Prepared for:
BASF Corporation
Florham Park, New Jersey

Work Plan
Hudson River Operable Unit 2 Investigation

Operable Unit 2
BASF Rensselaer
Rensselaer, New York

Draft

ENSR Corporation
August 2007
Document No.: 00760-171-275

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August 28, 2007

Mr. Daniel Lightsey
New York Department of Environmental Conservation
Region 4 Headquarters
1130 North Westcott Road
Schenectady, NY 12306

Subject: **Draft Work Plan**
Hudson River Operable Unit 2 Investigation
BASF Rensselaer

Dear Mr. Lightsey:

On behalf of BASF Corporation (BASF), ENSR Corporation (ENSR) is pleased to provide this draft Work Plan designed to address data gaps identified in the Site Investigation Report submitted to NYSDEC in June 2007. This Work Plan presents the scope of work for evaluating the potential for risks associated with exposure to constituents found in the Hudson River sediment adjacent to the BASF facility in Rensselaer, New York.

Please do not hesitate to contact Mr. J. Douglas Reid-Green at BASF (908-806-6472) if you have any questions concerning this Work Plan. We look forward to meeting with NYSDEC in the near future to discuss work plan implementation. Our goal is to be in the field implementing this program no later than October 15, 2007.

Sincerely yours,

John A. Bleiler
Project Manager

Paul A. Banks, P.E.
General Manager – Southeast Operations

cc: Daniel Geraghty (NYSDOH)
J. Douglas Reid-Green (BASF)
Hank Martin, P.E. (ELM)
Nathan Epler, PhD (Roux Associates)
Joan Gerhardt (Behan Communications, Inc.)

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Hudson River Operable Unit 2
Investigation

Operable Unit 2
BASF Rensselaer
Rensselaer, New York
Draft

Prepared By: Christine Archer

Reviewed By: John Bleiler

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1.0 Introduction

This Work Plan outlines the proposed approach for continued characterization of sediment quality in the Hudson River adjacent to the BASF Corporation (BASF) facility in Rensselaer, New York (Figure 1-1). In addition, this Work Plan outlines the scope of work for the baseline ecological risk assessment (BERA) and human health risk assessment (HHRA) for the Hudson River adjacent to the BASF facility. This Work Plan has been prepared by ENSR Corporation (ENSR) on behalf of BASF.

The BASF Rensselaer facility (the "Site") is the subject of an ongoing environmental investigation under New York State Department of Environmental Conservation (NYSDEC) regulatory authority. The Hudson River adjacent to the Rensselaer facility is part of Operable Unit 2 (OU-2), which was designated by NYSDEC to include offsite areas not evaluated under the Remedial Investigation (RI) of the BASF Rensselaer Main Plant (OU-1). The offsite OU-2 RI at the BASF Rensselaer facility also included investigations of offsite soil gas and groundwater; findings from these elements of the OU-2 RI are reported elsewhere (e.g., Roux Associates [Roux], 2000; Roux, 2001; Roux 2004a).

1.1 BASF Program Objectives

As reflected in the Risk Based Surface Water and Sediment Decision Path (Figure 1-2), BASF's objectives for the sediment and surface water in the river adjacent to the Site are consistent with those used for the remedial actions performed in the upland areas of the Site:

1. Eliminate any significant risk to human health or ecological receptors;
2. Provide for ongoing improvement of conditions in the river environment(s); and
3. Provide for beneficial reuse by providing ecological enhancement and value to the river.

This Work Plan provides the scope of work for evaluation of the initial objective (i.e., the Work Plan provides the basis for evaluation of the potential for risks to human health and ecological receptors relative to environmental media in the Hudson River in the vicinity of the Site).

1.2 Site History

Industrial use of the Rensselaer property dates to the late 1800s, when the first dye manufacturing plant was constructed by the Albany Aniline and Chemical Company. The Site was originally part of a larger property, which included the adjacent Albany Molecular Research, Inc. (Albany Molecular), property to the north. Dye manufacturing was conducted on both properties. The two properties were separated in approximately 1917 when Sterling Drug Company ("Sterling") acquired the properties and sold what is now the BASF Site. The two properties continued to use common utilities, such as production sewers. The Site was owned and operated as a dye manufacturing plant by several corporate entities and the United States government (from World War II until 1964). BASF acquired the property in 1978 from the GAF Corporation. BASF ended manufacturing operations at the Site on December 31, 2001.

BASF has been performing site investigation and remedial action activities at the Site since its closure and, as of this time, has: (1) installed a Site-wide groundwater treatment system; (2) completed the remedial action of two former wastewater treatment lagoons; (3) implemented a large interim remedial measure, consisting of the removal of several thousands of tons of soil in the area known as the Main Plant; (4) performed *in-situ* treatment of arsenic in groundwater; and (5) completed the majority of the actions required by the NYSDEC for closure of the former on-Site landfill.

1.3 Previously Completed Studies

The Hudson River study area has been the subject of several investigations during the past decade. The data collected from these various programs were used to develop the scope of work in this Work Plan, and are discussed in further detail in Section 2 of this Work Plan and in the OU-2 Site Investigation Report (ENSR, 2007).

1.3.1 Investigations Related to Future Industrial Use of the Property

Local river conditions immediately adjacent to the Site were characterized in March 2001 to support the design of a proposed water intake and discharge structure for a planned power plant and newspaper recycling facility (ENSR, 2001). The field survey spanned approximately 1,600 feet (ft) of river adjacent to the Site, and included bathymetric, river current and water quality data collection, side-scan and sub-bottom imaging, and sediment grab samples. As part of this effort, three surface sediment grab samples and nine sediment cores were collected and analyzed for grain size, moisture content, total organic carbon (TOC), total petroleum hydrocarbons (TPH) (gasoline range organics and diesel range organics), benzene, toluene, ethylbenzene, xylenes (BTEX), polychlorinated biphenyls (PCBs), pesticides, and metals.

1.3.2 BASF Sediment Screening Study

BASF conducted a screening level assessment of sediments in distinct locations within the Study Area in May 2004 (Roux, 2004b) as part of the evaluation of OU-2. As required by NYSDEC, historical maps and records were reviewed to identify all outfall locations to determine selection of river sediment sampling locations. Through this investigation, BASF identified the following five sewer outfalls to the Hudson River in the vicinity of the Site (Figure 1-3):

- One inactive, 8-inch, cast iron sewer in the northern part of the Lagoon Area (located in the westerly-most portion of the Site along the shoreline), probably related to storm water;
- Two inactive production sewers in the northern part of the Lagoon Area;
- A storm sewer owned and used by the Town of East Greenbush; and
- A storm sewer owned and used by the City of Rensselaer.

The two inactive production outfalls related to past facility operations were used until 1975, when the North and South Lagoons were constructed and the effluent from the GAF and Sterling wastewater treatment plants were discharged to the lagoons. One of the outfalls is an abandoned 30-inch tile sewer that was used before lagoon construction, and the other is a 30-inch diameter cast iron temporary effluent line that was apparently used only during lagoon construction. The abandoned 30-inch tile sewer was also used by Sterling, a prior owner of the Albany Molecular site.

The Town of East Greenbush and City of Rensselaer storm sewers are not related to past plant operations, but continue to be used by those municipalities. Bedding surrounding these sewers was identified during the OU-1 investigation as a potential migration route for dissolved phase volatile organic constituents (VOCs) in groundwater. The City of Rensselaer storm sewer originates east of the Main Plant area, and may represent a conduit for compounds originating east of the Site to be transported to the Hudson River.

As part of the Roux (2004b) study, 17 sediment samples were collected and analyzed. Two sediment samples were collected in the immediate vicinity of each of the five outfalls, and additional samples were collected upstream (north) and downstream (south) of the Site, and across the river (west) of the Site.

Samples collected in the vicinity of the two municipal outfalls were analyzed for TOC, Target Analyte List (TAL) metals, and VOCs. All other samples also included semivolatile organic compounds (SVOCs) in the analyte list. In addition, sludge samples were collected from manholes in the storm sewers near the outfalls, where possible. Analytical results were compared to NYSDEC regulatory screening criteria to provide a general understanding of sediment quality. Analysis of these results suggested that additional sediment sampling was needed to better characterize conditions in the area.

1.3.3 NYSDEC Benthic Survey Program

An extensive mapping survey of the entire 240-Kilometer tidal reach of the Hudson River, including swath bathymetry, side-scan sonar, sub-bottom profiling, sediment-profile imaging and grab samples, was performed by NYSDEC in 2003 (http://benthic.info). These data have been analyzed to develop reach-wide bathymetry, substrate, and sediment environment maps and were made available to researchers for additional, detailed analysis. ENSR, on behalf of BASF, obtained an electronic copy of the NYSDEC data in July 2005 for review relative to the BASF Hudson River sampling program.

As part of the Site Investigation Work Plan (ENSR, 2005) development, a critical review of the NYSDEC benthic survey was conducted to evaluate whether these existing geophysical data support bottom classifications and sediment transport regimes assigned by NYSDEC, and to determine whether or not the existing geophysical data were of adequate resolution to support the design of a sediment sampling and analysis program in the Study Area. This review determined that additional higher resolution survey work was needed in order to better understand substrate and habitat conditions.

1.3.4 2005-2006 Site Investigation

Based on the findings of the Sediment Screening Study (Roux, 2004b), BASF prepared a work plan (ENSR, 2005) to better characterize the river environment, evaluate the vertical and horizontal extent of selected inorganic and organic compounds in sediments in the near-Site environment, and preliminarily assess potential impacts of exposure to human health and the environment. Field work implementing this work plan was conducted from November 2005 through May 2006. Results and observations from this study were reported in the Site Investigation Report (ENSR, 2007), which was submitted in draft form to the NYSDEC for review in February 2007. On April 3, 2007, NYSDEC provided technical comments on the Draft Site Assessment Report, and the final, revised Site Assessment Report was provided to NYSDEC in June 2007.

The Site Investigation included a number of investigative studies, including the following activities:

- A geophysical investigation, including a side-scan sonar survey, was conducted over more than two miles of river bottom to provide information on river bathymetry and to identify the type of material on the river bottom. This information was used to help select sediment sampling locations.
- Surficial and sub-surficial sediment sampling was conducted in areas upstream of, adjacent to and downstream of the Site to better characterize distribution of compounds in the sediments.
- Surface water samples were collected from within the river water column to determine potential impacts to surface water.
- Sampling of the benthic macroinvertebrate communities was conducted to evaluate diversity and abundance of species and relationships between benthic community biology, substrate quality, and proximity to the Site.
- Screening level risk ecological and human health risk assessments were prepared to determine the potential for risk to human health and/or the environment associated with potential exposure to surface water and sediment.

The 2006-2007 Site Investigation program included the collection of nearly 200 sediment samples at depths ranging from the surface of the river bottom to approximately 12 feet below the surface. Samples were analyzed for a wide range of compounds and physical characteristics. The detailed evaluations presented in the Site Investigation Report (ENSR, 2007) resulted in the following conclusions:

- Compound concentrations in surface water samples adjacent to the Site were similar to upstream concentrations.
- River sediments located immediately adjacent to the Site contain high levels of inorganic compounds (e.g., cadmium, chromium, copper, lead, mercury, and zinc) and VOCs (e.g., several chlorinated benzenes, benzene, ethylbenzene, toluene and total xylenes). These compounds are primarily located in sediment near the five outfalls located adjacent to the Site. Compounds were detected in deep and surficial sediments.
- Coarser-grained sediments located in the vicinity of the Site, but further west of the nearshore area, do not contain elevated levels of compounds, suggesting that the extent of Site-related impacts does not extend far beyond the Site to the west.
- Elevated levels of certain inorganic compounds (e.g., cadmium, chromium, copper, lead, mercury, and zinc) are present in sediment in the central portion of the river located downstream of the southern-most outfall. This area is now a depositional environment that is located where historic navigational dredging operations occurred. It appears that at least some of the compounds present in these sediments may have originated at the Site.
- A screening level HHRA indicated there is no unacceptable risk to human health from exposure to sediment or surface water adjacent to the Site. Compound concentrations in surface water samples adjacent to the Site were similar to upstream concentrations and most were below applicable surface water standards. Individuals are not expected to come into contact with the sediments in the vicinity of the Site because of a vertical metal bulkhead that forms the shoreline between the Site and the river. Industrial facilities located on the opposite bank further limit Site access. The Site is securely fenced and guarded, further restricting access to the river. Finally, the impacted sediment is beneath at least five feet of water. The screening level HHRA concluded that additional data analysis may be required to better understand potential relationships between VOCs in the sediment and tissue residues in fish.
- A screening level ERA indicated that surface water is not a medium of concern at the Site. Compound concentrations in surface water samples adjacent to the Site were similar to upstream concentrations and most were below applicable surface water standards for the protection of aquatic life. Inorganic and VOC concentrations are present in excess of NYSDEC sediment screening criteria in surficial sediments near the Site; however, no significant difference was found in the diversity or abundance of the macroinvertebrate communities near the Site, and upstream of the Site there is no evidence of Site-related impacts. Similarly, no relationship between elevated levels of compounds in the sediment and the macroinvertebrate community health was observed. The screening level ERA concluded that additional risk analysis is necessary to better evaluate the potential for ecological risks associated with exposure to surficial sediments.
- A number of data gaps and data needs were identified. The horizontal and vertical extent of potentially impacted sediment is not fully evaluated, the river dynamics in the vicinity of the Site are complex and not fully understood, and additional evaluation is warranted to determine whether or not a potential for unacceptable risk to human health or the environment exists due to exposure to COPCs in sediment.

1.3.5 Work Plan Objectives

Based on the investigations outlined above, additional studies are warranted to further characterize conditions in river sediments adjacent to the BASF Rensselaer facility. This Work Plan presents the scope of work for these studies.

For the purposes of this Work Plan (and consistent with the previously issued Hudson River OU-2 Site Investigation Report [ENSR, 2007]), the data gathered from the various historic sampling and analysis activities have been segregated into discrete groupings based on proximity to the Site (Figure 1-4). Much of the remainder of this Work Plan discusses the historic data and the data needs within the context of the following reaches of the river:

- The **Upstream** data set includes samples collected upstream of the influence of the Site (i.e., this data set serves as the Reference Conditions data set). It is assumed that the data from this reach of the river are uninfluenced by Site conditions and represent anthropogenic urban background conditions. .
- The **Adjacent Nearshore** data set includes samples located within a band of muddy sand immediately adjacent and to the west of the Site. This band of muddy sand extends approximately 90 to 185 ft to the west of the Site bulkhead before transitioning to coarser-grained material (i.e., the Adjacent Far Field).
- The **Adjacent Far Field** data set includes samples collected in the more coarse-grained sediment located to the west of the muddy sand samples in the Adjacent Nearshore sampling reach. The Adjacent Far Field data set is within the same river reach as the Site, but may not be influenced by the Site.
- The **Upper Navigational Channel** data set includes samples collected immediately downstream of the Site, in a depositional environment that is co-located with what is understood to be the northernmost extent of an area where New York State has reportedly conducted periodic navigational dredging to maintain depth for shipping purposes (see Section 2.5 for a brief description of the navigational dredging operations). A deepwater (30-40 ft) navigational channel of the river continues north of the Site; however, navigational dredging is not known to occur beyond the southern edge of the Site. In response to comments from NYSDEC, the southernmost (downstream) extent of the Upper Navigational Channel has been expanded for the purpose of the proposed investigation (see Figure 1-4).
- The **Downstream** data set includes samples collected downstream of the Adjacent Nearshore reach of the river, approximately 1,800 feet downstream from the southerly Site outfall owned by the City of Rensselaer. These samples are also located within the dredged navigational channel. As a result of the findings in the Site Investigation Report (ENSR, 2007), no additional sampling or analysis of the Downstream Area is proposed. The COPC concentrations in this region are consistent with upstream reference conditions.

Findings of the previously completed Site Investigation (ENSR, 2007) identified potential exposure pathways and environmental media requiring further investigation, including the following:

1) Further evaluation of the nature and horizontal extent of inorganic COPCs is warranted, particularly in the vicinity of the Upper Navigational Channel.

2) Further evaluation of the vertical extent of selected inorganic COPCs and VOCs is warranted in the Adjacent Nearshore and to a lesser extent at the eastern boundary of the Adjacent Far Field study area.

3) Additional data are needed to help define the potential risk(s) posed by exposure to COPCs in the surficial matrix to human and ecological receptors.

4) Additional analysis of existing surface water and sediment data is required to better evaluate the complex hydrologic and hydrogeologic relationships existing between the Site and surrounding areas.

5) Evaluation of historical and newly collected bathymetric and navigational dredging data is warranted to better understand the dynamic estuarine environment adjacent to the Site.

In April 2007, NYSDEC provided comments on the Site Investigation Report and requested additional sampling and analysis activities to help fill data gaps identified in this report. This Work Plan has been designed to articulate the study design and data quality objectives (DQOs) required to achieve these objectives, incorporates sampling and analysis activities in response to comments provided by NYSDEC, and includes a description of the scope and nature of investigative and sampling programs which will be undertaken. Specifically, this Work Plan presents a scope of work for the following investigative and data analysis activities:

- Sampling and analysis of surficial and sub-surficial sediment;
- Sampling and analysis of surficial sediment porewater;
- Sampling and analysis of benthic macroinvertebrate communities;
- Laboratory toxicity testing;
- Focused geophysical and bathymetric surveys; and
- Preparation of a baseline ERA and HHRA report.

1.4 Regulatory Authority

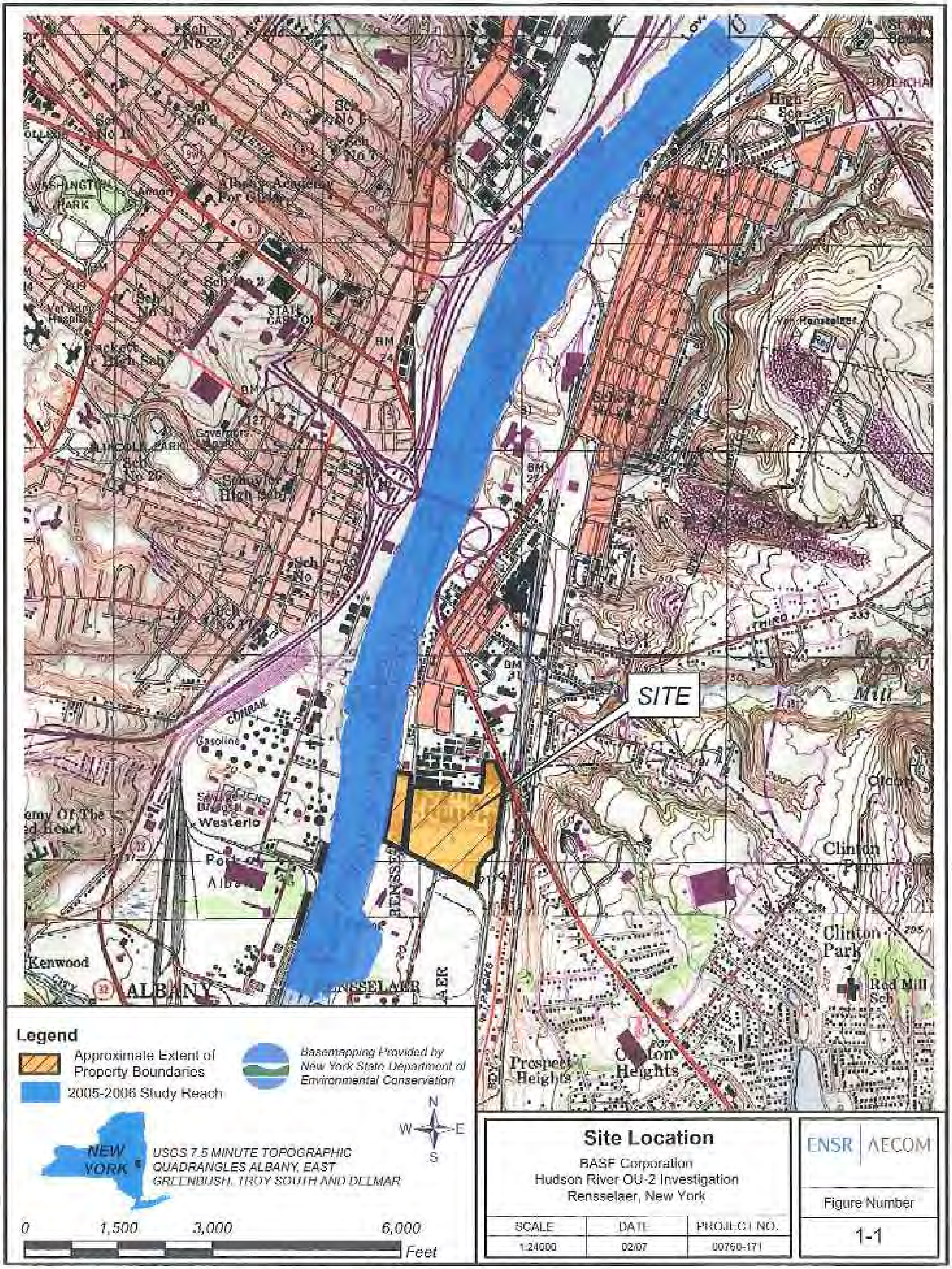
This Report has been prepared in accordance with the following relevant state guidance:

- Draft DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, 2002b).

