

FINAL

---

Sediment Collection Field Data Report  
*M/T ATHOS I* Oil Spill  
Delaware River  
New Jersey, Pennsylvania and Delaware

6 December 2005

*Prepared for:*

**U.S. Department of Commerce**  
National Oceanic and Atmospheric Administration

**U.S. Department of the Interior**  
U.S. Fish and Wildlife Service

**State of New Jersey**  
Department of Environmental Protection

**State of Delaware**  
Department of Natural Resources and Environmental Control

**Commonwealth Of Pennsylvania**  
Department of Conservation and Natural Resources  
Department of Environmental Protection  
Fish and Boat Commission  
Game Commission

*Prepared by:*

Industrial Economics, Incorporated  
2067 Massachusetts Avenue  
Cambridge, MA 02144

## **Background**

On Friday, November 26, 2004 (approximately 2100 hrs), the *M/T ATHOS I*, a 750 foot oil tanker, was reported to be leaking oil into the Delaware River while executing a berthing maneuver en route to its terminal at the CITGO asphalt refinery in Paulsboro, NJ. The spill occurred in the vicinity of the Mantua Creek, which is located directly across the river from the Philadelphia International Airport. As of January 14, 2005, the Coast Guard estimated that approximately 265,000 gallons of Venezuelan crude oil had been spilled into the Delaware River from the *M/T ATHOS I*. Despite aggressive response efforts by the U.S. Coast Guard, state response agencies, and the Responsible Party (RP), oil was reported along approximately 57 to 115 miles of shoreline from the Tacony-Palmyra Bridge to south of the Smyrna River in Delaware (Polaris Applied Sciences, Inc. 2005).

Of the total quantity of oil spilled into the Delaware River, roughly 221,910 gallons of oil and oily liquid and 17,761 tons of oily solids were recovered/collected from the river (Joint Information Center, April 22, 2005). As the ultimate fate of this oil is not known and the undetermined quantities of oil remaining in the environment have the potential to adversely affect natural resources in the Delaware River and Delaware Bay, the Natural Resources Trustees designed and implemented a sediment sampling and analysis plan to better characterize PAH concentrations in subtidal sediments within portions of the Delaware River and to provide information on potential sources of PAHs.

## **Sampling Plan Overview**

Based on an initial review of data collected during spill response and relevant information from the oil petroleum chemistry and toxicity literature (Donlan *et al.* 2005a), the Aquatic TWG determined that spill-associated PAHs pose a potential ongoing risk to sediment-dwelling biota, but that existing data do not provide a sufficient basis for assessing the extent and severity of potential sediment injury.

As a result, the Aquatic TWG determined that additional sediment data collection was necessary and designed a sampling and analysis program (Donlan *et al.* 2005b). The 2005 field sampling program was intended to provide the information needed to help determine if discharges of oil from the *M/T ATHOS I* spill are likely to have degraded sediment quality conditions in the Delaware River Estuary. More specifically, the objectives of the sampling program were as follows:

- (1) Obtain data on the concentrations of PAHs in 140 whole-sediment samples using a ultraviolet fluorescence (UVF) screening analysis;
- (2) Confirm the results of UVF-based analyses of whole-sediment samples through laboratory PAH analysis of a subset of the collected samples;
- (3) Collect and archive whole-sediment samples from each sampling station for possible future toxicity studies and further chemical analysis; and

- (4) Collect VSORS data to generate information on the presence/absence of submerged tarmats or other agglomerations of oil/oiled sediments that could be a source of ongoing, physical impacts to river sediment habitat.

The Field Sampling Plan (FSP, MacDonald *et al.* 2005), describes the procedures to be used to collect and analyze the 140 whole-sediment samples from the Delaware River to evaluate contamination by PAHs and perform VSORS monitoring.<sup>1</sup> In addition, the FSP documents the procedures to be used to collect and archive 140 whole-sediment samples from the Delaware River for possible future analysis of sediment chemistry and sediment toxicity.

The sediment collection effort described in the FSP for the 2005 Sediment Quality Evaluation of Delaware River Estuary was completed in September 2005. As proposed in the sampling plan, sediment grab samples were collected from designated areas of the Delaware River and some tributaries. In total, we collected sediment from 162 sites, and performed an initial PAH screening on all samples with UVF spectroscopy. Sampling procedures and conditions, including adjustments to the FSP and sampling procedures, are described in the following sections.

### **Implementation of Sampling Plan**

Sampling was conducted between 13 September 2005 and 16 September 2005. No major weather events prevented sampling, although some light rain fell on 14 and 15 September. Of the 140 samples specified in the plan, we successfully collected sediment from 121 sites. Typically, sites were skipped when obvious obstacles prevented sampling, or collection was not successful after three attempts. Table 1 lists each site where sediment collection was unsuccessful. Additional sediment grabs were made near two locations (sites 14 and 43) where a clear presence of oil was noted in the original sediment collection, resulting in the addition of four sites within the original collection area.

Initial testing of the VSORS apparatus indicated that the feasible towing speed was too slow to allow coverage of significant areas of the river in the time allotted. Rather than spend a significant amount of time gathering limited information, the VSORS effort was canceled and an additional day of sediment grabs was substituted into the schedule. We identified 40 new sites in the depositional zones near the Christina River and the Delaware Memorial Bridge, on both the Delaware and New Jersey sides of the river, and successfully collected sediment samples at 37 of those sites.

The sampling largely followed the sampling procedures as laid out in the FSP; however, some changes were made in response to field and logistical constraints (see Table 2). Overall, it was not possible to collect samples at some locations, nor could we obtain the large samples specified due to hard bottom, lack of sediment, and the size of the sampler. Sample volumes collected are sufficient for screening (UVF) and laboratory chemistry analyses. Where sediment

---

<sup>1</sup> Standard operating procedures (SOPs) are provided in the FSP for chemical analysis of PAHs by UVF, chemical analysis of PAHs by gas chromatography/mass spectrometry - single ion monitoring (GC/MS-SIM), and laboratory analysis of total organic carbon.

was too hard for the grab sampler to pick up or only consisted of rocks, smaller samples were collected or the site was skipped. Adjustments to quality control procedures included use of disposable scoops for transferring sediment to jars and Alconox soap solution to clean the sampler. Latitude and longitude were recorded by hand for each site once it (or closest accessible location) was reached, due to difficulties with transfer of electronic data from the shipboard GPS.

