analysis

Table 10. Summary of Collection and Holding Requirements Based on Analyte and Specimen.

Analytical Parameter	Matrix[1]	Container Type & Volume[2]	Preservation	Holding Times
Pest/PCB	S	8 oz glass ~500 g	4° C	7/40 days
TAL metals	S	8 oz glass ~10-100g	4 ° C	6 months
TAL metals	XE	8 oz glass ~10-100g	≤ 0 ° C	6 months
Pest/PCB	XE	8 oz glass~10-100g	≤ 0 ° C	7/40 days
Pest/PCB	XM	Foil/Ziploc ~500g	≤ 0 ° C	7/40 days
TAL metals	XM	Foil/Ziploc ~100g	≤ 0 ° C	6 months
Pest/PCB	SD	8 oz glass ~500g	4 ° C	7/40 days
TAL metals	SD	4 oz glass ~100g	4 ° C	6 months
Pest/PCB	XF	Foil/Ziploc ~500g	≤ 0 ° C	7/40 days
TAL metals	XF	Foil/Ziploc ~500g	≤ 0 ° C	6 months
Pest/PCB	XI	Foil/Ziploc ~100g	≤ 0 ° C	7/40 days
TAL metals	XI	Foil/Ziploc ~100g	≤ 0 ° C	6 months
Pest/PCB	W	1 L amber~1000 ml	4 ° C	7/40 days
TAL metals	W	1 L poly ~1000 ml	4 ° C	6 months
Lipids	X	Foil/Ziploc ~1-10g	NA	7 days
Grain size	S,SD	32 oz glass ~10-1000g	NA	NA
TOC	S,SD	8 oz glass ~1-10g	4 ° C	28 days

1. Matrix: S=soil, W=water, SD=sediment, XE=earthworm tissue, XF=forage fish, XI=invertebrate, X=animal lipids, XM=mammal
2. The container type is indicated but the amount needed is determined by the selected analytical technique and anticipated concentration level. The values listed in the table are recommendations (Dr. Brian Buckley personnel communication EOHSI analytical Laboratory), and actual amounts should be discussed with the analytical laboratory carrying out the analysis. Actual amounts collected can affect the detection limit for the sample.

6.0 Conclusion

Appendix 1 is a primer for assessing which chemicals may pose a threat to wildlife on NPS properties, and how samples should be collected and analyzed. Appendix 1 is presented in a manner that will allow National Park personnel to become familiar with the basic principles that underlie an environmental screening approach and to determine if a chemical concentration poses any hazard to wildlife species. It cannot be emphasized enough that the approach proposed in this chapter is a simplified approach to a very complex problem. In most environmental samples there are complex mixtures of compounds that can be assessed on an individual chemical basis, but there are likely complex chemical interactions that will influence the toxicity. Although much of Appendix 1 deals with individual compounds and their effects, most environmental situations have multiple contaminants. These contaminants, although dealt with on an individual compound by compound basis in toxicology, do not preclude the possibility that chemical compounds can result in less than additive, additive, or greater than additive effects when an organism is exposed to multiple chemicals from an environmental mixture. An exception occurs when the chemicals act through a common mechanism and the literature supports an additive approach. This is the case for dioxin-like compounds, but in the majority of cases such information is not available (Van den Berg et al. 2006). The difficulty in dealing with complex mixtures is that there is no way short of testing the mixture to determine how the chemicals interact in the biological system. The reader should also appreciate that both chemical contamination and species have a spotty distribution in the environment, which can affect the establishment of baseline values. The specific examples provided allow NPS staff to see how the equations are applied to determine if a compound is above a benchmark level that could adversely impact wildlife. It is important in any assessment to understand the activities that historically or presently (offsite and onsite) introduce chemicals into the exposure pathways of plants and animals within a park area. With this information and an understanding about the critical habitats and species an assessment can be made to predict if an adverse effect may result. It is important that both the personnel conducting chemical analysis and the natural resource personnel work together to assess impacts.

Appendix 2: Hazard Quotient Approaches and Sampling Protocols (continued)

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1.0 Chemicals Analyzed During Routine Sampling

One of the largest and continuous data sets that exist for bivalve mollusks can be obtained from the NOAA Status and Trends data for estuarine environments around the country. The data set goes back to 1986 and contains data for sediment and tissue values for only a few years over this period. Tissue data is available for most of the sites on a two to five year basis. The two bivalve species that are collected at these sites are the blue mussel (*Mytilus edulis*) and the Eastern oyster (*Crassostrea virginica*). Since these are filter-feeding bivalves, they will accumulate contaminants from chemicals adhering to particulates and food organisms (algae). These data can be used to make three different interpretations concerning the waters to which the bivalves are exposed. First, this data set is useful for examining temporal trends at a given site from 1986 to present for both trace metals and organic contaminants. Selecting specific sites that are in or near park locations enables a determination to be made concerning the trends in chemical concentrations in these organisms. These trends can be used as an indicator for the improvement in a specific watershed, no change in tissue levels, or an upward trend for a particular compound. A second use for these data can be the calculation of what the suspended sediment or particulate phase concentrations are for a specific compound. The assumption being made is that this calculated particulate phase value is equivalent to actual bulk sediment, which is likely a conservative assumption. This number can be compared to the sediment matrix benchmarks and a HQ derived. This is based on site specific BAF values generated when comparing the sediment to the tissue concentrations. If the estimated sediment concentration is greater than the NOAEL for sediment, then the specific compound should be considered a COC.

Site Specific BAF=Tissue Concentration/Sediment Concentration
Estimated Sediment Concentration=Tissue Concentration/Site Specific BAF *Eq. 1*

Third, the tissue concentrations can be used to establish exposure from food ingestion by mammals and birds that have bivalves as a portion of their diets. These data along with that generated in other trophic level organisms can be used to estimate a higher trophic levels organism's exposure through ingestion.

The EPA has also begun a long-term monitoring program that is examining not only chemical concentrations in sediment but also in fish and crustaceans inhabiting estuarine and near shore areas along the United States. There is also a biological component that examines toxicity associated with sediment and surface water. These data are useful when attempting to establish, whether there is an impact from multiple contaminants that may be present in an environmental sample. Examining whole organism toxicity allows for the total impact of all of the bioavailable compounds to be assessed as to whether there is an impact on the organism. These responses can be sublethal and lethal responses.

Other data sets that are useful include data from state and local authorities that have conducted regional or local collections. Local industry and federal government installations also are sources of contaminant information. NPS surveys are also useful in establishing the extent and number of COCs at any one location.

1.1 Calculation Uptake into Terrestrial Vegetation

Travis and Arms (1988) reported that uptake into vegetation from soil contaminated with organic compounds can be calculated by with Eq. 13. The concentration in the plant (B_v) is inversely proportional to the square-root of the octanol-partioning coefficient (K_{ow}).

$$Log_{10}\, B_v = 1.588 - 0.578\, Log_{10}\, K_{ow} \qquad Eq.\ 2$$

A recent reevaluation of this approach has supported the initial assumptions with several minor qualifications (Birak et al. 2001). Compounds that are readily metabolized will be overestimated in the plant material; the concentration of compounds with a Log_{10} K_{ow} greater than 6.5 may be overestimated in the plants.

In the case of elements present in soil, the concentration in plants can be estimated using specific elemental transport parameters developed by Baes et al. (1984) for both the vegetative and non-vegetative portions of plants. These values were developed to estimate the amount of transfer to agricultural crops and are a good tool for estimating soil to plant uptake. The transfer coefficients were derived to represent the ratio of the elemental concentration in the plant and soil at harvest, and were broken down into vegetative portions and non-vegetative (reproductive) portions (Table 2). To calculate the concentration in the plant, multiply the transfer coefficient of the specific element by the soil dry-weight concentration. Multiplication by a factor of four for conversion from dry to wet weight should be used for non-grain or grasses. For grains and dry grasses a factor of 1.1 should be used (Table 6, Appendix 1).

Within Table 1 are derived equations for estimating uptake by plants for a number of routinely sampled metals. Derived equations for a number of organic compounds are shown in Table 2. These tables were obtained from the ECOTOX database (http://cfpub.epa.gov/ecotox/).

1.2 Earthworm Uptake

Earthworms (oligochaeta) are an important food source for a number of vertebrate species and may comprise the majority of their food intake. Secondary poisoning from contaminated worms has been reported (Sheppard et al. 1997). Uptake of organic compounds can be estimated based on the method of Menzie et al. (1992) as shown in the equation below.

$$UF = (Y_L)/(0.66 \times f_{oc}) \qquad Eq.\ 2$$

UF=uptake factor
Y_L=earthworm lipid content (if not measured assume 0.84%)
f_{oc}=organic carbon content of soil

The soil organic carbon should be measured on a site by site basis. If this information is not available, estimations can be made based on the soil conservation information available from the U.S. Department of Agriculture Natural Resources Conservation Service Web Soil Survey (http://soils.usda.gov/).

Table 1. Summary of Compounds Routinely Analyzed for by NOAA and USEPA and Calculated Trophic Level BAFs.

Analyte	Class	Log Kow	Kow	BCF*	Trohic Level 3 FCM	Trohic Level 3 BAF	Trohic Level 4 FCM	Trohic Level 4 BAF	Carcinogen	Mutagen	Teratogen	Reference
1,2,3,4-Tetrachlorobenzene	Pesticide	4.67	4.68E+04	2.09E+03	2.175	4.54E+03	1.633	3.41E+03				5
1,6,7-Trimethylnaphthalene	PAH	4.30	2.00E+04	1.09E+03	1.491	1.63E+03	1.178	1.29E+03	X			7
1-Methylnaphthalene	PAH	3.84	6.87E+03	4.88E+02	1.161	5.67E+02	1.042	5.08E+02	X			1
1-Methylphenanthrene	PAH	5.04	1.09E+05	3.98E+03	3.181	1.27E+04	2.612	1.04E+04	X			1
2,4'-DDD	Pesticide	6.20	1.58E+06	3.03E+04	12.064	3.66E+05	19.907	6.04E+05	X			1
2,4'-DDE	Pesticide	7.00	1.00E+07	1.23E+05	14.305	1.76E+06	26.242	3.23E+06	X			1
2,4'-DDT	Pesticide	6.19	1.55E+06	2.98E+04	12.064	3.60E+05	19.907	5.93E+05	X	X		1
2,6-Dimethylnaphthalene	PAH	4.37	2.36E+04	1.23E+03	1.614	1.99E+03	1.242	1.53E+03	X			1
2-Methylnaphthalene	PAH	3.86	7.19E+03	5.05E+02	1.202	6.07E+02	1.054	5.33E+02	X			1
4,4'-DDD	Pesticide	6.20	1.58E+06	3.03E+04	12.064	3.66E+05	19.907	6.04E+05	X			1
4,4'-DDE	Pesticide	7.00	1.00E+07	1.23E+05	14.305	1.76E+06	26.424	3.25E+06	X			1
4,4'-DDT	Pesticide	6.19	1.55E+06	2.98E+04	12.064	3.60E+05	19.907	5.93E+05	X	X		1
Acenaphthene	PAH	4.01	1.03E+04	6.57E+02	1.253	8.23E+02	1.072	7.04E+02	X			1
Acenaphthylene	PAH	3.22	1.67E+03	1.65E+02	1.042	1.72E+02	1.009	1.66E+02	X			1
Aldrin	Pesticide	5.66	4.57E+05	1.18E+04	7.962	9.39E+04	10.209	1.20E+05	X			1
Alpha-Chlordane	Pesticide	6.00	1.00E+06	2.14E+04	10.556	2.26E+05	15.996	3.42E+05	X			6
Alpha-Hexachlorocyclohexane	Pesticide	3.80	6.31E+03	4.45E+02	1.161	5.17E+02	1.042	4.64E+02	X			8
Aluminum	Metal	NA	NA	NA	NA	NA	NA	NA				2
Anthracene	PAH	4.53	3.42E+04	1.63E+03	1.766	2.88E+03	1.334	2.18E+03	X			1
Antimony	Metal	NA	NA	NA	NA	NA	NA	NA				2
Arsenic	Metal	NA	NA	NA	NA	NA	NA	NA	X			2
Benz[a]anthracene	PAH	5.67	4.71E+05	1.20E+04	7.962	9.55E+04	10.209	1.23E+05	X			1
Benzo[a]pyrene	PAH	6.11	1.28E+06	2.59E+04	11.337	2.94E+05	17.783	4.61E+05	X			1
Benzo[b]fluoranthene	PAH	6.27	1.85E+06	3.43E+04	12.691	4.35E+05	21.677	7.43E+05	X			1
Benzo[e]pyrene	PAH	6.14	1.36E+06	2.71E+04	11.337	3.07E+05	17.783	4.82E+05	X			1
Benzo[g,h,i]perylene	PAH	6.51	3.21E+06	5.22E+04	13.662	7.13E+05	24.604	1.28E+06	X			1
Benzo[k]fluoranthene	PAH	6.29	1.95E+06	3.55E+04	12.691	4.51E+05	21.677	7.70E+05	X			1
Beta-Hexachlorocyclohexane	Pesticide	3.78	6.03E+03	4.39E+02	1.161	5.10E+02	1.042	4.57E+02	X			8
Biphenyl	PAH	3.95	8.91E+03	5.92E+02	1.253	7.41E+02	1.072	6.34E+02	X			1
C1-Chrysenes	PAH	6.42	2.63E+06	4.46E+04	13.228	5.90E+05	23.281	1.04E+06	X			7
C1-Dibenzothiophenes	PAH	NA	NA	NA	NA	NA	NA	NA	X			
C1-Fluoranthenes/Pyrenes	PAH	5.29	1.94E+05	6.17E+03	4.803	2.96E+04	4.742	2.93E+04	X			1
C1-Fluorenes	PAH	4.72	5.25E+04	2.28E+03	2.175	4.95E+03	1.633	3.72E+03	X			1
C1-Naphthalenes	PAH	3.80	6.31E+03	4.55E+02	1.161	5.28E+02	1.042	4.74E+02	X			1
C1-Phenanthrenes/Anthracenes	PAH	5.04	1.10E+05	3.98E+03	3.181	1.27E+04	2.612	1.04E+04	X			1

Table 1. Summary of Compounds Routinely Analyzed for by NOAA and USEPA and Calculated Trophic Level BAFs (continued).

Analyte	Class	Log Kow	Kow	BCF*	Trohic Level 3 FCM	Trohic Level 3 BAF	Trohic Level 4 FCM	Trohic Level 4 BAF	Carcinogen	Mutagen	Teratogen	Reference
C2-Chrysenes	PAH	6.88	7.59E+06	9.97E+04	14.388	1.43E+06	26.669	2.66E+06	X			7
C2-Dibenzothiophenes	PAH	NA	NA	NA	NA	NA	NA	NA	X			
C2-Fluoranthenes/Pyrenes	PAH	5.29	1.94E+05	6.17E+03	4.803	2.96E+04	4.742	2.93E+04	X			
C2-Fluorenes	PAH	5.20	1.58E+05	5.27E+03	4.188	2.21E+04	3.873	2.04E+04	X			1
C2-Naphthalenes	PAH	4.30	2.00E+04	1.09E+03	1.491	1.63E+03	1.178	1.29E+03	X			1
C2-Phenanthrenes/Anthracenes	PAH	5.46	2.88E+05	8.31E+03	6.266	5.21E+04	7.079	5.88E+04	X			1
C3-Chrysenes	PAH	7.44	2.75E+07	2.66E+05	12.987	3.45E+06	21.038	5.59E+06	X			7
C3-Dibenzothiophenes	PAH	NA	NA	NA	NA	NA	NA	NA	X			
C3-Fluoranthenes/Pyrenes	PAH	5.29	1.94E+05	6.17E+03	4.803	2.96E+04	4.742	2.93E+04	X			
C3-Fluorenes	PAH	5.70	5.01E+05	1.26E+04	7.962	1.01E+05	10.209	1.29E+05	X			1
C3-Naphthalenes	PAH	4.80	6.31E+04	2.62E+03	2.452	6.42E+03	1.871	4.90E+03	X			1
C3-Phenanthrenes/Anthracenes	PAH	5.92	8.32E+05	1.86E+04	9.716	1.81E+05	13.964	2.60E+05	X			1
C4-Chrysenes	PAH	8.00	1.00E+08	7.08E+05	8.222	5.82E+06	7.798	5.52E+06	X			7
C4-Naphthalenes	PAH	5.30	2.00E+05	6.28E+03	4.803	3.02E+04	4.742	2.98E+04	X			1
C4-Phenanthrenes/Anthracenes	PAH	6.32	2.09E+06	3.74E+04	12.691	4.75E+05	21.677	8.11E+05	X			1
Cadmium	Metal	NA	NA	NA	NA	NA	NA	NA	X			2
Chlorpyrifos	Pesticide	5.26	1.82E+05	5.86E+03	4.803	2.81E+04	4.742	2.78E+04				5
Chromium	Metal	NA	NA	NA	NA	NA	NA	NA	X			2
Chrysene	PAH	5.71	5.16E+05	1.29E+04	7.962	1.02E+05	10.209	1.31E+05	X			1
Cis-Nonachlor	Pesticide	5.70	5.01E+05	1.26E+04	7.962	1.01E+05	10.209	1.29E+05				6
Copper	Metal	NA	NA	NA	NA	NA	NA	NA				2
Delta-Hexachlorocyclohexane	Pesticide	4.14	1.38E+04	8.25E+02	1.315	1.08E+03	1.096	9.04E+02	X			8
Dibenzo[a,h]anthracene	PAH	6.71	5.16E+06	7.41E+04	14.223	1.05E+06	26.363	1.95E+06	X			1
Dibenzofuran		4.12	1.32E+04	7.97E+02	1.315	1.05E+03	1.069	8.51E+02				5
Dibenzothiophene	PAH	4.49	3.09E+04	1.52E+03	1.766	2.69E+03	1.334	2.03E+03	X			1
Dibutyltin	Organotin	NA	NA	NA	NA	NA	NA	NA				2
Dieldrin	Pesticide	5.16	1.45E+05	4.92E+03	4.188	2.06E+04	3.873	1.90E+04		X		1
Endosulfan	Pesticide	2.23	4.10E+00	2.90E+01	1.005	2.91E+01	1.000	2.90E+01				2
Endrin	Pesticide	4.56	3.63E+04	1.72E+03	1.950	3.35E+03	1.459	2.51E+03				1
Fluoranthene	PAH	5.08	1.21E+05	4.27E+03	3.643	1.56E+04	3.162	1.35E+04	X			1
Fluorene	PAH	4.21	1.61E+04	9.32E+02	1.380	1.29E+03	1.130	1.05E+03	X			1
Gamma-Chlordane	PAH	6.00	1.00E+06	2.14E+04	10.556	2.26E+05	15.996	3.42E+05	X		X	1
Gamma-Hexachlorocyclohexane	Pesticide	3.61	4.07E+03	3.26E+02	1.103	3.60E+02	1.023	3.34E+02	X			8
Heptachlor	Pesticide	5.44	2.75E+05	8.02E+03	5.502	4.41E+04	5.821	4.67E+04	X			1
Heptachlor-Epoxide	Pesticide	5.40	2.51E+05	7.48E+03	5.502	4.12E+04	5.821	4.36E+04	X			1
Hexachlorobenzene	Pesticide	5.66	4.57E+05	1.18E+04	7.962	9.39E+04	10.209	1.20E+05	X	X		1
Indeno[1,2,3-c,d]pyrene	PAH	6.72	5.27E+06	7.54E+04	14.223	1.07E+06	26.363	1.99E+06	X			1
Iron	Metal	NA	NA	NA	NA	NA	NA	NA				2
Lead	Metal	NA	NA	NA	NA	NA	NA	NA	X			2
Manganese	Metal	NA	NA	NA	NA	NA	NA	NA				2
Mercury	Metal	NA	NA	NA	NA	NA	NA	NA				2
Mirex	PAH	6.89	7.76E+06	1.01E+05	14.388	1.46E+06	26.669	2.71E+06	X			1
Monobutyltin	Organotin	NA	NA	NA	NA	NA	NA	NA				2
Naphthalene	PAH	3.36	2.27E+03	2.09E+02	1.067	2.23E+02	1.014	2.12E+02	X			1
Nickel	Metal	NA	NA	NA	NA	NA	NA	NA	X			2

Table 1. Summary of Compounds Routinely Analyzed for by NOAA and USEPA and Calculated Trophic Level BAFs (continued).

Analyte	Class	Log Kow	Kow	BCF*	Trohic Level 3 FCM	Trohic Level 3 BAF	Trohic Level 4 FCM	Trohic Level 4 BAF	Carcinogen	Mutagen	Teratogen	Reference
Oxychlordane	Pesticide	2.60	3.98E+02	5.57E+01	1.028	5.73E+01	1.007	5.61E+01				6
PCB101/90	PCB	6.64	4.37E+06	6.55E+04	13.980	9.16E+05	25.645	1.68E+06	X			3
PCB105	PCB	6.91	8.13E+06	1.05E+05	14.388	1.51E+06	26.669	2.80E+06	X			3
PCB118	PCB	7.40	2.52E+07	2.48E+05	12.987	3.22E+06	21.038	5.21E+06	X			4
PCB128	PCB	7.02	1.05E+07	1.27E+05	14.305	1.82E+06	26.242	3.34E+06	X			3
PCB138	PCB	7.11	1.29E+07	1.49E+05	14.142	2.11E+06	25.468	3.80E+06	X			3
PCB153/132/168	PCB	6.86	7.24E+06	9.63E+04	14.388	1.39E+06	26.669	2.57E+06	X			3
PCB170/190	PCB	7.57	3.72E+07	3.34E+05	11.708	3.91E+06	16.749	5.59E+06	X			3
PCB18	PCB	5.60	3.98E+05	1.06E+04	7.096	7.53E+04	8.551	9.08E+04	X			4
PCB180	PCB	7.66	4.57E+07	3.90E+05	10.914	4.26E+06	14.388	5.62E+06	X			3
PCB187	PCB	7.47	2.95E+07	2.80E+05	21.517	6.03E+06	18.967	5.31E+06	X			3
PCB195/208	PCB	7.88	7.59E+07	5.74E+05	9.162	5.26E+06	9.840	5.65E+06	X			3
PCB206	PCB	7.88	7.59E+07	5.74E+05	9.162	5.26E+06	9.840	5.65E+06	X			3
PCB209	PCB	7.88	7.59E+07	5.74E+05	9.162	5.26E+06	9.840	5.65E+06	X			3
PCB28	PCB	5.89	7.76E+05	1.76E+04	9.716	1.71E+05	13.964	2.46E+05	X			3
PCB44	PCB	5.99	9.77E+05	2.10E+04	10.556	2.22E+05	15.996	3.36E+05	X			3
PCB52	PCB	6.08	1.20E+06	2.46E+04	11.337	2.79E+05	17.783	4.37E+05	X			3
PCB66	PCB	6.44	2.75E+06	4.62E+04	13.228	6.11E+05	23.281	1.07E+06	X			3
PCB8/5	PCB	5.27	1.86E+05	5.96E+03	4.803	2.86E+04	4.742	2.83E+04	X			3
Pentachloroanisole	Pesticide	NA	NA	NA	NA	NA	NA	NA	X			
Pentachlorobenzene	Pesticide	5.26	1.82E+05	5.86E+03	4.803	2.81E+04	4.742	2.78E+04	X			5
Perylene	PAH	6.14	1.36E+06	2.73E+04	11.337	3.10E+05	17.783	4.86E+05	X			1
Phenanthrene	PAH	4.57	3.72E+04	1.75E+03	1.950	3.41E+03	1.459	2.55E+03				1
Pyrene	PAH	4.92	8.36E+04	3.23E+03	2.780	8.98E+03	2.193	7.08E+03	X			1
Selenium	Metal	NA	NA	NA	NA	NA	NA	NA				2
Silicon	Metal	NA	NA	NA	NA	NA	NA	NA				2
Silver	Metal	NA	NA	NA	NA	NA	NA	NA				2
Tetrabutyltin	Organotin	NA	NA	NA	NA	NA	NA	NA				2
Tin	Metal	NA	NA	NA	NA	NA	NA	NA				2
Total butyltins	Organotin	NA	NA	NA	NA	NA	NA	NA				2
Total chlordanes	Pesticide	5.50	3.16E+05	8.91E+03	6.266	5.58E+04	7.079	6.31E+04	X		X	6
Total DDT	Pesticide	6.19	1.55E+06	2.98E+04	12.064	3.60E+05	19.907	5.93E+05	X	X		1
Total dieldrin	Pesticide	4.60	3.98E+04	1.85E+03	1.950	3.60E+03	1.459	2.69E+03		X		6,2
Total PAH	PAH	5.98	9.55E+05	2.06E+04	9.716	2.01E+05	13.964	2.88E+05	X			1
Total PAHhmw (4 or more rings)	PAH	5.98	9.55E+05	2.06E+04	9.716	2.01E+05	13.964	2.88E+05	X			1
Total PAHlmw (2-3 rings)	PAH	5.98	9.55E+05	2.06E+04	9.716	2.01E+05	13.964	2.88E+05	X			1
Trans-Nonachlor	Pesticide	5.70	5.01E+05	1.26E+04	7.962	1.01E+05	10.209	1.29E+05	X			6
Tributyltin	Organotin	NA	NA	NA	NA	NA	NA	NA				2
Zinc	Metal	NA	NA	NA	NA	NA	NA	NA				2

logBCF=(0.76)(logKow)-(0.23)
BAF = (BCF)(FCM) NA=not available

Table 1. Summary of Compounds Routinely Analyzed for by NOAA and EPA and Calculated Trophic Level BAFs (continued).

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Table 2. Multiplication Factors for Elements Present in Soil for Estimating Plant Concentrations in the Vegetative and Non-Vegetative Portions of the Plant[1].

Element	Vegetative	Non-Vegetative
Hafnium (Hf)	0.0035	0.0009
Tantalum (Ta)	0.0100	0.0025
Tungsten (W)	0.0450	0.0100
Rhenium (Re)	1.5000	0.3500
Osmium (Os)	0.0150	0.0035
Iridium (Ir)	0.0550	0.0150
Platinum (Pt)	0.0950	0.0250
Gold (Au)	0.4000	0.1000
Mercury (Hg)	0.9000	0.2000
Thallium (Tl)	0.0040	0.0004
Lead (Pb)	0.0450	0.0090
Bismuth (Bi)	0.0350	0.0050
Polonium (Po)	0.0025	0.0004
Astatine (At)	1.0000	0.1500
Francium (Fr)	0.0300	0.0300
Radium (Ra)	0.0150	0.1500
Lanthanum (La)	0.0100	0.0040
Cerium (Ce)	0.0100	0.0040
Prasiodimium (Pr)	0.0100	0.0040
Neodymium (Nd)	0.0100	0.0040
Promethium (Pm)	0.0100	0.0040
Samarium (Sm)	0.0100	0.0040
Europium (Eu)	0.0100	0.0040
Gadolinium (Gd)	0.0100	0.0040
Terbium (Tb)	0.0100	0.0040
Dysprosium (Dy)	0.0100	0.0040
Holmium (Ho)	0.0100	0.0040
Erbium (Er)	0.0100	0.0040
Thulium (TM)	0.0100	0.0040
Ytterbium (Yb)	0.0100	0.0040
Lutetion (Lu)	0.0100	0.0040
Actinium (Ac)	0.0035	0.0004
Thorium (Th)	0.0010	0.0001
Protactinium (Pa)	0.0025	0.0003
Uranium (U)	0.0085	0.0040
Neptunium (Np)	0.1000	0.0100
Plutonium (Pu)	0.0005	0.00005
Americium (Am)	0.0055	0.0003
Curium (Cu)	0.0009	0.00002

1. Source: Baes, C.F., Sharp, R.D., Sjoreen, A.L., and Shor, R.W. (1984). A Review and Analyses of Parameters for Assessing transport of Environmentally Released Radionuclide's through Agriculture. Oakridge National Laboratory. Managed by Martin Marietta Systems, INC. for the U.S. Department of Energy.

An alternative model has been proposed by Jager (1998), which is currently being recommended by USEPA for determining the BCF in earthworms (Connell and Markwell 1990; Sample et al. 1997). The model is based on the theory that bioconcentration in earthworms is governed by thermodynamic partitioning between surrounding water and the water and lipid phases inside the organism (Eq 15). For risk assessment the equations below can be used to predict BCFs for chemicals taken up by earthworms in the Log_{10} K_{ow} range of zero to eight. Tables 3-5 are based on the Jager (1998) model.

$$C_{worm}=K_{ww}\times C_w \qquad \textit{Eq. 3}$$

C_{worm}=concentration in worm (mg/kg dry weight)
K_{ww}=biota to soil water partitioning coefficient (L soil pore water/kg ww tissue)
C_w=concentration in soil pore water (mg/L)

Jager (1998) derived the following equations for determining K_{ww} and C_w.

$$Log_{10}(K_{ww})=0.87\times Log_{10}(K_{ow}) - 2.0$$

$$C_w=C_s/K_d$$

C_s=concentration in soil (mg/kg soil)
K_d=soil to water partitioning coefficient (L soil pore water/kg dw soil)

For non-ionic organic compounds, K_d may be estimated using the following equation.

$$K_d=F_{oc}\times K_{oc}$$

F_{oc} = fraction of organic carbon in soil (kg organic carbon/kg soil)
K_{oc} = soil organic carbon to water partitioning coefficient
(volume soil pore water (L)/kg organic carbon)

We are recommending using Eq. 2 as the default if insufficient information is available. If the chemical is listed in Tables 1-3, utilize the equations to estimate tissue concentrations. Tables 1-3 were taken from the Ecological Soil Screening Levels Attachment 4-1 (2005), which is updated periodically as new information becomes available and is available through the ECOTOX database (http://cfpub.epa.gov/ecotox/). When sufficient data are available, and then utilize Eq. 3 to estimate the earthworm concentrations.

Table 3. Uptake Equations for Inorganic Compounds for Plants, Earthworms, and Small Mammals.

Analyte	Soil to Plants		Soil to Earthworms		Soil to Small Mammals	
	Equation	Source	Equation	Source	Equation	Source
Antimony	$\ln(C_p) = 0.938 * \ln(C_s) - 3.233$	a	$C_e = C_s$	g	$C_m = 0.001 * 50 * C_d$	f
Arsenic	$C_p = 0.03752 * C_s$	b	$\ln(C_e) = 0.706 * \ln(C_s) - 1.421$	e	$\ln(C_m) = 0.8188 * \ln(C_s) - 4.8471$	d
Barium	$C_p = 0.156 * C_s$	b	$C_e = 0.091 * C_s$	c	$C_m = 0.00015 * 50 * C_d$	f
Beryllium	$\ln(C_p) = 0.7345 * \ln(C_s) - 0.5361$	h	$C_e = 0.045 * C_s$	c	$C_m = 0.001 * 50 * C_d$	f
Cadmium	$\ln(C_p) = 0.546 * \ln(C_s) - 0.475$	b	$\ln(C_e) = 0.795 * \ln(C_s) + 2.114$	e	$\ln(C_m) = 0.4723 * \ln(C_s) - 1.2571$	d
Chromium	$C_p = 0.041 * C_s$	b	$C_e = 0.306 * C_s$	e	$\ln(C_m) = 0.7338 * \ln(C_s) - 1.4599$	d
Cobalt	$C_p = 0.0075 * C_s$	b	$C_e = 0.122 * C_s$	c	$\ln(C_m) = 1.307 * \ln(C_s) - 4.4669$	d
Copper	$\ln(C_p) = 0.394 * \ln(C_s) + 0.668$	b	$C_e = 0.515 * C_s$	e	$\ln(C_m) = 0.1444 * \ln(C_s) + 2.042$	d
Lead	$\ln(C_p) = 0.561 * \ln(C_s) - 1.328$	b	$\ln(C_e) = 0.807 * \ln(C_s) - 0.218$	e	$\ln(C_m) = 0.4422 * \ln(C_s) + 0.0761$	d
Manganese	$C_p = 0.079 * C_s$	b	$\ln(C_e) = 0.682 * \ln(C_s) - 0.809$	e	$C_m = 0.0205 * C_s$	d
Nickel	$\ln(C_p) = 0.748 * \ln(C_s) - 2.223$	b	$C_e = 1.059 * C_s$	e	$\ln(C_m) = 0.4658 * \ln(C_s) - 0.2462$	d
Selenium	$\ln(C_p) = 1.104 * \ln(C_s) - 0.677$	b	$\ln(C_e) = 0.733 * \ln(C_s) - 0.075$	e	$\ln(C_m) = 0.3764 * \ln(C_s) - 0.4158$	d
Silver	$C_p = 0.014 * C_s$	b	$C_e = 2.045 * C_s$	c	$C_m = 0.004 * C_s$	d
Vanadium	$C_p = 0.00485 * C_s$	b	$C_e = 0.042 * C_s$	c	$C_m = 0.0123 * C_s$	d
Zinc	$\ln(C_p) = 0.554 * \ln(C_s) + 1.575$	b	$\ln(C_e) = 0.328 * \ln(C_s) + 4.449$	e	$\ln(C_m) = 0.0706 * \ln(C_s) + 4.3632$	d

Source:

a. Regression derived from measured data [Appendix A]
b. Bechtel-Jacobs 1998
c. Sample et al. 1998b
d. Sample et al. 1998a
e. Sample et al. 1999
f. Baes et al. 1984
g. Assumed
h. Regression derived from measured data [Appendix A].

Abbreviations:

C_s = Concentration in soil (mg/kg)
C_p = Concentration in plant tissue (mg/kg dry weight)
C_e = Concentration in earthworm (mg/kg dry weight)
C_m = Concentration in small mammal tissue (mg/kg dry weight)
C_d = Concentration in diet (mg/kg dry weight)
where small mammal diet is assumed to be 100% earthworms

Table 4. Parameters Used in Calculating Earthworm BAFs for Selected Organic Compounds.

Chemical	K_{ow}: octanol to water partitioning coefficient			K_{ww}: worm to soil water partitioning coefficient			K_{oc}: water to soil organic carbon partitioning coefficient					K_d: soil to water partitioning coefficient	Soil to Earthworm BAF[5]
	log K_{ow}	K_{ow}	Source	log K_{ww}[1]	K_{ww} (L/kg worm ww)	K_{ww}[2] (L/kg worm dw)	slope	intercept	log K_{oc}	K_{oc}[3]	Source	K_d[4] (L/kg soil dw)	
Acenaphthene	3.92	8.32E+03	EPA 1996	1.41	2.57E+01	1.61E+02	0.762	1.051	4.04	1.09E+04	estimated (a)	1.09E+02	1.47
Acenaphthylene	4.07	1.17E+04	SRC, PP	1.54	3.47E+01	2.17E+02			2.98	9.47E+02	SRC, CF	9.47E+00	22.9
Anthracene	4.55	3.55E+04	EPA 1996	1.96	9.09E+01	5.68E+02			4.37	2.35E+04	EPA 1996	2.35E+02	2.42
Benzo(a)anthracene	5.7	5.01E+05	EPA 1996	2.96	9.10E+02	5.69E+03			5.55	3.58E+05	EPA 1996	3.58E+03	1.59
Benzo(a)pyrene	6.11	1.29E+06	EPA 1996	3.32	2.07E+03	1.29E+04			5.99	9.69E+05	EPA 1996	9.69E+03	1.33
Benzo(b)fluoranthene	6.2	1.58E+06	EPA 1996	3.39	2.48E+03	1.55E+04	0.762	1.051	5.78	5.96E+05	estimated (a)	5.96E+03	2.60
Benzo(e)pyrene	6.44	2.75E+06	SRC, PP	3.60	4.01E+03	2.50E+04	0.762	1.051	5.96	9.08E+05	estimated (a)	9.08E+03	2.76
Benzo(ghi)perylene	6.7	5.01E+06	EPA 1995	3.83	6.75E+03	4.22E+04	0.762	1.051	6.16	1.43E+06	estimated (a)	1.43E+04	2.94
Benzo(k)fluoranthene	6.2	1.58E+06	EPA 1996	3.39	2.48E+03	1.55E+04	0.762	1.051	5.78	5.96E+05	estimated (a)	5.96E+03	2.60
Chrysene	5.7	5.01E+05	EPA 1996	2.96	9.10E+02	5.69E+03	0.762	1.051	5.39	2.48E+05	estimated (a)	2.48E+03	2.29
Coronene	7.64	4.37E+07	SRC, PP	4.65	4.43E+04	2.77E+05	0.762	1.051	6.87	7.46E+06	estimated (a)	7.46E+04	3.72
Dibenzo(ah)anthracene	6.69	4.90E+06	EPA 1996	3.82	6.61E+03	4.13E+04			6.25	1.79E+06	EPA 1996	1.79E+04	2.31
Fluoranthene	4.95	8.91E+04	SRC, PP	2.31	2.03E+02	1.27E+03			4.62	4.17E+04	SRC, CF	4.17E+02	3.04
Fluorene	4.18	1.51E+04	SRC, PP	1.64	4.33E+01	2.71E+02			3.45	2.83E+03	SRC, CF	2.83E+01	9.57
Indeno(123 cd)pyrene	6.584	3.84E+06	SRC, PP	3.73	5.35E+03	3.34E+04	0.762	1.051	6.07	1.17E+06	estimated (a)	1.17E+04	2.86
Naphthalene	3.36	2.29E+03	EPA 1996	0.92	8.38E+00	5.24E+01			3.08	1.19E+03	EPA 1996	1.19E+01	4.40
Phenanthrene	4.55	3.55E+04	EPA 1995	1.96	9.09E+01	5.68E+02	0.762	1.051	4.52	3.30E+04	estimated (a)	3.30E+02	1.72
Pyrene	4.88	7.59E+04	SRC, PP	2.25	1.76E+02	1.10E+03			4.80	6.27E+04	SRC, CF	6.27E+02	1.75

Table 4. Parameters Used in Calculating Earthworm BAFs for Selected Organic Compounds (continued).

[1] $\log K_{ww} = 0.87 * \log K_{ow} - 2.0$ [model from Jager, 1998]

[2] Converted from wet weight to dry weight assuming 16% solids (Jager, 1998)

[3] Measured K_{oc} values from SRC Chem Fate Database or EPA, 1996 ($n > 2$).
If no measured K_{oc} values available, values modeled based on chemical class-specific models from Gerstl (1990).
where: $\log K_{oc} = \text{slope} * \log K_{ow} + \text{intercept}$
(a) slope and intercept for PAHs

[4] $K_d = f_{oc} * K_{oc}$ (assumes an f_{oc} of 1% [0.01])

[5] BAF = K_{ww} (L/kg worm dw) / K_d (L/kg soil dw)

Source Citations:

EPA (1995) = Internal report on summary of measured, calculated, and recommended Log Kow values. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. 38 pp.
EPA (1996) = Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128
SRC, PP = Syracuse Research Corp. Physical Properties Database. http://esc.syrres.com/interkow/PhysProp.htm
SRC, CF = Syracuse Research Corp. Chem Fate Database. http://www.syrres.com/esc/chemfate.htm

Table 5. Equations for Calculating Uptake into Plants, Earthworms, and Small Mammals.

Chemical	Soil to Plants		Soil to Earthworms		Soil to Small Mammals	
	Equation	Source	Equation	Source	Equation	Source
Non-PAHs						
Dieldrin	$C_p = 0.41 * C_s$	a	$\ln(C_e) = 0.8756 * \ln(C_s) + 2.2757$	a	$\ln(C_m) = 0.6076 * \ln(C_d) + 1.9582$	a
DDT, DDD and DDE Combined	$\ln(C_p) = 0.7524 * \ln(C_s) - 2.5119$	b	$\ln(C_e) = 0.8561 * \ln(C_s) + 2.1287$	b	$\ln(C_m) = 0.663 * \ln(C_d) + 2.3833$	b
DDT	*Not Available*		$\ln(C_e) = 0.8689 * \ln(C_s) + 2.1247$	b	$\ln(C_m) = 0.7254 * \ln(C_d) + 1.1788$	b
DDD	*Not Available*		$\ln(C_e) = 0.6975 * \ln(C_s) + 1.1613$	b	*Not Available*	
DDE	*Not Available*		$\ln(C_e) = 0.8804 * \ln(C_s) + 2.4771$	b	$\ln(C_m) = 0.641 * \ln(C_d) + 3.6401$	b
TNT	$C_p = 4.23 * C_s$	c	*Not Available*		$C_m = 0$	f
RDX	$C_p = 0.43 * C_s$	c	*Not Available*		$C_m = 0$	f
PAHs						
Acenaphthene	$\ln(C_p) = -0.8556 * \ln(C_s) - 5.562$	d	$C_e = 1.47 * C_s$	e	$C_m = 0$	f
Acenaphthylene	$\ln(C_p) = 0.791 * \ln(C_s) - 1.144$	g	$C_e = 22.9 * C_s$	e	$C_m = 0$	f
Anthracene	$\ln(C_p) = 0.7784 * \ln(C_s) - 0.9887$	d	$C_e = 2.42 * C_s$	e	$C_m = 0$	f
Benzo(a)anthracene	$\ln(C_p) = 0.5944 * \ln(C_s) - 2.7078$	d	$C_e = 1.59 * C_s$	e	$C_m = 0$	f
Benzo(a)pyrene	$\ln(C_p) = 0.9750 * \ln(C_s) - 2.0615$	d	$C_e = 1.33 * C_s$	e	$C_m = 0$	f
Benzo(b)fluoranthene	$C_p = 0.310 * C_s$	c	$C_e = 2.60 * C_s$	e	$C_m = 0$	f
Benzo(e)pyrene	$C_p = 0.19 * C_s$	c	$C_e = 2.76 * C_s$	e	$C_m = 0$	f
Benzo(ghi)perylene	$\ln(C_p) = 1.1829 * \ln(C_s) - 0.9313$	d	$C_e = 2.94 * C_s$	e	$C_m = 0$	f
Benzo(k)fluoranthene	$\ln(C_p) = 0.8595 * \ln(C_s) - 2.1579$	d	$C_e = 2.60 * C_s$	e	$C_m = 0$	f
Chrysene	$\ln(C_p) = 0.5944 * \ln(C_s) - 2.7078$	d	$C_e = 2.29 * C_s$	e	$C_m = 0$	f
Coronene	$C_p = 0.68 * C_s$	c	$C_e = 3.72 * C_s$	e	$C_m = 0$	f
Dibenz(ah)anthracene	$C_p = 0.13 * C_s$	c	$C_e = 2.31 * C_s$	e	$C_m = 0$	f
Fluoranthene	$C_p = 0.50 * C_s$	c	$C_e = 3.04 * C_s$	e	$C_m = 0$	f
Fluorene	$\ln(C_p) = -0.8556 * \ln(C_s) - 5.562$	d	$C_e = 9.57 * C_s$	e	$C_m = 0$	f
Indeno(123 cd)pyrene	$C_p = 0.11 * C_s$	c	$C_e = 2.86 * C_s$	e	$C_m = 0$	f
Naphthalene	$C_p = 12.2 * C_s$	c	$C_e = 4.40 * C_s$	e	$C_m = 0$	f
Phenanthrene	$\ln(C_p) = 0.6203 * \ln(C_s) - 0.1665$	d	$C_e = 1.72 * C_s$	e	$C_m = 0$	f
Pyrene	$C_p = 0.72 * C_s$	c	$C_e = 1.75 * C_s$	e	$C_m = 0$	f

Table 5. Equations for Calculating Uptake into Plants, Earthworms, and Small Mammals (continued).

Source:

a. Regression derived from measured data [Appendix E].
b. Regression derived from measured data [Appendix D].
c. Median BAF calculated from measured data [Appendix C].
d. Regression derived from measured data [Appendix C].
e. Modeled from K_{ow} based on Jager (1998) [Table 5].
f. Assumed to be negligible
g. Modeled using the rinsed PAH-specific equation [Figure 3]

Abbreviations:

C_s = Concentration in soil (mg/kg)
C_p = Concentration in plant tissue (mg/kg dry weight)
C_e = Concentration in earthworm (mg/kg dry weight)
C_m = Concentration in small mammal or bird tissue (mg/kg dry weight)
C_d = Concentration in diet (mg/kg dw) where diet is assumed to be 100% earthworms.

	Soil to Plants		Soil to Earthworms		Soil to Small Mammals	
Chemical	**Equation**	**Source**	**Equation**	**Source**	**Equation**	**Source**
Pentachlorophenol	$C_p = 5.93 * C_s$	a	$\ln(C_e) = 0.3308 * \ln(C_s) + 5.5463$	b	$C_m = 0.00452 * C_d + 0.198$	c

1.3 USEPA Environmental Response Team SOPs

1.3.1 General Field Sampling Guidelines (USEPA-Environmental Response Team)

SOP#: 2001
DATE:08/11/94
REV. #: 0.0

Scope and Application: The purpose of this SOP is to provide general field sampling guidelines that will assist personnel in choosing sampling strategies, location, and frequency for proper assessment of site characteristics. This SOP is applicable to all field activities that involve sampling. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required depending on site conditions, equipment limitations, and limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and reported. Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: Sampling is the selection of a representative portion of a larger population, universe, or body. Through examination of a sample, the characteristics of the larger body from which the sample was drawn can be inferred. In this manner, sampling can be a valuable tool for determining the presence, type, and extent of contamination by hazardous substances in the environment. The primary objective of all sampling activities is to characterize a hazardous waste site accurately so that its impact on human health and the environment can be properly evaluated. It is only through sampling and analysis that site hazards can be measured and the job of cleanup and restoration can be accomplished effectively with minimal risk. The sampling itself must be conducted so that every sample collected retains its original physical form and chemical composition. In this way, sample integrity is assured, quality assurance standards are maintained, and the sample can accurately represent the larger body of material under investigation.

The extent to which valid inferences can be drawn from a sample depends on the degree to which the sampling effort conforms to the project's objectives. For example, as few as one sample may produce adequate, technically valid data to address the project's objectives. Meeting the project's objectives requires thorough planning of sampling activities, and implementation of the most appropriate sampling and analytical procedures. These issues will be discussed in this procedure.

Sample Preservation, Containers, Handling, and Storage: The amount of sample to be collected, and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest. Sample preservation, containers, handling, and storage for air and waste samples are discussed in the specific SOPs for air and waste sampling techniques.

Interferences and Potential Problems: The nature of the object or materials being sampled may be a potential problem to the sampler. If a material is homogeneous, it will generally have a uniform composition throughout. In this case, any sample increment can be considered representative of the material. On the other hand, heterogeneous samples present problems to the

sampler because of changes in the material over distance, both laterally and vertically. Samples of hazardous materials may pose a safety threat to both field and laboratory personnel. Proper health and safety precautions should be implemented when handling this type of sample. Environmental conditions, weather conditions, or non-target chemicals may cause problems and interferences when performing sampling activities or when sampling for a specific parameter. Refer to the specific SOPs for sampling techniques.

Equipment/Apparatus: The equipment/apparatus required to collect samples must be determined on a site specific basis. Due to the wide variety of sampling equipment available, refer to the specific SOPs for sampling techniques, which include lists of the equipment/apparatus required for sampling.

Reagents: Reagents may be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

Procedure: *Types of Samples*: In relation to the media to be sampled, two basic types of samples can be considered: the environmental sample and the hazardous sample. Environmental samples are those collected from streams, ponds, lakes, and wells; there are offsite samples that are not expected to be contaminated with hazardous materials. They usually do not require the special handling procedures typically used for concentrated wastes. However, in certain instances, environmental samples can contain elevated concentrations of pollutants and in such cases would have to be handled as hazardous samples. Hazardous or concentrated samples are those collected from drums, tanks, lagoons, pits, waste piles, fresh spills, or areas previously identified as contaminated, and require special handling procedures because of their potential toxicity or hazard. These samples can be further subdivided based on their degree of hazard; however, care should be taken when handling and shipping any wastes believed to be concentrated regardless of the degree.

The importance of making the distinction between environmental and hazardous samples is two-fold:

(1) Personnel safety requirements: Any sample thought to contain enough hazardous materials to pose a safety threat should be designated as hazardous and handled in a manner which ensures the safety of both field and laboratory personnel.

(2) Transportation requirements: Hazardous samples must be packaged, labeled, and shipped according to the International Air Transport Association Dangerous Goods Regulations or Department of Transportation (DOT) regulations and USEPA guidelines.

Sample Collection Techniques: In general, two basic types of sample collection techniques are recognized, both of which can be used for either environmental or hazardous samples.

Grab Samples: A grab sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected all at once at one particular point in the sample medium. The representativeness of such samples is defined by the nature of the materials

being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

Composite Samples: Composites are nondiscrete samples composed of more than one specific aliquot collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can in certain instances be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask problems by diluting isolated concentrations of some hazardous compounds below detection limits. Compositing is often used for environmental samples and may be used for hazardous samples under certain conditions. For example, compositing of hazardous waste is often performed after compatibility tests have been completed to determine an average value over a number of different locations (group of drums). This procedure generates data that can be useful by providing an average concentration within a number of units, can serve to keep analytical costs down, and can provide information useful to transporters and waste disposal operations. For sampling situations involving hazardous wastes, grab sampling techniques are generally preferred because grab sampling minimizes the amount of time sampling personnel must be in contact with the wastes, reduces risks associated with compositing unknowns, and eliminates chemical changes that might occur due to compositing.

Types of Sampling Strategies: The number of samples that should be collected and analyzed depends on the objective of the investigation. There are three basic sampling strategies: random, systematic, and judgmental sampling. Random sampling involves collection of samples in a nonsystematic fashion from the entire site or a specific portion of a site. Systematic sampling involves collection of samples based on a grid or a pattern that has been previously established. When judgmental sampling is performed, samples are collected only from the portion(s) of the site most likely to be contaminated. Often, a combination of these strategies is the best approach depending on the type of the suspected/known contamination, the uniformity and size of the site, the level/type of information desired, etc.

Quality Analysis Work Plans (QAWP): A QAWP is required when it becomes evident that a field investigation is necessary. It should be initiated in conjunction with, or immediately following, notification of the field investigation. This plan should be clear and concise and should detail the following basic components, with regard to sampling activities:

1. Objective and purpose of the investigation.
2. Basis upon which data will be evaluated.
3. Information known about the site including location, type and size of the facility, and length of operations/abandonment.
4. Type and volume of contaminated material, contaminants of concern (including concentration), and basis of the information/data.
5. Technical approach including media/matrix to be sampled, sampling equipment to be used, sample equipment decontamination (if necessary), sampling design and rationale, and SOPs or description of the procedure to be implemented.
6. Project management and reporting, schedule, project organization and responsibilities, manpower and cost projections, and required deliverables.
7. QA objectives and protocols including tables summarizing field sampling and QA/QC analysis and objectives.

Note that this list of QAWP components is not all inclusive and that additional elements may be added or altered depending on the specific requirements of the field investigation. It should also be recognized that although a detailed QAWP is quite important, it may be impractical in some instances. Emergency responses and accidental spills are prime examples of such instances where time might prohibit the development of site-specific QAWPs prior to field activities. In such cases, investigators would have to rely on general guidelines and personal judgment, and the sampling or response plans might simply be a strategy based on preliminary information and finalized on site. In any event, a plan of action should be developed, no matter how concise or informal, to aid investigators in maintaining a logical and consistent order to the implementation of their task.

Legal Implications: The data derived from sampling activities are often introduced as critical evidence during litigation of a hazardous waste site cleanup. Legal issues in which sampling data are important may include cleanup cost recovery, identification of pollution sources and responsible parties, and technical validation of remedial design methodologies. Because of the potential for involvement in legal actions, strict adherence to technical and administrative SOPs is essential during both the development and implementation of sampling activities. Technically valid sampling begins with thorough planning and continues through the sample collection and analytical procedures. Administrative requirements involve thorough, accurate documentation of all sampling activities. Documentation requirements include maintenance of a chain of custody, as well as accurate records of field activities and analytical instructions. Failure to observe these procedures fully and consistently may result in data that are questionable, invalid and indefensible in court, and the consequent loss of enforcement proceedings.

Calculations: Refer to the specific SOPs for any calculations which are associated with sampling techniques.

QA/QC: Refer to the specific SOPs for the type and frequency of QA/QC samples to be analyzed, the acceptance criteria for the QA/QC samples, and any other QA/QC activities which are associated with sampling techniques.

Data Validation: Refer to the specific SOPs for data validation activities that are associated with sampling techniques.

Health and Safety: When working with potentially hazardous materials follow USEPA, OSHA, and corporate health and safety procedures.

1.3.2 Sampling Equipment Decontamination (USEPA - Environmental Response Team)

SOP#: 2006
DATE:08/11/94
REV. #: 0.0

Scope and Application: The purpose of this SOP is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 1910.120. This SOP does not address personnel decontamination.

These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required depending on site conditions, equipment limitation, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and reported.

Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances.

Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning.

The first step, a soap and water wash, removes all visible particulate matter, residual oils, and grease. This may be preceded by a steam or high-pressure water wash to facilitate residuals removal. The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent. An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected. It is followed by another distilled/deionized water rinse. If sample analysis does not include metals, the acid rinse step can be omitted. Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the priority pollutant list. If acetone is known to be a contaminant of concern at a given site or if target compound list analysis (which includes acetone) is to be performed, another solvent may be substituted. The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed. This rinse removes any residual traces of the solvent.

The decontamination procedure described above may be summarized as follows:

1. Physical removal
2. Non-phosphate detergent wash
3. Tap water rinse
4. Distilled/deionized water rinse
5. 10% nitric acid rinse
6. Distilled/deionized water rinse
7. Solvent rinse (pesticide grade)
8. Air dry
9. Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine step decontamination procedure specified above may be modified for site specificity. For example, the nitric acid rinse may be eliminated if metals are not of concern at a site. Similarly, the solvent rinse may be eliminated if organics are not of concern at a site. Modifications to the standard procedure should be documented in the site specific work plan or subsequent report.

Sample Preservation, Containers, Handling, and Storage: The amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest.

More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site. This should be determined prior to initiation of site activities.

Interferences and Potential Problems: The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern).

The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal or industrial water treatment system.

If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns.

Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment.

Equipment/Apparatus: Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. Most equipment and supplies can be easily procured. For example, softwash bristle scrub brushes or long-handled bottle brushes can be used to remove contaminants. Large galvanized wash tubs, stock tanks, or buckets can hold softwash and rinse solutions. Children's wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment. Contaminated liquid can be stored temporarily in metal or plastic cans or drums.

The following standard materials and equipment are recommended for decontamination activities:

Decontamination Solutions: Non-phosphate detergent, selected solvents (acetone, hexane, nitric acid, etc.), tap water, distilled or deionized water.

Decontamination Tools/Supplies: Long and short handled brushes, bottle brushes, drop cloth/plastic sheeting, paper towels, plastic or galvanized tubs or buckets, pressurized sprayers, solvent sprayers, and aluminum foil.

Health and Safety Equipment: Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, and emergency eye wash).

Waste Disposal: Trash bags, trash containers, 55-gallon drums, and metal/plastic buckets/containers for storage and disposal of decontamination solutions.

Reagents: There are no reagents used in this procedure aside from the actual decontamination solutions. Table 6 lists solvent rinses which may be required for elimination of particular chemicals. In general, the following solvents are typically utilized for decontamination purposes: 10% nitric acid is typically used for inorganic compounds such as metals. An acid rinse may not be required if inorganics are not a contaminant of concern.

Acetone (pesticide grade)(1)
Hexane (pesticide grade)(1)
Methanol(1)

(1)- Only if sample is to be analyzed for organics.

Procedures: As part of the health and safety plan, a decontamination plan should be developed and reviewed. The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- The number, location, and layout of decontamination stations.
- Decontamination equipment needed.
- Appropriate decontamination methods.
- Methods for disposal of contaminated clothing, equipment, and solutions.

Procedures can be established to minimize the potential for contamination. This may include: (1) work practices that minimize contact with potential contaminants; (2) using remote sampling techniques; (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material; (4) watering down dusty areas; (5) avoiding laying down equipment in areas of obvious contamination; and (6) use of disposable sampling equipment.

Table 6. Soluble Contaminants and Recommended Solvent Rinse.

Solvent[1]	Examples of Solvents	Soluble Contaminants
Water	Deionized water Tap water	Low-chain hydrocarbons Inorganic compounds Salts Some organic acids and other polar compounds
Dilute acids	Nitric acid Acetic acid Boric acid	Basic (caustic) compounds (e.g., amines and hydrazines)
Dilute bases	Sodium bicarbonate (e.g., soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic solvents[2]	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g., hexane) Common petroleum products (e.g., fuel, oil, kerosene	Nonpolar compounds (e.g., some organic compounds
Organic solvent[2]	Hexane	PCBs

- Material safety data sheets are required for all decontamination solvents or solutions as required by the hazard communication standard
- WARNING: Some organic solvents can permeate and/or degrade the protective clothing

Decontamination Methods: All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. Various decontamination methods will remove contaminants by: (1) flushing or other physical action, or (2) chemical complexing to inactivate contaminants by neutralization, chemical reaction, disinfection, or sterilization. Physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods, as follows:

Abrasive Cleaning Methods: Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites. The following abrasive methods are available:

> *Mechanical*: Mechanical methods of decontamination include using metal or nylon brushes. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface.
>
> *Air Blasting*: Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency. Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated.
>
> *Wet Blasting*: Wet blast cleaning involves use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using a very fine abrasive, the amount of materials removed can be carefully controlled.

Non-Abrasive Cleaning Methods: Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure. In general, the equipment surface is not removed using non-abrasive methods.

