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Monitoring Plan for Operable Unit 2 Sediments

File on eDocs? yes ✓ no
Site Name Hudson (Water Street) Site
Site # 4 11 005
County Columbia
Town City of Hudson
Foilable yes ✓ no
Please write the eDoc file name description
workplan.nw411005.2007-07.OU2MP.pdf

Niagara Mohawk
A **National Grid** Company

Hudson (Water Street) Site
Hudson, New York

September 2005

Revised July 2007

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engineers, scientists, economists

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1. Introduction

The *Comprehensive Sediment Investigation Report for Operable Unit 2 (OU2), Hudson (Water Street) Site, Hudson, New York* (Sediment Investigation Report) (BBL, 2003) documented the activities, results, and conclusions of several sediment investigations performed between 1995 and 2002 in the Hudson River adjacent to the Hudson (Water Street) Former Manufactured Gas Plant (MGP) Site in Hudson, New York (the Site).

Spatial distributions of concentrations of polynuclear aromatic hydrocarbons (PAHs), the principal chemicals of concern, in OU2 sediments in the Hudson River upstream, adjacent, and downstream of Embayment #1 (see Figure 1) were evaluated as part of the sediment investigation (BBL, 2003). In addition, three other embayments (Embayments #2, #3, and #4), which are progressively downstream of Embayment #1, were evaluated. The following conclusions were presented in the Sediment Investigation Report:

- Sediments immediately adjacent, near upstream (tidally influenced), and downstream of Embayment #1 contain Site-related PAHs.

- In those sediments containing elevated concentrations of Site-related PAHs, there is evidence of PAH compositional alterations that are attributable to ongoing natural attenuation processes (i.e., combined physical, chemical, and biological degradation processes).

- In Embayments #3 and #4, PAH concentrations and compositions indicate that the PAHs are characteristic of urban/industrial background sources and similar to upstream sediment.

- In Embayment #3, PAHs are likely accumulating in sediments from a local stormwater outfall, as total PAH concentrations are higher than those found in river sediments far upstream of Embayment #1 and downstream of Embayment #2.

In Embayment #2, surface sediment PAH concentrations were low (<10 mg/kg total PAHs).

In 2005, the sediments in Embayment #1 were remediated. Ongoing natural attenuation of Site-related PAHs in OU2 sediments is expected to accelerate as a result of OU1 remediation, with concentrations of PAHs in the surficial sediments decreasing over time. National Grid and NYSDEC agreed to postpone development of a Feasibility Study for OU2 sediments in order to monitor the sediment in the OU2 areas for natural attenuation (i.e., combined physical, chemical, and biological degradation processes) for a period of 2 years following the completion of the remediation activities in OU1. A *Monitoring Plan for Operable Unit 2 (OU2) Sediments, Hudson (Water Street) Site, Hudson, New York* (OU2 Monitoring Plan) describing the proposed monitoring activities was submitted by National Grid to the NYSDEC in September 2005. The NYSDEC provided comments to National Grid on the OU2 Monitoring Plan in an April 19, 2006 letter. The letter stated that the Monitoring Plan for OU 2 did not address areas of concern outside of the work completed in the OU1 remediation; specifically, the sediments just off shore of the peninsula between Embayment #1 and #2, the sediments immediately outside of Embayment 1, and the sediments below the "The Spirit of Hudson" dock area. These areas were identified by the NYSDEC as areas where data gaps exist, and therefore NYSDEC requested that additional sediment data be collected to ascertain the current conditions in these areas.

National Grid responded to NYSDEC's comment letter on May 3, 2006, and a follow-up meeting was held in early December 2006. In January 2007, in an effort to move the project forward and arrive at a resolution with NYSDEC, National Grid submitted a letter to the NYSDEC proposing to revise the OU2 Monitoring Plan to include supplemental sediment sampling in the three areas noted above, as was requested by the NYSDEC. On

May 31, 2007 National Grid received correspondence from the NYSDEC stating that National Grid's proposal was approved. This *Revised Monitoring Plan for Operable Unit 2 (OU2) Sediments, Hudson (Water Street) Site, Hudson, New York* describes the supplemental sampling to be performed in the three areas identified by NYSDEC, and also presents the overall monitoring approach for OU2 sediments.

2. Objectives

The objectives of the proposed supplemental sediment sampling activities and monitoring program for OU2 sediments are as follows:

1. Collect supplemental sediment samples from the areas immediately outside Embayment #1 and below "The Spirit of the Hudson" dock area to fill the perceived data gaps identified by the NYSDEC in these areas;
2. Collect supplemental sediment samples from the area just off-shore of the peninsula between Embayment #1 and #2 to determine if an IRM is necessary in this area for protection of human health;
3. Document baseline chemical conditions (PAH concentrations and compositions) in OU2 surficial sediments and visually characterize non-aqueous-phase liquid [NAPL] distribution in near-surface sediment following the OU1 remediation and source mitigation;
4. Measure/document changes in chemical and visual (NAPL) conditions in OU2 sediments over time;
5. Identify background PAHs entering the OU2 area that may contribute to PAH loading and concentrations in OU2 sediments;
6. Document the effectiveness of natural attenuation in reducing concentrations of MGP-related PAHs in OU2 sediments;
7. Estimate the timeframe to reach the limits of MGP-related PAH concentration reductions in OU2 sediments; and
8. Utilize the results of the monitoring program as a basis for determining sediments within OU2 that may require consideration in a feasibility study.