1.5 Document Organization

The remainder of this Work Plan is organized in the following manner:

- Section 2.0 Conceptual Site Model
- Section 3.0 Field Sampling Scope of Work
- Section 4.0 Reporting
- Section 5.0 Project Organization
- Section 6.0 Schedule
- Section 7.0 List of Commonly Used Acronyms
- Section 8.0 References



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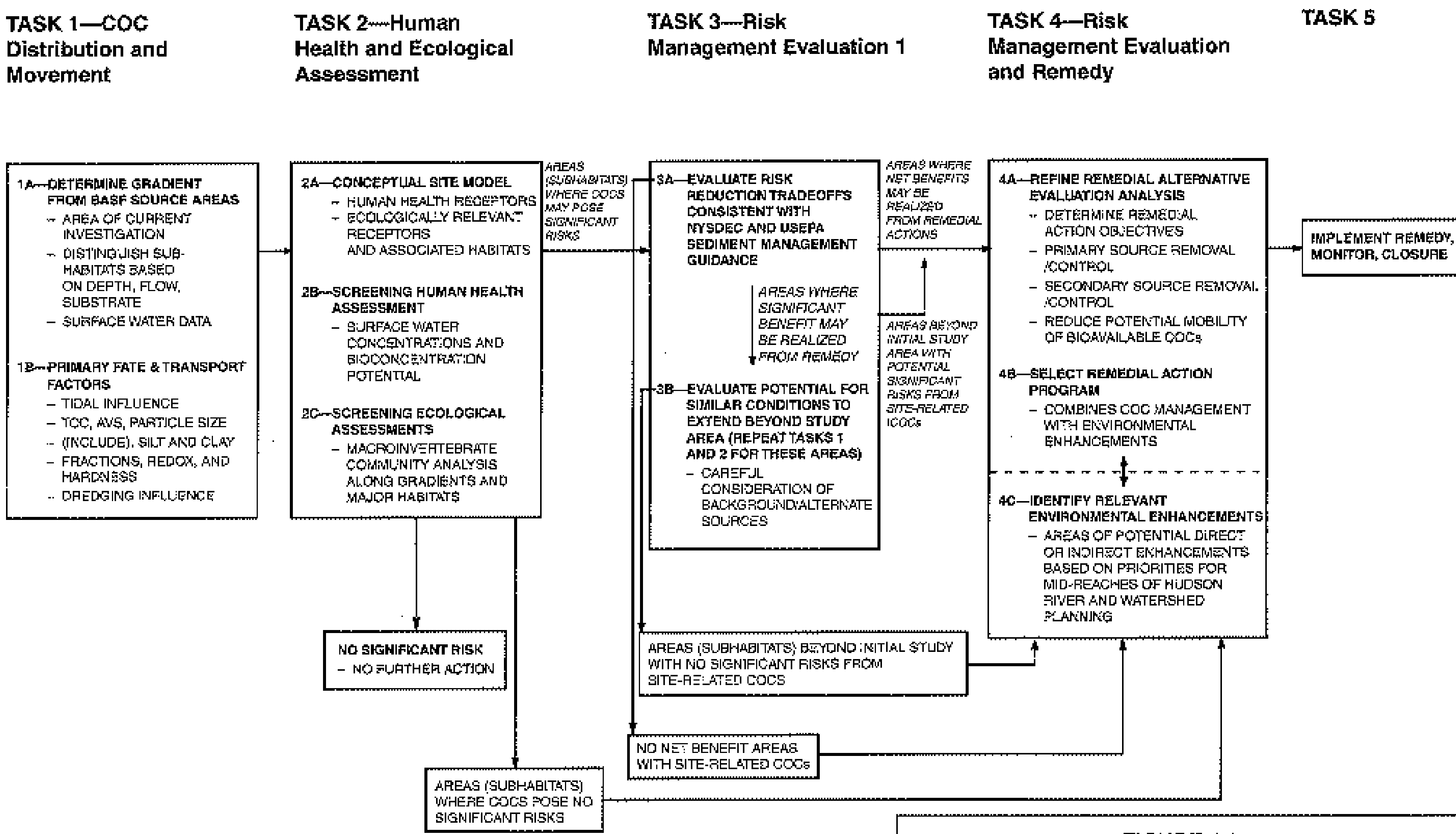

FIGURE 1-2
Risk-Based Surface Water and Sediment Decision Path
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

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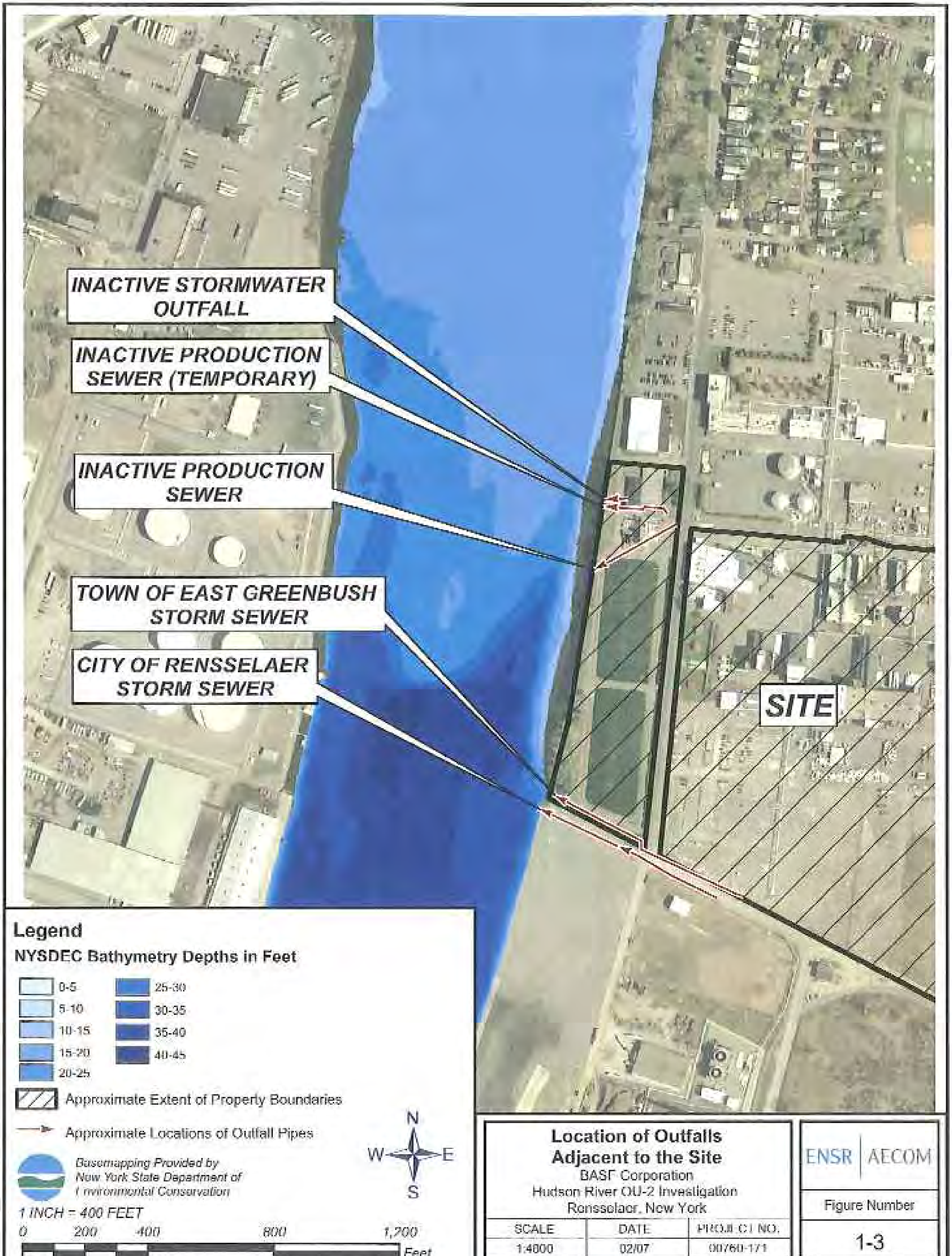

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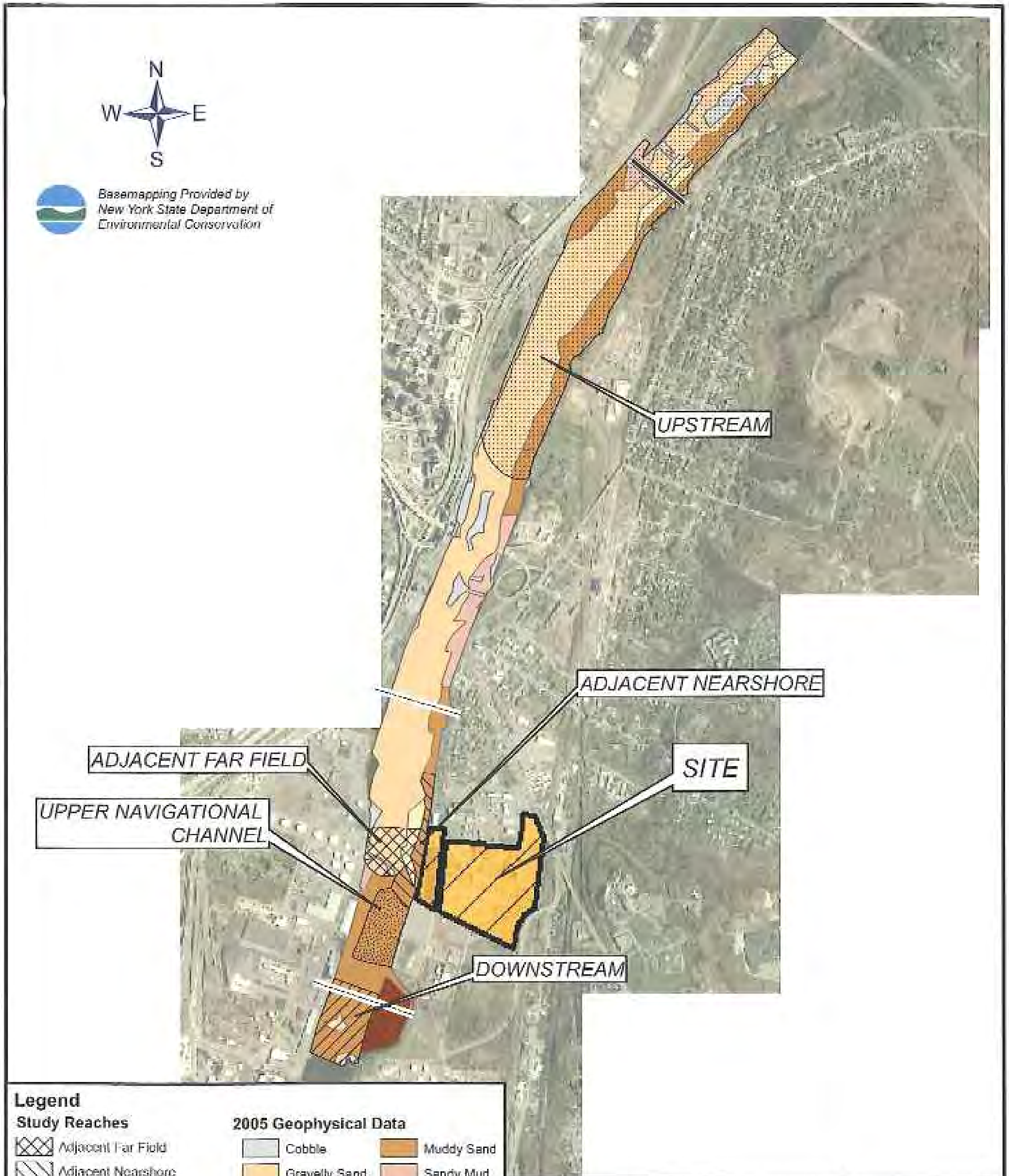

Hudson River Sampling Regions

BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

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Figure Number

1-4

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2.0 Conceptual Site Model

The conceptual site model (CSM) provides an important basis for the conceptualization and evaluation of constituent fate, transport, potential impacts, remediation, and restoration. Notably, the CSM is critical for defining the nature and extent of site-related constituents and observed concentrations relative to background conditions, as well as for developing an understanding of the effects of anthropogenic (e.g., releases and navigational dredging) and natural factors (e.g., effects of grain size, carbon content, depositional and erosional patterns, etc.) on compound concentration patterns in sediment. In addition, a well-designed CSM is helpful relative to identifying data gaps and data needs, should additional studies be required at a sediment site, and may be a valuable tool for evaluating the effectiveness of remedial alternatives, should unacceptable risks be identified.

The Hudson River CSM discusses the apparent mechanisms of constituent movement from the Site into the river as well as the distribution of various sediment environments/habitats in the river as they might affect constituent distribution. The CSM summary presented in this section describes the origin (sources) of COPCs, as well as potential transport pathways, exposure pathways, and receptors. This CSM is presented as a series of working hypotheses considering how chemical stressors in the river might interact with human and ecological receptors in the vicinity of the Site (Figure 2-1).

The previous Work Plan (ENSR, 2005) presented a preliminary CSM that defined the river system and the fate and transport mechanisms at work within it. The CSM narrative was extensively updated in the Site Investigation Report (ENSR, 2007) to incorporate results and observations from the November 2005 through May 2006 field effort. A brief summary of the CSM is presented below.

- Several sources of COPCs in sediment exist, including: (1) potential Site-related sources of sediment-associated compounds such as production sewers; (2) potential near-Site sources of compounds other than the Site such as storm sewers; and (3) potential anthropogenic sources of compounds in this urban system other than the Site (e.g., urban background sources of sediment-associated compounds).
- The evaluation of surface water in the Site Investigation Report (ENSR, 2007) indicated that very little dissolved phase transport of potentially Site-related compounds is occurring from the Site. With the exception of two relatively common laboratory contaminants, no VOCs were detected in surface water samples collected in the water column immediately adjacent to the Site and overlying some of the most VOC-impacted sediment. Dissolved phase metal concentrations in the water column (as well as concentrations of total recoverable metals) were consistent with upstream conditions.
- The nature and extent of potentially VOC-impacted sediment are well characterized and well delineated along most of the Site, with the possible exception of the deeper sediment horizons at the southern end of the Adjacent Nearshore area, and the westerly boundary of the Nearshore and Far Field Adjacent reaches. The available data suggest a historic discharge of VOCs, rather than a diffuse or ongoing source. The VOCs appear to be limited to the muddy sand in the immediate vicinity of the outfalls; no evidence of downstream transport of the VOCs exists. The VOCs of potential concern are generally concentrated around the outfalls (both the historic Site outfalls and the active municipal outfalls) (Figure 2-2). The sediment chemistry at the five outfalls is not entirely consistent, suggesting that several temporal or spatial primary sources may have contributed.
- VOC concentrations are variable in the sediments, both horizontally and vertically. A sharp transition exists between cleaner coarse-grained sediments in the Adjacent Far Field and Adjacent Nearshore muddy sands relative to VOC concentrations. Downstream transport of VOCs as well as transport to the west (across-river transport) is limited. The band of potentially-impacted Adjacent Nearshore

muddy sand extends 90 to 185 linear ft west of the Site bulkhead prior to transitioning to coarser-grained material in the Adjacent Far Field. Outside of the depositional sediments adjacent to the Site, VOC concentrations were lower or not detected. In general, higher VOC concentrations were observed in the sub-surficial sediments with some of the highest concentrations in the 4 to 6 ft horizon. While the vertical extent of VOC-impacted sediment has largely been delineated in this study, there are several areas where a potential data gap exists relative to the extent of VOCs in the deeper sediment horizons.

- Higher inorganic compound concentrations are found in areas of fine-grained sediments indicative of depositional areas, including those adjacent to the Site (Figures 2-3 and 2-4). The inorganic compounds immediately adjacent to the Site are similar in makeup to those previously observed in upland areas at the Site, suggesting that some of the metals may have originated on the Site. Inorganic compound concentrations upstream of and adjacent to the Site (in the Adjacent Far Field) are generally consistent with one-another, suggesting that the Site is not the source of these metals, but rather they are likely indicative of anthropogenic urban background concentrations in the river.
- Metals appear to be highest in the Adjacent Nearshore and the Upper Navigational Channel areas. In the Upstream reach, metals occur in surficial sediments at concentrations typical of urban/industrial areas, and at times occur at concentrations in excess of NYSDEC guidelines. In the immediate vicinity of the Site, concentrations are elevated relative to the main channel and exceed NYSDEC guidelines. The areas of higher concentrations correspond to depositional sediments (i.e., muddy sand) with finer grain sizes. The highest concentrations also correspond with the locations of historic outfalls; in general, more elevated concentrations are found in deeper strata, rather than in surficial sediment samples. In addition to the vertical trends, there is considerable horizontal variability in concentrations of several metals. It is possible that some of the observed heterogeneity is related to factors such as TOC and/or grain size. The western extent of potentially Site-associated inorganic compounds in sediments is clearly marked by the interface with the sandier substrate in the Adjacent Far Field where inorganic compounds were either not detected or were consistent with background samples in the Upstream reach.
- Elevated levels of metals are apparent in the vicinity of several sampling stations within the Upper Navigational Channel, immediately downstream of the southerly Site outfall owned by the City of Rensselaer. Although it is possible that metals in the Upper Navigational Channel originated at the Site, this area represents the northern extent of navigational dredging and these sampling locations are associated with a dramatic change in riverine bathymetry (Figure 2-5) as well as increases in sediment TOC and decreases in grain size, all consistent with a depositional zone. Therefore, it is unclear if the moderately elevated levels of inorganic compounds present in this area are related to the Site or are potentially associated with a change in sediment texture associated with the dredge-related depositional zone immediately downstream from the Site.
- Given the magnitude of water and sediment discharge in the river and the relatively low flux of groundwater and surface runoff from the Site, it is anticipated that any Site-related effects should be relatively localized. Few Site-related solids are likely to deposit in the relatively fast water of the main river channel; they are likely to have deposited only in the relatively slow moving water along the margins of the river.
- Human exposure pathways to sediment and surface water are largely incomplete. Potential human exposure to sediment at the Site is expected to be minimal, given the limited access to the Site and the adjacent sediments. Surface water does not appear to be a medium of concern at this Site and therefore surface water exposure pathways are assumed to be incomplete.
- The majority of potential ecological exposure pathways also appear to be incomplete. However, benthic macroinvertebrate receptors may be exposed to surficial sediments adjacent to the Site. The benthic community in this reach of the river is largely comprised of worms and midge larvae – a review of available data suggests that upstream and near-Site ecological communities are similar, and that

neither proximity to the Site nor compound concentrations relate to macroinvertebrate community fitness.

2.1 Potential Data Gaps

Following the completion of the Site Investigation Report (ENSR, 2007) and the updating of the CSM, the following potential data gaps were identified:

- Although the vertical extent of VOC-impacted sediment has largely been delineated, there are several areas where a potential data gap exists relative to the extent of VOCs in the deeper sediment horizons (i.e., below 10 ft).
- Sediment sampling horizons evaluated in the Site Investigation Report (ENSR, 2007) did not include the layer between 0.5 and 2 ft below sediment surface. This horizon may be occasionally accessed by deep burrowing benthic organisms that could be present in the Study Area, and could be re-suspended as a result of storm events or other disruptions.
- Although few PBT compounds were detected in sediment or surface water, NYSDEC's technical comments on the Draft Site Investigation Report indicated an interest in the possible bioaccumulation of COPCs into fish, particularly bottom-feeding species.
- The evaluation of the potential impacts to benthic receptors in the Site Investigation Report (ENSR, 2007) considered sediment chemistry and benthic community metrics, but not toxicity testing. Toxicity testing represents an important component of an ERA sediment evaluation and allows a direct measurement of potential risks to the benthic community. Furthermore, NYSDEC has historically requested chronic toxicity testing.

This Work Plan has been designed to address these data gaps, as well as other topics, through the collection of additional data and further review of existing information.