<b>Table 1</b>			
<b>Athos I Sediment Sampling - Unsuccessful Sediment Collection Sites</b>			
<b>Sample Number</b>	<b>Coordinates</b>		<b>Reason for non-collection (if given)</b>
25	39N52.542	75W12.175	
	39N52.595	75W12.189	
30	39N52.518	75W12.420	rock, asphalt
35	39N51.988	75W12.663	no sediment retrieved
41	39N51.773	75W13.109	no sediment retrieved
57	39N50.914	75W15.762	
66	39N50.717	75W16.543	
73	39N50.824	75W17.372	no sediment retrieved
74	39N58.823	75W17.378	no sediment retrieved
78	39N50.915	75W17.833	
89	39N51.385	75W19.101	
92	39N51.169	75W19.613	
96	39N50.901	75W19.874	hard bottom, rocks
101	39N50.954	75W20.387	
104	39N50.618	75W21.127	
108	39N50.095	75W21.686	
112	39N49.923	75W22.372	
115	39N49.191	75W22.811	
123	39N48.712	75W23.605	
x-S	39N47.909	75W26.722	
x-S	39N38.821	75W32.713	
4-S	39N42.913	75W30.670	rock
9-S	39N43.316	75W30.034	

<b>Table 2</b> <b>ATHOS I Sediment Sampling - Changes in Implementation of Field Sampling Plan</b>	
<b>Area of Modification</b>	<b>Changes Made</b>
<b>Overall Collection Modifications</b>	<ul style="list-style-type: none"> <li>• VSORS not undertaken, due to insufficient towing speed.</li> <li>• Forty new sediment grab sites added (samples with -S appended to their numbers)</li> <li>• One gallon toxicity testing samples not collected, due to difficulty in obtaining sufficient volume.</li> </ul>
<b>Site Identification and Documentation</b>	<ul style="list-style-type: none"> <li>• Up to 3 tries made at any given site, with slight movement between grabs. See Table 1 for sites where no sediment sample was obtained.</li> <li>• Pilot navigated close to specified location, actual coordinates documented by hand from GPS unit.</li> </ul>
<b>Collection Procedures</b>	<ul style="list-style-type: none"> <li>• Water generally drained out of bottom of sampler before sampler was opened.</li> <li>• Sediment sampler rinsed with site water, and scrubbed with Alconox soap solution if contamination was observed.</li> <li>• Sterile, single-use plastic (polyethylene) scoops used to transfer sediment</li> <li>• Kept 2x 8oz. jars to insure sufficient sample for all chemical analyses, including duplicates. At some locations, only 1 jar could be collected.</li> <li>• van Veen sampler provided by Delaware of approximately 2 L volume, and 25cm x 20cm - smaller than proposed in FSP.</li> <li>• Incompletely filled grabs were kept with low volume due to hard bottom which prevented fully filling the sampler at some locations</li> <li>• Generally used entire grab (depth of 2-6 cm) to obtain sufficient volume for chemical analysis (approximately 6 cm required to fill two jars).</li> </ul>

## **Screening Results**

In total, we collected sediment from 162 sites, and performed an initial PAH screening on all samples with UVF spectroscopy. In the initial screening, sample concentrations range from less than a part per million (ppm) up to 744 ppm.<sup>2</sup> Figures 1 through 4 in Appendix A show the concentration range at each site, while Table 3 provides a complete list of values. The majority of samples have low values: 52 below 5 ppm and an additional 76 below 20 ppm. Only 15 samples have screening values above 100 ppm. Most samples exhibiting very high PAH concentrations in the screening test are soft, silty sediments from sites within the depositional areas, with an odor indicating the presence of petroleum products.

---

<sup>2</sup> Based on the calibration study performed on sediment samples collected during the preassessment activities, UVF PAH screening values appear to generally overstate the PAH concentration by a factor of 2 to 3, with a factor of up to 10 possible in areas with high concentrations of organic matter. Similar results were found with the 20 samples sent to GERG, with ratios of 2 to 3 at low concentrations, averaging up to 6 to 7 at higher concentrations.

**Table 3**  
**Delaware River Sediment Quality Study Athos I Spill**  
**Initial PAH Screening Values by Ultraviolet Fluorescence**

Site Number	PAH Concentration (ppm)						
1	1.6	47	12.9	100	2.4	1-S	6.6
2	0.8	48	352.0	102	12.2	2-S	57.9
3	1.5	49	22.7	103	10.9	3-S	1.4
4	171.6	50	2.0	105	0.5	5-S	0.2
5	2.0	51	12.6	106	7.0	6-S	6.1
6	1.6	52	121.0	107	0.6	7-S	1.7
7	7.2	53	161.4	109	14.7	8-S	27.6
8	73.3	54	6.6	110	1.6	10-S	1.2
9	6.1	55	35.4	111	15.7	11-S	9.9
10	3.2	56	45.0	113	1.5	12-S	6.3
11	3.3	58	9.4	114	0.8	13-S	8.7
12	3.2	59	18.9	116	176.0	14-S	1.2
13	47.7	60	1.3	117	9.8	15-S	7.2
14	744.0	61	10.8	118	8.3	16-S	1.6
14A	1.8	62	15.1	119	12.5	17-S	1.2
14B	442.0	63	13.6	120	10.9	18-S	1.3
15	9.5	64	14.4	121	12.0	19-S	1.9
16	21.7	65	101.1	122	78.6	20-S	1.4
17	8.7	67	13.5	124	96.7	21-S	201.8
18	47.6	68	10.0	125	8.2	22-S	157.9
19	0.6	69	15.2	126	9.8	23-S	7.7
20	10.6	70	127.2	127	3.2	24-S	2.8
21	12.6	71	3.2	128	11.3	25-S	6.0
22	2.8	72	14.1	129	11.6	26-S	1.5
23	9.3	75	16.2	130	9.4	27-S	3.4
24	6.4	76	4.1	131	1.4	28-S	1.8
26	3.3	77	19.6	132	8.0	29-S	2.1
27	9.1	79	14.7	133	282.6	30-S	1.4
28	25.6	80	1.4	134	9.1	31-S	6.4
29	2.0	81	3.2	135	7.6	33-S	6.5
31	111.0	82	31.5	136	1.7	34-S	7.1
32	18.8	83	6.8	137	10.8	35-S	8.7
33	3.8	84	16.8	138	14.1	36-S	8.1
34	120.6	85	3.1	139	7.0	37-S	6.4
37	16.3	86	2.0	140	31.4	38-S	8.1
38	7.8	87	3.4			39-S	5.1
39	1.8	88	2.0			40-S	11.2
40	16.0	90	12.0				
42	62.2	91	211.0				
43	42.0	93	-0.4				
43A	70.6	94	12.6				
43B	13.6	95	16.8				
44	61.1	97	17.0				
45	10.8	98	18.8				
46	20.1	99	2.0				

The 20 samples selected for further laboratory analysis by GERG are weighted towards higher contaminant concentrations based on screening values, but still reflect a wide range of concentrations and locations. They are from each deposition zone sampled except 2B and 6A, and include several sites near the spill origin and other areas where heavy oiling was noted during spill response activities. Details on sample selection and supporting rationale is provided in a prior memorandum (Shellenbarger Jones and Donlan 2005); additional information on the 20 samples sent to GERG is provided in Table 4. UVF PAH concentration values in the samples range from 2.0 ppm to 352.0 ppm. Sediment types collected range from silt and mud to fine sand, coarse sand, gravel, rocks, and well-consolidated hard sediments. The most common sediment types are fine grain, consolidated, silt, and gravel. Many samples include bivalves, and one contained a black organic material. The samples are taken from water depths ranging from three feet to 38 feet. In seven of the proposed samples, we noted a petroleum odor during the UVF screening analysis; at site 43, an odor was also noticed during the collection.