> *Low-Pressure Water*: This method consists of a container that is filled with water. The user pumps air out of the container to create a vacuum. A slender nozzle and hose allow the user to spray in hard-to-reach places.
>
> *High-Pressure Water*: This method consists of a high-pressure pump, an operator controlled directional nozzle, and a highpressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute.
>
> *Ultra-High-Pressure Water*: This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm). Additives can be used to enhance the cleaning action.
>
> *Rinsing*: Contaminants are removed by rinsing through dilution, physical attraction, and solubilization.

Damp Cloth Removal: In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure. For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated. A damp cloth should be used to wipe off contaminants that may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set.

Disinfection/Sterilization: Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment. This method of decontamination is typically performed offsite.

Field Sampling Equipment Decontamination Procedures: The decontamination line is setup so that the first station is used to clean the most contaminated item. It progresses to the last station where the least contaminated item is cleaned. The spread of contaminants is further reduced by separating each decontamination station by a minimum of one meter. Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line.

A site is typically divided up into the following boundaries: hot zone or exclusion zone, the contamination reduction zone (CRZ), and the support or safe zone. The decontamination line should be setup in the contamination reduction corridor (CRC) which is in the CRZ. Figure 1 shows a typical contaminant reduction zone layout. The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area. The CRC boundaries should be conspicuously marked. The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone. The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site. Whenever possible, it should be a straight line.

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew. Another corridor may be required for the entry and exit of heavy equipment. Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC. Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline. One person (or more) dedicated to decontaminating equipment is recommended.

Decontamination Setup: Starting with the most contaminated station, the decontamination setup should be as follows:

Station 1: Segregate Equipment Drop
Place plastic sheeting on the ground (Figure 2). Size will depend on amount of equipment to be decontaminated. Provide containers lined with plastic if equipment is to be segregated. Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment that is likely to be heavily contaminated.

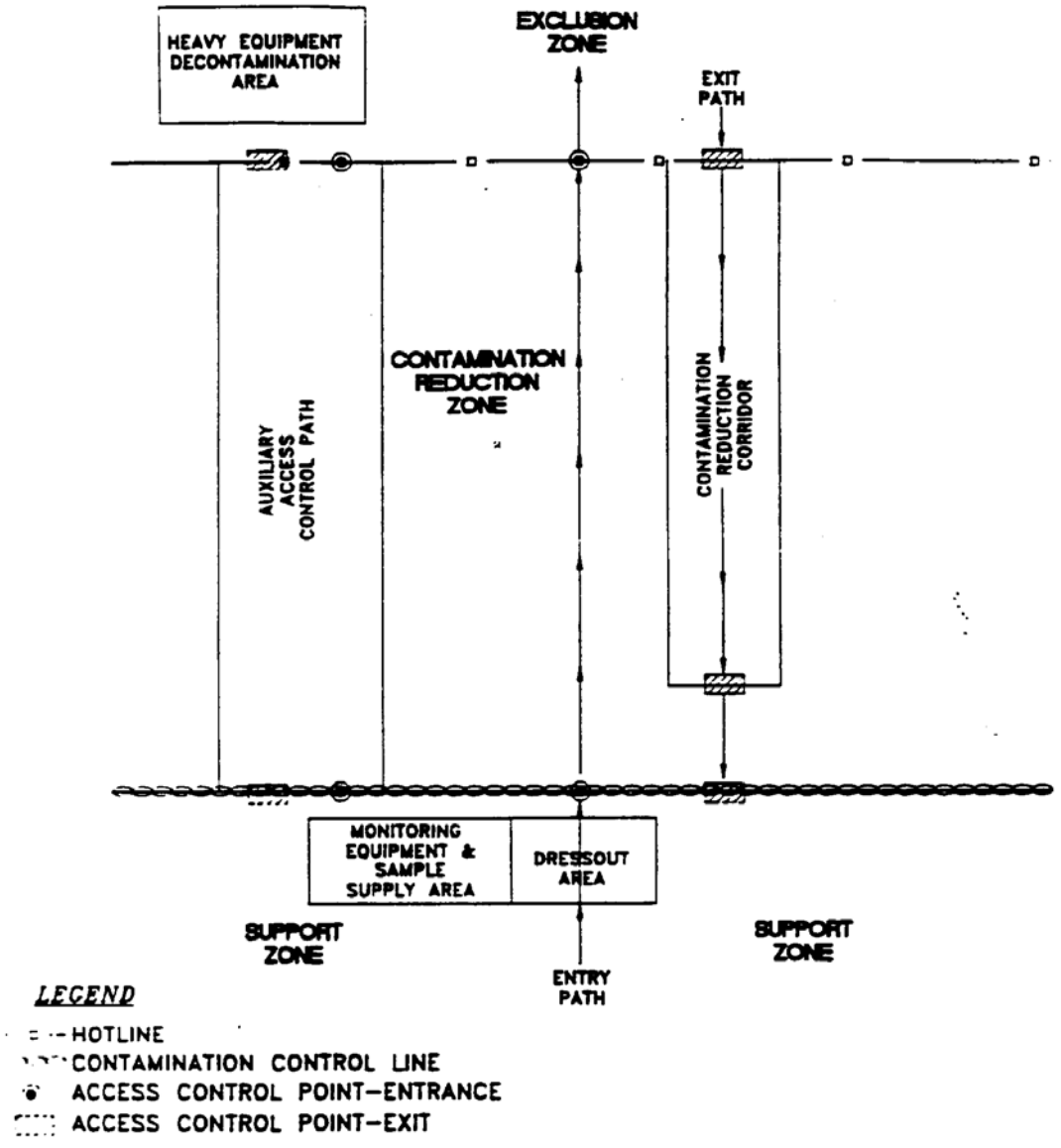


Figure 1. Contamination Reduction Zone Layout.

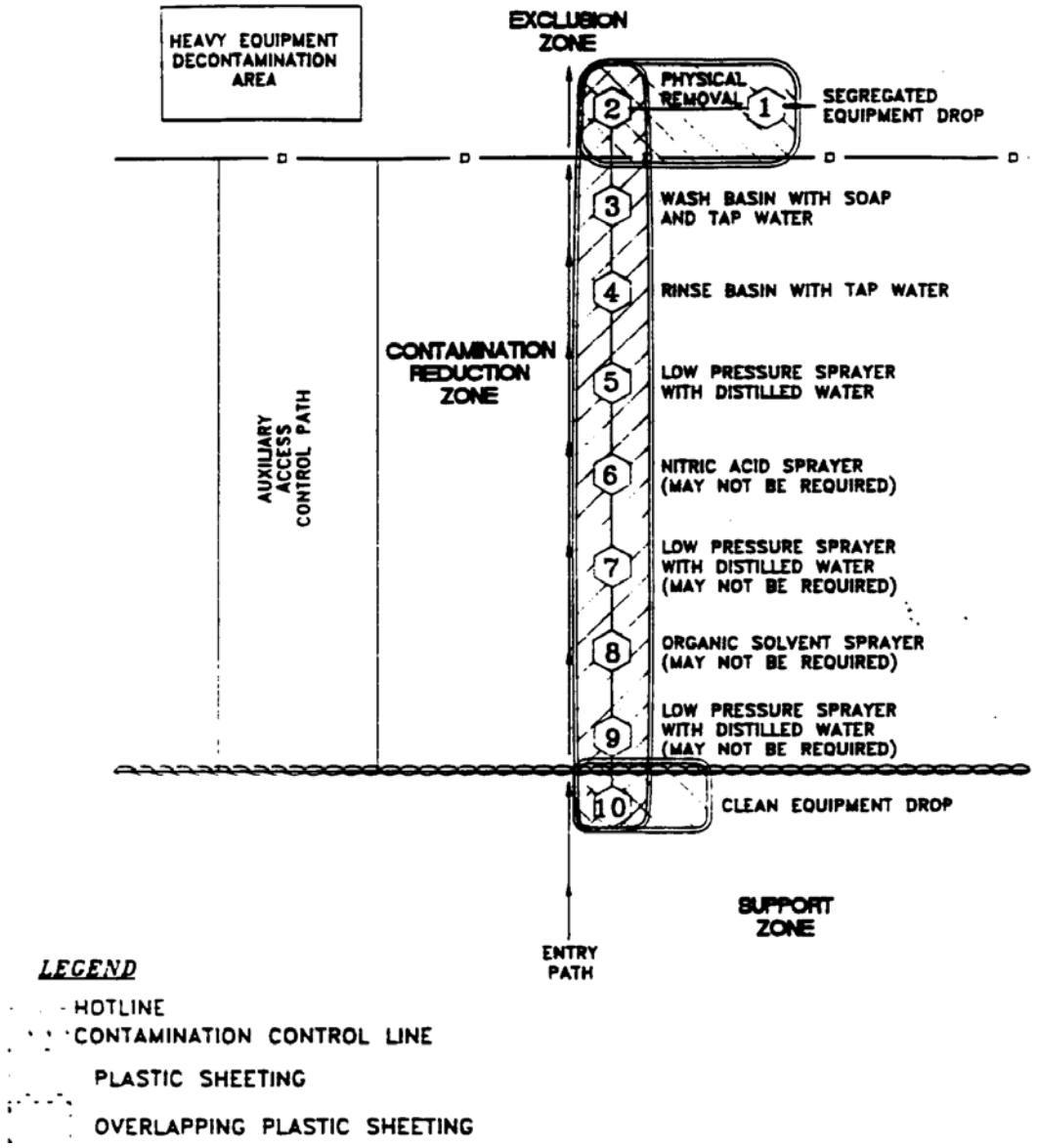


Figure 2. Decontamination Layout.

Station 2: Physical Removal with a High-Pressure Washer (Optional)
A high-pressure wash may be required for compounds that are difficult to remove by washing with brushes. The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds. High pressure washers require water and electricity.

A decontamination pad may be required for the high- pressure wash area. An example of a wash pad may consist of an approximately a half meter deep basin lined with plastic sheeting and sloped to a sump at one corner. A layer of sand can be placed over the plastic and the basin is filled with gravel or shell. The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse. A sump pump is used to remove the water from the sump for transfer into a drum.

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently. A separate decontamination pad may be required for heavy equipment.

Station 3: Physical Removal With Brushes and a Wash Basin
Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10.

Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water. Several bottle and bristle brushes to physically remove contamination should be dedicated to this station. Approximately 38 – 189 liters of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 4: Water Basin
Fill a wash basin, a large bucket, or child's swimming pool with tap water. Several bottle and bristle brushes should be dedicated to this station. Approximately 38 – 189 liters of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 5: Low-Pressure Sprayers
Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to contain the water during the rinsing process. Approximately 38 – 76 liters of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 6: Nitric Acid Sprayers
Fill a spray bottle with 10% nitric acid. An acid rinse may not be required if inorganics are not a contaminant of concern. The amount of acid will depend on the amount of equipment to be decontaminated. Provide a 5-gallon bucket or basin to collect acid during the rinsing process.

Station 7: Low-Pressure Sprayers
Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 8: Organic Solvent Sprayers
Fill a spray bottle with an organic solvent. After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried. Amount of solvent will depend on the amount of equipment to decontaminate. Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process.

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence.

Station 9: Low-Pressure Sprayers
Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 10: Clean Equipment Drop
Lay a clean piece of plastic sheeting over the bottom plastic layer. This will allow easy removal of the plastic in the event that it becomes dirty. Provide aluminum foil, plastic, or other protective material to wrap clean equipment.

Decontamination Procedures:

Station 1: Segregate Equipment Drop
Deposit equipment used on-site (e.g., tools, sampling devices and containers, monitoring instruments radios, and clipboards) on the plastic drop cloth/sheet or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross contamination. Loose leaf sampling data sheets or maps can be placed in plastic Ziploc bags if contamination is evident.

Station 2: Physical Removal With a High-Pressure Washer (Optional)
Use high pressure wash on grossly contaminated equipment. Do not use high-pressure wash on sensitive or non-waterproof equipment.

Station 3: Physical Removal With Brushes and a Wash Basin
Scrub equipment with soap and water using bottle and bristle brushes. Only sensitive equipment (i.e., radios, air monitoring and sampling equipment) that is waterproof should be washed. Equipment that is not waterproof should have plastic bags removed and wiped down with a damp cloth. Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended decontamination solutions.

Station 4: Equipment Rinse
Wash soap from equipment with water by immersing the equipment in the water while brushing. Repeat as many times as necessary.

Station 5: Low-Pressure Rinse
Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 6: Nitric Acid Sprayers (required only if metals are a contaminant of concern)
Using a spray bottle rinse sampling equipment with nitric acid. Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket. A rinsate blank may be required at this station.

Station 7: Low-Pressure Sprayers
Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 8: Organic Solvent Sprayers
Rinse sampling equipment with a solvent. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket. Allow the solvent to evaporate from the equipment before going to the next station. A QC rinsate sample may be required at this station.

Station 9: Low-Pressure Sprayers
Rinse sampling equipment with distilled/deionized water with a low-pressure washer.

Station 10: Clean Equipment Drop
Lay clean equipment on plastic sheeting. Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material.

Post Decontamination Procedures:

1. Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container. A sump pump can aid in the collection process. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
2. Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
3. Empty soap and water liquid wastes from basins and buckets and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
4. Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum. pH paper or an equivalent pH test is required for neutralization. Consult DOT requirements for appropriate drum for acid rinse waste.
5. Empty solvent rinse sprayer and solvent waste into an appropriate container. Consult DOT requirements for appropriate drum for solvent rinse waste.
6. Using low-pressure sprayers, rinse basins, and brushes. Place liquid generated from this process into the wash water rinse container.
7. Empty low-pressure sprayer water onto the ground.

8. Place all solid waste materials generated from the decontamination area (e.g., gloves and plastic sheeting) in an approved DOT drum. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.
9. Write appropriate labels for waste and make arrangements for disposal. Consult DOT regulations for the appropriate label for each drum generated from the decontamination process.

Calculations: This section is not applicable to this SOP.

QA/QC: A rinsate blank is one specific type of quality control sample associated with the field decontamination process. This sample will provide information on the effectiveness of the decontamination process employed in the field. Rinsate blanks are samples obtained by running analyte-free water over decontaminated sampling equipment to test for residual contamination. The blank water is collected in sample containers for handling, shipment, and analysis. These samples are treated identical to samples collected that day.

A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures. Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device samples to meet quality assurance objectives.

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs.

Data Validation: Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives.

Health and Safety: When working with potentially hazardous materials, follow OSHA, USEPA, corporate, and other applicable health and safety procedures.

Decontamination can pose hazards under certain circumstances. Hazardous substances may be incompatible with decontamination materials. For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products. Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion.

The decontamination solutions must be determined to be acceptable before use. Decontamination materials may degrade protective clothing or equipment; some solvents can permeate protective clothing. If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard. The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process.

Safety considerations should be addressed when using abrasive and non-abrasive decontamination equipment. Maximum air pressure produced by abrasive equipment could cause physical injury. Displaced material requires control mechanisms.

Material generated from decontamination activities requires proper handling, storage, and disposal. Personal protective equipment may be required for these activities.

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i.e., acetone, alcohol, and trisodiumphosphate). In some jurisdictions, phosphate containing detergents (i.e., TSP) are banned.

1.3.3 General Air Sampling Guidelines (USEPA - Environmental Response Team SOPs)

GENERAL AIR SAMPLING GUIDELINES

SOP#: 2008
DATE: 11/16/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments[1,2,3]. Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents[4].

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the

following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

C Emergency Response

Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

C Removal Site Assessment

Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

C Removal Actions

Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bagsor culture tubes) which are then placed into a shipping container.

Use bubble wrap or styrofoam peanuts when packing air samples for shipment. DO NOT USE VERMICULITE.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; volatile compounds from petrochemical facilities; and effluvium from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons

(PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites[5]," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical methods for sampling: *NIOSH Manual of Analytical Methods*[6], *American Society for Testing and Materials (ASTM) Methods*[7], *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*[8,9], and *OSHA Methods*[10]. Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)[11] and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*[12]. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon® tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels

- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height, provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local

meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.
- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.
- One-time: only one chance is given to collect a sample without regard to time or conditions.

Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the

sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and costlimitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.

- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.

- Topographic features that affect the dispersion and transport of airborne toxic constituents.

Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.

- Roadways (dirt or paved), which may generate dust that could mask site contaminants.

- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate, especially around major emission sources.

A short-term monitoring program ranges from sev
days to a few weeks and generally includes gathe
data for site assessments, removal actions, and so
determination data (for further modeling). Activ
involved in a short-term sampling strategy must n
the most of the limited possibilities for data collect
Consider moving upwind/downwind locations d
based on National Oceanic and Atmosph
Administration (NOAA) weather forecasts. Wea
monitoring becomes critical where complex ter
and local meteorological effects frequently cha
wind direction. Often, a number of alternatives
fulfill the same objective.

Prevailing winds running the length of a valley usu
require a minimum number of sampler locati
however, a complex valley may require more sam
locations to account for the wide variety of wi
Ocean/lake effects may require a radical plan
collect enough samples to reach a low detection li
Two sets of samplers may be placed next to e
other: one set would be activated during the sea br
while the other set is turned off, and vice versa w
there is no sea breeze. After the sampling event
respective upwind and downwind samples woul
combined. Another alternative for sampling ne
large body of water may be to use automatic, w
vector-operated samplers, which turn the sample
only when the wind comes from a specified ve
At sites located on hillsides, wind will move dov
valley and produce an upward fetch at the same ti
Sampling locations may have to ring the sit
measure the wind's impact.

Off-site sources may affect on-site monitoring. In
case, on-site meteorological data, concurrent
sampling data, is essential to interpreting the acqu
data. Also, additional upwind sampling sites ma
needed to fully characterize ambient backgro
contaminant levels. Multiple off-site sources
require several monitoring locations, but if the sou
are at a sufficient distance, only one monito
location is needed.

Topography and weather are not the only factor
sampler location; the sampling sites must be se
from vandals and mishap. Secure all samp
locations to maintain chain of custody, and to pre
tampering with samples or loss of sampling u
High-volume sampling methods often require the
of 110 VAC electric power. When port

generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to

be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

C Wind Speed

When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

C Wind Direction

Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

C Atmospheric Stability

Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

C Temperature

Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

C Humidity

High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase the detection limit.

C Atmospheric Pressure

Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITYASSURANCE/ QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must

occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

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APPENDIX A

Portable Screening Devices and Specialized Analytical Instruments

PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

C Total Hydrocarbon Analyzers

Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

C Oxygen and Combustible Gas Indicators

Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL).

The measurements are temperature-dependent. The property of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e, O_2 content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

C Toxic Atmosphere Analyzers

The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may be lead to erroneous results.

U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- Aerosol/Particulate Monitors

  A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

  The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- Chemical Detector Tubes (Colorimetric Tubes)

  A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- Radiation Meters

  Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

  Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- Infrared Detectors

  Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.

SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- Direct Air Sampling Portable Gas Chromatographs (GCs)

  Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

  This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

  The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.

APPENDIX B

Air Sampling Equipment and Media/Devices

AIR SAMPLING EQUIPMENT

C High-Volume, Total Suspended Particulate (TSP) Samplers

High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

C PM-10 Samplers

PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon filters.

C High-Volume PS-1 Samplers

High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

C Area Sampling Pumps

These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

C Personal Sampling Pumps

Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.

C Canister Samplers

Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control
device until the canister is near atmospheric pressure.

Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the

inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

C Summa® Canisters

Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

C Passive Dosimeters

Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

C Polyurethane Foam (PUF)

PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

C Sampling Bags (Tedlar®)

Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO_2, O_2, and N_2) and methane.

C Impingers

An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

C Sorbent Tubes/Cartridges

A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are

being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

C Tenax Tubes

Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

C Carbonized Polymers

The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

C Mixed Sorbent Tubes

Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

C Chemically Treated Silica Gel

Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

C XAD-2 Polymers

XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

C Charcoal Cartridges

Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

  Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

  MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

  Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

  Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon

  Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

  Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

  Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.

1.3.4 Surface Water Sampling (USEPA - Environmental Response Team SOPs)

SOP#: 2013
DATE:11/17/94
REV. #: 0.0

Scope and Application: This SOP is applicable to the collection of representative liquid samples, both aqueous and non-aqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, depending on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report. Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: Sampling situations vary widely, therefore, no universal sampling procedure can be recommended. However, sampling of both aqueous and non-aqueous liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- Bacon bomb sampler
- Dip sampler
- Direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

Sample Preservation Containers, Handling, and Storage: Once samples have been collected, the following procedure should be followed:

1. Transfer the sample(s) into suitable, labeled sample containers.
2. Preserve the sample if appropriate, or use pre-preserved sample bottles. Do not overfill bottles if they are pre-preserved.
3. Cap the container, place in a Ziploc plastic bag and cool to $4^{o}C$.
4. Record all pertinent data in the site logbook and on field data sheets.
5. Complete the chain of custody record.
6. Attach custody seals to cooler prior to shipment.
7. Decontaminate all sampling equipment prior to the collection of additional samples with that sampling device.

Interferences and Potential Problems: There are two primary interferences or potential problems with surface water sampling. These include cross contamination of samples and improper sample collection.

1. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Sampling Equipment Decontamination SOP.
2. Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area. Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

Equipment/Apparatus: Equipment needed for collection of surface water samples may include (depending on technique chosen):

- Kemmerer bottles
- Bacon bomb sampler
- Dip sampler
- Line and messengers
- Sample bottles/preservatives
- Ziploc bags
- Ice
- Coolers
- Chain of Custody records, custody seals
- Field data sheets
- Decontamination equipment
- Maps/plot plan
- Safety equipment
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Camera and film
- Logbook/waterproof pen
- Sample bottle labels

Reagents: Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be preserved.

Procedures: *Preparation*:

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
2. Obtain the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry, in accordance with the site specific health and safety plan.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. If required the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If collecting sediment samples, this procedure may disturb the bottom.

Representative Sampling Considerations: In order to collect a representative sample, the hydrology and morphometrics of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons, or impoundments, flow patterns in streams, and appropriate sample locations and depths. Water quality data should be collected in impoundments, and to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist that would affect analytical results. Measurements should be collected at one-meter intervals from the substrate to the surface using the appropriate instrument (i.e., a Hydrolab or equivalent).

Water quality measurements such as dissolved oxygen, pH temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths when surface water samples are collected. Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

1. Will the sample be collected from shore or from a boat?
2. What is the desired depth at which you wish to collect the sample?
3. What is the overall depth and flow direction of river or stream?
4. What type of sample will be collected (i.e., water or lagoon liquids)?

Sampler Composition: The appropriate sampling device must be of a proper composition. Selection of samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be based upon the analyses to be performed.

Sample Collection: *Kemmerer Bottle*: A Kemmerer bottle (Figure 3) may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the sampling end pieces (upper and lower stoppers) are pulled away from the sampling tube (body), allowing the substance to be sampled to pass through this tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.
3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

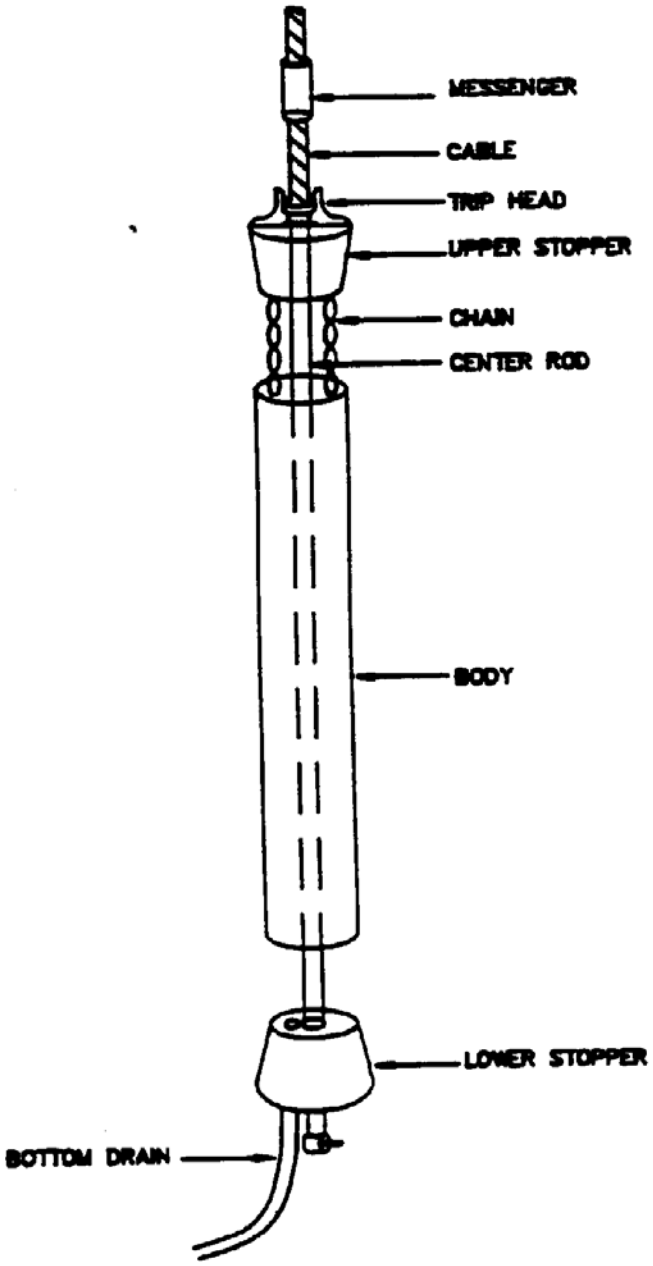


Figure 3. Kemmerer Bottle.

4. Retrieve the sampler and discharge from the bottom drain from the first 10-20 mL to clear any potential contamination of the valve. Transfer the sample to the appropriate sample container.

Bacon Bomb Sampler: A bacon bomb sampler (Figure 4) may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.
2. Release the trigger line and retrieve the sampler.
3. Transfer the sample to the appropriate sample container by pulling up on the trigger.

Dip Sampler: A dip sampler (Figure 5) is useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample by dipping the sampler into the substance.
3. Retrieve the sampler and transfer the sample to the appropriate sample container.

Direct Method: For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface directly into the sample bottle. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern. Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake. When using the direct method, do not use prepreserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

Calculations: This section is not applicable to this SOP.

QA/QC: There are no specific QA activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

Data Validation: This section is not applicable to this SOP.

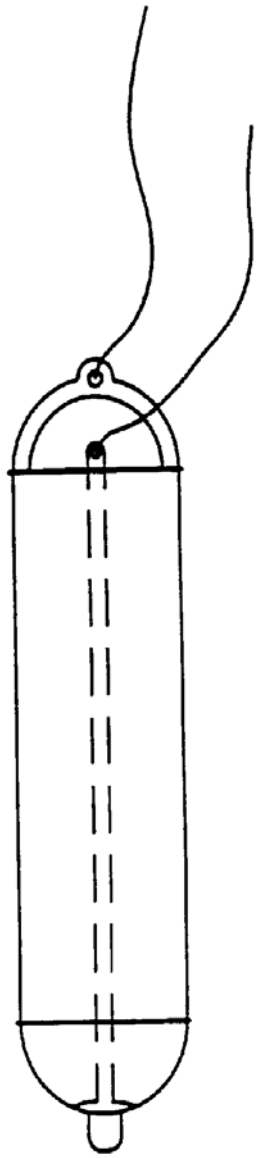


Figure 4. Bacon Bomb Sampler.

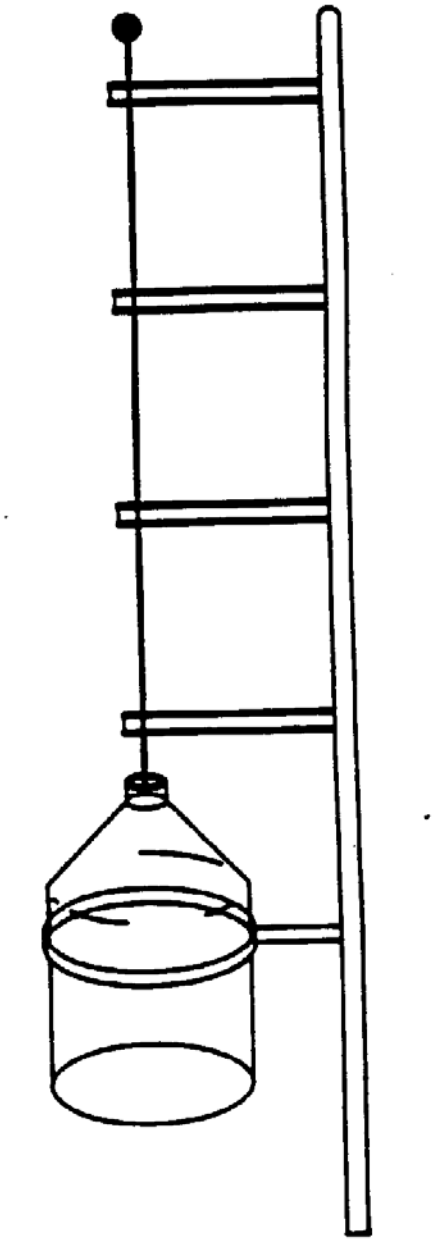


Figure 5. Dip Sampler

Health and Safety: When working with potentially hazardous materials, follow USEPA, OSHA, and corporate health and safety procedures. More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate precautions must be taken to ensure the safety of sampling personnel. The sampling team members collecting the samples should not get too close to the edge of the impoundment, where bank failure may cause them to lose their balance. The persons performing the samplings should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, appropriate boating safety procedures should be followed.

1.3.5 Groundwater Well Sampling (USEPA - Environmental Response Team)
SOP#: 2007
DATE:01/26/95
REV. #: 0.0

Scope and Application: The objective of this SOP is to provide general reference information on sampling of groundwater wells. This guideline is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of groundwater contaminants (e.g., volatile and semivolatile organic compounds, pesticides, metals, biological parameters). These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and reported. Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: In order to obtain a representative groundwater sample for chemical analysis it is important to remove stagnant water in the well casing and the water immediately adjacent to the well before collection of the sample. This may be achieved with one of a number of instruments. The most common of these are the bailer, submersible pump, non-contact gas bladder pump, inertia pump and suction pump. At a minimum, three well volumes should be purged, if possible. Equipment must be decontaminated prior to use and between wells. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments and need not be the same as the device used for purging. Care should be taken when choosing the sampling device as some will affect the integrity of the sample. Sampling should occur in a progression from the least to most contaminated well, if this information is known. The growing concern over the past several years over low levels of volatile organic compounds in water supplies has led to the development of highly sophisticated analytical methods that can provide detection limits at part per trillion levels. While the laboratory methods are extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed, and quality assured as the analytical procedures.

Sample Preservation, Containers, Handling, and Storage: The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering

requirements. Samples should be collected directly from the sampling device into appropriate laboratory cleaned containers. Check that a Teflon liner is present in the cap, if required. Attach a sample identification label. Complete a field data sheet, a chain of custody form, and record all pertinent data in the site logbook. Samples shall be appropriately preserved, labeled, logged, and placed in a cooler to be maintained at 4°C. Samples must be shipped well before the holding time is up and ideally should be shipped within 24 hours of collection. It is imperative that samples be shipped or delivered daily to the analytical laboratory in order to maximize the time available for the laboratory to perform the analyses. The bottles should be shipped with adequate packing and cooling to ensure that they arrive intact.

Sample retrieval systems suitable for the valid collection of volatile organic samples include positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona, 1984; Nielsen, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The focus of concern must remain to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible. Treatment of the sample with sodium thiosulfate preservative is required only if there is residual chlorine in the water that could cause free radical chlorination and change the identity of the original contaminants. It should not be used if there is no chlorine in the water. Holding time for volatiles analysis is seven days. It is imperative that the sample be shipped or delivered daily to the analytical laboratory. The bottles must be shipped on their sides to aid in maintaining the airtight seal during shipment; with adequate packing and cooling to ensure that they arrive intact. For collection of volatile organic samples, refer to the work plan to ensure that 40 mL glass sample vials with Teflon lined septa are ordered and in sufficient numbers. Check sampling supplies: field kit for chlorine, preservatives, parafilm, foam sleeves and coolers. Due to the extreme trace levels at which volatile organics are detectable, cross contamination and introduction of contaminants must be avoided. Trip blanks are incorporated into the shipment package to provide a check against cross contamination.

Interferences and Potential Problems: *General*: The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel.

Purging: In a nonpumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may lack the contaminants representative of the groundwater. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in an unrepresentative sample. To safeguard against collecting nonrepresentative stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. As a general rule, all monitor wells should be pumped or bailed prior to sampling. Purged water should be containerized onsite or handled as specified in the site specific project

plan. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical. However, in all cases where the monitoring data are to be used for enforcement actions, evacuation is recommended.

2. When purging with a pump (not a bailer), the pump should be set at the screened interval, or if the well is an open-rock well, it should be set at the same depth the sample will be collected. When sampling a screened well, the sample should also be collected from the same depth the pump was set at.
3. The well should be sampled as soon as possible after purging.
4. Analytical parameters typically dictate whether the sample should be collected through the purging device, or through a separate sampling instrument.
5. For wells that can be pumped or bailed to dryness with the equipment being used, the well should be evacuated and allowed to recover prior to collecting a sample. If the recovery rate is fairly rapid and time allows, evacuation of more than one volume of water is preferred. If recovery is slow, sample the well upon recovery after one evacuation.
6. A non-representative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

Materials: Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.

Materials of construction (bladders/ pumps, bailers, tubing, etc.) suitable for collecting and handling volatile organic samples should be limited to stainless steel, Teflon, and glass in areas in which detection limit range concentrations are expected. The tendency of organics to leach into and out of many materials, make the selection of materials critical for these trace analyses. The use of plastics should be avoided. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilization of trained personnel.

Advantages/Disadvantages of Certain Equipment:

Bailers:

Advantages	Disadvantages
Only practical limitations on size and materials	Time-consuming to flush a large well of stagnant water

Portable	Transfer of sample may cause aeration
Inexpensive, so it can be dedicated and hung in a well, thereby reducing the chances of cross contamination	Stoppers at the bottom of the bailer usually leak thus the bailer must be brought to the surface rapidly
Minimal outgassing of volatile organics while sample is in bailer	If the bailer is allowed to hit the bottom of the well boring, gravel can displace the ball valve not allowing the bailer to hold water
No power source needed	
Readily available	
Removes stagnant water first	
Rapid, simple method for removing small volumes of purge water	

Submersible Pumps:

Advantages	Disadvantages
Portable and can be transported to several wells	Potential for effects on analysis of trace organics
Depending upon the size of the pump and the pumping depths, relatively high pumping rates are possible	Heavy and cumbersome to deal with, particularly in deeper wells
Generally very reliable and does not require priming	Expensive
	Power source needed
	Sediment in water may cause problems with the pumps
	Impractical in low yielding or shallow wells

Non-Contact Gas Bladder Pumps:

Advantages	Disadvantages
Maintains integrity of sample	Difficulty in cleaning, though dedicated tubing and bladder may be used
Easy to use	Only useful to about 30.5 meters

Can sample from discrete locations within the monitor well	Supply of gas for operation, gas bottles and compressors are often difficult to obtain and are cumbersome
	Relatively low pumping rates
	Requires air compressor or pressurized gas source and control box

Suction Pumps:

Advantages	Disadvantages
Portable, inexpensive, and readily available	Restricted to areas with water levels within
	Vacuum can cause loss of dissolved gasses
	Pump must be primed and vacuum is often pumping approximately 6 to 8 meters of the ground surface and volatile organics difficult to maintain during initial stages of pumping

Inertia Pumps

Advantages	Disadvantages
Portable, inexpensive, and readily available	Restricted to areas with water levels within these manual pumps diameter wells approximately 21 meters of the ground surface
Offers a rapid method for purging relatively shallow wells	May be time consuming to purge wells
	Labor intensive
	WaTerra pumps are only effective in 51 millimeters

Equipment Apparatus: *Equipment Checklist*:

General

- Water level indicator
- Electric sounder
- Steel tape
- Transducer
- Reflection sounder
- Airline
- Depth sounder
- Appropriate keys for well cap locks
- Steel brush

- Hnu or ova (whichever is most appropriate)
- Logbook
- Calculator
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample containers
- Engineer's rule
- Sharp knife (locking blade)
- Tool box (to include at least: screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench)
- Leather work gloves
- Appropriate health and safety gear
- Plastic sheeting
- Shipping containers
- Packing materials
- Bolt cutters
- Ziploc plastic bags
- Containers for evacuation liquids
- Decontamination solutions
- Tap water
- Non phosphate soap
- Several brushes
- Pails or tubs
- Aluminum foil
- Garden sprayer
- Preservatives
- Distilled or deionized water
- Fire extinguisher (if using a generator for your power source)

Bailers

- Clean, decontaminated bailers of appropriate size and construction material
- Nylon line, enough to dedicate to each well
- Teflon-coated bailer wire
- Sharp knife
- Aluminum foil (to wrap clean bailers)
- Five gallon bucket

Submersible Pump

- Pump(s)
- Generator (110, 120, or 240 volt) or 12 volt battery if inaccessible to field vehicle – amp meter is useful
- 25.5 mm black PVC coil tubing - enough to dedicate to each well
- Hose clamps
- Safety cable

- Tool box supplement
- Pipe wrenches
- Wire strippers
- Electrical tape
- Heat shrink
- Hose connectors
- Teflon tape
- Winch, pulley or hoist
- Gasoline for generator/gas can
- Flow meter with gate valve
- 25.5 mm nipples and various plumbing (i.e., pipe connectors)
- Control box (if necessary)

Non-Gas Contact Bladder Pump

- Non-gas contact bladder pump
- Compressor or nitrogen gas tank
- Batteries and charger
- Teflon tubing - enough to dedicate to each well
- Swagelock fitting
- Toolbox supplements - same as submersible pump
- Control box (if necessary)

Suction Pump

- Pump
- 25.5 mm black PVC coil tubing - enough to dedicate to each well
- Gasoline - if required
- Toolbox
- Plumbing fittings
- Flow meter with gate valve

Inertia Pump

- Pump assembly (WaTerra pump, piston pump)
- Five gallon bucket

Reagents: Reagents may be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

Procedure: *Preparation*:

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed (i.e, diameter and depth of wells to be sampled).

2. Obtain necessary sampling and monitoring equipment, appropriate to type of contaminant being investigated. For collection of volatile organic samples, refer to the work plan to ensure that 40 mL glass sample vials with Teflon lined septa are ordered and in sufficient numbers. Check sampling supplies: field kit for chlorine, preservatives, parafilm, foam sleeves, and coolers. Due to extreme trace levels at which volatile organics are detectable, cross contamination and introduction of contaminants must be avoided. Trip blanks are incorporated into the shipment package to provide a check against cross-contamination.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site specific health and safety plan.
6. Identify and mark all sampling locations.

Field Preparation:

1. Start at the least contaminated well, if known.
2. Lay plastic sheeting around the well to minimize likelihood of contamination of equipment from soil adjacent to the well.
3. Remove locking well cap, note location, time of day, and date in field notebook or appropriate log form.
4. Remove well casing cap.
5. Screen headspace of well with an appropriate monitoring instrument to determine the presence of volatile organic compounds and record in site logbook.
6. Lower water level measuring device or equivalent (i.e., permanently installed transducers or airline) into well until water surface is encountered.
7. Measure distance from water surface to reference measuring point on well casing or protective barrier post and record in site logbook. Alternatively, if no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the well head. If floating organics are of concern, this can be determined by measuring the water level with an oil/water interface probe that measures floating organics.
8. Measure total depth of well (at least twice to confirm measurement) and record in site logbook or on field data sheet.
9. Calculate the volume of water in the well and the volume to be purged using the calculations near the end of this SOP.
10. Select the appropriate purging and sampling equipment.
11. If residual chlorine is suspected, use the Hach Field Test Kit for chlorine to determine if there is residual chlorine in the water to be sampled. If there is, treat the sample vial with a crystal of sodium thiosulfate prior to sample collection.

Purging: The amount of flushing a well receives prior to sample collection depends on the intent of the monitoring program and the hydrogeologic conditions. Programs where overall quality determination of water resources are involved may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume can be determined prior to sampling so that the sample is collected after a known volume of the water is

evacuated from the aquifer, or the well can be pumped until the stabilization of parameters such as temperature, electrical conductance, pH, or turbidity has occurred.

However, monitoring to define a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce flow from surrounding areas. Generally, three well volumes are considered effective, or calculations can be made to determine, on the basis of the aquifer parameters and well dimensions, the appropriate volume to remove prior to sampling.

During purging, water level measurements may be taken regularly at 15-30 second intervals. These data may be used to compute aquifer transmissivity and other hydraulic characteristics. The following well evacuation devices are most commonly used. Other evacuation devices are available, but have been omitted in this discussion due to their limited use.

Bailers: Bailers are the simplest purging device used and have many advantages. They generally consist of a rigid length of tube, usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well and retrieve a volume of water. The three most common types of bailer are PVC, Teflon, and stainless steel.

This manual method of purging is best suited to shallow or narrow diameter wells. For deep, larger diameter wells which require evacuation of large volumes of water, other mechanical devices may be more appropriate.

Operation: Equipment needed will include a clean decontaminated bailer, Teflon or nylon line, a sharp knife, and plastic sheeting.

1. Determine the volume of water to be purged as described in the calculations near the end of this SOP.
2. Lay plastic sheeting around the well to prevent contamination of the bailer line with. foreign materials.
3. Attach the line to the bailer and slowly lower until the bailer is completely submerged, being careful not to drop the bailer to the water, causing turbulence and the possible loss of volatile organic contaminants.
4. Pull bailer out ensuring that the line either falls onto a clean area of plastic sheeting or never touches the ground.
5. Empty the bailer into a pail until full to determine the number of bails necessary to achieve the required purge volume.
6. Thereafter, pour the water into a container and dispose of purge waters as specified in the site-specific sampling plan.

Submersible Pumps: The use of submersible pumps for sample collection is permissible provided they are constructed of suitable non-contaminating materials. The chief drawback, however, is the difficulty avoiding cross-contamination between wells. Although some units can be disassembled easily to allow surfaces contacted by contaminants to be cleaned, field decontamination may be difficult and require solvents that can affect sample analysis. The use of submersible pumps in multiple well-sampling programs, therefore, should be carefully

considered against other sampling mechanisms (bailers, bladder pumps). In most cases, a submersible pump, however, may be the only practical sampling device for extremely deep wells (greater than 91 meters of water). Under those conditions, dedicated pump systems should be installed to eliminate the potential for cross-contamination. A sample can be collected by bailer after purging.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas or air. Electric powered pumps can run off a 12 volt DC rechargeable battery, or a 110 or 220 volt AC power supply. Those units powered by compressed air normally use a small electric or gas-powered air compressor. They may also utilize compressed gas (i.e., nitrogen) from bottles. Different size pumps are available for different depth or diameter monitoring wells.

Operation:

1. Determine the volume of water to be purged as described in near the end of this SOP.
2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with foreign materials.
3. Assemble pump, hoses and safety cable, and lower the pump into the well. Make sure the pump is deep enough so all the water is not evacuated. (Running the pump without water may cause damage.)
4. Attach flow meter to the outlet hose to measure the volume of water purged.
5. Use a ground fault circuit interrupter (GFCI) or ground the generator to avoid possible electric shock.
6. Attach power supply, and purge the well until the specified volume of water has been evacuated (or until field parameters, such as temperature, pH, conductivity, etc., have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, lower the pump further into the well, and continue pumping.
7. Collect and dispose of purge waters as specified in the site-specific sampling plan.

Non-Contact Gas Bladder Pumps: For this procedure, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used to provide the least amount of material interference to the sample (Barcelona, 1985). Water comes into contact with the inside of the bladder (Teflon) and the sample tubing (also Teflon) which may be dedicated to each well. Some wells may have permanently installed bladder pumps, (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

Operation:

1. Assemble Teflon tubing, pump, and charged control box.
2. Procedure for purging with a bladder pump is the same as for a submersible pump.
3. Be sure to adjust flow rate to prevent violent jolting of the hose as sample is drawn in.

Suction Pumps: There are many different types of suction pumps. They include: centrifugal, peristaltic, and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses

rollers to squeeze the flexible tubing thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. Peristaltic pumps, however, require a power source.

Operation:

1. Assembly of the pump, tubing, and power source if necessary.
2. Procedure for purging with a suction pump is exactly the same as for a submersible pump.

Inertia Pumps: Inertia pumps such as the WaTerra pump and piston pump, are manually operated. They are most appropriate to use when wells are too deep to bail by hand, or too shallow or narrow (or inaccessible) to warrant an automatic (submersible, etc.) pump. These pumps are made of plastic and may be either decontaminated or discarded.

Operation:

1. Determine the volume of water to be purged as described near the end of this SOP.
2. Lay plastic sheeting around the well to prevent contamination of pumps or hoses with foreign materials.
3. Assemble pump and lower to the appropriate depth in the well.
4. Begin pumping manually, discharging water into a 5 gallon bucket (or other graduated vessel). Purge until specified volume of water has been evacuated (or until field parameters such as temperature, pH, conductivity, etc. have stabilized).
5. Collect and dispose of purge waters as specified in the site specific project plan.

Sampling: Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, purging and sample withdrawal equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power resources, and capable of delivering variable rates for sample collection. There are several factors to take into consideration when choosing a sampling device. Care should be taken when reviewing the advantages or disadvantages of any one device. It may be appropriate to use a different device to sample than that which was used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample.

Bailers: The positive-displacement volatile sampling bailer is perhaps the most appropriate for collection of water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions.

Operation:

1. Surround the monitor well with clean plastic sheeting. If using the GPI bailer, insert a vial into the claim and assemble the unit.
2. Attach a line to a clean decontaminated bailer.
3. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.
4. Allow bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign

materials into the bailer. If using the GPI bailer for collecting volatile organic samples, once at the surface, remove the bailer from and remove the vial. Begin slowly pouring from the bailer, and collect the duplicate the cable. Carefully open the GPI bailer unit samples from the midstream sample.

5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
6. Begin slowly pouring from the bailer.
7. Filter and preserve samples as required by sampling plan.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the well cap.
10. Log all samples in the site logbook and on field data sheets and label all samples.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

Submersible Pumps: Although it is recommended that samples not be collected with a submersible pump for the reasons stated earlier, there are some situations where they may be used.

Operation:

1. Allow the monitor well to recharge after purging, keeping the pump just above screened section.
2. Attach gate valve to hose (if not already fitted), and reduce flow of water to a manageable sampling rate.
3. Assemble the appropriate bottles.
4. If no gate valve is available, run the water down the side of a clean jar and fill the sample bottles from the jar.
5. Cap the sample container tightly and place prelabeled sample container in a carrier.
6. Replace the well cap.
7. Log all samples in the site logbook and on the field data sheets and label all samples.
8. Package samples and complete necessary paperwork.
9. Transport sample to decontamination zone for preparation for transport to the analytical laboratory.
10. Upon completion, remove pump and assembly and fully decontaminate prior to setting into the next sample well. Dedicate the tubing to the hole.

Non-Contact Gas Bladder Pumps: The use of a non-contact gas positive displacement bladder pump is often mandated by the use of dedicated pumps installed in wells. These pumps are also suitable for shallow (less than 30.5 meters) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Barcelona (1984) and Nielsen (1985) report that the non-contact gas positive displacement pumps cause the least amount of alteration in sample integrity as compared to other sample retrieval methods.

Operation:

1. Allow well to recharge after purging.
2. Assemble the appropriate bottles.
3. Turn pump on, increase the cycle time and reduce the pressure to the minimum that will allow the sample to come to the surface.
4. Cap the sample container tightly and place prelabeled sample container in a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.
9. On completion, remove the tubing from the well and either replace the Teflon tubing and bladder with new dedicated tubing and bladder or rigorously decontaminate the existing materials.
10. Nonfiltered samples shall be collected directly from the outlet tubing into the sample bottle.
11. For filtered samples, connect the pump outlet tubing directly to the filter unit. The pump pressure should remain decreased so that the pressure build up on the filter does not blow out the pump bladder or displace the filter. For the Geotech barrel filter, no actual connections are necessary so this is not a concern.

Suction Pumps: In view of the limitations of these type pumps, they are not recommended for sampling purposes.

Inertia Pumps: Inertia pumps may be used to collect samples. It is more common, however, to purge with these pumps and sample with a bailer.

Operation:

1. Following well evacuation, allow the well to recharge.
2. Assemble the appropriate bottles.
3. Since these pumps are manually operated, the flow rate may be regulated by the sampler. The sample may be discharged from the pump outlet directly into the appropriate sample container.
4. Cap the sample container tightly and place prelabeled sample container in a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to the analytical laboratory.
9. Upon completion, remove pump and decontaminate or discard, as appropriate.

Sample Retrieval – Syringe: A limited number of commercial syringe type samplers are available (IEA, TIMCO, etc.) and some are homemade devices. These devices are claimed to provide good quality samples for volatile analysis, but are severely limited in sample volume and are specific to sampling for volatiles. Essentially, they are operated with an evacuated chamber that is lowered down the well, and allowed to fill with the pressure of the water. The entire mechanism is then brought to the surface with the sample. The sample may then be transferred to a sample vial, or the entire unit may be sent as the sample container.

1. Evacuate the syringe if necessary, and lower the sampling device to just below the well screen.
2. Remove the constriction from the device and allow the sample to fill the syringe, apply slight suction as necessary.
3. Bring unit to the surface. If necessary, transfer the sample to vials, as outlined in steps 2 through 7 above.

Filtering: For samples requiring filtering, such as total metals analysis, the filter must be decontaminated prior to and between uses. Filters work by two methods. A barrel filter such as the "Geotech" filter works with a bicycle pump, used to build up positive pressure in the chamber containing the sample which is then forced through the filter paper (minimum size 0.45 μm) into a jar placed underneath. The barrel itself is filled manually from the bailer or directly via the hose of the sampling pump. The pressure must be maintained up 0.0202 kg/mm^2 by periodic pumping.

A vacuum type filter involves two chambers; the upper chamber contains the sample and a filter (minimum size 0.45 μm) divides the chambers. Using a hand pump or a Gilian type pump, air is withdrawn from the lower chamber, creating a vacuum and thus causing the sample to move through the filter into the lower chamber where it is drained into a sample jar. Repeated pumping may be required to drain all the sample into the lower chamber. If preservation of the sample is necessary, this should be done after filtering.

Post Operation: After all samples are collected and preserved, the sampling equipment should be decontaminated prior to sampling another well to prevent cross-contamination of equipment and monitor wells between locations.

1. Decontaminate all equipment.
2. Replace sampling equipment in storage containers.
3. Prepare and transport groundwater samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment.

Special Considerations for Volatile Organic Analysis (VOA) Sampling: The proper collection of a sample for volatile organics requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers, and bailers

(Barcelona, 1984; Nielsen, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The focus of concern must be to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible.

The following procedures should be followed:

1. Open the vial, set cap in a clean place, and collect the sample during the middle of the cycle. When collecting duplicates, collect both samples at the same time.
2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overflow it. There should be a convex meniscus on the top of the vial.
3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap.
4. Invert the vial and tap gently. Observe vial for at least ten seconds. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air is in the sample vial.
5. Immediately place the vial in the protective foam sleeve and place into the cooler, oriented so that it is lying on its side, not straight up.
6. The holding time for VOAs is seven days. Samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4°C, but do not allow them to freeze.

Calculations: If it is necessary to calculate the volume of the well, utilize the following equation:

Well volume $nr^2h(cf)$ [Equation 1]:

n = pi
r = radius of monitoring well (meters)
h = height of the water column (meters) [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf = conversion factor (L/m^3) = 1,000 L/m^3
[In this equation, 1,000 L/m^3 is the necessary conversion factor.]

$v(L/m)\ nr^2(cf)$ [Equation 2]

Monitor well diameters are typically 50.8mm, 76.2mm, 101.6mm, or 152.4mm. Knowing the diameter of the monitor well, there are a number of standard conversion factors which can be used to simplify the equation above.
The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:
n = pi
r = radius of monitoring well (m)
cf = conversion factor (1,000 L/m^3)

For a 50.8mm diameter well, the volume per linear foot can be calculated as follows:
vol/linear meter $nr^2(cf)$ [Equation 3]

3.14 $(0.0254m)^2$ 1,000 L/m^3
2.03 L/m

Remember that if you have a 50.8mm diameter well, you must convert this to the radius in feet to be able to use the equation.

The conversion factors for the common size monitor wells are as follows:

Well diameter (mm)	50.8	76.2	101.6	152.4
Volume (L/m.)	2.027	4.560	8.107	18.24

If you utilize the conversion factors above, the equation should be modified as follows:

Well volume (h)(cf) [Equation 4]

h = height of water column (meters)

cf = the conversion factor calculated from Equation 2

The well volume is typically tripled to determine the volume to be purged.

QA/QC: There are no specific QA activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
3. The collection of rinsate blanks is recommended to evaluate potential for cross contamination from the purging and/or sampling equipment.
4. Trip blanks are required if analytical parameters include VOAs.

Data Validation: This section is not applicable to this SOP.

Health and Safety: When working with potentially hazardous materials, follow U.S. EPA, OSHA or REAC health and safety guidelines. More specifically, depending upon the site specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

When working around volatile organic contaminants:

1. Avoid breathing constituents venting from the well.
2. Pre-survey the well head-space with flame ionization/photoionization prior to sampling.
3. If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling:

1. Lifting injuries associated with pump and bailers retrieval; moving equipment.
2. Use of pocket knives for cutting discharge hose.

3. Heat/cold stress as a result of exposure to extreme temperatures and protective clothing.
4. Slip, trip, and fall conditions as a result of pump discharge.
5. Restricted mobility due to the wearing of protective clothing.
6. Electrical shock associated with use of submersible pumps is possible. Use a GFCI or a copper grounding stake to avoid this problem.

1.3.6 Sediment Sampling (USEPA- Environmental Response Team)
SOP#: 2016
DATE: 11/17/94
REV. #: 0.0

Scope and Application: This SOP is applicable to the collection of representative sediment samples. Sediments may be analyzed for biological, chemical, or physical characteristics to determine the following:

- Toxicity
- Biological availability and effects of contaminants
- Benthic biota
- Extent and magnitude of contamination
- Contaminant migration pathways and source
- Fate of contaminants
- Grain size distribution

The methodologies discussed in this SOP are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by site conditions and equipment limitations. However, if modifications occur, they should be documented in a site or personal logbook and discussed in reports summarizing field activities and analytical results.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static (lakes, ponds, and impoundments) or flowing (rivers and streams).

Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: Sediment samples may be collected using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface vs. subsurface), the type of sample required (disturbed vs. undisturbed), contaminants present, and sediment type.

Sediment is collected from beneath an aqueous layer either directly (using a hand held device such as a shovel, trowel, or auger) or indirectly (using a remotely activated device such as an Ekman or Ponar dredge). Following collection, sediment is transferred from the sampling device to a sample container of appropriate size and construction for the analyses requested. If

composite sampling techniques are employed, multiple grabs are placed into a container constructed of inert material, homogenized, and transferred to sample containers appropriate for the analyses requested. The homogenization procedure should not be used if sample analysis includes volatile organics; in this case, sediment, or multiple grabs of sediment, should be transferred directly from the sample collection device or homogenization container to the sample container.

Sample Preservation, Containers, Handling, and Storage:

1. Chemical preservation of solids is generally not recommended. Cooling to 4°C is usually the best approach, supplemented by the appropriate holding time for the analyses requested.
2. Wide mouth glass containers with Teflon-lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the work plan.
3. If analysis of sediment from a discrete depth or location is desired, sediment is transferred directly from the sampling device to a labeled sample container(s) of appropriate size and construction for the analyses requested. Transfer is accomplished with a stainless steel or plastic lab spoon or equivalent.
4. If composite sampling techniques or multiple grabs are employed, equal portions of sediment from each location are deposited into a stainless steel, plastic, or other appropriate composition (e.g., Teflon) containers. The sediment is homogenized thoroughly to obtain a composite representative of the area sampled. The composite sediment sample is transferred to a labeled container(s) of appropriate size and construction for the analyses requested. Transfer of sediment is accomplished with a stainless steel or plastic lab spoon or equivalent. Samples for volatile organic analysis must be transferred directly from the sample collection device or pooled from multiple areas in the homogenization container prior to mixing. This is done to minimize loss of contaminant due to volatilization during homogenization.
5. All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampling device should remain in this wrapping until it is needed. Each sampling device should be used for only one sample. Disposable sampling devices for sediment are generally impractical due to cost and the large number of sediment samples that may be required. Sampling devices should be cleaned in the field using the decontamination procedure described in the Sampling Equipment Decontamination SOP.

Interferences and Potential Problems: Substrate particle size and organic matter content are a direct consequence of the flow characteristics of a waterbody. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic matter content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic matter content do not typically concentrate pollutants and are generally found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results and should be justified and specified in the Work Plan.