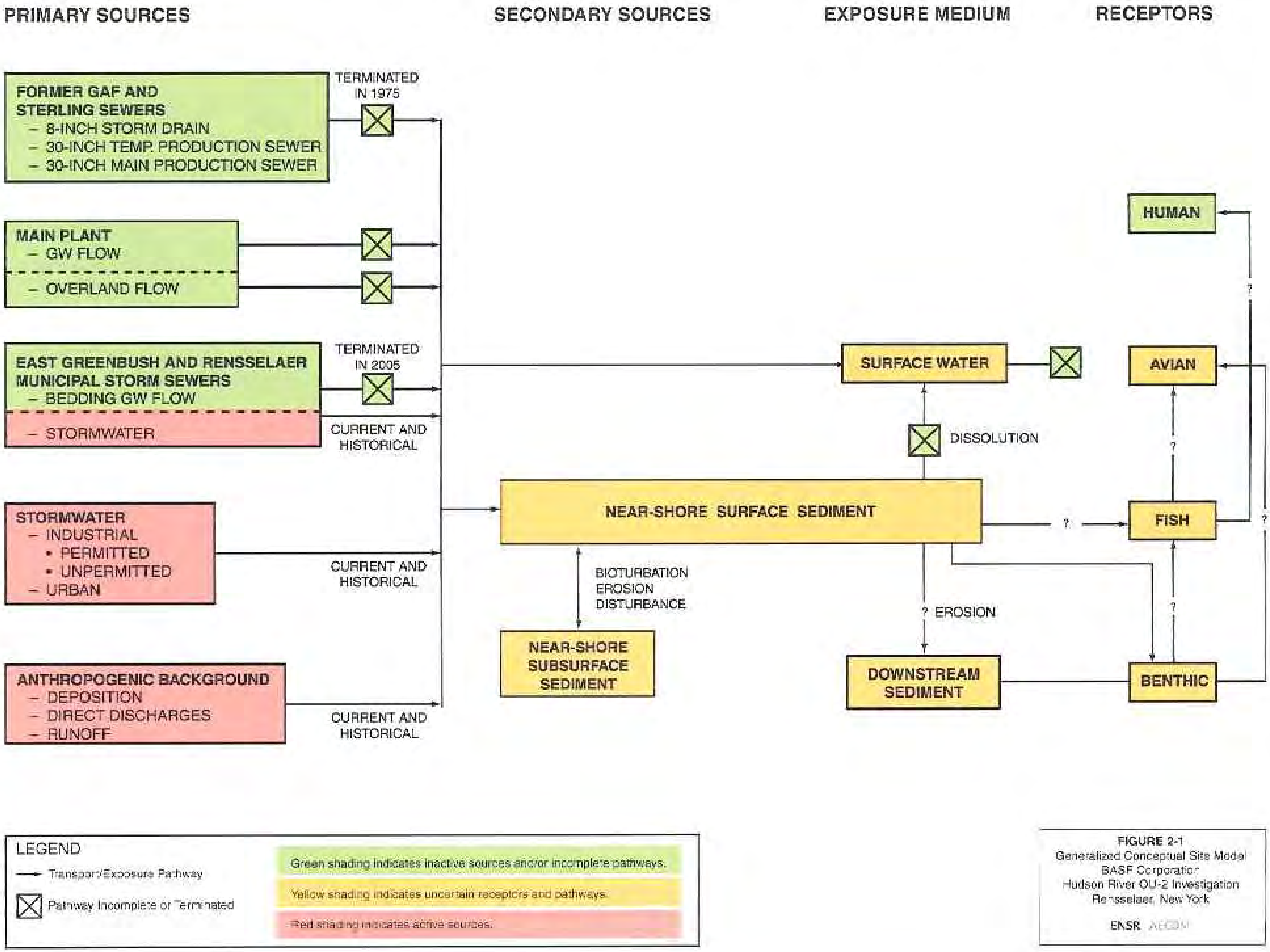
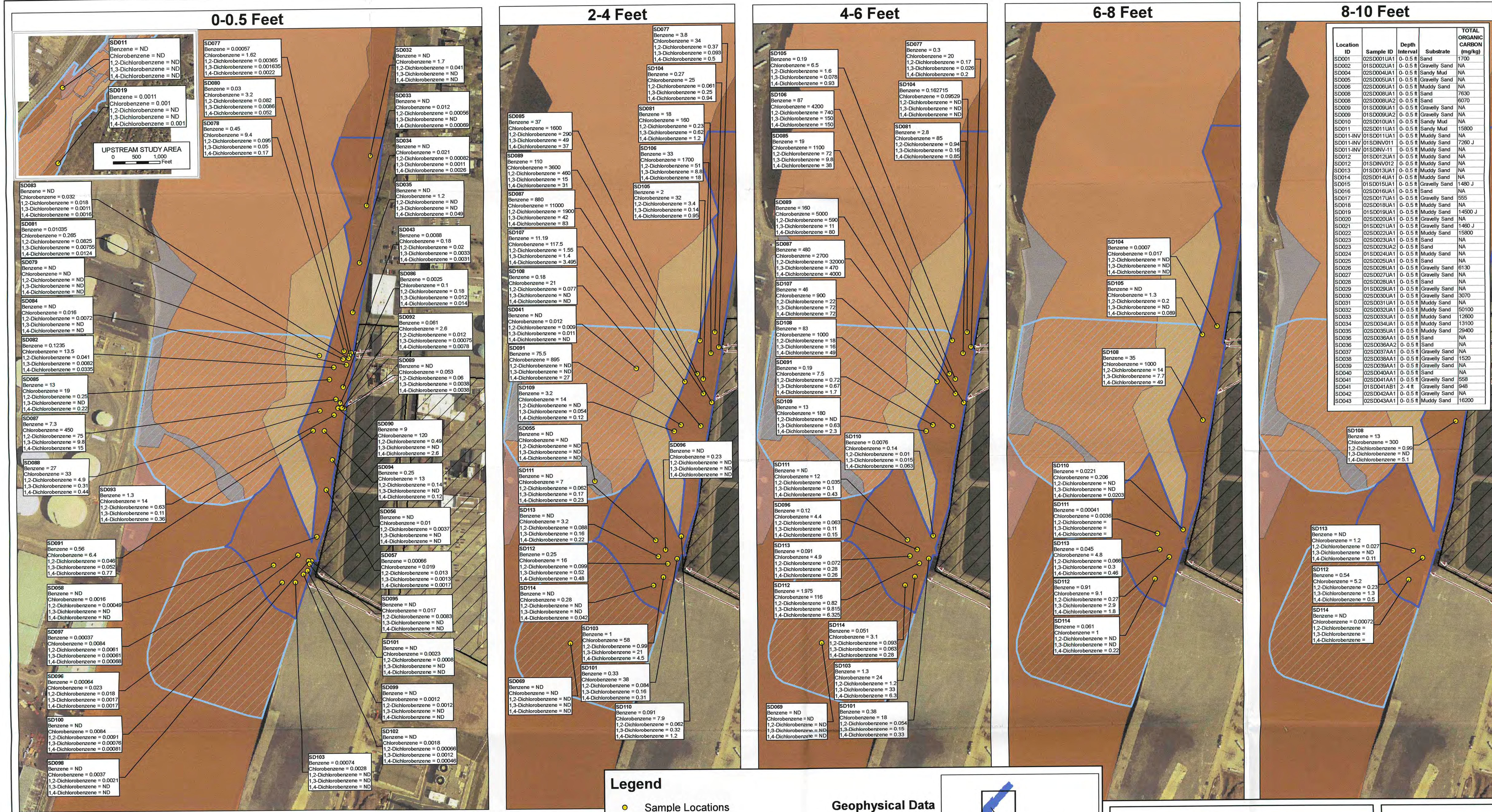


FIGURE 2-1
Generalized Conceptual Site Model
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

ENSR AECOM

0-0.5 Feet | 2-4 Feet | 4-6 Feet | 6-8 Feet | 8-10 Feet



Location ID	Sample ID	Depth Interval	Substrate	TOTAL ORGANIC CARBON (mg/kg)
SD001	02SD001UA1	0- 0.5 ft	Sand	1700
SD002	01SD002UA1	0- 0.5 ft	Gravelly Sand	NA
SD004	02SD004UA1	0- 0.5 ft	Sandy Mud	NA
SD005	02SD005UA1	0- 0.5 ft	Gravelly Sand	NA
SD006	02SD006UA1	0- 0.5 ft	Muddy Sand	NA
SD008	02SD008UA1	0- 0.5 ft	Sand	7630
SD008	02SD008UA2	0- 0.5 ft	Sand	6070
SD009	01SD009UA1	0- 0.5 ft	Gravelly Sand	NA
SD009	01SD009UA2	0- 0.5 ft	Gravelly Sand	NA
SD010	02SD010UA1	0- 0.5 ft	Sandy Mud	NA
SD011	02SD011UA1	0- 0.5 ft	Sandy Mud	15800
SD011-INV	01SD011UA1	0- 0.5 ft	Muddy Sand	NA
SD011-INV	01SDINV011	0- 0.5 ft	Muddy Sand	7260 J
SD011-INV	01SDINV-11	0- 0.5 ft	Muddy Sand	NA
SD012	01SD012UA1	0- 0.5 ft	Muddy Sand	NA
SD012	01SDINV012	0- 0.5 ft	Muddy Sand	NA
SD013	01SD013UA1	0- 0.5 ft	Muddy Sand	NA
SD014	02SD014UA1	0- 0.5 ft	Muddy Sand	NA
SD015	01SD015UA1	0- 0.5 ft	Gravelly Sand	1480 J
SD016	02SD016UA1	0- 0.5 ft	Sand	NA
SD017	02SD017UA1	0- 0.5 ft	Gravelly Sand	555
SD018	02SD018UA1	0- 0.5 ft	Muddy Sand	NA
SD019	01SD019UA1	0- 0.5 ft	Muddy Sand	14500 J
SD020	02SD020UA1	0- 0.5 ft	Gravelly Sand	NA
SD021	01SD021UA1	0- 0.5 ft	Gravelly Sand	1460 J
SD022	02SD022UA1	0- 0.5 ft	Muddy Sand	15800
SD023	02SD023UA1	0- 0.5 ft	Sand	NA
SD023	02SD023UA2	0- 0.5 ft	Sand	NA
SD024	01SD024UA1	0- 0.5 ft	Muddy Sand	NA
SD025	02SD025UA1	0- 0.5 ft	Sand	NA
SD026	02SD026UA1	0- 0.5 ft	Gravelly Sand	6130
SD027	02SD027UA1	0- 0.5 ft	Gravelly Sand	NA
SD028	02SD028UA1	0- 0.5 ft	Sand	NA
SD029	01SD029UA1	0- 0.5 ft	Gravelly Sand	NA
SD030	02SD030UA1	0- 0.5 ft	Gravelly Sand	3070
SD031	02SD031UA1	0- 0.5 ft	Muddy Sand	NA
SD032	02SD032UA1	0- 0.5 ft	Muddy Sand	50100
SD033	02SD033UA1	0- 0.5 ft	Muddy Sand	12600
SD034	02SD034UA1	0- 0.5 ft	Muddy Sand	13100
SD035	02SD035UA1	0- 0.5 ft	Muddy Sand	29400
SD036	02SD036AA1	0- 0.5 ft	Sand	NA
SD036	02SD036AA2	0- 0.5 ft	Sand	NA
SD037	02SD037AA1	0- 0.5 ft	Gravelly Sand	NA
SD038	02SD038AA1	0- 0.5 ft	Gravelly Sand	1520
SD039	02SD039AA1	0- 0.5 ft	Gravelly Sand	NA
SD040	02SD040AA1	0- 0.5 ft	Sand	NA
SD041	02SD041AA1	0- 0.5 ft	Gravelly Sand	558
SD041	01SD041AB1	2- 4 ft	Gravelly Sand	948
SD042	02SD042AA1	0- 0.5 ft	Gravelly Sand	NA
SD043	02SD043AA1	0- 0.5 ft	Muddy Sand	16200

Notes:

1) Duplicates are averaged.
2) Units are mg/kg

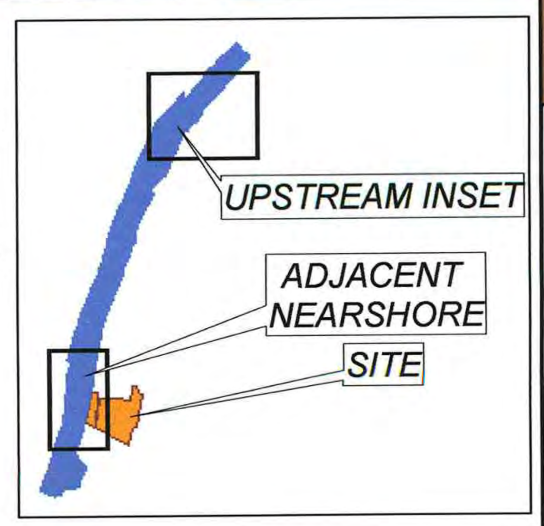
0 200 400 800 1,200 1,600 Feet

Legend

- Sample Locations
- Approximate Locations of Outfall Pipes
- Adjacent Nearshore Study Area
- Other Study Areas
- Approximate Property Boundaries

Geophysical Data

- Cobble
- Gravelly Sand
- Sand
- Muddy Sand
- Sandy Mud
- Mud



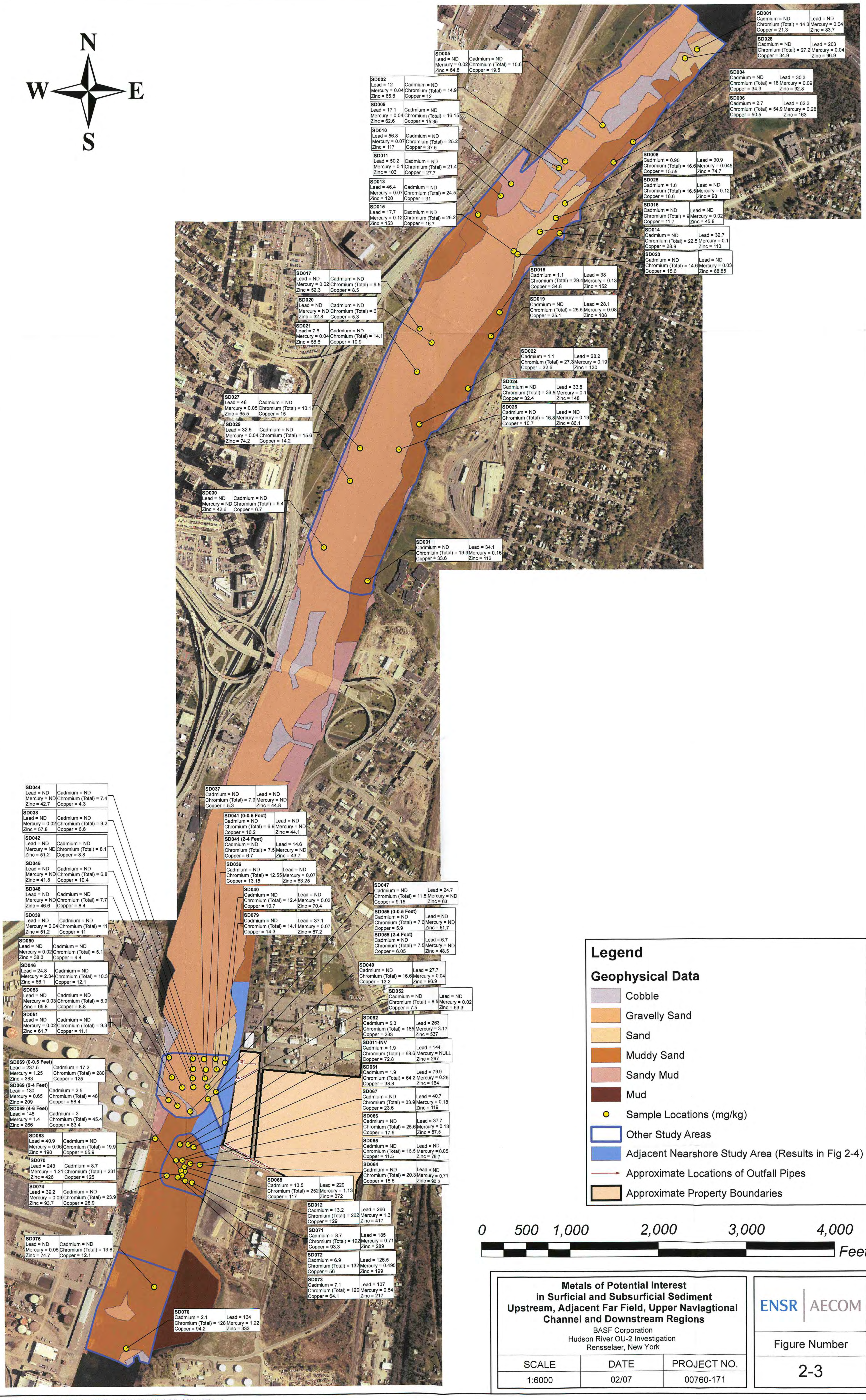
Selected VOCs in Surficial and Subsurficial Sediment
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

SCALE	DATE	PROJECT NO.
1:2400	02/07	00760-171

ENSR | AECOM

Figure Number 2-2

J:\Indi_Service\Project Files\BASF-0760\Rensselaer NY\GIS\Projects\MXD2007\Fig2-2_SelectedVOCs_Nearshore_DSheet_BERA.mxd



Metals of Potential Interest in Surficial and Subsurficial Sediment Upstream, Adjacent Far Field, Upper Naviagtional Channel and Downstream Regions

BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

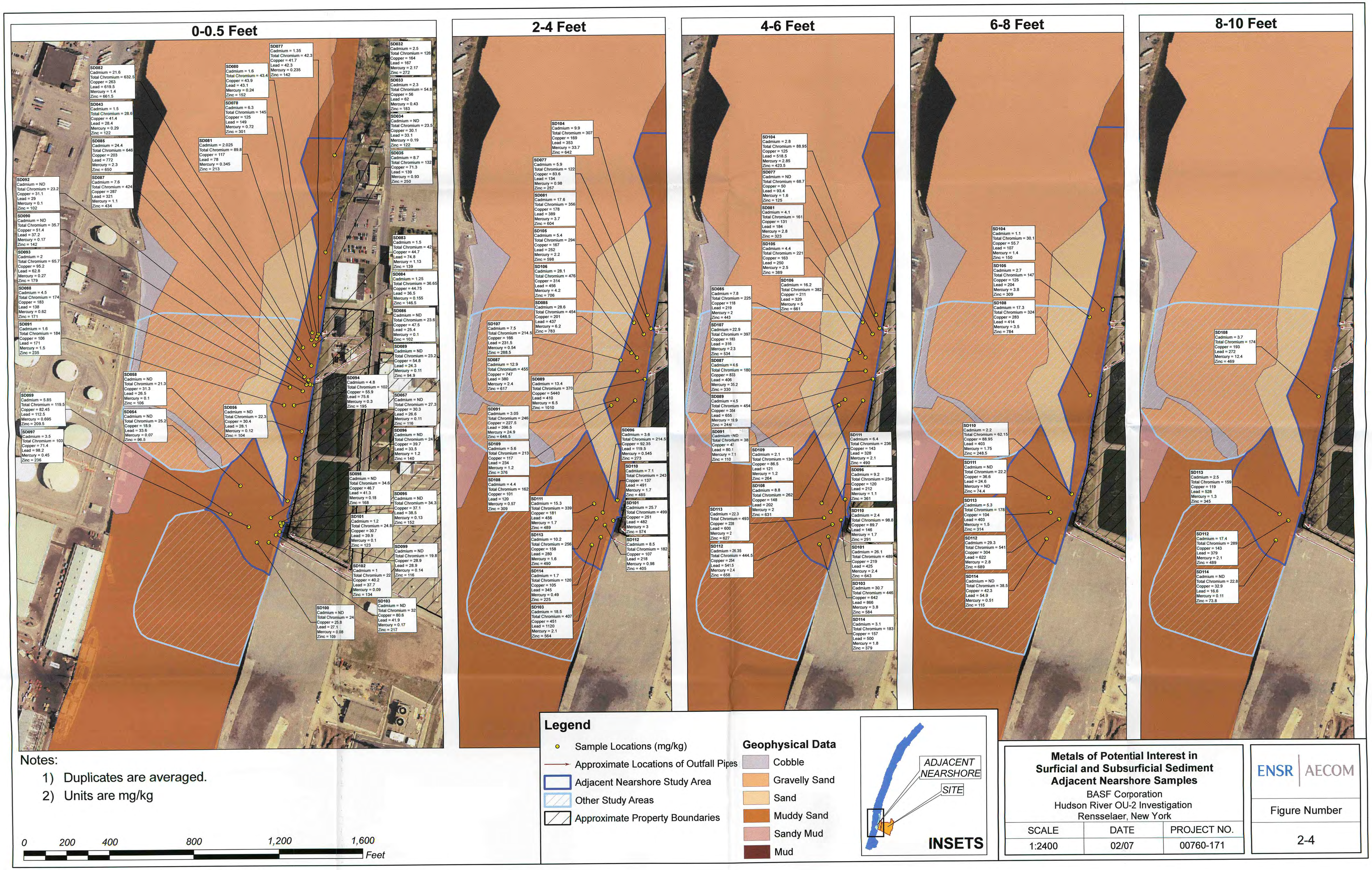
SCALE	DATE	PROJECT NO.
1:6000	02/07	00760-171

ENSR | AECOM

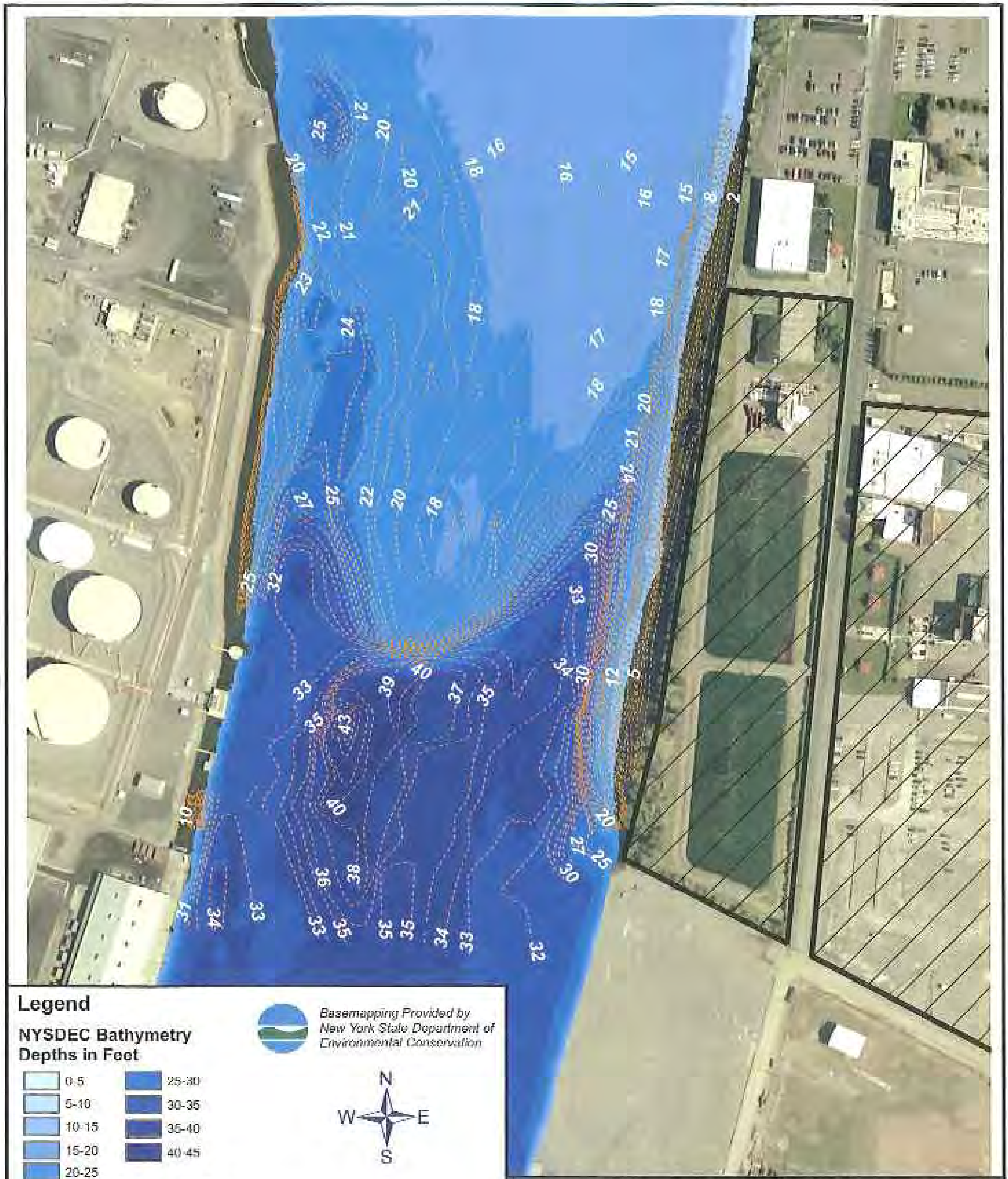
Figure Number

2-3

J:\Indl_Service\Project Files\BASF-0760\Rensselaer NY\GIS\Projects\MXD2007\Fig2-8_MetalsofInterest_DSheet_BERA.mxd



0-0.5 Feet
2-4 Feet
4-6 Feet
6-8 Feet
8-10 Feet
Notes:
1) Duplicates are averaged.
2) Units are mg/kg
0
200
400
800
1,200
1,600
Feet
Legend
Sample Locations (mg/kg)
Approximate Locations of Outfall Pipes
Adjacent Nearshore Study Area
Other Study Areas
Approximate Property Boundaries
Geophysical Data
Cobble
Gravelly Sand
Sand
Muddy Sand
Sandy Mud
Mud
ADJACENT NEARSHORE
SITE
INSETS
Metals of Potential Interest in Surficial and Subsurficial Sediment Adjacent Nearshore Samples
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York
SCALE
1:2400
DATE
02/07
PROJECT NO.
00760-171
ENSR | AECOM
Figure Number
2-4



Bathymetric Profile Based on ENSR 2001 Survey

BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

SCALE	DATE	PROJECT NO.
1:3000	02/07	00760-171

ENSR | AECOM

Figure Number

2-5

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3.0 Field Sampling and Data Gathering Scope of Work

This section of the Work Plan describes the procedures that will be implemented for the field sampling and data gathering activities at the Site. The field program includes the following activities

- Sampling and analysis of surficial sediment;
- Sampling and analysis of sub-surficial sediment;
- Characterization of pore water from surficial sediment;
- Benthic macroinvertebrate community characterization;
- Laboratory toxicity testing with a benthic macroinvertebrate species;
- Storm drain and catch basin sampling efforts; and
- Focused geomorphology and bathymetric surveys.