### **Sample Storage**

During the collection (both on the boat and during the screening analysis) sample containers were stored on ice in 120 quart coolers with temperature maintained between 2 and 6 °C. Following screening analysis, samples were transferred to dry 120 quart coolers, Chain of Custody (COC) forms were initiated, and the coolers were moved to the Delaware Avenue Distribution Center (DADC) refrigerated warehouse in Philadelphia. In total, four coolers holding 296 samples were stored. The four coolers were shrink-wrapped and are being maintained at 2 °C in the warehouse.

### **Data Collection and Storage**

Currently, field sampling data are in both paper and electronic formats. Each sample has a field data sheet, listing sampling conditions, vessel, and sampler type, location, water depth, and sediment type. These data exist in hard copy, and are now also recorded in an Excel spreadsheet, along with the storage location of each sample including cooler tracking numbers (see Appendix B). Digital photographs of samples were taken at each site after collection. Copies of Chain of Custody (COC) forms are kept with data sheets, and the originals are stored inside the coolers. Sample lists for each cooler are attached to outside of each cooler, and copies are stored with the data sheets. Storage location data is also recorded electronically in an Excel spreadsheet. PAH screening data are recorded on hard copy datasheets. An Excel spreadsheet was created from the data sheets for the initial PAH screenings with the following information: sample number, dilution factor, UVF reading, and actual PAH value. All hard copies are in binders, or otherwise kept together. A CD is available with spreadsheets, images, and scanned copies of data sheets from the sampling and subsequent analysis. The contents of the CD are listed in Appendix C.

Review of the data sheets following collection indicated that data sheets for some locations were mislabeled or unlabeled, or missing altogether. Cross-checking container IDs, planned collection sites, and recorded GPS coordinates from the data sheets resulted in identification of most of the locations. Table 5 shows the locations under question.

**Table 4**  
**Delaware River Sediment Quality Study Athos I Spill**  
**Samples Analyzed at GERG for PAHs**

<b>Site Number</b>	<b>UVF-PAH value (ppm)</b>	<b>Deposition Zone</b>	<b>Sediment Type</b>	<b>Depth (feet)</b>	<b>Odor</b>
8	73.3	NE of 1B	clay, gravel	11	
13	47.7	1B	rock, firm consolidated clay, gravel, bivalves	5	
18	47.6	N of 1A in Schuylkill River	fine grain mud	38	
34	120.6	1A	clay, thick mud	26	
43	42.0	1B	fine grain, small gravel, coarse sand	14	petroleum odor
48	352.0	1B at Mantua Creek	sand, fine grain, gravel, bivalves	30; 25	petroleum odor
55	35.4	2A	coarse grain sand, brown mud, sparkly black flecks	6	
65	101.1	2A	grey silty clay	30	
79	14.7	2A	brown silt	4	
82	31.5	2A	grey silt, fine grain, sand, bivalves	15	
86	2.0	3	fine grain, silty, brown/grey	6	
97	17.0	3	silty, brown/grey	3	
116	176.0	4B	rocks, sand, bivalves	10	petroleum odor
124	96.7	NE edge of 4A	fine grain, consolidated, brown/grey, bivalves	20	petroleum odor
128	11.3	4B	brown, consolidated fine sediments, bivalves	17	
2-S	57.9	5	fine grain, silt, well consolidated	23	petroleum odor
8-S	27.6	5	mixed fine grain, coarse grain sand, gravel	23	
21-S	201.8	6B	hard bottom, well consolidated	31	petroleum odor
22-S	157.9	6B	consolidated	32	petroleum odor
36-S	8.1	6C	fine grain	6	

<b>Table 5</b> <b>Missing, Mislabeled, or Unlabeled Sampling Sites</b> <b>(Based on Field Data Sheets)</b>			
<b>Sample Number</b>	<b>Labeled Sample in Storage</b>	<b>Identification Confirmed</b>	<b>Explanation</b>
5	yes		Mislabeled data sheet. Two data sheets labeled as site 4.
27	yes		
36	no		Site missed: no data sheet, no sample.
32-S	yes		
34-S	yes		Mislabeled data sheet. Two data sheets labeled as 24-S.
36-S	yes		
37-S	yes		
39-S	yes		
Note: The identification of the sites is being confirmed from the GPS coordinates on unlabelled datasheets and will be included shortly.			

### **Laboratory results**

As indicated in Table 4, twenty samples were sent to GERG for further analysis. The results for total PAH and total organic carbon are shown in Table 6. GERG analyzed for 41 PAHs and PAH groups, as well as five alkyl naphthalenes. Total PAH values ranged between 1.5 ppm and 32 ppm. TOC values ranged between 1.13 and 7.25, with an average of 2.93. The sum of the 18 NOAA National Status and Trends (NS&T) PAHs are also included.<sup>3</sup> Complete analytical results and QA/QC reports are available electronically in Appendix C.

### **List of Appendices**

Appendix A: Sediment Collection Maps Indicating Screening Concentrations of PAHs

Appendix B: Field Data Tables

Appendix C: Additional Electronic Information

Appendix D: Subcontractor Information

---

<sup>3</sup> The 18 NS&T PAHs are naphthalene, biphenyl, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(e)pyrene, benzo(a)pyrene, perylene, dibenzo(a,h)-anthracene, 2-methylnaphthalene, 1-methylnaphthalene, 2,6-dimethylnaphthalene, and 1-methylphenanthrene.

**Table 6  
Laboratory PAH Results for Selected Samples**

<b>Sample Number</b>	<b>Approx Distance from Spill Origin (km)</b>	<b>Screening PAH value (ppb)</b>	<b>GERG Total PAH value (ppb)</b>	<b>GERG NS&amp;T PAHs (ppb)</b>	<b>TOC</b>	<b>% Moisture</b>
48	0	352,000	18,472	3764.0	3.84	41.5
21-S	45	201,800	14,583	5413.6	3.48	56.0
116	13.5	176,000	20,304	8383.5	3.20	47.8
22-S	45	157,900	24,715	9586.8	7.25	53.0
34	3	120,600	25,134	7476.4	3.77	61.5
65	3.5	101,100	19,891	7641.8	3.48	46.6
124	14	96,700	11,348	2618.2	3.52	64.1
8	6	73,300	10,491	4865.7	1.48	32.5
2-S	37	57,900	6,239	2525.8	2.10	46.4
13	4	47,700	13,500	7338.9	3.33	51.1
18	5.5	47,600	32,154	13503.3	4.53	65.5
43	0.5	42,000	5,179	1908.0	1.94	32.3
55	2.5	35,400	1,813	924.8	1.13	22.6
82	6.5	31,500	25,072	12211.8	2.45	42.5
8-S	34	27,600	7,447	3514.1	3.25	65.3
97	9	17,000	6,209	3105.3	2.12	49.1
79	5.5	14,700	6,841	3444.4	1.82	48.1
128	15	11,300	4,018	2029.2	2.22	67.9
36-S	40	8,100	4,416	2278.9	2.16	54.1
86	7	2,000	1,481	977.5	1.56	46.9

Note: Total PAH value is the sum of 41 PAHs and PAH groups. NS&T PAHs is the sum of 18 PAH compounds.