3. Supplemental Sediment Sampling, Monitoring, and Analytical Program

3.1 Supplemental Sediment Sampling

To address the perceived data gaps in the areas identified by the NYSDEC, and to supplement the data previously collected from 1995 to 2002, National Grid has agreed to perform additional sampling at the following three areas:

- The area just off-shore of the peninsula between Embayment #1 and #2;
- The sediments below the "The Spirit of Hudson" dock area; and
- The sediments just outside of Embayment #1.

Following completion of these supplemental sediment sampling activities, the existing *Comprehensive Sediment Investigation Report for Operable Unit 2* (BBL, 2003) will be revised to incorporate information obtained from the supplemental sediment sampling event. Based on the results of the supplemental sampling activities, including laboratory results for the sediment samples, visual observations made during sample processing, and discussions with the NYSDEC, some or all of these supplemental sample locations may be incorporated into the overall monitoring program for OU2 sediments (Section 3.2). The locations of the supplemental sediment sample locations are shown on Figure 1.

3.1.1 Sediments along the Shore between Embayments #1 and #2

This area has been identified by the NYSDEC to pose a potential health risk to individuals that may wade along the shore while swimming or boating. Therefore, sampling of shallow sediments will be conducted for visual characterization of the presence of tar and DNAPL in the area extending from the south shore of Embayment #1 to the north shore of Embayment #2 (Figure 1). The investigation will extend into the river to a water depth of approximately 3 feet. This water depth was selected since it is approximately waist deep on an individual of average height, and would therefore represent the sediments to which a wader could potentially be exposed.

Three supplemental sediment samples will be collected from the locations shown on Figure 2. Lexan tubes (or a similar device) will be manually advanced into the sediment to a maximum depth of 12 inches below the sediment/water interface using a slide hammer, or other appropriate means. The samples will be collected and transported to a sample processing area located on the shore for visual observation for the presence of tar and free DNAPL. Chemical analyses (i.e., by a laboratory) will not be performed on these samples. The results of the sampling will be discussed with the NYSDEC, and the need for additional sampling locations will be evaluated based on the outcome of the initial sampling effort and discussions with NYSDEC.

The results of the sampling activities will be used to determine if an IRM will be considered for this area of the Site. The need for an IRM will be based on the following criteria:

- The presence of MGP-related tar or free DNAPL at a significant number of sample locations;
- The presence of MGP-related tar or free DNAPL of a significantly large aerial extent at any individual location; and/or
- The presence of MGP-related tar or free DNAPL constituting a potential threat to human health.

3.1.1.1 Sediments Immediately Outside Embayment #1

Two supplemental sediment cores will be collected to further define the extent of PAHs in the area immediately outside Embayment 1, as shown on Figure 1. Each sediment core will be advanced to approximately 4 feet below the sediment/water interface using a barge-mounted drill rig, as further described in Section 4.1. The sediment cores will be extracted and immediately transported to the on-shore sample processing area. Visual observations, including the presence of NAPL and physical characteristics of the sediment core, will be documented in a dedicated field book. After recording these visual observations, sediment samples from the 0- to 6-inch, 6- to 24-inch, and 24- to 48-inch depth intervals will be collected from each core, and sent to the laboratory for subsequent analysis for PAHs, in accordance with EPA Method 8270C (EPA SW-846, 2001), and for TOC, in accordance with EPA Method 9060 (see Section 3-4, Analytical Program).

3.1.1.2 Sediments Below the "The Spirit of Hudson" Dock Area

During the salvage operations for the "The Sprit of the Hudson", tar-like substances were observed to be present on the divers' wet suites. As a result, the sediments below the "The Spirit of Hudson" dock area, located just north of Embayment #1, were targeted by NYSDEC for additional investigation to ascertain the current conditions of this area.

Three supplemental sediment samples will be collected from this area. Each sediment core will be advanced to approximately 4 feet below the sediment/water interface using a barge-mounted drill rig, as further described in Section 4.1. The sediment cores will be extracted and immediately transported to the on-shore sample processing area. Visual observations, including the presence of NAPL and physical characteristics of the sediment core will be documented in a dedicated field book. After recording these visual observations, a sediment samples from the 0- to 6-inch, 6- to 24-inch, and 24- to 48-inch depth intervals will be collected from each core, and sent to the laboratory for subsequent analysis for PAHs, in accordance with EPA Method 8270C (EPA SW-846, 2001), and for TOC, in accordance with EPA Method 9060.

3.2 Monitoring Program

To satisfy the objectives of the proposed supplemental sediment sampling activities and monitoring program, a comprehensive sampling and analysis program will be implemented. The sampling and analysis program will focus on the upper 6 inches of sediment (i.e., surficial sediment in the biologically active zone). Subsurface sediments will be collected for visual observation; however these subsurface sediments will not be subject to chemical analyses.

The area for this OU2 monitoring includes sediments which appeared to contain Site-related PAHs during performance of the RI. The monitoring area is bounded by the river navigation channel to the west, the banks of the river, including the embayments to the east, upstream of the mouth of Embayment #1 for approximately 1/4 mile to the north, and downstream of Embayment #1 for approximately 1 mile to the south. The upstream and downstream boundaries are defined by the extent of the OU2 delineation sampling (Figure 1). The locations of monitoring stations have been selected to represent sediment in three major areas of OU2: 1) upstream of OU1; 2) adjacent to OU1; and 3) downstream of OU1, including Embayment #2. For continuity and use of data from previous work (BBL, 2003), all stations selected correspond to previously sampled locations.

As part of the Sediment Investigation Report for OU2, sediments in Embayments #3 and #4 were found to contain PAHs from background sources unrelated to MGP operations. The PAH sources to these embayment sediments very likely also contributed to the PAH concentrations in sediments in the river portion of OU2. Since these two embayments were determined to contain PAHs from background rather than Site-related sources, Embayments #3 and #4 will not be included in this monitoring program. In Embayment #2, however, the source(s) of PAHs in some of the sediment samples were not conclusively identified and, therefore, Embayment #2 remains part of the monitoring program.