The sampling and analysis activities presented herein were selected to fill the data gaps identified in Section 2 of this Work Plan. The proposed sampling activities address the request for additional studies outlined by NYSDEC in their April 2007 comment letter on the Site Investigation Report. In this comment letter, NYSDEC identified the need for the following sampling activities:

- Additional downstream sediment sampling and analysis. This request is addressed in Sections 3.3 and 3.4, below.
- Core sampling for Toxic Characteristic Leaching Procedure (TCLP) analysis. Because BASF is currently undertaking an investigative phase of work to determine the need for and extent of any remedial response action at this Site, TCLP sampling for waste characterization is pre-mature. If the results of the human health and ecological risk assessments indicate that an unacceptable risk occurs in the Hudson River at the Site, then TCLP sampling and other characterization studies will need to be conducted in support of the feasibility study.
- Additional coring outside of the Adjacent Nearshore Area to better delineate the horizontal and vertical extent of impacted sediments. This request is addressed in Section 3.4, below.
- Sampling and analysis of sediments in the 0.5 ft to 2.0 ft zone. This request is addressed in Section 3.4, below.
- Assessment of potential chronic exposure risks to benthic organisms. This request is addressed in Sections 3.6 and 3.7, below.
- Evaluation of the potential for VOCs to bioaccumulate into fish. The proposed evaluation focuses on key parameters used in the derivation of the NYSDEC sediment criteria and is presented in Section 4.1.

As depicted in Figure 3-1, not all analyses will be conducted in all reaches of the river; rather, the sampling and analysis program has been designed to fill reach-specific data gaps. An additional reach of the river, identified as the Western Shoreline, has been included in the proposed field sampling and data gathering activities. This data set includes samples collected within the gravelly sand and muddy sand along the western shoreline of the Hudson River across from the Site. It is assumed that the data from this reach of the river represent anthropogenic urban background conditions.

The tasks described in these sections are supported by the Quality Assurance Project Plan (QAPP), which was appended as Appendix B to the earlier work plan (ENSR, 2005). All work will be performed in strict conformance with OSHA standard 1910.120 as detailed in the Project Health and Safety Plan (HASP; Appendix C to the ENSR (2005) Work Plan). The HASP describes the level of personal protective equipment (PPE) required for this field program. In general, field program personnel will be required to wear OSHA Level D ensembles of PPE.

Sampling station locations to support the river characterization are depicted on Figure 3-2 and described in the following sub-sections of this chapter. The actual sampling locations may be slightly modified based on Site conditions encountered in the field and based on the recommendations of NYSDEC upon field program initiation.

3.1 Data Quality Objectives

The Data Quality Objectives (DQOs) for the proposed investigation were developed using the EPA's DQO process, a multi-step, iterative process that ensures that the type, quantity, and quality of environmental data used in the decision making process are appropriate for its intended application. Table 3-1 presents the general DQOs for this evaluation, and Table 3-2 presents the analytical chemistry DQOs. Data quality indicators are presented in the QAPP (ENSR, 2005).

3.2 Mobilization/Demobilization

The NYSDEC will be given a minimum of two weeks notice prior to the initiation of any field activities identified in this Work Plan. Mobilization for the field effort will include a kick-off meeting for the field team (and NYSDEC, should they be interested), subcontracting all required laboratories, purchasing/renting field equipment, coordinating receipt of sample bottles from the laboratory and verifying mass and volume requirements, obtaining site security passes for the field team (if required), location of all sampling stations with Global Positioning System (GPS), and coordinating with NYSDEC and BASF personnel during the field investigation. Field data sheets will be prepared during project mobilization. Prior to the mobilization/demobilization, a field reconnaissance trip may be held with NYSDEC to refine sampling location selection.

3.3 Surficial Sediment Sampling and Analysis

Surficial sediment sampling will be conducted in the Hudson River adjacent to and downstream of the Site (Adjacent Nearshore, Adjacent Far Field, and Upper Navigational Channel), as well as in the Upstream reference area and along the western shoreline across the Hudson River from the Site. This sampling effort will be conducted to obtain a more comprehensive analytical chemistry data set for specific exposure areas, as well as to evaluate the potential risk to ecological receptors due to exposure to the surficial matrix in that area. Data will be collected to further characterize the nature, distribution, and potential sources of chemical stressors in the surficial sediment in the vicinity of the Site, particularly in the vicinity of the Upper Navigational Channel. Sediment data will be used to support the proposed BERA and HHRA evaluations, and to further refine the CSM. The risk to ecological receptors due to exposure to VOCs and inorganic constituents in the surficial matrix is not currently known.

A total of 36 discrete surficial sediment sampling locations (0 to 6 inches [0 to 15 cm]) have been selected for investigation. A sub-set of these stations has been selected for additional chemical, ecological, and toxicological measurements. Preliminary sampling station locations are depicted on Figure 3-2. The rationale supporting the selection of each sampling station location is detailed on Table 3-3. Table 3-4 presents a summary of the chemical, physical, and biological analyses planned at each station. Surficial sediment samples will be collected from the following areas of interest:

- Upstream (reference) Area (6 surficial sediment sampling locations);
- Adjacent Nearshore (11 surficial sediment sampling locations);
- Adjacent Far Field (2 surficial sediment sampling locations);
- Upper Navigational Channel (11 surficial sediment sampling locations); and
- along the Western Shoreline (6 surficial sediment sampling locations).

The majority of surficial sediment samples will be collected from muddy sand substrate. Based on the previous investigations and the nature of the sediment, this substrate is potentially the most impacted.

A list of sample station IDs is presented in Table 3-4, and preliminary station locations are depicted on Figure 3-2. As described in the USEPA's (2001) Method for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis: Technical Manual, the sampling station locations were selected following a "Targeted Sampling Design" where prior knowledge of site-related factors are incorporated into the process of selected station locations. The targeting sampling design was selected to minimize sampling error attributable to selecting sampling stations that may not represent the defined area of interest or stations with similar physical characteristics as described in the study DQO process (USEPA, 2001). Sampling station locations were targeted to represent "worst case" conditions by selecting sampling locations in the vicinity of known outfalls and depositional areas. Station locations may be slightly modified based on site conditions encountered in the field and based on the results of the NYSDEC/BASF interaction at the commencement of the field program.

3.3.1 Upstream Surficial Sediment Sampling

Within the Upstream environment, 6 surficial sediment samples will be collected from sampling locations which were selected to represent the chemical and spatial variability within the system. Tables 3-3 and 3-4 present a summary of the proposed sampling program and the rationale for the sampling effort. These sampling locations include:

- A range of background (reference condition) COPC concentrations (based on the Site Investigation data). Collection of sampling data from locations with a range of known COPC concentrations will allow for interpretation of synoptically collected chemistry, biology, and toxicology data, will assist risk managers in understanding concentration-response curves, and will allow for consideration of the potential upstream anthropogenic inputs into this urban river system; and
- A geographic distribution designed to evaluate the potential risks associated with primary source areas. Proposed sampling locations are situated within upstream muddy sand and gravelly sand substrates.

The Upstream surficial sediment samples will be analyzed for the following parameters:

- Target Compound List (TCL) VOCs;
- TAL Metals;
- Simultaneously extracted metals (SEM) and acid volatile sulfides (AVS);
- Grain size; and
- TOC.

As described in subsequent sections, a sub-set of the Upstream surficial sediment sampling locations will also be selected for biological, toxicological, and pore water sampling.

3.3.2 Adjacent Nearshore Surficial Sediment Sampling

Within the Adjacent Nearshore environment, 11 surficial sediment samples will be collected from sampling locations which were selected to represent the chemical and spatial variability within the system. Tables 3-3 and 3-4 present a summary of the proposed sampling program and the rationale for the sampling effort. These sampling locations include:

- A range of COPC concentrations (based on the Site Investigation data). Collection of sampling data from locations with a range of known COPC concentrations will allow for interpretation of synoptically collected chemistry, biology, and toxicology data, and will assist risk managers in understanding concentration-response curves; and
- A geographic distribution designed to evaluate the potential risks associated with primary source areas. Proposed sampling locations are situated within the vicinity of the five outfall locations, and adjacent to the bulkhead between outfalls. In general, sampling locations will be situated slightly to the south of outfalls, to account for the predominance of downstream flow.

The Adjacent Nearshore sediment samples will be analyzed for the following parameters:

- TCL VOCs;
- TAL Metals;
- SEM and AVS;
- Grain size; and
- TOC.

As described in subsequent sections, a sub-set of the Adjacent Nearshore sampling locations will also be selected for biological, toxicological, and pore water sampling.

3.3.3 Adjacent Far Field Surficial Sediment Sampling

Within the Adjacent Far Field environment, 2 surficial sediment samples will be collected from sampling locations which were selected to represent the chemical and spatial variability within the system. Tables 3-3 and 3-4 present a summary of the proposed sampling program and the rationale for the sampling effort. These sampling locations include locations from the area bordering bounding the western extent of the Adjacent Nearshore (an area with a primarily muddy sand substrate) and the eastern extent of the Adjacent Far Field (an area with a coarser grained sandy gravel substrate). Historical data indicate that the western extent of potentially impacted sediments may not be fully characterized in this region.

The Adjacent Far Field sediment samples will be analyzed for the following parameters:

- TCL VOCs;
- TAL Metals;
- SEM and AVS;
- Grain size; and
- TOC.

As described in subsequent sections, Adjacent Far Field sampling locations will also be selected for biological and toxicological sampling.

3.3.4 Upper Navigational Channel Surficial Sediment Sampling

Within the Upper Navigational Channel, 11 surficial sediment samples will be collected from sampling locations which were selected to represent the chemical and spatial variability within the system. Tables 3-3 and 3-4 presents a summary of the proposed sampling program and the rationale for the sampling effort. The Upper Navigational Channel represents the upstream extent of routine navigational dredging in the Hudson, and has historically been characterized by elevated concentrations of inorganic constituents; however, available data indicate that VOCs are not present in this region.

The Upper Navigational Channel sediment samples will be analyzed for the following parameters:

- TAL Metals;
- SEM and AVS;
- Grain size; and
- TOC.

As described in subsequent sections, a sub-set of the Upper Navigational Channel sampling locations will also be selected for biological, toxicological, and pore water sampling.

3.3.5 Western Shoreline Surficial Sediment Sampling

Within the Western Shoreline environment, 6 surficial sediment samples will be collected from sampling locations which were selected to represent the chemical and spatial variability within the system. Tables 3-3 and 3-4 presents a summary of the proposed sampling program and the rationale for the sampling effort. The Western Shoreline environment is being sampled in order to will allow for consideration of additional potential anthropogenic inputs into this urban river system.

The Western Shoreline sediment samples will be analyzed for the following parameters:

- TCL VOCs;
- TAL Metals;
- SEM and AVS;
- Grain size; and
- TOC.

As described in subsequent sections, a sub-set of the Western Shoreline sampling locations will also be selected for biological, toxicological, and pore water sampling.

3.3.6 Surficial Sediment Sampling Procedures

Discrete surficial sediment samples will be collected using a petit ponar dredge, pole-mounted Ekman grab sampler, Ted Young dredge, vibracore barrel, a gravity-corer, or equivalent depending upon specific sampling-station characteristics in accordance with Section 3.2 of the USEPA's (2001) Method for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis: Technical Manual.

Surficial sediment will be collected from the upper 0 to 15 cm horizon. Generally, this is the sediment horizon of interest as it contains the most recently deposited sediments and the most epifaunal and infaunal organisms are found within this horizon (USEPA, 2001).

The top 0 to 4 cm horizon will be collected and placed in the appropriate sample container for SEM and AVS analyses prior to the homogenization of the remaining sample. Only the top 0 to 4 cm of sediment will be collected for analysis of SEM and AVS because the AVS concentration increases dramatically below the top few centimeters, whereas sampling at greater depths may fail to indicate the toxicity of the top few centimeters (van der Berg et. al 1998).

The appropriate sediment horizon will be removed from the appropriate sampling device using a stainless steel spoon/scoop and placed in a decontaminated 1-gallon stainless steel or pyrex glass mixing bowl. Each sample will be visually examined for physical characteristics such as composition, layering, odor, and discoloration. Samples for VOC (as the method precludes homogenizing), as well as SEM and AVS (as discussed above), analysis will be collected prior to sediment homogenization. The remaining sample will be homogenized in the mixing bowl and placed in appropriate sample containers. When appropriate, homogenized sediment samples will be sub-sampled for biological and toxicological sampling events. Sediment sampling equipment such as bowls, spoons, augers, and dredges will be decontaminated prior to and following sample collection as described below.

The sample containers will be labeled using the label code described in the QAPP and in sub-section 3.11. Sample container, preservation, and holding time requirements are provided in Table 3-5. Field notebooks and sample collection forms will be used to record pertinent data while sampling. The time of sampling will be recorded on each pre-labeled bottle. All samples will be stored on ice (at 4°C), packed in coolers, and shipped under chain of custody for laboratory analysis

The collection of sample duplicates will be consistent with the procedures outlined above for sediment sample collection. Other field QC samples will be collected as described in the QAPP (ENSR, 2005). Sample depth will be recorded for each sampling location along with sample station positioning using GPS. Data validation will be performed as specified in the QAPP (ENSR, 2005).

3.3.7 Sediment Dewatering

Some of the surficial sediment samples collected under this field effort are expected to contain less than 30% solids. Moisture content of this magnitude has a substantial impact on analytical sensitivity, causing significant increases in laboratory practical quantitation limits (PQLs). The severity of the impact can be lessened by increasing sample aliquot size and/or dewatering the samples prior to analysis. A combination of these procedures will be used to optimize sensitivity while maintaining the integrity of the environmental sample.

- Sample aliquots used for chemical tests (except VOCs) will be homogenized in the field, allowed to settle, and standing water will be decanted to the extent possible. The remaining sediment will be placed into appropriate sampling containers and shipped to the laboratories.
- Analytical laboratories will be requested to decant any standing water from the sample jars prior to analysis.
- Analytical laboratories may analyze percent moisture of samples prior to analysis. Samples containing less than 30% solids may require additional dewatering using filter paper or decanting.

3.3.8 Decontamination

Sampling equipment (e.g., petit ponar, stainless spoons, stainless bowls, etc.) will be decontaminated prior to sampling and between samples. Cleaning of equipment is performed to prevent cross-contamination between samples and to maintain a clean working environment for all personnel. Decontamination will generally consist of a station river water rinse to remove gross contamination (if needed), followed by a non-phosphate detergent (e.g., Alconox) water rinse, a rinse with deionized water, and followed by another a river station water rinse. If equipment is to be stored or transported, it should be wrapped in aluminum foil after air-drying.

Water generated during decontamination of sampling equipment will be returned downstream of sampling stations.

Personnel decontamination is discussed in the HASP.

3.4 Sub-Surficial Sediment Sampling and Analysis

VOCs and selected inorganic compounds are known to occur in sub-surficial sediment in the Adjacent Nearshore reach of the river, especially near the historic outfalls. Higher concentrations of these constituents typically occurred several feet below the sediment surface. In the Adjacent Nearshore, the vertical extent of VOCs is not currently fully understood, and additional data are required to better understand the western extent of potentially impacted sub-surficial sediments. It is possible that the western extent extends into the Adjacent Far Field reach of the river. Therefore, the objective of the sub-surficial sampling effort is to further delineate the vertical extent of the VOCs and metals in this region through collection and analysis of sub-surficial sediment cores. Proposed coring sediment sampling locations are displayed in Figure 3-2.

The following sampling program is proposed to better characterize the sub-surficial conditions in this portion of the study area:

- A total of 20 sub-surficial cores will be installed for evaluation of VOCs and inorganic compounds in the sub-surface sediments.
- In the Adjacent Nearshore, 6 cores will be taken to examine the first sampling horizon (0.5 to 2 ft) and 7 cores will be taken to examine deeper sediments (0.5 to 12+ ft).
- In the Adjacent Far Field, 4 cores will be taken to a depth of 0.5 to 12+ ft.
- In the Upper Navigational Channel, 3 cores will be taken to a depth of 0.5 to 12+ ft.
- An attempt will be made to advance several of the sediment cores to a depth of 20 ft.
- Sub-surficial samples will be collected from approximately two foot intervals, with the exception of the first sampling horizon (0.5 to 2 ft).
- Several of the core sampling locations will be co-located with surficial sampling locations.

A total of up to 84 sub-surficial samples will be collected for evaluation of inorganic constituents and VOCs in the deep sub-surface sediments at this site (i.e., the 0.5-12+ ft cores). Up to 6 sub-surface samples will be collected from each 2 ft interval from each of the 14 cores, yielding a total of up to 84 sub-surface samples. Additional samples will be necessary for cores which advance beyond 12 ft. Each of the 6 cores taken from the 0.5 to 2 ft horizon will compose a single sample.

The sub-surface sediment samples will be analyzed for the following parameters:

- TAL Metals;
- TCL VOCs;
- Grain size; and
- TOC.

In response to a NYSDEC comment on the Site Investigation Report (ENSR, 2007), a potential sub-surface data gap exists relative to understanding the nature and extent of potential impacts in the 0.5 to 2.0 foot sampling horizon (this horizon was not sampled in the previous study, which included surficial grab sampling from the 0 to 0.5 ft horizon, and a coring effort with the shallow horizons starting at 2.0 ft bgs).

In order to fill this data gap, particularly within the Adjacent Nearshore reach, at 4 of the 11 Site surficial sediment sampling locations being evaluated in this program (see Section 3.3), shallow sub-surface sediment samples will also be collected from the 0.5 to 2 ft horizon. At 2 additional locations within the Adjacent Nearshore reach, only the 0.5 to 2 ft horizon will be sampled in order to further evaluate this horizon. These data will not be used in the risk characterization since they are presumed to be largely from below the bioactive zone, but may be useful for future analyses of sediment stability, resuspension, and scouring. The identical analytical program will be included for these 6 sampling stations (TAL metals; TCL VOCs; grain size; and TOC).

3.4.1 Sub-Surficial Sediment Sampling Procedures

Sub-surface samples will be collected using a vibracore sampling device and will target cores from the 0.5 to 2 foot sampling horizon and from five other 2-foot interval horizons at each sampling station. These depth horizons are well below the bioactive zone, and will be selected based on field observations to provide data on the vertical distribution of VOCs and metals.

As described in Tables 3-3 and 3-4, all sub-surficial sediment samples will be evaluated for inorganic constituents, VOCs, TOC, and grain size. Additional detail regarding sampling (including sample containers, preservatives, holding times, and QC samples) and validation is presented above (in the surficial sampling sub-section). Decontamination procedures are presented in Section 3.3.

3.5 Characterization of Organic and Inorganic Compound Bioavailability

The presence of COPCs in sediment at concentrations which exceed benchmark screening values does not necessarily constitute ecological risk. For instance, certain COPCs may not be absorbed into an organism's system following ingestion, may not be absorbed through direct contact due to the chemical form of the COPCs, or may not adversely affect the organism due to a lack of bioavailability. USEPA (2001; 2003a) and others have long recognized that the concentration of a number of organic and inorganic constituents in sediment interstitial water (i.e., pore water) is a better estimate of the potential for ecological risk than bulk sediment concentrations. Pore water (or interstitial water) can be defined as the water occupying the spaces between sediment particles (USEPA, 2001).