Equipment/Apparatus: Equipment needed for collection of sediment samples may include:

- Maps/plot plan

- Safety equipment
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Camera and film
- Stainless steel, plastic, or other appropriate composition bucket
- 4-oz., 8-oz., and 1 liter, wide mouth jars with Teflon-lined lids
- Ziploc plastic bags
- Logbook
- Sample jar labels
- Chain of custody records, field data sheets
- Cooler(s)
- Ice
- Decontamination supplies/equipment
- Spade or shovel
- Spatula
- Scoop
- Trowel
- Bucket auger
- Tube auger
- Extension rods
- "T" handle
- Sediment coring device (tube, drive head, eggshell check value, nosecone, acetate tube, extension rods, "T" handle)
- Ponar dredge
- Ekman dredge
- Nylon rope or steel cable
- Messenger device

Reagents: Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

Procedures: *Preparation*:

1. Determine the objective(s) and extent of the sampling effort. The sampling methods to be employed, and the types and amounts of equipment and supplies required will be a function of site characteristics and objectives of the study.
2. Obtain the necessary sampling and monitoring equipment.
3. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.
4. Decontaminate or pre-clean equipment, and ensure that it is in working order.
5. Perform a general site survey prior to site entry in accordance with the site specific health and safety plan.
6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, contaminant source, and extent and nature of contamination

should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Sample Collection: Selection of a sampling device is most often contingent upon: (1) the depth of water at the sampling location, and (2) the physical characteristics of the sediment to be sampled. The following procedures may be utilized:

Sampling Surface Sediment with a Trowel or Scoop from Beneath a Shallow Aqueous Layer: For the purpose of this method, surface sediment is considered to range from zero to 152.5 millimeters in depth and a shallow aqueous layer is considered to range from zero to 305 millimeters in depth. Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with tools such as spades, shovels, trowels, and scoops. Although this method can be used to collect both unconsolidated/consolidated sediment, it is limited somewhat by the depth and movement of the aqueous layer. Deep and rapidly flowing water render this method less accurate than others discussed below. However, representative samples can be collected with this procedure in shallow sluggish water provided care is demonstrated by the sample team member. A stainless steel or plastic sampling implement will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials; plating is particularly common with garden trowels.

The following procedure will be used to collect sediment with a scoop, shovel, or trowel:

1. Using a decontaminated sampling implement, remove the desired thickness and volume of sediment from the sampling area.
2. Transfer the sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.
3. Surface water should be decanted from the sample or homogenization container prior to sealing or transfer; care should be taken to retain the fine sediment fraction during this procedure.

Sampling Surface Sediment with a Bucket Auger or Tube Auger from Beneath a Shallow Aqueous Layer: For the purpose of this method, surface sediment is considered to range from zero to 152.5 in depth and a shallow aqueous layer is considered to range from zero to 610 millimeters in depth. Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of bucket auger or tube auger, a series of extensions, and a "T" handle (Figure 6). The use of additional extensions in conjunction with a bucket auger can increase the depth of water from which sediment can be collected from 610 millimeters to three meters or more. However, sample handling and manipulation increases in difficulty with increasing depth of water. The bucket auger or tube auger is driven into the sediment and used to extract a core. The various depths represented by the core are homogenized or a subsample of the core is taken from the appropriate depth.

The following procedure will be used to collect sediment samples with a bucket auger or tube auger:

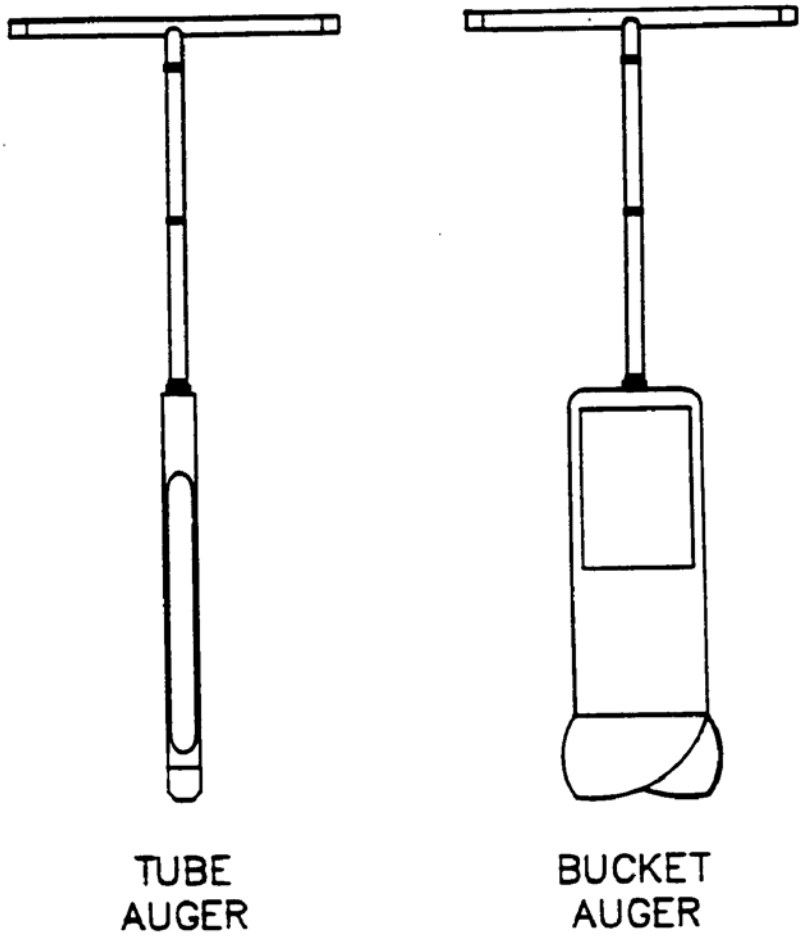


Figure 6. Sampling Augers.

1. An acetate core may be inserted into the bucket auger or tube auger prior to sampling if characteristics of the sediments or waterbody warrant. By using this technique, an intact core can be extracted.
2. Attach the auger head to the required length of extensions, then attach the "T" handle to the upper extension.
3. Clear the area to be sampled of any surface debris.
4. Insert the bucket auger or tube auger into the sediment at a 0 to 20° angle from vertical. This orientation minimizes spillage of the sample from the sampler upon extraction from the sediment and water.
5. Rotate the auger to cut a core of sediment.
6. Slowly withdraw the auger; if using a tube auger, make sure that the slot is facing upward.
7. Transfer the sample or a specified aliquot of sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.

Sampling Deep Sediment with a Bucket Auger or Tube Auger from Beneath a Shallow Aqueous Layer: For the purpose of this method, deep sediment is considered to range from 152.5 to greater than 457 millimeters in depth and a shallow aqueous layer is considered to range from zero to 610 millimeters. Collection of deep sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of a bucket auger, a tube auger, a series of extensions and a "T" handle. The use of additional extensions can increase the depth of water from which sediment can be collected from 610 millimeters to 1.5 meters or more. However, water clarity must be high enough to permit the sampler to directly observe the sampling operation. In addition, sample handling and manipulation increases in difficulty with increasing depth of water. The bucket auger is used to bore a hole to the upper range of the desired sampling depth and then withdrawn. The tube auger is then lowered down the borehole, and driven into the sediment to the lower range of the desired sampling depth. The tube is then withdrawn and the sample recovered from the tube. This method can be used to collect firmly consolidated sediments, but is somewhat limited by the depth of the aqueous layer, and the integrity of the initial borehole.

The following procedure will be used to collect deep sediment samples with a bucket auger and a tube auger:

1. Attach the bucket auger bit to the required lengths of extensions, then attach the "T" handle to the upper extension.
2. Clear the area to be sampled of any surface debris.
3. Begin augering, periodically removing any the auger bucket. Cuttings should be disposed far enough from the sampling area to minimize cross contamination of accumulated sediment (i.e., cuttings) from various depths.
4. After reaching the upper range of the desired depth, slowly and carefully remove bucket auger from the boring.
5. Attach the tube auger bit to the required lengths of extensions, then attach the "T" handle to the upper extension.

6. Carefully lower the tube auger down borehole using care to avoid making contact with the borehole sides and, thus, cross-contaminating the sample. Gradually force the tube auger into sediment to the lower range of the desired sampling depth. Hammering of the tube auger to facilitate coring should be avoided as the vibrations may cause the boring walls to collapse.
7. Remove the tube auger from the borehole, again taking care to avoid contact with the borehole sides and, thus, cross-contaminating the sample.
8. Discard the top of core (approximately 25.5 mm); as this represents material collected by the tube auger before penetration to the layer of concern.
9. Transfer sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.

Sampling Surface Sediment with an Ekman or Ponar Dredge from Beneath a Shallow or Deep Aqueous Layer: For the purpose of this method, surface sediment is considered to range from zero to 152.5 millimeters in depth. Collection of surface sediment can be accomplished with a system consisting of a remotely activated device (dredge) and a deployment system. This technique consists of lowering a sampling device (dredge) to the surface of the sediment by use of a rope, cable, or extended handle. The mechanism is activated, and the device entraps sediment in spring loaded or lever operated jaws. An Ekman dredge is a lightweight sediment sampling device with spring activated jaws. It is used to collect moderately consolidated, fine textured sediment. The following procedure will be used for collecting sediment with an Ekman dredge (Figure 7):

1. Attach a sturdy nylon rope or stainless steel cable through the hole on the top of the bracket, or secure the extension handle to the bracket with machine bolts.
2. Attach springs to both sides of the jaws. Fix the jaws so that they are in open position by placing trip cables over the release studs. Ensure that the hinged doors on the dredge top are free to open.
3. Lower the sampler to a point 102 to 152.5 millimeters above the sediment surface.
4. Drop the sampler to the sediment.
5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extension handle.
6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Care should be taken to retain the fine sediment fraction during this procedure.
7. Open the dredge jaws and transfer the sample into a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment grabs until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenize and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

A Ponar dredge is a heavyweight sediment sampling device with weighted jaws that are lever or spring activated. It is used to collect consolidated fine to coarse textured sediment. The following procedure will be used for collecting sediment with a Ponar dredge (Figure 8):

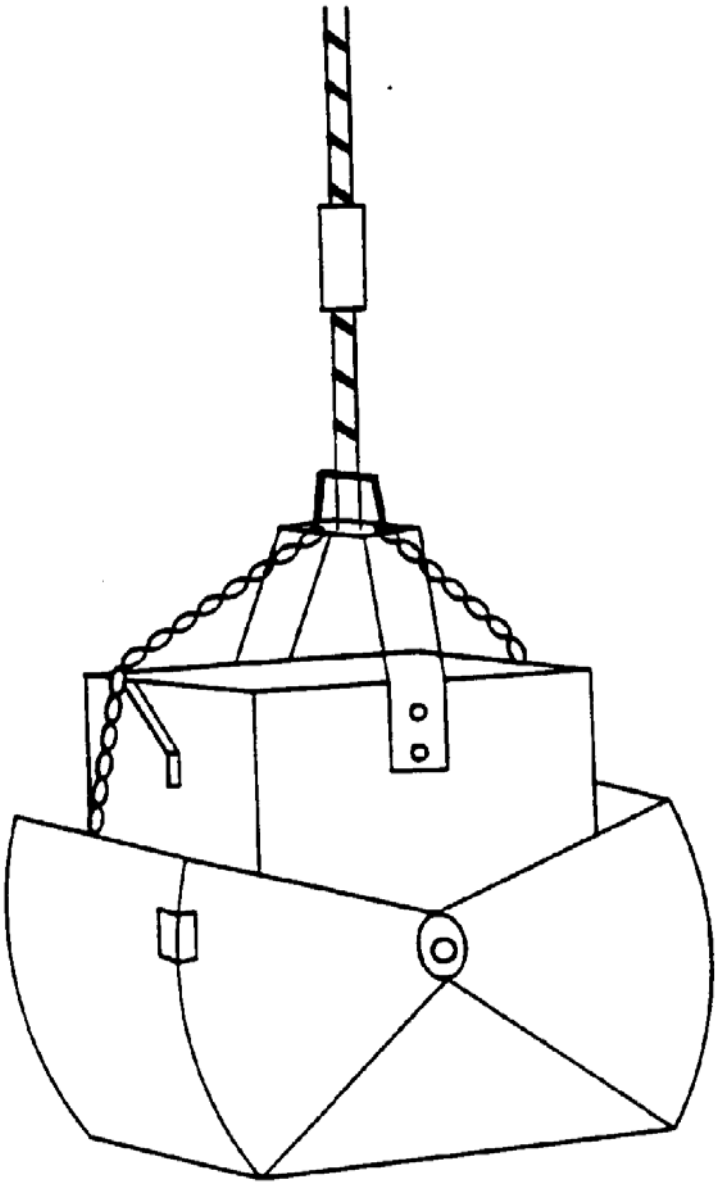


Figure 7. Ekman Dredge.

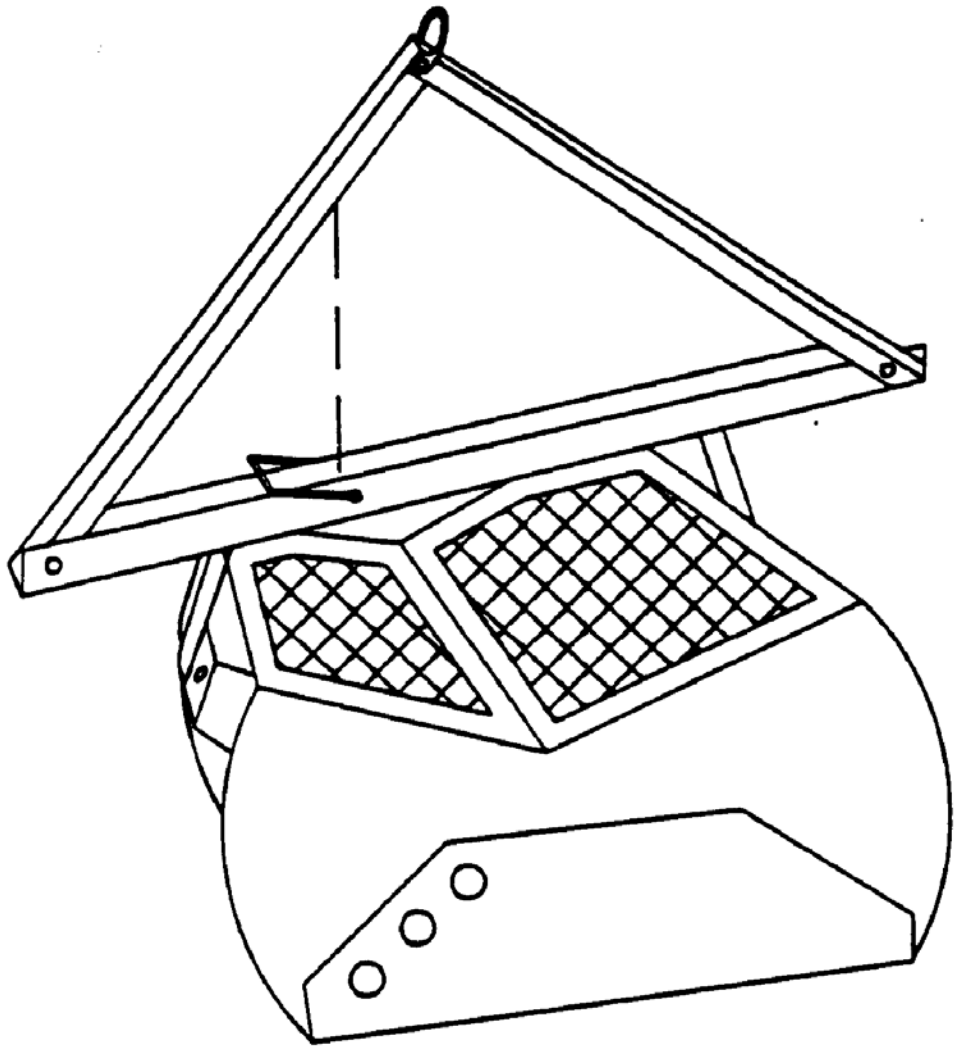


Figure 8. Ponar Dredge.

1. Attach a sturdy nylon rope or steel cable to the ring provided on top of the dredge.
2. Arrange the Ponar dredge with the jaws in the open position, setting the trip bar so the sampler remains open when lifted from the top. If the dredge is so equipped, place the spring loaded pin into the aligned holes in the trip bar.
3. Slowly lower the sampler to a point approximately 51 millimeters above the sediment.
4. Drop the sampler to the sediment. Slack on the line will release the trip bar or spring loaded pin; pull up sharply on the line closing the dredge.
5. Raise the dredge to the surface and slowly decant any free liquid through the screens on top of the dredge. Care should be taken to retain the fine sediment fraction during this operation.
6. Open the dredge and transfer the sediment to a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenized and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

Sampling Subsurface Sediment with a Coring Device from Beneath a Shallow Aqueous Layer: For purposes of this method, subsurface sediment is considered to range from 152.5 to 610 millimeters in depth and a shallow aqueous layer is considered to range from zero to 610 millimeters in depth. Collection of subsurface sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of a tube sampler, acetate tube, eggshell check valve, nosecone, extensions, and "T" handle, or drivehead. The use of additional extensions can increase the depth of water from which sediment can be collected from 610 millimeters to three meters or more. This sampler may be used with either a drive hammer for firm sediment, or a "T" handle for soft sediment. However, sample handling and manipulation increases in difficulty with increasing depth of water.

The following procedure describes the use of a sample coring device (Figure 9) used to collect subsurface sediments.

1. Assemble the coring device by inserting the acetate core into the sampling tube.
2. Insert the "egg shell" check valve into the lower end of the sampling tube with the convex surface positioned inside the acetate core.
3. Screw the nosecone onto the lower end of the sampling tube, securing the acetate tube and eggshell check valve.
4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.
5. Place the sampler in a perpendicular position on the sediment to be sampled.
6. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. After the desired depth is reached, rotate the sampler to shear off the core at the bottom. Slowly withdraw the sampler from the sediment and proceed to Step 15.

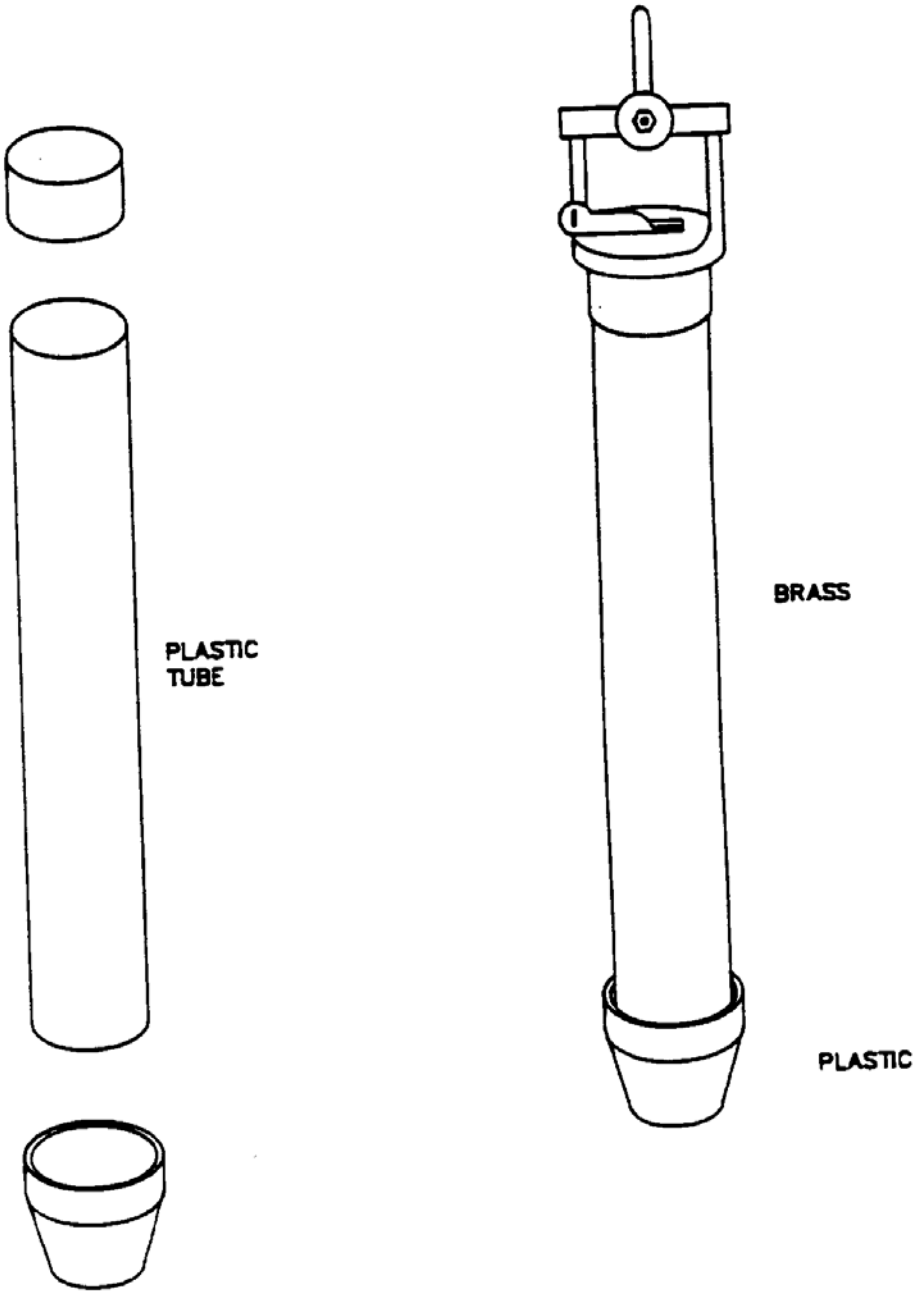


Figure 9. Sample Coring Device.

7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.
8. Drive the sampler into the sediment to the desired depth.
9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.
10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.
11. Rotate the sampler to shear off the core at the bottom.
12. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90°.
13. Slowly withdraw the sampler from the sediment. If the drivehead was used, pull the hammer upwards and dislodge the sampler from the sediment.
14. Carefully remove the coring device from the water.
15. Unscrew the nosecone and remove the eggshell check valve.
16. Slide the acetate core out of the sampler tube. Decant surface water, using care to retain the fine sediment fraction. If head space is present in the upper end, a hacksaw may be used to shear the acetate tube off at the sediment surface. The acetate core may then be capped at both ends. Indicate on the acetate tube the appropriate orientation of the sediment core using a waterproof marker. The sample may be used in this fashion, or the contents transferred to a sample or homogenization container.
17. Open the acetate tube and transfer the sediment to a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenize and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

Calculations: This section is not applicable to this SOP.

QA/QC: There are no specific QA activities that apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

Data Validation: This section is not applicable to this SOP.

Health and Safety: When working with potentially hazardous materials, follow USEPA/OSHA and corporate health and safety procedures.

More specifically, when sampling sediment from waterbodies, physical hazards must be identified and adequate precautions must be taken to ensure the safety of the sampling team. The team member collecting the sample should not get too close to the edge of the waterbody, where bank failure may cause loss of balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is determined to be necessary, appropriate protective measures must be implemented.

1.3.7 Soil Sampling (USEPA- Environmental Response Team)

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Scope and Application: The purpose of this SOP is to describe the procedures for the collection of representative soil samples. Sampling depths are assumed to be those that can be reached without the use of a drill rig, direct-push, or other mechanized equipment (except for a backhoe). Analysis of soil samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, depending on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the actual procedures used should be documented and described in an appropriate site report. Mention of trade names or commercial products does not constitute USEPA endorsement or recommendation for use.

Method Summary: Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, continuous flight auger, a trier, a split-spoon, or, if required, a backhoe.

Sample Preservation, Containers, Handling, and Storage: Chemical preservation of solids is not generally recommended. Samples should, however, be cooled and protected from sunlight to minimize any potential reaction. The amount of sample to be collected and proper sample container type are discussed in ERT/REAC SOP #2003 Rev. 0.0 08/11/94, Sample Storage, Preservation and Handling.

Interferences and Potential Problems: There are two primary potential problems associated with soil sampling - cross contamination of samples and improper sample collection. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

Equipment: Soil sampling equipment includes the following:

- Maps/plot plan
- Safety equipment, as specified in the site-specific health and safety plan
- Survey equipment or global positioning system (GPS) to locate sampling points
- Tape measure
- Survey stakes or flags
- Camera and film
- Stainless steel, plastic, or other appropriate homogenization bucket, bowl or pan
- Appropriate size sample containers
- Ziploc plastic bags
- Logbook
- Labels
- Chain of custody records and custody seals
- Field data sheets and sample labels
- Cooler(s)
- Ice
- Vermiculite
- Decontamination supplies/equipment
- Canvas or plastic sheet
- Spade or shovel
- Spatula
- Scoop
- Plastic or stainless steel spoons
- Trowel(s)
- Continuous flight (screw) auger
- Bucket auger
- Post hole auger
- Extension rods
- T-handle
- Sampling trier
- Thin wall tube sampler
- Split spoons
- Vehimeyer soil sampler outfit
- Tubes
- Points
- Drive head
- Drop hammer
- Puller jack and grip
- Backhoe

Reagents: Reagents are not used for the preservation of soil samples. Decontamination solutions are specified in ERT/REAC SOP #2006 Rev. 0.0 08/11/94, Sampling Equipment Decontamination, and the site specific work plan.

Procedures: *Preparation*:

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site specific health and safety plan.
6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminant, should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations should be utility-cleared by the property owner or the on-scene-coordinator prior to soil sampling; and utility clearance should always be confirmed before beginning work.

Sample Collection:

Surface Soil Samples: Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. Surface material is removed to the required depth and a stainless steel or plastic scoop is then used to collect the sample.

This method can be used in most soil types but is limited to sampling at or near the ground surface. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials should not be used. Plating is particularly common with garden implements such as potting trowels. The following procedure is used to collect surface soil samples:

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.
2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area that came in contact with the spade.
3. If volatile organic analysis is to be performed, transfer the sample directly into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

Sampling at Depth with Augers and Thin Wall Tube Samplers: This system consists of an auger, or a thin-wall tube sampler, a series of extensions, and a "T" handle (Figure 6). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The system is then lowered down the borehole, and driven into the soil to the completion depth. The system is withdrawn and the core is collected from the thin wall tube sampler.

Several types of augers are available; these include: bucket type, continuous flight (screw), and post-hole augers. Bucket type augers are better for direct sample recovery because they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights. The continuous flight augers are satisfactory when a composite of the complete soil column is desired. Post-hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil and cannot be used below a depth of approximately one meter.

The following procedure is used for collecting soil samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.
2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first 76 to 152.5 millimeters of surface soil for an area approximately 152.5 in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the hole. When sampling directly from the auger, collect the sample after the auger is removed from the hole and proceed to Step 10.
5. Remove auger tip from the extension rods and replace with a pre-cleaned thin wall tube sampler. Install the proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 25.5mm), as this possibly represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.
10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or if composite samples are to be collected, place a sample from another sampling interval into the homogenization

container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

Sampling with a Trier: The system consists of a trier and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

The following procedure is used to collect soil samples with a sampling trier:

1. Insert the trier (Figure 10) into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

Sampling at Depth with a Split Spoon (Barrel) Sampler: Split spoon sampling is generally used to collect undisturbed soil cores of 457 or 610 millimeters in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1586-98, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

The following procedures are used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top.
2. Place the sampler in a perpendicular position on the sample material.
3. Using a well ring, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.

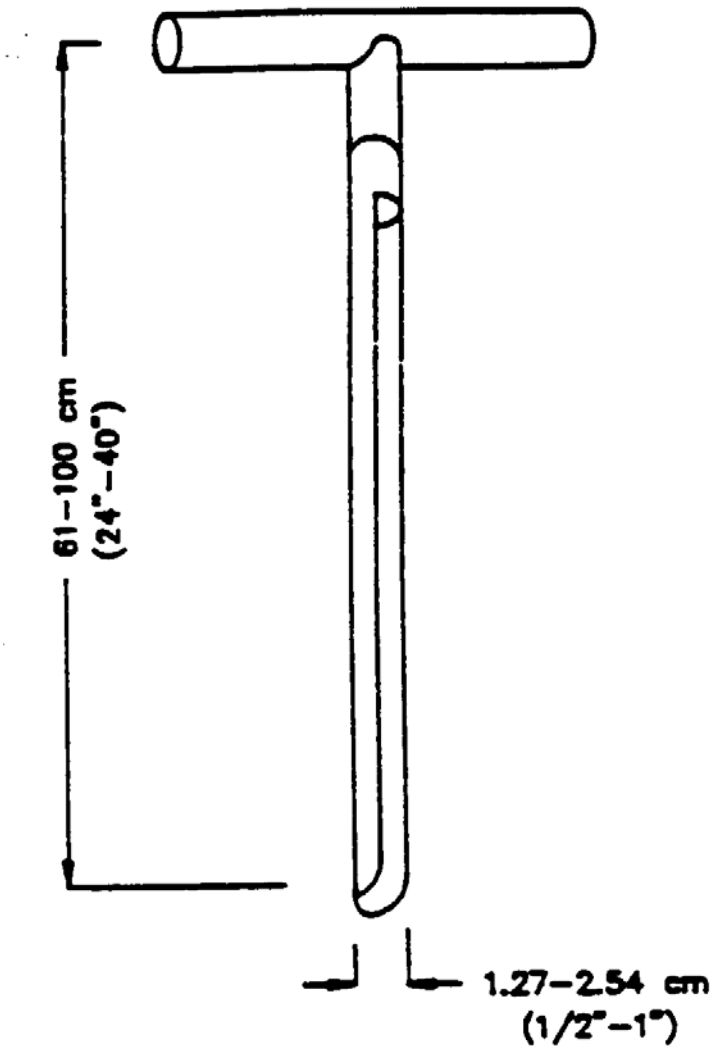


Figure 10. Sampling Trier.

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.
5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 51 and 89 millimeter diameters. A larger barrel may be necessary to obtain the required sample volume.
6. Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly.

Test Pit/Trench Excavation: A backhoe can be used to remove sections of soil, when detailed examination of soil characteristics are required. This is probably the most expensive sampling method because of the relatively high cost of backhoe operation.

The following procedures are used for collecting soil samples from test pits or trenches:

1. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities.
2. Review the site specific health and safety plan and ensure that all safety precautions including appropriate monitoring equipment are installed as required.
3. Using the backhoe, excavate a trench approximately one meter wide and approximately 305 millimeters deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than 1.5 meters deep must be sloped or protected by a shoring system, as required by OSHA regulations.
4. A shovel is used to remove a 25.5 to 51 millimeter layer of soil from the vertical face of the pit where sampling is to be done.
5. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.
6. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
7. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

Calculations: This section is not applicable to this SOP.

QA/QC: There are no specific QA activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

Data Validation: This section is not applicable to this SOP.

Health and Safety: When working with potentially hazardous materials, follow USEPA, OHSA, and corporate health and safety procedures, in addition to the procedures specified in the site specific health and safety plan.

1.3.8 Survey of Environmental Contaminants National Park Service

- Dedicated to improving the health of diverse populations -

1	What park are you reporting on? What is your position at the park? Do you have a WWTP or WTP operation within your park?	 Neither
2	Does your waste go to a municipal waste facility or do you have septic systems or both?	Waste
3	How large a janitorial staff do you have?	
4	Have you converted to “green” products? What products are used?	No
5	Do you have a paint shop? What type of products are used?	No
6	Do you have an autoshop?	No
7	Do you recycle oil or antifreeze?	Neither
8	What is your vehicle fleet size?	
9	Do you use diesel or gas or both? Underground storage tanks? Have the tanks been recently replaced?	Neither No No
10	Do you have a hazardous waste storage area? What types of wastes are stored?	No

11	Have you had a spill, if so what/when/where?	No
12	Do you have a lab? If so what is its primary use? What chemicals do you routinely use. How much waste is generated per year roughly from lab activities?	No
13	Do you have a landfill in close proximity (either historic or currently used)? If so, name the facility.	No
14	Do you have boat operations? If so, estimate the fleet size.	No
15	Do you have marina?	No
16	Does illegal dumping occur within your park? Is one particular area targeted?	No
17	Is there a hazardous waste site within or near your boundaries? If so where and name the site.	No
18	What contaminant threats pose the greatest concern to you from outside the boundaries?	
19	What contaminant threats pose the greatest concern to you from inside the boundaries?	

20	Do you salt your roads, if so what is sand/salt ratio? Is it under cover?	No
21	Are there any historic practices that existed in the park that you would now consider a contaminant problem (i.e., oiling sand roads with used motor oil)?	No
22	Do you fertilize lawns? Do you use pesticides? What types? With what frequency does your use of pesticides need to be supplemented?	No No Infrequently
23	Do you flush wells? If so what is technique?	No
24	Do you use pressure treated wood? Creosote or CCA treated?	No Both
25	Do you do prescribed fires? How many acres per year?	No
26	Have you burned buildings for demolition or training historically? Currently?	No No
27	Do you store batteries for recycling?	No
28	Do you have a photo lab?	No

29	Do you own buildings which are being renovated? (concern associated with Hg, PCB)?	No No
30	Do you have a waste oil furnace?	No
31	Do you ave buildings with asbestos tiles or lead paint?	No
32	Are your pipes covered in asbestos wraps?	No
33	Do you have termites? If so how are they treated?	No
34	Are any of your facilities formerly used Defense Sites?	No
35	Do you know of any unexploded ordnance issues?	No
36	Do you have old transformers?	No
37	How do you deal with refrigerant coolants?	
38	Do you have any incinerators?	No
39	How do you store and dispose of tires?	

Natural Resource Assessment Questions (to establish setting and exposure pathways)		
40	Do you have any T&E species present in your boundaries?	No
41	What do you consider as your most sensitive habitats?	
42	What type of water resources do you have?	
43	What other threats (other than contaminants) exist within your park?	

Please provide a recent copy of your General Management Plan and an old Resource Management Plan (if available).

Submit

Appendix 3: USEPA EMAP Data

Tables

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Table 1. USEPA EMAP Tissue Chemistry Concentration Data (1991 only) for the Virginian Province - James River (USEPA 2006d).

Station		VA91-263				VA91-269			
Sample Type		fish				fish			
Species		Micropogonias undulatus				Micropogonias undulatus			
Composite Organism Count*		1		4		1		4	
Analyte	**Unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Silver	ug/g		0.0042		0.00446		0.00299	0.00382	
Aluminum	ug/g		3.15	5.69			2.24		2.86
Aldrin	ng/g		0.1	0.0558			0.104	0.0583	
Arsenic	ug/g	0.506		0.792		0.232		0.311	
Cadmium	ug/g	0.0021		0.00223		0.0015		0.0191	
alpha-Chlordane	ng/g	0.983		0.915		0.953		0.428	
Chromium	ug/g	0.0189		0.245		0.0165		0.0649	
Copper	ug/g	0.801		2.77		0.275		0.841	
Total DDTs	ng/g	22		10.5		26.1		6.57	
Dieldrin	ng/g	3.07		1.26		1.97		0.642	
Iron	ug/g	2.81		5.91		1.94		4.48	
Heptachlor	ng/g		0.106	0.0892			0.11	0.0583	
Heptachlor epoxide	ng/g		0.117	0.312		0.127		0.214	
Hexachlorobenzene	ng/g		0.111	0.0223		0.0212		0.0194	
Mercury	ug/g	**ND**	**ND**	0.0178		**ND**	**ND**	0.0114	
Lindane	ng/g		0.0676	0.279		0.0847		0.214	
Mirex	ng/g	0.246		0.424		0.169		0.331	
Nickel	ug/g	0.0713		0.0424			0.015	0.021	
2,4'-DDD	ng/g	0.573		0.324		0.148		0.214	
2,4'-DDE	ng/g		0.0614	0.402		0.0424		0.331	
2,4'-DDT	ng/g	0.328		0.335		0.0424		0.136	
Lead	ug/g		0.021		0.0223		0.015	0.021	
2,2',4,5,5'-pentachlorobiphenyl	ng/g	5.59		3.38		2.39		1.61	
2,3,3',4,4'-pentachlorobiphenyl	ng/g	2.33		0.814		0.995		0.467	
2,3',4,4',5-pentachlorobiphenyl	ng/g	6.02		2.8		4.04		0.992	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g	2.62		1.13		1.25		0.506	
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	18.1		7.84		12		4.74	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	29		13.7		22.8		6.71	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g	3.11		2.57		2.52		1.3	
2,2',5-trichlorobiphenyl	ng/g		0.106	0.29		0.296			0.101
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	8.56		6.94		6.56		3.46	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	8.97		4.66		5.08		2.55	
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	1.11		1.1		0.381		0.544	
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g	0.778		1		0.212		0.35	
decachlorobiphenyl	ng/g	1.51		1.03		0.699		0.564	
2,4,4'-trichlorobiphenyl	ng/g		0.0717	0.1		0.233		0.0778	
2,2',3,5'-tetrachlorobiphenyl	ng/g	0.942			0.0268	0.593		0.272	
2,2',5,5'-tetrachlorobiphenyl	ng/g	1.19		0.558		0.635			0.179
2,3',4,4'-tetrachlorobiphenyl	ng/g	1.6		0.469		0.72		0.311	
2,4'-dichlorobiphenyl	ng/g		0.172		0.0937		0.178		0.163
Total PCBs	ng/g	91.4		48.3		61.5		24.5	
Total Chlorinated Pesticides	ng/g	7.04		4.65		5.46		2.57	
4,4'-DDD	ng/g	4.54		1.63		5.59		0.972	
4,4'-DDE	ng/g	16		7.5		20.3		4.71	
4,4'-DDT	ng/g	0.553		0.335		0.0212		0.214	
Selenium	ug/g	0.512		0.558		0.335		0.784	
Tin	ug/g	0.12			0.0446		0.0299		0.0382
trans-Nonachlor	ng/g	2.74		1.29		2.14		0.603	
Zinc	ug/g	4.3		5.76		2.9		5.04	

Table 1. USEPA EMAP Tissue Chemistry Concentration Data (1991 only) for the Virginian Province - James River (USEPA 2006d). (continued)

Station		VA91-273		VA91-275			
Sample Type		fish		fish			
Species		Morone americana		Ictalurus punctatus			
Composite Organism Count*		5		1		4	
Analyte	**Unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Silver	ug/g				0.00398		0.00397
Aluminum	ug/g	4.85	4.85		2.98	5.12	
Aldrin	ng/g			0.0204			0.0938
Arsenic	ug/g	0.156	0.156	0.0537			0.0709
Cadmium	ug/g	0.00385	0.00385	0.00398		0.00199	
alpha-Chlordane	ng/g	2	2	4.34		1.91	
Chromium	ug/g				0.0159	0.0834	
Copper	ug/g	0.312	0.312	0.503		1.95	
Total DDTs	ng/g	22.2	22.2	34.5		16	
Dieldrin	ng/g	1.12	1.12	2.81		1.99	
Iron	ug/g	3.79	3.79	3.94		4.53	
Heptachlor	ng/g				0.106		0.0996
Heptachlor epoxide	ng/g	0.135	0.135	0.387		0.23	
Hexachlorobenzene	ng/g			0.224		0.0766	
Mercury	ug/g	0.0442	0.0442	**ND**	**ND**	0.0139	
Lindane	ng/g	0.308	0.308	0.529		0.517	
Mirex	ng/g	0.289	0.289	0.265		0.46	
Nickel	ug/g				0.0199		0.0199
2,4'-DDD	ng/g	0.385	0.385	0.305		0.249	
2,4'-DDE	ng/g	0.501	0.501	0.224			0.0574
2,4'-DDT	ng/g	1	1	0.285		0.268	
Lead	ug/g				0.0199		0.0199
2,2',4,5,5'-pentachlorobiphenyl	ng/g	8.19	8.19	5.5		3.91	
2,3,3',4,4'-pentachlorobiphenyl	ng/g			1.81		1.91	
2,3',4,4',5-pentachlorobiphenyl	ng/g	5.16	5.16	8.63		5.73	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g	2.14	2.14	2.93		2.03	
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	17.2	17.2	26.9		15.1	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	20.9	20.9	44.9		20.2	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g	5.41	5.41	8.65		4.92	
2,2',5-trichlorobiphenyl	ng/g	0.0771	0.0771	0.427		0.249	
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	10	10	23.3		14	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	7.03	7.03	12.5		6.86	
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	1.37	1.37	1.69		1.78	
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g	1.08	1.08	1.3		1.55	
decachlorobiphenyl	ng/g	1.46	1.46	2.73		2.97	
2,4,4'-trichlorobiphenyl	ng/g	0.27	0.27	0.733		0.498	
2,2',3,5'-tetrachlorobiphenyl	ng/g	0.944	0.944	2.75		1.07	
2,2',5,5'-tetrachlorobiphenyl	ng/g	1.73	1.73	3.01		1.8	
2,3',4,4'-tetrachlorobiphenyl	ng/g	1.19	1.19	1.91		1.26	
2,4'-dichlorobiphenyl	ng/g				0.171		0.161
Total PCBs	ng/g	84.2	84.2	150		85.8	
Total Chlorinated Pesticides	ng/g	6.47	6.47	15.1		8.25	
4,4'-DDD	ng/g	3.54	3.54	6.19		3.64	
4,4'-DDE	ng/g	16.3	16.3	27.3		11.6	
4,4'-DDT	ng/g	0.405	0.405	0.224		0.211	
Selenium	ug/g	0.781	0.781	0.262		0.349	
Tin	ug/g				0.0398		0.0397
trans-Nonachlor	ng/g	2.62	2.62	6.49		3.06	
Zinc	ug/g	5.35	5.35	5.43		5.66	

Table 1. USEPA EMAP Tissue Chemistry Concentration Data (1991 only) for the Virginian Province - James River (USEPA 2006d). (continued)

Station		VA91-278			
Sample Type		fish			
Species		Ictalurus punctatus			
Composite Organism Count*		1		4	
Analyte	**Unit**	Concen.	Det. Limit	Concen.	Det. Limit
Silver	ug/g		0.0039		0.00386
Aluminum	ug/g		2.93	10.4	
Aldrin	ng/g		0.0984		0.0961
Arsenic	ug/g	0.0371			0.0438
Cadmium	ug/g	0.0039		0.00193	
alpha-Chlordane	ng/g	3.17		3.45	
Chromium	ug/g		0.0156		0.0409
Copper	ug/g	1.15		0.241	
Total DDTs	ng/g	25.9		20.7	
Dieldrin	ng/g	2.79		2.39	
Iron	ug/g	3.3		2.64	
Heptachlor	ng/g		0.104		0.102
Heptachlor epoxide	ng/g		0.114	0.255	
Hexachlorobenzene	ng/g	0.763		0.157	
Mercury	ug/g	**ND**	**ND**	0.0193	
Lindane	ng/g		0.0663	0.471	
Mirex	ng/g	0.442		0.471	
Nickel	ug/g	0.0371		0.0193	
2,4'-DDD	ng/g		0.128	0.294	
2,4'-DDE	ng/g		0.0602		0.0588
2,4'-DDT	ng/g	0.462		0.471	
Lead	ug/g	0.0468			0.0193
2,2',4,5,5'-pentachlorobiphenyl	ng/g	5		5.25	
2,3,3',4,4'-pentachlorobiphenyl	ng/g	4.52		2.39	
2,3',4,4',5-pentachlorobiphenyl	ng/g	10.2		8.24	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g	4.3		2.73	
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	28.1		22.2	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	41		30.7	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g	11.2		8.39	
2,2',5-trichlorobiphenyl	ng/g		0.104	0.353	
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	34.1		22.2	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	13.4		10.6	
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	3.39		2.27	
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g	4		2.35	
decachlorobiphenyl	ng/g	4.5		2.06	
2,4,4'-trichlorobiphenyl	ng/g	1.18		0.686	
2,2',3,5'-tetrachlorobiphenyl	ng/g	2.09		1.29	
2,2',5,5'-tetrachlorobiphenyl	ng/g	2.15		2	
2,3',4,4'-tetrachlorobiphenyl	ng/g	1.95		1.65	
2,4'-dichlorobiphenyl	ng/g		0.169		0.165
Total PCBs	ng/g	171		125	
Total Chlorinated Pesticides	ng/g	13.1		12.2	
4,4'-DDD	ng/g	7.17		3.73	
4,4'-DDE	ng/g	17		15.5	
4,4'-DDT	ng/g	1.33		0.706	
Selenium	ug/g	0.398		0.556	
Tin	ug/g		0.039		0.0386
trans-Nonachlor	ng/g	5.92		4.96	
Zinc	ug/g	6.62		6.44	

*A composite consisted of homogenized tissue from three to five individuals of a single species collected at a station. All individuals in a composite were of a similar size, with the smallest individual being no less than 75% the length of the largest.

VA91-263: 36.977 -76.483 Newport News, VA91-289 37.163 -76.629 South of Jamestown, VA91-273: 37.241 -76.955 Claremont, VA91275 37.32 -77.192 Hopewell, VA91-278: 37.379 -77.316 South of Richmond**.**

Table 2. USEPA - EMAP Sediment Analyte Concentration Data (Virginia Province 1990).

		VA90-087		VA90-202		VA90-204	
Analyte	**units**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g	0.93			140		40.2
Acenaphthlylene	ng/g	0.93			143		41.1
Silver	ug/g		1		1		1
Aluminum	ug/g	20600		61900		88700	
Anthracene	ng/g	2.78			121		34.7
Arsenic	ug/g	1.69		***9.27***		***11.3***	
Benz(a)anthracene	ng/g	***92.5***		45.2			32.5
Benzo(a)pyrene	ng/g	42.6			151		43.4
Benzo(e)pyrene	ng/g	85.1			153		43.9
Benzo(b+k)fluoranthene	ng/g	146			145		41.6
Benzo(g,h,i)perylene	ng/g	81.4			220		63.1
Biphenyl	ng/g	0.93			150		43.2
Cadmium	ug/g	0.075		0.42		0.204	
Chrysene	ng/g	68.5		45.2			41.8
Chromium	ug/g	16.6		***54.4***		***76.2***	
Copper	ug/g	3.1		***22.2***		***37.3***	
Dibutyltin	ng/g		5		9		7
Dibenz(a,h)anthracene	ng/g	***34***			170		48.9
2,6-dimethylnaphthalene	ng/g	0.93			156		44.8
Iron	ug/g	8410		34500		49100	
Fluoranthene	ng/g	105			114		32.7
Fluorene	ng/g	0.93			176		50.5
Mercury	ug/g		0.03	0.129		0.119	
Indeno(1,2,3-c,d)pyrene	ng/g	8.33			169		48.5
Monobutyltin	ng/g		10		23		16
1-methylnaphthalene	ng/g		30		150		43.2
2-methylnaphthalene	ng/g	0.93			162		46.4
1-methylphenanthrene	ng/g	9.25			85.9		24.7
Manganese	ug/g	216		457		1240	
Naphthalene	ng/g	11.1		***55.6***			38.6
Nickel	ug/g	7.7		***24***		***36.4***	
Total High Molecular Wt. PAHs	ng/g	***780.93***		212.4		**ND**	**ND**
Total Low Molecular Wt. PAHs	ng/g	60.21		145.9		**ND**	**ND**
Total PAHs	ng/g	841.14		358.3		**ND**	**ND**
Lead	ug/g	7.7		28.3		***41.9***	
Perylene	ng/g	25			189		54.2
Phenanthrene	ng/g	31.5		***90.3***			31.3
Pyrene	ng/g	92.5		122			27.9
Antimony	ug/g	0.009		0.248		0.381	
Selenium	ug/g	0.104		0.579		0.69	
Tin	ug/g	0.668		3.69		3.95	
Tributyltin	ng/g		5		9		7
2,3,5-trimethylnaphthalene	ng/g		29.5		148		42.5
Zinc	ug/g	32.7		***151***		***215***	

VA90-087: 37.00 -76.333 Hampton Roads Rt. 60 Bridge, VA90-202: 36.922 -76.351 Norfolk/Portsmouth Harbor, VA90-204: 37.032 -76.572 Smithfield.

Table 2. USEPA - EMAP Sediment Analyte Concentration Data (Virginia Province 1990). (continued)

		VA90-206		VA90-208		VA90-210	
Analyte	**units**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g		34.2		35.4		31.9
Acenaphthlylene	ng/g		35		36.2		32.6
Silver	ug/g		1		1		1
Aluminum	ug/g	14600		14000		25800	
Anthracene	ng/g		29.5	2.98			27.5
Arsenic	ug/g	1.01		0.636		0.655	
Benz(a)anthracene	ng/g		27.6	30.6		4.29	
Benzo(a)pyrene	ng/g		36.9		38.2		34.4
Benzo(e)pyrene	ng/g		37.3		38.6		34.8
Benzo(b+k)fluoranthene	ng/g		35.3	27.6			33
Benzo(g,h,i)perylene	ng/g		53.6		55.5		50
Biphenyl	ng/g		36.7		38		34.2
Cadmium	ug/g	0.599		0.076		0.072	
Chrysene	ng/g		35.5	20.9		2.58	
Chromium	ug/g	24.4		22		14.5	
Copper	ug/g	5.5		4.8		2.24	
Dibutyltin	ng/g		4		4		4
Dibenz(a,h)anthracene	ng/g		41.6		43		38.8
2,6-dimethylnaphthalene	ng/g		38.1		39.4		35.5
Iron	ug/g	26700		27400		9360	
Fluoranthene	ng/g		27.8	19.4		2.58	
Fluorene	ng/g		42.9		44.4		40
Mercury	ug/g		0.011	***0.211***			0.018
Indeno(1,2,3-c,d)pyrene	ng/g		41.2		42.6		38.4
Monobutyltin	ng/g		10		10		10
1-methylnaphthalene	ng/g		36.7	2.98			34.2
2-methylnaphthalene	ng/g		39.4	6.71			36.8
1-methylphenanthrene	ng/g		21		21.7		19.6
Manganese	ug/g	1110		1180		254	
Naphthalene	ng/g		32.8		34	4.29	
Nickel	ug/g	4.41		4.3		4.78	
Total High Molecular Wt. PAHs	ng/g	**ND**	**ND**	98.5		21.45	
Total Low Molecular Wt. PAHs	ng/g	**ND**	**ND**	27.57		7.72	
Total PAHs	ng/g	**ND**	**ND**	126.07		29.17	
Lead	ug/g	10.6		13		14.6	
Perylene	ng/g		46		47.6		42.9
Phenanthrene	ng/g		26.6	14.9		3.43	
Pyrene	ng/g		23.7		24.5	12	
Antimony	ug/g	0.063		0.06		0.033	
Selenium	ug/g	0.137		0.129		0.289	
Tin	ug/g	0.925		0.348		0.333	
Tributyltin	ng/g		4		4		4
2,3,5-trimethylnaphthalene	ng/g		36.1		37.4		33.7
Zinc	ug/g	61.9		62.6		26.2	

VA90-206: 37.209 -76.798 Jamestown, VA90-208: 37.27 -77.071 Garysville, VA90-210: 37.333 -77.273 Hopewell.

Pink: Concentration is above both the TEL and ERL (SQuiRT)
Blue: Concentration is above the TEL (SQuiRT)

Table 3. COLO Sediment Analyte Concentration Data (Virginia Province 1991).

		VA91-263		VA91-269		VA91-273		VA91-275	
Analyte	**unit**	Concen	Det.Limit	Concen.	Det.Limit	Concen	Det.Limit	Concen.	Det.Limit
Acenaphthene	ng/g	5.61		14.6		*19.2*			9.976
Acenaphthlylene	ng/g	3.66		***9.89***		***12.8***		0.0595	
Silver	ug/g	0.15		0.326		0.419		0.0603	
Aluminum	ug/g	65200		85500		89300		50700	
Aldrin	ng/g		0.25		0.25		0.25		0.25
Anthracene	ng/g	19.3		43.3		***85.3***			9.976
Arsenic	ug/g	*8.82*		*8.69*		***7.95***		*11.6*	
Acid-Volatile-Sulfides	umoles/g	3.28		8.7		1.91		0.0521	
Benz(a)anthracene	ng/g	44.4		34.4		***93.3***			9.976
Benzo(a)pyrene	ng/g	48.3		***123***		88.2			9.976
Benzo(e)pyrene	ng/g	45.4		106		80.6			9.976
Benzo(b+k)fluoranthene	ng/g	105		271		193			9.976
Benzo(g,h,i)perylene	ng/g	41.7		73.6		74.7			9.976
Biphenyl	ng/g	7.23		19.1		30.4			9.976
Cadmium	ug/g	0.169		0.207		0.597		0.149	
Chrysene	ng/g	51.7		53.7		***114***			9.976
alpha-Chlordane	ng/g		0.25		0.25		0.25		0.25
Chromium	ug/g	51.8		***64.7***		***63.4***		*61.8*	
Copper	ug/g	***26.3***		*39*		*45.2*		17.5	
Dibutyltin	ng/g	9.3		5.99			4.994		4.978
Total-DDTs	ng/g	1.659		4.091		4.855		**ND**	**ND**
Dibenz(a,h)anthracene	ng/g	***8.29***		***12.7***		***16.4***			9.976
Dieldrin	ng/g		0.25	0.296		0.438			0.25
2,6-dimethylnaphthalene	ng/g	18.5		39.7		51.7			9.976
Iron	ug/g	34600		45300		46600		32400	

Table 3. COLO Sediment Analyte Concentration Data (Virginia Province 1991) (continued).

Fluoranthene	ng/g	80.1		116		206			9.976
Fluorene	ng/g	13.7		31.8		40.2			9.976
Heptachlor	ng/g		0.25		0.25		0.25		0.25
Heptachlor epoxide	ng/g		0.25		0.25		0.25		0.25
Hexachlorobenzene	ng/g		0.25		0.25		0.25		0.25
Mercury	ug/g	0.0864		0.102		0.147		0.021	
Indeno(1,2,3-c,d)pyrene	ng/g	37.4		75.5		68.6			9.976
Lindane	ng/g		0.25		0.25		0.25		0.25
Monobutyltin	ng/g		11.92	10			11.99		11.95
1-methylnaphthalene	ng/g	11.9		19.2		29			9.976
2-methylnaphthalene	ng/g	22		47.7		62.9			9.976
1-methylphenanthrene	ng/g		9.954	24.8		61.4			9.976
Mirex	ng/g		0.25		0.25		0.25		0.25
Manganese	ug/g	730		740		1560		692	
Naphthalene	ng/g	21.5		26.8		34.9		1.14	
Nickel	ug/g	24.5		33.8		37		25.7	
2,4'-DDD	ng/g		0.25		0.25		0.25		0.25
2,4'-DDE	ng/g		0.25	0.573		0.679			0.25
2,4'-DDT	ng/g	0.286		0.368		0.284			0.25
Total High Molecular Wt. PAHs	ng/g	664.39		1864.9		2358.8		1.04	
Total Low Molecular Wt. PAHs	ng/g	187.4		423.49		660.6		2.92	
Total PAHs	ng/g	851.79		2288.39		3019.4		3.9595	
Lead	ug/g	35.4		50.8		44.9		274	
2,2',4,5,5'-pentachlorobiphenyl	ng/g	0.695		1.23		1.93			0.25
2,3,3',4,4'-pentachlorobiphenyl	ng/g	0.403		0.81		1.23			0.25
2,3',4,4',5-pentachlorobiphenyl	ng/g	0.862		1.37		1.73			0.25
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g		0.25	0.385		0.645			0.25
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	0.937		1.82		2.58			0.25
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	1.15		1.85		2.36			0.25
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g	0.511		0.721		1.02			0.25

Table 3. COLO Sediment Analyte Concentration Data (Virginia Province 1991) (continued).

2,2',5-trichlorobiphenyl	ng/g		0.25		0.25	0.623			0.25
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	0.694		1.31		1.8			0.25
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	0.524		0.84		1.13			0.25
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	0.233		0.338		0.409			0.25
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g		0.25	0.253		0.352			0.25
decachlorobiphenyl	ng/g	0.649		2.32		2.17			0.25
2,4,4'-trichlorobiphenyl	ng/g	0.659		0.848		1.9			0.25
2,2',3,5'-tetrachlorobiphenyl	ng/g		0.25	0.255		0.612			0.25
2,2',5,5'-tetrachlorobiphenyl	ng/g	0.319		0.545		1.02			0.25
2,3',4,4'-tetrachlorobiphenyl	ng/g	0.714		1.36		2.08			0.25
2,4'-dichlorobiphenyl	ng/g	0.531		0.707		1.21			0.25
Total PCBs	ng/g	8.881		16.962		24.801		**ND**	**ND**
Perylene	ng/g	104		821		1170			9.976
Phenanthrene	ng/g	52.4		***125***		***206***		1.72	
4,4'-DDD	ng/g	0.513		1.3		0.812			0.25
4,4'-DDE	ng/g	0.86		1.85		3.08			0.25
4,4'-DDT	ng/g		0.25		0.25		0.25		0.25
Pyrene	ng/g	98.1		***178***		***254***		1.04	
Antimony	ug/g	0.537		0.8		0.775		0.775	
Selenium	ug/g	0.317		0.542		0.821		0.377	
Tin	ug/g	3.44		4.09		4.57		2.36	
Tributyltin	ng/g	49		38.4			4.994		4.978
trans-Nonachlor	ng/g		0.25		0.25		0.25		0.25
2,3,5-trimethylnaphthalene	ng/g	11.6		21.6		26.8			9.976
Zinc	ug/g	***145***		***189***		***189***		73.9	

VA91-263: 36.977 -76.483 Rt. 17 Bridge, VA91-269 37.163 -76.629 Lee Hall, VA91-273 37.241 -76.955 Claremont, VA91-275: 37.32 -77.192 Hopewell.