The number and locations of monitoring stations were selected to spatially represent Site-related PAHs, and background and other potential source PAHs in OU2 sediments. The station selections provide adequate sensitivity to detect changes in PAH concentrations and compositions, indicative of natural attenuation, over time. PAH results from previously collected samples in the OU2 area were used to guide the selection of sample locations for the monitoring program. Accordingly, the monitoring program samples will be collected in the same general location as those collected in previous studies. With this sampling design, the natural attenuation of Site-related PAHs in the OU2 area can be monitored over time in the presence of ongoing PAH inputs from background sources (e.g., stormwater discharge, overland runoff, atmospheric deposition).

One-foot sediment cores will be collected at each monitoring station. After recording visual observations for the entire length of the core, surficial (0-6 inches) sediment will be subsampled for tiered chemical and physical analyses (see Section 3.4, Analytical Program).

During the 2002 survey, NAPL was observed to a depth of 4 feet in the sediment at OU2 stations SD-05, SD-08, SD-09, and SD-12 just outside the mouth of Embayment #1. Accordingly, 4-foot cores will be collected at these stations, renamed MPA-5, MPA-3, MPA-4, and MPA-1, respectively (see Table 1), to monitor any changes in the vertical extent of NAPL in the area near OU1. For these deeper cores, surficial (0-6 inches) sediment will be subsampled for tiered analysis; NAPL visual observations will be recorded for the entire core.

During the OU2 sediment monitoring program events, sediment samples may be split, or collected from additional locations for a separate investigation concerning the bioavailability of PAHs in sediments.

3.2.1 Monitoring Locations and Rationale

The monitoring station locations selected for each of the three areas of OU2 (Figure 1) cover areas of sediment exhibiting various PAH compositional characteristics and concentration ranges in OU2 sediments. Selection of locations that were previously sampled will help to establish initial post-OU1 remediation conditions in the OU2 area. Table 1 lists the proposed monitoring station IDs and corresponding IDs for the same locations sampled in previous studies.

3.2.1.1 River Area Upstream of OU1

Because of the tidal influence in this portion of the Hudson River, some sediments upstream of Embayment #1 likely contain Site-related PAHs. The sediment samples obtained from monitoring stations upstream of OU1 will support the assessment of natural attenuation reductions in Site-related PAHs over time, and indicate monitoring conditions that may result from PAHs entering the river from upstream sources. A total of three stations (MPU-1 through MPU-3) have been selected.

3.2.1.2 River Area Adjacent to OU1

The sediment samples from selected monitoring stations adjacent to OU1 are known to contain Site-related PAHs and will, therefore, provide an important basis for evaluating the progress of PAH natural attenuation. A total of five monitoring stations (MPA-1 through MPA-5) were selected to represent the concentration range of Site-related PAHs in sediments from this area. At 4 of the 5 locations, 4-foot cores will be collected (stations MPA-1, MPA-3, MPA-4, and MPA-5) where NAPL was previously observed within the top 4 feet of sediment.

3.2.1.3 River Area Downstream from OU1

The samples from monitoring stations in the Hudson River downstream of OU1 will be used to monitor changes in Site-related PAHs in sediments that likely contain Site-related and background PAHs in varying proportions. Samples containing predominantly Site-related PAHs will enable monitoring the progress of natural attenuation. A total of eight monitoring stations (MPD-1 through MPD-8) were selected to represent PAH concentrations and composition in this downstream river area. Three monitoring stations (MPE2-1 through MPE2-3) will also be monitored in Embayment #2.

3.3 Schedule of Sampling and Monitoring Events

Samples for the supplemental sampling program will be collected during a one time sampling event tentatively scheduled to occur in fall 2007. Based on the results of the supplemental sampling activities, including laboratory results for the sediment samples, visual observations made during sample processing, and discussions with the NYSDEC, some or all of these supplemental sample locations may be incorporated into the additional monitoring program sampling events discussed below.

The OU1 remediation activities were completed in May 2005. The three monitoring events are tentatively scheduled to occur in fall 2007, 2008 and 2009. The supplemental sediment sampling activities described in Section 3.1 will be collected concurrent with the first monitoring event in the fall of 2007.

3.4 Analytical Program

OU2 sediments will be analyzed for PAHs and total organic carbon (TOC). The PAH results will help to evaluate the progress of natural attenuation of MGP-related PAHs and provide information on possible background sources of PAHs (or other point sources unrelated to the Site) affecting OU2 sediments, while the TOC will be used primarily to better understand PAH distribution in the sediment. If evidence is found of other sources affecting OU2 sediments, additional chemical and/or physical analyses will be considered. Any additional PAH analyses for purposes of source differentiation would be performed on selected samples (samples will be archived (i.e., frozen) to extend laboratory analysis holding times).

PAHs will be determined using gas chromatography/mass spectrometry (GC/MS) methodology (EPA Method 8270). The PAH data will be used to calculate PAH diagnostic ratios and evaluate PAH compositions characteristic of MGP-related PAHs, background PAHs, and other source PAHs This source categorization is a necessary first step in identifying Site-related PAHs and in monitoring reduction in Site-related PAH concentrations attributable to natural attenuation processes (i.e., combined physical-chemical weathering and biodegradation). The proposed evaluation of conventional PAH data has been successfully applied in differentiating MGP site-related and background PAH sources at several sites in New York State (Costa and

Sauer, 2005; Costa et al., 2004). It has also been applied to estuarine systems to determine PAH inputs from multiple background sources, including petroleum combustion sources from urban/industrial areas and coal/wood combustion sources from rural and some industrial areas (Yunker et al., 2002). PAH source signatures may be evaluated graphically using simple scatter plots of PAH diagnostic ratios (Figure 2).