As described elsewhere in this Work Plan, the potential for selected inorganic constituents to be bioavailable will be evaluated using relationships between SEM, AVS, and TOC. In addition, dissolved phase TAL metals will be analyzed for in pore water. While it is recognized that there are some uncertainties with the equilibrium partitioning model that forms the basis of the SEM-AVS relationship, this evaluation serves as the basis of the USEPA (2005a) equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms, and needs to be considered in a metals-impacted environment such as the Hudson River in the vicinity of the Site.

Recent research has shown that the organic carbon normalized sediment-water distribution coefficients (K_{oc}) for chlorinated benzenes are higher than would be expected if black carbon is present in the sediment. Jonker and Smedes (2000) measured K_{oc} values for 10 di- through hexa- chlorinated benzenes from historically contaminated surface sediment (0 to 30 cm) and found the K_{oc} values were 2 to 3 orders of magnitude higher than would be expected by sorption to natural organic matter. Kleineidam et al. (2002) measured the K_{oc} for 1,2-dichlorobenzene and 1,4-dichlorobenzene sorption to humic soil organic matter and various types of black carbons commonly found in sediments (lignite, coal charcoal, and coke). The results of their study showed that both chlorinated benzenes sorbed more strongly to black carbon than natural organic matter with there being approximately one order of magnitude difference between sorption of 1,2 and 1,4-dichlorobenzenes to natural organic matter and coke.

Characterization of the organic carbon present in sediment samples collected from historically industrial areas along the Hudson River has also demonstrated a large fraction of the total organic carbon is anthropogenic in origin consisting of coal fines, coke and soot-like material (Kreitinger et al., 2007; Kalhil et al., 1996). The presence of anthropogenic carbonaceous materials may result in significantly lower pore water concentrations than predicted from default assumptions, and therefore less toxicity to benthic species from sediment bound chlorinated benzenes than is currently assumed by NYSDEC sediment screening values. This reduced toxicity is due directly to the reduced concentration in pore water relative to the normal EqP assumptions. In addition, lower pore water concentrations of COPCs also effects the EqP assumptions used by NYSDEC relative to development of their sediment screening values for protection of human health via the fish ingestion pathway. This issue is further explored in Section 4.1 of this Work Plan.

3.5.1 Rationale for Developing Site-Specific Estimates of Bioavailability

In 2003 the National Research Council (NRC) reviewed the implications and science regarding the bioavailability of contaminants in sediments and determined that there is a need to improve risk-based assessments by including more explicit consideration of contaminant bioavailability (NRC, 2003). Their conclusion was that inadequate scientific understanding has hampered the widespread consideration of bioavailability processes in remedial decision-making. The NRC concluded that specific steps needed to be taken to improve the understanding of bioavailability of contaminants at individual sites for use in regulation and decision-making.

In 2005, the USEPA provided guidance for remediation of contaminated sediments which identified contaminant bioavailability as a key parameter for remedial investigations, risk characterization, and feasibility studies (USEPA 2005b). The guidance emphasized the importance of evaluating contaminant bioavailability in the RI/FS process and the need for assessing contaminant bioavailability. Although the USEPA has defined contaminant bioavailability as an important parameter for developing site-specific sediment remedial action objectives (RAOs), little or no guidance has been provided on the analytical methods and approach for evaluating contaminant bioavailability.

The following elements of this Work Plan are designed to address data gaps in the knowledge of organic constituent bioavailability in sediments and pore water from the Hudson River.

3.5.1.1 Bioavailability Assessment Objectives

The primary objective of the work related to organic constituent bioavailability is to conduct a preliminary survey of the site-specific chlorinated constituent aqueous partitioning coefficients (partitioning between sediment and pore water) in selected sediment samples which have been collected from sediments representing a range of chemical concentrations. In addition, the measured inorganic and organic concentrations of COPCs in pore water will be evaluated relative to the results of the proposed biological and toxicological sampling programs. Other uses of pore water, as outlined by the USEPA's technology innovation program (http://clu-in.org/programs/21m2/sediment) include the following (only some of these factors are applicable at the BASF site):

- Estimate contaminant flux from the sediments into the overlying surface water.
- Establish the presence of contaminated pore water in the sediments.
- Determine the concentrations of contaminants that are actually in the pore water within the biologically active surficial layer of sediments.
- Perform biotoxicity tests using water taken from the biologically active layer of the sediments.
- Determine if there is a concentration gradient of contaminants within the sediments.

- Determine flux and composition within the sediments when the surface water is gaining and a ground-water contaminant plume is present. This determination might also try to locate preferential pathways into the surface water from the sediment bed.
- Determine the general flux of contaminants into ground water when the surface water is losing and the sediments are contaminated.

3.5.1.2 Pore Water Sampling and Analysis

Bulk sediment samples for pore water analysis will be collected from the 0 to 15 cm horizon. Per the request of NYSDEC (June 26, 2007 project team meeting), the 0 to 15 cm bulk sediment samples for pore water analysis will be collected via vibracore, rather than from a dredge sampler. The principle goal associated with the sampling effort will be to use procedures that minimize changes to the *in situ* conditions of the interstitial (pore) water – all samples for pore water analysis will be collected using identical procedures from the identical depth horizon, and will be collected using procedures outlined in USEPA (2001) to minimize changes in the integrity of the sample. Any overlying water from the core barrel will be removed via siphoning, not decanting. It is recognized that several cores may need to be collected from any one sampling location to obtain sufficient pore water volume for chemical analysis requirements.

At each pore water sampling location, field personnel will remove sediment from a capped core barrel that has undergone minimal disturbance into 1-liter PTFE-lined bottles designated for VOC analysis. These bottles will be pre-cleaned by the laboratory and will be accompanied by a 1-liter PTFE-lined bottle containing analyte-free water. This "bottle blank" will serve as a QC check to determine if VOCs are migrating into the samples through the bottle during storage and shipment resulting in cross-contamination of the samples, or if the PTFE material itself is releasing VOCs into the sample (outgassing). The 1-liter PTFE-lined bottles will be filled without headspace and will be placed on ice and maintained at 4°C at the site and during shipment to the laboratory. This sampling procedure is proposed in order to minimize volatilization of VOCs during sampling and shipping. In order to generate a sufficient volume of porewater to be analyzed for metals (total and dissolved), TSS, and dissolved organic carbon (DOC), additional sediment from each pore water sampling location will be placed in 1-gallon sampling containers. The 1-gallon sampling containers will also be placed on ice and maintained at 4°C at the site and during shipment to the laboratory.

At the laboratory, the 1-liter PTFE-lined bottles will be placed directly into the centrifuge which will minimize loss of VOCs. Sample centrifugation will be carried out at or below 10°C. The bottles will be centrifuged for 30 minutes at 1000-3000 G. The pore water will be decanted into HCl-preserved VOA vials. The VOC analyses will be performed within 24 hours following the generation of the pore water. The VOC analyses will be performed with all EPA 8260B method-required QC, including MS/MSD analyses on the pore water if sufficient sample is available.

Sediment from the 1-gallon sampling containers will be placed into polycarbonate bottles at the laboratory. The polycarbonate bottles containing sediment will be centrifuged along with a polycarbonate bottle containing analyte-free water which will serve as a bottle blank. The samples will be centrifuged as described above. The pore water will be decanted into pre-preserved containers for total metals and unpreserved containers for TSS analysis. Pore water will be filtered prior to preservation for dissolved metals and DOC analyses through 0.45 micron filters. The metals, TSS, and DOC analyses will be performed with all associated method-required QC.

In addition, total organic carbon and soot carbon will also be determined on air-dried sediment samples using the method proposed by Gustafsson et al. (1997) and Accardi-Dey and Gschwend, (2002). Pore water sampling is proposed for 10 surficial sediment sampling locations, depicted in Figure 3-2. A total of 5 samples will be taken from the Adjacent Nearshore, 2 from the Upstream reach, 1 from the Western Shoreline, and 2 from the Upper Navigational Channel.

3.6 Benthic Macroinvertebrate Sampling and Analysis

A benthic macroinvertebrate community analysis will be performed to provide a measurement endpoint for evaluating the *in situ* response of the benthic community to potential stressors in the Hudson River directly adjacent to the Site. A review of recently collected macroinvertebrate community data (ENSR, 2007) suggest that a macroinvertebrate community is present throughout the study area, and that additional analysis of this community in the context of an ecological risk assessment is warranted. Benthic macroinvertebrate sampling locations will be co-located in time and space with sediment chemistry and sediment toxicity sampling locations. The results of the benthic macroinvertebrate community analysis will provide a direct measure of the integrity of the benthic community in relation to Site-specific chemical and physical stressors. Objectives of the benthic community evaluation, which will be conducted at Adjacent Nearshore, Adjacent Far Field, Western Shoreline, Upper Navigational Channel, and Upstream sampling locations, include:

- Determining the abundance of macroinvertebrate infauna at sampling locations and within sampling reaches;
- Assessing the level of taxonomic diversity and evenness at selected sampling locations and sampling reaches;
- Evaluating the macroinvertebrate community structure relative to proximity to the Site and COPC sediment concentrations.

Biological impairment may be indicated by the absence of pollution-sensitive macroinvertebrate taxa, excess dominance by one taxon, low overall taxa richness, or reduced community composition relative to reference conditions.

3.6.1 Macroinvertebrate Community Survey Station Locations

Macroinvertebrate community survey stations will be co-located with a sub-set of the surficial sediment chemistry and sediment toxicity sampling stations in an attempt to relate the results of the benthic community survey with measured concentrations of target chemicals. Preliminary station locations are depicted on Figure 3-2.

Sampling locations were preliminarily selected to spatially represent the study area of interest, while limiting stations to similar habitat type (e.g., cover, grain size) to reduce the variability associated with external environmental factors. Sampling locations also represent a concentration gradient (based on historic data) and may be refined based on substrate type and other local modifications (e.g., obstructions) which may affect the availability of suitable habitat. An effort will be made to select homogenous sampling stations with regard to habitat conditions. Sampling locations will be finalized following the planned agency site reconnaissance.

3.6.2 Field Macroinvertebrate Sampling Procedures

The macroinvertebrate sampling technique is designed after a modified version of the USEPA (1999) Rapid Bioassessment Protocols (RBP) and will incorporate sampling method aspects from the USEPA (2000) Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance. The depth of the Hudson River limits the selection of gear type to conduct a macroinvertebrate survey to grab samplers. Therefore, a Ted Young grab, petite Ponar or equivalent will be used to collect the benthic invertebrate samples from each location. This method will permit sampling of deep habitats that preclude the use of shallow water sampling techniques such as Kick nets or Dip nets. Prior to sampling, a physical/chemical field data sheet will be completed to document supplementary information including water quality, depth, etc. A field sketch of the sampling reach will be drawn to document major habitats, riparian habitat, and other instream attributes and weather conditions will be documented.

Sampling techniques to collect the benthic macroinvertebrates will be consistent with the technique used to collect sediment. Once the sample is collected, the top of the grab sampler will be opened to determine whether the sample collected is acceptable for analysis. In accordance with USEPA (2000a) guidance, an acceptable grab is one having relatively level, intact sediment over the entire area of the grab, and a sediment depth at the center of at least 7 centimeters. Samples deemed unacceptable may result form inadequate penetration, angle of closure, completeness of closure of the jaws, and potential loss of sample material during retrieval.

Duplicate samples will be collected at each sampling location. Samples will emptied into a collection bucket and any sediment remaining in the grab will be washed directly into the bucket. The bucket will be transferred to a sample-processing table where be sieved through a 500 micron sieve bucket to remove fine material. Large debris (e.g., rocks) will be removed from the sample; however, no attempt will be made to remove small debris. All matter retained on the sieve will be transferred to labeled storage bottles and preserved in 95 percent ethanol to cover the sample. Sample bottles will be labeled with the site name, the station number, a unique sample identification number as described in Section 3.11, date and time of collection, depth of collection, preservative use, and name of collectors. Detailed field notes will be kept to document the macroinvertebrate community survey.

The preserved samples will be sent to the contract laboratory under chain-of-custody for identification and enumeration.

3.6.3 Macroinvertebrate Data Analysis

All preserved samples will be sent under chain-of-custody to a taxonomic laboratory for sample processing and identification. The duplicate samples from each sampling station will be analyzed in accordance with the USEPA guidance (1999).

All organisms will be identified to the lowest practical taxon (e.g., genus or species) by a qualified macroinvertebrate taxonomist, as described in USEPA (1999). If the preponderance of samples are found to contain gross quantities of invertebrate organisms, then each sample analyzed will be separated into 100-organism sub-samples and will be sorted and preserved separately from the remaining sample. Sorting techniques are described in detail in USEPA (1999) and include thoroughly rinsing the sample in a No. 35 mesh (500-micron) screen to remove preservative and fine sediment and spreading the washed sample evenly in a gridded pan with a light colored bottom. Grids will be randomly selected and all organisms within these grids will be collected until a 100-organism sub-sample is obtained.

Samples will be labeled and voucher specimens of all taxa will be archived in denatured 70 percent ethanol for a minimum of three years. The numbers of each taxon will be recorded on an RBP Laboratory Bench Sheet. Quality control for taxonomy will be conducted as outlined by USEPA (1999).

The data analysis of the biological samples will integrate several community, population, and functional parameters into a qualitative evaluation of biological integrity. Metrics to be evaluated include richness measures, diversity indices, percent similarity measures, and trophic measures. The exact metrics to be used at the site will be dependent upon the data generated through the field sampling program. Examples of the metrics that may be used in addition to those mentioned above are listed in the RBP Manual (USEPA 1999) and in the USEPA (2000a) Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance, as well as in the NYSDEC guidance for macroinvertebrate community assessment (Bode et al., 1990; Bode et al., 2002).

Metrics that have relevancy to the assemblage of organisms found in the Hudson River watershed will initially be considered for use in the macroinvertebrate data analysis. After the initial screening of candidate metrics, key metrics will be selected for further evaluation. Ideally, the site-specific data will permit selection of core metrics which represent diverse measurements of community structure, composition, trophic status, and pollution-sensitivity. Metrics will be eliminated from consideration in the Hudson River data analysis if there are too many zero values to calculate the metric at a large proportion of sampling locations, or if the metric is so variable that it will not serve to help discriminate among sampling stations.

As described in USEPA (1999) and Bode et al. (1990), an attempt will be made to determine the association and/or linkages between biological, habitat condition, and physicochemical metrics. As appropriate, metric values will be plotted against analytical chemical data, and an inferential statistical evaluation (e.g., multivariate ordination) of the raw data may be conducted to elucidate relationships between metrics and the raw data from the various sampling stations. The application of inferential statistics will be used to determine if significant differences exist between Upstream, Adjacent and Downstream sampling stations and try to measure the relative importance of environmental variables and chemical concentrations influence on the observed patterns.

3.7 Sediment Toxicity Testing

The results of the screening level ERA included in the Site Investigation (ENSR, 2007) indicated potential risks to ecological receptors through direct exposure to sediment. A number of chemical stressors were detected at concentrations in excess of ecological screening benchmarks for these media. To evaluate whether or not direct exposures to sediments have the potential to cause toxicity to ecological receptors, laboratory toxicity tests are planned. All toxicity tests will be conducted under specified laboratory conditions using whole environmental media only (e.g., no dilution series toxicity testing is planned).

The bioavailability of chemicals is dependent on a number of factors, which are both site-specific and medium-specific. Although many of these factors can be estimated using equilibrium partitioning techniques, it is difficult to account for all the physical and chemical properties which could potentially affect bioavailability. Laboratory toxicity tests can be used to help estimate the potential adverse effects of target chemicals on ecological receptors. These tests can be used to demonstrate the reaction of selected organisms to the combination of physical and chemical characteristics in an environmental medium.

Although the results of toxicity tests can be used to evaluate potential effects that might occur to aquatic receptors *in situ*, it is important to recognize that:

- Motile organisms may be able to avoid prolonged exposure to contaminated media.
- Although the tests are designed to predict adverse effects on biological communities based on chronic exposures, they are not multi-generation chronic tests, in that they do not consider population effects by assessing potential effects over several generations during the test period.
- Toxicity to organisms in situ may be dependent upon physical characteristics and equilibrium partitioning that are not replicated under laboratory conditions.
- The species used in toxicity testing programs are typically chosen to be representative and protective of the organisms, which may be found on site, but the use of surrogate species cannot precisely predict the health of ecological communities on site.

In order to provide an assessment of ecological community response to potential stressors in Hudson River sediments adjacent to the Site, sediment samples will be collected for laboratory toxicity testing. Laboratory toxicity test sampling locations will be co-located in time and space with sediment chemistry and benthic macroinvertebrate sampling locations (Figure 3-2), allowing for a detailed evaluation of the co-occurring data in the ERA.

The results of the laboratory toxicity tests will be compared to the results of both laboratory control tests and tests conducted with samples collected from Upstream and Western Shoreline stations. Standardized statistical tests, such as analysis of variance (ANOVA) will be conducted to determine if significant differences in survival, growth, or other measured response are observed. Samples of environmental media for toxicity testing will be collected concurrently with samples for analytical chemistry, thereby allowing for co-evaluation of chemical, physical, and toxicological stressors. Attempts will be made to relate the results of the toxicity-testing program with measured concentrations of target chemicals to develop potential associations between observed toxicity and chemical concentrations.

Chronic toxicity tests will be conducted to assess the toxicity of sediments to invertebrate organisms. The objective of the sediment toxicity tests will be to obtain laboratory data to evaluate potential ecological risks to invertebrate receptors. A midge (*Chironomus tentans*) has been selected as the invertebrate species for sediment toxicity testing. This species was selected as the appropriate and relevant test organism since the December 2005 macroinvertebrate community sampling indicated that sediment samples (including those collected from Upstream reference stations) contained numerous members of the stress-tolerant chironomid genera (i.e. *Chironomus* sp., *Cryptochironomous* sp., and *Procladius* sp.).

The proposed test method is based on the life-cycle test described by USEPA (2000b) and ASTM (2006). The *C. tentans* chronic sediment toxicity test begins with 12 replicates per sample, each containing 12 newly hatched larvae (less than 24 hours old). On Day 20, four of the replicates are selected for survival and growth measurements. Emergence traps are placed on the remaining eight replicates on Day 20 and from Day 23 to the end of the test, *C. tentans* emergence is monitored daily. The test is terminated when no emergence has occurred for 7 days or after a maximum test duration of 35 days. Test endpoints include survival, growth, and emergence measurements.

The midge test is conducted during a critical early life-stage and is intended to evaluate potential effects of exposure to sediment on midge populations.

3.8 Focused Geomorphology and Bathymetric Surveys

As part of the previously completed Site Investigation (2007), a focused geophysical survey was conducted of the Hudson River in the vicinity of the Site. These side-scan sonar surveys were used to produce a 30-cm resolution mosaic which allowed for the determination of sediment classifications on a broad scale. These data were used to help focus the sediment sampling effort on depositional environments, and to develop the CSM relative to riverine geomorphology and sedimentation dynamics.

Using the classification system employed by NYSDEC (2000b), the primary substrate categories observed during the 2005 geophysical survey included cobble, sandy gravel (or gravelly sand), sand, muddy sand, sandy mud, and mud. The results of the survey indicate that sandy gravel (or gravelly sand) is the dominant substrate throughout the Study Area. However, in the Adjacent Nearshore reach, muddy sand and sandy mud comprise the majority of the substrate observed. In the Adjacent Far Field reach, immediately to the west of the muddy sand/sandy mud complex, a lobe of sand bounds the muddy sand. Immediately downstream of the Site, in the Upper Navigational Channel and in the Downstream reach adjacent to the turning basin, much of the substrate consists of muddy sand. Approximately three miles upstream of the Site, at the reference area, the river is dominated by sandy gravels and gravelly sands, with areas of muddy sand on both the eastern and western edges of the river.

An area of uncertainty related to the geomorphology and the nature and extent of inorganic COPCs was identified in the Site Investigation Report (ENSR, 2007); namely, the source of inorganic constituents downstream of the Site, in the depositional Upper Navigational Channel, can not be determined with the existing data. It is possible that some of the detected metals in this area originated at the Site; however, it is possible that some of these metals are representative of anthropogenic background.

Additional investigation and data analysis is recommended in order to better understand the role that navigational dredging (and sedimentation following dredging) has played relative to the distribution of inorganic constituents in this portion of the river. BASF is in the process of obtaining and reviewing U.S. Army Corps of Engineers dredging records for this portion of the river. These records will be reviewed relative to the current bathymetry and geomorphology, and if necessary a focused geophysical survey (single or multi-beam side scan and/or sub-bottom sonar) will be conducted in this portion of the river. It is possible that this survey will involve a one-time sampling event; conversely, depending upon the results of the information review phase of work and the sensitivity of the instrumentation, it is possible that time-series high resolution bathymetric surveys may be conducted to better understand changes in river bed geomorphology over time.

The goal of this analysis will be to develop a strong semi-quantitative discussion of sediment dynamics in the vicinity of the Site including prediction of likely sediment stability in the future. The nature of sediment loads and the current and historic sediment bed-forms will be considered when assessing likely bed stability in the future.

3.9 Evaluation of River Conditions

The project area in the Upper Hudson Estuary has been significantly altered physically, chemically, and biologically over the past century. The ecological community currently observed in the river in the vicinity of the BASF Site integrates exposure from a variety of stressors (including but not limited to the chemical stressors identified in this Work Plan). In order to better understand the current status of the ecological community relative to these multiple stressors and to understand the potential responses of the community, it is critical to develop a more complete inventory of the physical, chemical, and biological stressors in this portion of the river.

Limited ambient river data will be collected as a part of this program to help characterize the nutrient, dissolved oxygen and temperature regime in the vicinity of the BASF plant, and to establish if these parameters could be affecting the biological community. As a part of this effort, dissolved oxygen, temperature and conductivity profiles at 1 meter intervals will be collected in conjunction with the collection of sediment and biological data described elsewhere in this work plan. In addition, total suspended solids concentrations will be determined from samples collected at the surface and within 0.5 m of the bottom at a minimum of 1 location in both the near shore environment and mid channel environment. Results from these samples will help describe sediment transport through the system. The ambient water quality data set will be used to describe the temporal and spatial variability in water quality in the vicinity of the BASF plant. On at least two occasions, profiles will be measured at a minimum of three sites in the vicinity of the BASF plant within 1 hour of sunrise and again in the late afternoon to characterize the diurnal variability in these parameters. The target time period for these surveys will be during a low flow period in late summer when dissolved oxygen concentrations are anticipated to be high and dissolved oxygen concentrations low.