## REFERENCES

- Donlan, M.C., G. Douglas, and D.D. MacDonald. 2005a. An evaluation of the composition, and potential environmental fate and toxicity of heavy Venezuelan crude oil released into the Delaware River during the M/T ATHOS I oil spill. Prepared for the Aquatic Technical Work Group for ATHOS I Spill. Prepared by Industrial Economics, Incorporated, Cambridge, Massachusetts; New Fields Environmental Forensics Practice LLC, Rockland, Massachusetts; and MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia
- Donlan, M.C., A. Shellenbarger Jones, and D. D. MacDonald. 2005b. Proposed Aquatic Sediment Sampling and Analysis Design. Prepared for the Aquatic Technical Work Group for ATHOS I Spill. Prepared by Industrial Economics, Incorporated, Cambridge, Massachusetts and MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia.
- MacDonald, D.D., M.C. Donlan, A. Shellenbarger Jones, and C. Miller. 2005. Field Sampling Plan for the 2005 Sediment Quality Evaluation of Delaware River Estuary. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Industrial Economics, Incorporated, Cambridge, Massachusetts.
- Polaris Applied Sciences, Inc. 2005. Preassessment data report MT/Athos I oil spill, Delaware River, New Jersey, Pennsylvania and Delaware. Prepared for US Department of Commerce-National Oceanic and Atmospheric Administration, US Department of the Interior-US Fish and Wildlife Service, State of New Jersey-Department of Environmental Regulation, State of Delaware-Department of Natural Resources and Environmental Control, and Commonwealth Pennsylvania-Department of Conservation and Natural Resources. Prepared by Polaris Applied Sciences Inc. Kirkland, Washington.
- Shellenbarger Jones, A. and M.C. Donlan. 2005. Preliminary Screening Results on Delaware River Sediment. Prepared for the Aquatic Technical Work Group for ATHOS I Spill. Prepared by Industrial Economics, Incorporated, Cambridge, Massachusetts.

## **APPENDIX A**

### **Sediment Collection Maps Indicating Screening Concentrations of PAHs**

Figure 1. Screening-level results for the 2005 field sampling program, Schuylkill River area, Delaware River Estuary; PAH concentrations based on UV fluorescence spectroscopy (UVF).

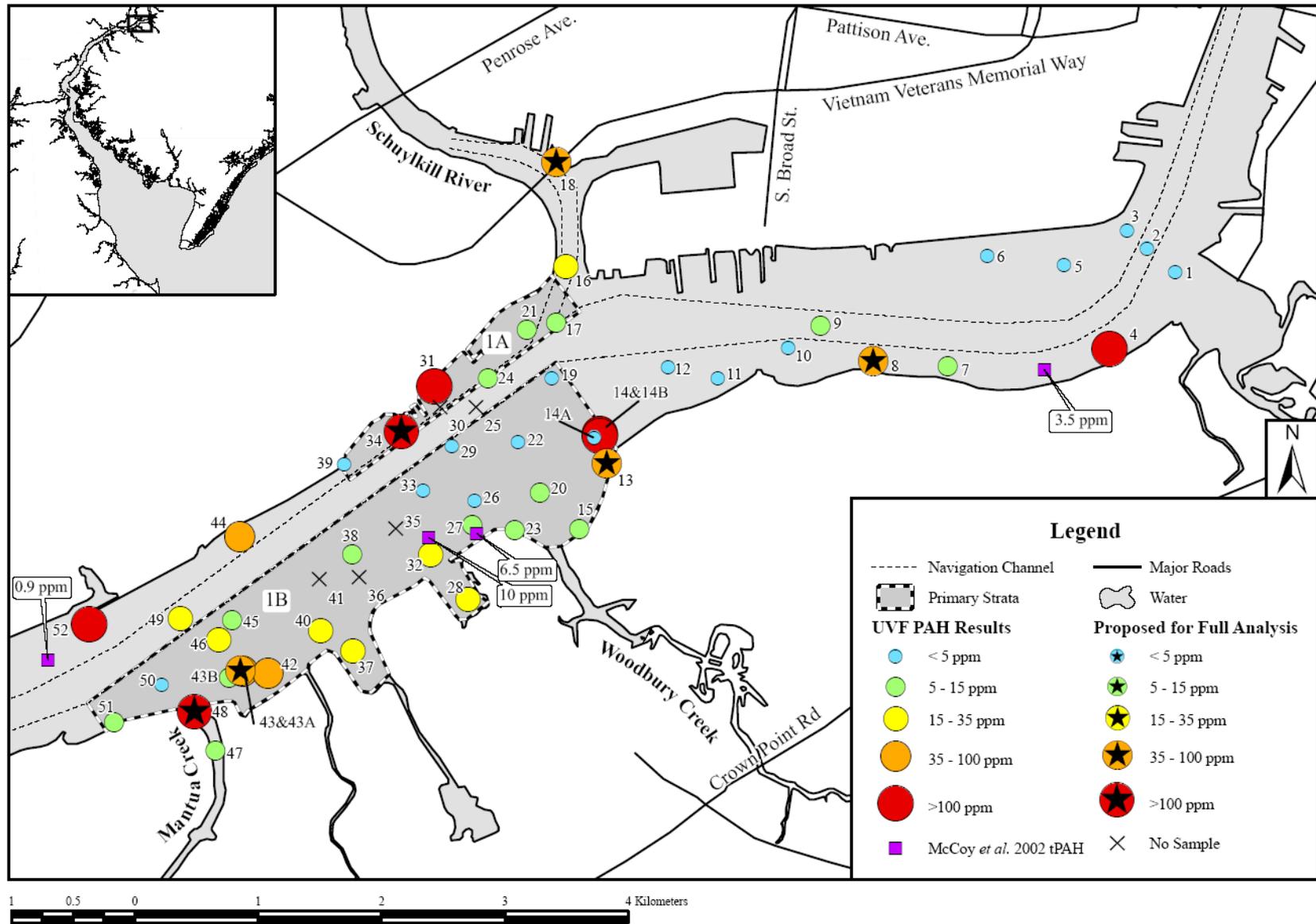


Figure 2. Screening-level results for the 2005 field sampling program, Tinicum Island area, Delaware River Estuary; PAH concentrations based on UV fluorescence spectroscopy (UVF).