Table 4. COLO Sediment Analyte Concentration Data (Virginia Province1992)

		VA92-453		VA92-456		VA92-457	
Analyte	**unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g		9.9		9.9		9.8
Acenaphthlylene	ng/g		9.9		9.9		9.8
Silver	ug/g	0.0955		0.129		0.202	
Aluminum	ug/g	42300		61600		43400	
Aldrin	ng/g		0.25		0.25		0.25
Anthracene	ng/g	16.6		29.9		20.6	
Arsenic	ug/g	5.75		*9.54*		*9.96*	
Acid Volatile Sulfides	umoles/g	0.655		0.465		0.614	
Benz(a)anthracene	ng/g	46.8		73.9		58.1	
Benzo(a)pyrene	ng/g	38.2		45		40.1	
Benzo(e)pyrene	ng/g	38.1		44.7		37.7	
Benzo(b+k)fluoranthene	ng/g	95.8		115		101	
Benzo(g,h,i)perylene	ng/g	33.8		45.6		36.1	
Biphenyl	ng/g	67.3		34.4		28.4	
Cadmium	ug/g	0.136		0.184		0.15	
Chrysene	ng/g	55.6		85.2		70.8	
alpha-Chlordane	ng/g		0.25	0.571		0.553	
Chromium	ug/g	30.9		*55.4*		50.3	
Copper	ug/g	12.3		*25*		*23.7*	
Dibutyltin	ng/g		5		5	6.64	
Total DDTs	ng/g	0.819		1.897		1.952	
Dibenz(a,h)anthracene	ng/g	*6.5*		*10.5*			9.8
Dieldrin	ng/g		0.25		0.25		0.25

Table 4. COLO Sediment Analyte Concentration Data (Virginia Province1992) (continued)

2,6-dimethylnaphthalene	ng/g	14.4		70'		56.7	
Iron	ug/g	18700'		37800'		33400'	
Fluoranthene	ng/g	101		133'		103'	
Fluorene	ng/g	15		38'		33.2'	
Heptachlor	ng/g		0.25		0.25		0.25
Heptachlor epoxide	ng/g		0.25		0.25		0.25
Hexachlorobenzene	ng/g		0.25		0.25		0.25
Mercury	ug/g	0.0678'		0.12		0.109	
Indeno(1,2,3-c,d)pyrene	ng/g	37.8		51.4		57.1	
Lindane	ng/g		0.25		0.25		0.25
Monobutyltin	ng/g		12		12'	7	
1-methylnaphthalene	ng/g		9.9	55.9		46.8	
2-methylnaphthalene	ng/g	16		122'		103'	
1-methylphenanthrene	ng/g	19		24.9		15.8	
Mirex	ng/g		0.25		0.25		0.25
Manganese	ug/g	336		769		880'	
Naphthalene	ng/g	25		82.4'		72.4'	
Nickel	ug/g	13.7		24.4'		22.9'	
2,4'-DDD	ng/g		0.25	0.439		0.346	
2,4'-DDE	ng/g		0.25		0.25	0.251	
2,4'-DDT	ng/g		0.25		0.25		0.25
Total High Molecular Wt. PAHs	ng/g	627.2		917.3'		772.9'	
Total Low Molecular Wt. PAHs	ng/g	236.1		623.4'		507.4'	
Total PAHs	ng/g	863.3		1540.7		1280.3	
Lead	ug/g	23.6		33.6'		26.5	
2,2',4,5,5'-pentachlorobiphenyl	ng/g	0.66		1.09		0.965	
2,3,3',4,4'-pentachlorobiphenyl	ng/g		0.25	0.646		0.627	

Table 4. COLO Sediment Analyte Concentration Data (Virginia Province1992) (continued)

2,3',4,4',5-pentachlorobiphenyl	ng/g	0.617		0.868		0.814	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g		0.25		0.25		0.25
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	0.752		1.46		1.47	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	0.788		1.6		1.61	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g		0.25	0.361		0.329	
2,2',5-trichlorobiphenyl	ng/g		0.25		0.25		0.25
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	0.374		0.743		0.768	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	0.27		0.637		0.588	
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g		0.25		0.25		0.25
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g		0.25		0.25		0.25
decachlorobiphenyl	ng/g	0.414		1.26		1.4	
2,4,4'-trichlorobiphenyl	ng/g	0.356		0.48		0.408	
2,2',3,5'-tetrachlorobiphenyl	ng/g		0.25		0.25		0.25
2,2',5,5'-tetrachlorobiphenyl	ng/g	0.388		0.49		0.399	
2,3',4,4'-tetrachlorobiphenyl	ng/g		0.25	0.965		0.979	
2,4'-dichlorobiphenyl	ng/g		0.25	0.565		0.447	
Total PCBs	ng/g	4.619		11.165		10.804	
Perylene	ng/g	63.6		153		144	
Phenanthrene	ng/g	62.8		128		100	
4,4'-DDD	ng/g	0.389		0.559		0.542	
4,4'-DDE	ng/g	0.43		0.899		0.813	
4,4'-DDT	ng/g		0.25		0.25		0.25
Pyrene	ng/g	110		160		125	
Antimony	ug/g	0.372		0.62		0.515	
Selenium	ug/g	0.239		0.4		0.525	
Tin	ug/g	1.37		3.07		2.63	
Tributyltin	ng/g	12.7		13.8		13.2	
trans-Nonachlor	ng/g		0.25		0.25		0.25
2,3,5-trimethylnaphthalene	ng/g		9.9	37.9		30.5	
Zinc	ug/g	72.6		147		162	

VA92-453: 36.927 -76.417 Rt 684 Bridge, VA92-456: 37.057 -76.62 Rushmere (south), VA92-457: 37.087 -76.599 Rushmere (north)

Table 5. USEPA - EMAP Sediment Analyte Concentration Data (Virginia Province 1992).

		VA92-461		VA92-464		VA92-469	
Analyte	**unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g	*49.7*		*12.8*		*36.1*	
Acenaphthlylene	ng/g	*27.3*			10	*19.3*	
Silver	ug/g	0.331		0.135		0.292	
Aluminum	ug/g	83000		41100		55100	
Aldrin	ng/g		0.25		0.25		0.25
Anthracene	ng/g	*98.9*		22		*56.9*	
Arsenic	ug/g	*8.89*		5.32		*7.93*	
Acid Volatile Sulfides	umoles/g	5.8		0.179		2.64	
Benz(a)anthracene	ng/g	*223*		64.6		*152*	
Benzo(a)pyrene	ng/g	*107*		46.1		*106*	
Benzo(e)pyrene	ng/g	52.9		38.8		78.1	
Benzo(b+k)fluoranthene	ng/g	274		97.2		253	
Benzo(g,h,i)perylene	ng/g	96.6		45.5		90	
Biphenyl	ng/g	85.7		16.3		56.8	
Cadmium	ug/g	0.417		0.297		0.408	
Chrysene	ng/g	*277*		69.5		*187*	
alpha-Chlordane	ng/g	0.364			0.25	0.711	
Chromium	ug/g	*69.2*		36.5		*54.8*	
Copper	ug/g	*46.2*		*19.6*		*34.4*	
Dibutyltin	ng/g		5	4			5
Total DDTs	ng/g	4.464		1.774		10.945	
Dibenz(a,h)anthracene	ng/g	*19.5*		*14.3*		*13.5*	
Dieldrin	ng/g	0.644			0.25	0.825	
2,6-dimethylnaphthalene	ng/g	155		29.1		95.4	
Iron	ug/g	49500		28200		35900	
Fluoranthene	ng/g	*354*		96.4		*267*	
Fluorene	ng/g	*92.6*		*21.2*		*66.6*	
Heptachlor	ng/g		0.25		0.25		0.25

Table 5. USEPA - EMAP Sediment Analyte Concentration Data (Virginia Province 1992).

Heptachlor epoxide	ng/g	0.896			0.25	0.29	
Hexachlorobenzene	ng/g		0.25		0.25		0.25
Mercury	ug/g	0.154		0.0741		0.113	
Indeno(1,2,3-c,d)pyrene	ng/g	110		53.3		103	
Lindane	ng/g	0.467			0.25		0.25
Monobutyltin	ng/g		12		12		12
1-methylnaphthalene	ng/g	132		24.7		92	
2-methylnaphthalene	ng/g	310		53.5		205	
1-methylphenanthrene	ng/g	59		19.3		39.8	
Mirex	ng/g		0.25		0.25		0.25
Manganese	ug/g	1320		718		1110	
Naphthalene	ng/g	251		50.2		131	
Nickel	ug/g	38.7		16.4		27	
2,4'-DDD	ng/g	0.964		0.317		0.28	
2,4'-DDE	ng/g		0.25	0.287		0.725	
2,4'-DDT	ng/g		0.25		0.25	1.36	
Total High Molecular Wt. PAHs	ng/g	2463		986.7		1894.6	
Total Low Molecular Wt. PAHs	ng/g	1688.5		348		1093.2	
Total PAHs	ng/g	4151.5		1334.7		2987.8	
Lead	ug/g	47.1		21.9		32.4	
2,2',4,5,5'-pentachlorobiphenyl	ng/g	1.84		0.765		1.19	
2,3,3',4,4'-pentachlorobiphenyl	ng/g	1.21		0.613		1.04	
2,3',4,4',5-pentachlorobiphenyl	ng/g	1.5		0.603		1.27	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g	0.556			0.25		0.25
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	2.81		1.12		2.17	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	2.54		1.07		1.82	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g	0.868		0.372		0.574	
2,2',5-trichlorobiphenyl	ng/g	0.362		0.661		0.289	
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	1.86		0.804		1.31	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	1.2		0.398			0.25
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	0.414			0.25	0.258	
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g	0.386			0.25		0.25
decachlorobiphenyl	ng/g	2.21		0.717		0.725	

Table 5. USEPA - EMAP Sediment Analyte Concentration Data (Virginia Province 1992).

2,4,4'-trichlorobiphenyl	ng/g		0.25	0.899		0.623	
2,2',3,5'-tetrachlorobiphenyl	ng/g	0.511		0.394		0.33	
2,2',5,5'-tetrachlorobiphenyl	ng/g	0.978		0.594		0.571	
2,3',4,4'-tetrachlorobiphenyl	ng/g	2.35		1.03		1.32	
2,4'-dichlorobiphenyl	ng/g	0.906		1.08		0.689	
Total PCBs	ng/g	22.501		11.12		14.179	
Perylene	ng/g	474		334		323	
Phenanthrene	ng/g	362		82.2		252	
4,4'-DDD	ng/g	1.14			0.25	1.48	
4,4'-DDE	ng/g	2.36		1.07		2.3	
4,4'-DDT	ng/g		0.25	0.1		4.8	
Pyrene	ng/g	475		127		322	
Antimony	ug/g	0.983		0.359		1.36	
Selenium	ug/g	0.858		0.436		0.803	
Tin	ug/g	3.64		1.9		3.05	
Tributyltin	ng/g	18.8		17.1			5
trans-Nonachlor	ng/g	0.439		0.489		0.785	
2,3,5-trimethylnaphthalene	ng/g	65.3		16.7		42.3	
Zinc	ug/g	198		94.5		142	

VA92-461: 37.226 -76.895 Claremont, VA92-464: 37.312 -77.106 near Charles City. VA92-469 37.356 -77.271 North Hopewell Tributary.

Table 6. COLO Sediment Analyte Concentration Data (Virginia Province 1993).

		VA93-602		VA93-606		VA93-609	
Analyte	**unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g		9.9		9.9	*18.6*	
Acenaphthlylene	ng/g		9.9		9.9		11
Silver	ug/g	0.283		0.0397		0.221	
Aluminum	ug/g	82000		15100		72500	
Aldrin	ng/g		0.49		0.49		0.49
Anthracene	ng/g	18.9			9.9	43.8	
Arsenic	ug/g	***7.91***		1.78		*9.27*	
Acid Volatile Sulfides	umoles/g	0.742			0.0284	1.23	
Benz(a)anthracene	ng/g	59.3			9.9	***154***	
Benzo(a)pyrene	ng/g	81.1			9.9	198	
Benzo(e)pyrene	ng/g	73.2			9.9	179	
Benzo(b+k)fluoranthene	ng/g	200			9.9	462	
Benzo(g,h,i)perylene	ng/g	51.5			9.9	89.3	
Biphenyl	ng/g		9.9		9.9	22.2	
Cadmium	ug/g		0.099		0.095	0.488	
Chrysene	ng/g	54.1			9.9	***136***	
alpha-Chlordane	ng/g	0.29			0.49	1.45	
Chromium	ug/g	***69.3***		17		***55.6***	
Copper	ug/g	***33.9***		6.81		***33.7***	
Dibutyltin	ng/g		5		5		5
Total DDTs	ng/g	4.6		**ND**	**ND**	3.368	
Dibenz(a,h)anthracene	ng/g		9.9		9.9		11
Dieldrin	ng/g		0.49		0.49		0.49
2,6-dimethylnaphthalene	ng/g	19.1			9.9	40.1	
Endosulfan I	ng/g		0.49		0.49		0.49
Endosulfan II	ng/g		0.25		0.49		0.25
Endosulfan	ng/g		0.49		0.49		0.49
Endrin	ng/g		0.25		0.49	0.708	
Endrin Aldehyde	ng/g		0.49		0.49		0.49
Endrin Ketone	ng/g		0.49		0.49		0.49
Iron	ug/g	46400		20100		42100	
Fluoranthene	ng/g	103			9.9	***207***	
Fluorene	ng/g	13.3			9.9	*31.9*	
Heptachlor	ng/g		0.49		0.49		0.49
Heptachlor epoxide	ng/g	0.848			0.49	0.707	

Table 6. COLO Sediment Analyte Concentration Data (Virginia Province 1993)(continued).

Hexachlorobenzene	ng/g		0.49		0.49		0.49
Mercury	ug/g	*0.18*		0.0199		0.122	
Indeno(1,2,3-c,d)pyrene	ng/g	47.3			9.9	122	
Lindane	ng/g	1.05			0.49		0.49
Monobutyltin	ng/g		12		12		12
1-methylnaphthalene	ng/g	16			9.9	26.8	
2-methylnaphthalene	ng/g	***34.6***			9.9	***62.8***	
1-methylphenanthrene	ng/g	22.8			9.9	47.4	
Mirex	ng/g		0.49		0.49		0.49
Manganese	ug/g	1480		919		1180	
Naphthalene	ng/g	***39.1***			9.9	***43.7***	
Nickel	ug/g	*27.2*			2.4	*22.6*	
2,4'-DDD	ng/g		0.49		0.49		0.25
2,4'-DDE	ng/g		0.49		0.49	0.978	
2,4'-DDT	ng/g		0.49		0.49		0.49
Total·High·Molecular·Wt.·PAHs	ng/g	***1048.5***		**ND**	**ND**	*2388.3*	
Total·Low·Molecular·Wt.·PAHs	ng/g	248.4		**ND**	**ND**	***523.4***	
Total·PAHs	ng/g	1296.9		**ND**	**ND**	***2911.7***	
Lead	ug/g	***43.7***		27.6		***31.6***	
2,2',4,5,5'-pentachlorobiphenyl	ng/g	1.67			0.49	1.41	
2,3,3',4,4'-pentachlorobiphenyl	ng/g	1.22			0.49	1.15	
2,3',4,4',5-pentachlorobiphenyl	ng/g	1.53			0.49	1.12	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g		0.49		0.49		0.25
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	2.32			0.49	2.22	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	2.97			0.49	2.11	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g		0.25		0.49	0.653	
2,2',5-trichlorobiphenyl	ng/g	1.07			0.49	0.541	
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g	1.29			0.49	1.77	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g	0.947			0.49	0.892	

Table 6. COLO Sediment Analyte Concentration Data (Virginia Province 1993)(continued).

2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	4.89			0.49	0.733	
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g		0.49		0.49		0.49
decachlorobiphenyl	ng/g	1.37			0.49	2.22	
2,4,4'-trichlorobiphenyl	ng/g	6.84		1.54		12.2	
2,2',3,5'-tetrachlorobiphenyl	ng/g		0.49		0.49	0.619	
2,2',5,5'-tetrachlorobiphenyl	ng/g	1.11			0.49	0.847	
2,3',4,4'-tetrachlorobiphenyl	ng/g	0.813			0.49	1.07	
2,4'-dichlorobiphenyl	ng/g		0.25		0.49	2.34	
Total PCBs	ng/g	***28.04***		1.54		***31.895***	
Perylene	ng/g	270			9.9	609	
Phenanthrene	ng/g	74.2			9.9	***165***	
4,4'-DDD	ng/g	1.62			0.49	1.58	
4,4'-DDE	ng/g	2.98			0.49	0.81	
4,4'-DDT	ng/g		0.49		0.49		0.49
Pyrene	ng/g	109			9.9	***232***	
Antimony	ug/g	0.774			0.2	0.653	
Selenium	ug/g	0.623			0.3	0.604	
SEM-Cadmium	ug/g	0.594			0.074		0.92
SEM-Copper	ug/g	11		0.833		10.6	
SEM-Nickel	ug/g	5.25		0.468			4.6
SEM-Lead	ug/g	24.5		2.92		15.2	
SEM-Zinc	ug/g	72.8		6.45		63.1	
Tin	ug/g	2.62		1.04		2.87	
Tributyltin	ng/g		5		5		5
trans-Nonachlor	ng/g		0.49		0.49		0.49
2,3,5-trimethylnaphthalene	ng/g	10.4			9.9	21.1	
Zinc	ug/g	***176***		40		***144***	

VA93-602: 37.007 -76.533 Smithfield, VA93-606: 37.201 -76.689 Jamestown south, VA93-609: 37.302 -77.0 Brandon North.

Table 7. COLO Sediment Analyte Concentration Data (Virginia Province 1993)(continued).

		VA93-610		VA93-613		VA93-728	
Analyte	**unit**	Concen.	Det. Limit	Concen.	Det. Limit	Concen.	Det. Limit
Acenaphthene	ng/g	***10.1***			10	***15.8***	
Acenaphthlylene	ng/g		9.7		10		9.9
Silver	ug/g	0.0495		0.0902		0.3	
Aluminum	ug/g	35200		37500		81900	
Aldrin	ng/g		0.5		0.25		0.5
Anthracene	ng/g	10.8			10	43.3	
Arsenic	ug/g		0.99		0.95	4.23	
Acid Volatile Sulfides	umoles/g		0.0873	0.49		1.41	
Benz(a)anthracene	ng/g	43.7		11.4		***154***	
Benzo(a)pyrene	ng/g	57.2			10	201	
Benzo(e)pyrene	ng/g	34.6			10	140	
Benzo(b+k)fluoranthene	ng/g	91.5		12.1		375	
Benzo(g,h,i)perylene	ng/g	21.6			10	81.9	
Biphenyl	ng/g		9.7		10	21.2	
Cadmium	ug/g		0.099		0.095	0.242	
Chrysene	ng/g	34.1		11.8		***140***	
alpha-Chlordane	ng/g		0.5		0.26	0.25	
Chromium	ug/g	25.3		24.1		***64***	
Copper	ug/g	6.53		11.8		*38.7*	
Dibutyltin	ng/g		5	8.83			4.9
Total DDTs	ng/g	**ND**	**ND**	**ND**	**ND**	4.85	
Dibenz(a,h)anthracene	ng/g		9.7		10		9.9
Dieldrin	ng/g		0.5		0.26		0.5
2,6-dimethylnaphthalene	ng/g	10.7			10	36	
Endosulfan I	ng/g		0.5		0.26		0.5
Endosulfan II	ng/g		0.5		0.26		0.25
Endosulfan	ng/g		0.5		0.26		0.5
Endrin	ng/g		0.5		0.26	1.2	
Endrin Aldehyde	ng/g		0.5		0.26		0.5
Endrin Ketone	ng/g		0.5		0.26		0.5
Iron	ug/g	20400		20000		46300	
Fluoranthene	ng/g	52.6		37.3		***213***	
Fluorene	ng/g	10.9			10	*28.6*	
Heptachlor	ng/g		0.5		0.26		0.5
Heptachlor epoxide	ng/g		0.5		0.26	1.06	
Hexachlorobenzene	ng/g		0.5		0.26		0.5

Table 7. COLO Sediment Analyte Concentration Data (Virginia Province 1993)(continued).

Mercury	ug/g	0.0295		0.0506		***0.144***	
Indeno(1,2,3-c,d)pyrene	ng/g	24.8			10	98.6	
Lindane	ng/g		0.5		0.26	0.54	
Monobutyltin	ng/g		12		12		12
1-methylnaphthalene	ng/g		9.7		10	23.5	
2-methylnaphthalene	ng/g	12.7			10	***59.7***	
1-methylphenanthrene	ng/g	11.1			10	38.6	
Mirex	ng/g		0.5		0.26		0.5
Manganese	ug/g	437		482		1360	
Naphthalene	ng/g	15.5			10	***52.4***	
Nickel	ug/g	3.66		6.36		***27.8***	
2,4'-DDD	ng/g		0.5		0.26		0.25
2,4'-DDE	ng/g		0.5		0.26	1.4	
2,4'-DDT	ng/g		0.5		0.26		0.25
Total·High·Molecular·Wt.·PAHs	ng/g	584.7		95.1		***2237.5***	
Total·Low·Molecular·Wt.·PAHs	ng/g	136.2		31.3		***497.7***	
Total·PAHs	ng/g	720.9		126.4		***2735.2***	
Lead	ug/g	21		23.9		***37.8***	
2,2',4,5,5'-pentachlorobiphenyl	ng/g		0.5		0.26	1.71	
2,3,3',4,4'-pentachlorobiphenyl	ng/g		0.5		0.26	1.78	
2,3',4,4',5-pentachlorobiphenyl	ng/g		0.5		0.26	1.27	
2,2',3,3',4,4'-hexachlorobiphenyl	ng/g		0.5		0.26	0.673	
2,2',3,4,4',5'-hexachlorobiphenyl	ng/g	0.72			0.26	2.73	
2,2',4,4',5,5'-hexachlorobiphenyl	ng/g	0.511			0.26	2.44	
2,2',3,3',4,4',5-heptachlorobiphenyl	ng/g		0.5		0.26	0.674	
2,2',5-trichlorobiphenyl	ng/g		0.5	0.259		0.526	
2,2',3,4,4',5,5'-heptachlorobiphenyl	ng/g		0.5		0.26	2.06	
2,2',3,4',5,5',6-heptachlorobiphenyl	ng/g		0.5		0.26	1.37	
2,2',3,3',4,4',5,6-octachlorobiphenyl	ng/g	2.11			0.26		0.5
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl	ng/g		0.5		0.26		0.5
decachlorobiphenyl	ng/g		0.5		0.26	2.33	
2,4,4'-trichlorobiphenyl	ng/g		0.5		0.26	7.3	
2,2',3,5'-tetrachlorobiphenyl	ng/g		0.5		0.26	1.02	
2,2',5,5'-tetrachlorobiphenyl	ng/g	1.26			0.26	1.49	
2,3',4,4'-tetrachlorobiphenyl	ng/g		0.5		0.26	1.67	

Table 7. COLO Sediment Analyte Concentration Data (Virginia Province 1993)(continued).

2,4'-dichlorobiphenyl	ng/g	3.91			0.26	2.87	
Total PCBs	ng/g	8.511		0.259		***31.913***	
Perylene	ng/g	167			10	586	
Phenanthrene	ng/g	54.4		31.3		***160***	
4,4'-DDD	ng/g		0.5		0.26	2.25	
4,4'-DDE	ng/g		0.5		0.26	1.2	
4,4'-DDT	ng/g		0.5		0.26		0.5
Pyrene	ng/g	57.6		22.5		***248***	
Antimony	ug/g		0.2	0.445		0.757	
Selenium	ug/g	0.369		0.301		0.764	
SEM-Cadmium	ug/g		0.23		0.67	0.679	
SEM-Copper	ug/g	1.88		2.98		12.6	
SEM-Nickel	ug/g	2.05			3.4	6.84	
SEM-Lead	ug/g	4.8		7.99		21.4	
SEM-Zinc	ug/g	16.8		22.7		67.9	
Tin	ug/g	1.66		1.61		3.09	
Tributyltin	ng/g		5	9.39			4.9
trans-Nonachlor	ng/g		0.5		0.26		0.5
2,3,5-trimethylnaphthalene	ng/g		9.7		10	18.6	
Zinc	ug/g	49.2		67.7		***166***	

VA93-610: 37.307 -77.25 Hopewell, VA93-613 37.404 -77.394 Near Bellwood, VA93-728: 37.289 -76.992 Jamestown North.

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Tissue					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
1,2,3,4-Tetrachlorobenzene	1995	0		ng/dry g	1.34
1,2,3,4-Tetrachlorobenzene	1997	0.33		ng/dry g	1.34
1,2,3,4-Tetrachlorobenzene	1999	2.118		ng/dry g	1.34
1,2,3,4-Tetrachlorobenzene	2001	0.163		ng/dry g	1.34
1,2,3,4-Tetrachlorobenzene	2003	0		ng/dry g	1.34
1,2,4,5-Tetrachlorobenzene	1995	0.425		ng/dry g	3.55
1,2,4,5-Tetrachlorobenzene	1997	2.38		ng/dry g	3.55
1,2,4,5-Tetrachlorobenzene	1999	3.823		ng/dry g	3.55
1,2,4,5-Tetrachlorobenzene	2001	0		ng/dry g	3.55
1,2,4,5-Tetrachlorobenzene	2003	0		ng/dry g	3.55
1,6,7-Trimethylnaphthalene	1989	0		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	1990	2.758		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	1994	0		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	1995	2.03		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	1997	4.8		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	1999	2.35		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	2001	0.5		ng/dry g	12.63
1,6,7-Trimethylnaphthalene	2003	2.5		ng/dry g	12.63
1-Methylnaphthalene	1989	19.333		ng/dry g	17.85
1-Methylnaphthalene	1990	3.28		ng/dry g	17.85
1-Methylnaphthalene	1994	8.12		ng/dry g	17.85
1-Methylnaphthalene	1995	4.06		ng/dry g	17.85
1-Methylnaphthalene	1997	7.9		ng/dry g	17.85
1-Methylnaphthalene	1999	3.28		ng/dry g	17.85
1-Methylnaphthalene	2001	2.5		ng/dry g	17.85
1-Methylnaphthalene	2003	20.5		ng/dry g	17.85
1-Methylphenanthrene	1989	0		ng/dry g	21.76
1-Methylphenanthrene	1990	5.396		ng/dry g	21.76
1-Methylphenanthrene	1994	0		ng/dry g	21.76
1-Methylphenanthrene	1995	2.7		ng/dry g	21.76
1-Methylphenanthrene	1997	6.7		ng/dry g	21.76
1-Methylphenanthrene	1999	3.83		ng/dry g	21.76
1-Methylphenanthrene	2001	2.3		ng/dry g	21.76
1-Methylphenanthrene	2003	2.9		ng/dry g	21.76
2,4'-DDD	1989	13.333		ng/dry g	7.27
2,4'-DDD	1990	0.591		ng/dry g	7.27
2,4'-DDD	1994	1.34		ng/dry g	7.27
2,4'-DDD	1995	2.885		ng/dry g	7.27
2,4'-DDD	1997	3.62		ng/dry g	7.27
2,4'-DDD	1999	2.01		ng/dry g	7.27
2,4'-DDD	2001	2.77		ng/dry g	7.27
2,4'-DDD	2003	4.825		ng/dry g	7.27

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
2,4'-DDE	1989	0		ng/dry g	3.45
2,4'-DDE	1990	0.237		ng/dry g	3.45
2,4'-DDE	1994	0		ng/dry g	3.45
2,4'-DDE	1995	0.094		ng/dry g	3.45
2,4'-DDE	1997	0.35		ng/dry g	3.45
2,4'-DDE	1999	0		ng/dry g	3.45
2,4'-DDE	2001	0.326		ng/dry g	3.45
2,4'-DDE	2003	0.265		ng/dry g	3.45
2,4'-DDT	1989	0		ng/dry g	3.77
2,4'-DDT	1990	3.133		ng/dry g	3.77
2,4'-DDT	1994	0		ng/dry g	3.77
2,4'-DDT	1995	0.85		ng/dry g	3.77
2,4'-DDT	1997	1.25		ng/dry g	3.77
2,4'-DDT	1999	1.365		ng/dry g	3.77
2,4'-DDT	2001	0.815		ng/dry g	3.77
2,4'-DDT	2003	1.953		ng/dry g	3.77
2,6-Dimethylnaphthalene	1989	0		ng/dry g	15.7
2,6-Dimethylnaphthalene	1990	0		ng/dry g	15.7
2,6-Dimethylnaphthalene	1994	0		ng/dry g	15.7
2,6-Dimethylnaphthalene	1995	5.37		ng/dry g	15.7
2,6-Dimethylnaphthalene	1997	4.8		ng/dry g	15.7
2,6-Dimethylnaphthalene	1999	2.19		ng/dry g	15.7
2,6-Dimethylnaphthalene	2001	2.2		ng/dry g	15.7
2,6-Dimethylnaphthalene	2003	13		ng/dry g	15.7
2-Methylnaphthalene	1989	31.333		ng/dry g	32.4
2-Methylnaphthalene	1990	6.501		ng/dry g	32.4
2-Methylnaphthalene	1994	11.74		ng/dry g	32.4
2-Methylnaphthalene	1995	8.4		ng/dry g	32.4
2-Methylnaphthalene	1997	9.4		ng/dry g	32.4
2-Methylnaphthalene	1999	4.92		ng/dry g	32.4
2-Methylnaphthalene	2001	4.1		ng/dry g	32.4
2-Methylnaphthalene	2003	44		ng/dry g	32.4
4,4'-DDD	1989	23.333		ng/dry g	21.4
4,4'-DDD	1990	12.313		ng/dry g	21.4
4,4'-DDD	1994	2.68		ng/dry g	21.4
4,4'-DDD	1995	6.378		ng/dry g	21.4
4,4'-DDD	1997	5.32		ng/dry g	21.4
4,4'-DDD	1999	3.644		ng/dry g	21.4
4,4'-DDD	2001	2.281		ng/dry g	21.4
4,4'-DDD	2003	2.747		ng/dry g	21.4

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
4,4'-DDE	1989	29.667		ng/dry g	52.48
4,4'-DDE	1990	41.127		ng/dry g	52.48
4,4'-DDE	1994	14.09		ng/dry g	52.48
4,4'-DDE	1995	17.198		ng/dry g	52.48
4,4'-DDE	1997	17.23		ng/dry g	52.48
4,4'-DDE	1999	15.731		ng/dry g	52.48
4,4'-DDE	2001	8.147		ng/dry g	52.48
4,4'-DDE	2003	14.955		ng/dry g	52.48
4,4'-DDT	1989	5		ng/dry g	4.87
4,4'-DDT	1990	0		ng/dry g	4.87
4,4'-DDT	1994	0		ng/dry g	4.87
4,4'-DDT	1995	0		ng/dry g	4.87
4,4'-DDT	1997	0.98		ng/dry g	4.87
4,4'-DDT	1999	0.669		ng/dry g	4.87
4,4'-DDT	2001	0.163		ng/dry g	4.87
4,4'-DDT	2003	0.227		ng/dry g	4.87
Acenaphthene	1989	0		ng/dry g	11.5
Acenaphthene	1990	3.781		ng/dry g	11.5
Acenaphthene	1994	0		ng/dry g	11.5
Acenaphthene	1995	3.21		ng/dry g	11.5
Acenaphthene	1997	3.8		ng/dry g	11.5
Acenaphthene	1999	4.28		ng/dry g	11.5
Acenaphthene	2001	1.4		ng/dry g	11.5
Acenaphthene	2003	11.1		ng/dry g	11.5
Acenaphthylene	1989	4		ng/dry g	9.5
Acenaphthylene	1990	5.072		ng/dry g	9.5
Acenaphthylene	1994	0		ng/dry g	9.5
Acenaphthylene	1995	2.65		ng/dry g	9.5
Acenaphthylene	1997	6		ng/dry g	9.5
Acenaphthylene	1999	2.88		ng/dry g	9.5
Acenaphthylene	2001	0.9		ng/dry g	9.5
Acenaphthylene	2003	6.1		ng/dry g	9.5
Aldrin	1989	0		ng/dry g	0.69
Aldrin	1990	0		ng/dry g	0.69
Aldrin	1994	0		ng/dry g	0.69
Aldrin	1995	0		ng/dry g	0.69
Aldrin	1997	0		ng/dry g	0.69
Aldrin	1999	0.754		ng/dry g	0.69
Aldrin	2001	0		ng/dry g	0.69
Aldrin	2003	0		ng/dry g	0.69

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Alpha-Chlordane	1989	15		ng/dry g	11.45
Alpha-Chlordane	1990	8.623		ng/dry g	11.45
Alpha-Chlordane	1994	2.33		ng/dry g	11.45
Alpha-Chlordane	1995	0		ng/dry g	11.45
Alpha-Chlordane	1997	3.62		ng/dry g	11.45
Alpha-Chlordane	1999	4.426		ng/dry g	11.45
Alpha-Chlordane	2001	1.466		ng/dry g	11.45
Alpha-Chlordane	2003	1.701		ng/dry g	11.45
Alpha-Hexachlorocyclohexane	1995	0.886		ng/dry g	1.43
Alpha-Hexachlorocyclohexane	1997	0		ng/dry g	1.43
Alpha-Hexachlorocyclohexane	1999	1.775		ng/dry g	1.43
Alpha-Hexachlorocyclohexane	2001	0		ng/dry g	1.43
Alpha-Hexachlorocyclohexane	2003	0		ng/dry g	1.43
Aluminum	1989	403.333		µg/dry g	763
Aluminum	1990	250		µg/dry g	763
Aluminum	1994	940		µg/dry g	763
Aluminum	1995	201.069		µg/dry g	763
Aluminum	1997	496		µg/dry g	763
Aluminum	1999	195		µg/dry g	763
Aluminum	2001	319		µg/dry g	763
Aluminum	2003	34.7		µg/dry g	763
Anthracene	1989	0		ng/dry g	22.22
Anthracene	1990	11.861		ng/dry g	22.22
Anthracene	1994	5.53		ng/dry g	22.22
Anthracene	1995	5.22		ng/dry g	22.22
Anthracene	1997	15.1		ng/dry g	22.22
Anthracene	1999	6.87		ng/dry g	22.22
Anthracene	2001	1.6		ng/dry g	22.22
Anthracene	2003	9.3		ng/dry g	22.22
Antimony	1990	0.007		µg/dry g	0.06
Antimony	1994	0.01		µg/dry g	0.06
Arsenic	1989	5.633		µg/dry g	15.5
Arsenic	1990	6.02		µg/dry g	15.5
Arsenic	1994	5.68		µg/dry g	15.5
Arsenic	1995	4.958		µg/dry g	15.5
Arsenic	1997	7.4		µg/dry g	15.5
Arsenic	1999	4.48		µg/dry g	15.5
Arsenic	2001	4.49		µg/dry g	15.5
Arsenic	2003	4.47		µg/dry g	15.5

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Benz[a]anthracene	1989	0		ng/dry g	46
Benz[a]anthracene	1990	12.447		ng/dry g	46
Benz[a]anthracene	1994	8.37		ng/dry g	46
Benz[a]anthracene	1995	5.74		ng/dry g	46
Benz[a]anthracene	1997	13.9		ng/dry g	46
Benz[a]anthracene	1999	4.05		ng/dry g	46
Benz[a]anthracene	2001	2.1		ng/dry g	46
Benz[a]anthracene	2003	4		ng/dry g	46
Benzo[a]pyrene	1989	0		ng/dry g	15.3
Benzo[a]pyrene	1990	0		ng/dry g	15.3
Benzo[a]pyrene	1994	0		ng/dry g	15.3
Benzo[a]pyrene	1995	1.03		ng/dry g	15.3
Benzo[a]pyrene	1997	5.2		ng/dry g	15.3
Benzo[a]pyrene	1999	0.95		ng/dry g	15.3
Benzo[a]pyrene	2001	0		ng/dry g	15.3
Benzo[a]pyrene	2003	0		ng/dry g	15.3
Benzo[b]fluoranthene	1989	0		ng/dry g	51.67
Benzo[b]fluoranthene	1990	21.907		ng/dry g	51.67
Benzo[b]fluoranthene	1994	8.42		ng/dry g	51.67
Benzo[b]fluoranthene	1995	6.19		ng/dry g	51.67
Benzo[b]fluoranthene	1997	14.2		ng/dry g	51.67
Benzo[b]fluoranthene	1999	4.76		ng/dry g	51.67
Benzo[b]fluoranthene	2001	7.4		ng/dry g	51.67
Benzo[b]fluoranthene	2003	6.8		ng/dry g	51.67
Benzo[e]pyrene	1989	0		ng/dry g	48
Benzo[e]pyrene	1990	24.383		ng/dry g	48
Benzo[e]pyrene	1994	5.08		ng/dry g	48
Benzo[e]pyrene	1995	5.22		ng/dry g	48
Benzo[e]pyrene	1997	12.7		ng/dry g	48
Benzo[e]pyrene	1999	3.31		ng/dry g	48
Benzo[e]pyrene	2001	8.7		ng/dry g	48
Benzo[e]pyrene	2003	7.7		ng/dry g	48
Benzo[g,h,i]perylene	1989	0		ng/dry g	14
Benzo[g,h,i]perylene	1990	0		ng/dry g	14
Benzo[g,h,i]perylene	1994	2.66		ng/dry g	14
Benzo[g,h,i]perylene	1995	1.37		ng/dry g	14
Benzo[g,h,i]perylene	1997	4.6		ng/dry g	14
Benzo[g,h,i]perylene	1999	0.92		ng/dry g	14
Benzo[g,h,i]perylene	2001	0.9		ng/dry g	14
Benzo[g,h,i]perylene	2003	0		ng/dry g	14
Benzo[k]fluoranthene	1989	0		ng/dry g	25.9
Benzo[k]fluoranthene	1990	8.856		ng/dry g	25.9
Benzo[k]fluoranthene	1994	1.85		ng/dry g	25.9
Benzo[k]fluoranthene	1995	1.57		ng/dry g	25.9
Benzo[k]fluoranthene	1997	4		ng/dry g	25.9
Benzo[k]fluoranthene	1999	1.06		ng/dry g	25.9
Benzo[k]fluoranthene	2001	4.8		ng/dry g	25.9
Benzo[k]fluoranthene	2003	4.9		ng/dry g	25.9

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Beta-Hexachlorocyclohexane	1995	0		ng/dry g	0.99
Beta-Hexachlorocyclohexane	1997	0.26		ng/dry g	0.99
Beta-Hexachlorocyclohexane	1999	0.958		ng/dry g	0.99
Beta-Hexachlorocyclohexane	2001	0		ng/dry g	0.99
Beta-Hexachlorocyclohexane	2003	0		ng/dry g	0.99
Biphenyl	1989	4		ng/dry g	10.7
Biphenyl	1990	5.088		ng/dry g	10.7
Biphenyl	1994	0		ng/dry g	10.7
Biphenyl	1995	3.55		ng/dry g	10.7
Biphenyl	1997	6.4		ng/dry g	10.7
Biphenyl	1999	1.74		ng/dry g	10.7
Biphenyl	2001	3.3		ng/dry g	10.7
Biphenyl	2003	8.2		ng/dry g	10.7
C1-Chrysenes	1994	0		ng/dry g	40.7
C1-Chrysenes	1995	12.65		ng/dry g	40.7
C1-Chrysenes	1997	14.5		ng/dry g	40.7
C1-Chrysenes	1999	2.47		ng/dry g	40.7
C1-Chrysenes	2001	0		ng/dry g	40.7
C1-Chrysenes	2003	0		ng/dry g	40.7
C1-Dibenzothiophenes	1994	0		ng/dry g	19.4
C1-Dibenzothiophenes	1995	0		ng/dry g	19.4
C1-Dibenzothiophenes	1997	9.6		ng/dry g	19.4
C1-Dibenzothiophenes	1999	3		ng/dry g	19.4
C1-Dibenzothiophenes	2001	1.9		ng/dry g	19.4
C1-Dibenzothiophenes	2003	0		ng/dry g	19.4
C1-Fluoranthenes/Pyrenes	1994	29.32		ng/dry g	106.8
C1-Fluoranthenes/Pyrenes	1995	25		ng/dry g	106.8
C1-Fluoranthenes/Pyrenes	1997	34		ng/dry g	106.8
C1-Fluoranthenes/Pyrenes	1999	7.89		ng/dry g	106.8
C1-Fluoranthenes/Pyrenes	2001	5		ng/dry g	106.8
C1-Fluoranthenes/Pyrenes	2003	9.6		ng/dry g	106.8
C1-Fluorenes	1994	0		ng/dry g	24.17
C1-Fluorenes	1995	0		ng/dry g	24.17
C1-Fluorenes	1997	9		ng/dry g	24.17
C1-Fluorenes	1999	3.93		ng/dry g	24.17
C1-Fluorenes	2001	0		ng/dry g	24.17
C1-Fluorenes	2003	0		ng/dry g	24.17
C1-Naphthalenes	1994	14.9		ng/dry g	38.6
C1-Naphthalenes	1995	12.46		ng/dry g	38.6
C1-Naphthalenes	1997	17.3		ng/dry g	38.6
C1-Naphthalenes	1999	8.2		ng/dry g	38.6
C1-Naphthalenes	2001	4.5		ng/dry g	38.6
C1-Naphthalenes	2003	29.3		ng/dry g	38.6

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
C1-Phenanthrenes/Anthracenes	1994	26.69		ng/dry g	84.02
C1-Phenanthrenes/Anthracenes	1995	33.56		ng/dry g	84.02
C1-Phenanthrenes/Anthracenes	1997	19.6		ng/dry g	84.02
C1-Phenanthrenes/Anthracenes	1999	7.47		ng/dry g	84.02
C1-Phenanthrenes/Anthracenes	2001	7.6		ng/dry g	84.02
C1-Phenanthrenes/Anthracenes	2003	12.1		ng/dry g	84.02
C2-Chrysenes	1994	0		ng/dry g	32.3
C2-Chrysenes	1995	9.56		ng/dry g	32.3
C2-Chrysenes	1997	13.1		ng/dry g	32.3
C2-Chrysenes	1999	1.36		ng/dry g	32.3
C2-Chrysenes	2001	0		ng/dry g	32.3
C2-Chrysenes	2003	0		ng/dry g	32.3
C2-Dibenzothiophenes	1994	0		ng/dry g	55.82
C2-Dibenzothiophenes	1995	17.77		ng/dry g	55.82
C2-Dibenzothiophenes	1997	19		ng/dry g	55.82
C2-Dibenzothiophenes	1999	5.38		ng/dry g	55.82
C2-Dibenzothiophenes	2001	0		ng/dry g	55.82
C2-Dibenzothiophenes	2003	0		ng/dry g	55.82
C2-Fluoranthenes/Pyrenes	2003	0		ng/dry g	55.8
C2-Fluorenes	1994	0		ng/dry g	66.5
C2-Fluorenes	1995	0		ng/dry g	66.5
C2-Fluorenes	1997	21.8		ng/dry g	66.5
C2-Fluorenes	1999	3.9		ng/dry g	66.5
C2-Fluorenes	2001	0		ng/dry g	66.5
C2-Fluorenes	2003	0		ng/dry g	66.5
C2-Naphthalenes	1994	0		ng/dry g	39.3
C2-Naphthalenes	1995	13.64		ng/dry g	39.3
C2-Naphthalenes	1997	36.9		ng/dry g	39.3
C2-Naphthalenes	1999	5.29		ng/dry g	39.3
C2-Naphthalenes	2001	4.9		ng/dry g	39.3
C2-Naphthalenes	2003	33.7		ng/dry g	39.3
C2-Phenanthrenes/Anthracenes	1994	0		ng/dry g	135
C2-Phenanthrenes/Anthracenes	1995	47.61		ng/dry g	135
C2-Phenanthrenes/Anthracenes	1997	30.9		ng/dry g	135
C2-Phenanthrenes/Anthracenes	1999	9.88		ng/dry g	135
C2-Phenanthrenes/Anthracenes	2001	8.5		ng/dry g	135
C2-Phenanthrenes/Anthracenes	2003	9.8		ng/dry g	135
C3-Chrysenes	1994	0		ng/dry g	0.92
C3-Chrysenes	1995	0		ng/dry g	0.92
C3-Chrysenes	1997	0		ng/dry g	0.92
C3-Chrysenes	1999	0.07		ng/dry g	0.92
C3-Chrysenes	2001	0		ng/dry g	0.92
C3-Chrysenes	2003	0		ng/dry g	0.92

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
C3-Dibenzothiophenes	1994	0		ng/dry g	72.24
C3-Dibenzothiophenes	1995	21.79		ng/dry g	72.24
C3-Dibenzothiophenes	1997	23.5		ng/dry g	72.24
C3-Dibenzothiophenes	1999	4.12		ng/dry g	72.24
C3-Dibenzothiophenes	2001	0		ng/dry g	72.24
C3-Dibenzothiophenes	2003	0		ng/dry g	72.24
C3-Fluoranthenes/Pyrenes	2003	0		ng/dry g	17.9
C3-Fluorenes	1994	0		ng/dry g	117.08
C3-Fluorenes	1995	0		ng/dry g	117.08
C3-Fluorenes	1997	50.8		ng/dry g	117.08
C3-Fluorenes	1999	3.73		ng/dry g	117.08
C3-Fluorenes	2001	0		ng/dry g	117.08
C3-Fluorenes	2003	0		ng/dry g	117.08
C3-Naphthalenes	1994	0		ng/dry g	58.06
C3-Naphthalenes	1995	42.52		ng/dry g	58.06
C3-Naphthalenes	1997	58.2		ng/dry g	58.06
C3-Naphthalenes	1999	10.69		ng/dry g	58.06
C3-Naphthalenes	2001	4.4		ng/dry g	58.06
C3-Naphthalenes	2003	10.3		ng/dry g	58.06
C3-Phenanthrenes/Anthracenes	1994	0		ng/dry g	135.82
C3-Phenanthrenes/Anthracenes	1995	0		ng/dry g	135.82
C3-Phenanthrenes/Anthracenes	1997	37.3		ng/dry g	135.82
C3-Phenanthrenes/Anthracenes	1999	6.73		ng/dry g	135.82
C3-Phenanthrenes/Anthracenes	2001	0		ng/dry g	135.82
C3-Phenanthrenes/Anthracenes	2003	0		ng/dry g	135.82
C4-Chrysenes	1994	0		ng/dry g	0.83
C4-Chrysenes	1995	0		ng/dry g	0.83
C4-Chrysenes	1997	0		ng/dry g	0.83
C4-Chrysenes	1999	0.07		ng/dry g	0.83
C4-Chrysenes	2001	0		ng/dry g	0.83
C4-Chrysenes	2003	0		ng/dry g	0.83
C4-Naphthalenes	1994	0		ng/dry g	60.6
C4-Naphthalenes	1995	32.69		ng/dry g	60.6
C4-Naphthalenes	1997	30.3		ng/dry g	60.6
C4-Naphthalenes	1999	9.01		ng/dry g	60.6
C4-Naphthalenes	2001	4.7		ng/dry g	60.6
C4-Naphthalenes	2003	7.9		ng/dry g	60.6
C4-Phenanthrenes/Anthracenes	1994	0		ng/dry g	79.8
C4-Phenanthrenes/Anthracenes	1995	0		ng/dry g	79.8
C4-Phenanthrenes/Anthracenes	1997	14.9		ng/dry g	79.8
C4-Phenanthrenes/Anthracenes	1999	0.83		ng/dry g	79.8
C4-Phenanthrenes/Anthracenes	2001	0		ng/dry g	79.8
C4-Phenanthrenes/Anthracenes	2003	0		ng/dry g	79.8

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Cadmium	1989	10.467		µg/dry g	5.4
Cadmium	1990	7.897		µg/dry g	5.4
Cadmium	1994	7.6		µg/dry g	5.4
Cadmium	1995	10.137		µg/dry g	5.4
Cadmium	1997	15.6		µg/dry g	5.4
Cadmium	1999	7.02		µg/dry g	5.4
Cadmium	2001	9.78		µg/dry g	5.4
Cadmium	2003	10.8		µg/dry g	5.4
Chlorpyrifos	1995	0		ng/dry g	1.79
Chlorpyrifos	1997	0		ng/dry g	1.79
Chlorpyrifos	1999	0		ng/dry g	1.79
Chlorpyrifos	2001	1.629		ng/dry g	1.79
Chlorpyrifos	2003	0.832		ng/dry g	1.79
Chromium	1989	0.863		µg/dry g	3.2
Chromium	1990	0.883		µg/dry g	3.2
Chromium	1994	0.79		µg/dry g	3.2
Chromium	1995	0		µg/dry g	3.2
Chromium	1997	0		µg/dry g	3.2
Chromium	1999	0.439		µg/dry g	3.2
Chromium	2001	0.808		µg/dry g	3.2
Chromium	2003	0		µg/dry g	3.2
Chrysene	1989	14.667		ng/dry g	95
Chrysene	1990	28.993		ng/dry g	95
Chrysene	1994	19.23		ng/dry g	95
Chrysene	1995	17.2		ng/dry g	95
Chrysene	1997	25.8		ng/dry g	95
Chrysene	1999	12.36		ng/dry g	95
Chrysene	2001	12.8		ng/dry g	95
Chrysene	2003	15.6		ng/dry g	95
Cis-Nonachlor	1995	2.516		ng/dry g	4.66
Cis-Nonachlor	1997	2.25		ng/dry g	4.66
Cis-Nonachlor	1999	1.973		ng/dry g	4.66
Cis-Nonachlor	2001	1.141		ng/dry g	4.66
Cis-Nonachlor	2003	0.983		ng/dry g	4.66
Copper	1989	443.333		µg/dry g	183.33
Copper	1990	730		µg/dry g	183.33
Copper	1994	540		µg/dry g	183.33
Copper	1995	882.71		µg/dry g	183.33
Copper	1997	1724		µg/dry g	183.33
Copper	1999	627		µg/dry g	183.33
Copper	2001	596		µg/dry g	183.33
Copper	2003	598		µg/dry g	183.33

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Delta-Hexachlorocyclohexane	1995	0		ng/dry g	0.18
Delta-Hexachlorocyclohexane	1997	0		ng/dry g	0.18
Delta-Hexachlorocyclohexane	1999	1.033		ng/dry g	0.18
Delta-Hexachlorocyclohexane	2001	0		ng/dry g	0.18
Delta-Hexachlorocyclohexane	2003	0.126		ng/dry g	0.18
Dibenzo[a,h]anthracene	1989	0		ng/dry g	2.79
Dibenzo[a,h]anthracene	1990	0		ng/dry g	2.79
Dibenzo[a,h]anthracene	1994	0		ng/dry g	2.79
Dibenzo[a,h]anthracene	1995	0.55		ng/dry g	2.79
Dibenzo[a,h]anthracene	1997	2.7		ng/dry g	2.79
Dibenzo[a,h]anthracene	1999	0.24		ng/dry g	2.79
Dibenzo[a,h]anthracene	2001	0		ng/dry g	2.79
Dibenzo[a,h]anthracene	2003	0		ng/dry g	2.79
Dibenzofuran	1994	7.16		ng/dry g	13.1
Dibenzofuran	2003	8.3		ng/dry g	13.1
Dibenzothiophene	1994	0		ng/dry g	6.71
Dibenzothiophene	1995	2.35		ng/dry g	6.71
Dibenzothiophene	1997	4.8		ng/dry g	6.71
Dibenzothiophene	1999	0.83		ng/dry g	6.71
Dibenzothiophene	2001	1.4		ng/dry g	6.71
Dibenzothiophene	2003	1.9		ng/dry g	6.71
Dibutyltin	1989	25.15		ng Sn/dry	25.3
Dibutyltin	1990	94.6		ng Sn/dry	25.3
Dibutyltin	1994	9		ng Sn/dry	25.3
Dibutyltin	1995	28.848		ng Sn/dry	25.3
Dibutyltin	1997	0		ng Sn/dry	25.3
Dibutyltin	1999	17.56		ng Sn/dry	25.3
Dibutyltin	2001	15.35		ng Sn/dry	25.3
Dibutyltin	2003	10.49		ng Sn/dry	25.3
Dieldrin	1989	18.333		ng/dry g	9.53
Dieldrin	1990	0		ng/dry g	9.53
Dieldrin	1994	3.97		ng/dry g	9.53
Dieldrin	1995	2.603		ng/dry g	9.53
Dieldrin	1997	3.84		ng/dry g	9.53
Dieldrin	1999	3.294		ng/dry g	9.53
Dieldrin	2001	1.629		ng/dry g	9.53
Dieldrin	2003	2.432		ng/dry g	9.53
Endosulfan I	1997	0		ng/dry g	2.32
Endosulfan I	2001	0		ng/dry g	2.32
Endosulfan I	2003	0		ng/dry g	2.32
Endosulfan II	1995	8.296		ng/dry g	1.94
Endosulfan II	1997	0		ng/dry g	1.94
Endosulfan II	1999	0		ng/dry g	1.94
Endosulfan II	2001	0		ng/dry g	1.94
Endosulfan II	2003	0		ng/dry g	1.94

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Endosulfan Sulfate	2001	0		ng/dry g	0.42
Endosulfan Sulfate	2003	0		ng/dry g	0.42
Endrin	1994	0		ng/dry g	0.71
Endrin	1995	0		ng/dry g	0.71
Endrin	1997	1.31		ng/dry g	0.71
Endrin	1999	0.452		ng/dry g	0.71
Endrin	2001	0		ng/dry g	0.71
Endrin	2003	0		ng/dry g	0.71
Fluoranthene	1989	42.667		ng/dry g	202
Fluoranthene	1990	115.937		ng/dry g	202
Fluoranthene	1994	65.74		ng/dry g	202
Fluoranthene	1995	34.84		ng/dry g	202
Fluoranthene	1997	59.2		ng/dry g	202
Fluoranthene	1999	38.32		ng/dry g	202
Fluoranthene	2001	24.3		ng/dry g	202
Fluoranthene	2003	43.6		ng/dry g	202
Fluorene	1989	5.167		ng/dry g	14.2
Fluorene	1990	5.452		ng/dry g	14.2
Fluorene	1994	0		ng/dry g	14.2
Fluorene	1995	3.22		ng/dry g	14.2
Fluorene	1997	7.5		ng/dry g	14.2
Fluorene	1999	14.01		ng/dry g	14.2
Fluorene	2001	2.6		ng/dry g	14.2
Fluorene	2003	7		ng/dry g	14.2
Gamma-Chlordane	1995	2.178		ng/dry g	6.16
Gamma-Chlordane	1997	2.55		ng/dry g	6.16
Gamma-Chlordane	1999	2.235		ng/dry g	6.16
Gamma-Chlordane	2001	1.304		ng/dry g	6.16
Gamma-Chlordane	2003	1.21		ng/dry g	6.16
Gamma-Hexachlorocyclohexane	1989	0		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	1990	5.033		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	1994	1.31		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	1995	0.991		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	1997	0.39		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	1999	0.737		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	2001	0.326		ng/dry g	2.15
Gamma-Hexachlorocyclohexane	2003	0		ng/dry g	2.15
Heptachlor	1989	0		ng/dry g	0.58
Heptachlor	1990	0		ng/dry g	0.58
Heptachlor	1994	0		ng/dry g	0.58
Heptachlor	1995	0		ng/dry g	0.58
Heptachlor	1997	0.39		ng/dry g	0.58
Heptachlor	1999	1.65		ng/dry g	0.58
Heptachlor	2001	0		ng/dry g	0.58
Heptachlor	2003	0.126		ng/dry g	0.58

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Heptachlor-Epoxide	1989	0		ng/dry g	2.25
Heptachlor-Epoxide	1990	0		ng/dry g	2.25
Heptachlor-Epoxide	1994	0.22		ng/dry g	2.25
Heptachlor-Epoxide	1995	0.324		ng/dry g	2.25
Heptachlor-Epoxide	1997	0.91		ng/dry g	2.25
Heptachlor-Epoxide	1999	0.15		ng/dry g	2.25
Heptachlor-Epoxide	2001	0.489		ng/dry g	2.25
Heptachlor-Epoxide	2003	0		ng/dry g	2.25
Hexachlorobenzene	1989	0		ng/dry g	0.72
Hexachlorobenzene	1990	0		ng/dry g	0.72
Hexachlorobenzene	1994	0		ng/dry g	0.72
Hexachlorobenzene	1995	0.111		ng/dry g	0.72
Hexachlorobenzene	1997	1.2		ng/dry g	0.72
Hexachlorobenzene	1999	0		ng/dry g	0.72
Hexachlorobenzene	2001	0.163		ng/dry g	0.72
Hexachlorobenzene	2003	0.063		ng/dry g	0.72
Indeno[1,2,3-c,d]pyrene	1989	0		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	1990	0		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	1994	2.25		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	1995	0.73		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	1997	4.1		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	1999	0.47		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	2001	0		ng/dry g	10.87
Indeno[1,2,3-c,d]pyrene	2003	0		ng/dry g	10.87
Iron	1989	476.667		µg/dry g	921
Iron	1990	540		µg/dry g	921
Iron	1994	480		µg/dry g	921
Iron	1995	288.009		µg/dry g	921
Iron	1997	658		µg/dry g	921
Iron	1999	226		µg/dry g	921
Iron	2001	561		µg/dry g	921
Iron	2003	218		µg/dry g	921
Lead	1989	0.467		µg/dry g	2.97
Lead	1990	0.517		µg/dry g	2.97
Lead	1994	0.61		µg/dry g	2.97
Lead	1995	0.263		µg/dry g	2.97
Lead	1997	0.73		µg/dry g	2.97
Lead	1999	0.289		µg/dry g	2.97
Lead	2001	0.582		µg/dry g	2.97
Lead	2003	0.235		µg/dry g	2.97
Manganese	1990	19.233		µg/dry g	44.22
Manganese	1994	13.4		µg/dry g	44.22
Manganese	1995	20.922		µg/dry g	44.22
Manganese	1997	33		µg/dry g	44.22
Manganese	1999	10.6		µg/dry g	44.22
Manganese	2001	32.7		µg/dry g	44.22
Manganese	2003	10.9		µg/dry g	44.22