For OU2 sediments that contain only, or primarily, Site-related PAHs, an internal chemical indicator approach will be applied to evaluate changes (depletion) in PAH concentrations attributable to natural attenuation. In order to calculate PAH depletion, it is necessary to identify a component of the hydrocarbon residue that does not degrade, or degrades very slowly relative to the other components (Bragg et al. 1993, Douglas et al. 1994). Such a component is referred to as an "internal chemical indicator." Once identified for a particular hydrocarbon product or source, the mass of the internal chemical indicator in a residue can be compared to the degradable hydrocarbon content. The mass ratio of the internal chemical indicator to degradable hydrocarbons increases as the residue degrades, enabling the calculation of depletion. High-molecular-weight PAHs (e.g., benzo(a)pyrene) may be used as internal chemical indicators for calculating PAH depletion (Brenner et al., 2002).

4. Scope of Work

Upon approval of this Revised Monitoring Plan for Operable Unit 2 Sediments, a sampling team will be assembled to conduct the first sampling event in the fall of 2007. NYSDEC will be provided a 7-day advanced notice of the intended field sampling schedule.

4.1 Sampling Methods

ARCADIS BBL will conduct sediment sampling activities in a manner similar to the previously performed sediment investigations in OU2 and in conformance with the procedures set forth in the following reports and associated Work Plans:

- National Grid's Generic Field Sampling Plan (GFSP);
- National Grid's Generic Quality Assurance Project Plan for Site Investigations (QAPP); and
- United States Environmental Protection Agency- (EPA-) approved Health and Safety Plan (HASP) (Parsons ES, 1995), and HASP Addendum (BBL, 1995), updated by BBL in 1999.

4.1.1 Shallow Water Sediment Samples

Supplemental sediment samples to be collected in the area between Embayments #1 and #2 will be collected in areas where water depths are approximately 3 feet. These shallow water sediment sampling locations are illustrated on Figure 1. As indicated in Section 3.1.1, 12-inch sediment cores will be collected at proposed supplemental sampling locations SD-91, SD-92, and SD-93. The sediment cores will be collected by manually advancing a sufficient length of Lexan tube into the sediment to a maximum depth of approximately 12 inches using a slide hammer, or other appropriate means. Upon reaching the targeted depth, the sediment cores will be extracted and the ends of the Lexan tube will be capped. The sediment cores will be immediately transported to the on-shore sample processing area for subsequent visual observation for the presence of tar and free DNAPL.

4.1.2 Deep Water Sediment Samples

The monitoring stations, as well as the supplemental sediment sampling locations are illustrated on Figure 1. Sediment samples that will be collected for the monitoring program are also summarized in Table 1. The analytical program for the sediment samples will be in accordance with the approach presented in Section 4.2.

Based upon experience from previous sampling rounds, a barge-mounted drill rig will be required for the collection of the deep water sediment samples. Physical attributes of the site, including, but not limited to, river depth and river currents, dictate the need to use this type of equipment. The specific size and type of equipment used will be dependent upon the drilling subcontractor selected to perform the work at the Site.

Sediment core collection will be performed as presented in Section 3. Samples for laboratory analysis will be collected from each of the cores for analysis according to the analysis approach presented in Section 4.2. For the supplemental sediment sampling, the entire core will be analyzed as described in Sections 3.1.1.1 and 3.1.1.2. For the monitoring station, only the top six inches will be analyzed as described in Section 3.2 and the remainder of each core will be used for visual characterization.

Prior sampling experience at the Site indicates that the sediment surface closer to the navigation channel is composed of larger grained cobbles and boulders. This factor will dictate the type of sampling equipment used to obtain sediment cores. Where possible, a standard split-spoon sampler will be used to collect the sediment samples from the 0 to 1 foot depth interval. However, the type and diameter of the sampling equipment will be dictated by the grain size of the sediments encountered at each location. The drilling subcontractor will have several different diameter samplers available for use during sampling activities. The 4-foot cores will be collected with a standard MacroCore sampling device equipped with a disposable acetate liner. Similar to the 1-foot samples, additional equipment will be available to tailor the sampling equipment and method to the grain size of the sediments encountered at each location.

If self-contained cores are collected, they will be stored on the barge upright in a cooler containing ice until processing on shore. If split spoon sampling is employed, which does not provide a self-contained core, the samples will be processed immediately after collection. Photoionization detector (PID) readings will be taken from each depth interval to monitor for the presence or absence of volatile organic compounds (VOCs). In addition, the entire length of each core will be visually characterized by ARCADIS BBL's field personnel to include color, texture, presence of NAPL, and olfactory observations. PID readings and visual observations will be recorded in a field logbook. Sediment samples will be collected as described above. Samples will be preserved and stored pending submittal to an analytical laboratory in accordance with Table 2. Sediment boring locations will be surveyed by ARCADIS BBL using global positioning system (GPS) equipment.

4.2 Analytical Methods

Sediment samples for chemical analyses will be analyzed for priority pollutant PAHs by EPA Method 8270C (EPA SW-846, 2001). This method involves solvent extraction of the sediment sample, silica column cleanup of the extract, and instrumental analysis of the extract using a GC/MS in the full-scan mode. As part of the GC/MS analysis, a total ion chromatogram will be produced that is similar to a 'GC fingerprint.' In addition to the PAH analysis, each sediment sample will be analyzed for TOC by EPA Method 9060.