Beyond this limited field scope, the initial step in the evaluation of potential alternative stressors involves review of literature which describes the physical and chemical environment in the vicinity of the plant. The documents expected to yield relevant information include NPDES discharge permits, combined sewer overflow (CSO) reports, stormwater survey data, dredging reports, habitat maps, biological survey data, fisheries studies and instream water quality data. These studies are expected to contain data related to COPCs (including but not limited to the potentially Site-related chemical stressors), physical data such as current velocities and temperature, and biological data related to invasive, predatory or competing species.

The second part of the evaluation of alternative stressors involves confirmation of data collected in the initial steps. Several stressors seem to be likely candidates for further characterization. If additional evaluation is warranted, a brief technical memorandum style work plan addendum will be prepared to summarize these studies:

- The physical environment in the vicinity of the BASF plant is characterized by deep fast moving water with relatively coarse grained and constantly shifting sediments. The riparian zone at the site and elsewhere along this reach of the river has been largely bulkheaded, filled or armored limiting the amount of low energy littoral habitat available. This high energy physical environment would not be expected to harbor a large or diverse macroinvertebrate community even in the absence of sediment contamination. Confirmation of velocities and substrates may be required as a part of the field program.
- Chemical stressors are currently released or have been historically released to the river both above and below the BASF plant. These include permitted discharges, legacy pollutants from other sites, stormwater discharges, combined sewer overflows and non-point source pollution. Each of these, in addition to historic discharges from the BASF plant, has the potential to influence the biological community in the vicinity of the BASF plant. The literature review may result in a targeted list of analytes originating upstream or downstream of the BASF site that may need to be sampled both at the source and at the project area.
- The biological community of the Hudson River has been significantly altered through the introduction of numerous exotic plant and fish species in recent years. Some of these species have the ability to significantly alter the biological community. Foremost in terms of ecological impact among those species that have invaded the Upper Hudson in recent years is the zebra mussel (*Dreissena polymorpha*). The zebra mussel has the ability to not only directly compete with other benthic fauna for resources but also to alter the chemical environment locally when it forms dense colonies. Zebra mussels are also a major source of mortality for some native mussel species through competition and colonization on native mussel shells. Changes in the aquatic community that may have the potential to impact macroinvertebrate resources in the vicinity of the BASF plant will be assessed. Although the proposed macroinvertebrate sampling program is likely to provide sufficient data to address this concern, it is possible that additional sampling may be required to confirm the presence and distribution of aquatic invasive species in the vicinity of the BASF site.

3.10 Field Operations/Documentation

This section discusses field custody and documentation procedures. Laboratory and project file custody is discussed in the QAPP (ENSR, 2005).

3.10.1 Field Log Book and/or Sample Field Sheets

The Field Team Leader (FTL) will be responsible for maintaining a detailed log of field activities within a bound field notebook. The field notebook will contain a chronological description of sample collection activities. The notebook will include information such as names and times for which all project-related personnel (consultant, subcontractors, client) who are on-site, health and safety information, work-area assignments and goals, general notation of time and weather conditions, description of work-related problems and their solutions, any specific scope of work deviations, among other information. Each page of this notebook will identify the project name and the date and location of each activity described on a specific page. Individual notebook pages will be numbered sequentially and signed by the individual making the entry.

Other field records such as sampling logs will be organized in a loose-leaf notebook for each field investigation. The notebook will be assembled prior to each field investigation including the appropriate logs, as presented below. The notebook will include loose-leaf plastic pockets for collection of documents generated in the field (e.g., shipping records). For convenience in the field (as well as neatness), clipboards may be used on a daily basis during completion of specific field activities. At the end of each day, all completed field records will be returned to the loose-leaf notebook. The notebook will be kept by the FTL in an accessible location for use as a reference by project personnel as needed. At the completion of each field investigation, the notebooks will be returned to the office, and the logs separated and filed into the appropriate project files. Logs which are relevant to several different tasks (or units), such as calibration logs or photographic logs, will be copied and filed in each of the relevant project files.

Field records will be recorded in black waterproof ink, or in pencil if weather prevents use of ink. Logs will include entries in every blank, with appropriate use of the abbreviations NA (not available) and NR (not recorded). Field record corrections will include a single line crossing out the incorrect data, such that the incorrect data remains legible, and initialed by the field staff member.

Field measurements will be made by geologists, engineers, or other scientists and technicians. Field measurements will be recorded to the level of precision indicated in the QAPP and the relevant SOP. The appropriate logs for this project will be employed, including site-specific media sampling logs.

3.10.2 Photographic Records

Photographs from the site investigations and from site visits will be included in the reporting process. Photographs will be numbered and documented sequentially. The numbering system will include date and location for each photograph taken.

3.10.3 Sample Documentation

3.10.3.1 Sample Numbering System

Each field sample will be assigned a unique sample identifier as discussed in the QAPP (ENSR, 2005) and modified herein. This identifier will be used throughout collection, analysis, and reporting activities. The sample identifier will be clearly shown on the chain-of-custody form and sample container labels and tags. The sample identifier will be cross-referenced to the field identification of the sample point in both field notebooks and the project database management system. Samples will be assigned unique sample identifications as described below.

The first two characters will define the sampling round (e.g., 03).

The third and fourth characters will define the matrix type:

SD – sediment

PW – pore water

The fifth, sixth, and seventh characters will be a three digit number that will correspond to a specific location on a map (e.g., 001, 002, 038, etc.):

The eighth character will indicate the station area and will be followed by a dash (e.g., U-, F-, etc.):

U – Upstream (reference) Area

F – Adjacent Far Field

N – Adjacent Nearshore

U – Upper Navigational Channel

W – Western Shoreline

The ninth and tenth digits will identify the analysis planned for the sample:

TX Toxicity

MC Macroinvertebrate community survey

SC Sediment chemistry

WC Water chemistry (for pore waters)

The eleventh character will be a letter representing depth. An "A" will represent the first sample collected and letter assignment will proceed sequentially (B, C, etc.) as samples from increasing depth are collected. The cross-reference between the letter assigned and the actual depth at which the sample was collected will be recorded in the field records.

The last character of the sample ID will represent the sample type:

1 – Field sample

2 – Field duplicate

3 – Equipment blank

Samples being designated for MS/MSD analysis will not include an identifier as part of the sample code, but will be identified as such on the chain-of-custody form. The sample identification for Trip Blanks (for VOC analysis only) will be "TB" followed by the date (day/month/year).

3.10.3.2 Sample Labels

Immediately upon collection, sample will be labeled with a pre-printed adhesive label, which includes test to be performed, preservation conditions and a unique identifier. Field personnel will mark the date and time of collection and sampler's initials once the label is affixed to the sampling container with a permanent marker.

3.10.3.3 Chain-of-Custody Records

Samples will be accompanied by a properly completed chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler, to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage location. An example chain-of-custody form is included as Figure 3-3.

Minimum information recorded on the chain-of-custody record in addition to the signatures and dates of all custodians will include:

- Client/project name,
- Project location,
- Project number,
- Field logbook number,
- Chain-of-custody tape numbers,
- The person to whom results should be reported,
- Field sampling number/identification,
- Sampling date and time,
- Type of sample (grab or composite),
- Identification of sample collector and his/her affiliation,

- Sample container number, size, and material,
- Sample description (matrix),
- Sample preservative,
- The performance of field filtration, and
- Analyses to be performed.

The field sampler will be personally responsible for the care and custody of the samples until the samples are transferred or dispatched properly. As few people as possible should handle the samples.

Each sample container will have a pre-affixed label. This label will be completed in the field with a unique sample identifier, the site name, sample collection date and time, analysis requested, and preservative and will be signed by the sampler. The FTL will review field activities to determine whether proper custody procedures were followed during the field work and will decide if additional samples are required.

3.10.4 Sample Packaging and Shipping Requirements

Samples will be packaged properly for shipment and dispatched to the laboratories for analysis with a separate signed custody record enclosed in each sample cooler. Shipping containers will be locked or secured with strapping tape and sealed with custody seals. The preferred procedure is to attach a custody seal to the front right and back left of the cooler. The cooler will be taped closed with fiberglass tape covering the chain-of-custody seals.

Samples will be shipped daily from the field to the laboratory using an overnight courier or onsite pickup by the laboratory. All shipments will be accompanied by the chain-of-custody record identifying the contents. The back copy will be detached and kept as part of the field records. The original record and remaining copies will accompany the shipment.

Laboratory custody procedures are described in the QAPP (ENSR, 2005).

3.11 Investigation Derived Wastes

The purpose of this section is to ensure that the guidance specified in the April 1992 EPA Publication 9345.3-03FS titled Guide to Management of Investigation-Derived Wastes is followed when performing investigative activities at the site. Methods for collection and handling of Investigation-Derived Wastes (IDW) will be consistent with this document.

Given the nature of the Hudson River field sampling effort (e.g., primarily sediment, surface water, and potentially biota sampling), it is anticipated that only very limited waste materials will be generated during the field investigation. These materials include:

- Decontamination fluid;
- Used PPE;
- Used sampling equipment.

These wastes will be handled in the following manner:

- River water used for rinsing sampling equipment will be released back to the River in the immediate vicinity of its point of generation. Phosphate-free detergent wash water and deionized rinsate water used for decontamination will be contained in 55-gallon drums or bulk containers.

- Used PPE, such as sampling gloves, paper towels, or other materials will be bagged and sealed prior to disposal as general refuse. If PPE becomes grossly contaminated, it will be segregated from other PPE, labeled and staged as "contaminated material". Contaminated material will be drummed and staged in the IDW area designated by BASF personnel. The field team will arrange for off-site disposal of drums by a licensed waste hauler at an approved facility.
- Used sampling equipment, which generally has minor contamination, will be disposed of with the PPE as general refuse. Contaminated disposable equipment will require segregation from other equipment and proper disposal.
- The field team will be responsible for arranging the removal and proper disposal of all accumulated waste materials following completion of the field program. Disposal will be arranged with licensed waste haulers at approved receiving facilities.

Table 3-1
Data Quality Objectives
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

DQO Step	Site-Specific Information
Step 1: State the Problems	Based on previous sediment sampling, metals and VOCs were detected at elevated levels in the Hudson River in the vicinity of the BASF facility. Additional sampling and analysis is necessary to evaluate the horizontal and vertical extent of metals and VOCs in the river adjacent to the site, to evaluate the relationship of these constituents to factors such as grain size and bathymetry, and to evaluate the potential for risk to human health and the environment. Potential ecological effects associated with exposure to the contaminants found in the sediments of the Hudson River are varied and likely dependent on site-specific characteristics Therefore, additional data are needed to better characterize the Site, to evaluate the potential bioavailability and toxicity of contaminants in sediments, to assess whether the ecological community is stressed or impaired from BASF related activities, and allow for more robust statistical analyses of site and upstream data.
Step 2: Identify the Decisions	1) Has the extent of sediment contamination been adequately delineated vertically and horizontally? 2) Can relationships be established between sediment constituent burden and factors such as grain size, sample depth, depositional patterns, etc. 3) Are the target chemical concentrations in sediments greater than sediment quality benchmarks? 4) Are target compounds bioavailable to ecological receptors? 5) What is the chronic toxicity of the sediments to representative ecological receptors? 6) Are benthic receptors in the Hudson River adjacent to the BASF Site at risk from exposure to chemical stressors in Hudson River sediment? 7) Are human receptors in the Hudson River adjacent to the Site at risk from exposure (direct or indirect) to chemical stressors in sediment?

DQO Step	Site-Specific Information
Step 3: Identify Inputs to the Decision	The key inputs for making the required decisions are briefly summarized as follows: VOCs - Sediment (surface and sub-surface) samples will be collected from the near-shore study area and submitted for laboratory analysis of VOCs. Inorganics - Sediment (surface and sub-surface) samples will be collected from the near-shore study area, upstream reach and downstream reach and submitted for laboratory analysis of inorganics, grain size, TOC, and SEM/AVS. Surficial sediment samples will be collected from the following locations: (1) Upstream Reach; (2) Adjacent Nearshore Reach; (3) Adjacent Far Field Reach; (4) Western Shoreline; and (5) Upper Navigational Channel. A sub-set of these samples will be used for chronic sediment toxicity tests. Macroinvertebrate community metrics will also be measured at these locations.
Step 4: Define the Study Boundaries	The BASF site is located on Riverside Avenue in Rensselaer, NY. The study area within the Hudson River has been defined as the portion of the river within 1500 feet upstream and downstream of the facility boundary. Although this extent of the river is likely to include background areas (i.e., upstream) not impacted by the site, in order to achieve similar upstream conditions regarding sediment composition and deposition, a reach of the river approximately 2 miles upstream has been selected as the background or reference condition reach. The river has been sub-divided into sampling reaches to facilitate data evaluation.

DQO Step	Site-Specific Information
Step 5: Develop a Decision Rule	1) The constituent concentrations of the sampled sediment will be compared to sediment quality benchmarks developed in the Site investigation to determine if a conclusion may be drawn concerning selection of these constituents as COPCs. <u>Decision rule for organic and inorganic constituents.</u> If the constituent concentrations in bulk sediment and/or pore water are less than the relevant sediment quality benchmarks, then those contaminants are not expected to contribute to total site risk. If the contaminant concentrations are greater than the sediment quality benchmarks, then further evaluation may be required. 2) Total concentrations may overstate the risk to ecological receptors. An assessment of constituent bioavailability is necessary to refine the risk assessment. <u>Decision rule for SEM/AVS results.</u> The [SUM SEM-AVS/foc] data will be reviewed in the context of USEPA (2005b) guidance to determine if the sediments are "likely to be toxic", "predictions of effect are uncertain", or sediments are presumed to "not likely" be toxic 3) Results from the bulk sediment chronic toxicity tests will be used to evaluate potential lethal (survival) and sub-lethal (growth and emergence) effects associated with exposure to site/downstream sediment relative to background sediment. <u>Decision rule for toxicity evaluations.</u> If the survival/growth/emergence are consistent with or greater than the laboratory controls or comparable Upstream and Western Shoreline reaches, this suggests no unacceptable risk attributable to the Site. If the survival/growth/emergence are less than comparable Upstream and Western Shoreline reaches, further investigation may be warranted. 4) Results from the macroinvertebrate study will be used to evaluate macroinvertebrate exposure to site/downstream sediment relative to background sediment. <u>Decision rule for macroinvertebrate evaluations.</u> If the metrics evaluated are consistent with or greater than the Upstream and Western Shoreline reaches, this suggests no unacceptable risk attributable to the Site. If the evaluated metrics are less than comparable Upstream and Western Shoreline reaches, further investigation may be warranted. 5) The BERA uncertainty analysis will include a statistical analysis of data. If the Site data are statistically similar to Upstream and Western Shoreline data, this suggests no unacceptable risks attributable to the Site. If the data are inconsistent, further investigation may be warranted.

DQO Step	Site-Specific Information
Step 6: Specify Tolerable Limits of Decision Errors	The data quality indicators for screening and definitive data are defined in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. The assessment of the data quality indicators is necessary to determine data usability and involves the evaluation of the PARCC parameters: precision, accuracy, representativeness, completeness, and comparability. To ensure the quality and integrity of the project data, the precision and accuracy of the analysis, the representativeness of the results the completeness of the data, and the comparability of the data to existing data will be evaluated. Data that meet the DQOs and fulfill project goals will be deemed acceptable. Data that do not meet objectives and goals will be reviewed on a case-by-case basis to ascertain its usefulness. For ecological risk assessment purposes, each sample (or sample reach) will be used to make a decision, especially in the case of co-located biological, chemical, and toxicological endpoints. However, inferential statistical analyses will be conducted to evaluate consistency of the different data sets
Step 7: Optimize the Design	The variability of data will have an effect on the sampling design. If necessary, the sample frequency and the analytical procedures may undergo changes to optimize the design. The design options, such as sample collection design, sample size and analytical procedures will be evaluated based on cost and ability to meet the DQOs.

Table 3-2
Analyte List, Project Required Detection Limits, and Reporting Limits
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

CAS No.	Parameter	Aqueous PRDL (µg/L)	Note	Sediment PRDL (mg/Kg)	Note	Aqueous PQL* (µg/L)	Sediment PQL* (mg/Kg)
TCL VOCs by SW-846 8260B							
79-34-5	1,1,2,2-Tetrachloroethane	0.2	1	1.4	2	1.0	0.005
71-55-6	1,1,1-Trichloroethane	5	1	0.030	2	1.0	0.005
79-00-5	1,1,2-Trichloroethane	1	1	1.2	2	1.0	0.005
96-12-8	1,2-Dibromo-3-chloropropane	0.04	1	NV, **	--	2.0	0.005
106-93-4	1,2-Dibromoethane	0.0006	1	NV, **	--	1.0	0.005
75-34-3	1,1-Dichloroethane	5	1	0.027	2	1.0	0.005
107-06-2	1,2-Dichloroethane	0.6	1	0.250	2	1.0	0.005
75-35-4	1,1-Dichloroethene	0.07	1	0.031	2	1.0	0.005
156-59-4	cis-1,2-Dichloroethene	5	1	0.400	2	1.0	0.005
156-60-5	trans-1,2-Dichloroethene	5	1	0.400	2	1.0	0.005
78-87-5	1,2-Dichloropropane	1	1	0.333	6	1.0	0.005
10061-01-5	cis-1,3-Dichloropropene	0.055	2	0.000051	2	1.0	0.005
10061-02-6	trans-1,3-Dichloropropene	0.055	2	0.000051	2	1.0	0.005
78-93-3	2-Butanone	50	1	0.270	2	5.0	0.010
591-78-6	2-Hexanone	99	2	0.022	2	5.0	0.010
108-10-1	4-Methyl-2-pentanone	170	2	0.033	2	5.0	0.010
67-64-1	Acetone	50	1	0.0087	2	10	0.020
71-43-2	Benzene	1	1	0.280	7	1.0	0.005
75-27-4	Bromodichloromethane	50	1	NV, **	--	1.0	0.005
75-25-2	Bromoform	50	1	0.650	2	1.0	0.005
74-83-9	Bromomethane	5	1	NV, **	--	2.0	0.005
75-15-0	Carbon disulfide	0.92	2	0.00085	2	1.0	0.010
56-23-5	Carbon tetrachloride	0.4	1	0.047	2	1.0	0.005
108-90-7	Chlorobenzene	5	1	0.035	7	1.0	0.005
75-00-3	Chloroethane	5	1	NV, **	--	2.0	0.010
67-66-3	Chloroform	7	1	0.022	2	1.0	0.005
74-87-3	Chloromethane	5	1	NV, **	--	2.0	0.005
124-48-1	Dibromochloromethane	50	1	NV, **	--	1.0	0.005
75-71-8	Dichlorodifluoromethane	5	1	NV, **	--	1.0	0.005
100-41-4	Ethylbenzene	5	1	0.064	7	1.0	0.005
75-09-2	Methylene chloride	5	1	0.370	2	1.0	0.005
100-42-5	Styrene	5	1	0.254	6	1.0	0.005
127-18-4	Tetrachloroethene	0.7	1	0.410	2	1.0	0.005

CAS No.	Parameter	Aqueous PRDL (µg/L)	Note	Sediment PRDL (mg/Kg)	Note	Aqueous PQL* (µg/L)	Sediment PQL* (mg/Kg)
108-88-3	Toluene	5	1	0.450	7	1.0	0.005
78-01-6	Trichloroethene	5	1	0.220	2	5.0	0.002
75-69-4	Trichlorofluoromethane	5	1	NV, **	--	1.0	0.005
75-01-4	Vinyl chloride	0.3	1	0.202	6	1.0	0.005
95-47-6	o-Xylene	5	1	0.920	7	1.0	0.005
1330-20-7	m,p-Xylene	5	1	0.920	7	1.0	0.005
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5	1	NV, **	--	1.0	0.005
79-20-9	Methyl Acetate	610	1	NV, **	--	10	0.010
1634-04-4	Methyl-tert-butyl-ether	10	1	NV, **	--	1.0	0.005
110-82-7	Cyclohexane	1000	4	NV, **	--	1.0	0.005
108-87-2	Methylcyclohexane	520	4	NV, **	--	1.0	0.005
98-82-8	Isopropylbenzene	2.6	3	0.120	7	1.0	0.005
120-82-1	1,2,4-Trichlorobenzene	5	1	0.91	7	1.0	0.005
95-50-1	1,2-Dichlorobenzene	3	1	0.120	7	1.0	0.005
541-73-1	1,3-Dichlorobenzene	3	1	0.120	7	1.0	0.005
106-46-7	1,4-Dichlorobenzene	3	1	0.120	7	1.0	0.005
123-91-1	1,4-Dioxane	22,000	6	0.119	6	100	0.100
74-97-5	Bromochloromethane	5	1	NV, **	--	1.0	0.005
87-61-6	1,2,3-Trichlorobenzene	5	1	0.91	7	1.0	0.005
TAL Metals by SW-846 6010B/6020/7471A7470A/7740							
7429-90-5	Aluminum	100	3,5	2600	8	100	10.0
7440-36-0	Antimony	3	1	2	7	1	1.0
7440-38-2	Arsenic	50	1	0.39	7	10	1.0
7440-39-3	Barium	1000	1	0.7	8	20	2.0
7440-41-7	Beryllium	3	1	15.4	7	1	0.5
7440-43-9	Cadmium	2.1	3	0.6	7	1	0.5
7440-70-2	Calcium	NV, **	--	NV, **	--	1000	100
7440-47-3	Chromium	50	1	26	7	10	1.0
7440-48-4	Cobalt	5.0	3	10	8	1	5.0
7440-50-8	Copper	9.0	3	16	7	1	2.0
7439-89-6	Iron	300	3	20,000	7	100	10.0
7439-92-1	Lead	4.5	3	31	7	1	0.5
7439-95-4	Magnesium	35000	3	NV, **	--	1000	100
7439-96-5	Manganese	300	3	460	7	10	1.0
7439-97-6	Mercury	0.77	3	0.15	7	0.2	0.0333
7440-02-0	Nickel	52.0	3	16	7	40	4.0
7440-09-7	Potassium	NV, **	--	NV, **	--	2000	100
7782-49-2	Selenium	4.6	3	0.29	8	2	0.5
7440-22-4	Silver	0.1	3,5	1	7	1	1.0

CAS No.	Parameter	Aqueous PRDL (µg/L)	Note	Sediment PRDL (mg/Kg)	Note	Aqueous PQL* (µg/L)	Sediment PQL* (mg/Kg)
7440-23-5	Sodium	20000	3	NV, **	--	1000	1.0
7440-28-0	Thallium	0.5	1	NV, **	--	1	1.0
7440-62-2	Vanadium	14	3	50	8	1	5.0
7440-66-6	Zinc	82.6	3	120	7	20	2.0
SEM/AVS by EPA 821/R-91-100 Draft							
7440-43-9	Cadmium	NA	--	NV, **	--	NA	0.004 µmol/g
7440-50-8	Copper	NA	--	NV, **	--	NA	0.0.031 µmol/g
7439-92-1	Lead	NA	--	NV, **	--	NA	0.024 µmol/g
7439-97-6	Mercury	NA	--	NV, **	--	NA	0.00017 µmol/g
7440-02-0	Nickel	NA	--	NV, **	--	NA	0.068 µmol/g
7440-66-6	Zinc	NA	--	NV, **	--	NA	0.015 µmol/g
NA	Acid Volatile Sulfide	NA	--	NV, **	--	NA	0.1 µmol/g
NA	**Total Organic Carbon by Lloyd Kahn**	NA	--	NV, **	--	NA	300
NA	**Dissolved Organic Carbon by SW 846 9060**	NV, **	--	NA	--	1.0 mg/L	NA
NA	**Total Organic Carbon by SW-846 9060**	NV, **	--	NA	--	1.0 mg/L	NA
NA	**Grain Size by ASTM D-422**	NA	--	NA	--	NA	NA
NA	**Soot Carbon**	NA	--	NA	--	NA	TBD

PRDL – Project Required Detection Limit
PQL – Practical Quantitation Limit
NV – No screening value identified
NA – Not Applicable

* Data are to be reported to the MDL, J-qualified between the MDL and RL, and U-qualified at the PQL if not detected.
** The project required detection limit will default to the laboratory's PQL in the absence of a readily available screening value.