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Mercury	1989	0.087		µg/dry g	0.22
Mercury	1990	0		µg/dry g	0.22
Mercury	1994	0.08		µg/dry g	0.22
Mercury	1995	0.088		µg/dry g	0.22
Mercury	1997	0.104		µg/dry g	0.22
Mercury	1999	0.047		µg/dry g	0.22
Mercury	2001	0.087		µg/dry g	0.22
Mercury	2003	0.055		µg/dry g	0.22
Mirex	1989	0		ng/dry g	0.98
Mirex	1990	0		ng/dry g	0.98
Mirex	1994	0.31		ng/dry g	0.98
Mirex	1995	0.46		ng/dry g	0.98
Mirex	1997	0.87		ng/dry g	0.98
Mirex	1999	0.322		ng/dry g	0.98
Mirex	2001	0.489		ng/dry g	0.98
Mirex	2003	0.466		ng/dry g	0.98
Monobutyltin	1989	0		ng Sn/dry	9.89
Monobutyltin	1990	13.65		ng Sn/dry	9.89
Monobutyltin	1994	32.84		ng Sn/dry	9.89
Monobutyltin	1995	4.714		ng Sn/dry	9.89
Monobutyltin	1997	0		ng Sn/dry	9.89
Monobutyltin	1999	2.33		ng Sn/dry	9.89
Monobutyltin	2001	6.14		ng Sn/dry	9.89
Monobutyltin	2003	2.1		ng Sn/dry	9.89
Naphthalene	1989	4.667		ng/dry g	31.9
Naphthalene	1990	12.974		ng/dry g	31.9
Naphthalene	1994	14.99		ng/dry g	31.9
Naphthalene	1995	21.84		ng/dry g	31.9
Naphthalene	1997	15.5		ng/dry g	31.9
Naphthalene	1999	5.71		ng/dry g	31.9
Naphthalene	2001	7.3		ng/dry g	31.9
Naphthalene	2003	58.7		ng/dry g	31.9
Nickel	1989	4.133		µg/dry g	4.02
Nickel	1990	5.287		µg/dry g	4.02
Nickel	1994	4.33		µg/dry g	4.02
Nickel	1995	4.085		µg/dry g	4.02
Nickel	1997	3.2		µg/dry g	4.02
Nickel	1999	3.36		µg/dry g	4.02
Nickel	2001	4.5		µg/dry g	4.02
Nickel	2003	5		µg/dry g	4.02
Oxychlordane	1995	0		ng/dry g	1.58
Oxychlordane	1997	0		ng/dry g	1.58
Oxychlordane	1999	0.55		ng/dry g	1.58
Oxychlordane	2001	0.326		ng/dry g	1.58
Oxychlordane	2003	0.466		ng/dry g	1.58

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
PCB101/90	1989	9.267		ng/dry g	20.51
PCB101/90	1990	20.01		ng/dry g	20.51
PCB101/90	1994	5.73		ng/dry g	20.51
PCB101/90	1995	1.341		ng/dry g	20.51
PCB101/90	1997	9.35		ng/dry g	20.51
PCB101/90	1999	9.567		ng/dry g	20.51
PCB101/90	2001	5.703		ng/dry g	20.51
PCB101/90	2003	9.79		ng/dry g	20.51
PCB105	1989	6.533		ng/dry g	5.86
PCB105	1990	0		ng/dry g	5.86
PCB105	1994	1.68		ng/dry g	5.86
PCB105	1995	0		ng/dry g	5.86
PCB105	1997	1.88		ng/dry g	5.86
PCB105	1999	0		ng/dry g	5.86
PCB105	2001	0.652		ng/dry g	5.86
PCB105	2003	1.89		ng/dry g	5.86
PCB118	1989	4.467		ng/dry g	20
PCB118	1990	9.023		ng/dry g	20
PCB118	1994	3.31		ng/dry g	20
PCB118	1995	5.874		ng/dry g	20
PCB118	1997	6.47		ng/dry g	20
PCB118	1999	3.911		ng/dry g	20
PCB118	2001	3.096		ng/dry g	20
PCB118	2003	4.485		ng/dry g	20
PCB128	1989	1.2		ng/dry g	4.29
PCB128	1990	0.794		ng/dry g	4.29
PCB128	1994	0.37		ng/dry g	4.29
PCB128	1995	0.727		ng/dry g	4.29
PCB128	1997	0		ng/dry g	4.29
PCB128	1999	0.601		ng/dry g	4.29
PCB128	2001	0.652		ng/dry g	4.29
PCB128	2003	0.63		ng/dry g	4.29
PCB138	1989	13.667		ng/dry g	29.22
PCB138	1990	29.327		ng/dry g	29.22
PCB138	1994	7.58		ng/dry g	29.22
PCB138	1995	12.734		ng/dry g	29.22
PCB138	1997	13.62		ng/dry g	29.22
PCB138	1999	10.546		ng/dry g	29.22
PCB138	2001	6.844		ng/dry g	29.22
PCB138	2003	28.6		ng/dry g	29.22
PCB153/132/168	1989	26.667		ng/dry g	40.46
PCB153/132/168	1990	63.083		ng/dry g	40.46
PCB153/132/168	1994	11.01		ng/dry g	40.46
PCB153/132/168	1995	21.057		ng/dry g	40.46
PCB153/132/168	1997	26.37		ng/dry g	40.46
PCB153/132/168	1999	16.199		ng/dry g	40.46
PCB153/132/168	2001	18.901		ng/dry g	40.46
PCB153/132/168	2003	34.875		ng/dry g	40.46

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
PCB170/190	1989	0		ng/dry g	3.5
PCB170/190	1990	0		ng/dry g	3.5
PCB170/190	1994	0.76		ng/dry g	3.5
PCB170/190	1995	1.272		ng/dry g	3.5
PCB170/190	1997	0.93		ng/dry g	3.5
PCB170/190	1999	0.81		ng/dry g	3.5
PCB170/190	2001	1.304		ng/dry g	3.5
PCB170/190	2003	2.81		ng/dry g	3.5
PCB18	1989	0		ng/dry g	2.74
PCB18	1990	0		ng/dry g	2.74
PCB18	1994	0		ng/dry g	2.74
PCB18	1995	0		ng/dry g	2.74
PCB18	1997	0		ng/dry g	2.74
PCB18	1999	0		ng/dry g	2.74
PCB18	2001	0.489		ng/dry g	2.74
PCB18	2003	0.403		ng/dry g	2.74
PCB180	1989	0		ng/dry g	8.43
PCB180	1990	0.194		ng/dry g	8.43
PCB180	1994	0.34		ng/dry g	8.43
PCB180	1995	0		ng/dry g	8.43
PCB180	1997	3.14		ng/dry g	8.43
PCB180	1999	2.242		ng/dry g	8.43
PCB180	2001	1.141		ng/dry g	8.43
PCB180	2003	0.58		ng/dry g	8.43
PCB187	1989	11.667		ng/dry g	12.13
PCB187	1990	24.783		ng/dry g	12.13
PCB187	1994	7.81		ng/dry g	12.13
PCB187	1995	9.532		ng/dry g	12.13
PCB187	1997	12.56		ng/dry g	12.13
PCB187	1999	9.153		ng/dry g	12.13
PCB187	2001	7.984		ng/dry g	12.13
PCB187	2003	14.577		ng/dry g	12.13
PCB195/208	1989	0		ng/dry g	0.43
PCB195/208	1990	0		ng/dry g	0.43
PCB195/208	1994	0		ng/dry g	0.43
PCB195/208	1995	0		ng/dry g	0.43
PCB195/208	1997	0.11		ng/dry g	0.43
PCB195/208	1999	0.231		ng/dry g	0.43
PCB195/208	2001	0		ng/dry g	0.43
PCB195/208	2003	0		ng/dry g	0.43
PCB206	1989	0		ng/dry g	0.24
PCB206	1990	0		ng/dry g	0.24
PCB206	1994	0		ng/dry g	0.24
PCB206	1995	0		ng/dry g	0.24
PCB206	1997	0		ng/dry g	0.24
PCB206	1999	0		ng/dry g	0.24
PCB206	2001	0		ng/dry g	0.24
PCB206	2003	0		ng/dry g	0.24

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
PCB209	1989	1.967		ng/dry g	0.67
PCB209	1990	0		ng/dry g	0.67
PCB209	1994	0.85		ng/dry g	0.67
PCB209	1995	0		ng/dry g	0.67
PCB209	1997	0.87		ng/dry g	0.67
PCB209	1999	0		ng/dry g	0.67
PCB209	2001	0.163		ng/dry g	0.67
PCB209	2003	0		ng/dry g	0.67
PCB28	1989	0		ng/dry g	4.52
PCB28	1990	0		ng/dry g	4.52
PCB28	1994	0		ng/dry g	4.52
PCB28	1995	0.382		ng/dry g	4.52
PCB28	1997	0.91		ng/dry g	4.52
PCB28	1999	0.684		ng/dry g	4.52
PCB28	2001	0.326		ng/dry g	4.52
PCB28	2003	0		ng/dry g	4.52
PCB44	1989	0		ng/dry g	6.2
PCB44	1990	0.165		ng/dry g	6.2
PCB44	1994	1.18		ng/dry g	6.2
PCB44	1995	2.333		ng/dry g	6.2
PCB44	1997	2.33		ng/dry g	6.2
PCB44	1999	1.8		ng/dry g	6.2
PCB44	2001	0.489		ng/dry g	6.2
PCB44	2003	0.958		ng/dry g	6.2
PCB52	1989	0		ng/dry g	12.23
PCB52	1990	2.503		ng/dry g	12.23
PCB52	1994	1.11		ng/dry g	12.23
PCB52	1995	0.832		ng/dry g	12.23
PCB52	1997	3.51		ng/dry g	12.23
PCB52	1999	3.05		ng/dry g	12.23
PCB52	2001	1.629		ng/dry g	12.23
PCB52	2003	2.999		ng/dry g	12.23
PCB66	1989	9.733		ng/dry g	7.84
PCB66	1990	2.113		ng/dry g	7.84
PCB66	1994	0		ng/dry g	7.84
PCB66	1995	0.58		ng/dry g	7.84
PCB66	1997	1.24		ng/dry g	7.84
PCB66	1999	0.541		ng/dry g	7.84
PCB66	2001	0.489		ng/dry g	7.84
PCB66	2003	1.638		ng/dry g	7.84
PCB8/5	1989	0		ng/dry g	2.3
PCB8/5	1990	0		ng/dry g	2.3
PCB8/5	1994	0		ng/dry g	2.3
PCB8/5	1995	0		ng/dry g	2.3
PCB8/5	1997	2.51		ng/dry g	2.3
PCB8/5	1999	0		ng/dry g	2.3
PCB8/5	2001	0		ng/dry g	2.3
PCB8/5	2003	0		ng/dry g	2.3

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Pentachloroanisole	1995	0.251		ng/dry g	2.08
Pentachloroanisole	1997	1.66		ng/dry g	2.08
Pentachloroanisole	1999	1.23		ng/dry g	2.08
Pentachloroanisole	2001	0.652		ng/dry g	2.08
Pentachloroanisole	2003	1.008		ng/dry g	2.08
Pentachlorobenzene	1995	0		ng/dry g	1.12
Pentachlorobenzene	1997	0.63		ng/dry g	1.12
Pentachlorobenzene	1999	4.283		ng/dry g	1.12
Pentachlorobenzene	2001	0		ng/dry g	1.12
Pentachlorobenzene	2003	0		ng/dry g	1.12
Percent lipid dry weight	1989	10.333		Percent	10.38
Percent lipid dry weight	1990	9.667		Percent	10.38
Percent lipid dry weight	1994	8		Percent	10.38
Percent lipid dry weight	1995	4.957		Percent	10.38
Percent lipid dry weight	1997	4.7		Percent	10.38
Percent lipid dry weight	1999	6.045		Percent	10.38
Percent lipid dry weight	2001	5.08		Percent	10.38
Percent lipid dry weight	2003	10.02		Percent	10.38
Perylene	1989	0		ng/dry g	15.8
Perylene	1990	11.289		ng/dry g	15.8
Perylene	1994	6.15		ng/dry g	15.8
Perylene	1995	7.52		ng/dry g	15.8
Perylene	1997	27.6		ng/dry g	15.8
Perylene	1999	8.32		ng/dry g	15.8
Perylene	2001	8		ng/dry g	15.8
Perylene	2003	0		ng/dry g	15.8
Phenanthrene	1989	18		ng/dry g	72.33
Phenanthrene	1990	16.212		ng/dry g	72.33
Phenanthrene	1994	16.12		ng/dry g	72.33
Phenanthrene	1995	12.48		ng/dry g	72.33
Phenanthrene	1997	11.3		ng/dry g	72.33
Phenanthrene	1999	10.44		ng/dry g	72.33
Phenanthrene	2001	14.6		ng/dry g	72.33
Phenanthrene	2003	26.1		ng/dry g	72.33
Pyrene	1989	26.667		ng/dry g	169
Pyrene	1990	85.07		ng/dry g	169
Pyrene	1994	43.75		ng/dry g	169
Pyrene	1995	24.32		ng/dry g	169
Pyrene	1997	79		ng/dry g	169
Pyrene	1999	22.39		ng/dry g	169
Pyrene	2001	11.7		ng/dry g	169
Pyrene	2003	19.6		ng/dry g	169

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Selenium	1989	4.433		µg/dry g	3.89
Selenium	1990	4.327		µg/dry g	3.89
Selenium	1994	4.33		µg/dry g	3.89
Selenium	1995	4.544		µg/dry g	3.89
Selenium	1997	4.12		µg/dry g	3.89
Selenium	1999	1.75		µg/dry g	3.89
Selenium	2001	0.675		µg/dry g	3.89
Selenium	2003	3.55		µg/dry g	3.89
Silicon	1990	1296.667		µg/dry g	3100
Silicon	1994	0		µg/dry g	3100
Silver	1989	10.01		µg/dry g	3.67
Silver	1994	13.9		µg/dry g	3.67
Silver	1995	20.422		µg/dry g	3.67
Silver	1997	27.2		µg/dry g	3.67
Silver	1999	2.52		µg/dry g	3.67
Silver	2001	12.8		µg/dry g	3.67
Silver	2003	11.9		µg/dry g	3.67
Tetrabutyltin	1995	3.709		ng Sn/dry	0.11
Tetrabutyltin	1997	0		ng Sn/dry	0.11
Tetrabutyltin	2001	0		ng Sn/dry	0.11
Tin	1989	0.08		µg/dry g	0.37
Tin	1990	0.153		µg/dry g	0.37
Tin	1994	0.39		µg/dry g	0.37
Tin	1995	0.566		µg/dry g	0.37
Tin	1997	0.43		µg/dry g	0.37
Tin	1999	0		µg/dry g	0.37
Tin	2001	0.133		µg/dry g	0.37
Tin	2003	0.393		µg/dry g	0.37
Total butyltins	1989	313.48		ng Sn/dry	164.57
Total butyltins	1990	393.6		ng Sn/dry	164.57
Total butyltins	1994	41.84		ng Sn/dry	164.57
Total butyltins	1995	399.114		ng Sn/dry	164.57
Total butyltins	1997	106.2		ng Sn/dry	164.57
Total butyltins	1999	170.52		ng Sn/dry	164.57
Total butyltins	2001	172.14		ng Sn/dry	164.57
Total butyltins	2003	110.1		ng Sn/dry	164.57
Total chlordanes	1989	27		ng/dry g	24.17
Total chlordanes	1990	17.36		ng/dry g	24.17
Total chlordanes	1994	4.22		ng/dry g	24.17
Total chlordanes	1995	2.618		ng/dry g	24.17
Total chlordanes	1997	7.92		ng/dry g	24.17
Total chlordanes	1999	9.285		ng/dry g	24.17
Total chlordanes	2001	3.096		ng/dry g	24.17
Total chlordanes	2003	3.037		ng/dry g	24.17

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Total DDT	1989	71.333		ng/dry g	100.1
Total DDT	1990	57.401		ng/dry g	100.1
Total DDT	1994	18.11		ng/dry g	100.1
Total DDT	1995	27.405		ng/dry g	100.1
Total DDT	1997	28.75		ng/dry g	100.1
Total DDT	1999	23.419		ng/dry g	100.1
Total DDT	2001	14.502		ng/dry g	100.1
Total DDT	2003	24.972		ng/dry g	100.1
Total dieldrin	1989	18.333		ng/dry g	10.54
Total dieldrin	1990	0		ng/dry g	10.54
Total dieldrin	1994	3.97		ng/dry g	10.54
Total dieldrin	1995	2.603		ng/dry g	10.54
Total dieldrin	1997	3.84		ng/dry g	10.54
Total dieldrin	1999	4.048		ng/dry g	10.54
Total dieldrin	2001	1.629		ng/dry g	10.54
Total dieldrin	2003	2.432		ng/dry g	10.54
Total PAH	1989	170.501		ng/dry g	1018
Total PAH	1990	387.257		ng/dry g	1018
Total PAH	1994	220		ng/dry g	1018
Total PAH	1995	181.01		ng/dry g	1018
Total PAH	1997	352.2		ng/dry g	1018
Total PAH	1999	159.65		ng/dry g	1018
Total PAH	2001	124		ng/dry g	1018
Total PAH	2003	311.6		ng/dry g	1018
Total PAHhmw (4 or more rings)	1989	84.001		ng/dry g	721.3
Total PAHhmw (4 or more rings)	1990	308.882		ng/dry g	721.3
Total PAHhmw (4 or more rings)	1994	163.5		ng/dry g	721.3
Total PAHhmw (4 or more rings)	1995	106.28		ng/dry g	721.3
Total PAHhmw (4 or more rings)	1997	253		ng/dry g	721.3
Total PAHhmw (4 or more rings)	1999	97.15		ng/dry g	721.3
Total PAHhmw (4 or more rings)	2001	80.7		ng/dry g	721.3
Total PAHhmw (4 or more rings)	2003	102.2		ng/dry g	721.3
Total PAHlmw (2-3 rings)	1989	86.5		ng/dry g	273.9
Total PAHlmw (2-3 rings)	1990	78.375		ng/dry g	273.9
Total PAHlmw (2-3 rings)	1994	56.5		ng/dry g	273.9
Total PAHlmw (2-3 rings)	1995	74.73		ng/dry g	273.9
Total PAHlmw (2-3 rings)	1997	99.2		ng/dry g	273.9
Total PAHlmw (2-3 rings)	1999	62.5		ng/dry g	273.9
Total PAHlmw (2-3 rings)	2001	43.3		ng/dry g	273.9
Total PAHlmw (2-3 rings)	2003	209.4		ng/dry g	273.9
Total PCBcg	1989	170.336		ng/dry g	374.94
Total PCBcg	1990	303.99		ng/dry g	374.94
Total PCBcg	1994	83.46		ng/dry g	374.94
Total PCBcg	1995	113.328		ng/dry g	374.94
Total PCBcg	1997	171.6		ng/dry g	374.94
Total PCBcg	1999	118.67		ng/dry g	374.94
Total PCBcg	2001	99.724		ng/dry g	374.94
Total PCBcg	2003	208.47		ng/dry g	374.94

Table 1. Analyte Concentration in Tissue from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006) Target Species: *Crassostrea virginica.* (continued)

Tissue					
ANALYTE NAME	**YEAR**	**CONCENTRATION**	**DETECTION LIMIT**	**UNITS**	**85TH PERCENTILE**
Trans-Nonachlor	1989	12		ng/dry g	10.38
Trans-Nonachlor	1990	8.737		ng/dry g	10.38
Trans-Nonachlor	1994	1.67		ng/dry g	10.38
Trans-Nonachlor	1995	2.294		ng/dry g	10.38
Trans-Nonachlor	1997	3		ng/dry g	10.38
Trans-Nonachlor	1999	3.059		ng/dry g	10.38
Trans-Nonachlor	2001	1.141		ng/dry g	10.38
Trans-Nonachlor	2003	1.21		ng/dry g	10.38
Tributyltin	1989	288.33		ng Sn/dry	116.75
Tributyltin	1990	285.35		ng Sn/dry	116.75
Tributyltin	1994	0		ng Sn/dry	116.75
Tributyltin	1995	365.552		ng Sn/dry	116.75
Tributyltin	1997	106.2		ng Sn/dry	116.75
Tributyltin	1999	150.63		ng Sn/dry	116.75
Tributyltin	2001	150.65		ng Sn/dry	116.75
Tributyltin	2003	97.51		ng Sn/dry	116.75
Zinc	1989	5000		µg/dry g	2970
Zinc	1990	6566.667		µg/dry g	2970
Zinc	1994	4300		µg/dry g	2970
Zinc	1995	7497.032		µg/dry g	2970
Zinc	1997	12685		µg/dry g	2970
Zinc	1999	5140		µg/dry g	2970
Zinc	2001	4360		µg/dry g	2970
Zinc	2003	5310		µg/dry g	2970

PERCENTILE 85th: 85 percentile based on all sites and all years in the Mussel Watch database by matrix (sediment or tissue).

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006).

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
1,2,3,4-Tetrachlorobenzene	1997	0.05		ng/dry g	0.2
1,2,4,5-Tetrachlorobenzene	1997	0.42		ng/dry g	0.71
1,6,7-Trimethylnaphthalene	1989	7.633		ng/dry g	10.74
1,6,7-Trimethylnaphthalene	1997	4.9		ng/dry g	10.74
1-Methylnaphthalene	1989	14.333		ng/dry g	17.3
1-Methylnaphthalene	1997	6.9		ng/dry g	17.3
1-Methylphenanthrene	1989	12.667		ng/dry g	29.91
1-Methylphenanthrene	1997	7.6		ng/dry g	29.91
2,4'-DDD	1989	0		ng/dry g	1.56
2,4'-DDD	1997	0.75		ng/dry g	1.56
2,4'-DDE	1989	0		ng/dry g	0.47
2,4'-DDE	1997	0		ng/dry g	0.47
2,4'-DDT	1989	0		ng/dry g	0.27
2,4'-DDT	1997	0		ng/dry g	0.27
2,6-Dimethylnaphthalene	1989	16		ng/dry g	19.37
2,6-Dimethylnaphthalene	1997	8.3		ng/dry g	19.37
2-Methylnaphthalene	1989	***23.333***		ng/dry g	28.67
2-Methylnaphthalene	1997	11.7		ng/dry g	28.67
4,4'-DDD	1989	1.067		ng/dry g	4.93
4,4'-DDD	1997	0.41		ng/dry g	4.93
4,4'-DDE	1989	3.767		ng/dry g	4.64
4,4'-DDE	1997	0.74		ng/dry g	4.64
4,4'-DDT	1989	1.4		ng/dry g	1.79
4,4'-DDT	1997	0.35		ng/dry g	1.79
Acenaphthene	1989	4.067		ng/dry g	11.4
Acenaphthene	1997	4.1		ng/dry g	11.4
Acenaphthylene	1989	***10.467***		ng/dry g	23.49
Acenaphthylene	1997	***6.9***		ng/dry g	23.49
Aldrin	1989	0		ng/dry g	0.24
Aldrin	1997	0.11		ng/dry g	0.24
Alpha-Chlordane	1989	0		ng/dry g	0.95
Alpha-Chlordane	1997	0.04		ng/dry g	0.95
Alpha-Hexachlorocyclohexane	1997	0		ng/dry g	0.09
Aluminum	1989	67666.667		µg/dry g	70156.74
Aluminum	1997	71458		µg/dry g	70156.74

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006). (continued)

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
Anthracene	1989	16.667		ng/dry g	62.7
Anthracene	1997	11.5		ng/dry g	62.7
Antimony	1997	0.48		µg/dry g	1.23
Arsenic	1989	5.9		µg/dry g	13.33
Arsenic	1997	*10.1*		µg/dry g	13.33
Benz[a]anthracene	1989	37.667		ng/dry g	161.5
Benz[a]anthracene	1997	34.1		ng/dry g	161.5
Benzo[a]pyrene	1989	45.333		ng/dry g	182.2
Benzo[a]pyrene	1997	50.6		ng/dry g	182.2
Benzo[b]fluoranthene	1989	51.667		ng/dry g	237.58
Benzo[b]fluoranthene	1997	61.8		ng/dry g	237.58
Benzo[e]pyrene	1989	40		ng/dry g	150.2
Benzo[e]pyrene	1997	37		ng/dry g	150.2
Benzo[g,h,i]perylene	1989	32.667		ng/dry g	107.9
Benzo[g,h,i]perylene	1997	42.3		ng/dry g	107.9
Benzo[k]fluoranthene	1989	38.333		ng/dry g	94.3
Benzo[k]fluoranthene	1997	20.5		ng/dry g	94.3
Beta-Hexachlorocyclohexane	1997	0		ng/dry g	0.14
Biphenyl	1989	7.833		ng/dry g	8.5
Biphenyl	1997	4.3		ng/dry g	8.5
C1-Chrysenes	1997	39.6		ng/dry g	116.1
C1-Dibenzothiophenes	1997	5.2		ng/dry g	17.8
C1-Fluoranthenes/Pyrenes	1997	45.5		ng/dry g	217.5
C1-Fluorenes	1997	7.8		ng/dry g	15.01
C1-Naphthalenes	1997	18.6		ng/dry g	32.7
C1-Phenanthrenes/Anthracenes	1997	29.7		ng/dry g	110.15
C2-Chrysenes	1997	23.8		ng/dry g	89.7
C2-Dibenzothiophenes	1997	7.8		ng/dry g	34.61
C2-Fluorenes	1997	10.2		ng/dry g	27.8
C2-Naphthalenes	1997	15.7		ng/dry g	38.37
C2-Phenanthrenes/Anthracenes	1997	23.8		ng/dry g	111.5

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006). (continued)

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
C3-Chrysenes	1997	2.8		ng/dry g	13.57
C3-Dibenzothiophenes	1997	8.8		ng/dry g	37.27
C3-Fluorenes	1997	12.4		ng/dry g	39.8
C3-Naphthalenes	1997	15.2		ng/dry g	40.3
C3-Phenanthrenes/Anthracenes	1997	15.4		ng/dry g	96.97
C4-Chrysenes	1997	5.9		ng/dry g	28.7
C4-Naphthalenes	1997	8.4		ng/dry g	26.7
C4-Phenanthrenes/Anthracenes	1997	14.5		ng/dry g	59.67
Cadmium	1989	0.157		µg/dry g	0.57
Cadmium	1997	0.14		µg/dry g	0.57
Chlorpyrifos	1997	0.29		ng/dry g	0.43
Chromium	1989	***58***		µg/dry g	111
Chromium	1997	***61***		µg/dry g	111
Chrysene	1989	47.333		ng/dry g	221.2
Chrysene	1997	44.9		ng/dry g	221.2
Cis-Nonachlor	1997	0		ng/dry g	0.37
Clay	1989	36.767		Percent	38.53
Clay	1997	31.89		Percent	38.53
Copper	1989	***23.333***		µg/dry g	47
Copper	1997	***19.8***		µg/dry g	47
Delta-Hexachlorocyclohexane	1997	0		ng/dry g	0.06
Dibenzo[a,h]anthracene	1989	***6.8***		ng/dry g	63.91
Dibenzo[a,h]anthracene	1997	***11.3***		ng/dry g	63.91
Dibenzothiophene	1997	3.4		ng/dry g	12.96
Dibutyltin	1997	0.79		ng Sn/dry g	1.87
Dieldrin	1989	0		ng/dry g	1.01
Dieldrin	1997	***0.14***		ng/dry g	1.01
Endosulfan II	1997	0		ng/dry g	0.3
Endrin	1997	0		ng/dry g	0.06
Fines	1989	0.717		Decimal	0.86
Fines	1997	0.601		Decimal	0.86

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006). (continued)

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
Fluoranthene	1989	88.667		ng/dry g	332
Fluoranthene	1997	66.5		ng/dry g	332
Fluorene	1989	8.267		ng/dry g	21
Fluorene	1997	6.9		ng/dry g	21
Gamma-Chlordane	1997	0.13		ng/dry g	0.61
Gamma-Hexachlorocyclohexane	1989	0.51		ng/dry g	0.3
Gamma-Hexachlorocyclohexane	1997	0.04		ng/dry g	0.3
Gravel	1989	0.18		Percent	3.23
Gravel	1997	0		Percent	3.23
Heptachlor	1989	0		ng/dry g	0.12
Heptachlor	1997	0		ng/dry g	0.12
Heptachlor-Epoxide	1989	0		ng/dry g	0.2
Heptachlor-Epoxide	1997	0		ng/dry g	0.2
Hexachlorobenzene	1989	0.927		ng/dry g	0.66
Hexachlorobenzene	1997	0.1		ng/dry g	0.66
Indeno[1,2,3-c,d]pyrene	1989	33		ng/dry g	118.08
Indeno[1,2,3-c,d]pyrene	1997	35.8		ng/dry g	118.08
Iron	1989	38000		µg/dry g	37666.67
Iron	1997	37982		µg/dry g	37666.67
Lead	1989	***39***		µg/dry g	41
Lead	1997	***32.7***		µg/dry g	41
Manganese	1997	1043		µg/dry g	756.67
Mercury	1989	0.093		µg/dry g	0.23
Mercury	1997	0.085		µg/dry g	0.23
Mirex	1989	0		ng/dry g	0.22
Mirex	1997	0.08		ng/dry g	0.22
Monobutyltin	1997	3.22		ng Sn/dry	3.22
Naphthalene	1989	18.333		ng/dry g	42.55
Naphthalene	1997	14.3		ng/dry g	42.55
Nickel	1989	***28.667***		µg/dry g	38
Nickel	1997	***28.4***		µg/dry g	38
Oxychlordane	1997	0		ng/dry g	0.13
PCB101/90	1989	1.233		ng/dry g	2.2
PCB101/90	1997	0.56		ng/dry g	2.2

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006). (continued)

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
PCB105	1989	0		ng/dry g	0.91
PCB105	1997	0.13		ng/dry g	0.91
PCB118	1989	1.44		ng/dry g	2.17
PCB118	1997	0.54		ng/dry g	2.17
PCB128	1989	0.14		ng/dry g	0.77
PCB128	1997	0.1		ng/dry g	0.77
PCB138	1989	2.633		ng/dry g	2.9
PCB138	1997	0.83		ng/dry g	2.9
PCB153/132/168	1989	4.467		ng/dry g	3.03
PCB153/132/168	1997	1.39		ng/dry g	3.03
PCB170/190	1989	5.8		ng/dry g	1.88
PCB170/190	1997	0		ng/dry g	1.88
PCB18	1989	0		ng/dry g	0.83
PCB18	1997	0.26		ng/dry g	0.83
PCB180	1989	0.807		ng/dry g	1.37
PCB180	1997	0.52		ng/dry g	1.37
PCB187	1989	0.413		ng/dry g	0.97
PCB187	1997	0.48		ng/dry g	0.97
PCB195/208	1989	0.143		ng/dry g	0.44
PCB195/208	1997	0.12		ng/dry g	0.44
PCB206	1989	0		ng/dry g	0.41
PCB206	1997	0		ng/dry g	0.41
PCB209	1989	1.093		ng/dry g	0.67
PCB209	1997	0.95		ng/dry g	0.67
PCB28	1989	0		ng/dry g	1.57
PCB28	1997	0.34		ng/dry g	1.57
PCB44	1989	0.033		ng/dry g	1.12
PCB44	1997	0.29		ng/dry g	1.12
PCB52	1989	0.707		ng/dry g	2.11
PCB52	1997	0.29		ng/dry g	2.11
PCB66	1989	3.067		ng/dry g	1.78
PCB66	1997	0.19		ng/dry g	1.78
PCB8/5	1989	0		ng/dry g	1.35
PCB8/5	1997	0.24		ng/dry g	1.35
Pentachloroanisole	1997	0.11		ng/dry g	0.14
Pentachlorobenzene	1997	0.04		ng/dry g	0.17
Perylene	1989	123.333		ng/dry g	116.97
Perylene	1997	130.7		ng/dry g	116.97

Table 2. Analyte Concentration in Sediment from Chesapeake Bay, James River (CBJR) in All Years (NOAA 2006). (continued)

Sediment					
ANALYTE NAME	YEAR	CONCENTRATION	DETECTION LIMIT	UNITS	85TH PERCENTILE
Phenanthrene	1989	45.333		ng/dry g	144.69
Phenanthrene	1997	30.6		ng/dry g	144.69
Pyrene	1989	102		ng/dry g	339.5
Pyrene	1997	75.5		ng/dry g	339.5
Sand	1989	25.333		Percent	86.77
Sand	1997	39.94		Percent	86.77
Selenium	1989	0.707		µg/dry g	0.77
Selenium	1997	0.47		µg/dry g	0.77
Silt	1989	34.9		Percent	50.67
Silt	1997	26.17		Percent	50.67
Silver	1989	0.203		µg/dry g	0.58
Silver	1997	0.17		µg/dry g	0.58
Tetrabutyltin	1997	0		ng Sn/dry	0
Thallium	1997	0.53		µg/dry g	0.53
Tin	1989	3.067		µg/dry g	3.25
Tin	1997	3.3		µg/dry g	3.25
Total butyltins	1997	26.37		ng Sn/dry	9.42
Total chlordanes	1989	0		ng/dry g	2.04
Total chlordanes	1997	0.12		ng/dry g	2.04
Total DDT	1989	6.234		ng/dry g	17.45
Total DDT	1997	2.25		ng/dry g	17.45
Total dieldrin	1989	0		ng/dry g	1.47
Total dieldrin	1997	0.25		ng/dry g	1.47
Total Inorganic Carbon	1989	0.067		Percent	1.03
Total Inorganic Carbon	1997	0.138		Percent	1.03
Total Organic Carbon	1989	1.133		Percent	2.63
Total Organic Carbon	1997	1.307		Percent	2.63
Total PAH	1989	831.733		ng/dry g	2657.74
Total PAH	1997	729		ng/dry g	2657.74
Total PAHhmw (4 or more rings)	1989	846.8		ng/dry g	2101.38
Total PAHhmw (4 or more rings)	1997	611		ng/dry g	2101.38
Total PAHlmw (2-3 rings)	1989	184.933		ng/dry g	390.4
Total PAHlmw (2-3 rings)	1997	118		ng/dry g	390.4
Total PCBcg	1989	43.952		ng/dry g	54.87
Total PCBcg	1997	14.46		ng/dry g	54.87
Trans-Nonachlor	1989	0		ng/dry g	0.65
Trans-Nonachlor	1997	0.08		ng/dry g	0.65
Tributyltin	1997	22.36		ng Sn/dry	3.11
Zinc	1989	156.667		µg/dry g	135
Zinc	1997	166		µg/dry g	135

PERCENTILE 85th: 85 percentile based on all sites and all years in the Mussel Watch database by matrix (sediment or tissue).

Red: Analyte concentration is above the ERL (NOAA SQuiRT)
Blue: Analyte concentration is above the TEL (NOAA SQuiRT)
Pink: Analyte concentration is above the TEL and ERL (NOAA SQuiRT)

Table 3. COLO- CBJR Sand, Silt, and total organic carbon (TOC) Concentrations.

ANALYTE NAME	YEAR	CONCENTRATION	UNITS	85TH PERCENTILE
Sand	1989	25.333	Percent	86.77
Sand	1997	39.94	Percent	86.77
Silt	1989	34.9	Percent	50.67
Silt	1997	28.17	Percent	50.67
Total Organic Carbon	1989	1.133	Percent	2.63
Total Organic Carbon	1997	1.307	Percent	2.63

Table 4. James River (CBJR) Site Specific *Crassostrea virginica* BAF (1997).

Analyte	Tissue	Sediment	Units	BAF
1,2,3,4-Tetrachlorobenzene	0.33	0.42	ng/dry g	0.786
1,6,7-Trimethylnaphthalene	4.8	4.9	ng/dry g	0.980
1-Methylnaphthalene	7.9	6.9	ng/dry g	1.145
1-Methylphenanthrene	6.7	7.6	ng/dry g	0.882
2,4'-DDD	3.62	0.75	ng/dry g	4.827
2,4'-DDE	0.35	0	ng/dry g	0.000
2,4'-DDT	1.25	0	ng/dry g	0.000
2,6-Dimethylnaphthalene	4.8	8.3	ng/dry g	0.578
2-Methylnaphthalene	9.4	11.7	ng/dry g	0.803
4,4'-DDD	5.32	0.41	ng/dry g	12.976
4,4'-DDE	17.23	0.74	ng/dry g	23.284
4,4'-DDT	0.98	0.35	ng/dry g	2.800
Acenaphthene	3.8	4.1	ng/dry g	0.927
Acenaphthylene	6	6.9	ng/dry g	0.870
Aldrin	0	0.11	ng/dry g	0.000
Alpha-Chlordane	3.62	0.04	ng/dry g	90.500
Alpha-Hexachlorocyclohexane	0	0	ng/dry g	0.000
Aluminum	496	71458	µg/dry g	0.007
Anthracene	15.1	11.5	ng/dry g	1.313
Antimony	ND	0.48	µg/dry g	
Arsenic	7.4	10.1	µg/dry g	0.733
Benz[a]anthracene	13.9	34.1	ng/dry g	0.408
Benzo[a]pyrene	5.2	50.6	ng/dry g	0.103
Benzo[b]fluoranthene	14.2	61.8	ng/dry g	0.230
Benzo[e]pyrene	12.7	37	ng/dry g	0.343
Benzo[g,h,i]perylene	4.6	42.3	ng/dry g	0.109
Benzo[k]fluoranthene	4	20.5	ng/dry g	0.195
Beta-Hexachlorocyclohexane	0.26	0	ng/dry g	0.000
Biphenyl	6.4	4.3	ng/dry g	1.488
C1-Chrysenes	14.5	39.6	ng/dry g	0.366
C1-Dibenzothiophenes	9.6	5.2	ng/dry g	1.846
C1-Fluoranthenes/Pyrenes	34	45.5	ng/dry g	0.747
C1-Fluorenes	9	7.8	ng/dry g	1.154
C1-Naphthalenes	17.3	18.6	ng/dry g	0.930
C1-Phenanthrenes/Anthracenes	19.6	29.7	ng/dry g	0.660
C2-Chrysenes	13.1	23.8	ng/dry g	0.550
C2-Dibenzothiophenes	19	7.8	ng/dry g	2.436
C2-Fluorenes	ND	10.2	ng/dry g	
C2-Naphthalenes	36.9	15.7	ng/dry g	2.350
C2-Phenanthrenes/Anthracenes	30.9	23.8	ng/dry g	1.298
C3-Chrysenes	0	2.8	ng/dry g	0.000
C3-Dibenzothiophenes	23.5	8.8	ng/dry g	2.670
C3-Fluorenes	50.8	12.4	ng/dry g	4.097
C3-Naphthalenes	58.2	15.2	ng/dry g	3.829
C3-Phenanthrenes/Anthracenes	37.3	15.4	ng/dry g	2.422
C4-Chrysenes	0	5.9	ng/dry g	0.000
C4-Naphthalenes	30.3	8.4	ng/dry g	3.607
C4-Phenanthrenes/Anthracenes	14.9	14.5	ng/dry g	1.028
Cadmium	15.6	0.14	µg/dry g	111.429

Table 4. James River (CBJR) Site Specific *Crassostrea virginica* BAF (1997). (continued)

Analyte	Tissue	Sediment	Units	BAF
Chlorpyrifos	0	0.29	ng/dry g	0.000
Chromium	0	61	µg/dry g	0.000
Chrysene	25.8	44.9	ng/dry g	0.575
Cis-Nonachlor	2.25	0	ng/dry g	0.000
Copper	1724	19.8	µg/dry g	87.071
Delta-Hexachlorocyclohexane	0	0	ng/dry g	0.000
Dibenzo[a,h]anthracene	2.7	11.3	ng/dry g	0.239
Dibenzothiophene	4.8	3.4	ng/dry g	1.412
Dibutyltin	0	0.79	ng Sn/dry	0.000
Dieldrin	3.84	0.14	ng/dry g	27.429
Endosulfan II	0	0	ng/dry g	0.000
Endrin	1.31	0	ng/dry g	0.000
Fluoranthene	59.2	66.5	ng/dry g	0.890
Fluorene	7.5	6.9	ng/dry g	1.087
Gamma-Chlordane	2.55	0.13	ng/dry g	19.615
Gamma-Hexachlorocyclohexane	0.39	0.04	ng/dry g	9.750
Heptachlor	0.39	0	ng/dry g	0.000
Heptachlor-Epoxide	0.91	0	ng/dry g	0.000
Hexachlorobenzene	1.2	0.1	ng/dry g	12.000
Indeno[1,2,3-c,d]pyrene	4.1	35.8	ng/dry g	0.115
Iron	658	37982	µg/dry g	0.017
Lead	0.73	32.7	µg/dry g	0.022
Manganese	33	1043	µg/dry g	0.032
Mercury	0.104	0.085	µg/dry g	1.224
Mirex	0.87	0.08	ng/dry g	10.875
Monobutyltin	0	3.22	ng Sn/dry	0.000
Naphthalene	15.5	14.3	ng/dry g	1.084
Nickel	3.2	28.4	µg/dry g	0.113
Oxychlordane	0	0	ng/dry g	0.000
PCB101/90	9.35	0.56	ng/dry g	16.696
PCB105	1.88	0.13	ng/dry g	14.462
PCB118	6.47	0.54	ng/dry g	11.981
PCB128	0	0.1	ng/dry g	0.000
PCB138	13.62	0.83	ng/dry g	16.410
PCB153/132/168	26.37	1.39	ng/dry g	18.971
PCB170/190	0.93	0	ng/dry g	0.000
PCB18	0	0.26	ng/dry g	0.000
PCB180	3.14	0.52	ng/dry g	6.038
PCB187	12.56	0.48	ng/dry g	26.167
PCB195/208	0.11	0.12	ng/dry g	0.917
PCB206	0	0	ng/dry g	0.000
PCB209	0.87	0.95	ng/dry g	0.916
PCB28	0.91	0.34	ng/dry g	2.676
PCB44	2.33	0.29	ng/dry g	8.034
PCB52	3.51	0.29	ng/dry g	12.103
PCB66	1.24	0.19	ng/dry g	6.526
PCB8/5	2.51	0.24	ng/dry g	10.458

Table 4. James River (CBJR) Site Specific *Crassostrea virginica* BAF (1997). (continued)

Analyte	Tissue	Sediment	Units	BAF
Pentachloroanisole	1.66	0.11	ng/dry g	15.091
Pentachlorobenzene	0.63	0.04	ng/dry g	15.750
Perylene	27.6	130.7	ng/dry g	0.211
Phenanthrene	11.3	30.6	ng/dry g	0.369
Pyrene	79	75.5	ng/dry g	1.046
Selenium	4.12	0.47	µg/dry g	8.766
Silver	27.2	0.17	µg/dry g	160.000
Tetrabutyltin	0	0	ng Sn/dry	0.000
Thallium	ND	0.53	µg/dry g	
Tin	0.43	3.3	µg/dry g	0.130
Total butyltins	106.2	26.37	ng Sn/dry	4.027
Total chlordanes	7.92	0.12	ng/dry g	66.000
Total DDT	28.75	2.25	ng/dry g	12.778
Total dieldrin	3.84	0.25	ng/dry g	15.360
Total Inorganic Carbon	0	0.138	Percent	0.000
Total Organic Carbon	0	1.307	Percent	0.000
Total PAH	352.2	729	ng/dry g	0.483
Total PAHhmw (4 or more rings)	253	611	ng/dry g	0.414
Total PAHlmw (2-3 rings)	99.2	118	ng/dry g	0.841
Total PCBcg	171.6	14.46	ng/dry g	11.867
Trans-Nonachlor	3	0.08	ng/dry g	37.500
Tributyltin	106.2	22.36	ng Sn/dry	4.750
Zinc	12685	166	µg/dry g	76.416

BAF = Sediment/Tissue

Appendix 5: VADEQ Data

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Table 1. Key for VADEQ Data Tables:

Blue font indicates analyte concentration greater than or equal to DEQ's screening value
Red font indicates analyte concentration greater than or equal to VDH level of concern
Yellow highlighted record indicates Lead (Pb) concentration above detection limit
Peach highlighted mummichog and other samples analyzed as homogenized whole fish
Light Blue highlighted sample analyzed as duplicate (twice)
Italicized analytes or compound names have not been routinely reported previously

[1] ppm denotes parts per million (aka - ug/g or mg/kg); wet weight basis, edible fillet
[2] PCB denotes sum of polychlorinated biphenyl congeners
As: Total Arsenic
Cd: Cadmium
Cr: Chromium
Hg: Mercury
Pb: Lead
Se: Selenium
PAH: sum PAH (Polycyclic Aromatic Hydrocarbons or Polynuclear Aromatic Hydrocarbons-PNAs) denotes sum of all 35 PAH compounds reported
[22] PAHs: sum PAH (Polycyclic Aromatic Hydrocarbons or Polynuclear Aromatic Hydrocarbons-PNAs) denotes sum of 27 PAH compounds reported per 2004
[22] PAHs: sum PAH (Polycyclic Aromatic Hydrocarbons or Polynuclear Aromatic Hydrocarbons-PNAs) denotes sum of 24 PAH compounds reported pre 2004
[3] PEC: sum PEC, Potency Equivalency Concentration, denotes sum of seven PAHs based on their Relative Potency estimates
[4] NAP: Naphthalene
[5] 2-Me: Methyl
[6] 1-Me: Methyl
[7] d-Me: 2,6-Dimethyl
[8] d-Me: 1,3-Dimethyl — d-Me[8]: '1,3 dimethylnaphthalene
[9] d-Me: 1,6-Dimethyl — d-Me[9]: '1,6 dimethylnaphthalene
[10] d-Me: 1,4 & 2,3-Dimethyl — d-Me[10]: '1,4 & 2,3 dimethylnaphthalene
[11] d-Me: 1,5-Dimethyl — d-Me[11]: '1,5 dimethylnaphthalene
[12] d-Me: 1,2-Dimethyl — d-Me[12]: '1,2 dimethylnaphthalene
[13] d-Me: 1,8-Dimethyl — d-Me[13]: '1,8 dimethylnaphthalene
[14] t-Me: 2,3,5-Trimethyl — d-Me[17]: '3,6 dimethylphenanthrene
[15] PHH: Phenanthrene
[16] ATH: Anthracene
[17] d-Me: 3,6-Dimethyl
[18] FTH: Fluoranthene
[19] IND: indeno(1,2,3-cd)
[20] db(a,h): dibenzo(a,h)
[21] NA: not available, denotes insufficient toxiclogical information for this chemical to calculate a screening value

Table 2. Virginia DEQ 2005 Fish Metals Results for Upper James River Basin.

			ppm [1] (wet weight basis)					
Station Name-Location-Description	Fish Species	# of Fish	As	Cd	Cr	Hg	Pb	Se
DEQ Screening Values			0.072	11	32	0.3/0.5	NA	54
Lake Moomaw	Bluegill Sunfish	9	0.44	<0.01	0.12	0.04	<0.1	<0.5
Lake Moomaw	Rock Bass	5	<0.05	<0.01	0.22	0.06	<0.1	<0.5
Lake Moomaw	Smallmouth Bass	3	<0.05	<0.01	<0.05	0.50	<0.1	<0.5
Lake Moomaw	Largemouth Bass	3	0.60	<0.01	0.13	0.14	<0.1	<0.5
Lake Moomaw	Carp #1 - 1	1						
Lake Moomaw	Carp #3 - 2	1						
Lake Moomaw	Carp #2 - 3	1						
Lake Moomaw	Carp #4 - 4	1						
Jackson River near Covington	Redbreast Sunfish	4	<0.05	<0.01	<0.05	0.02	<0.1	<0.5
Jackson River near Covington	Rock Bass - 1	7	<0.05	<0.01	0.07	0.04	<0.1	1.23
Jackson River near Covington	Rock Bass - 2	7	<0.05	<0.01	0.26	0.02	<0.1	0.67
Jackson River near Covington	Smallmouth Bass	4	<0.05	<0.01	<0.05	0.02	<0.1	<0.5
Jackson River near Covington	Rainbow Trout	2	<0.05	<0.01	<0.05	<0.01	<0.1	<0.5
Jackson River near Covington	Carp #2 - 1	1						
Jackson River near Covington	Carp #1 - 2	1						
Jackson River near Covington	Carp #5 - 3	1						
Jackson River near Covington	Carp #7 - 4	1						
Jackson River near Covington	Carp - 5	3	<0.05	<0.01	<0.05	0.05	<0.1	0.78
Jackson River near Rt. 727 at Iron Gate	Rock Bass	6	0.13	<0.01	0.33	0.03	<0.1	<0.5
Jackson River near Rt. 727 at Iron Gate	Central Stoneroller	10	0.14	<0.01	0.19	<0.01	<0.1	<0.5
Cowpasture River near Rt. 633	Redbreast Sunfish	3	0.28	<0.01	0.47	0.06	<0.1	<0.5
Cowpasture River near Rt. 633	Rock Bass - 1	10	0.28	<0.01	0.18	0.07	<0.1	<0.5
Cowpasture River near Rt. 633	Rock Bass - 2	10	0.37	0.01	0.19	0.04	<0.1	<0.5
James River near Rt. 11 bridge at Buchanan	Redbreast Sunfish	5	<0.05	<0.01	0.08	0.02	<0.1	<0.5
James River near Rt. 11 bridge at Buchanan	Rock Bass	10	<0.05	<0.01	<0.05	0.05	<0.1	<0.5
James River near Rt. 11 bridge at Buchanan	Smallmouth Bass	3	<0.05	<0.01	0.09	0.03	<0.1	<0.5
James River near Rt. 11 bridge at Buchanan	Flathead Catfish #1	1						
James River near Rt. 11 bridge at Buchanan	Catfish	4	<0.05	<0.01	0.43	0.04	<0.1	<0.5

Table 2. Virginia DEQ 2005 Fish Metals Results for Upper James River Basin. (continued)

			ppm [1] (wet weight basis)					
Station Name-Location-Description	Fish Species	# of Fish	As	Cd	Cr	Hg	Pb	Se
DEQ Screening Values			0.072	11	32	0.3/0.5	NA	54
Maury River upstream Rt. 39 at the Chessie Trail Park	Rock Bass - 1	10	<0.05	<0.01	0.21	0.06	<0.1	<0.5
Maury River upstream Rt. 39 at the Chessie Trail Park	Rock Bass - 2	10	<0.05	<0.01	0.29	0.05	<0.1	<0.5
Maury River upstream Rt. 39 at the Chessie Trail Park	Smallmouth Bass	4	<0.05	<0.01	<0.05	0.03	<0.1	<0.5
Maury River upstream Rt. 39 at the Chessie Trail Park	River Chub	5						
Maury River upstream Rt. 39 at the Chessie Trail Park	Central Stoneroller	12						
Maury River near Buena Vista	Redbreast Sunfish	5	0.14	<0.01	0.16	0.05	<0.1	<0.5
Maury River near Buena Vista	Green Sunfish	7	<0.05	<0.01	0.12	0.02	<0.1	<0.5
Maury River near Buena Vista	Black Crappie	6	<0.05	0.19	<0.05	0.04	0.13	<0.5
Maury River near Buena Vista	Rock Bass - 1	11	<0.05	0.01	0.19	0.04	<0.1	<0.5
Maury River near Buena Vista	Rock Bass - 2	11	<0.05	<0.01	0.23	0.06	<0.1	<0.5
Maury River near Buena Vista	White Sucker	2						
Maury River near Buena Vista	Carp #3 - 1	1						
Maury River near Buena Vista	Carp #4 - 2	1						
Maury River near Buena Vista	Carp #1 - 3	1						
Maury River near Buena Vista	Carp #2 - 4	1						

Table 2. Virginia DEQ 2005 Fish Metals Results for Upper James River Basin. (continued)

			ppm' wet weight basis					
Station Name-Location-Description	Fish Species	# of Fish	As	Cd	Cr	Hg	Pb	Se
DEQ Screening Values			0.072	11	32	0.3/0.5	NA	54
James River below Blue Ridge Parkway near Big Island	Rock Bass - 1	5	<0.05	<0.01	<0.05	0.03	<0.1	<0.5
James River below Blue Ridge Parkway near Big Island	Rock Bass - 2	5	<0.05	<0.01	0.11	0.04	0.15	<0.5
James River below Blue Ridge Parkway near Big Island	Smallmouth Bass - 1	2						
James River below Blue Ridge Parkway near Big Island	Smallmouth Bass - 2	2	<0.05	<0.01	<0.05	0.08	<0.1	<0.5
James River below Blue Ridge Parkway near Big Island	Smallmouth Bass #5 - 3	1	0.10	<0.01	<0.05	0.16	<0.1	<0.5
James River below Blue Ridge Parkway near Big Island	Largemouth Bass - 1	2						
James River below Blue Ridge Parkway near Big Island	Largemouth Bass - 2	2	<0.05	<0.01	<0.05	0.13	0.19	<0.5
James River below Blue Ridge Parkway near Big Island	Largemouth Bass #5 - 3	1	<0.05	<0.01	0.12	0.10	<0.1	<0.5
James River below Blue Ridge Parkway near Big Island	Redhorse Sucker - 1	3						
James River below Blue Ridge Parkway near Big Island	Redhorse Sucker - 2	2	<0.05	<0.01	<0.05	0.06	<0.1	<0.5
Harris Creek near Rt. 130	Redbreast Sunfish	10	0.02	<0.01	<0.05	0.05	<0.1	<0.5
Harris Creek near Rt. 130	Smallmouth Bass	3	<0.05	<0.01	<0.05	0.15	<0.1	<0.5
Harris Creek near Rt. 130	Largemouth Bass	2	<0.05	<0.01	<0.05	0.03	<0.1	<0.5
Harris Creek near Rt. 130	Northern Hogsucker	2						
Harris Creek near Rt. 130	White Sucker	8						
Blackwater Creek near Rt. 291 bridge	Redbreast Sunfish - 1	5	<0.05	<0.01	0.18	0.07	<0.1	<0.5
Blackwater Creek near Rt. 291 bridge	Redbreast Sunfish - 2	5	<0.05	<0.01	<0.05	0.04	<0.1	<0.5
Blackwater Creek near Rt. 291 bridge	Redear Sunfish	3	<0.05	<0.01	<0.05	0.02	<0.1	<0.5
Blackwater Creek near Rt. 291 bridge	Northern Hogsucker - 1	3	<0.05	<0.01	<0.05	<0.01	<0.1	<0.5
Blackwater Creek near Rt. 291 bridge	Northern Hogsucker - 2	2	<0.05	<0.01	<0.05	0.04	<0.1	<0.5
James River near Rt. 29 bridge	Black Crappie	3	0.11	<0.01	0.39	0.12	<0.1	<0.5
James River near Rt. 29 bridge	Smallmouth Bass	8	<0.05	<0.01	<0.05	0.07	<0.1	<0.5
James River near Rt. 29 bridge	Channel Catfish - 1	3	<0.05	<0.01	0.18	0.02	<0.1	<0.5
James River near Rt. 29 bridge	Channel Catfish - 2	4	0.16	<0.01	0.30	0.02	<0.1	<0.5
James River near Rt. 29 bridge	Flathead Catfish #1 - 1	1	<0.05	<0.01	<0.05	0.34	<0.1	<0.5
James River near Rt. 29 bridge	Flathead Catfish #2 - 2	1	<0.05	<0.01	<0.05	0.19	<0.1	<0.5
James River near Rt. 29 bridge	Flathead Catfish #3 - 3	1	<0.05	<0.01	0.08	0.04	0.14	<0.5
James River near Rt. 29 bridge	Flathead Catfish - 4	2	<0.05	<0.01	0.25	0.12	<0.1	<0.5
James River near Rt. 29 bridge	Gizzard Shad	5						
James River near Rt. 29 bridge	Redhorse Sucker	4	<0.05	<0.01	0.15	0.10	<0.1	<0.5

Table 2. Virginia DEQ 2005 Fish Metals Results for Upper James River Basin. (continued)

			ppm [1]-wet weight basis					
Station Name-Location-Description	Fish Species	# of Fish	As	Cd	Cr	Hg	Pb	Se
DEQ Screening Values			0.072	11	32	0.3/0.5	NA	54
Piney River near Rt. 674	Redbreast Sunfish	7	<0.05	<0.01	<0.05	0.03	<0.1	<0.5
Piney River near Rt. 674	Rock Bass	7	<0.05	<0.01	0.39	0.09	<0.1	<0.5
Piney River near Rt. 674	American Eel	8	<0.05	0.01	0.39	0.07	<0.1	<0.5
Piney River near Rt. 674	White Sucker	2	<0.05	<0.01	0.25	0.06	<0.1	<0.5
Stonehouse Lake	Bluegill Sunfish	6	<0.05	<0.01	0.28	0.03	<0.1	<0.5
Stonehouse Lake	Black Crappie	10	<0.05	<0.01	0.15	0.04	<0.1	<0.5
Stonehouse Lake	Redear Sunfish	6	0.83	<0.01	0.13	0.02	<0.1	<0.5
Stonehouse Lake	Largemouth Bass#2 - 1	1	0.44	<0.01	<0.05	0.25	0.18	<0.5
Stonehouse Lake	Largemouth Bass#1 - 2	1	0.40	<0.01	<0.05	0.24	<0.1	<0.5
Stonehouse Lake	Largemouth Bass - 3	5	0.71	<0.01	0.09	0.04	<0.1	<0.5
Mill Creek Reservoir	Bluegill Sunfish	8	<0.05	<0.01	0.49	0.04	<0.1	<0.5
Mill Creek Reservoir	Black Crappie	10	0.81	<0.01	<0.05	0.02	<0.1	<0.5
Mill Creek Reservoir	Redear Sunfish	5	<0.05	<0.01	<0.05	0.06	<0.1	<0.5
Mill Creek Reservoir	Largemouth Bass	10	<0.05	<0.01	<0.05	0.03	<0.1	<0.5
Mill Creek Reservoir	Channel Catfish - 1	2	<0.05	<0.01	0.17	0.01	<0.1	<0.5
Mill Creek Reservoir	Channel Catfish - 2	5	0.72	<0.01	<0.05	0.02	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Smallmouth Bass	2	<0.05	<0.01	0.25	0.02	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Channel Catfish - 1	4	<0.05	<0.01	0.17	0.03	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Channel Catfish #5 - 2	1	<0.05	<0.01	<0.05	0.44	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Flathead Catfish #3 - 1	1	<0.05	<0.01	<0.05	0.32	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Flathead Catfish #2 - 2	1	<0.05	<0.01	<0.05	0.13	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Flathead Catfish #1 - 3	1	<0.05	<0.01	<0.05	0.08	<0.1	<0.5
James River near Virginia at State Wildlife Management Area	Redhorse Sucker	5	<0.05	<0.01	0.16	0.01	<0.1	<0.5
James River downstream of Rt. 15	Redbreast Sunfish	4	<0.05	<0.01	0.22	0.03	<0.1	<0.5
James River downstream of Rt. 15	Channel Catfish - 1	4	<0.05	<0.01	0.48	0.01	<0.1	<0.5
James River downstream of Rt. 15	Channel Catfish #6 - 2	1	<0.05	<0.01	<0.05	0.22	<0.1	<0.5
James River downstream of Rt. 15	Flathead Catfish #2 - 1	1	<0.05	<0.01	<0.05	0.12	<0.1	<0.5
James River downstream of Rt. 15	Flathead Catfish #1 - 2	1	<0.05	<0.01	0.07	0.13	<0.1	<0.5
James River downstream of Rt. 15	Carp #1	1						