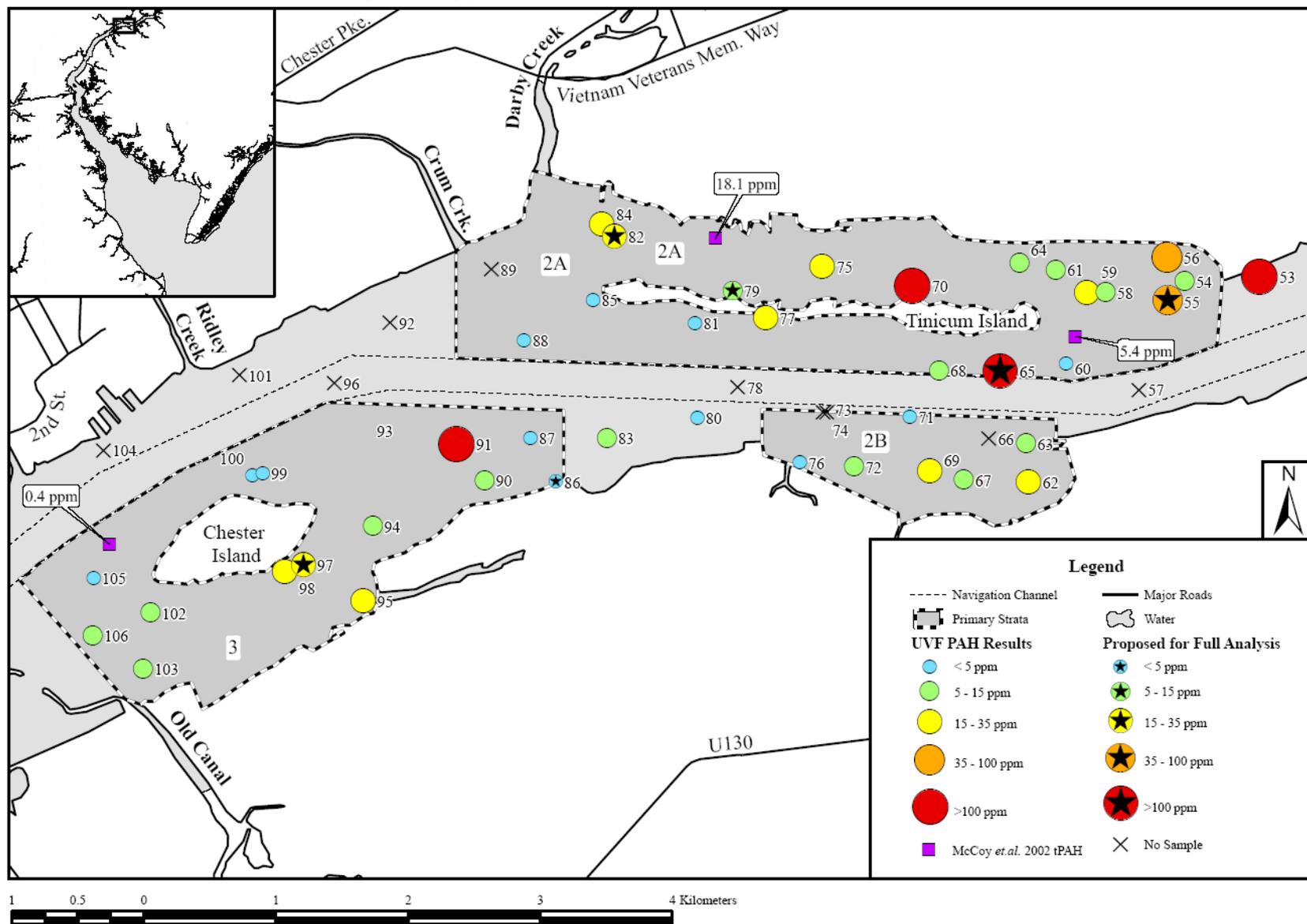


Figure 3. Screening-level results for the 2005 field sampling program, Marcus Hook area, Delaware River Estuary; PAH concentrations based on UV fluorescence spectroscopy (UVF).

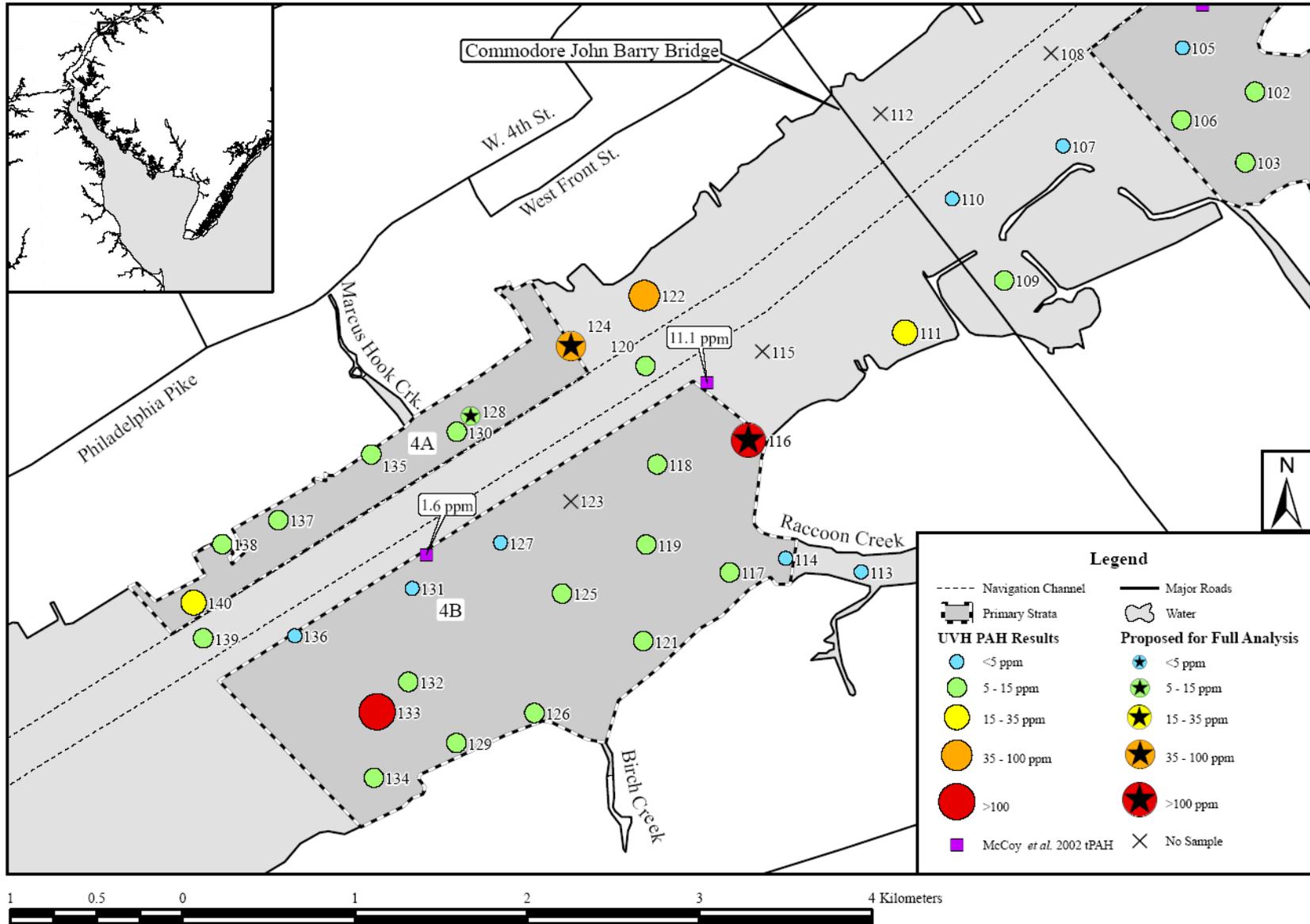
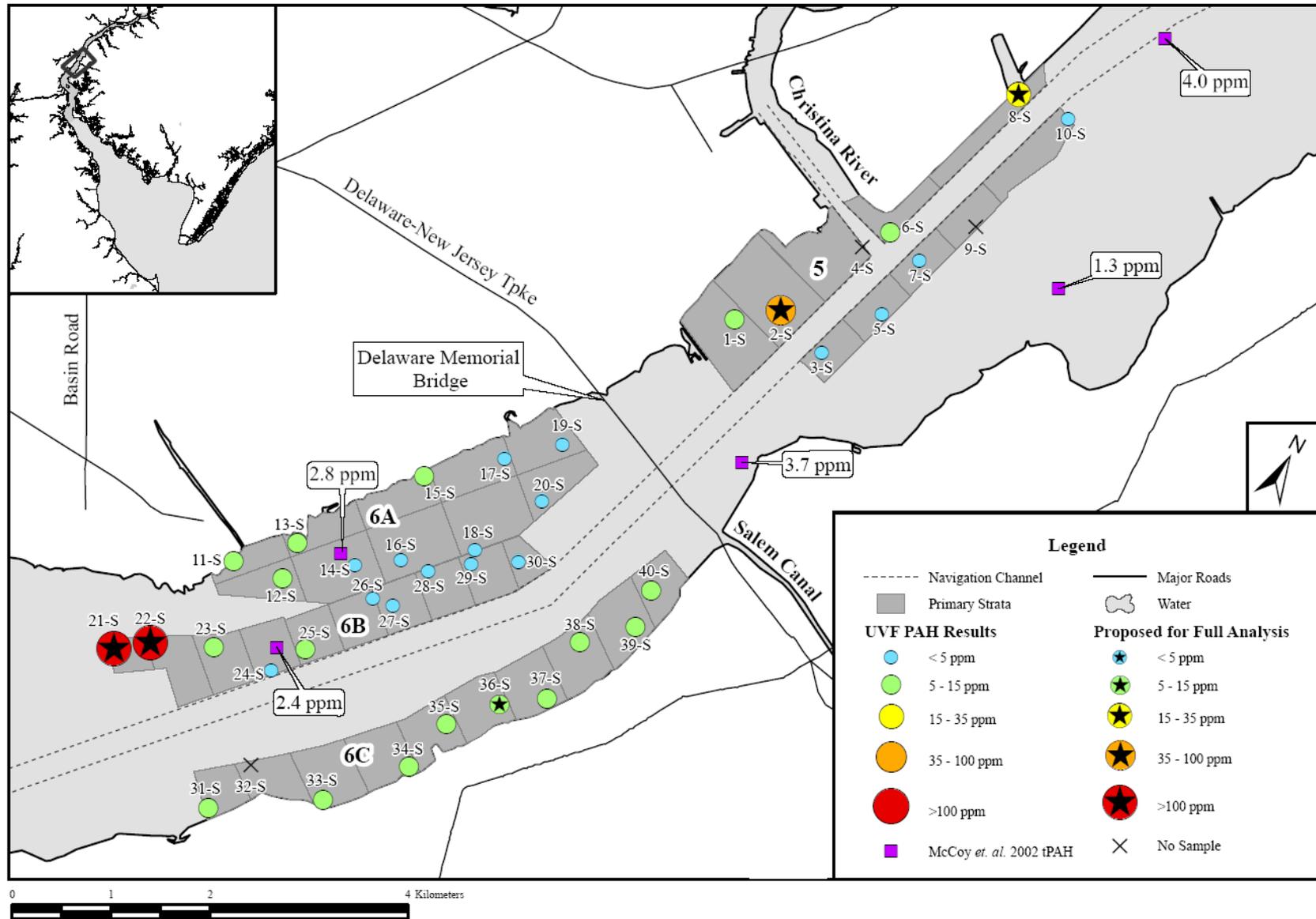