1 – NYSDEC values for Class A surface waters used as drinking water source (NYSDEC, 1998; NYSDEC, 1999b; NYSDEC, 2000c).
2 – Sediment: Secondary Chronic Value (Jones, et. al., 1997) Surface water: Secondary Chronic Value (Suter and Tsao, 1996).
3 – NYSDEC aquatic life water quality criteria (NYSDEC, 1998).
4 – No NYSDEC value available. Therefore, USEPA Region 9 Preliminary Remediation Goal for tapwater used. October 2004.
5 – Value presented is for ionic form.
6 – Ecological Screening Level (USEPA, 2003b).
7 – NYSDEC sediment criteria (NYSDEC, 1999a).
8 – NOAA Screening Quick Reference Tables (SQuiRTs) available at http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html

Table 3-3
Sampling Program Rationale
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Number of Sampling Stations	Location Description	Number of Stations in Each Surficial Substrate Type				Number of Analyses							Rationale
		Sand	Sandy gravel	Gravelly sand	Muddy sand	TCL VOCs	TAL Metals	SEM and AVS[a]	TOC and Grain Size	Macro-Invertebrate Community Survey	Chronic Toxicity Testing	Pore Water[b]	
Surficial Sediment Sampling (0 to 0.5 ft sampling horizon)													
11	Adjacent Nearshore	0	0	0	11	11	11	6	11	9	9	5	Eleven samples are located within the Adjacent Nearshore area within the vicinity of the five outfall locations, and adjacent to the bulkhead between outfalls. These locations were selected to account for a range of known COPC concentrations and to represent surficial conditions at five new core locations. These samples will help to: (1) further delineate the horizontal extent of inorganic and organic compounds in the nearshore environment; (2) determine the potential risk to ecological receptors from exposure to COPCs in the surficial matrix through an evaluation of sediment chemistry data, toxicity tests, and macroinvertebrate community surveys. Porewater sampling will also be conducted in a sub-set of surficial sediment samples in the Adjacent Nearshore area in order to better understand the potential bioavailability of organic compounds in muddy sand sediments adjacent to the Site.
2	Adjacent Far Field	2	0	0	0	2	2	1	2	2	2	0	Two samples are located within the Adjacent Far Field area. Historical data indicates that the western extent of potentially impacted sediments may not be fully characterized in this area. These samples will help to: (1) further delineate the horizontal extent of inorganic and organic compounds in the far field environment; (2) determine the potential risk to ecological receptors from exposure to COPCs in the surficial matrix through an evaluation of sediment chemistry data, toxicity tests, and macroinvertebrate community surveys.
11	Upper Navigational Channel	0	0	0	11	0	11	6	11	9	9	2	Eleven samples are located within the Upper Navigational Channel which represents the upstream extent of routine navigational dredging in the Hudson, and has historically been characterized by elevated concentrations of inorganic constituents. These samples will help to: (1) further delineate the horizontal extent of inorganic downstream of the Site; (2) determine the potential risk to ecological receptors from exposure to COPCs in the surficial matrix through an evaluation of sediment chemistry data, toxicity tests, and macroinvertebrate community surveys. Porewater sampling will also be conducted in a sub-set of samples to in order to better understand the potential bioavailability of compounds in sediments down river of the Site.

Number of Sampling Stations	Location Description	Number of Stations in Each Surficial Substrate Type: Sand	Sandy gravel	Gravelly sand	Muddy sand	Number of Analyses: TCL VOCs	TAL Metals	SEM and AVS[a]	TOC and Grain Size	Macro - invertebrate Community Survey	Chronic Toxicity Testing	Pore Water[b]	Rationale
6	Upstream (Reference Conditions)	1	1	1	3	6	6	3	6	6	6	2	Six samples are located in the Upstream area to determine background (reference condition) COPC concentrations in locations unimpacted by the Site. Locations have been selected to account for a range of known COPC concentrations and a range of surfical substrates. These stations will: (1) provide an indication of upstream, anthropogenic levels of COPCs associated with a large river in an urbanized environment; (2) represent the muddy sand substrate and allow for comparison with samples collected from the Adjacent Nearshore environment; (3) provide information on grain size distribution, bathymetry, depositional characteristics, and other geophysical properties of the upstream environment; and (4) provide comparison samples for biological evaluation (toxicity testing and macroinvertebrate survey).Porewater sampling will also be conducted in a sub-set of samples in the Upstream area in order to better understand the potential bioavailability of organic compounds in sediment and provide comparison samples for the pore water evaluation.
6	Western Shoreline	0	0	3	3	6	6	3	6	6	6	1	Six samples are located along the Western Shoreline across the Hudson River from the Site in locations unimpacted by the Site. These stations will: (1) provide an indication of anthropogenic levels of COPCs associated with a large river in an urbanized environment; (2) provide information on grain size distribution, bathymetry, depositional characteristics, and other geophysical properties of the Western Shoreline environment; and (3) provide comparison samples for biological evaluation (toxicity testing and macroinvertebrate survey). Porewater sampling will also be conducted in a sub-set of samples in the Western Shoreline area in order to better understand the potential bioavailability of organic compounds in sediment and provide comparison samples for the pore water evaluation.
Sub-Surficial Sediment Sampling (0.5 to 2 ft sampling horizon)													
6	Adjacent Nearshore	0	0	0	6	6	6	0	6	0	0	0	These samples will help to address the existing data gap relative to the sediment horizon between 0.5 and 2 ft, which has not previously been sampled. These locations were selected to account for a range of known COPC concentrations and will help to further delineate the vertical extent of inorganic and organic compounds in the nearshore environment.
Sub-Surficial Sediment Sampling (0.5 to 12+ ft sampling horizon) [c]													
7	Adjacent Nearshore	0	0	0	7	42	42	0	21	0	0	0	These samples will help to further delineate the vertical extent of inorganic and organic compounds in the nearshore environment and will also address the existing data gap relative to the sediment horizon between 0.5 and 2 ft, which has not previously been sampled. An attempt will be made to advance several of the sediment cores to a depth of 20 ft.
4	Adjacent Far Field	4	0	0	0	24	24	0	12	0	0	0	These samples will help to further delineate the vertical extent of inorganic and organic compounds in the far field environment in order to better understand the western extent of potentially impacted sub-surficial sediments. These samples will also address the existing data gap relative to the sediment horizon between 0.5 and 2 ft, which has not previously been sampled.
3	Upper Navigational Channel	0	0	0	3	0	18	0	9	0	0	0	These samples will help to further delineate the vertical extent of inorganic compounds in the Upper Navigational Channel. These samples will also address the existing data gap relative to the sediment horizon between 0.5 and 2 ft, which has not previously been sampled.

[a] SEM and AVS to be evaluated in approximately 50% of samples selected for inorganic constituents.
[b] TCL VOCs, TAL Metals, TOC, and DOC analyzed in pore water. Co-located sediment samples analyzed for TOC and Soot Carbon.
[c] Assume up to 6 horizons analyzed per core.

Table 3-4
Summary of Proposed Samples
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Station ID	Analytical Parameter							Notes
	Chemical Analyses				Biological Analyses	Toxicological Analyses	Other	
	TCL VOCs	TAL Metals	SEM/ AVS	Pore Water[a]	Macroinvertebrate Community Survey [b]	Chronic Toxicity Testing[c]	TOC and Grain Size	
Adjacent Nearshore								
32	X	X	X	X	X	X	X	surficial sediment plus 0.5 - 2 ft horizon will be sampled
56	X	X	X		X	X	X	surficial sediment plus 0.5 - 2 ft horizon will be sampled
59	X	X	X		X	X	X	
80	X	X					X	only 0.5 - 2 ft horizon will be sampled
82	X	X	X		X	X	X	surficial sediment plus 0.5 - 2 ft horizon will be sampled
85	X	X	X	X	X	X	X	surficial sediment plus 0.5 - 2 ft horizon will be sampled
87	X	X	X	X	X	X	X	
94	X	X	X	X	X	X	X	
97	X	X	X	X	X	X	X	
98	X	X					X	only 0.5 - 2 ft horizon will be sampled
100	X	X	X		X	X	X	
115	X	X					X	only 0.5 - 12+ ft horizon will be sampled
116	X	X					X	only 0.5 - 12+ ft horizon will be sampled
121	X	X					X	only 0.5 - 12+ ft horizon will be sampled
122	X	X					X	only 0.5 - 12+ ft horizon will be sampled
123	X	X	X				X	surficial sediment plus 0.5 - 12ft horizon will be sampled
129	X	X	X				X	surficial sediment plus 0.5 - 12ft horizon will be sampled
135	X	X					X	only 0.5 - 12+ ft horizon will be sampled
Adjacent Far Field								
117	X	X					X	only 0.5 - 12+ ft horizon will be sampled
118	X	X	X		X	X	X	surficial sediment plus 0.5 - 12+ ft horizon will be sampled
119	X	X					X	only 0.5 - 12+ ft horizon will be sampled
120	X	X	X		X	X	X	surficial sediment plus 0.5 - 12+ ft horizon will be sampled
Upper Navigational Channel								
61		X	X		X	X	X	
64		X	X		X	X	X	
67		X	X		X	X	X	

Station ID	Analytical Parameter							Notes
	Chemical Analyses				Biological Analyses	Toxicological Analyses	Other	
	TCL VOCs	TAL Metals	SEM/ AVS	Pore Water[a]	Macroinvertebrate Community Survey [b]	Chronic Toxicity Testing[c]	TOC and Grain Size	
69		X	X	X	X	X	X	surficial sediment plus 0.5 - 12+ ft horizon will be sampled
71		X	X		X	X	X	
124		X	X		X	X	X	surficial sediment plus 0.5 - 12+ ft horizon will be sampled
125		X	X		X	X	X	surficial sediment plus 0.5 - 12+ ft horizon will be sampled
126		X	X	X	X	X	X	
127		X	X				X	
128		X	X				X	
SD-11 INV		X	X		X	X	X	
Upstream (Reference Conditions)								
4	X	X	X		X	X	X	
6	X	X	X	X	X	X	X	
10	X	X	X		X	X	X	
18	X	X	X		X	X	X	
27	X	X	X	X	X	X	X	
28	X	X	X		X	X	X	
Western Shoreline								
130	X	X	X		X	X	X	
131	X	X	X		X	X	X	
132	X	X	X		X	X	X	
063	X	X	X		X	X	X	
133	X	X	X	X	X	X	X	
134	X	X	X		X	X	X	

Surficial sediment grab sampling (0 - 0.5 ft) occurs at all sampling locations, unless otherwise noted. Notes column indicates samples with additional core sampling.

[a] Pore water samples to include VOCs, Metals, TOC, and DOC. Co-located sediment samples will be analyzed for TOC and Soot Carbon.

[b] Macroinvertebrate samples will be collected in triplicate at each chronic toxicity testing station.

[c] Chronic toxicity testing will be conducted with *C. tentans* and will include lethal (survival) and sub-lethal (growth, time to emergence, % emergence) endpoints.

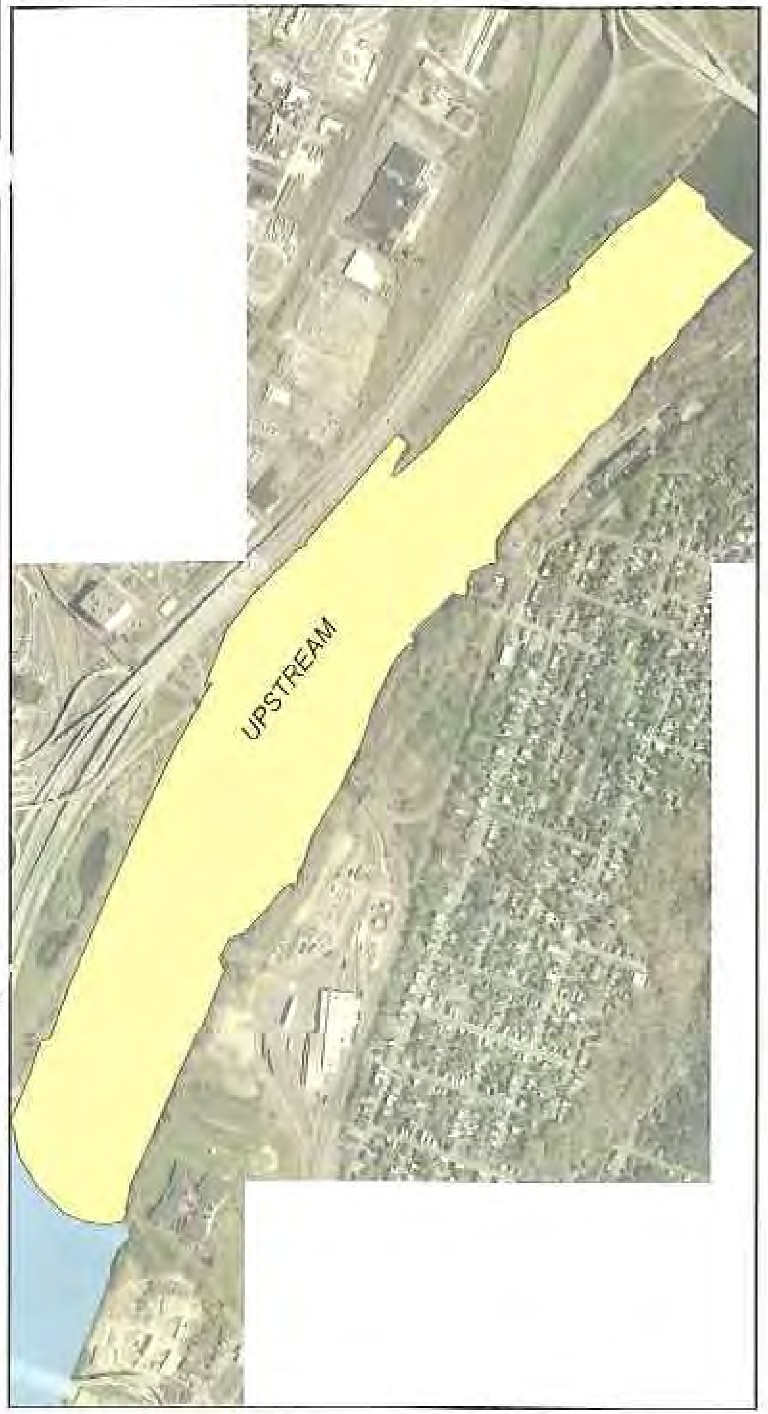
Table 3-5
Sample Container, Preservation, and Holding Time Requirements
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Parameter	Container	Preservation	Holding Time [1]
Pore Water			
VOCs	TBD	TBD	14 days
Dissolved Organic Carbon	TBD	TBD	28 days
Metals	TBD	TBD	28 days for mercury; 180 days other metals
Total Organic Carbon	TBD	TBD	28 days
Sediment			
VOCs	2 40-ml glass vials with Teflon lined septum caps w/ stir bar and 10ml DI water 1 40-ml glass vial with Teflon-lined septum cap w/ 10ml MeOH	Cool 4°C	Low level analysis: 48 hours to preservation (freezing) Low level and high level analyses: 14 days from collection to analysis:
% Solids	1-125 ml glass	Cool 4°C	None
Metals	One 4-oz. wide mouth clear glass jar with Teflon- lined lid	Cool 4°C	6 months (28 days for mercury)
Total Organic Carbon	One 4-oz. wide mouth clear glass jar with Teflon- lined lid	Cool 4°C	14 days
SEM/AVS	One 4-oz. wide mouth clear glass jar with Teflon- lined lid	Cool 4°C	14 days
Grain Size	1 8-oz wide mouth clear glass jar with Teflon-lined lid	None	None
Soot carbon	TBD	TBD	TBD

1. From time of sample collection

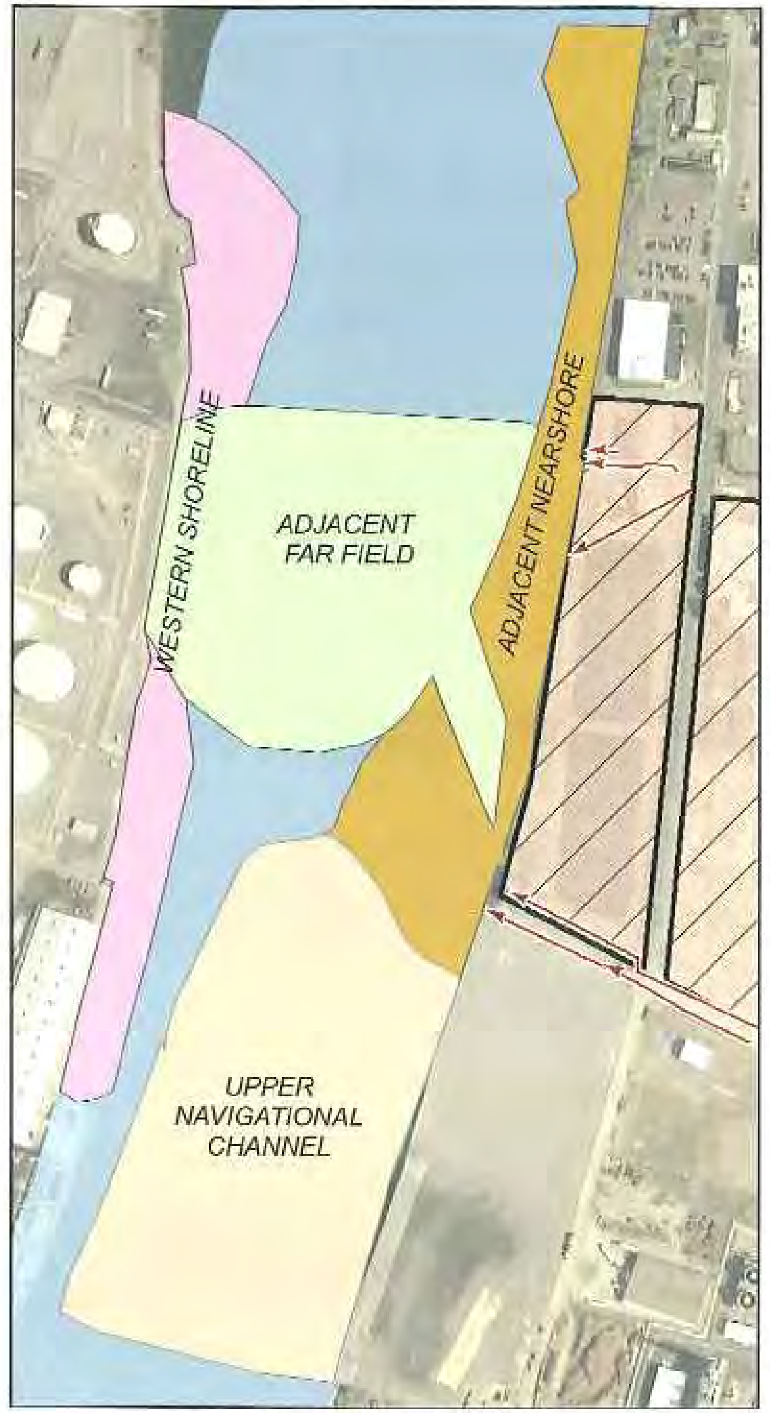
TBD - To be determined

Description	Upstream	Adjacent Nearshore	Adjacent Far Field	Upper Navigational Channel	Western Shoreline
SEDIMENT SAMPLING AND ANALYSIS					
Surface sediment chemistry	X	X	X	X	X
Pore water chemistry	X	X	X	X	X
Physical/chemical data	X	X	X	X	X
Sub-surface coring/sediment chemistry		X	X	X	
Sediment toxicity testing	X	X	X	X	X
ECOLOGICAL AND BIOLOGICAL MATRIX SAMPLING					
Macroinvertebrate survey	X	X	X	X	X
SURFACE WATER / GROUNDWATER ANALYSIS					
Stormwater sampling	X	X		X	
Confounding factors evaluation	X	X	X	X	X
WATER COLUMN PHYSICAL MONITORING					
Focused bathymetry		X	X	X	X
SITE MAPPING					
Identify alternative sources		X	X	X	X