Table 2. Virginia DEQ 2005 Fish Metals Results for Upper James River Basin. (continued)

			ppm (wet weight basis)					
Station Name-Location-Description	Fish Species	# of Fish	As	Cd	Cr	Hg	Pb	Se
DEQ Screening Values			0.072	11	32	0.3/0.5	NA	54
James River near Rt. 45 bridge	Black Crappie	4	<0.05	0.01	0.78	0.02	<0.1	<0.5
James River near Rt. 45 bridge	Smallmouth Bass	3						
James River near Rt. 45 bridge	Channel Catfish - 1	5	<0.05	<0.01	0.11	0.05	<0.1	<0.5
James River near Rt. 45 bridge	Channel Catfish #1 - 2	1	<0.05	<0.01	<0.05	0.25	<0.1	<0.5
James River near Rt. 45 bridge	Flathead Catfish - 1	3	<0.05	<0.01	0.28	0.07	<0.1	<0.5
James River near Rt. 45 bridge	Flathead Catfish #4 - 2	1	<0.05	<0.01	<0.05	0.09	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Bluegill Sunfish	10	<0.05	<0.01	<0.05	0.08	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Smallmouth Bass #1	1	0.39	<0.01	0.41	0.48	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Channel Catfish	3	<0.05	<0.01	0.06	0.07	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Flathead Catfish - 3	3	<0.05	<0.01	0.17	0.08	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Flathead Catfish #5 - 1	1	<0.05	<0.01	<0.05	0.21	<0.1	<0.5
James River near Rt. 652 end at Watkins Landing	Flathead Catfish #1 - 2	1	<0.05	<0.01	<0.05	0.04	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Flathead Catfish #2B - 1	1	<0.05	<0.01	<0.05	0.11	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Flathead Catfish #2C - 2	1	<0.05	<0.01	<0.05	0.21	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Flathead Catfish #1B - 3	1	<0.05	<0.01	<0.05	0.08	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Flathead Catfish #1C - 4	1	<0.05	<0.01	<0.05	0.16	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Flathead Catfish - 5	2	0.13	<0.01	0.30	0.12	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Blue Catfish #1	1						
James River near Rt. 150 downstream Bosher Dam	Gizzard Shad	10	0.16	<0.01	0.59	0.08	<0.1	<0.5
James River near Rt. 150 downstream Bosher Dam	Carp #1A - 1	1						
James River near Rt. 150 downstream Bosher Dam	Carp #3B - 2	1						
James River near Rt. 150 downstream Bosher Dam	Carp #3A - 3	1						
James River near Rt. 150 downstream Bosher Dam	Carp #4B - 4	1						
James River near Rt. 150 downstream Bosher Dam	Carp #2B - 5	1						
James River near Rt. 150 downstream Bosher Dam	Carp #2A - 6	1						
James River near Rt. 150 downstream Bosher Dam	Carp #1B - 7	1						

Table 3. VADEQ 2005 Fish PAHs Results for James River.

			ppb[1] (wet wt)				
Station Name/Location/Description	Fish Species	# of Fish	Total PAHs[2]	Total PAH[22]	Total PAH[23]	sum PAH PEC[3]	NAP[4] .
DEQ Screening Values			NA[21]	NA[21]		15	220000
Fresh Tidal James River Basin - Chickahominy River watershed							
Chickahominy River below Walkers Dam	Bluegill Sunfish	6	12.57	12.57	12.57	0.0000	1.08
Chickahominy River below Walkers Dam	Gizzard Shad	10	8.95	8.79	8.79	0.0000	0.71
Chickahominy River below Walkers Dam	Brown Bullhead Catfish	3	5.57	5.44	5.44	0.0000	1.89
Little Creek Reservoir	Bluegill Sunfish	11	25.04	24.59	24.59	0.0000	2.71
Chichahominy River near Rt. 5	Largemouth Bass - 1	3	1.90	1.90	1.90	0.0000	0.58
Chichahominy River near Rt. 5	Gizzard Shad	9	10.65	7.52	7.52	0.0000	1.47
Lower James River Basin - Elizabeth River watershed							
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Largemouth Bass	3	2.14	2.14	2.14	0.0000	0.41
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Bluegill Sunfish	10	6.75	6.67	6.67	0.0000	0.47

Table 3. VADEQ 2005 Fish PAHs Results for James River. (continued)

			ppb[1] (wet weight basis)											
Station Name/Location/Description	Fish Species	# of Fish	NAP 2-Me[5]	NAP 1-Me[6]	biphenyl	*diphenyl ether*	NAP d-Me[7]	*NAP d-Me*[8]	*NAP d-Me*[9]	*NAP d-Me*[10]	*NAP d-Me*[11]	naphthylene ace~	*NAP d-Me*[12]	*NAP d-Me*[13]
DEQ Screening Values			NA	NA	540000	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fresh Tidal James River Basin - Chickahominy River watershed														
Chickahominy River below Walkers Dam	Bluegill Sunfish	6	1.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chickahominy River below Walkers Dam	Gizzard Shad	10	0.59	0.23	0.00	0.00	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.00
Chickahominy River below Walkers Dam	Brown Bullhead Catfish	3	1.53	0.54	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00
Little Creek Reservoir	Bluegill Sunfish	11	2.58	1.25	0.10	0.00	0.07	0.12	0.09	0.00	0.00	0.00	0.00	0.00
Chichahominy River near Rt. 5	Largemouth Bass - 1	3	0.31	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chichahominy River near Rt. 5	Gizzard Shad	9	1.65	0.57	0.00	0.00	0.00	0.33	0.28	0.00	0.00	0.00	0.00	0.00
Lower James River Basin - Elizabeth River watershed														
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Largemouth Bass	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Bluegill Sunfish	10	0.44	0.28	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. VADEQ 2005 Fish PAHs Results for James River. (continued)

			ppb[1] (wet weight basis)											
Station Name/Location/Description	Fish Species	# of Fish	naphthene ace~	*furan dibenzo*	NAP t-Me[14]	fluorene	*thiophene dibenzo*	PHH[15]	ATH[16]	*PHH 2-Me*	PHH 1-Me	*PHH d-Me*[17]	FTH[18]	pyrene
DEQ Screening Values			650000	NA	NA	430000	NA	NA	3E+06	NA	NA	NA	430000	320000
Fresh Tidal James River Basin - Chickahominy River watershed														
Chickahominy River below Walkers Dam	Bluegill Sunfish	6	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	1.44	8.35
Chickahominy River below Walkers Dam	Gizzard Shad	10	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.72	6.22
Chickahominy River below Walkers Dam	Brown Bullhead Catfish	3	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.20	1.12
Little Creek Reservoir	Bluegill Sunfish	11	0.08	0.00	0.00	0.00	0.00	0.68	0.00	0.24	0.00	0.00	2.47	14.66
Chichahominy River near Rt. 5	Largemouth Bass - 1	3	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.14	0.53
Chichahominy River near Rt. 5	Gizzard Shad	9	0.00	0.00	0.00	0.00	0.00	0.61	0.00	2.52	0.00	0.00	1.45	1.78
Lower James River Basin - Elizabeth River watershed														
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Largemouth Bass	3	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.39	0.23
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Bluegill Sunfish	10	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.74	4.13

Table 3. VADEQ 2005 Fish PAHs Results for James River. (continued)

			ppb[1] (wet weight basis)									
Station Name/Location/Description	Fish Species	# of Fish	ATH benz(a)	chrysene	FTH benzo(b)	FTH benzo(k)	pyrene benzo(e)	pyrene benzo(a)	perylene	pyrene IND[19]	ATH db(a,h)[20]	perylene benzo(ghi)
DEQ Screening Values			15	15	15	15	NA	15	NA	15	15	NA
Fresh Tidal James River Basin - Chickahominy River watershed												
Chickahominy River below Walkers Dam	Bluegill Sunfish	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chickahominy River below Walkers Dam	Gizzard Shad	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chickahominy River below Walkers Dam	Brown Bullhead Catfish	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Creek Reservoir	Bluegill Sunfish	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chichahominy River near Rt. 5	Largemouth Bass - 1	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chichahominy River near Rt. 5	Gizzard Shad	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower James River Basin - Elizabeth River watershed												
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Largemouth Bass	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	Bluegill Sunfish	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4. VADEQ 2005 Fish PCBs Results for James River.

Station Name/Location/Description	Fish Species	# of Fish	ppb[1] (wet wt) Total PCB[2]
DEQ Screening Values			50/54/500
Upper James River Basin			
Lake Moomaw	Rock Bass	5	0.00
Jackson River near Rt. 727 at Iron Gate	Rock Bass	6	2.34
Jackson River near Rt. 727 at Iron Gate	Central Stoneroller	10	0.00
Jackson River near Covington	Rainbow Trout	2	5.36
Jackson River near Covington	Carp - 5	3	37.48
Jackson River near Covington	Rock Bass - 1	7	1.86
Jackson River near Covington	Rock Bass - 2	7	6.67
Cowpasture River near Rt. 633	Rock Bass - 1	10	0.87
Cowpasture River near Rt. 633	Rock Bass - 2	10	1.11
Cowpasture River near Rt. 633	Redbreast Sunfish	3	3.54
James River near Rt. 11 bridge at Buchanan	Fallfish	4	1.26
James River near Rt. 11 bridge at Buchanan	Rock Bass	10	2.00
Upper James River Basin - Maury River watershed			
Maury River upstream Rt. 39 at the Chessie Trail Park	Rock Bass - 1	10	3.45
Maury River upstream Rt. 39 at the Chessie Trail Park	Rock Bass - 2	10	2.81
Maury River near Buena Vista	Rock Bass - 1	11	14.56
Maury River near Buena Vista	Rock Bass - 2	11	4.98
Middle James River Basin			
James River below Blue Ridge Parkway near Big Island	Largemouth Bass - 2	2	1.18
James River below Blue Ridge Parkway near Big Island	Smallmouth Bass - 2	2	4.66
James River near Rt. 29 bridge	Flathead Catfish - 4	2	17.39
James River near Rt. 29 bridge	Channel Catfish - 2	4	9.93
James River near Rt. 29 bridge	Redhorse Sucker	4	55.35
Blackwater Creek near Rt. 291 bridge	Northern Hogsucker - 2	2	1.44
Harris Creek near Rt. 130	Smallmouth Bass	3	1.43

Table 5. VADEQ 2005 Sediment Metals Results for York River Basin

DEQ rivermile	Stream name/location/description	% TOC[2]	% Al	ppm[1] (dry weight basis) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
NOAA's Effects Range-Median (ERM)		**>>>>**	**	**3.7**	**70**	**9.6**	**370**	**270**	**0.71**	**51.6**	**218**	**	**	**	**410**
NOAA's Effects Range-Low (ERL)		**>>>>**	**	**1**	**8.2**	**1.2**	**81**	**34**	**0.15**	**20.9**	**46.7**	**	**	**	**150**
Freshwater Consensus-Based Probable Effect Concentration				NA	33	4.98	111	149	1.06	48.6	128				459
8-CAM001.00	Bowies Pond (Campbell Creek)		0.78	0.25	**18.3**	0.85	15.9	25.4	**0.57**	2.0	7.3	<0.5	<0.5	<0.3	79

Table 5. VADEQ 2005 Sediment Metals Results for York River Basin. (continued)

DEQ rivermile	Stream name/location/description	% TOC[2]	% Al	ppm[1] (dry weight basis) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
NOAA's Effects Range-Median (ERM)		**>>>>**	**	**3.7**	**70**	**9.6**	**370**	**270**	**0.71**	**51.6**	**218**	**	**	**	**410**
NOAA's Effects Range-Low (ERL)		**>>>>**	**	**1**	**8.2**	**1.2**	**81**	**34**	**0.15**	**20.9**	**46.7**	**	**	**	**150**
Freshwater Consensus-Based Probable Effect Concentration (PEC)				**NA**	**33**	**4.98**	**111**	**149**	**1.06**	**48.6**	**128**				**459**
Upper James River Basin															
2AJKS047.06	Lake Moomaw		0.03	0.03	**26.2**	<0.01	16.4	30.4	0.03	13.6	29.7	<0.5	<0.5	<0.3	40
2AJKS022.50	Jackson River near Covington		0.42	**1.92**	**23.7**	0.98	8.6	**79.6**	0.08	19.4	**51.9**	<0.5	<0.5	<0.3	**569**
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate		0.48	0.53	**24.7**	0.48	14.0	**35.2**	0.02	**50.3**	26.9	<0.5	<0.5	<0.3	**305**
2ACWP002.55	Cowpasture River near Rt. 633		0.01	0.19	**17.0**	0.48	8.6	20.4	<0.01	**26.3**	14.6	<0.5	<0.5	<0.3	112
2AJMS309.13	James River near Rt. 11 bridge at Buchanan		0.32	0.17	**14.9**	0.41	10.2	25.0	<0.01	**40.0**	18.9	<0.5	<0.5	<0.3	**235**
Upper James River Basin - Maury River Watershed															
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park		0.34	0.02	**12.5**	0.20	9.0	**108.7**	0.01	10.6	17.4	<0.5	<0.5	<0.3	90
2AMRY011.23	Maury River near Buena Vista		0.12	<0.02	8.2	0.12	7.1	20.1	<0.01	10.7	12.0	<0.5	<0.5	<0.3	15
Middle James River Basin															
2BJMS279.41	James River below Blue Ridge Parkway near Big Island		0.29	<0.02	1.2	0.29	9.9	23.2	0.01	20.9	15.3	<0.5	<0.5	<0.3	93
2BBKW006.76	Blackwater Creek near Rt. 291 bridge		0.47	<0.02	1.6	0.06	40.7	25.8	<0.01	17.0	12.1	<0.5	<0.5	<0.3	47
2BJMS258.54	James River near Rt. 29 bridge		0.43	0.03	7.5	0.15	15.3	20.9	<0.01	15.1	16.5	<0.5	<0.5	<0.3	74
2BHAZ007.16	Harris Creek near Rt. 130		0.49	0.06	**12.2**	0.03	21.4	20.9	0.01	11.1	11.3	<0.5	<0.5	<0.3	68
2BPNY003.06	Piney River near Rt. 674	1.34	1.96	<0.02	<0.5	0.11	10.9	12.2	0.11	13.2	23.1	<0.5	<0.5	<0.3	102
2BMIN002.00	Mill Creek Reservoir	1.17	3.50	<0.02	<0.5	<0.01	0.6	25.8	0.04	20.3	<0.1	<0.5	<0.5	<0.3	**150**
2BSHS001.00	Stonehouse Lake	3.00	3.24	<0.02	<0.5	0.05	24.2	22.5	0.10	13.4	36.0	<0.5	<0.5	<0.3	**221**
2BJMS213.00	James River near Wingina at State Widlife Mngmt Area	0.84	0.91	<0.02	1.3	0.28	25.3	18.4	**0.38**	12.1	20.7	<0.5	<0.5	<0.3	81
2BJMS176.63	James River downstream of Rt. 15	2.15	1.40	<0.02	<0.5	**1.28**	51.8	33.8	**0.49**	**28.6**	22.9	<0.5	<0.5	<0.3	88
2BJMS157.28	James River near Rt. 45 bridge	0.84	0.99	<0.02	0.8	0.22	23.7	17.6	0.10	13.2	18.1	<0.5	<0.5	<0.3	67
2BJMS127.50	James River at Rt. 652 end, Watkins Landing	2.65	1.41	<0.02	<0.5	0.38	31.3	29.3	**0.40**	18.6	25.2	<0.5	<0.5	<0.3	119

Table 5 . VADEQ 2005 Sediment Metals Results for York River Basin. (continued)

			%	ppm[1] (dry weight basis)											
DEQ rivermile	Stream name/location/description	% TOC[2]	Al	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
NOAA's Effects Range-Median (ERM)		>>>>	**	**3.7**	**70**	**9.6**	**370**	**270**	**0.71**	**51.6**	**218**	**	**	**	**410**
NOAA's Effects Range-Low (ERL)		>>>>	**	**1**	**8.2**	**1.2**	**81**	**34**	**0.15**	**20.9**	**46.7**	**	**	**	**150**
Freshwater Consensus-Based Probable Effect Concentration (PEC)				**NA**	**33**	**4.98**	**111**	**149**	**1.06**	**48.6**	**128**				**459**
Fresh Tidal James River Basin below fall line															
2CJMS091.00	James River Off Deep Bottom Landing	3.06	1.91	0.16	3.1	0.60	30.5	**42.1**	**0.80**	**29.1**	38.9	<0.5	<0.5	<0.3	**241**
2CPTH000.23	Poythress Creek	1.56	0.97	**4.50**	1.8	0.53	35.2	**52.4**	**0.86**	14.4	**47.0**	<0.5	<0.5	<0.3	**196**
2CGRV000.57	Gravelly Run	1.72	1.67	**1.19**	6.5	0.47	26.9	**85.2**	**2.00**	**22.3**	45.5	<0.5	<0.5	<0.3	**273**
2CBLY000.65	Bailey Creek near Rt. 10 bridge		0.08	0.38	**14.3**	0.40	20.6	**34.1**	0.11	10.2	21.8	<0.5	<0.5	<0.3	134
2CCTC000.02	Cattail Creek	1.36	0.96	0.39	**9.9**	0.95	33.1	**52.5**	**2.53**	7.5	**60.6**	<0.5	<0.5	<0.3	**226**
2CJMS074.44	James River near Jordan Point, Rt. 156		0.25	0.37	**9.9**	0.27	14.8	23.4	0.05	11.1	13.8	<0.5	<0.5	<0.3	76
2CHEC006.22	Harrison Lake (Herring Creek)	5.38	1.21	0.03	0.7	0.61	43.8	14.9	0.05	**20.9**	35.6	<0.5	<0.5	<0.3	85
2CJMS057.69	James River near Bachelor Point, Buoy 74A		0.96	**3.26**	**24.4**	0.51	32.1	**48.2**	0.11	**24.9**	29.9	<0.5	<0.5	<0.3	**165**
Fresh Tidal James River Basin - Chickahominy River watershed															
2CCHK023.64	Chickahominy River near Chickahominy Shores (Below \	3.76	1.94	0.04	3.0	0.57	28.7	24.4	**0.33**	16.3	31.3	<0.5	<0.5	<0.3	**175**
2CDCD007.54	Diascund Creek Reservoir		0.41	<0.02	1.5	0.12	10.6	12.9	0.02	5.5	10.8	<0.5	<0.5	<0.3	20
2CLTL001.20	Little Creek Reservoir	1.00	0.51	<0.02	1.5	<0.01	10.2	3.5	0.01	11.2	7.6	<0.5	<0.5	<0.3	8.8
2CCHK002.17	Chickahominy River near Rt. 5	1.65	2.06	0.11	2.7	0.35	21.8	28.0	**0.56**	12.1	28.2	<0.5	<0.5	<0.3	105
Lower James River Basin															
2CJMS040.03	James River Off southern tip of Jamestown Island		0.72	**1.02**	**22.2**	0.39	26.9	**38.2**	0.05	**22.1**	28.4	<0.5	<0.5	<0.3	133
2CJMS021.04	James River near Buoy 12		0.13	<0.02	**9.3**	0.07	11.5	19.6	0.02	9.0	11.4	<0.5	<0.5	<0.3	59
2CJMS013.10	James River near Rt. 17		0.55	0.13	**13.6**	0.12	13.7	25.7	0.01	11.5	15.7	<0.5	<0.5	<0.3	73
2CPGN006.03	Pagan River near Rt. 10		0.26	0.09	**18.4**	0.24	26.1	**34.6**	0.04	18.5	22.0	<0.5	<0.5	<0.3	100
2CWWK011.48	Newport News Reservoir at Rt. 105 bridge (Warwick Cre	3.46	2.33	0.08	2.8	<0.01	40.2	**145.0**	0.07	20.8	<0.1	<0.5	<0.5	<0.3	130
Lower James River Basin - Elizabeth River watershed															
2CWLY001.37	Willoughby Bay near I-64	1.51	0.56	0.05	**26.5**	0.59	43.6	**37.8**	**0.60**	**26.5**	27.0	<0.5	<0.5	<0.3	**197**
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River	1.60	1.50	0.31	5.0	**7.08**	12.5	**60.2**	**2.21**	**23.8**	**53.6**	<0.5	<0.5	<0.3	**315**
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge	1.39	0.74	0.39	**27.4**	1.06	43.8	**63.9**	**1.63**	**29.9**	**53.6**	<0.5	<0.5	<0.3	**527**
2CWBE006.18	Western Branch Elizabeth River	3.22	0.47	0.10	**19.2**	0.90	55.8	**69.9**	**2.07**	**35.5**	**52.0**	<0.5	<0.5	<0.3	**523**
2CEBE001.20	Eastern Branch Elizabeth River	0.62	0.75	0.08	3.4	<0.01	11.7	**56.6**	**0.18**	6.7	<0.1	<0.5	<0.5	<0.3	**176**
2CSBE006.00	Southern Branch Elizabeth River	2.88	1.94	0.06	8.1	0.46	41.8	**89.4**	**1.93**	**23.5**	**53.9**	<0.5	<0.5	<0.3	**292**
2CSTJ000.81	St. Julian Creek	2.26	1.98	<0.02	8.0	<0.5	47.8	**89.0**	**2.62**	**22.9**	**51.6**	<0.5	<0.5	<0.3	**317**
2CDEC000.54	Deep Creek near I-64	0.58	0.33	0.02	1.0	<0.01	18.8	19.7	0.04	7.1	<0.1	<0.5	<0.5	<0.3	59

VADEQ 2005 Sediments PCBs Results for James River.

DEQ rivermile	Stream name/location/description	% TOC[2]	ppb[1] (dry weight basis) Total PCB[3]
NOAA's Effects Range-Median (ERM)		>>>>>	**180**
NOAA's Effects Range-Low (ERL)		>>>>>	**22.7**
Freshwater Consensus-Based Probable Effect Concentration			**676**
Upper James River Basin			
2AJKS047.06	Lake Moomaw	0.28	0.00
2AJKS022.50	Jackson River near Covington	0.95	81.68
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate	1.09	0.00
2ACWP002.55	Cowpasture River near Rt. 633	1.37	0.00
2AJMS309.13	James River near Rt. 11 bridge at Buchanan	1.38	0.00
Upper James River Basin - Maury River watershed			
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park	4.33	18.52
2AMRY011.23	Maury River near Buena Vista	0.65	0.00
Middle James River Basin			
2BJMS279.41	James River below Blue Ridge Parkway near Big Island	1.19	0.00
2BHAZ007.16	Harris Creek near Rt. 130	1.33	0.00
2BBKW006.76	Blackwater Creek near Rt. 291 bridge	0.97	0.12
2BJMS258.54	James River near Rt. 29 bridge	1.77	0.00
2BPNY003.06	Piney River near Rt. 674	1.34	0.00
2BSHS001.00	Stonehouse Lake	3.00	0.00
2BMIN002.00	Mill Creek Reservoir	1.17	0.36
2BJMS213.00	James River near Wingina at State Widlife Management Area	0.84	0.00
2BJMS176.63	James River downstream of Rt. 15	2.15	0.00
2BJMS157.28	James River near Rt. 45 bridge	0.84	1.06
2BJMS127.50	James River near Rt. 652 end, Watkins Landing	2.65	0.00
Fresh Tidal James River Basin below fall line			
2CJMS091.00	James River Off Deep Bottom Landing	3.06	1.05
2CPTH000.23	Poythress Creek near Station Street	1.56	**2170.22**
2CGRV000.57	Gravelly Run near Hummel Ross Road	1.72	19.39
2CCTC000.02	Cattail Creek near confluence with Bailey Creek	1.36	**1145.97**
2CBLY000.65	Bailey Creek near Rt. 10 bridge	1.25	**361.80**
2CHEC006.22	Harrison Lake (Herring Creek)	5.38	0.00
2CJMS074.44	James River near Jordan Point, Rt. 156	0.66	48.76
2CJMS057.69	James River near Bachelor Point, Buoy 74A	1.70	71.13
Fresh Tidal James River Basin - Chickahominy River watershed			
2CCHK023.64	Chickahominy River below Walkers Dam	3.76	2.79
2CDCD007.54	Diascund Creek Reservoir	2.89	0.23
2CLTL001.20	Little Creek Reservoir	1.00	0.00
2CCHK002.17	Chickahominy River near Rt. 5	1.65	1.48
Lower James River Basin			
2CJMS040.03	James River near Lower Point at Jamestown Island	1.89	15.22
2CWWK011.48	Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	3.46	34.57
2CJMS021.04	James River near Buoy 12	0.62	0.00
2CPGN006.03	Pagan River near Rt. 10	1.19	1.68
2CJMS013.10	James River near Rt. 17	0.52	**0.56**
Lower James River Basin - Elizabeth River watershed			
2CWLY001.37	Willoughby Bay near I-64	1.51	19.61
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River	1.60	31.91
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge on Churchland Rd	1.39	7.55
2CWBE006.18	Western Branch Elizabeth River	3.22	7.27
2CEBE001.20	Eastern Branch Elizabeth River	0.62	14.06
2CSTJ000.81	St. Julian Creek	2.26	39.85
2CSBE006.00	Southern Branch Elizabeth River	2.88	103.60
2CDEC000.54	Deep Creek near I-64	0.58	21.49

VA DEQ 2005 Sediments Pesticides Results for James River.

			ppb[1] (dry weight basis)					
DEQ		%	Total[4]	Sum	Sum	Sum		Total[8]
rivermile	Stream name/location/description	TOC[2]	Chlordane	DDE[5]	DDD[6]	DDT[7]	DDMU[15]	DDT
NOAA's Effects Range-Median		>>>>	**6**	**27**	**20**	**7**	**	**46.1**
NOAA's Effects Range-Low		>>>>	**0.5**	**2.2**	**2**	**1**	**	**1.58**
Freshwater Consensus-Based Probable Effect Concentration			**17.6**	**31.3**	**28**	**62.9**		**572**
Upper James River Basin								
2AJKS047.06	Lake Moomaw	0.28		0.46	0.42			0.88
2AJKS022.50	Jackson River near Covington	0.95		0.28	0.37			0.64
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate	1.09	0.52	0.32	0.46	0.75		1.53
2ACWP002.55	Cowpasture River near Rt. 633	1.37		0.25	0.43	0.43		1.12
2AJMS309.13	James River near Rt. 11 bridge at Buchanan	1.38		0.35	0.50	0.83		1.68
Upper James River Basin - Maury River watershed								
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park	4.33		0.42	0.72			1.14
2AMRY011.23	Maury River near Buena Vista	0.65		0.34	0.45	0.70		1.48
Middle James River Basin								
2BJMS279.41	James River below Blue Ridge Parkway near Big Island	1.19		0.29	0.53	**11.70**		12.52
2BHAZ007.16	Harris Creek near Rt. 130	1.33		1.10	3.09	3.24		7.43
2BBKW006.76	Blackwater Creek near Rt. 291 bridge	0.97	0.46	0.37	0.53	0.32		1.21
2BJMS258.54	James River near Rt. 29 bridge	1.77		0.28	0.44	0.52		1.23
2BPNY003.06	Piney River near Rt. 674	1.34		0.51	1.38	**7.92**		9.81
2BSHS001.00	Stonehouse Lake	3.00			6.02	**19.60**		25.62
2BMIN002.00	Mill Creek Reservoir	1.17			0.10	0.68		0.78
2BJMS213.00	James River near Wingina at State Widlife Management Area	0.84			0.23	**7.62**		7.85
2BJMS176.63	James River downstream of Rt. 15	2.15			1.06	**13.10**		14.16
2BJMS157.28	James River near Rt. 45 bridge	0.84			0.37	5.14		5.51
2BJMS127.50	James River near Rt. 652 end, Watkins Landing	2.65			0.65	**13.67**		14.32
Fresh Tidal James River Basin below fall line								
2CJMS091.00	James River Off Deep Bottom Landing	3.06	1.17		1.12	**10.57**		11.69
2CPTH000.23	Poythress Creek near Station Street	1.56	**11.13**	4.95	1.88	**16.71**		23.54
2CGRV000.57	Gravelly Run near Hummel Ross Road	1.72			1.48	**15.12**		16.60
2CCTC000.02	Cattail Creek near confluence with Bailey Creek	1.36	**53.30**	4.98	9.38	**10.34**		24.70
2CBLY000.65	Bailey Creek near Rt. 10 bridge	1.25	3.79	2.91	14.47			17.38
2CHEC006.22	Harrison Lake (Herring Creek)	5.38			1.14	2.96		4.09
2CJMS074.44	James River near Jordan Point, Rt. 156	0.66		2.18	3.27			5.45
2CJMS057.69	James River near Bachelor Point, Buoy 74A	1.70		5.08	7.09	**9.29**		21.46
Fresh Tidal James River Basin - Chickahominy River watershed								
2CCHK023.64	Chickahominy River below Walkers Dam	3.76			1.42	**9.39**		10.82
2CDCD007.54	Diascund Creek Reservoir	2.89		0.52	0.94			1.47
2CLTL001.20	Little Creek Reservoir	1.00			0.07			0.07
2CCHK002.17	Chickahominy River near Rt. 5	1.65			1.19	**7.96**		9.15
Lower James River Basin								
2CJMS040.03	James River near Lower Point at Jamestown Island	1.89		1.83	2.02	**8.99**		12.85
2CWWK011.48	Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	3.46			2.27	**25.26**		27.53
2CJMS021.04	James River near Buoy 12	0.62		0.43	0.50	0.46		1.39
2CPGN006.03	Pagan River near Rt. 10	1.19		1.28	2.43			3.71
2CJMS013.10	James River near Rt. 17	0.52		0.53	0.54	0.67		1.73
Lower James River Basin - Elizabeth River watershed								
2CWLY001.37	Willoughby Bay near I-64	1.51		1.25	1.33	5.41		7.99
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River	1.60	1.64	12.54	9.36	6.56	3.27	31.73
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge on Churchland Rd	1.39		2.17	1.78	4.18		8.13
2CWBE006.18	Western Branch Elizabeth River	3.22	1.18	2.06	2.96	**7.39**		12.41
2CEBE001.20	Eastern Branch Elizabeth River	0.62	0.19		3.81	**136.42**	0.80	**141.03**
2CSTJ000.81	St. Julian Creek	2.26	**8.43**	**38.66**	**32.51**		12.81	**83.99**
2CSBE006.00	Southern Branch Elizabeth River	2.88	0.70		5.02			5.02
2CDEC000.54	Deep Creek near I-64	0.58			0.45		0.15	0.60

Pesticides (sediment) - James River continued

		ppb[1] (dry weight basis)							
DEQ		Total		Heptachlor	Heptachlor				*
rivermile	Stream name/location/description	BDE[9]	HCB[10]	.	epoxide	PCA[11]	Mirex	OCDD[14]	cpd 1
NOAA's Effects Range-Median		**	**	**	**	**	**	**	
NOAA's Effects Range-Low		**	**	**	**	**	**	**	
Freshwater Consensus-Based Probable Effect Concentration				16					
Upper James River Basin									
2AJKS047.06	Lake Moomaw							11.03	
2AJKS022.50	Jackson River near Covington								
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate	1.26							
2ACWP002.55	Cowpasture River near Rt. 633	0.29						0.27	
2AJMS309.13	James River near Rt. 11 bridge at Buchanan	0.21						0.20	
Upper James River Basin - Maury River watershed									
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park	1.04						0.85	
2AMRY011.23	Maury River near Buena Vista	0.24						0.33	
Middle James River Basin									
2BJMS279.41	James River below Blue Ridge Parkway near Big Island	1.13						0.72	
2BHAZ007.16	Harris Creek near Rt. 130	0.27						0.44	
2BBKW006.76	Blackwater Creek near Rt. 291 bridge								
2BJMS258.54	James River near Rt. 29 bridge	0.21							
2BPNY003.06	Piney River near Rt. 674	1.67						0.97	
2BSHS001.00	Stonehouse Lake	1.38						5.03	
2BMIN002.00	Mill Creek Reservoir	0.05						0.71	
2BJMS213.00	James River near Wingina at State Widlife Management Area	0.75						0.51	
2BJMS176.63	James River downstream of Rt. 15	4.08						0.61	
2BJMS157.28	James River near Rt. 45 bridge	1.43						0.44	
2BJMS127.50	James River near Rt. 652 end, Watkins Landing	17.77						1.21	
Fresh Tidal James River Basin below fall line									
2CJMS091.00	James River Off Deep Bottom Landing	4.37						1.68	
2CPTH000.23	Poythress Creek near Station Street	6.04						2.17	
2CGRV000.57	Gravelly Run near Hummel Ross Road	3.53	0.32					2.22	
2CCTC000.02	Cattail Creek near confluence with Bailey Creek	14.32	1.69					9.20	
2CBLY000.65	Bailey Creek near Rt. 10 bridge	2.10	0.37				2.68	2.42	
2CHEC006.22	Harrison Lake (Herring Creek)							2.98	
2CJMS074.44	James River near Jordan Point, Rt. 156	0.41						0.40	
2CJMS057.69	James River near Bachelor Point, Buoy 74A							4.30	
Fresh Tidal James River Basin - Chickahominy River watershed									
2CCHK023.64	Chickahominy River below Walkers Dam	1.30						3.66	
2CDCD007.54	Diascund Creek Reservoir							4.21	
2CLTL001.20	Little Creek Reservoir	0.03						1.64	
2CCHK002.17	Chickahominy River near Rt. 5	0.26						2.45	
Lower James River Basin									
2CJMS040.03	James River near Lower Point at Jamestown Island							4.94	
2CWWK011.48	Newport News Reservoir near Rt. 105 bridge (Warwick Creek)							10.01	
2CJMS021.04	James River near Buoy 12							0.85	
2CPGN006.03	Pagan River near Rt. 10							3.81	
2CJMS013.10	James River near Rt. 17	0.10						1.74	
Lower James River Basin - Elizabeth River watershed									
2CWLY001.37	Willoughby Bay near I-64	1.70						3.75	
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River							4.85	
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge on Churchland Rd							3.79	
2CWBE006.18	Western Branch Elizabeth River							7.57	
2CEBE001.20	Eastern Branch Elizabeth River	1.38						1.08	
2CSTJ000.81	St. Julian Creek								
2CSBE006.00	Southern Branch Elizabeth River							7.56	
2CDEC000.54	Deep Creek near I-64							1.08	

VA DEQ 2005 Sediment PAHs Results for James River.

			ppb[1] (dry weight basis)										ppb[1] (dry weight basis)									
DEQ rivermile	Stream name/location/description	% TOC[2]	Total PAH[3]	Total PAH[31]	Total PAH[33]	High MW[4] PAH	Low MW PAH	NAP[5] .	NAP 2-Me[6]	NAP 1-Me[7]	biphenyl .	diphenyl ether	NAP d-Me[8]	NAP d-Me[81]	NAP d-Me[82]	NAP d-Me[83]	NAP d-Me[84]	naphthylene ace~	NAP d-Me[85]	NAP d-Me[86]	naphthene ace~	furan dibenzo	NAP t-Me[9]
NOAA's Effects Range-Median		>>>>>			44792	9600	3160	2100	670	**	**		**					640			500		**
NOAA's Effects Range-Low		>>>>>			4022	1700	552	160	70	**	**		**					44			16		**
Freshwater Consensus-Based Probable Effect Concentration					22800	NA	NA	561	NA									NA			NA		
Upper James River Basin																							
2AJKS047.06	Lake Moomaw	0.28	8.58	8.53	8.53	2.57	2.36	0.92	0.00	0.34	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.16
2AJKS022.50	Jackson River near Covington	0.95																					
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate	1.09																					
2ACWP002.55	Cowpasture River near Rt. 633	1.37																					
2AJMS309.13	James River near Rt. 11 bridge at Buchanan	1.38																					
Upper James River Basin - Maury River watershed																							
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park	4.33																					
2AMRY011.23	Maury River near Buena Vista	0.65																					
Middle James River Basin																							
2BJMS279.41	James River below Blue Ridge Parkway near Big Island	1.19																					
2BHAZ007.16	Harris Creek near Rt. 130	1.33																					
2BBKW006.76	Blackwater Creek near Rt. 291 bridge	0.97	3209.01	3165.57	3153.42	1691.25	290.09	2.24	4.17	3.27	0.70	0.00	1.40	2.64	2.59	1.00	0.35	3.91	0.72	0.00	4.67	5.74	3.46
2BJMS258.54	James River near Rt. 29 bridge	1.77																					
2BPNY003.06	Piney River near Rt. 674	1.34																					
2BSHS001.00	Stonehouse Lake	3.00	992.00	984.28	982.56	27.37	13.81	3.75	2.11	1.06	0.71	0.00	10.84	0.77	0.94	0.33	0.33	0.43	0.16	0.03	0.38	1.20	0.00
2BMIN002.00	Mill Creek Reservoir	1.17	25.84	21.74	20.78	3.10	8.46	4.14	1.94	1.12	0.58	0.00	0.80	0.66	1.67	0.38	0.37	0.21	0.23	0.02	0.28	0.88	0.71
2BJMS213.00	James River near Wingina at State Widlife Management Area	0.84																					
2BJMS176.63	James River downstream of Rt. 15	2.15																					
2BJMS157.28	James River near Rt. 45 bridge	0.84																					
2BJMS127.50	James River near Rt. 652 end, Watkins Landing	2.65																					
Fresh Tidal James River Basin below fall line																							
2CJMS091.00	James River Off Deep Bottom Landing	3.06	1472.40	1433.83	1422.73	536.13	108.26	11.03	10.53	6.29	3.55	0.81	5.26	4.92	8.46	2.82	2.81	9.79	1.42	0.00	1.63	7.99	5.14
2CPTH000.23	Poythress Creek near Station Street	1.56																					
2CGRV000.57	Gravelly Run near Hummel Ross Road	1.72																					
2CCTC000.02	Cattail Creek near confluence with Bailey Creek	1.36																					
2CBLY000.65	Bailey Creek near Rt. 10 bridge	1.25																					
2CHEC006.22	Harrison Lake (Herring Creek)	5.38	647.72	639.91	634.82	106.96	44.52	9.85	2.96	1.49	1.75	0.42	2.70	1.24	1.37	0.64	0.20	1.48	0.28	0.00	1.30	3.05	0.57
2CJMS074.44	James River near Jordan Point, Rt. 156	0.66																					
2CJMS057.69	James River near Bachelor Point, Buoy 74A	1.70																					
Fresh Tidal James River Basin - Chickahominy River watershed																							
2CCHK023.64	Chickahominy River below Walkers Dam	3.76																					
2CDCD007.54	Diascund Creek Reservoir	2.89	410.29	396.95	391.78	57.62	26.44	3.74	2.43	1.95	2.44	0.00	2.69	1.38	4.35	0.74	1.54	0.76	0.38	1.83	0.54	4.73	3.25
2CLTL001.20	Little Creek Reservoir	1.00	40.01	36.71	36.00	12.16	8.60	3.47	1.52	0.82	0.38	0.21	0.58	0.49	1.67	0.27	0.26	0.23	0.12	0.00	0.26	0.41	0.27
2CCHK002.17	Chickahominy River near Rt. 5	1.65																					
Lower James River Basin																							
2CJMS040.03	James River near Lower Point at Jamestown Island	1.89																					
2CWWK011.48	Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	3.46	1781.55	1747.97	1738.41	349.05	79.35	6.59	7.56	4.67	1.73	0.17	9.53	5.71	3.93	2.88	1.15	5.30	1.52	0.08	2.38	5.80	3.40
2CJMS021.04	James River near Buoy 12	0.62																					
2CPGN006.03	Pagan River near Rt. 10	1.19																					
2CJMS013.10	James River near Rt. 17	0.52																					
Lower James River Basin - Elizabeth River watershed																							
2CWLY001.37	Willoughby Bay near I-64	1.51																					
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River	1.60																					
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge on Churchland Rd	1.39																					
2CWBE006.18	Western Branch Elizabeth River	3.22																					
2CEBE001.20	Eastern Branch Elizabeth River	0.62	4991.72	4918.24	4887.10	2815.11	323.02	21.35	17.52	8.79	4.15	0.17	11.02	8.08	4.71	4.34	1.36	13.28	2.35	0.00	14.46	19.48	3.45
2CSTJ000.81	St. Julian Creek	2.26																					
2CSBE006.00	Southern Branch Elizabeth River	2.88																					
2CDEC000.54	Deep Creek near I-64	0.58	875.77	864.65	859.11	379.60	52.43	7.20	4.49	2.27	1.35	0.12	2.46	1.70	1.15	0.87	0.33	6.94	0.49	0.02	2.23	3.91	0.53

PAHs (sediment) - for James River continued

			ppb[1] (dry weight basis)							
DEQ rivermile	Stream name/location/description	% TOC[2]	FTH benzo(b)	FTH benzo(k)	pyrene benzo(e)	pyrene benzo(a)	perylene .	pyrene IND[13]	ATH db(a,h)[14]	perylene benzo(ghi)
NOAA's Effects Range-Median		>>>>>	**	**	**	1600	**	**	260	**
NOAA's Effects Range-Low		>>>>>	**	**	**	430	**	**	63.4	**
Freshwater Consensus-Based Probable Effect Concentration						**1450**			**NA**	
Upper James River Basin										
2AJKS047.06	Lake Moomaw	0.28	0.00	0.00	0.00	0.00	2.70	0.00	0.00	0.00
2AJKS022.50	Jackson River near Covington	0.95								
2AJKS000.38	Jackson River near Rt. 727 at Iron Gate	1.09								
2ACWP002.55	Cowpasture River near Rt. 633	1.37								
2AJMS309.13	James River near Rt. 11 bridge at Buchanan	1.38								
Upper James River Basin - Maury River watershed										
2AMRY020.82	Maury River upstream Rt. 39 at the Chessie Trail Park	4.33								
2AMRY011.23	Maury River near Buena Vista	0.65								
Middle James River Basin										
2BJMS279.41	James River below Blue Ridge Parkway near Big Island	1.19								
2BHAZ007.16	Harris Creek near Rt. 130	1.33								
2BBKW006.76	Blackwater Creek near Rt. 291 bridge	0.97	308.92	252.56	183.59	210.73	79.13	173.94	20.31	147.29
2BJMS258.54	James River near Rt. 29 bridge	1.77								
2BPNY003.06	Piney River near Rt. 674	1.34								
2BSHS001.00	Stonehouse Lake	3.00	8.05	6.29	5.61	5.11	895.84	5.84	0.84	5.53
2BMIN002.00	Mill Creek Reservoir	1.17	1.45	0.78	0.94	0.11	0.44	1.19	0.21	0.83
2BJMS213.00	James River near Wingina at State Widlife Management Area	0.84								
2BJMS176.63	James River downstream of Rt. 15	2.15								
2BJMS157.28	James River near Rt. 45 bridge	0.84								
2BJMS127.50	James River near Rt. 652 end, Watkins Landing	2.65								
Fresh Tidal James River Basin below fall line										
2CJMS091.00	James River Off Deep Bottom Landing	3.06	182.62	178.11	120.18	79.78	61.64	117.54	17.55	89.28
2CPTH000.23	Poythress Creek near Station Street	1.56								
2CGRV000.57	Gravelly Run near Hummel Ross Road	1.72								
2CCTC000.02	Cattail Creek near confluence with Bailey Creek	1.36								
2CBLY000.65	Bailey Creek near Rt. 10 bridge	1.25								
2CHEC006.22	Harrison Lake (Herring Creek)	5.38	23.43	18.45	12.06	11.39	394.84	14.10	1.61	10.44
2CJMS074.44	James River near Jordan Point, Rt. 156	0.66								
2CJMS057.69	James River near Bachelor Point, Buoy 74A	1.70								
Fresh Tidal James River Basin - Chickahominy River watershed										
2CCHK023.64	Chickahominy River below Walkers Dam	3.76								
2CDCD007.54	Diascund Creek Reservoir	2.89	15.13	4.25	4.88	2.37	260.38	6.72	0.47	4.28
2CLTL001.20	Little Creek Reservoir	1.00	2.82	2.15	1.77	1.80	1.66	2.13	0.38	2.14
2CCHK002.17	Chickahominy River near Rt. 5	1.65								
Lower James River Basin										
2CJMS040.03	James River near Lower Point at Jamestown Island	1.89								
2CWWK011.48	Newport News Reservoir near Rt. 105 bridge (Warwick Creek)	3.46	76.31	66.23	52.05	61.82	997.97	46.58	7.03	42.35
2CJMS021.04	James River near Buoy 12	0.62								
2CPGN006.03	Pagan River near Rt. 10	1.19								
2CJMS013.10	James River near Rt. 17	0.52								
Lower James River Basin - Elizabeth River watershed										
2CWLY001.37	Willoughby Bay near I-64	1.51								
2CLAF003.00	Lafayette River near Rt. 460, Elizabeth River	1.60								
2CWBE002.11	Western Branch Elizabeth River near Rt. 17 bridge on Churchland Rd	1.39								
2CWBE006.18	Western Branch Elizabeth River	3.22								
2CEBE001.20	Eastern Branch Elizabeth River	0.62	502.53	456.38	275.13	348.79	89.70	212.93	38.25	156.53
2CSTJ000.81	St. Julian Creek	2.26								
2CSBE006.00	Southern Branch Elizabeth River	2.88								
2CDEC000.54	Deep Creek near I-64	0.58	124.72	107.46	77.57	88.67	22.47	48.86	8.64	35.58

Table. 6 VADEQ – Fish Tissue and Sediment Toxics Evaluation Fish Tissue and Sediment Monitoring Program. [http://www.deq.state.va.us/fishtissue/background.html]

RISK BASED SCREENING VALUES (SV) FOR FISH TISSUE BASED ON THE SAME TOXICOLOGICAL DATA USED FOR CALCULATING THE HUMAN HEALTH WATER QUALITY CRITERIA IN 9 VAC-25-260-140.B UNDER "ALL OTHER WATERS" FOR GENERAL POPULATION (ADULT)

BODY WEIGHT (KG)	70
RISK LEVEL	10^{-5}
CONSUMPTION RATE (KG/DAY)	0.0065

COMPOUND	CAS No.	Non Carcinogen Screening Value	Carcinogen Screening Value
		(wet weight) ppb	(wet weight) ppb
Acenaphthene	83-32-9	650,000	
Aldrin	309-00-2	320	6.3
Anthracene	120-12-7	3,200,000	
Antimony	7440-36-0	4,300	
Benzene	71-43-2		3,700
Benzo(a)anthracene	56-55-3		15
Benzo(b)fluoranthene	205-99-2		15
Benzo (k)fluoranthene	207-08-9		15
Benzo(a)pyrene	50-32-8		15
Bromoform	75-25-2		14,000
Butyl benzyl phthalate	85-68-7	2,200,000	
Carbon tetrachloride	56-23-5		830
Total Chlordane	57-74-9	650	310*
Chlorodibromomethane	124-48-1	220,000	
Chloroform	67-66-3		18,000
2-Chlorophenol	95-57-8	54,000	
Chrysene	218-01-9		15
Cyanide	57-12-5	220,000	
DDD	72-54-8		450
DDE	72-55-9		320
Total DDT	50-29-3	5,380	320
Dibenz(a,h)anthracene	53-70-3		15
Dibutyl phthalate	84-74-2	1,100,000	
Dichloromethane	75-09-2		14,000
1,2-Dichlorobenzene	95-50-1	970,000	
1,3-Dichlorobenzene	541-73-1	140,000	
1,4-Dichlorobenzene	106-46-7	140,000	
Dichlorobromomethane	75-27-4		1,700
1,2-Dichloroethane	107-06-2		1,200
1,1-Dichloroethylene	75-35-4	97,000	
2,4-Dichlorophenol	120-83-2	32,000	
Dieldrin	60-57-1	540	6.7
Diethyl phthalate	84-66-2	8,600,000	
Di-2-ethylhexyl phthalate	117-81-7		7,700
2,4-Dimethylphenol	105-67-9	220,000	
2,4-Dinitortoluene	121-14-2		350
Dioxin	1746-01-6		0.0062
Endosulfan (I and II)	115-29-7	65,000	
Endrin	72-20-8	3,200	
Ethylbenzene	100-41-4	1,100,000	
Fluoranthene	206-44-0	430,000	
Fluorene	86-73-7	430,000	
Heptachlor	76-44-8	5,400	24
Hexachlorocyclohexane (lindane) or BHC - gamma	58-89-9	3,200	

Indeno(1,2,3-cd)pyrene	193-39-5		15
Isophrone	78-59-1	2,200,000	
Mercury (Methyl)	22967-92-6	1,100	
Monochlorobenzene	108-90-7	220,000	
Nickel	744-00-2	220,000	
Nitrobenzine	98-95-3	5,400	
PCB Total/congeners	1336-36-3	220	54*
Pentachlorophenol	87-86-5		900
Phenol	108-95-2	6,500,000	
Pyrene	129-00-0	320,000	
Selenium	7782-49-2	54,000	
Tetracholoethylene	127-18-4	110,000	
Toluene	108-88-3	2,200,000	
Toxaphene	8001-35-2	2,700	98
1,2,4-Trichlorobenzene	120-82-1	110,000	
Trichloroethylene	79-01-6		860
2,4,6-Trichlorophenol	88-06-2		9,800
Vinyl Chloride	75-01-4		6,200

* These screening values are based in EPA recommended cancer slope factors for these compounds which have been updated since DEQ adopted the water quality criteria. These screening values have been used by DEQ in previous years in assessing fish tissue.

RISK BASED SCREENING VALUES (SV) FOR FISH TISUE UPDATED FROM INTEGRATED RISK INFORMATION SYSTEM (IRIS) FOR GENERAL POPULATION (ADULT)

BODY WEIGHT (KG)	70
RISK LEVEL	10^{-6}
CONSUMPTION RATE (KG/DAY)	0.0065

COMPOUND	CAS No.	Non Carcinogen Screening Value	Carcinogen Screening Value
		(wet weight) ppb	(wet weight) ppb
Arsenic (inorganic)	74440-38-2	3,200	72**
Barium	7440-39-3	750,000	
Benzene	71-43-2		2,000**
BHC alpha	319-84-6		20
BHC beta	319-85-7		60
Total BHC isomers	608-93-1		20
Brominated Diphenyl Ethers			5,000

(BDEs)			
Cadmium	7440-43-9	11,000	
Chromium III	16065-83-1	16,000,000	
Chromium VI	18540-29-9	32,000	
Chlorpyrifos	2921-88-2	32,000	
Diazinon	333-41-5	970	
Dicofol	115-32-2	11,000	
Dioxin	1746-01-6		0.003**
Disulfoton	298-04-4	430	
Ethion	563-12-2	54,000	
Heptachlor epoxide	1024-57-3	140	10
Hexachlorobenzene	118-74-1	8,600	70
Kepone	143-50-0	300	
Mercury (Methyl)	22967-92-6	300 (EPA 2001) 500 (VDH 2000)	
Methoxychlor	72-43-5	54,000	
Mirex	2385-85-5	2,200	
Oxyfluorfen	42874-03-3	32,000	830
PAH (sum PEC)***			15
PCB Total/congeners	1336-36-3	220	54
Terbufos	13071-79-9	1,400	
Toxaphene	8001-35-2	2,700	100
Tributyltin	56-35-9	320	
Selenium	7782-49-2	54,000	
Vinyl Chloride	75-01-4		72**

CAS No. = Chemical Abstract Service Number
ppb = parts per billion

** These screening values are based on recent changes to the toxicological data used to calculate the screening values, or recent recommendations from U.S. EPA or the Virginia Department of Health. These screening values are not based on the same toxicological data that were used to develop the existing water quality criteria.

*** Mixtures of seven polynuclear aromatic hydrocarbons (PAHs) that are classed as probable human carcinogens were assessed based on a screening value concentration of 15 ppb calculated as a sum potency equivalency concentration (PEC) using methods described in EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 1, (EPA 823-R-95-007) and Vol. 2 (EPA 823 B-00-008) using the following equation:

$$PEC = \sum_{i} (RP_i \times C_i)$$

where; RP_i = relative potency for the ith PAH
C_i = concentration of the ith PAH in fish tissue)

The relative potency estimates used for these PAHs were:

Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.145
Benzo(b) fluoranthene	0.167
Benzo(k)fluoranthene	0.020
Chrysene	0.0044
Dibenz(a,h)anthracene	1.11
Indeno(1,2,3-cd)pyrene	0.055

• **Sediment (aquatic life use)**

Like the sediment monitoring and analysis conducted by Water Quality Standards and Biological Programs, the regional offices will assess the AWQM sediment data. Sediment contaminant data collected during scheduled AWQM monitoring should be compared to National Oceanic and Atmospheric Administration (NOAA 1995) effects range-medium (ER-M) SVs for sediment. If the ER-M is not available, use the VA 99th percentiles (Table 7). One or more exceedences of an ER-M value results in a fully supporting but threatened status for aquatic life use support. In these cases, additional biological monitoring should be scheduled to assess actual aquatic life use support.

Table 7 Sediment criteria for use in the assessment of aquatic life support.

• **Trace Elements –parts per million (ppm), dry weight**

Substance		**ER-M Value**	**99th %tile**
		Dry weight	dry weight
		Ppm	ppm
Antimony (Sb)		NA	
Arsenic(As)		70	
Beryllium (Be)		NA	5.0
Cadmium (Cd)		9.6	
Chromium (Cr)		370	
Copper (Cu)		270	
Lead (Pb)		218	
Manganese (Mn)		NA	
Mercury(Hg)		0.71	
Nickel (Ni)		51.6	
Selenium (Se)		NA	20.0
Silver (Ag)		3.7	
Thallium (Tl)		NA	13.5
Zinc (Zn)		410	

• **Pesticides and Other Organic Substances –parts per billion (ppb), dry weight**

Substance	CAS No.	ER-M Value	99th %tile
		Dry weight	dry weight
		Ppb	Ppb
Polychlorinated Biphenyls (PCBs)	1336-36-3	180	
Aldrin	309-00-2	NA*	
Total Chlordane	57-74-9	6	
DDD	72-54-8	20	
DDE	72-55-9	27	
DDT	50-29-3	7	
Total DDT (include metabolites)	NA	46.1	
Dieldrin	60-57-1	8**	
Endrin	72-20-8	NA	
Heptachlor	76-44-8	NA	
Heptachlor epoxide	1024-57-3	NA	
Hexachlorobenzene	118-74-1	NA	
Total BHC isomers Hexachlorocyclohexane	608-73-1	NA	
BHC gamma Lindane	58-89-9	NA	
Mirex	2385-85-5	NA	
Phenol	108-95-2	NA	
Di-2-ethylhexyl phthalate	117-81-7	NA	
N-Butyl phthalate	84-74-2	NA	
Acenapthene	83-32-9	500	
Acenapthylene	208-96-8	640	
Anthracene	120-12-7	1,100	
Benzo(a)pyrene	50-32-8	1,600	
Benzo(g,h,i)perylene	191-24-2	NA	
Benz(a)anthracene	56-55-3	1,600	
Chrysene	218-01-9	2,800	
Dibenz (a,h)anthracene	53-70-3	260	
Fluoranthene	206-44-0	5,100	
Fluorene	86-73-7	540	
Indeno[1,2,3-cd]pyrene	193-39-5	NA	
2-Methylnaphthalene	91-57-6	670	
Naphthalene	91-20-3	2,100	
Phenanthrene	85-01-8	1,500	
Pyrene	129-00-0	2,600	
Low Molecular Weight PAHs	NA	3,160	
High Molecular Weight PAHs	NA	9,600	
Total PAHs	NA	44,792	

- * NA implies not available
- ** (EPA proposed criteria)

Appendix 6: VIMS DATA

Tables

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Table 2. York River- VIMS Data……...262

Table 1. James River – VIMS Data.