Figure 4. Screening-level results for the 2005 field sampling program, Christina River and City of Newcastle area, Delaware River Estuary; PAH concentrations based on UV fluorescence spectroscopy (UVF).



## **APPENDIX B**

### **Field Data Tables**

**ATHOS I Delaware River Sediment Sampling Data**

**Highlighted** samples were sent to GERG for complete PAH analysis

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
1	53.125	8.236	yes	no jar 1	17	rock, gravel			x	2						
2	53.216	8.399	yes		50	gravel, sand	clams		x	1,2						
3	53.304	8.527	yes	only filled jar 2	24	rocks, hard clay			x	2						
4	52.800	8.617	yes		10	hard, mud			x	1,2						
5	53.168	8.879	yes		14	sand		petroleum	x	1,2						
6	53.203	9.318	yes		18	clay	1 clam		x	1,2						
7	52.744	9.563	yes		50	mud	clams		x	1,2						
8	52.755	9.986	yes	no jar 1, partial jar 2	11	clay, gravel	1 clam		x	2						
9	52.890	10.309	yes		48	sand, gravel, rock			x	1,2						
10	52.782	10.497	yes		26	gravel, sand, shells			x	1						
11	52.679	10.847	yes	second reading listed: 39.52.665; 75.10.862	12'-13'	mud, clay, gravel	clams		x	1,2						
12	52.711	11.136	yes		25 -23	sand			x	1,2						
13	52.281	11.559	yes	only enough for 1 jar	5	rocks, clay, pebbles	clams		x	2						
14	52.404	11.501	yes	jar 2 combined of grabs 1 and 2; jar 1 is from grab 2	22	rocks, pebbles, sand, mud	clams	petroleum	x	2		x	1			
14A	52.392	11.540	yes		22	coarse sand	bivalves					x	1			
14B	52.402	11.507	yes		22	silt, mud, sheen		strong petroleum				x	1			
15	52.241	11.610	yes		3	mud	clams		x	1,2						
16	53.132	11.704	yes		38	mud			x	1						
17	52.898	11.756	yes		47	sand	>50% clams		x	1,2						
18	53.609	11.810	yes		38	fine mud			x	1,2						
19	52.646	11.799	yes	second reading listed: 39.52.616; 75.11.866 'not able to collect considerable sample'	18	sand			x	2						

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
20	52.145	11.849	yes		10	fine sand	some clam shells		x	1,2						
21	52.854	11.952	yes		30.4	coarse sand, pebbles	clams		x	1,2						
22	52.376	11.971	yes		16	sand, gravel, pebbles	clams		x	1,2						
23	52.013	11.970	yes		3	silt, mud	eelgrass		x	1,2						
24	52.656	12.136	yes	second reading listed; 39.52.660; 75.12.162; only kept 1 jar	48.3	silt, rock						x	2			
25	52.542	12.175	no	second reading listed; 39.52.595; 75.12.189	48; 47											
26	52.121	12.212	yes	only 1 jar	3	rock, shells	clams					x	2			
27	52.006	12.230	yes					x	1,2							
28	51.681	12.291	yes		2.5	silt, mud		petroleum	x	1		x	2			
29	52.346	12.363	yes		46	clean sand			x	1,2						
30	52.518	12.420	no		40.5	rock, asphalt										
31	52.566	12.444	yes		15	mud	1 clam	fuel odor?	x	1,2						
32	51.874	12.447	yes		4	silt		hydrogen sulfide	x	1,2						
33	52.147	12.517	yes		43	sand, silt			x	1		x	2			
34	52.404	12.638	yes		26	clay, mud	lots of clams		x	1,2						
35	51.988	12.663	no	all grabs = only water	42	no sediment										
37	51.516	12.904	yes		3	fine grain, sheen	eelgrass	petroleum	x	1,2						
38	51.872	12.923	yes		40	silt	clams		x	1						
39	52.177	12.955	yes		49	small rocks, clay layer						x	1,2			
40	51.538	13.065	yes		9	fine grain			x	2	3	1	x	1		
41	51.773	13.109	no		40	no sediment										
42	51.360	13.385	yes		5	silt		petroleum				x	1,2			
43	51.356	13.545	yes		14	fine grain, small gravel, sheen, coarse sand		strong petroleum				x	1,2			
43A	51.358	13.531	yes		16	fine sand		slight petroleum				x	1			