An important data quality objective for this PAH analysis is to attain reporting limits for individual PAHs of 300 micrograms per kilogram (µg/kg) or lower. If sample dilution is required, no analyte is to be reported as a non-detect above the neat analysis reporting limit. Also, all detectable concentrations, including those below the reporting limits (but above laboratory method detection limits), are to be reported.

Chemical analyses will be performed by Alpha Woods Hole Laboratories in Mansfield, Massachusetts. The laboratory standard operating procedures (SOPs) that apply to these analyses are:

- Extraction of Soil, Tissue, Vegetation and Sediment Samples by Pressurized Fluid Extraction (Rev. 2.1, 3/4/03, Lab #OP-004)
- Alumina Column Cleanup of Organic Extracts (Rev. 0, 2/21/99, Lab #OP-009)
- Analysis of PAHs by GC/MS (Rev. 1.0, 3/3/00, Lab #O-007)
- Total Organic Carbon in Soil/Sediment and Water (Rev. 2.0, 1/22/03, Lab #W-028)

5. Data Analysis

After each monitoring event, laboratory analytical data will undergo data validation for compliance with the analytical data quality objectives (DQOs). Information from calculated diagnostic ratios of PAHs and sample chromatograms, as discussed in the Analytical Program section, will be interpreted and used to address the objectives of the monitoring program. If there are questions concerning the background sources of PAHs contributing to the PAHs observed in OU2 sediments, which would require more comprehensive chemical or physical analysis to resolve, then a more comprehensive PAH characterization analysis would be considered for a selected set of samples. When all the analyses are completed for a particular monitoring event, the data will be evaluated for evidence of ongoing PAH natural attenuation.

Considering the PAH data generated from this monitoring program and previous studies, the natural attenuation of Site-related PAHs in surface sediments will be evaluated in three steps. The first is the comparison of PAH concentrations and compositional depletions of Site-related PAHs (see examples in Figures 3 and 4), the second is the estimation of PAH concentration endpoints upon completion of natural attenuation, and the third is the estimation of timeframe for reaching the maximum extent of PAH depletion from natural attenuation. This evaluation of natural attenuation will be performed at the end of the monitoring program.

Step 1: Comparison of PAH Concentrations and Compositional Depletions

PAH compositional data will be evaluated for evidence of natural attenuation processes. The relative concentrations of the PAHs measured in the Method 8270 analysis comprise the "composition" of the PAH assemblage. Alterations in PAH composition reveal the degree to which a PAH residue has degraded through a combination of physical-chemical weathering (primarily dissolution and evaporation) and biodegradation when the original composition is known. Compositional analysis has been widely used for evaluating weathering and biodegradation of petroleum residues (Atlas et al. 1981, Boehm et al. 1981, Sauer at al. 1993), whose aromatic fraction is dominated by alkylated PAHs. Compositional analysis is similarly useful in identifying natural weathering and biodegradation in pyrogenic tars (e.g., coal tar, creosote), which are dominated by the unsubstituted PAH compounds that are measured in the Method 8270 analysis. Using OU2 data, Figure 3 illustrates typical PAH compositional alterations for pyrogenic tar residues exposed to the environment to different degrees. With greater exchange of porewater and surface water, as occurs in surficial sediments, the more soluble and volatile 2- and 3-ring PAHs are preferentially lost.

To compare PAH depletions over time, PAH depletions will be calculated after each survey for sediment samples that are identified to contain MGP-related PAHs in the OU2 area. The equation for depletion of PAHs in sediments is:

$$\text{Total PAH Depletion} = (1 - H_0/H_1) \times 100$$

Where H_1 = Benzo(a)pyrene/Total PAH mass ratio in the sample residue
H_0 = Benzo(a)pyrene/Total PAH mass ratio in a creosote NAPL (assumed source)

As discussed previously, the conservative analyte used in the depletion calculation will be benzo(a)pyrene. Where applicable, PAH data generated during previous surveys will be included in the comparison of concentrations as well as depletions. PAH concentrations and depletions from individual sample locations will be calculated and compared over time, as will average and range of PAH concentrations/depletions of spatially grouped samples (e.g., upstream stations, Embayment #2 stations). Figure 4 provides an example plot illustrating a large range of PAH depletions at various depths within a sediment core collected from OU2.

Step 2: Estimating PAH Concentration Endpoints

The range of PAH depletions calculated in sediments under Step 1 will enable predicting the potential extent of PAH depletion attributable to natural attenuation under existing conditions, i.e., combined physical-chemical weathering and biodegradation. The beneficial effects of burial/mixing with clean sediments are not accounted for using the compositional estimation of Total PAH Depletion described above, making it a conservative predictive tool. The maximum potential percent depletion will be applied to all sediment residues containing MGP-related PAHs to estimate PAH concentration endpoints (i.e., the predicted total PAH concentration when natural attenuation has reached its limit). The PAH depletion limit or endpoint will be influenced by the extent and concentration of background PAHs in the OU2 sediments in addition to the depletion of the MGP-related PAHs.

Not nec. beneficial

Step 3: Estimating Timeframes for PAH Natural Attenuation Depletion

For those samples that have not reached their PAH endpoint, the final step of the natural attenuation evaluation will be to estimate the time required for PAHs at each sample location and selected areas within the OU2 area to reach a total PAH concentration limit of maximum depletion. A myriad of factors govern the natural attenuation kinetics of PAH residues. PAH depletion tends to exhibit varying rates, as the more soluble 2- and 3-ringed PAHs are more rapidly depleted, followed by slower degradation of the higher-molecular-weight 4- and 5-ringed PAHs (e.g., Figure 7 in Brenner et al., 2002). The results from the three sampling/analysis events (and possibly pre-monitoring survey data) should provide a sufficient set of timeline data points to help estimate the timeframe for PAH depletion.