VIMS Fish Metals Data for James River

Station	As(ppm)	Cd(ppm)	Cr(ppm)	Hg(ppm)	Pb(ppm)	Se(ppm)	Species
James River near Chippokes Pt., Buoy 71	<0.05	<0.01	<0.05	0.120777690494894	<0.1	<0.5	Morone saxatilis
Skiffes Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Dorosoma cepedianum
Skiffes Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Morone americanus
Skiffes Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Micropogonias undulatus
Skiffes Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Leiostomus xanthrus
Chickahominy River near Rt. 5 bridge Kepone Sample	<0.05	<0.01	<0.05	5.8524987426272E-02	<0.1	<0.5	Morone saxatilis
Chickahominy River near Rt. 5 bridge Kepone Sample	<0.05	<0.01	<0.05	0.147171989226626	<0.1	<0.5	Morone saxatilis
Chickahominy River near Rt. 5 bridge Kepone Sample	<0.05	<0.01	0.71377192497	0.120621922204393	<0.1	<0.5	Morone saxatilis
Chickahominy River near Rt. 5 bridge Kepone Sample	<0.05	0.32445668809	<0.05	0.068870523415978	<0.1	<0.5	Morone saxatilis
Chickahominy River near Rt. 5 bridge Kepone Sample	<0.05	0.042181424423	<0.05	0.080720578825614	<0.1	<0.5	Morone saxatilis

Sediment Organics for James River.

Location	James River	James River	Skiffes Creek	James River near Dancing Point	Chickahominy River near Rt. 5 Bridge
Sample Date	6/10/1997	6/10/1997	9/10/2001	7/8/2004	4/7/2004
River Mile	2-JMS053.34	2-JMS059.24	2-SFF000.17	2-JMS055.XX	2-CHK002.17
Compound	Cdry (ppm)				
Total PCBs	13.88916725	59.556361	20.313902	1.4942529	2.2875817
DDT,4,4'-	4.469385624	3.821842432	ND	ND	ND
DDE,4,4'-	1.555266023	4.401264191	1.042600989	ND	ND
DDD,4,4'-	0.722517312	1.790939927	ND	ND	ND

Fish Organics for James River (ppb).

Species	Total PCBs	DDT,4,4'-	DDE,4,4'-	DDD,4,4'-
Skiffes Creek (Collected 9/10/2001)				
Shadd, gizzard	1027.098	3.727	83.257	12.833
Perch, white	280.738	2.336	24.109	ND
Croaker, Atlantic	310.109	2.674	17.501	ND
Spot	272.349	2.994	21.246	ND
James River near Bachelor Pt., Buoy 74A (Collected 7/3/2002)				
Perch, white	175.112	ND	ND	ND
Catfish, white	422.538	ND	ND	ND
Shadd, gizzard	1091.014	ND	ND	ND
Catfish, channel	587.500	ND	ND	ND
James River near Chippokes Pt., Buoy 71 (Collected 7/3/2002)				
Bass, largemouth	114.669	ND	ND	ND
James River near Chippokes Pt., Buoy 71 (Collected 7/10/2002)				
Carp, common	8520.107	64.858	823.794	59.104
Catfish, blue	1355.225	6.316	177.974	10.835
Bass, Striped	551.632	ND	ND	ND
Catfish, channel	969.840	ND	ND	ND
Catfish, white	2016.478	ND	ND	ND
Perch, white	68.330	ND	ND	ND
Shad, gizzard	759.721	ND	ND	ND
Bass, largemouth	232.050	ND	ND	ND
Crappie, black	71.823	ND	ND	ND
Bass, largemouth	54.979	ND	ND	ND
James River near Chippokes Pt., Buoy 71 (Collected 5/8/2003)				
Catfish, blue	13328.285	111.037	1931.533	190.580
Chickahominy River near Rt. 5 bridge (Collected 4/7/2004)				
Bass, striped	2093.001	ND	ND	ND
Chickahominy River near Rt. 5 bridge (Collected 4/27/2004)				
Bass, striped	5889.8872	ND	ND	ND

Sediment Metals for James River.

Analyte	Concentration
Aluminum (%)	0.78
Silver (ppm)	<0.02
Arsenic	<0.5
Cadmium	<0.01
Chromium	49
Copper	37
Mercury	0.13
Nickel	15
Lead	11
Antimony	<0.5
Selenium	<0.5
Thallium	<0.3
Zinc	68

VIMS Data for James River Sediment Organics (Collected 6/10/1997)

Compound	Cdry (ppm)
PCB-52	0.379797578
PCB-44	0.27958712
PCB-70	0.374787062
PCB-95	0.947990775
Chlordane,trans-	0.398837566
PCB-90,101	0.707485735
PCB-99	0.600260556
DDE,4,4'-	1.555266023
PCB-110	1.005110741
PCB-149	0.745565712
PCB-118	1.65848279
DDD,4,4'-	0.722517312
PCB-153,132	0.936967611
PCB-105	0.126265153
DDT,4,4'-	4.469385624
PCB-138,158	1.918027878
PCB-187	0.526104808
PCB-174	0.330694467
PCB-180	1.80479002
PCB-170,190	0.416875452
PCB-199	0.239502952
PCB-196,203	0.259545058
PCB-209	0.631325781
Dibenzodioxin,octachloro-	1.772722721

VIMS Data for James River Sediment Organics (Collected 6/10/1997)

Compound	Cdry (ppm)
PCB-34	0.6063444
Unidentified halogenated compound	0.3956456
PCB-28,31	0.9832612
PCB-33,20	0.3242421
PCB-52	1.2138593
PCB-49	1.0453002
PCB-47,75,48	1.4901088
PCB-44	1.3941238
PCB-37,42,59	1.5837528
PCB-41,64	1.1424558
PCB-40	0.5981506
Heptachlor epoxide	0.4190565
PCB-70	1.2887745
PCB-95	2.8725271
PCB-91	0.1896289
Chlordane,trans-	0.225916
PCB-60,56	1.2782395
PCB-92	0.5068477
PCB-84	0.7128643
PCB-90,101	2.6150064
PCB-99	1.5708767
Nonachlor,trans-	0.3101955
PCB-83	0.8685473
Chlordane(7)	0.3698935
PCB-87,115	0.7023294
DDE,4,4'-	4.4012642
PCB-85	3.6486013
PCB-136	0.4518319
PCB-110	3.0539622
Unidentified halogenated compound	0.2294276
PCB-82,151	0.7152054
PCB-135	0.6121971
PCB-149	2.5951071
PCB-118	4.2760153
DDD,4,4'-	1.7909399
Nonachlor,cis-	0.620391
PCB-146	0.4483203
PCB-153,132	3.1359007
PCB-105	2.1456163
Unidentified halogenated compound	0.3464825
PCB-179,141	0.4389559
DDT,4,4'-	3.8218424
PCB-138,158	4.2233405
PCB-187	1.3402786
PCB-183	0.5173827
PCB-128	0.6285848
PCB-174	0.776074
PCB-177	0.4857778
PCB-171,156	0.6367787
PCB-180	2.9930937
PCB-170,190	0.6438019
PCB-199	0.4342737
PCB-196,203	0.4424675
PCB-194	0.2657146
PCB-209	1.6598384
Dibenzodioxin,octachloro-	1.6528152

VIMS Data for James River, Skiffes Creek Sediment Organics (Collected 9/10/2001)

Compound	Cdry (ppm)
PCB-49	0.2690583
PCB-47,75,48	0.3026906
PCB-95	0.4820628
PCB-90,101	0.8744395
PCB-99	0.6502242
DDE,4,4'-	1.042601
PCB-136	0.3251121
PCB-110	1.1883408
PCB-82,151	0.2914798
PCB-149	1.6816144
PCB-118	0.706278
PCB-146	0.4035875
PCB-153,132	2.7578478
PCB-179,141	0.616592
PCB-138,158	2.836323
PCB-187	0.9753364
PCB-183	0.3026906
PCB-174	0.6614349
PCB-177	0.4035875
PCB-180	1.6591929
PCB-170,190	0.7623318
PCB-199	0.3811659
PCB-196,203	0.4147982
PCB-194	0.4147982
PCB-209	0.9529148
Dibenzodioxin,octachloro-	3.5426011

VIMS Data for James River, Skiffes Creek Fish Organics (Collected 9/10/2001)

Shad, gizzard

Compound	Cdry (ng/g)
Unknown tetra-BDE	7.7178903
PCB-183	18.096331
PCB-128	8.75
PCB-167	2.6261468
PCB-185	2.5229359
PCB-174	21.68578
PCB-187	63.360092
PCB-171,156	14.461009
PCB-158	8.9334869
PCB-172	5.4931192
PCB-177	15.619267
PCB-153,132	160.77982
PCB-175	1.1697248
PCB-178,129	10.493119
PCB-138,158	81.215599
DDT,4,4'-	3.7270644
PCB-176,137	9.9770641
PCB-130	1.6399082
PCB-179,141	21.5711
PCB-105	4.7706423
Unidentified Halogenated Cpd	2.0412846
Unidentified Halogenated Cpd	3.0160553
Unidentified Halogenated Cpd	1.0091743
Unidentified Halogenated Cpd	1.3302753
PCB-146	29.208715
Unidentified Halogenated Cpd	1.674312
Unidentified Halogenated Cpd	2.1674314
PCB-209	18.761469
Unidentified Halogenated Cpd	0.8027523
PCB-206	9.2889919
PCB-205	0.5963303
PCB-194	18.268349
BDE-100	1.4334863
Unidentified Halogenated Cpd	0.8715597
Unidentified Halogenated Cpd	1.7431194
PCB-189	0.8027523
Aroclor 5460	11.123854
PCB-196,203	20.424313
PCB-199	19.415138
Unidentified Halogenated Cpd	1.2844037
PCB-170,190	26.479359
Unidentified Halogenated Cpd	1.2958716
PCB-193	1.3876147
Unidentified Halogenated Cpd	0.9862386
BDE-47	21.020643
PCB-95	28.899084
PCB-180	65.091743
PCB-208,195	9.7477064
PCB-47,75,48	13.80734

Compound	Cdry (ng/g)
PCB-70	6.7316513
PCB-74	2.5802753
Heptachlor epoxide	1.7660551
Unidentified Halogenated Cpd	3.2339449
Unidentified Halogenated Cpd	1.4449542
Chlordane(1)	2.1444955
Unidentified Halogenated Cpd	1.1811926
PCB-41,64	5.3899083
PCB-37,42,59	2.6376147
PCB-52	12.018349
PCB-49	10.240827
PCB-22,51	2.1559634
PCB-28,31	2.0412846
Chlordane cpd	1.2385322
Anisole,pentachloro-	0.630734
Benzene,hexachloro-	0.6422018
PCB-91 + Chlordane cpd	20.550459
Nonachlor,cis-	13.715597
PCB-44	5.1949544
PCB-82,151	20.27523
PCB-53	1.2844037
Chordane cpd	3.9449544
DDD,4,4'-	12.832569
PCB-118	30.160551
PCB-149	78.876144
Unidentified Halogenated Cpd	1.8463304
PCB-135	11.387615
Unidentified Halogenated Cpd	0.7568808
PCB-110	43.864681
PCB-136	10.722478
DDE,4,4'-	83.256882
DDE,2,4'- + PCB-84	9.7821102
Chlordane,trans-	5.6192665
PCB-107	5.9633026
PCB-92 + Chlordane cpd	26.525229
PCB-87,115	7.1215601
PCB-90,101	42.465595
PCB-99 + Chlordane,cis-	56.628445
Nonachlor,trans-	11.433487
Unidentified Halogenated Cpd	1.364679
Unidentified Halogenated Cpd	0.9288991
PCB-83	3.6009176
PCB-97	6.9724774
Unidentified Halogenated Cpd	3.2224772

VIMS Data for James River, Skiffes Creek Fish Organics (Collected 9/10/2001)

Perch, white

Compound	Cdry (ng/g)
PCB-185	0.8176615
PCB-167	0.9695129
PCB-128	2.6398785
PCB-183	5.3147998
PCB-187	22.053497
PCB-178,129	2.604836
PCB-138,158	29.727837
DDT,4,4'-	2.3361757
PCB-146	8.6672115
PCB-179,141	4.5672235
PCB-153,132	50.029205
PCB-118	6.5996966
DDD,4,4'- + Nonachlor,cis-	7.4991241
PCB-206	1.4250672
PCB-174	3.6210723
PCB-176,137	1.0512791
BDE-47	6.7749095
PCB-99 + Chlordane,cis-	13.491415
PCB-149	20.523304
PCB-209	4.6723514
PCB-194	3.8196473
PCB-196,203	4.5088191
PCB-208,195	2.1025581
PCB-170,190	7.7327414
PCB-177	3.4341784
PCB-180	19.308493
PCB-172	0.8176615
Unidentified Halogenated Cpd	1.1330452
Unknown tetra-BDE	2.2777715
PCB-171,156	3.3056886
PCB-199	3.9948604
PCB-47,75,48	3.0136666
PCB-95	6.5880151
PCB-66	1.3666627
Heptachlor epoxide + PCB-74	0.8176615
Chlordane(1)	0.7826189
Unidentified Halogenated Cpd	1.06296
PCB-49	2.3011332
PCB-52	4.0766268
PCB-29	1.2732158
PCB-107	1.8105361
Unidentified Halogenated Cpd	0.8994276
Unidentified Halogenated Cpd	1.0746409
PCB-110	12.451817
PCB-135	2.698283
PCB-44	1.1213644
PCB-82,151	5.4900126
PCB-91 + Chlordane cpd	3.6210723
PCB-136	3.0253475

Compound	Cdry (ng/g)
DDE,4,4'-	24.109333
PCB-87,115	2.020792
PCB-97	1.6353229
Nonachlor,trans-	1.8689406
PCB-90,101	13.269478
DDE,2,4'- + PCB-84 + Chlordane(5)	2.674921
PCB-92	4.2868824
Chlordane,trans-	0.9928747
Chlordane cpd	1.530195

VIMS Data for James River, Skiffes Creek Fish Organics (Collected 9/10/2001)

Croaker, Atlantic

Compound	Cdry (ng/g)
PCB-176,137	1.0164623
PCB-177	5.004972
PCB-174	4.9718266
PCB-167	1.1711413
PCB-128	3.6570544
PCB-183	4.8281956
PCB-187	17.688654
PCB-178,129	3.0935807
PCB-105	4.7840018
DDT,4,4'-	2.6737378
PCB-146	6.8279748
PCB-179,141	5.2590876
PCB-153,132	46.635731
PCB-171,156	2.9720473
PCB-138,158	30.725885
PCB-199	4.4414983
DDD,4,4'- + Nonachlor,cis-	6.7285385
Unidentified Halogenated Cpd	1.2263838
PCB-206	1.5909845
PCB-207	0.9833168
PCB-208,195	2.4306707
PCB-194	4.540935
PCB-196,203	4.1542373
Unknown tetra-BDE	2.7400289
PCB-170,190	8.0875044
PCB-209	4.8834386
BDE-47	3.0935807
PCB-180	20.08618
PCB-172	1.4031599
Unidentified Halogenated Cpd	1.2042868
Chlordane(1)	1.1158988
PCB-118	9.2475967
PCB-66	1.9445366
PCB-52	6.1208706
PCB-49	4.5298862
PCB-47,75,48	4.7398076
PCB-44	2.2759914
PCB-95	11.402055
PCB-91 + Chlordane cpd	11.755608
Chlordane(3)	1.9887304
Chlordane,trans-	2.28704
PCB-92	5.6457853
DDE,4,4'-	17.50083
PCB-107	1.602033
PCB-149	22.671528
DDE,2,4'- + PCB-84 + Chlordane(5)	3.6018119
PCB-135	2.3201854
PCB-82,151	4.6845651
PCB-136	3.7785881
PCB-87,115	2.8063197
PCB-97	2.4417193
Unidentified Halogenated Cpd	1.2374324
Nonachlor,trans-	2.1655066
PCB-99 + Chlordane,cis-	16.860016
PCB-90,101	17.832283
PCB-110	14.827091

VIMS Data for James River, Skiffes Creek Fish Organics (Collected 9/10/2001)

Spot

Compound	Cdry (ng/g)
PCB-187	17.649084
PCB-149	19.167402
DDT,4,4'-	2.9935606
PCB-183	5.2225785
PCB-178,129	2.6920509
PCB-138,158	29.472574
PCB-176,137	1.0445157
PCB-179,141	5.3841019
PCB-105	3.4673615
PCB-153,132	43.611225
PCB-146	8.9053049
PCB-118	8.4853449
PCB-128	3.284302
PCB-206	1.0983567
DDD,4,4'- + Nonachlor,cis-	10.682058
PCB-180	17.896755
PCB-209	2.8966467
PCB-92 + DDE, 2,4'-	11.134322
PCB-194	3.4996662
PCB-107	1.8952038
PCB-196,203	3.639653
PCB-199	3.2196929
PCB-208,195	1.6690714
BDE-47	3.3596795
PCB-167	1.2275752
PCB-172	1.5721577
Unknown tetra-BDE	2.2720909
PCB-171,156	3.1227791
PCB-177	5.0502877
PCB-174	2.8105011
PCB-170,190	7.8715568
PCB-66	1.3460255
PCB-52	4.2749767
PCB-49	3.6288846
PCB-47,75,48	4.9749098
PCB-44	1.5829259
Unidentified Halogenated Cpd	1.4967803
Unidentified Halogenated Cpd	1.0983567
Chlordane(1)	0.796847
PCB-90,101	16.48612
PCB-70	1.1521978
PCB-135	1.9598131
PCB-95	6.4286175
PCB-97	1.852131
PCB-82,151	5.7071481
PCB-110	13.514095
PCB-136	3.5858116
Heptachlor epoxide + PCB-74	0.9368337
PCB-87,115	2.7889645
Unidentified Halogenated Cpd	1.0552839
Unidentified Halogenated Cpd	1.0122111
Nonachlor,trans-	2.1105678
PCB-99 + Chlordane,cis-	16.292292
PCB-84 + Chlordane(5)	3.2089248
Chlordane,trans-	1.5290848
Chlordane cpd	1.2598797
PCB-91 + Chlordane cpd	6.4393859
DDE,4,4'-	21.245665

VIMS Data for James River near Chippokes Pt., Buoy 71 Fish Organics (Collected 9/10/2001)

Carp, common

Compound	Cdry (ng/g)
PCB-26	0.0962696
Unidentified Halogenated Cpd	0.6137184
Benzene,hexachloro-	0.1805054
Anisole,pentachloro-	0.5535499
PCB-18	0.4091456
PCB-17,15	0.156438
PCB-16,32	0.2286402
Unidentified Halogenated Cpd	0.3008424
Unidentified Halogenated Cpd	0.3730445
Heptachlor + chlordene, alpha-	0.2527076
PCB-53	0.6859206
PCB-41,64	4.2358603
PCB-22,51	0.2647413
PCB-45	0.6498196
Unidentified Halogenated Cpd	1.0108303
PCB-46	0.1925391
PCB-52	9.0734053
PCB-49	7.2563181
PCB-37,42,59	3.826715
PCB-83	4.0914564
PCB-92	6.8471723
Chlordene + dihydroheptachlor	1.2033695
PCB-44	4.5968714
PCB-60,56	5.5836339
PCB-135	6.9795432
C3-Dihydroheptachlor	0.746089
PCB-91	9.4825516
PCB-66,95	17.039711
PCB-70	3.3333333
PCB-74	2.6955476
Chlordane(5)	4.5848374
Chlordane,trans-	3.0084236
PCB-87,115	7.3044529
PCB-28,31	2.8038507
PCB-90,101	36.269554
PCB-99	23.586042
Chlordane, cis-	6.8592057
Nonachlor,trans-	5.1263542
PCB-82,151	12.912153
PCB-97	6.6305661
DDE,4,4'-	80.914558
PCB-136	6.3537908
PCB-110	29.08544
Unidentified Halogenated Cpd	0.4693141
PCB-40	3.1167269
DDT,4,4'-	5.7641397
PCB-149	38.038509
PCB-118	32.021664
BDE-28	2.8760531
DDD,4,4'-	7.8219013
PCB-122,131	0.8062575
Nonachlor,cis-	7.0878458
PCB-146	20.300844
PCB-153,132	98.953072

VIMS Data for James River near Dancing Point Sediment Organics (Collected 7/8/2004)

Compound	Cdry (ppm)
PCB 153, 132	0.6896552
PCB 138, 158	0.3448276
PCB 180, 193	0.4597701

VIMS Data for James River, Chickahominy River near Rt. 5 bridge Sediment Organics (Collected 4/7/2004)

Compound	Cdry (ppm)
PCB 153, 132	1.30718958
PCB 180, 193	0.98039216

Table 2. York River- VIMS Data.

York River Fish Metals(VIMS)

DateColl	Station	As(ppm)	Cd(ppm)	Cr(ppm)	Hg(ppm)	Pb(ppm)	Se(ppm)	Species
6/16/2003	York River near Buoy 59 at West Point	<0.05	<0.01	<0.05	2.31709721948334E-02	<0.1	<0.5	Dorosoma cepedianum
6/16/2003	York River near Buoy 59 at West Point	<0.05	<0.01	<0.05	6.22762712695533E-02	<0.1	<0.5	Micropogonias undulatus
6/16/2003	York River near Buoy 59 at West Point	<0.05	0.064242753229	<0.05	7.47264104572657E-02	<0.1	<0.5	Callinectes sapidus
7/28/2003	York River near Purtan Island	<0.05	0.056044835869	<0.05	5.50440352281826E-02	<0.1	<0.5	Callinectes sapidus
7/28/2003	York River near Purtan Island	<0.05	<0.01	<0.05	0.130500907619094	<0.1	<0.5	Micropogonias undulatus
7/28/2003	York River near Purtan Island	<0.05	<0.01	<0.05	0.042624749917427	<0.1	<0.5	Dorosoma cepedianum
7/28/2003	York River near Purtan Island	<0.05	<0.01	<0.05	5.09189661025169E-02	<0.1	<0.5	Leiostomus xanthrus
7/31/2003	York River between Ferry Pt. & Clay bank	<0.05	0.032140571935	<0.05	8.21971747797411E-02	<0.1	<0.5	Callinectes sapidus
7/31/2003	York River between Ferry Pt. & Clay bank	<0.05	<0.01	<0.05	5.49702244617499E-02	<0.1	<0.5	Dorosoma cepedianum
7/31/2003	York River between Ferry Pt. & Clay bank	<0.05	<0.01	<0.05	0.160778289810548	0.45622119816	<0.5	Micropogonias undulatus
6/1/2000	York River near Carter Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Dorosoma cepedianum
6/1/2000	York River near Carter Creek (Set A)	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Micropogonias undulatus
6/1/2000	York River near Carter Creek (Set B)	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Micropogonias undulatus
6/1/2000	York River near Carter Creek	<0.5	0.05	0.28	<0.01	<0.1	<0.5	Callinectes sapidus
6/5/2000	York River near West Point	<0.5	0.031	<0.05	<0.01	<0.1	<0.5	Leiostomus xanthrus
6/5/2000	York River near West Point	<0.5	<0.01	<0.05	0.022	<0.1	<0.5	Micropogonias undulatus
6/5/2000	York River near West Point	<0.5	<0.01	<0.05	0.012	<0.1	<0.5	Dorosoma cepedianum
6/5/2000	York River near West Point	<0.5	<0.01	<0.05	0.031	<0.1	<0.5	Callinectes sapidus
6/5/2000	York River near West Point	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Fundulus heteroclitus
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Paralichthys dentatus
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	<0.05	0.042	<0.1	<0.5	
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	<0.05	0.026	<0.1	<0.5	Micropogonias undulatus
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	<0.05	0.019	<0.1	<0.5	Leiostomus xanthrus
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	<0.05	0.028	<0.1	<0.5	Callinectes sapidus
7/5/2000	York River at Rt. 17 Bridge	<0.5	<0.01	0.14	0.02	<0.1	<0.5	Fundulus heteroclitus

York River Fish Metals, Queen Creek

DateColl	Station	As(ppm)	Cd(ppm)	Cr(ppm)	Hg(ppm)	Pb(ppm)	Se(ppm)	Species
7/29/2003	Queen Creek upstream of Rt. 64 near Rt. 132	<0.05	<0.01	0.11025743365	0.023947315905009	<0.1	<0.5	Dorosoma cepedianum
7/29/2003	Queen Creek upstream of Rt. 64 near Rt. 132	<0.05	<0.01	0.23831215536	4.17166147206905E-02	0.70486693838	<0.5	Fundulus heteroclitus
7/30/2003	Queen Creek near Camp Peary	<0.05	<0.01	<0.05	6.11695620259359E-02	<0.1	<0.5	Fundulus heteroclitus
7/30/2003	Queen Creek near Camp Peary	<005	<0.01	<0.05	0.122094148908439	<0.1	<0.5	Micropogonias undulatus
7/30/2003	Queen Creek near Camp Peary	<0.05	<0.01	0.076072623998	2.13003347195456E-02	<0.1	<0.5	Dorosoma cepedianum
7/29/2003	Queen Creek upstream of Rt. 64 near Rt. 132	<0.05	<0.01	<0.05	0.203464050801297	<0.1	<0.5	Morone americanus
7/30/2003	Queen Creek near Camp Peary	<0.05	0.034854437393	<0.05	3.22353178200866E-02	0.48201873678	<0.5	Callinectes sapidus
7/30/2003	Queen Creek near Camp Peary	<0.05	<0.01	0.12226446111	0.087845474160074	<0.1	<0.5	Morone americanus

York River Fish Metals, King Creek

DateColl	Station	As(ppm)	Cd(ppm)	Cr(ppm)	Hg(ppm)	Pb(ppm)	Se(ppm)	Species
8/5/2003	King Creek near Penniman Spit	0.46978247239	0.021993922732	0.12009839386	0.047749963825785	<0.1	<0.5	Callinectes sapidus
8/5/2003	King Creek near Penniman Spit	<0.05	<0.01	0.088902207572	0.182798921186695	0.16282089701	<0.5	Micropogonias undulatus
8/5/2003	King Creek near Penniman Spit	<0.05	<0.01	<0.05	2.52806419047086E-02	<0.1	<0.5	Dorosoma cepedianum
8/6/2003	King Creek near Penniman Lake	<0.05	<0.01	<0.05	2.37640130185463E-02	<0.1	<0.5	Dorosoma cepedianum
8/6/2003	King Creek near Penniman Lake	<0.05	<0.01	0.152846189	0.127456456608947	<0.1	<0.5	Micropogonias undulatus
8/5/2003	King Creek near Penniman Spit	<0.05	<0.01	<0.05	0.171580711961345	<0.1	<0.5	Fundulus heteroclitus
8/5/2003	King Creek near Penniman Spit	0.0888671875	<0.01	<0.05	0.20849609375	<0.1	<0.5	Leiostomus xanthrus
6/13/2000	King Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Paralichthys dentatus
6/13/2000	King Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Leiostomus xanthrus
6/13/2000	King Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Dorosoma cepedianum
6/13/2000	King Creek	<0.5	0.016	<0.05	<0.01	<0.1	<0.5	Callinectes sapidus
6/13/2000	King Creek	<0.5	<0.01	<0.05	0.005	<0.1	<0.5	Micropogonias undulatus
6/13/2000	King Creek	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Fundulus heteroclitus

York River Fish Metals, Wormley Creek

DateColl	Station	As(ppm)	Cd(ppm)	Cr(ppm)	Hg(ppm)	Pb(ppm)	Se(ppm)	Species
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	0.01	<0.1	<0.5	Paralichthys dentatus
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Leiostomus xanthrus
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	0.012	<0.05	0.01	<0.1	<0.5	Micropogonias undulatus
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	0.034	<0.1	<0.5	
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	<0.01	<0.1	<0.5	Dorosoma cepedianum
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	0.022	<0.1	<0.5	Callinectes sapidus
6/14/2000	Wormley Creek at Amoco, Yorktown	<0.5	<0.01	<0.05	0.022	<0.1	<0.5	Fundulus heteroclitus

Fish Organics for the York River.

Species	Total PCB	DDT,4,4'-	DDE,4,4'-	DDD,4,4'-	DDT,2,4'-	DDE,2,4'-	DDD,2,4'-
York River near Carter Creek (Collected 6/1/2000)							
Shad, gizzard	712.665	3.815	57.153	7.153	5.559	ND	28.379
Croaker, Atlantic (set A)	183.027	ND	11.604	ND	0.440	ND	2.781
Croaker, Atlantic (set B)	157.345	ND	10.049	ND	0.536	ND	2.156
Crab, blue	80.207	ND	3.361	ND	ND	ND	ND
York River, King Creek (6/13/2000)							
Flounder, summer	119.987	ND	4.373	ND	ND	ND	1.162
Spot	346.132	2.039	14.726	2.166	0.633	ND	8.411
Shad, gizzard	1041.379	6.385	55.273	11.880	3.582	ND	28.910
Crab, blue	202.771	ND	13.813	1.276	ND	ND	2.277
Croaker, Atlantic	460.588	2.541	24.531	3.279	0.964	11.239	ND
Mummichog	419.432	2.548	25.906	2.174	ND	0.640	5.664
York River, Wormley Creek at Amoco, Yorktown (Collected 6/14/2000)							
Flounder, summer	102.019	ND	4.182	ND	ND	ND	1.843
Spot	211.769	1.318	21.283	2.879	4.451	1.896	6.520
Croaker, Atlantic	309.785	2.542	25.751	3.627	4.237	1.944	11.220
Bluefish	277.793	1.731	17.096	0.999	1.870	ND	9.117
Shad, gizzard	775.753	7.345	37.503	8.451	9.231	5.469	23.857
Crab, blue	120.401	ND	4.478	ND	1.748	ND	2.172
Mummichog	252.923	1.323	7.963	1.139	2.750	0.955	4.787
York River near West Point (Collected 6/5/2000)							
Spot	112.666	ND	5.231	0.956	ND	ND	3.340
Croaker, Atlantic	165.075	ND	11.961	0.981	0.948	0.959	6.433
Shad, gizzard	538.308	2.343	31.670	4.675	3.807	2.451	2.451
Crab, blue	81.100	ND	3.515	ND	ND	ND	ND
Mummichog	116.324	ND	6.069	ND	ND	ND	2.961
York River at Rt. 17 Bridge (Collected 7/30/2003)							
Croaker, Atlantic	224.229	ND	ND	ND	ND	ND	ND
Spot	44.266	ND	ND	ND	ND	ND	ND
Crab, blue	97.167	ND	ND	ND	ND	ND	ND
Perch, white	105.000	ND	ND	ND	ND	ND	ND
Mummichog	180.762	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	125.517	ND	ND	ND	ND	ND	ND
Shad, gizzard	857.64	ND	ND	ND	ND	ND	ND
York River between Ferry Pt. & Clay Bank (near Carter Creek), Collected 7/31/2003							
Spot	30.975	ND	ND	ND	ND	ND	ND
Crab, blue	907.423	ND	ND	ND	ND	ND	ND
Shad, gizzard	98.795	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	28.725	ND	ND	ND	ND	ND	ND
King Creek near Penniman Spit (Collected 8/5/2003)							
Croaker, Atlantic	484.538	ND	ND	ND	ND	ND	ND
Shad, gizzard	1324.622	ND	ND	ND	ND	ND	ND
Mummichog	295.259	ND	ND	ND	ND	ND	ND
Spot	572.114	ND	ND	ND	ND	ND	ND
Crab, blue	167.509	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	321.763	ND	ND	ND	ND	ND	ND
Shad, gizzard	285.000	ND	ND	ND	ND	ND	ND

York River Fish Organics continued.

Species	Total PCB	DDT,4,4'-	DDE,4,4'-	DDD,4,4'-	DDT,2,4'-	DDE,2,4'-	DDD,2,4'-
King Creek near Penniman Lake (Collected 8/6/2003)							
Shad, gizzard	1084.881	ND	ND	ND	ND	ND	ND
Perch, white	115.680	ND	ND	ND	ND	ND	ND
Shad, gizzard	775.758	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	391.221	ND	ND	ND	ND	ND	ND
Queen Creek upstream of Rt. 64 near Rt. 132 (Collected 7/29/2003)							
Perch, white	115.680	ND	ND	ND	ND	ND	ND
Shad, gizzard	594.970	ND	ND	ND	ND	ND	ND
Mummichog	105.523	ND	ND	ND	ND	ND	ND
York River near Buoy 59 at West Point (Collected 6/16/2003)							
Croaker, Atlantic	28.330	ND	ND	ND	ND	ND	ND
Shad, gizzard	376.225	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	251.892	ND	ND	ND	ND	ND	ND
Crab, blue	54.379	ND	ND	ND	ND	ND	ND
York River near Purtan Island (Collected 7/28/2003)							
Gar, longnose	81.198	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	17.477	ND	ND	ND	ND	ND	ND
Shad, gizzard	115.179	ND	ND	ND	ND	ND	ND
Perch, white	108.971	ND	ND	ND	ND	ND	ND
Crab, blue	53.079	ND	ND	ND	ND	ND	ND
Croaker, Atlantic	97.151	ND	ND	ND	ND	ND	ND
Shad, gizzard	411.513	ND	ND	ND	ND	ND	ND
Spot	34.974	ND	ND	ND	ND	ND	ND
Back Creek (Collected 6/10/1998)							
Crab, blue	ND	ND	5.183	ND	ND	ND	ND
Mummichog	22.842	ND	9.938	ND	ND	ND	ND
Spot	14.849	ND	8.877	ND	ND	ND	ND

Sediment Metals for York River.

DateColl	Station	Al%	Ag(ppm)	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
6/1/2000	York River near Carter Creek	1.4	<0.02	2.8	0.27	38	83	0.22	19	27	<0.5	<0.5	<0.3	121
6/14/2000	King Creek near York River	1.3	<0.02	<0.5	0.16	41	36	0.19	19	29	<0.5	<0.5	<0.3	101
6/15/2000	Wormley Creek at Amoco, Yorktown	1.2	<0.02	1.5	0.25	39	45	0.2	14	3	<0.5	<0.5	<0.3	89
6/6/2000	York River near West Point	1.6	<0.02	2	0.25	41	43	0.17	21	32	<0.5	<0.5	<0.3	126
7/6/2000	York River at Rt. 17 Bridge	1.3	<0.02	1.1	0.4	41	33	0.11	20	24	<0.5	<0.5	<0.3	81
7/31/2000	Felgates Creek at Felgates Road	1.6	0.74	2.9	0.28	37	27	0.15	17	27	<0.5	<0.5	<0.3	65
6/21/2000	Back Creek at Rt. 100	0.4	<0.02	1.3	0.06	16	21	0.047	11	9.6	<0.5	<0.5	<0.3	19
8/5/2003	King Creek near Penniman Spit	1.2	0.05	7.456	0.161	42.007	26.677	0.108	14.463	16.843	<0.5	<0.5	<0.3	106.510
8/6/2003	King Creek near Penniman Lake	1.3	0.068	8.444	0.115	45.613	27.747	0.118	15.401	20.162	<0.5	<0.5	<0.3	94.700
7/30/2003	Queen Creek near Camp Peary	1.2	0.061	5.951	0.323	35.267	39.241	0.153	15.736	26.624	<0.5	<0.5	1.838	82.426
7/29/2003	Queen Creek upstream of Rt. 64 near Rt. 132	0.7	0.035	3.313	0.220	19.162	27.645	0.072	8.184	19.940	<0.5	<0.5	0.845	39.651
7/31/2003	York River between Ferry Pt. & Clay bank	1.3	0.061	5.521	0.267	39.604	18.505	0.117	17.427	24.041	<0.5	<0.5	<0.3	101.354
6/16/2003	York River near Buoy 59 at West Point	1	0.055	4.069	0.403	29.151	15.222	0.081	12.576	19.899	<0.5	<0.5	<0.3	82.191
7/28/2003	York River near Purtan Island	0.9	0.077	3.659	0.210	28.811	15.153	0.093	14.236	20.138	<0.5	<0.5	0.962	80.441

Sediment Organics for the York River.

Total PCB	DDT,4,4'-	DDE,4,4'-	DDD,4,4'-	DDT,2,4'-	DDE,2,4'-	DDD,2,4'-
Back Creek at Rt. 618 (Rutrough Road), Collected 7/29/1999						
0.759	ND	ND	ND	ND	ND	ND
York River near Carter Creek, Collected 6/1/2000						
7.108	ND	0.783	0.133	ND	ND	1.100
York River near West Point, Collected 6/6/2000						
2.468	ND	ND	ND	ND	ND	ND
King Creek near York River, Collected 6/14/2000						
63.152	1.081	1.1964	0.767	ND	1.881	ND
Wormley Creek at Amoco, Yorktown, Collected 6/15/2000						
ND	ND	ND	ND	ND	ND	ND
York River at Rt. 17 Bridge, Collected 7/6/2000						
2.843	ND	ND	ND	ND	ND	1.456
Felgates Creek at Felgates Road, Collected 7/31/2000						
29.230	ND	0.506	ND	ND	ND	1.241
York River near Buoy 59, Collected 6/16/2003						
0.448	ND	ND	ND	ND	ND	ND
York River near Purtan Island, 7/28/2003						
1.201	ND	ND	ND	ND	ND	ND
Queen Creek upstream of Rt. 64 near Rt. 132, Collected 7/29/2003						
11.199	ND	ND	ND	ND	ND	ND
Queen Creek near Camp Peary, Collected 7/30/2003						
27.232	ND	ND	ND	ND	ND	ND
King Creek near Penniman Spit, Collected 8/5/2003						
73.432	ND	ND	ND	ND	ND	ND
King Creek near Penniman Lake, Collected 8/6/2003						
46.451	ND	ND	ND	ND	ND	ND
Sinking Creek, Collected 8/13/2004						
0.891	ND	ND	ND	ND	ND	ND

IMS Fish Organics Data for York River, Back Creek, (Collected 6/10/1998)

Crab, blue

Compound	Cdry
DDE,4,4'-	5.183002

VIMS Fish Organics Data for York River, Back Creek, (Collected 6/10/1998)

Mummichog

Compound	Cdry
PCB-138,158	4.711591
PCB-187	2.785204
PCB-153,132	8.059879
PCB-118	2.51877
DDE,4,4'-	9.93774
Nonachlor,trans-	2.039919
PCB-99 + cis chlordane	0.978758
PCB-149	1.815602
PCB-180	2.950925

VIMS Fish Organics Data for York River, Back Creek, (Collected 6/10/1998)

Spot

Compound	Cdry
PCB-187	1.705905
PCB-149	0.998649
PCB-138,158	4.062138
PCB-153,132	4.425897
DDE,4,4'-	8.876882
Nonachlor,trans-	1.572752
PCB-99 + cis chlordane	0.723659
PCB-180	1.638364
PCB-90,101	2.017561

VIMS Fish Organics Data for York River near Carter Creek., (Collected 6/1/2000)

Shad, gizzard

Compound	Cdry
PCB-138,158	48.66485
PCB-178,129	5.803815
PCB-187	34.00545
PCB-183	10.54496
PCB-128	1.103542
DDT,4,4'-	3.814714
PCB-122,131	5.122616
PCB-167	1.103542
PCB-128	3.405994
PCB-176,137	2.997275
PCB-179,141	7.275204
PCB-179,141	3.623978
Unidentified halogenated cpd	20.55858
Chlordane(K)	75.21798
PCB-153,132	80.01362
DDT,2,4'-	5.558583
DDD,4,4'-	7.152588
PCB-174	11.81199
PCB-146	13.37875
PCB-196,203	7.861035
Chlordane(C)	0.640327
DDE,4,4'-	57.15259
PCB-45	1.989101
PCB-134	6.13079
PCB-209	2.997275
BDE-116	4.441417
PCB-206	2.029973
PCB-52	4.86376
PCB-208,195	3.365123
Endrin ketone	13.26975
PCB-199	7.138964
PCB-170,190	13.20163
BDE-47	11.14441
PCB-180	5.13624
PCB-180	34.6594
Unknown tetra-BDE	23.36512
PCB-171,156	11.53951
PCB-177	10.08174
BDE-100	13.26975
PCB-66	9.237058
Chlordane(5)	21.63488
PCB-92	3.637602
PCB-60,56	6.307902
Chlordane,trans-	4.400545
Unidentified halogenated cpd	4.536785
PCB-91	3.746594
PCB-149	58.32425
PCB-90,101	27.73842

Compound	Cdry
PCB-136	5.817439
PCB-88	94.91825
Unidentified halogenated cpd	1.485014
PCB-74	1.566757
Heptachlor epoxide	1.185286
Chlordane(1)	2.438692
PCB-67,100	3.351499
PCB-44	1.702997
PCB-47,75,48	2.956403
PCB-49	3.80109
PCB-88	8.269754
PCB-77	7.098093
Endrin	6.485014
PCB-107	1.634877
PCB-95	8.269754
Endosulfan I	17.97003
PCB-82,151	10.35422
PCB-110	23.52861
PCB-135	6.185286
PCB-85	47.37057
PCB-83	3.283379
PCB-99	17.52044
Chlordane,cis-	11.9346
PCB-119	12.82016
DDD,2,4'-	28.37875
Nonachlor,trans-	9.836512
Chlordane(7)	6.226158
Chlordane(7)	2.60218
PCB-97	3.337875

VIMS Fish Organics Data for York River near Carter Creek (Set A)., (Collected 6/1/2000)

Croaker, atlantic

Compound	Cdry
PCB-178,129	0.983182
PCB-179,141	0.569211
Endrin ketone	1.021992
PCB-209	0.711514
PCB-138,158	10.50453
PCB-183	2.677878
PCB-174	0.905563
PCB-187	9.80595
PCB-177	1.112548
PCB-171,156	2.238034
PCB-180	10.75032
PCB-170,190	2.496766
PCB-199	1.720569
PCB-196,203	1.940492
PCB-206	0.72445
BDE-116	1.591203
Chlordane(K)	22.00517
Chlordane(5)	2.97542
BDE-100	2.496766
PCB-90,101	3.8163
PCB-153,132	23.41526
PCB-88	76.41656
Endosulfan I	4.631306
PCB-99	4.514877
PCB-119	1.293661
Nonachlor,trans-	0.983182
DDE,4,4'-	11.60414
PCB-85	9.624838
PCB-146	3.324709
DDD,2,4'-	2.781371
PCB-82,151	1.177232
Endosulfan II	10.75032
PCB-149	9.598965
PCB-122,131	0.401035
DDT,2,4'-	0.439845
PCB-110	2.302716

VIMS Fish Organics Data York River near Carter Creek (Set B)., (Collected 6/1/2000)

Croaker, atlantic

Compound	Cdry
Chlordane(K)	15.12789
PCB-179,141	0.523752
PCB-138,158	7.758831
PCB-178,129	0.767357
PCB-187	6.552984
PCB-183	1.510353
PCB-174	0.560292
Endrin ketone	0.633374
PCB-177	1.010962
PCB-196,203	0.974421
PCB-180	8.18514
PCB-170,190	1.559074
PCB-199	0.88916
PCB-153,132	16.10231
PCB-149	7.113277
PCB-171,156	1.668697
Endosulfan I	4.604141
PCB-85	8.331304
PCB-88	77.74665
DDT,2,4'-	0.535932
PCB-90,101	3.605359
PCB-146	2.338611
PCB-99	4.482339
PCB-119	2.460414
Nonachlor,trans-	1.887941
PCB-110	1.778319
DDD,2,4'-	2.155907
PCB-82,151	0.937881
PCB-122,131	0.487211
Nonachlor,cis-	1.961023
DDE,4,4'-	10.04872
Chlordane(5)	2.801462

VIMS Fish Organics Data for York River near Carter Creek, (Collected 6/1/2000)

Crab, blue

Compound	Cdry
PCB-88	66.90179
PCB-187	0.912863
PCB-138,158	1.383126
Chlordane(K)	3.070539
PCB-153,132	3.264177
PCB-85	2.780083
DDE,4,4'-	3.360996
PCB-119	0.760719
PCB-180	4.204702
Nonachlor,trans-	0.580913

VIMS Fish Organics Data for York River, near West Point, (Collected 6/5/2000)

Crab, blue

Compound	Cdry
PCB-85	2.918808
PCB-209	65.77595
PCB-138,158	1.243577
Chlordane(K)	3.288797
PCB-153,132	3.504625
PCB-187	0.791367
PCB-180	3.854059
PCB-99	1.726619
Endosulfan I	1.778006
PCB-90,101	1.284686
DDE,4,4'-	3.514902

VIMS Fish Organics Data for York River, near West Point, (Collected 6/5/2000)

Spot

Compound	Cdry
PCB-183	0.633803
PCB-134	0.82495
DDD,4,4'-	0.955734
PCB-146	1.177062
Endrin aldehyde	1.237424
PCB-153,132	11.19718
Chlordane(K)	10.52314
PCB-118	2.283702
PCB-187	2.585513
BDE-47	6.156941
PCB-180	5.150905
PCB-170,190	0.955734
BDE-100	1.619718
PCB-194	0.764588
PCB-209	64.38631
PCB-138,158	4.195171
PCB-196,203	0.643863
Endosulfan II	2.344064
PCB-90,101	3.380281
Endosulfan I	3.400403
PCB-99	3.319919
DDD,2,4'-	3.34004
Endosulfan II	2.565392
PCB-119	1.146881
PCB-149	2.293762
PCB-82,151	0.623742
PCB-110	2.7666
PCB-85	4.336016
DDE,4,4'-	5.231388
Nonachlor,trans-	0.885312

VIMS Fish Organics Data for York River, near West Point, (Collected 6/5/2000)

Croaker, atlantic

Compound	Cdry
PCB-128	0.743534
Endrin aldehyde	2.37069
PCB-174	0.818965
PCB-187	5.075431
PCB-178,129	0.980603
PCB-138,158	8.297413
PCB-183	1.573276
PCB-179,141	0.969828
PCB-146	2.262931
PCB-153,132	15.96983
Endrin ketone	0.926724
PCB-194	0.818965
DDT,2,4'-	0.948276
Chlordane(K)	15.01078
PCB-177	0.625
PCB-171,156	1.206897
Unknown tetra-BDE	2.456897
PCB-180	5.290948
PCB-170,190	1.767241
PCB-199	0.926724
PCB-196,203	0.862069
BDE-100	1.734914
PCB-206	0.560345
BDE-116	1.217672
PCB-209	68.95474
DDD,4,4'-	0.980603
PCB-134	0.840517
PCB-208,195	0.635776
Nonachlor,trans-	1.573276
PCB-119	2.05819
PCB-99	6.185344
Endosulfan I	6.346982
PCB-90,101	5.226293
PCB-83	0.700431
PCB-84	0.797414
DDE,2,4'-	0.959052
PCB-95	1.023707
PCB-118	2.144397
PCB-122,131	0.872845
Chlordane(5)	0.614224
Endrin	0.948276
PCB-88	1.023707
PCB-97	0.9375
PCB-149	6.756465
Endosulfan II	7.575431
Endosulfan II	2.198276
PCB-135	0.905172
DDE,4,4'-	11.96121
DDD,2,4'-	6.433189
PCB-110	5.323276
PCB-77	1.896552
PCB-85	9.913793
PCB-82,151	1.163793
PCB-87,115	1.023707

VIMS Fish Organics Data for York River, near West Point, (Collected 6/5/2000)

Mummichog

Compound	Cdry
Chlordane(K)	10.94118
PCB-153,132	11.63725
Endrin aldehyde	1.372549
PCB-146	1.303922
PCB-118	2.107843
PCB-138,158	4.392157
PCB-149	2.137255
PCB-180	7.029412
DDD,2,4'-	2.960784
Endosulfan II	2.166667
PCB-187	3.676471
PCB-183	1.656863
PCB-110	2.45098
PCB-170,190	0.823529
PCB-199	0.803922
PCB-196,203	0.872549
BDE-100	1.078431
PCB-194	0.509804
PCB-209	62.7451
PCB-177	0.539216
PCB-2	1.666667
unidentified halogenated cpd	0.803922
unidentified halogenated cpd	0.823529
unidentified halogenated cpd	2.352941
Endosulfan II	2.392157
PCB-85	5.029412
PCB-66	0.627451
DDE,4,4'-	6.068627
PCB-88	0.558824
Chlordane(5)	1.313725
PCB-90,101	1.686275
Endosulfan I	2.754902
PCB-99	2.686275
PCB-119	0.823529
Nonachlor,trans-	0.627451
PCB-95	0.558824
unidentified halogenated cpd	2.068627

VIMS Fish Organics Data for York River, near West Point, (Collected 6/5/2000)

Shad, gizzard

Compound	Cdry
Chlordane(K)	57.79827
unidentified halogenated cpd	19.50109
PCB-179,141	1.70282
unidentified halogenated cpd	7.765727
PCB-178,129	6.279827
PCB-138,158	35.6833
PCB-153,132	61.4859
PCB-187	36.25814
DDT,4,4'-	2.342733
Endrin aldehyde	11.65944
PCB-146	11.12798
DDT,2,4'-	3.806942
Endosulfan II	17.3102
PCB-122,131	3.503254
PCB-134	4.013015
PCB-118	16.87636
PCB-149	15.45553
PCB-183	14.18655
BDE-100	15.61822
DDD,4,4'-	4.674621
BDE-47	15.43384
BDE-116	6.778742
PCB-149	26.4859
PCB-209	69.41432
PCB-206	3.101952
PCB-194	7.386117
PCB-208,195	3.503254
PCB-199	8.752711
PCB-196,203	9.815619
PCB-193	0.596529
PCB-128	7.158351
PCB-180	34.47939
Unknown tetra-BDE	20.06508
PCB-171,156	9.913233
PCB-177	6.637744
Endrin ketone	9.793926
PCB-174	8.720174
PCB-185	2.158351
PCB-170,190	10.21692
PCB-67,100	1.225597
PCB-84	2.039046
PCB-92	3.24295
Chlordane,trans-	1.127983
PCB-91	6.496746
PCB-88	4.284165
PCB-95	4.284165
Chlordane(5)	1.583514
Chlordane(1)	0.889371

Compound	Cdry
DDE,2,4'-	2.451193
PCB-47,75,48	1.334056
PCB-49	1.507592
PCB-52	2.147506
Endosulfan II	29.67462
PCB-70	0.921909
PCB-85	26.24729
PCB-107	2.006508
Endrin	4.132321
PCB-135	3.937093
PCB-82,151	6.518439
DDD,2,4'-	20.21692
PCB-60,56	1.616052
PCB-77	5.48807
PCB-90,101	11.14967
DDE,4,4'-	31.67028
PCB-87,115	1.507592
PCB-99	8.839479
PCB-110	16.75705
Endosulfan I	9.067245
PCB-97	2.624729
Chlordane,cis-	7.928417
PCB-119	7.093276
Nonachlor,trans-	5.444685
PCB-83	2.125813
Chlordane(7)	2.049892

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Flounder, summer

Compound	Cdry
PCB-149	4.412533
PCB-177	0.939948
PCB-135	0.391645
PCB-138,158	5.913838
PCB-178,129	0.678851
PCB-187	4.308094
PCB-183	1.409922
PCB-128	0.469974
PCB-179,141	0.535248
Endrin ketone	0.796345
Chlordane(K)	8.955614
PCB-171,156	1.005222
Unknown tetra-BDE	2.036553
PCB-180	7.767624
PCB-170,190	1.396867
PCB-199	0.509138
PCB-196,203	0.613577
PCB-174	0.718016
PCB-85	3.629243
Chlordane(5)	1.449086
PCB-90,101	1.866841
Endosulfan I	1.762402
PCB-99	1.723238
PCB-119	0.78329
PCB-179,141	0.796345
DDE,4,4'-	4.373368
PCB-88	66.74935
PCB-110	0.966057
DDD,2,4'-	1.16188
PCB-82,151	1.18799
BDE-100	1.227154
Endrin	0.4047
PCB-146	1.697128
PCB-153,132	9.516972
Nonachlor,trans-	0.600522

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Crab, blue

Compound	Cdry
PCB-183	4.622771
PCB-187	8.106996
PCB-178,129	1.33059
PCB-138,158	16.51577
Chlordane(K)	35.37723
PCB-146	2.949246
PCB-180	16.43347
PCB-153,132	37.6406
PCB-128	2.030178
PCB-177	0.631001
PCB-196,203	1.591221
Unknown tetra-BDE	6.159122
PCB-170,190	3.264746
PCB-199	1.33059
Nonachlor,cis-	2.482853
DDE,4,4'-	13.81344
PCB-171,156	3.045268
PCB-110	1.879287
PCB-47,75,48	1.33059
PCB-88	76.57064
Endosulfan I	6.886145
PCB-99	6.721536
PCB-119	1.138546
Nonachlor,trans-	0.877915
PCB-85	11.44033
DDD,4,4'-	1.27572
DDD,2,4'-	2.277092
Endosulfan II	0.891632
PCB-149	0.79561
Endosulfan II	2.60631
PCB-149	2.318244
PCB-134	1.083676
BDE-100	2.222222

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Spot

Compound	Cdry
PCB-146	6.343179
Nonachlor,trans-	1.308017
DDD,4,4'-	2.165963
PCB-134	1.85654
PCB-149	25.04923
Endosulfan II	28.05907
PCB-107	1.420534
Endrin	3.47398
PCB-135	3.305204
PCB-82,151	5.879044
DDD,2,4'-	8.410689
PCB-110	6.97609
PCB-77	3.375528
Chlordane(K)	39.87342
DDE,4,4'-	14.72574
DDT,2,4'-	0.632911
PCB-119	1.715893
PCB-99	7.116737
Endosulfan I	7.299578
PCB-90,101	8.157525
Chlordane(5)	6.357244
PCB-92	0.815752
PCB-88	72.25035
Chlordane(1)	0.745429
PCB-67,100	1.026723
PCB-47,75,48	1.153305
PCB-49	0.632911
PCB-85	12.20816
PCB-128	3.628692
PCB-208,195	0.998594
PCB-196,203	3.699016
PCB-199	2.30661
PCB-170,190	8.762307
BDE-47	7.566808
PCB-180	3.488045
PCB-180	22.72855
Unknown tetra-BDE	11.98312
PCB-171,156	5.921238
PCB-177	6.329114
Endrin ketone	4.739803
PCB-185	1.012658
PCB-122,131	0.590717
PCB-183	9.774964
PCB-187	23.24895
PCB-178,129	4.43038
Unidentified halogenated cpd	1.786217
PCB-138,158	27.49648
DDT,4,4'-	2.039381
PCB-176,137	1.603376
PCB-179,141	4.711674
PCB-179,141	2.165963
PCB-105	7.313643
PCB-153,132	42.41913
BDE-100	6.568214
PCB-174	4.219409

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Mummichog

Compound	Cdry
PCB-178,129	4.830918
PCB-138,158	5.181159
PCB-138,158	33.70773
DDT,4,4'-	2.548309
PCB-176,137	2.004831
Endosulfan sulfate	2.258454
PCB-179,141	1.533816
PCB-179,141	2.198068
Chlordane(K)	68.06763
PCB-180	37.24638
PCB-153,132	72.41546
PCB-146	9.130434
Unidentified halogenated cpd	4.528986
PCB-187	32.57246
PCB-183	13.04348
PCB-128	3.623188
PCB-174	4.68599
Endrin ketone	5.2657
PCB-170,190	11.60628
PCB-171,156	8.490338
PCB-180	2.149758
BDE-47	4.649758
Unidentified halogenated cpd	2.572464
Nonachlor,cis-	7.657005
PCB-119	3.405797
PCB-47,75,48	0.89372
PCB-199	5.700483
PCB-177	8.369565
PCB-85	21.47343
PCB-208,195	1.980676
PCB-196,203	6.449275
PCB-67,100	0.809179
Chlordane(1)	0.591787
Heptachlor epoxide	0.724638
PCB-74	0.966184
BDE-100	7.065217
PCB-88	69.78261
Chlordane(5)	4.770531
PCB-90,101	6.111111
Endosulfan I	9.287439
DDE,4,4'-	25.9058
Nonachlor,trans-	2.608696
DDT,2,4'-	0.640097
PCB-110	4.698068
DDD,2,4'-	5.664251
PCB-82,151	5.108696
PCB-135	2.125604
Endrin	2.234299
PCB-107	1.400966
PCB-149	21.7029
Endosulfan II	2.826087
PCB-149	2.524154
PCB-134	1.871981
DDD,4,4'-	2.173913
PCB-122,131	0.57971
PCB-99	9.057971

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Shad, gizzard

Compound	Cdry
PCB-85	45.81757
Chlordane(K)	126.9855
DDD,2,4'-	28.9099
PCB-82,151	18.3426
PCB-135	12.08009
Endrin	12.65851
PCB-107	4.238042
PCB-149	90.14461
PCB-134	10.1891
DDD,4,4'-	11.87987
PCB-122,131	3.303671
DDT,2,4'-	3.581758
PCB-183	26.41824
PCB-153,132	135.0945
DDE,4,4'-	55.27252
Unidentified halogenated cpd	31.60178
PCB-179,141	7.641824
PCB-179,141	15.50612
Endosulfan sulfate	5.650723
PCB-176,137	5.027809
DDT,4,4'-	6.384871
PCB-138,158	75.22803
Unidentified halogenated cpd	8.598443
PCB-178,129	9.866518
PCB-77	10.1891
PCB-146	21.17909
PCB-92	4.471635
PCB-52	2.98109
PCB-49	2.836485
PCB-47,75,48	3.826474
PCB-67,100	2.547275
Chlordane(1)	1.85762
PCB-66	10.55617
PCB-95	9.443826
PCB-88	9.443826
PCB-88	83.18131
PCB-91	9.833148
PCB-110	23.95996
PCB-60,56	3.025584
PCB-136	8.342603
Chlordane(5)	25.41713
PCB-90,101	32.58065
Endosulfan I	23.19244
PCB-99	22.60289
Chlordane,cis-	6.407119
PCB-119	9.076752
Nonachlor,trans-	6.974416
PCB-83	1.802002