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)	Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
43B	51.330	13.608	yes		30	fine grain						x	1		
44	51.937	13.570	yes		12.6	crusty layer, gray mud		x	1,2						
45	51.583	13.601	yes		43	mud, silt, fine grain		x	1,2						
46	51.496	13.678	yes		44	rocks, sand, gravel	clams	x	1,2						
47	51.004	13.674	yes	2 jars	20	detritus		x	1,2						
48	51.182	13.805	yes		30; 25	sand, fine grain, gravel	bivalves	petroleum	x	1,2					
49	51.597	13.899	yes		46	sand, silt		x	1,2						
50	51.301	13.992	yes		50	sand, gravel, coarse grain	bivalves	x	1,2						
51	51.159	14.272	yes		45	fine grain, sheen, black flecks	bivalves	x	1,2						
52	51.568	14.398	yes		29	thick mud, rocks	clams	strong petroleum	x	1,2					
53	51.374	15.137	yes		6.6	fine-grained mud		petroleum	x	1,2					
54	51.353	15.554	yes		15	fine sand, sparkly						x	1,2		
55	51.275	15.580	yes		6	coarse grain sand, mud, sparkly black flecks		x	1,2						
56	51.448	15.668	yes		6.8	silt, sand, organics, sheen	clams	petroleum	x	1		x	2		
57	50.914	15.762	no		54										
58	51.301	15.944	yes		9.2	silt, sand, organics, sheen	clams					x	1,2		
59	51.302	16.003	yes		9.4	silt, sand	clams	x	1,2						
60	15.019	16.172	yes	1/3 jar	27	and, silt, clay						x	1		
61	51.396	16.131	yes	only 1 jar	14.9	silt, sand	bivalves					x	1		
62	50.547	16.298	yes		6	fine silt, 1-2mm tarballs	eelgrass			x	1,2				
63	50.701	16.321	yes		37	silt				x	2	x	1		
64	51.432	16.346	yes		23.1	mud, sheen, silt				x	1,2				
65	50.991	16.512	yes		30	silt, clay						x	1,2		
66	50.717	16.543	no		56	sand									
67	50.556	16.669	yes		7	silt, mud				x	1,2				
68	50.984	16.838	yes		33	silt						x	1,2		
69	50.595	16.883	yes		8	silt				x	1,2				
70	51.325	17.054	yes		10.9	silt, clay, anaerobic	bivalves	petroleum			x	1,2			

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
71	50.808	16.958	yes	only 1 jar	55-58	sand				x		2				
72	50.607	17.214	yes		8	sand	many clams			x		1,2				
73	50.824	17.372	no		60	no sediment										
74	58.823	17.378	no		60	no sediment										
75	51.407	17.362	yes		17.6	rock, mud, silt, sand, brown/black flecks	bivalves			x		1,2				
76	50.624	17.502	yes		7	fine grained, silt	bivalves, eelgrass			x		1	x		2	
77	51.171	17.687	yes		4	silt, some sand, sheen		petroleum		x		1,2				
78	50.915	17.833	no		53	clay										
79	51.306	17.847	yes		4	silt				x		1,2				
80	50.797	18.055	yes	1/2 jar	not listed	hard clay, silt						x			1	
81	51.191	18.033	yes		6	silt, consolidated clay						x			1,2	
82	51.505	18.493	yes		15	silt, some sand	bivalves			x		1,2				
83	50.720	18.505	yes		16	sand, silt	1 corbicula			x		1,2				
84	51.527	18.557	yes		16	fine grained, silt	bivalves			x		2	x		1	
85	51.257	18.564	yes		10	gravel, silt				x		1,2				
86	50.529	18.763	yes		6	fine grain, silt				x		1,2				
87	50.724	18.911	yes	1/4 jar	14	hardpan						x			1	
88	51.105	19.009	yes	only 1 jar	25	hard, sand, gray/black flecks						x			1	
89	51.385	19.101	no		20											
90	50.527	19.132	yes		6	fine grained, silt	bivalves, eelgrass			x		2	x		1	
91	50.684	19.265	yes	only 1 jar	8	sand, silt, gravel, detritus	several corbicula	petroleum		x		2	x		1	
92	51.169	19.613	no		32											
93	50.721	19.698	yes	1/3 jar	13	fine sand, gravel						x			1	
94	50.361	19.696	yes		4	fine silt	eelgrass					x			1,2	
95	50.152	19.736	yes		3	fine grained, silt				x		1	x		2	
96	50.901	19.874	no		48	hard bottom, rocks										
97	50.187	20.057	yes		3	silt				x		1	x		2	
98	50.157	20.149	yes		3	fine silt, sheen				x		1,2				
99	50.559	20.268	yes		8	fine sand	few corbicula shells			x		1,2				

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
100	50.550	20.323	yes		12	sand, silt, gravel	1 clam			x		1,2				
101	50.954	20.387	no		30											
102	50.008	20.833	yes		3	silt, fine grained	eelgrass	petroleum		x	2	x	1			
103	49.759	20.875	yes		6	fine grained, silt						x	1,2			
104	50.618	21.127	no		30											
105	50.140	21.135	yes		6	sand				x		1,2				
106	49.914	21.150	yes		9	silt, sand, black flecks	clams			x		1,2				
107	49.830	21.610	yes		20	hardpan, fine grain sand, gravel	corbicula					x	1,2			
108	50.095	21.686	no		48											
109	49.408	21.894	yes		5	fine grain, sheen						x	1,2			
110	49.672	22.099	yes	1/2 jar	24	sand, rocks	bivalves, amphipods					x	1,2			
111	49.229	22.243	yes		5.6	fine grain, silt						x	1,2			
112	49.923	22.372	no		30											
113	48.488	22.405	yes		13	consolidated fine, sand						x	1,2			
114	48.519	22.713	yes		13	coarse sand						x				
115	49.191	22.811	no		35											
116	48.882	22.879	yes		10	rocks, sand, black organic, silt, some sheen	bivalves	petroleum				x	1,2			
117	48.489	22.946	yes		5	[brown top, gray beneath]	bivalves, eelgrass					x	1,2			
118	48.821	23.256	yes		45	fine sand, organic flecks						x	1,2			
119	48.567	23.309	yes		7	fine grain, silt						x	1,2			
120	49.122	23.317	yes	only 1 jar	50	sand, gravel, rocks, hardbottom, pebbles						x	1,2			
121	48.255	23.317	yes		6	fine grained, some detritus	bivalves, eelgrass					x	1,2			
122	49.344	23.320	yes		33	fine grain, consolidated	bivalves	petroleum				x	1,2			
123	48.712	23.605	no		51											
124	49.185	23.629	yes		20	fine grain, consolidated	bivalves	petroleum				x	1,2			
125	48.403	23.642	yes		7	fine sand, gravel, black flecks of organics	bivalves					x	1,2			