6. Reporting and Schedule

Following completion of the supplemental sediment sampling activities described in Section 3.1, the *Comprehensive Sediment Investigation Report for Operable Unit 2* will be revised to incorporate the supplemental sediment data. The revised report will be submitted to the NYSDEC for review and approval.

After each monitoring event, a brief letter report will be provided summarizing completion of sampling activities, any deviations from the monitoring plan, and data findings warranting changes to subsequent monitoring events. For example, stations with no PAH detections would warrant recommendations for additional or different sampling locations. Per NYSDEC's comment letter dated May 31, 2007, each letter report will include a log of any community complaints or observations of Site conditions that are noted. Letter reports will be submitted approximately 10 weeks after each sampling event.

At the end of the 2-year monitoring program, a final report will be prepared that will include the results of the three steps of the PAH natural attenuation determination. The final report will be delivered approximately 16 weeks after the last sampling event.

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Tables

Table 1. Proposed OU2 Monitoring Program Stations

Monitoring Station IDs	Distance From OU1 (ft)[1]	Bathymetric Elevation (ft)	RI Program Station IDs[2]	RI Program Total PAH (mg/kg)[3]
River Area Upstream of OU1				
MPU-1	-570	26	SD-66	10.8
MPU-2	-300	32	SD-17	14.8
MPU-3	-200	28	SD-16	49.1
River Area Adjacent to OU1				
MPA-1	-100	40	SD-12	7270 (0.3)
MPA-2	-100	28	SD-13	36 (330)
MPA-3	0	24	SD-08	1240 (3340)
MPA-4	20	34	SD-09	8260 (487)
MPA-5	100	24	SD-05	662 (63200)
River Area Downstream of OU1				
MPD-1	130	38	SD-03	58.7
MPD-2	130	30	SD-04	431
MPD-3	250	36	SD-02	448
MPD-4	350	26	SD-22	55.5
MPD-5	430	26	SD-25	47.1
MPD-6	550	32	SD-29	135
MPD-7	630	32	SD-34	28.5
MPD-8	1040	26	SD-75	28.8
Embayment #2				
MPE2-1	-	<16	SD-58	32.0
MPE2-2	-	<16	SD-63	6.2
MPE2-3	-	<16	SD-65	9.6

[1] Values are based on the distance away from approximate center of the mouth of OU1 represented by MPA-3 (SD-08)

[2] Sample IDs and PAH results from previous studies of the OU2 area are provided in the OU2 Sediment Investigation Report (BBL, 2003; Figure 5).

[3] Values are total PAH concentrations in samples collected from the upper 6 inches of sediment. Values in parenthesis are total PAH concentrations in samples collected from 2- to 4-foot depths.

Table 2. Analytical Methods, Sample Containers, Preservation, and Analytical Holding Times

Parameter	Methodology	Laboratory	Container	Minimum Sample	Preservation[1] and Holding Time[2]
Priority Pollution PAHs	EPA SW-846 Method 8270C	Alpha Woods Hole Laboratories	2x8-oz glass jar, filled to 2/3 capacity to allow space for freezing of sediments	50 grams	Cool 4 °C; 14 days[3]
TOC (sediments only)	EPA SW-846 Method 9060			1 gram	Cool 4 °C; 28 days[3]

Notes:

[1] Sample preservation is performed at time of sample collection.

[2] Hold time is based on day of sample collection, not Verified Time of Sample Receipt.

[3] Solid samples at -10°C can be stored for up to one year.

Figures

SYR-85-GMS BGP LAYER: ON=*, OFF=*REF*
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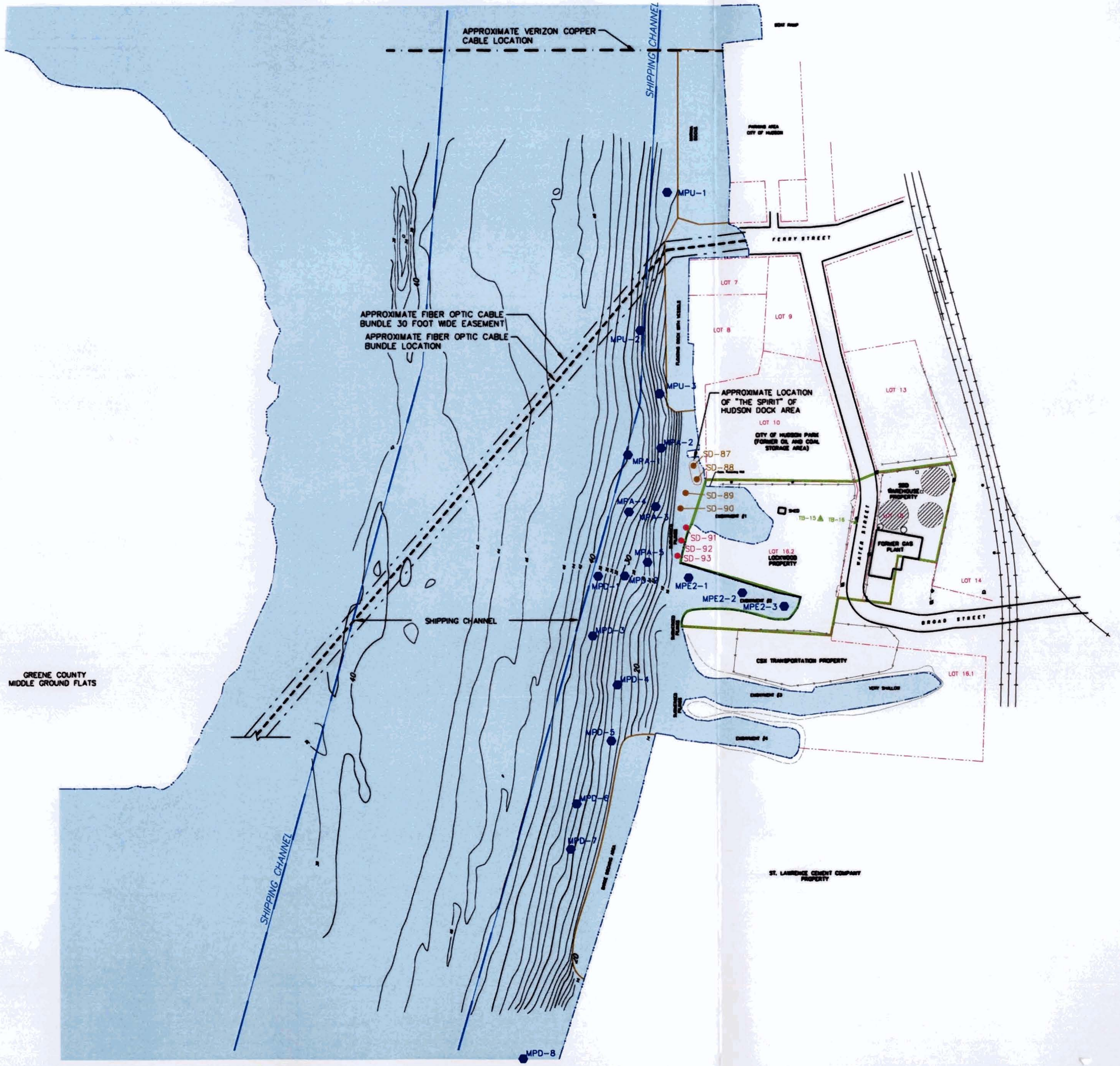