Compound	Cdry
Chlordane(7)	1.657397
PCB-97	2.124583
PCB-128	11.4683
Chlordane,trans-	2.102336
BDE-116	7.964405
PCB-187	66.48499
PCB-209	2.458287
PCB-206	3.648498
BDE-100	30.901
PCB-208,195	6.540601
PCB-196,203	18.5762
PCB-199	15.0723
PCB-170,190	28.89878
PCB-193	1.268076
PCB-174	24.31591
PCB-180	7.363737
PCB-180	77.10789
Unknown tetra-BDE	42.13571
PCB-171,156	20.81201
PCB-177	21.34594
Endrin ketone	27.31924
PCB-185	3.114572
BDE-47	15.95106

VIMS Fish Organics Data for York River, King Creek, (Collected 6/13/2000)

Croaker, atlantic

Compound	Cdry
PCB-178,129	3.266583
PCB-90,101	13.62954
Endrin	3.279099
PCB-135	3.128911
PCB-82,151	5.957447
DDD,2,4'-	11.23905
PCB-110	9.31164
PCB-77	10.41302
PCB-77	3.579474
PCB-136	2.928661
DDE,4,4'-	24.53066
PCB-97	0.725907
Chlordane(7)	0.563204
Nonachlor,trans-	2.052566
PCB-119	2.678348
PCB-107	1.226533
PCB-88	80.62578
PCB-183	11.4393
PCB-52	1.526909
PCB-49	1.46433
PCB-67,100	1.401752
PCB-66	2.753442
PCB-99	11.8398
PCB-88	2.465582
Endosulfan I	12.15269
PCB-91	5.018774
Chlordane,trans-	1.326658
PCB-60,56	1.902378
PCB-92	1.702128
Chlordane(5)	10.6383
Chlordane(1)	1.013767
PCB-95	2.465582
PCB-208,195	2.077597
PCB-47,75,48	2.265332
PCB-149	34.94368
Unidentified halogenated cpd	1.989987
BDE-100	9.737171
PCB-196,203	6.733417
PCB-199	5.043805
PCB-170,190	10.87609
PCB-180	37.80976
PCB-171,156	7.58448
PCB-177	6.270338
Endrin ketone	7.321652
PCB-174	6.520651
PCB-128	3.141427
PCB-187	29.24906
PCB-153,132	66.03254

Compound	Cdry
PCB-122,131	0.888611
DDD,4,4'-	3.279099
PCB-138,158	39.04881
PCB-146	8.535669
DDT,2,4'-	0.963705
Chlordane(K)	62.06508
Unidentified halogenated cpd	13.29161
PCB-179,141	2.72841
PCB-179,141	4.4806
Endosulfan sulfate	2.2403
PCB-176,137	1.989987
DDT,4,4'-	2.540676
PCB-134	2.81602
Nonachlor,cis-	7.158948

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Flounder, summer

Compound	Cdry
PCB-149	2.04969
PCB-187	2.142857
PCB-118	2.256729
Endrin aldehyde	1.200828
Chlordane(K)	6.490683
PCB-138,158	3.850932
Endosulfan II	2.318841
PCB-183	0.641822
PCB-180	4.513458
PCB-170,190	0.496894
unidentified halogenated cpd	14.26501
Endosulfan II	2.298137
PCB-146	1.138716
PCB-209	66.25259
PCB-153,132	6.904762
PCB-82,151	0.63147
Chlordane(5)	2.008282
PCB-90,101	2.567288
Endosulfan I	2.867495
PCB-119	0.786749
Nonachlor,trans-	0.600414
DDE,4,4'-	4.182195
PCB-85	3.457557
DDD,2,4'-	1.84265
PCB-99	2.795031
PCB-110	1.532091

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Crab, blue

Compound	Cdry
PCB-122,131	1.614078
PCB-180	3.398058
PCB-118	2.123786
PCB-146	1.808252
Endrin aldehyde	1.893204
Chlordane(K)	11.04369
DDT,2,4'-	1.747573
PCB-138,158	3.36165
PCB-187	1.856796
BDE-47	4.308252
PCB-209	77.6699
PCB-153,132	11.74757
Endosulfan II	2.184466
PCB-183	1.262136
PCB-90,101	1.601942
PCB-105	1.796116
PCB-149	0.667476
Endosulfan I	4.07767
PCB-99	3.980582
PCB-119	2.002427
Nonachlor,trans-	1.541262
DDE,4,4'-	4.478155
PCB-85	3.713592
PCB-110	1.796116
DDD,2,4'-	2.17233
Endosulfan II	0.740291

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Spot

Compound	Cdry
Endosulfan II	3.526011
PCB-146	3.271676
DDT,2,4'-	4.450867
PCB-122,131	4.092485
DDD,4,4'-	2.878613
PCB-134	2.462428
PCB-118	4.578035
PCB-149	4.196532
PCB-82,151	1.16763
PCB-149	3.144509
Endrin	0.612717
PCB-135	0.578035
PCB-153,132	23.45665
PCB-171,156	1.32948
PCB-110	5.398844
DDD,2,4'-	6.520231
Endosulfan II	4.693642
Unknown tetra-BDE	2.693641
PCB-194	0.508671
PCB-77	6.046243
PCB-209	73.98844
BDE-100	1.075145
PCB-196,203	0.820809
PCB-170,190	1.676301
PCB-128	1.606936
Chlordane(K)	22.0578
PCB-177	0.543353
PCB-183	2.254335
PCB-187	3.653179
PCB-138,158	8.890174
DDT,4,4'-	1.317919
PCB-179,141	0.855491
PCB-180	9.82659
Heptachlor epoxide	0.49711
PCB-60,56	26.13873
Chlordane,trans-	18.25434
PCB-88	0.566474
PCB-95	0.566474
DDE,2,4'-	1.895954
PCB-74	0.65896
PCB-44	0.913295
PCB-52	0.936416
PCB-85	17.64162
unidentified halogenated cpd	1.352601
PCB-66	0.635838
PCB-83	1.468208
PCB-49	0.520231
PCB-84	1.572254

Compound	Cdry
DDE,4,4'-	21.28324
PCB-87,115	1.028902
Chlordane(7)	0.763006
Nonachlor,trans-	3.398844
PCB-119	4.427745
PCB-90,101	6.01156
Chlordane(5)	1.225433
PCB-97	0.971098
Chlordane(5)	4.693642
Chlordane,cis-	3.537572
Endosulfan I	2.878613
PCB-99	2.797688
Endosulfan I	4.647399
PCB-99	4.531792

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Croaker, atlantic

Compound	Cdry
DDT,2,4'-	4.237288
Endrin	2.677966
PCB-138,158	29.74011
PCB-178,129	3.435028
PCB-179,141	3.333333
PCB-179,141	0.949153
Chlordane(K)	54.23729
PCB-153,132	57.69492
Endrin aldehyde	7.186441
PCB-146	6.847457
DDT,4,4'-	2.542373
PCB-122,131	3.898305
DDD,4,4'-	3.627119
PCB-134	3.107345
PCB-118	7.276836
PCB-149	6.666667
Endosulfan II	7.468927
PCB-149	23.25424
PCB-107	1.615819
PCB-187	20.38418
BDE-100	5.389831
Endosulfan II	26.0565
BDE-47	20.20339
PCB-209	72.31638
BDE-116	2.463277
PCB-206	1.129943
Permethrin,trans-	1.887006
PCB-194	2.553672
DDD,2,4'-	11.22034
PCB-208,195	1.107345
PCB-199	2.632768
PCB-196,203	3.649718
unidentified halogenated cpd	1.19774
PCB-183	7.175141
PCB-180	17.60452
Unknown tetra-BDE	10.80226
PCB-171,156	5.333333
PCB-177	3.254237
Endrin ketone	2.903955
PCB-174	2.587571
PCB-185	0.39548
PCB-128	3.79661
PCB-170,190	5.830508
Chlordane(1)	0.99435
PCB-60,56	1.107345
Chlordane,trans-	0.768362
unidentified halogenated cpd	0.768362
PCB-91	2.508475

Compound	Cdry
PCB-88	3.762712
PCB-95	3.762712
PCB-70	1.073446
Chlordane,trans-	0.858757
Heptachlor epoxide	1.514124
PCB-67,100	1.367232
unidentified halogenated cpd	0.836158
PCB-44	0.892655
PCB-82,151	4.40678
PCB-47,75,48	0.858757
PCB-135	2.553672
PCB-52	1.649718
PCB-74	2
PCB-136	3.19774
PCB-49	0.99435
PCB-60,56	1.231638
PCB-77	3.898305
PCB-85	21.34463
DDE,4,4'-	25.75141
PCB-87,115	1.062147
PCB-97	1.581921
Chlordane(7)	1.231638
PCB-83	2.169492
Nonachlor,trans-	6.508475
DDE,2,4'-	1.943503
PCB-99	17.12994
Endosulfan I	17.57062
PCB-90,101	13.45763
Chlordane(5)	10.49718
Chlordane(5)	1.254237
PCB-84	1.60452
PCB-92	1.107345
PCB-92	1.570621
PCB-110	9.299435
PCB-119	8.485876

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Bluefish

Compound	Cdry
PCB-138,158	20.74332
PCB-178,129	2.9036
PCB-209	74.33218
DDT,4,4'-	1.730546
BDE-116	5.783972
Endrin aldehyde	4.111498
PCB-183	4.657375
PCB-187	12.63647
PCB-179,141	1.358885
PCB-179,141	0.615563
PCB-153,132	34.40186
PCB-146	3.914053
DDT,2,4'-	1.869919
PCB-128	3.809524
PCB-208,195	2.601626
Chlordane(K)	32.3345
BDE-47	18.80372
PCB-122,131	1.730546
PCB-136	1.718932
PCB-206	2.648084
PCB-194	2.288037
BDE-100	4.843206
PCB-196,203	4.239257
PCB-199	3.658537
PCB-193	0.801394
PCB-174	1.660859
PCB-180	13.76307
Unknown tetra-BDE	11.44019
PCB-171,156	5.644599
PCB-177	2.439024
Endrin ketone	1.858304
PCB-170,190	3.554007
DDD,4,4'-	0.998839
PCB-110	7.560976
PCB-52	0.627178
PCB-95	1.219512
PCB-88	1.219512
PCB-92	0.963995
PCB-90,101	6.817654
Endosulfan I	7.816493
PCB-99	7.619048
PCB-119	4.45993
Nonachlor,trans-	3.426249

Compound	Cdry
Chlordane(7)	0.836237
PCB-149	6.434379
PCB-118	10.30197
PCB-134	0.859466
PCB-97	1.080139
Endosulfan II	10.56911
Endosulfan II	7.212544
PCB-107	0.929152
PCB-77	2.090592
PCB-135	1.300813
PCB-82,151	2.578397
PCB-87,115	1.440186
DDD,2,4'-	9.117306
DDE,4,4'-	17.0964
Endrin	1.358885
PCB-85	14.16957

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Shad, gizzard

Compound	Cdry
PCB-146	15.02634
Endrin aldehyde	15.74289
PCB-153,132	75.25816
PCB-179,141	10.48472
PCB-105	29.84194
PCB-179,141	3.445732
DDT,2,4'-	9.230769
PCB-107	4.193888
PCB-176,137	5.774499
Chlordane(K)	70.74815
PCB-122,131	8.503688
DDD,4,4'-	8.451001
PCB-134	7.249737
PCB-118	25.75343
PCB-149	23.58272
Endosulfan II	26.41728
Endosulfan II	41.27502
Endrin	7.544784
PCB-135	7.197049
PCB-82,151	9.747102
DDT,4,4'-	7.344573
PCB-199	7.123288
PCB-149	36.84932
PCB-180	50.96944
PCB-209	67.43941
BDE-116	4.994731
PCB-206	2.286618
PCB-194	7.755532
BDE-100	16.39621
PCB-208,195	3.350896
PCB-196,203	8.482614
Endrin ketone	11.52792
PCB-170,190	13.22445
PCB-193	2.623815
BDE-47	13.83562
PCB-138,158	54.26765
Unknown tetra-BDE	27.46048
PCB-177	9.441517
PCB-174	10.26343
PCB-185	1.116965
PCB-128	8.81981
PCB-183	14.3098
PCB-187	35.64805
PCB-178,129	8.893572
DDD,2,4'-	23.85669
PCB-37,42,59	1.580611
unidentified halogenated cpd	2.813488
Chlordane(3)	1.601686

Compound	Cdry
PCB-91	5.795574
PCB-88	9.125395
PCB-70	3.045311
Heptachlor epoxide	1.454162
Chlordane(1)	1.42255
PCB-67,100	1.959958
Chlordane,trans-	4.973656
PCB-40	0.737619
PCB-95	9.125395
PCB-44	2.402529
PCB-47,75,48	2.623815
PCB-49	2.792413
PCB-52	3.256059
PCB-171,156	13.56164
PCB-110	19.77872
PCB-103	0.653319
PCB-97	4.214963
PCB-77	6.269757
PCB-136	5.131717
PCB-85	31.08535
PCB-74	1.928346
PCB-87,115	2.613277
PCB-60,56	7.123288
Chlordane(7)	3.287671
PCB-83	3.382508
Nonachlor,trans-	8.925184
PCB-119	11.6333
Chlordane,cis-	10.45311
Chlordane(5)	3.530031
PCB-92	5.616438
DDE,4,4'-	37.50263
PCB-99	13.40358
DDE,2,4'-	5.468915
PCB-84	4.531085
Chlordane(5)	17.85037
PCB-90,101	22.87671
Endosulfan I	10.84299
PCB-99	10.57956
Endosulfan I	13.75132

VIMS Fish Organics Data for York River, Wormley Creek at Amoco, Yorktown, (Collected 6/14/2000)

Mummichog

Compound	Cdry
PCB-178,129	1.910242
PCB-138,158	19.04488
DDT,4,4'-	1.32336
PCB-179,141	0.667434
PCB-179,141	0.483314
Chlordane(K)	38.80322
PCB-153,132	41.27733
Endrin aldehyde	4.211738
PCB-146	4.01611
DDT,2,4'-	2.750288
PCB-187	12.10587
DDD,4,4'-	1.139241
PCB-180	13.49827
PCB-122,131	2.531646
PCB-194	1.806674
BDE-100	3.820483
PCB-208,195	0.690449
PCB-196,203	1.944764
PCB-199	1.334868
PCB-170,190	3.601841
Unknown tetra-BDE	7.284235
DDD,2,4'-	4.787111
PCB-183	5.120828
PCB-134	0.978136
PCB-171,156	3.590333
PCB-177	2.151899
Endrin ketone	1.162255
PCB-174	1.024166
PCB-128	1.818182
BDE-47	16.36364
PCB-90,101	5.270426
PCB-209	73.64787
PCB-84	0.794016
unidentified halogenated cpd	2.405063
PCB-52	0.621404
Heptachlor epoxide	0.817031
PCB-74	1.093211
PCB-95	1.116226
PCB-88	1.116226
DDE,2,4'-	0.955121
PCB-135	0.667434
PCB-85	6.605293
PCB-149	6.651323
Endosulfan II	7.445339
PCB-149	7.16916
Endosulfan II	8.032221
Endrin	0.690449
Chlordane(5)	0.609896

Compound	Cdry
PCB-110	3.958573
Chlordane(5)	4.119678
DDE,4,4'-	7.963176
Nonachlor,trans-	4.994246
PCB-119	6.501726
PCB-99	7.917146
Endosulfan I	8.112773
PCB-118	7.26122
PCB-82,151	2.140391
PCB-92	0.794016

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Flounder, summer

Compound	Cdry
PCB-209	66.52807
Endosulfan II	0.893971
PCB-149	0.790021
PCB-153,132	1.943867
Chlordane(K)	1.829522
PCB-138,158	1.424116
PCB-187	0.717256
PCB-180	2.234927
PCB-99	0.654886
Endosulfan I	0.675676
PCB-90,101	1.715177
Chlordane(5)	1.330561
DDE,4,4'-	2.016632
PCB-85	1.673597

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Crab, blue

Compound	Cdry
PCB-187	1.299505
DDD,2,4'-	3.985148
Endosulfan II	2.178218
PCB-118	2.128713
PCB-146	0.717822
BDE-47	4.282178
PCB-153,132	6.868812
PCB-138,158	3.155941
PCB-110	3.304456
PCB-180	4.405941
PCB-95	1.596534
PCB-105	2.289604
PCB-85	4.938118
DDE,4,4'-	5.965346
PCB-99	2.809406
Endosulfan I	2.883663
PCB-90,101	2.004951
Chlordane(5)	1.559406
PCB-88	1.596534
PCB-66	1.782178
Chlordane(K)	6.44802
PCB-209	79.20792
Endrin aldehyde	0.75495

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Bluefish

Compound	Cdry
Endrin aldehyde	4.08297
PCB-128	1.39738
PCB-183	4.432314
PCB-187	10.15284
PCB-178,129	1.353712
PCB-138,158	15.10917
PCB-179,141	2.117904
PCB-174	1.441048
PCB-153,132	29.60699
PCB-180	13.23144
PCB-146	3.886463
Chlordane(K)	27.83843
Endrin ketone	1.615721
PCB-177	1.550218
PCB-171,156	2.707424
PCB-118	7.991267
PCB-170,190	1.746725
PCB-199	2.379913
BDE-100	3.646288
PCB-194	1.724891
PCB-206	1.812227
BDE-116	3.995633
PCB-209	139.738
Unknown tetra-BDE	5.502183
Endosulfan I	5.917031
PCB-196,203	2.401747
PCB-95	1.746725
PCB-88	1.746725
Endosulfan II	8.187773
PCB-90,101	6.790393
PCB-99	5.764193
PCB-119	1.637555
Nonachlor,trans-	1.266376
PCB-82,151	2.532751
PCB-149	6.069869
Chlordane(7)	1.375546
PCB-135	1.310044
Endosulfan II	6.812227
DDD,2,4'-	6.943232
PCB-110	5.764193
PCB-85	9.585153
DDE,4,4'-	11.57205
PCB-87,115	1.484716
PCB-97	1.768559
Endrin	1.353712

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Croaker, atlantic

Compound	Cdry
PCB-128	0.968661
PCB-177	0.731244
Endrin ketone	1.139601
PCB-174	1.016144
PCB-187	8.110161
PCB-138,158	9.040836
PCB-179,141	0.788224
Chlordane(K)	21.88034
Endrin aldehyde	2.440646
PCB-153,132	23.27635
PCB-171,156	1.576448
Unknown tetra-BDE	3.190883
PCB-180	10.99715
PCB-180	1.528965
BDE-47	3.31434
PCB-170,190	2.592592
PCB-199	1.063628
PCB-196,203	1.424501
PCB-146	2.326686
PCB-194	1.120608
Endosulfan I	5.242165
BDE-100	2.364672
PCB-99	5.109212
PCB-183	3.523267
PCB-209	60.77872
PCB-66	0.892688
PCB-95	0.797721
PCB-88	0.797721
PCB-119	1.272555
PCB-90,101	4.169041
PCB-118	3.48528
Nonachlor,trans-	0.978158
PCB-87,115	0.921178
DDE,4,4'-	7.046534
PCB-85	5.840456
PCB-110	3.02944
DDD,2,4'-	3.646724
PCB-82,151	0.759734
Endosulfan II	4.577398
PCB-149	4.093067
Endosulfan II	3.580247
Chlordane(5)	3.247863
PCB-178,129	0.674264

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Spot

Compound	Cdry
PCB-177	1.797753
PCB-118	7.00715
PCB-134	1.225741
DDD,4,4'-	1.430031
PCB-122,131	1.695608
DDT,2,4'-	1.848825
PCB-146	3.268641
Endrin aldehyde	3.421859
PCB-153,132	27.48723
Chlordane(K)	25.8427
unidentified halogenated cpd	2.053115
PCB-178,129	1.031665
PCB-183	3.207355
Endosulfan II	7.191011
Endrin ketone	0.755873
PCB-138,158	13.11542
PCB-171,156	2.594484
Unknown tetra-BDE	5.26047
PCB-180	8.539326
BDE-47	8.34525
PCB-170,190	2.492339
PCB-199	1.041879
PCB-196,203	1.348315
BDE-100	2.951992
PCB-194	1.389173
PCB-209	65.37283
PCB-174	0.663943
PCB-52	1.123595
PCB-187	8.610827
PCB-149	6.384065
PCB-95	1.501532
PCB-88	1.501532
Chlordane,trans-	0.643514
PCB-60,56	0.92952
PCB-92	1.24617
PCB-90,101	9.305413
Endosulfan I	8.672114
PCB-99	8.457609
PCB-119	4.53524
PCB-135	1.154239
Nonachlor,trans-	3.483146
Endrin	1.205311
PCB-82,151	2.522983
DDD,2,4'-	7.191011
PCB-110	5.955056
PCB-77	2.022472
DDE,4,4'-	12.43105
PCB-87,115	1.184883
PCB-97	0.694586
PCB-85	10.30644
Endosulfan II	7.150153
Chlordane(7)	0.541369

VIMS Fish Organics Data for York River, at Rt. 17 Bridge, (Collected 7/5/2000)

Mummichog

Compound	Cdry
PCB-118	6.037515
Chlordane(K)	20.78546
PCB-153,132	22.1102
Endrin aldehyde	2.450176
PCB-146	2.344666
DDT,2,4'-	2.473622
PCB-122,131	2.274326
unidentified halogenated cpd	0.656506
PCB-134	0.87925
PCB-187	6.049238
Endosulfan II	6.189918
PCB-149	2.966002
Endosulfan II	3.329425
PCB-82,151	0.785463
DDD,2,4'-	6.987104
DDD,4,4'-	1.01993
PCB-209	75.0293
PCB-194	0.715123
BDE-100	1.524033
PCB-196,203	1.01993
PCB-199	0.867526
PCB-170,190	1.594373
PCB-138,158	10.11723
PCB-180	7.327081
PCB-178,129	0.621336
Unknown tetra-BDE	2.872216
PCB-177	0.762016
PCB-174	0.45721
PCB-128	1.852286
PCB-183	2.602579
DDE,4,4'-	16.6823
BDE-47	5.439624
PCB-2	2.590856
PCB-110	5.791325
PCB-74	1.289566
Heptachlor epoxide	0.973036
Chlordane(1)	0.52755
PCB-67,100	0.726846
PCB-88	0.926143
unidentified halogenated cpd	0.750293
unidentified halogenated cpd	1.4068
unidentified halogenated cpd	1.348183
unidentified halogenated cpd	1.101993

Compound	Cdry
unidentified halogenated cpd	1.418523
PCB-52	0.691676
PCB-90,101	5.076201
PCB-171,156	1.418523
PCB-87,115	0.867526
PCB-83	0.937866
Nonachlor,trans-	4.384525
PCB-119	5.720984
Chlordane,cis-	3.927315
PCB-95	0.926143
Endosulfan I	2.426729
PCB-85	13.82181
PCB-90,101	1.512309
Chlordane(5)	1.172333
PCB-84	1.512309
DDE,2,4'-	1.828839
PCB-60,56	1.617819
Chlordane,trans-	1.12544
PCB-99	2.368112
Endrin ketone	0.515826

VIMS Fish Organics Data, York River near Buoy 59 at West Point, (Collected 6/16/2003)

Shad, gizzard

Compound	Cdry
PCB 110	19.41924
PCB 28, 31	4.174229
PCB 70	3.811252
PCB 199	5.444646
PCB 18	1.451906
PCB 100	1.451906
PCB 44	2.177859
PCB 49	3.811252
PCB 91	3.448276
PCB 87, 115	1.088929
PCB 101, 90	13.24864
PCB 99	11.07078
PCB 97	2.359347
PCB 52	3.0853
PCB 187	22.14156
PCB 149	66.24319
PCB 118	14.51906
PCB 146	13.06715
PCB 178	4.174229
PCB 138, 158	26.67877
PCB 130	16.51543
PCB 179	5.08167
PCB 132	3.629764
PCB 183	6.715064
PCB 153	50.63521
PCB 174	6.533576
PCB 177	6.715064
PCB 171	3.811252
PCB 185	0.725953
PCB 170, 190	9.800364
PCB 209	6.352087
PCB 180, 193	21.5971
PCB 194	3.448276
PCB 195	1.814882
PCB 208	4.537205
PCB 203, 196	5.444646

VIMS Fish Organics Data for York River, near Buoy 59 at West Point, (Collected 6/16/2003)

Croaker, atlantic

Compound	Cdry
PCB 34	0.277008
PCB 101, 90	0.692521
PCB 99	1.385042
PCB 183	0.692521
PCB 149	2.493075
PCB 118	0.969529
PCB 146	0.831025
PCB 180, 193	1.800554
PCB 187	3.047092
PCB 138, 158	1.523546
PCB 130	0.831025
PCB 153	4.293629
PCB 110	0.415513
PCB 149	1.256983
PCB 130	0.558659
PCB 118	0.558659
PCB 138, 158	0.837989
PCB 153	3.49162
PCB 146	0.977654
PCB 180, 193	1.396648

VIMS Fish Organics Data, York River near Buoy 59 at West Point, (Collected 6/16/2003)

Crab, blue

Compound	Cdry
PCB 110	13.23829
PCB 118	4.684318
PCB 146	2.443992
PCB 153	18.32994
PCB 28, 31	0.814664
PCB 138, 158	4.07332
PCB 180, 193	4.07332
PCB 99	3.258656
PCB 187	3.462322

VIMS Fish Organics Data, York River near Buoy 59 at West Point, (Collected 6/16/2003)

Croaker, atlantic

Compound	Cdry
PCB 52	2.342342
PCB 28, 31	3.423423
PCB 41, 64	0.900901
PCB 44	1.801802
PCB 42, 59	0.720721
PCB 70	1.801802
PCB 92	2.702703
PCB 99	5.945946
PCB 97	1.441441
PCB 49	2.882883
PCB 87, 115	1.261261
PCB 101, 90	9.90991
PCB 183	3.963964
PCB 149	35.4955
PCB 118	10.63063
PCB 146	8.468468
PCB 132	2.342342
PCB 187	12.97297
PCB 138, 158	16.57658
PCB 130	9.369369
PCB 74	0.900901
PCB 105	2.162162
PCB 153	31.53153
PCB 177	2.342342
PCB 174	2.702703
PCB 172	1.261261
PCB 180, 193	14.59459
PCB 206	3.063063
PCB 110	26.12613
PCB 208	4.324325
PCB 203, 196	3.243243
PCB 209	16.03604
PCB 199	2.162162
PCB 170, 190	6.486486

VIMS Fish Organics Data for York River, near Purtan Island, (Collected 7/28/2003)

Shad, gizzard

Compound	Cdry
PCB 52	1.071429
PCB 70	0.982143
PCB 49	1.696429
PCB 87, 115	1.071429
PCB 95, 66	2.946429
PCB 101, 90	4.732143
PCB 99	5
PCB 97	1.785714
PCB 110	4.285715
PCB 187	11.42857
PCB 135	1.875
PCB 149	12.14286
PCB 118	4.375
PCB 146	2.946429
PCB 178	2.142857
PCB 138, 158	8.571429
PCB 130	4.464286
PCB 179	1.964286
PCB 105	1.071429
PCB 153	15
PCB 180, 193	8.571429
PCB 174	2.410714
PCB 177	2.232143
PCB 183	3.214286
PCB 136	1.160714
PCB 199	2.767857
PCB 170, 190	5.267857

VIMS Fish Organics Data for York River, near Purtan Island, (Collected 7/28/2003)

Gar, longnose

Compound	Cdry
PCB 180, 193	8.21727
PCB 49	0.696379
PCB 95, 66	0.97493
PCB 99	4.317548
PCB 101, 90	1.392758
PCB 153	16.15599
PCB 187	8.21727
PCB 149	8.21727
PCB 110	0.97493
PCB 118	2.089136
PCB 172	0.835655
PCB 130	1.392758
PCB 179	1.114206
PCB 105	0.557103
PCB 146	2.785515
PCB 138, 158	6.963788
PCB 174	1.532033
PCB 177	1.949861
PCB 183	4.038997
PCB 199	2.785515
PCB 206	2.228412
PCB 170, 190	3.760446

VIMS Fish Organics Data for York River, near Purtan Island, (Collected 7/28/2003)

Croaker, atlantic

Compound	Cdry
PCB 101, 90	0.720721
PCB 99	1.621622
PCB 187	2.792793
PCB 149	2.972973
PCB 118	0.45045
PCB 146	0.720721
PCB 153	5.045045
PCB 138, 158	1.621622
PCB 180, 193	1.531532

VIMS Fish Organics Data for York River, near Purtan Island, (Collected 7/28/2003)

Perch, white

Compound	Cdry
PCB 180, 193	5.615763
PCB 187	4.729064
PCB 138, 158	5.221675
PCB 130	2.463054
PCB 153, 132	12.0197
PCB 146	1.970443
PCB 118	0.886699
PCB 149	1.37931
PCB 99	5.812808
PCB 101, 90	1.576355
PCB 34	0.985222

VIMS Fish Organics Data,
York River near Purtan Island,
(Collected 7/28/2003)

Crab, blue

Compound	Cdry
PCB 18	0.733138
PCB 28, 31	1.466276
PCB 99	3.372434
PCB 52	0.293255
PCB 183	1.466276
PCB 149	0.733138
PCB 118	2.346041
PCB 153	19.79472
PCB 146	2.492669
PCB 187	4.83871
PCB 138, 158	5.718475
PCB 130	1.759531
PCB 180, 193	6.304986
PCB 170, 190	1.759531

VIMS Fish Organics Data ,
York River near Purtan Island,
(Collected 7/28/2003)

Spot

Compound	Cdry
PCB 95, 66	0.777202
PCB 49	0.518135
PCB 101, 90	1.295337
PCB 110	0.777202
PCB 99	2.202073
PCB 149	5.440414
PCB 118	1.03627
PCB 146	1.554404
PCB 153	7.512954
PCB 130	2.072539
PCB 138, 158	2.46114
PCB 187	4.533679
PCB 177	0.906736
PCB 179	0.647668
PCB 180, 193	3.238342

VIMS Fish Organics Data,
York River near Purtan Island,
(Collected 7/28/2003)

Shad, gizzard

Compound	Cdry
PCB 18	0.401606
PCB 28, 31	2.141901
PCB 33, 20	0.267738
PCB 70	2.409639
PCB 91	1.874163
PCB 92	1.740295
PCB 101, 90	4.685409
PCB 99	10.97724
PCB 97	1.338688
PCB 52	2.945114
PCB 49	2.409639
PCB 135	4.283802
PCB 149	28.11245
PCB 180, 193	45.5154
PCB 153	91.70013
PCB 146	14.99331
PCB 118	7.362785
PCB 105	1.204819
PCB 183	9.638555
PCB 178	3.882196
PCB 138, 158	31.45917
PCB 130	15.66265
PCB 187	39.22356
PCB 179	8.433736
PCB 174	10.44177
PCB 132	0.937082
PCB 177	9.370817
PCB 209	4.55154
PCB 194	7.496654
PCB 195	4.149933
PCB 208	2.811245
PCB 203, 196	10.97724
PCB 199	11.11111
PCB 170, 190	14.45783
PCB 206	2.543507

VIMS Fish Organics Data,
York River near Purtan Island,
(Collected 7/28/2003)

Croaker, atlantic

Compound	Cdry
PCB 8, 5	0.14245
PCB 136	0.712251
PCB 18	0.569801
PCB 34	0.569801
PCB 28, 31	2.279202
PCB 70	0.997151
PCB 41, 64	1.709402
PCB 91	0.854701
PCB 92	0.42735
PCB 101, 90	2.564103
PCB 99	3.846154
PCB 97	0.712251
PCB 52	1.424502
PCB 49	1.424502
PCB 146	3.988604
PCB 180, 193	8.404559
PCB 183	2.136752
PCB 149	6.552707
PCB 118	3.418804
PCB 187	9.11681
PCB 138, 158	9.97151
PCB 130	3.561254
PCB 105	0.712251
PCB 132	0.997151
PCB 153	24.07407
PCB 174	1.282051
PCB 177	1.709402
PCB 170, 190	2.991453

VIMS Fish Organics Data for York River, Queen Creek upstream of Rt. 64 near Rt. 132, (Collected 7/29/2003)

Perch, white

Compound	Cdry
PCB 194	2.908587
PCB 34	1.939058
PCB 52	1.246537
PCB 44	0.692521
PCB 70	0.692521
PCB 149	2.077562
PCB 118	8.864266
PCB 153	9.279778
PCB 105	3.3241
PCB 130	5.67867
PCB 138, 158	24.09972
PCB 187	1.66205
PCB 174	1.939058
PCB 177	1.66205
PCB 172	1.385042
PCB 180, 193	18.69806
PCB 170, 190	6.509696
PCB 199	1.939058
PCB 34	1.939058
PCB 118	8.864266
PCB 44	0.692521
PCB 52	1.246537
PCB 194	2.908587
PCB 70	0.692521
PCB 130	5.67867
PCB 149	2.077562
PCB 153	9.279778
PCB 105	3.3241
PCB 138, 158	24.09972
PCB 174	1.939058
PCB 187	1.66205
PCB 177	1.66205
PCB 199	1.939058
PCB 170, 190	6.509696
PCB 180, 193	18.69806
PCB 172	1.385042

VIMS Fish Organics Data for York River, Queen Creek upstream of Rt. 64 near Rt. 132, (Collected 7/29/2003)

Shad, gizzard

Compound	Cdry
PCB 18	2.142857
PCB 8, 5	0.612245
PCB 53	0.306122
PCB 16, 32	0.408163
PCB 49	3.877551
PCB 28, 31	6.428572
PCB 85	3.265306
PCB 33, 20	3.163265
PCB 22	1.632653
PCB 128	3.77551
PCB 70	7.653061
PCB 41, 64	4.081633
PCB 42, 59	1.326531
PCB 44	3.571429
PCB 52	5.612245
PCB 101, 90	14.4898
PCB 27, 24	0.204082
PCB 95, 66	12.65306
PCB 91	2.857143
PCB 87, 115	5.918367
PCB 84	3.571429
PCB 99	10.10204
PCB 97	7.346939
PCB 92	3.061224
PCB 82	1.938776
PCB 135	3.163265
PCB 187	27.7551
PCB 149	34.08163
PCB 110	14.4898
PCB 118	14.89796
PCB 138, 158	28.57143
PCB 153	35.30612
PCB 178	4.285714
PCB 130	12.7551
PCB 176	1.938776
PCB 141	6.122449
PCB 179	5.714286
PCB 105	5
PCB 132	8.163265
PCB 146	7.244898
PCB 180, 193	33.06123
PCB 185	1.836735
PCB 174	10.71429
PCB 177	5.510204
PCB 156	3.673469
PCB 183	10.30612
PCB 172	3.367347
PCB 136	3.367347
PCB 194	6.530612
PCB 195	4.183673
PCB 189	0.714286
PCB 199	8.367347
PCB 170, 190	19.08163
PCB 191	0.510204
PCB 206	3.77551

VIMS Fish Organics Data for York River, Queen Creek upstream of, (Collected 7/29/2003)

Shad, gizzard

Compound	Cdry
PCB 151	1.923077
PCB 135	7.840237
PCB 82	2.514793
PCB 110	19.23077
PCB 136	6.360947
PCB 87, 115	6.360947
PCB 97	8.579882
PCB 149	52.95858
PCB 130	22.63314
PCB 146	11.2426
PCB 153	59.61538
PCB 132	12.86982
PCB 105	6.952662
PCB 179	8.579882
PCB 118	18.19527
PCB 178	6.656805
PCB 141	9.763313
PCB 176	3.254438
PCB 177	10.2071
PCB 174	16.42012
PCB 185	2.95858
PCB 128	5.177515
PCB 183	14.94083
PCB 187	41.42012
PCB 156	4.585799
PCB 180, 193	47.48521
PCB 189	1.183432
PCB 170, 190	28.25444
PCB 199	12.13018
PCB 138, 158	41.56805
PCB 206	6.213017
PCB 51	0.591716
PCB 209	2.366864
PCB 28, 31	1.47929
PCB 53	0.443787
PCB 52	5.91716
PCB 49	4.142012
PCB 44	2.810651
PCB 42, 59	0.887574
PCB 84	4.43787
PCB 194	6.804734
PCB 101, 90	20.71006
PCB 208	1.775148
PCB 92	3.846154
PCB 95, 66	17.15976
PCB 70	6.213017
PCB 41, 64	3.550296
PCB 99	13.7574

VIMS Fish Organics Data for York River, Queen Creek upstream of, (Collected 7/29/2003)

Mummichog

Compound	Cdry
PCB 34	0.591716
PCB 49	0.7889546
PCB 95, 66	2.7613411
PCB 99	3.9447732
PCB 70	1.3806705
PCB 101, 90	4.3392506
PCB 52	1.183432
PCB 97	0.9861933
PCB 87, 115	1.183432
PCB 110	4.7337279
PCB 183	2.9585798
PCB 149	7.2978306
PCB 118	6.3116369
PCB 187	8.4812622
PCB 146	2.7613411
PCB 178	1.3806705
PCB 130	4.7337279
PCB 105	2.1696253
PCB 180, 193	10.059172
PCB 153	16.962524
PCB 174	1.7751478
PCB 138, 158	10.25641
PCB 172	0.7889546
PCB 177	1.9723866
PCB 170, 190	5.7199211

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Croaker, atlantic

Compound	Cdry
PCB 34	1.651982
PCB 18	0.770925
PCB 8, 5	0.330396
PCB 52	2.643172
PCB 28, 31	2.53304
PCB 53	0.550661
PCB 51	0.770925
PCB 41, 64	1.762115
PCB 44	0.881057
PCB 70	2.422907
PCB 101, 90	1.651982
PCB 136	4.185022
PCB 149	8.810573
PCB 118	11.01322
PCB 105	3.0837
PCB 132	1.211454
PCB 128	4.735683
PCB 138, 158	44.93392
PCB 130	12.77533
PCB 141	6.718061
PCB 187	7.268722
PCB 170, 190	13.87665
PCB 153	27.42291
PCB 177	6.718061
PCB 174	7.268722
PCB 180, 193	31.05727
PCB 194	7.378854
PCB 195	3.414097
PCB 203, 196	2.863436
PCB 199	3.524229

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Spot

Compound	Cdry
PCB 18	0.857449
PCB 34	1.500536
PCB 28, 31	2.036442
PCB 51	0.428725
PCB 41, 64	2.465166
PCB 42, 59	0.428725
PCB 44	2.250804
PCB 49	4.072883
PCB 56, 60	2.143623
PCB 136	8.252947
PCB 101, 90	6.002143
PCB 52	6.538049
PCB 97	1.714898
PCB 187	9.110396
PCB 200	0.643087
PCB 82	5.251875
PCB 128	14.68382
PCB 149	12.43301
PCB 118	36.12004
PCB 153	35.90568
PCB 178	1.071811
PCB 138, 158	89.60342
PCB 130	21.65059
PCB 141	18.32797
PCB 105	15.96999
PCB 183	3.429796
PCB 199	6.323687
PCB 137	5.894962
PCB 174	10.93248
PCB 177	9.539121
PCB 156	10.28939
PCB 167	4.71597
PCB 194	12.54019
PCB 195	4.501607
PCB 203, 196	4.287245
PCB 180, 193	49.83923
PCB 170, 190	21.54341
PCB 85	0.96463

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Shad, gizzard

Compound	Cdry
PCB 52	5.209513
PCB 44	1.812004
PCB 100	4.19026
PCB 70	4.416761
PCB 95, 66	20.15855
PCB 91	9.060022
PCB 92	3.284258
PCB 101, 90	18.6863
PCB 99	25.36806
PCB 132	4.19026
PCB 136	9.173273
PCB 110	17.66704
PCB 135	18.12004
PCB 149	93.31823
PCB 118	15.85504
PCB 153	132.5028
PCB 105	3.737259
PCB 179	15.85504
PCB 130	32.95583
PCB 138, 158	58.21064
PCB 180, 193	87.31596
PCB 187	84.59795
PCB 146	23.89581
PCB 183	28.08607
PCB 185	3.624009
PCB 174	25.82106
PCB 177	21.06455
PCB 97	4.416761
PCB 199	20.61155
PCB 178	13.81653
PCB 170, 190	50.62288

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Crab, blue

Compound	Cdry
PCB 34	1.469045
PCB 28, 31	0.944386
PCB 118	9.233997
PCB 105	2.833158
PCB 138, 158	32.94858
PCB 183	0.839454
PCB 153	14.37566
PCB 128	4.302203
PCB 177	1.573977
PCB 199	1.049318
PCB 170, 190	6.925498
PCB 180, 193	17.8384
PCB 194	2.833158

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Perch, white

Compound	Cdry
PCB 149	3.229167
PCB 101, 90	0.625
PCB 118	7.604167
PCB 70	1.5625
PCB 52	1.145833
PCB 44	0.625
PCB 28, 31	0.416667
PCB 174	2.8125
PCB 153	11.25
PCB 105	1.458333
PCB 130	8.541666
PCB 138, 158	26.25
PCB 187	1.666667
PCB 146	1.979167
PCB 194	2.604167
PCB 183	0.729167
PCB 177	2.5
PCB 170, 190	7.8125
PCB 172	1.458333
PCB 180, 193	18.125
PCB 203, 196	0.9375
PCB 199	1.666667

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Mummichog

Compound	Cdry
PCB 49	1.333333
PCB 41, 64	0.380952
PCB 52	1.52381
PCB 199	3.809524
PCB 170, 190	8
PCB 180, 193	14.66667
PCB 174	2.857143
PCB 177	3.619048
PCB 157	8.380953
PCB 172	1.142857
PCB 183	4.952381
PCB 70	1.142857
PCB 179	0.571429
PCB 95, 66	3.619048
PCB 149	13.90476
PCB 92	1.142857
PCB 187	16.95238
PCB 99	5.904762
PCB 107	3.238095
PCB 97	0.952381
PCB 87, 115	0.952381
PCB 135	1.714286
PCB 110	4.952381
PCB 101, 90	5.333333
PCB 130	9.142858
PCB 118	7.047619
PCB 178	2.666667
PCB 105	2.47619
PCB 153	27.04762
PCB 146	5.333333
PCB 138, 158	16

VIMS Fish Organics Data for York River, Queen Creek near Camp Peary, (Collected 7/30/2003)

Croaker, atlantic

Compound	Cdry
PCB 170, 190	2.62069
PCB 199	2.206897
PCB 177	2.482759
PCB 174	2.482759
PCB 97	1.931034
PCB 183	3.310345
PCB 87, 115	0.551724
PCB 138, 158	11.44828
PCB 130	5.655172
PCB 179	1.655172
PCB 105	1.241379
PCB 146	3.862069
PCB 187	11.44828
PCB 149	13.24138
PCB 110	4.551724
PCB 136	1.241379
PCB 153	20.27586
PCB 99	5.793103
PCB 101, 90	5.103448
PCB 92	0.689655
PCB 95, 66	2.758621
PCB 70	1.931034
PCB 49	2.068965
PCB 52	1.655172
PCB 118	5.517241
PCB 180, 193	9.241379
PCB 51	0.551724

VIMS Fish Organics Data for York River, between Ferry Pt. & Clay Bank (near Carter Creek), (Collected 7/31/2003)

Spot

Compound	Cdry
PCB 34	1.607717
PCB 18	1.714898
PCB 8, 5	0.428725
PCB 28, 31	2.893891
PCB 170, 190	2.465166
PCB 41, 64	0.643087
PCB 187	0.535906
PCB 118	0.750268
PCB 153	4.072883
PCB 138, 158	6.430868
PCB 130	2.465166
PCB 177	1.286174
PCB 174	0.750268
PCB 180, 193	4.930332

VIMS Fish Organics Data for York River, between Ferry Pt. & Clay bank near Carter Creek, (Collected 7/31/2003)

Shad, gizzard

Compound	Cdry
PCB 170, 190	5.679862
PCB 199	3.098107
PCB 209	1.549053
PCB 183	3.098107
PCB 110	2.409639
PCB 174	2.581756
PCB 177	2.753873
PCB 153	14.97418
PCB 187	11.70396
PCB 178	1.893288
PCB 138, 158	7.401033
PCB 130	5.163511
PCB 179	1.893288
PCB 146	3.270224
PCB 118	1.72117
PCB 149	12.56454
PCB 99	4.130809
PCB 101, 90	1.893288
PCB 95, 66	2.409639
PCB 180, 193	8.605852

VIMS Fish Organics Data for York River, between Ferry Pt. & Clay bank near Carter Creek, (Collected 7/31/2003)

Croaker, atlantic

Compound	Cdry
PCB 170, 190	1.436266
PCB 180, 193	2.513465
PCB 177	0.5386
PCB 174	0.5386
PCB 146	1.256732
PCB 183	1.077199
PCB 187	3.590664
PCB 138, 158	2.154399
PCB 130	1.256732
PCB 179	0.359066
PCB 153	5.924596
PCB 118	0.718133
PCB 149	3.411131
PCB 99	1.795332
PCB 101, 90	0.897666
PCB 95, 66	0.359066
PCB 34	0.359066
PCB 110	0.5386

VIMS Fish Organics Data for York River, between Ferry Pt. & Clay bank near Carter Creek, (Collected 7/31/2003)

Crab, blue

Compound	Cdry
PCB 199	16.66667
PCB 189	1.977401
PCB 195	9.322033
PCB 194	11.29943
PCB 206	5.367231
PCB 185	3.954802
PCB 200	3.107345
PCB 174	22.31638
PCB 180, 193	78.24859
PCB 172	8.19209
PCB 202	5.367231
PCB 84	3.389831
PCB 105	3.107345
PCB 132	3.672316
PCB 183	23.72881
PCB 187	73.16384
PCB 175	2.259887
PCB 129	10.16949
PCB 178	11.58192
PCB 138, 158	49.43502
PCB 130	30.50847
PCB 176	5.367231
PCB 167	5.649717
PCB 179	12.99435
PCB 177	18.64407
PCB 153	108.4746
PCB 170, 190	46.32768
PCB 146	20.0565
PCB 131	2.824859
PCB 118	12.71186
PCB 149	77.9661
PCB 107	18.36158
PCB 151	4.237288
PCB 141	10.45198
PCB 95, 66	14.97175
PCB 110	13.55932
PCB 136	7.909604
PCB 87, 115	2.542373
PCB 97	6.214689
PCB 101, 90	12.42938
PCB 91	5.932203
PCB 92	4.519774
PCB 70	3.389831

Compound	Cdry
PCB 100	3.954802
PCB 41, 64	1.694915
PCB 44	1.694915
PCB 99	19.20904
PCB 51	0.847458
PCB 49	3.954802
PCB 52	3.672316
PCB 53	0.282486
PCB 28, 31	0.564972
PCB 180, 193	4.770642
PCB 110 (suspec	2.844037
PCB 187	5.688073
PCB 138, 158	8.623853
PCB 130	2.93578
PCB 105	1.559633
PCB 146	2.93578
PCB 118	4.40367
PCB 149	2.660551
PCB 99	7.706422
PCB 101, 90	2.844037
PCB 95, 70, 66	1.834862
PCB 153, 132	15.68807
PCB 28, 31	4.587156
PCB 52	4.495413
PCB 18	5.59633

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Croaker, atlantic

Compound	Cdry
PCB 28, 31	0.840336
PCB 53	0.588235
PCB 49	5.210084
PCB 70	0.504202
PCB 101, 90	2.773109
PCB 95, 66	0.92437
PCB 52	1.680672
PCB 118	10.58824
PCB 149	23.94958
PCB 128	7.647059
PCB 153	70.67226
PCB 105	1.344538
PCB 138, 158	91.84874
PCB 130	33.69748
PCB 187	20.08403
PCB 174	18.82353
PCB 177	19.91597
PCB 180, 193	77.89915
PCB 172	5.630252
PCB 136	10.7563
PCB 194	17.31092
PCB 195	7.731092
PCB 203, 196	9.495798
PCB 199	8.235294
PCB 170, 190	36.38655

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Shad, gizzard

Compound	Cdry
PCB 28, 31	1.596639
PCB 95, 66	2.857143
PCB 101, 90	5.714286
PCB 187	55.63025
PCB 135	11.2605
PCB 149	62.35294
PCB 118	17.98319
PCB 146	29.15966
PCB 153	170.7563
PCB 130	82.521
PCB 141	42.77311
PCB 105	1.764706
PCB 129	12.18487
PCB 132	6.05042
PCB 138, 158	195.042
PCB 167	12.35294
PCB 174	65.21008
PCB 177	57.73109
PCB 202	15.37815
PCB 156	13.10924
PCB 172	20
PCB 128	15.96639
PCB 194	41.09244
PCB 195	20.84034
PCB 203, 196	14.95798
PCB 170, 190	99.74789
PCB 180, 193	223.6134
PCB 199	26.97479

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Mummichog

Compound	Cdry
PCB 34	1.185345
PCB 174	6.788793
PCB 170, 190	24.67672
PCB 101, 90	0.646552
PCB 99	1.616379
PCB 183	2.909483
PCB 180, 193	57.75862
PCB 149	6.465517
PCB 118	5.603448
PCB 146	6.357759
PCB 153	35.34483
PCB 105	0.646552
PCB 167	4.310345
PCB 128	5.603448
PCB 187	9.051723
PCB 138, 158	64.11638
PCB 130	20.90517
PCB 141	6.357759
PCB 177	14.11638
PCB 194	9.267241
PCB 195	5.064655
PCB 203, 196	1.831897
PCB 199	4.633621

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Spot

Compound	Cdry
PCB 51	1.382114
PCB 101, 90	2.113821
PCB 99	2.276423
PCB 183	4.390244
PCB 187	7.723577
PCB 135	1.463415
PCB 128	10.4065
PCB 149	18.37398
PCB 118	10.2439
PCB 146	10.3252
PCB 138, 158	110
PCB 141	20.0813
PCB 105	1.382114
PCB 153	58.86179
PCB 130	49.6748
PCB 180, 193	100.813
PCB 177	30.1626
PCB 156	8.211383
PCB 174	17.96748
PCB 172	8.455284
PCB 194	26.01626
PCB 195	10.0813
PCB 203, 196	4.95935
PCB 199	6.260162
PCB 170, 190	50.4878

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Crab, blue

Compound	Cdry
PCB 170, 190	10.64982
PCB 180, 193	16.06498
PCB 172	1.263538
PCB 177	2.527076
PCB 146	5.415162
PCB 153	37.72563
PCB 128	3.790613
PCB 178	2.527076
PCB 138, 158	25.27076
PCB 130	4.693141
PCB 187	11.55235
PCB 105	1.083032
PCB 183	6.498195
PCB 118	4.33213
PCB 149	4.33213
PCB 110	1.805054
PCB 41, 64	1.083032
PCB 99	15.70397
PCB 101, 90	1.624549
PCB 91	3.249097
PCB 18	1.083032
PCB 28, 31	1.624549
PCB 100	2.888087
PCB 16, 32	0.722022

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Croaker, atlantic

Compound	Cdry
PCB 170, 190	19.28375
PCB 187	34.57301
PCB 180, 193	28.92562
PCB 199	4.820937
PCB 172	2.754821
PCB 183	10.33058
PCB 177	7.438017
PCB 174	7.024794
PCB 178	4.683196
PCB 138, 158	25.61983
PCB 130	13.49862
PCB 179	5.23416
PCB 105	0.688705
PCB 153	60.0551
PCB 146	10.7438
PCB 118	5.785124
PCB 149	39.66942
PCB 110	4.958678
PCB 99	12.12121
PCB 101, 90	11.43251
PCB 92	2.341598
PCB 91	4.820937
PCB 95, 66	3.581267
PCB 52	1.377411

VIMS Fish Organics Data for York River, King Creek near Penniman Spit, (Collected 8/5/2003)

Shad, gizzard

Compound	Cdry
PCB 170, 190	17.54717
PCB 199	1.886792
PCB 105	0.471698
PCB 183	9.81132
PCB 174	6.226415
PCB 177	7.264151
PCB 153	53.1132
PCB 187	31.79245
PCB 178	4.339622
PCB 138, 158	23.11321
PCB 130	8.773585
PCB 179	4.90566
PCB 132	1.132076
PCB 146	9.81132
PCB 118	4.716981
PCB 149	36.41509
PCB 97	1.509434
PCB 99	11.79245
PCB 101, 90	7.735849
PCB 92	1.415094
PCB 52	1.509434
PCB 180, 193	24.71698
PCB 95, 66	5
PCB 110	4.811321
PCB 51	0.849057
PCB 53	0.566038
PCB 18	0.943396
PCB 49	2.830189

VIMS Fish Organics Data for York River, King Creek near Penniman Lake, (Collected 8/6/2003)

Shad, gizzard

Compound	Cdry
PCB 136	24.40605
PCB 16, 32	2.37581
PCB 51	3.455724
PCB 28, 31	2.267818
PCB 202	10.79914
PCB 53	1.511879
PCB 33, 20	1.187905
PCB 70	2.159827
PCB 47, 48, 75	6.37149
PCB 41, 64	2.267818
PCB 42, 59	0.539957
PCB 44	1.079914
PCB 49	10.0432
PCB 101, 90	4.103672
PCB 97	0.863931
PCB 52	3.13175
PCB 135	7.667387
PCB 82	6.047516
PCB 183	11.77106
PCB 149	51.18791
PCB 118	14.57883
PCB 180, 193	163.6069
PCB 141	32.61339
PCB 153	158.2074
PCB 138, 158	170.4104
PCB 130	66.63067
PCB 105	2.051836
PCB 187	36.82505
PCB 170, 190	77.75378
PCB 167	9.50324
PCB 185	1.403888
PCB 177	41.2527
PCB 18	0.431965
PCB 172	14.57883
PCB 174	42.33261
PCB 128	15.33477
PCB 194	34.9892
PCB 195	13.39093
PCB 189	3.887689
PCB 203, 196	18.03456
PCB 199	13.8229

VIMS Fish Organics Data for York River, King Creek near Penniman Lake, (Collected 8/6/2003)

Perch, white

Compound	Cdry
PCB 8, 5	0.438597
PCB 136	1.644737
PCB 34	1.425439
PCB 28, 31	1.754386
PCB 51	0.328947
PCB 52	0.438597
PCB 18	1.20614
PCB 49	1.096491
PCB 70	0.328947
PCB 149	3.72807
PCB 180, 193	20.50439
PCB 187	3.947368
PCB 118	3.399123
PCB 138, 158	22.69737
PCB 130	8.333334
PCB 141	3.618421
PCB 105	0.438597
PCB 153	15.67982
PCB 156	1.644737
PCB 128	2.302632
PCB 174	2.741228
PCB 177	3.837719
PCB 194	4.276316
PCB 195	1.535088
PCB 203, 196	1.864035
PCB 199	1.864035
PCB 170, 190	4.605263

VIMS Fish Organics Data, King Creek near Penniman Lake, (Collected 8/6/2003)

Croaker, atlantic

Compound	Cdry
PCB 101, 90	2.941176
PCB 49	0.882353
PCB 52	0.514706
PCB 95, 66	3.014706
PCB 99	4.779412
PCB 187	11.91177
PCB 183	3.455882
PCB 149	13.52941
PCB 118	1.617647
PCB 180, 193	10.73529
PCB 153	19.77941
PCB 178	1.397059
PCB 138, 158	8.455882
PCB 130	5.808824
PCB 179	1.838235
PCB 105	0.514706
PCB 146	3.75
PCB 174	2.132353
PCB 177	2.573529
PCB 110	2.279412
PCB 170, 190	7.058824

VIMS Fish Organics Data for York River, King Creek near Penniman Lake, (Collected 8/6/2003)

Shad, gizzard

Compound	Cdry
PCB 209	1.818182
PCB 170, 190	50.66666
PCB 199	20
PCB 189	1.818182
PCB 195	6.30303
PCB 194	10.18182
PCB 180, 193	80.48485
PCB 172	9.090909
PCB 174	22.90909
PCB 177	21.09091
PCB 146	24.60606
PCB 95, 66	14.42424
PCB 187	83.51515
PCB 178	13.93939
PCB 138, 158	50.78788
PCB 130	31.39394
PCB 176	5.69697
PCB 183	27.0303
PCB 105	0.606061
PCB 153	108
PCB 185	4.121212
PCB 118	6.545455
PCB 149	85.45454
PCB 135	8.363636
PCB 179	14.90909
PCB 87, 115	1.333333
PCB 97	1.212121
PCB 99	23.15152
PCB 101, 90	11.51515
PCB 92	4.363636
PCB 49	4.606061
PCB 91	8.121212
PCB 100	2.424242
PCB 191	1.575758
PCB 70	1.333333
PCB 51	1.818182
PCB 110	10.54545

VIMS Fish Organics Data for York River, King Creek near Penniman Lake, (Collected 8/6/2003)

Croaker, atlantic

Compound	Cdry
PCB 187	41.41221
PCB 180, 193	40.07634
PCB 200	2.099237
PCB 170, 190	27.09924
PCB 199	10.49618
PCB 183	13.74046
PCB 174	11.0687
PCB 185	1.717557
PCB 177	10.1145
PCB 138, 158	25.76336
PCB 130	17.36641
PCB 176	2.862595
PCB 179	7.824427
PCB 153	62.0229
PCB 118	4.580153
PCB 149	43.51145
PCB 107	9.541985
PCB 110	5.534351
PCB 146	12.40458
PCB 99	11.64122
PCB 101, 90	8.969465
PCB 91	4.007633
PCB 95, 66	8.015266
PCB 49	2.862595
PCB 52	2.099237
PCB 135	4.389313

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NPS 333/105048, July 2010

National Park Service
U.S. Department of the Interior

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