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75deg.W)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
126	48.032	23.755	yes		6	fine grained, silt							x	1,2		
127	48.568	23.885	yes		50	fine sand							x	1,2		
128	48.966	24.026	yes		17	consolidated fine	bivalves						x	1,2		
129	47.935	24.069	yes		6	fine grained, silt, some coarse		non-petroleum odor					x	1,2		
130	48.911	24.091	yes		21	fine							x	1,2		
131	48.450	24.261	yes		48	mottled, coarse sand, detrital organic matter							x	1,2		
132	48.133	24.260	yes		44	fine silt							x	1,2		
133	48.034	24.388	yes		12	consolidated fine grain							x	1,2		
134	47.827	24.401	yes		6	fine grain, silt									x	1,2
135	48.729	24.418	yes		45	fine, water-rich									x	1,2
136	48.278	24.753	yes		48	coarse grain sand									x	1,2
137	48.534	24.799	yes		33	fine sand		possible odor							x	1,2
138	48.417	25.050	yes		45	fine grain, silt									x	1,2
139	48.256	25.108	yes		47	very fine silt									x	1,2
140	48.363	25.149	yes		47	mixed coarse sand, fine grain consolidated	bivalves								x	1,2
no number (a)	47.909	26.722	no		7	fine grain	bivalves									
no number (b)	46.415	28.598	yes		6	mixed fine sand and silt										
no number ( c )	38.821	32.713	no		26											
no number (d) possibly 39-S based on coord's.	40.389	30.742	yes		5	coarse grain sand										
1-S	42.231	31.159	yes		5	fine grain mud									x	1,2
2-S	42.403	30.964	yes		23	fine grain, silt, well consolidated		possible petroleum							x	1,2
3-S	42.315	30.553	1 jar		68	coarse sand, gravel, rock, some consolidated silt clay									x	1,2
4-S	42.913	30.670	no		50	rock									x	1,2
5-S	42.648	30.313	1 jar		53	rock, coarse grain									x	1,2
6-S	43.053	30.544	yes		45	fine grain									x	1,2

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75degW)	Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
7-S	43.013	30.259	yes	40	fine consolidated silty clay									x	1,2
8-S	44.056	30.220	yes	23	mixed fine grain, coarse sand, gravel, some sheen									x	1,2
9-S	43.316	30.034	no	31										x	1,2
10-S	44.076	29.828	yes	29	hard, consolidated clay									x	1,2
11-S	39.761	33.429	yes	4	fine grain									x	1,2
12-S	39.790	33.126	yes	20	consistent fine grain									x	1,2
13-S	39.999	33.159	yes	3	fine grain									x	1,2
14-S	40.048	32.720	yes	22	hard well consolidated fine grain									x	1,2
15-S	40.650	32.592	yes	6	well consolidated									x	1,2
16-S	40.204	32.438	yes	25	mixed well consolidated firm clay, coarse sand, gravel, rocks									x	1,2
17-S	40.958	32.170	yes	16	fine grain, well consolidated, clay	bivalves								x	1,2
18-S	40.449	32.017	yes	24	coarse sand, mottled									x	1,2
19-S	41.175	31.853	yes	17	fine grain consolidated									x	1,2
20-S	40.846	31.773	yes	30	sand, fine grain									x	1,2
21-S	39.011	33.926	yes	31	hard, well consolidated		petroleum							x	1,2
22-S	39.130	33.715	yes	32	consolidated		petroleum							x	1,2
23-S	39.276	33.305	yes	29	fine sand with organics									x	1,2
24-S	39.310	32.871	yes	37	fine sand, small rocks, silt									x	1,2
25-S	39.515	32.733	yes	26	fine grain, unconsolidated									x	1,2
26-S	39.937	32.491	1.5jars	30	mixed fine sand, small gravel, fine grain consolidated									x	1,2
27-S	39.984	32.386	yes	23	fine sand									x	1,2

Sample Site Number	GPS Coordinates (in minutes. All sample sites are 39deg.N / 75degW)		Sample taken	Notes	Water Depth (feet)	Sediment Type	Organisms	Odor	Storage Cooler 1	Jar #	Storage Cooler 2	Jar #	Storage Cooler 3	Jar #	Storage Cooler 4	Jar #
28-S	40.275	32.105	yes		23	fine sand, black organic fragments, mottled									x	1,2
29-S	40.377	32.007	yes		24	sand, coarse mottled sand, small gravel									x	1,2
30-S	40.460	31.651	yes		40	well consolidated fine grain, sand, gravel									x	1,2
31-S	38.494	32.730	yes		5	fine, silt									x	1,2
32-S			no													
33-S	38.823	32.131	yes		5	fine silt, fluid									x	1,2
34-S see notes	39.220	31.672	yes	was recorded as 24-S - coord's, water depth indicate that it is 34-s instead.	5	fine grain, organic matter, detritus									x	1,2
35-S	39.520	31.633	yes		8	fine grain	small bivalves								x	1,2
36-S	39.703	31.373	yes		6	fine grain									x	1,2
37-S	39.839	31.136	yes		shallow	fine grain									x	1,2
38-S	40.262	31.125	yes		11	fine grain consolidated									x	1,2
40-S	40.717	30.778	yes		8	fine grain	bivalves								x	1,2

## **APPENDIX C**

### **Additional Electronic Information**

The following items are available to accompany this report on a CD.

- (1) Shipboard digital photograph of each sample following collection.
- (2) Copies of each field data sheet (PDF)
- (3) Copies of each UVF analysis sheet (PDF)
- (4) Copies of COCs (PDF)
- (5) Complete analytical data and QA/QC report from GERG

## **APPENDIX D**

### **Subcontractor Information**

#### **Sediment Collection**

Spencer Oceanographic Services (R/V Abigail)  
Wayne Spencer  
2920 Patriot Lane  
Fredericksburg, VA 22408  
540-368-1258

#### **UVF Screening Equipment**

Sitelab Corporation  
Steve Greason  
Sales and Technical Support Manager  
4 Crane Neck Street  
West Newbury, MA 01985  
978-363-2299

#### **Sample Storage**

Delaware Avenue Distribution Center  
700 Pattison Avenue, Bay #1  
Philadelphia, PA 19148

Tom Kenny  
Account Executive  
215-755-8771 Ext. 206

Dennis Nardella  
Floor Supervisor  
215-755-3200

#### **Full PAH Analysis**

Geochemical and Environmental Research Group (GERG)  
Texas A&M University  
Guy Denoux  
833 Graham Road  
College Station, TX 77845  
979-862-2323 Ext. 115