LEGEND:

—OL—	CHAIN-LINK FENCE
● MPD-8	PROPOSED MONITORING STATION LOCATION
● SD-92	PROPOSED SHALLOW SEDIMENT SAMPLE LOCATION
● SD-87	PROPOSED DEEP SEDIMENT SAMPLE LOCATION
———	BOUNDARY OF OPERABLE UNIT 1
—··—··—	PROPERTY LINE
——— 18 ———	BATHYMETRIC CONTOUR (2-FOOT INTERVAL)
———	AREAS NOT ACCESSIBLE BY BATHYMETRIC SURVEY BOAT
—·· —·· —	APPROXIMATE FIBER OPTIC CABLE EASEMENT
- - - - - -	APPROXIMATE FIBER OPTIC CABLE LOCATION (SEE NOTE #5)
— · — — · — —	APPROXIMATE VERIZON COPPER CABLE LOCATION (SEE NOTE #6)
— — — —	APPROXIMATE BOUNDARY OF THE SHIPPING CHANNEL

NOTES:

1. BASE MAP FROM TOPOGRAPHIC SURVEY BY BOSK ASSOCIATES, DRAWING FILE HUDSONDL.DWG, DATED 3/24/95.
2. MONITORING STATIONS AND PORTIONS OF THE RIVER SHORELINE ARE BASED ON BBL SURVEYS CONDUCTED IN DECEMBER 1995, AUGUST 1996, MARCH 1998, AND SPRING 2002.
3. ALL LOCATIONS ARE APPROXIMATE.
4. ADDITIONAL LOT AND SHORELINE INFORMATION NORTHEAST OF LOT 10 WAS TAKEN FROM CITY OF HUDSON TAX MAP, 109.11, DATED MARCH 1987.
5. APPROXIMATE LOCATION OF BURIED FIBER OPTIC CABLES SCANNED FROM SHEET 2 OF 2 "PLAN & PROFILE HUDSON RIVER CROSSING BETWEEN HUDSON AND ATHENS, COLUMBIA AND GREEN COUNTIES, NEW YORK" BARRETT, BONACCI, HYMAN AND VANWEELE, P.C., 175 A COMMERCE DRIVE, HAUPPAUGE, NEW YORK, OCTOBER 13, 1993. RECEIVED FROM DAVID FINGER, CHIEF ENGINEER, MID-HUDSON CABLE, CATSKILL, NEW YORK.
6. APPROXIMATE LOCATION OF VERIZON UNBURIED COPPER CABLE POINTED OUT BY GERALD DALY CONTRACT INSPECTOR, VERIZON SOUTH CAIRO, NEW YORK ON APRIL 17, 2002.
7. BATHYMETRIC SURVEY CONDUCTED BY OCEAN SURVEYS INC., ON APRIL 26, 2002.

0 200' 400'
GRAPHIC SCALE

NIAGARA MOHAWK, A NATIONAL GRID COMPANY
HUDSON (WATER STREET) SITE, HUDSON, NEW YORK
MONITORING PLAN FOR OU2 SEDIMENTS

PROPOSED SEDIMENT SAMPLE AND MONITORING STATION LOCATIONS

ARCADIS BBL
infrastructure, environment, facilities

FIGURE
1

Figure 2. Total PAHs and Selected Ratios Plotted Versus Fluoranthene/Pyrene Distinguish Site-related, Background, and Mixed Source HMW PAH Signatures in Surficial Sediments (From Costa et al., 2004).

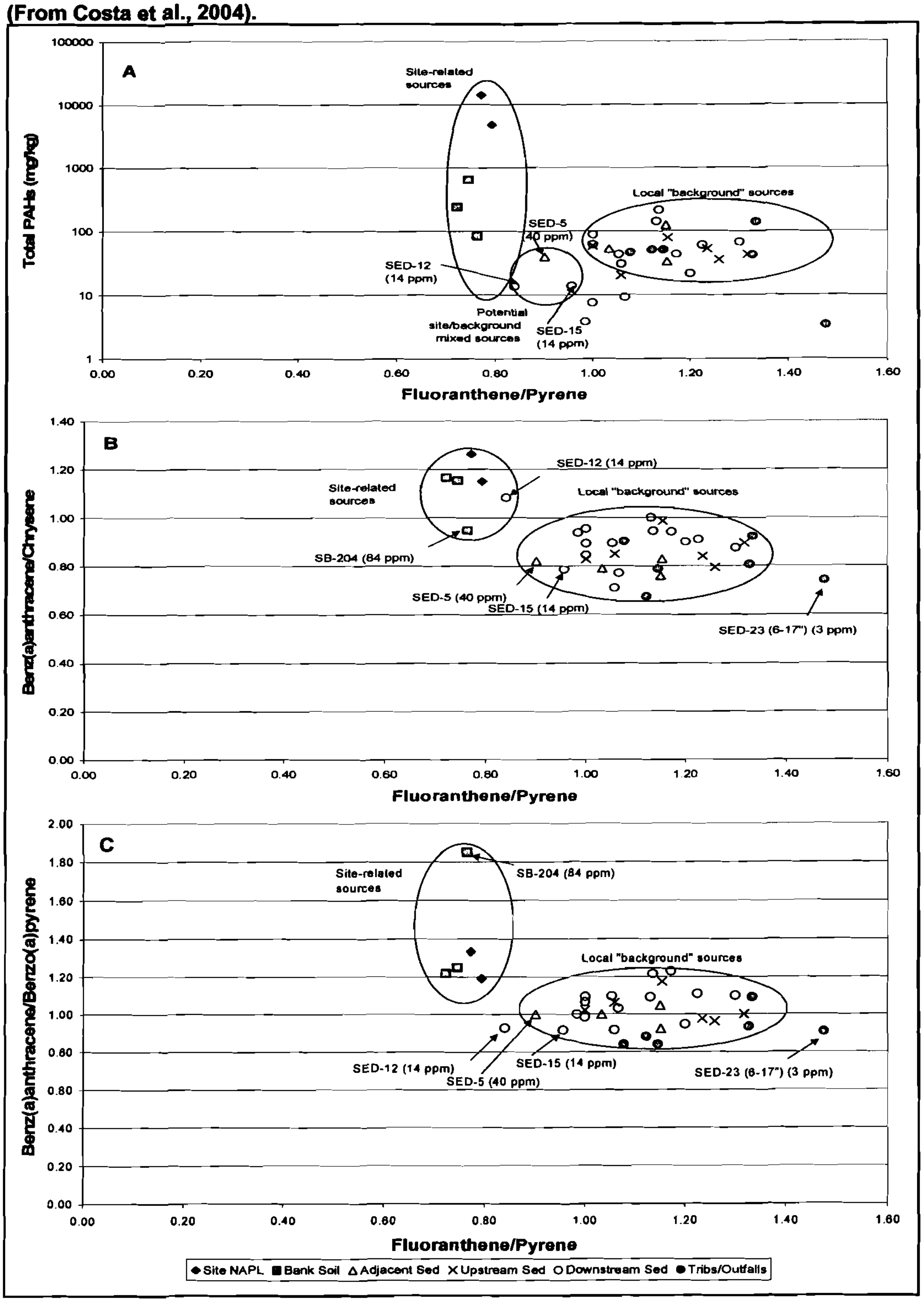

Figure 3. PAH Depletion from Natural Attenuation Is Evident as Preferential Depletion of 2- and 3-Ring PAHs in Core SD-78 Sediments

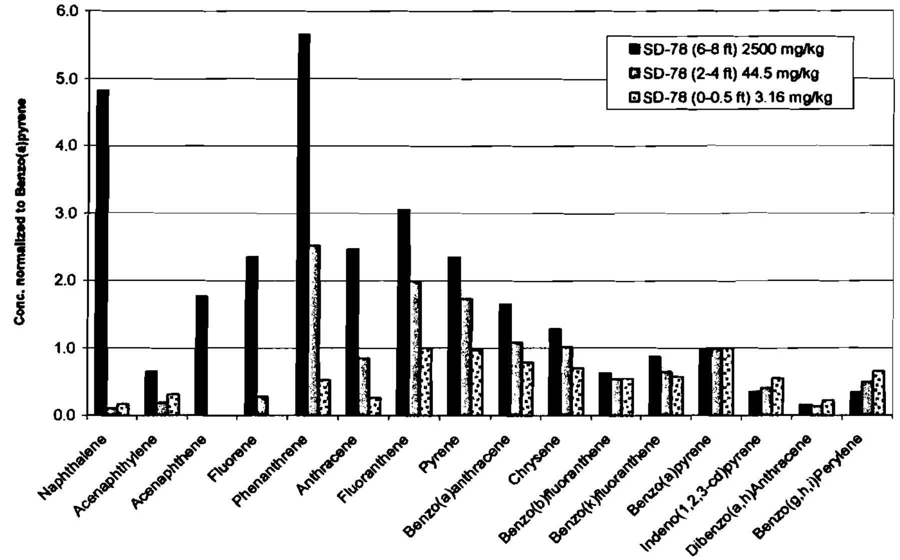

Figure 4. PAH Concentration Reductions Attributable to Natural Attenuation are Indicated by High Percent Depletion in Core SD-78 Sediments