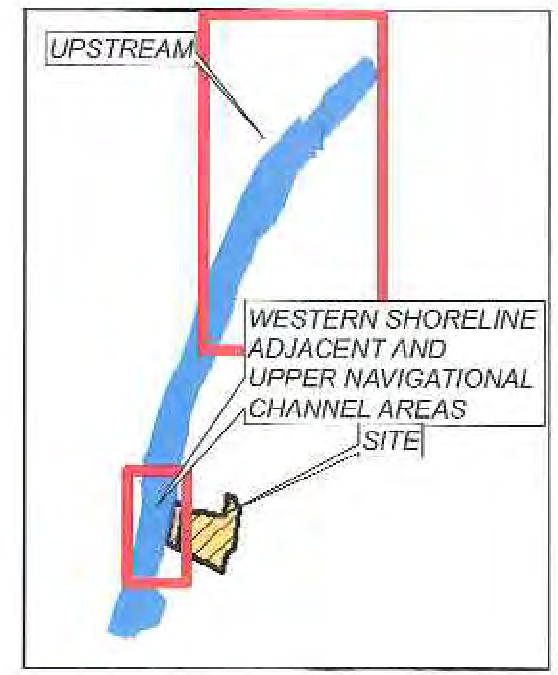
UPSTREAM

0 600 1,200 2,400 3,600 Feet



WESTERN SHORELINE
ADJACENT AND UPPER NAVIGATIONAL CHANNEL

0 200 400 800 1,200 Feet



Legend

- Approximate Locations of Outfall Pipes
- Approximate Property Boundaries
- Western Shoreline
- Hudson River

N W E S

StudyAreas

- Adjacent Nearshore
- Upper Navigational Channel
- Upstream
- Adjacent Far Field

Proposed Sediment Sampling Reaches
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

SCALE	DATE	PROJECT NO.
See Insets	05/07	00760-171

ENSR | AECOM

Figure Number
3-1

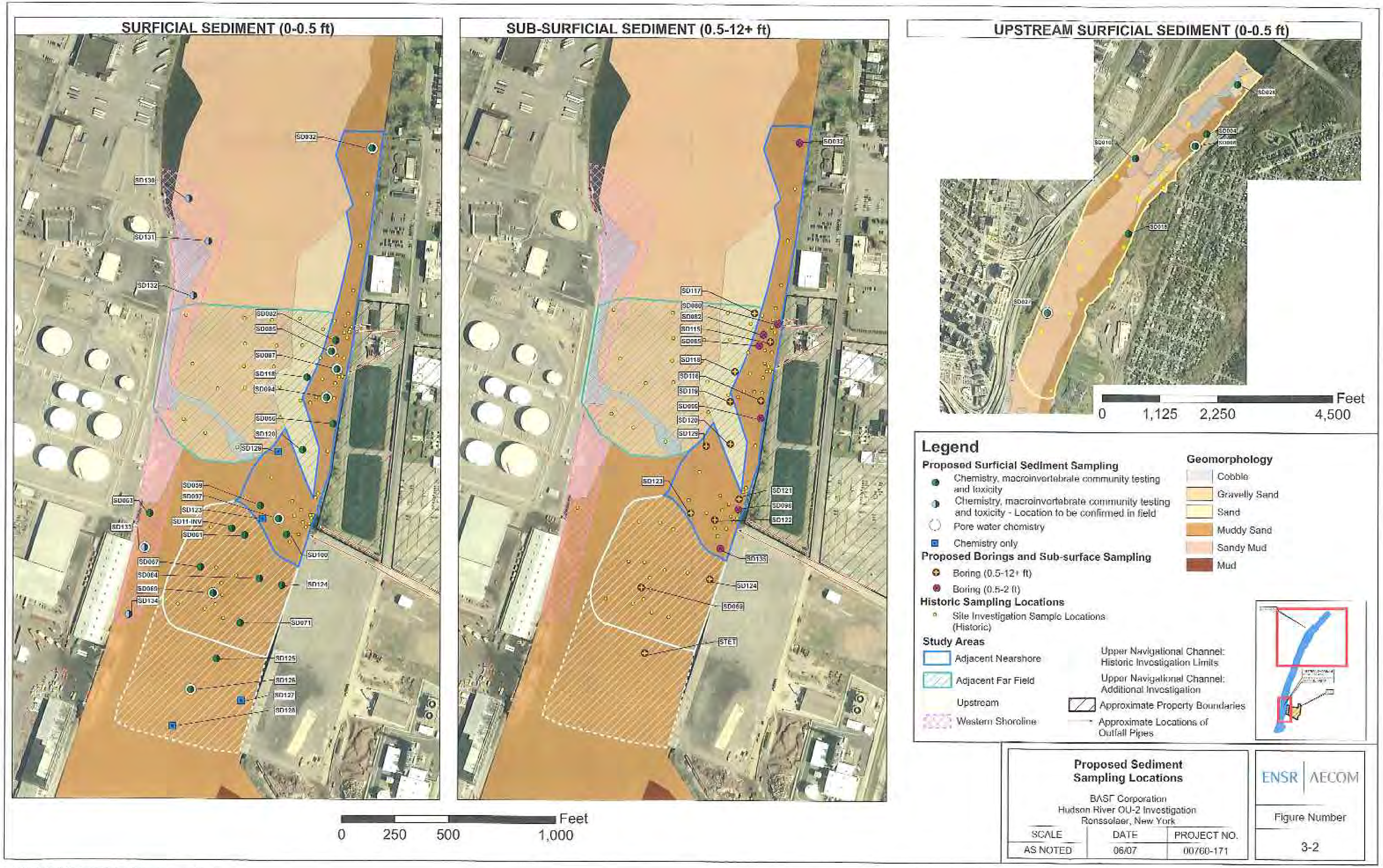

SURFICIAL SEDIMENT (0-0.5 ft)
SUB-SURFICIAL SEDIMENT (0.5-12+ ft)
UPSTREAM SURFICIAL SEDIMENT (0-0.5 ft)
Feet
0
1,125
2,250
4,500
Feet
0
250
500
1,000
Legend
Proposed Surficial Sediment Sampling
Chemistry, macroinvertebrate community testing and toxicity
Chemistry, macroinvertebrate community testing and toxicity - Location to be confirmed in field
Pore water chemistry
Chemistry only
Proposed Borings and Sub-surface Sampling
Boring (0.5-12+ ft)
Boring (0.5-2 ft)
Historic Sampling Locations
Site Investigation Sample Locations (Historic)
Study Areas
Adjacent Nearshore
Adjacent Far Field
Upstream
Western Shoreline
Upper Navigational Channel: Historic Investigation Limits
Upper Navigational Channel: Additional Investigation
Approximate Property Boundaries
Approximate Locations of Outfall Pipes
Geomorphology
Cobble
Gravelly Sand
Sand
Muddy Sand
Sandy Mud
Mud
Proposed Sediment Sampling Locations
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York
SCALE
AS NOTED
DATE
06/07
PROJECT NO.
00760-171
ENSR | AECOM
Figure Number
3-2

Figure 3-3 Example Copy of Chain-of-Custody Form

ENSR | AECOM

CHAIN OF CUSTODY RECORD

Page ___ of ___

Client/Project Name:	Project Location:	
Project Number:	Field Logbook No.:	
Sampler (Print Name)/(Affiliation):	Chain of Custody Tape Nos.:	
Signature:	Send Results/Report to:	TAT:

Analysis Requested

Container Type: P – Plastic, A – Amber Glass, G – Clear Glass, V – VOA Vial, O – Other, E – Encore

Preservation: 1 – HCl, 4°; 2 – H_2SO_4, 4°; 3 – HNO_3, 4°; 4 – NaOH, 4°; 5 – NaOH/ZnAc, 4°; 6 – $Na_2S_2O_3$, 4°; 7 – 4°

Matrix Codes: DW – Drinking Water, WW – Wastewater, GW – Groundwater, SW – Surface Water, ST – Storm Water, W – Water, S – Soil, SL – Sludge, SD – Sediment, SO – Solid, A – Air, L – Liquid, P – Product

Field Sample No./Identification	Date	Time	COMP	GRAB	Sample Container (Size/Mat'l)	Matrix	Preserv.	Field Filtered											Lab I.D.	Remarks

Relinquished by: (Print Name)(Affiliation) Signature:	Date: Time:	Received by: (Print Name)(Affiliation) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name)(Affiliation) Signature:	Date: Time:	Received by: (Print Name)(Affiliation) Signature:	Date: Time:	
Relinquished by: (Print Name)(Affiliation) Signature:	Date: Time:	Received by: (Print Name)(Affiliation) Signature:	Date: Time:	Sample Shipped Via: UPS FedEx Courier Other — Temp Blank Yes ___ No

Serial No. ___________

4.0 Reporting

The report for this investigation will include several components designed to address the objectives of the investigation and conform to NYSDEC requirements. These objectives were presented in Section 1 and included the following:

- Delineating the horizontal and vertical nature and extent of selected metals and VOCs within the sediments in the vicinity of the BASF facility;
- Developing a better understanding of riverine dynamics and primary and secondary source areas as they relate to the geomorphology of the river in the vicinity of the Site; and
- Determining whether there are areas/sub-habitats in the river where Site-related COPCs represent a significant potential risk to human health or ecological receptors.

The report will include the following:

- Summary of the results of previous sampling activities;
- Discussion of investigation activities including sediment sampling, macroinvertebrate surveys, toxicity testing, and geophysical evaluations, as appropriate;
- Tabular presentation of analytical results for all media sampled during the field effort;
- Discussion of the nature and extent of any contaminants identified, in the context of riverine bathymetric and geophysical conditions;
- Evaluation of the vertical and horizontal distribution of metals and VOCs in the near-shore areas near the outfalls;
- Discussion of the distribution of metals in the near-Site reaches of the river relative to reference conditions in the Upstream and Western Shoreline reaches.
- Discussion of the geophysical survey results, including relevant mapping;
- Conclusions and recommendations drawn from interpretation of the data, including a discussion of the CSM and the potential for any risks to human health or the environment; and
- Supporting data including any analytical data packages, statistical support, and/or photographs.

If additional phases of investigation are necessary, BASF will discuss with NYSDEC options for future evaluations and/or sampling plans.

Ecological and human health risk assessment will be conducted in accordance with relevant NYSDEC guidance. Additional detail regarding ERA reporting is included in Appendix A; the scope of work for the refined HHRA is presented in Section 4.1, below.

4.1 HHRA Scope

The results of the screening level HHRA (ENSR, 2007) indicate that there is no potential current risk to human health associated with exposure to sediment or surface water adjacent to the Site. This conclusion is based on a comparison of site data to conservative NYSDEC screening criteria and consideration of the limited accessibility of site sediments. However, due to limitations of and uncertainties in the screening criteria, further evaluation may be warranted to better understand potential relationships between biota (fish) tissue residue concentrations and human health. This refined evaluation would focus on key parameters used in the derivation of the NYSDEC sediment criteria, as well as the method itself, as discussed below.

The NYSDEC sediment criteria (SC) have been derived for a limited suite of organic constituents (52 non-polar organic compounds) using an equilibrium partitioning (EqP) methodology (NYSDEC, 1999a). Several parameters are included in the development of the NYSDEC SC, including a water quality criterion (WQC), the constituent octanol-water partitioning coefficient (K_{ow}), and the organic carbon content of the sediment (f_{oc}). For some constituents, no USEPA ambient water quality criterion or NYSDEC WQC (from TOGS 1.1.1) is available. For these constituents, derivation of the SC includes derivation of a proposed WQC specific to protection of sediment (i.e., those noted with footnote (P) in NYSDEC, 1999a). The WQC and proposed WQC used in the derivation of the SC are derived to be protective of human ingestion of fish. Therefore, the NYSDEC SC for human health are, by default, protective of potential fish consumption. There are, however, several uncertainties associated with the approach for the SC. As part of the refined HHRA, these uncertainties will be evaluated to refine the applicability of the NYSDEC SC to the sediment risk assessment and, as appropriate, derive site-specific SC.

The derivation of the WQC and proposed WQC includes three parameters: the acceptable daily intake (ADI), the daily human ingestion rate of fish, and a constituent-specific bioaccumulation factor (BF). The ingestion rate (0.033 kg/d) has been taken from 6 NYCRR 702.8. The ADI is constituent-specific and, according to NYSDEC (1999a), is taken "from fact sheets supporting drinking water standards and guidance values in TOGS 1.1.1." The BFs for the proposed WQC are based on 3% lipid and were "determined as a best judgment from review of available information in USEPA water quality criteria documents (USEPA, 1979), and other scientific literature" (NYSDEC, 1999a). For WQC cited in TOGS 1.1.1, BFs were derived in accordance with TOGS 1.1.4, which follows guidance from USEPA (1995) Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors (TSD) EPA-820-B-95-005. The two procedures are slightly different, including age of supporting literature and dietary trophic structure considerations.

In addition to the uncertainties associated with the BFs, K_{ow}s, and other input parameters to the EqP model, there are limitations and uncertainties inherent to the EqP methodology and its application in derivation of sediment criteria. The EqP methodology is uncertain and variable depending on factors including the value of the K_{ow} used, the organic content of the sediment sample, the type of organic matter present, and whether the sediment and pore water are at an equilibrium (which may not be the case for sites that are dredged). For compounds with a K_{ow} less than 100 ($\log_{10}K_{ow} \leq 2$), the methodology may underestimate acceptable sediment concentrations (NYSDEC, 1999a).

The model used to derive the BF assumes a steady-state environment where constituent concentrations are in equilibrium between binding to sediment and particles in porewater, and dissolved state in porewater. Many natural and anthropogenic factors may lead to a disruption in the presumed equilibrium. As mentioned above, the maintenance dredging that occurs in the Hudson River is one factor that may disrupt equilibrium. Boat traffic (i.e., prop wash) may also cause constituents to be out of equilibrium between sediment and porewater. Seasonal changes in a temperate system such as the Hudson River may disrupt the steady-state assumed in the EqP model, leading to changes in the equilibrium. Lastly, as described in Section 3.5, the nature of the EqP relationship relative to the type of carbon present is highly variable. For the VOCs of concern at the Site, K_{oc} values have been shown to vary by 2 to 3 orders of magnitude, depending upon the type of carbon available. Use of Site-specific K_{oc}'s (rather than literature-based values) may yield alternative sediment benchmarks.

Measures of fish bioaccumulation of constituents from water or sediment are difficult to predict. BFs or biota-sediment accumulation factors (BSAFs) that are based on K_{ow} values or derived from laboratory studies do not take into consideration food chain effects. Values derived from field studies do not reflect the site-specific complexities in the local food web. And no literature-based BF or BSAF can reflect the natural variation in exposure due to the transient nature of many fish species coupled with the heterogeneity of constituent concentrations in a system as large as the Hudson River.

The uncertainties associated with the parameters and the methods discussed above will be explored further in an evaluation that accounts for site-specific considerations.

5.0 Project Organization and Responsibilities

Key personnel and their specific responsibilities are discussed below. Table 5-1 includes names of individual personnel, telephone numbers, and e-mail addresses.

5.1 BASF Project Manager

The BASF Project Manager, Mr. J. Douglas Reid-Green, is responsible for project direction and decisions concerning technical issues and strategies, including technical, financial, and scheduling matters.

5.2 ENSR Project Manager

The ENSR Project Manager, Mr. John Bleiler, has responsibility for sub-contracted technical, financial, and scheduling matters. Other duties, as necessary, include

- Subcontractor procurement,
- Assignment of duties to project staff and orientation of the staff to the specific needs and requirements of the project,
- Ensuring that data assessment activities are conducted in accordance with the Quality Assurance Project Plan (QAPP),
- Approval of project-specific procedures and internally prepared plans, drawings, and reports,
- Serving as the focus for coordination of all field and laboratory task activities, communications, reports, and technical reviews, and other support functions, and facilitating site activities with the technical requirements of the project, and
- Maintenance of the project files.

5.3 ENSR Technical Leader

ENSR's project manager will be assisted by a Technical Lead, whose duties, as necessary, include:

- Ensuring that data assessment activities are conducted in accordance with the QAPP,
- Approval of project-specific procedures and internally prepared plans, drawings, and reports,
- Serving as the focus for coordination of all field and laboratory task activities, communications, reports, and technical reviews, and other support functions, and facilitating sampling activities with the technical requirements of the project, and
- Maintenance of the project files.

5.4 ENSR Technical Reviewer

ENSR's technical reviewer(s) will provide added technical guidance to ENSR's Project Manager and Technical Lead as needed, and review all reports.

5.5 ENSR Health and Safety Officer

The ENSR Project Health and Safety Officer, Ms. Kathy Harvey will serve as a health and safety advisor to the Project Manager and ENSR staff including:

- Recommending appropriate personal protective equipment (PPE) to protect ENSR personnel from potential hazards,
- Conducting accident investigations.

5.6 ENSR Project QA Officer

The ENSR Project QA Officer, Debra McGrath, has overall responsibility for quality assurance oversight. The ENSR Project QA Officer communicates directly to the ENSR Project Manager. Specific responsibilities include:

- Preparing the QAPP,
- Reviewing and approving QA procedures, including any modifications to existing approved procedures,
- Ensuring that QA audits of the various phases of the project are conducted as required,
- Providing QA technical assistance to project staff,
- Ensuring that data validation/data assessment is conducted in accordance with the QAPP, and
- Reporting on the adequacy, status, and effectiveness of the QA program to the ENSR Project Manager.

5.7 ENSR Analytical Task Manager

The ENSR Project Chemist/Laboratory Coordinator, Lori Herberich, will be responsible for managing the subcontractor laboratories, serving as the liaison between field and laboratory personnel, and assessing the quality of the analytical data.

5.8 ENSR Field Team Leader

The ENSR Field Team Leader will be responsible for implementing the field program, including management of field services subcontractors. The FTL will have overall responsibility and authority for the various field activities. The FTL will be responsible for coordinating and managing the field sampling team and subcontractors. The FTL will report directly to the Project Manager.

A field team consisting of at least two people will be used during the field activities. The team will coordinate directly with the FTL and Project Manager.

The SSO will be responsible for training and monitoring site conditions. The SSO will report directly to the Project Manager and work closely with the FTL.

A Quality Assurance/Quality Control (QA/QC) Officer will be responsible for ensuring that all field work performed by ENSR or their subcontractors is being conducted in accordance with this FSP. The QA/QC Officer will be responsible for conducting on-site and laboratory audit(s) and reporting of deficiencies. The QA/QC Officer will report directly to the Project Manager.

5.9 ENSR Data Manager

The ENSR Data Manager will be responsible for managing the project data.

Table 5-1
Proposed Project Team
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Title	Name	Telephone Number	Email
BASF Project Manager	J. Douglas Reid-Green	908 806-6472	Douglas.Reid-Green@BASF.COM
ENSR Project Manager	John Bleiler	978-589-3000 ext 3056	jbleiler@ensr.aecom.com
ENSR Technical Leader	John Bleiler Mark Gerath	978 589 3000 ext 3056 978 589 3000 ext 3189	Jbleiler@ensr.aecom.com MGerath@ensr.aecom.com
ENSR Technical Reviewer	To be determined	To be determined	To be determined
ENSR Project QA Officer	Debra McGrath	978 589 3000 ext. 3358	dmcgrath@ensr.aecom.com
ENSR Analytical Task Manager	Lori Herberich	978-589-3000 ext 3383	lherberich@ensr.aecom.com
ENSR Health and Safety	Kathy Harvey	978-589-3000 ext 3325	kharvey@ensr.aecom.com
Field Team Leader	To be determined	To be determined	To be determined
Data Manager	To be determined	To be determined	To be determined

6.0 Schedule

Field activities are anticipated to commence in the late summer of 2007, depending on weather conditions and NYSDEC approval of the final Work Plan. The field program is projected to be complete within 30 days of mobilization.

Activity	Duration (days)	Anticipated Start Date*	Anticipated Finish Date
Notify NYSDEC of intent to mobilize	0	October 1, 2007	October 1, 2007
Mobilize (subcontract procurement equipment rental etc.)	15	October 1, 2007	October 15, 2007
Field Effort	30	October 15, 2007	November 15, 2007
Laboratory Analysis	60	November 15, 2007	January 15, 2008
Data Validation	30	January 15, 2008	February 15, 2008
Database Development	15	February 15, 2008	February 29, 2008
Report Preparation	90	February 29, 2008	May 30, 2008
Submission of Draft Characterization Report to NYSDEC	0	May 30, 2008	

* Anticipated start date is dependent upon final Work Plan approval

7.0 List of Commonly Used Acronyms

ANOVA	Analysis of Variance
ASTM	American Society for Testing Materials
AVS	Acid Volatile Sulfide
BERA	Baseline Ecological Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
COPC	Chemicals of Potential Concern
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective
EqP	Equilibrium Partitioning
ESG	Equilibrium Sediment Guidelines
ERA	Ecological Risk Assessment
FTL	Field Team Leader
foc	Fraction Organic Carbon
FSP	Field Sampling Plan
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
IDW	Investigation-Derived Waste
NA	Not Available
NR	Not Recorded
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety and Health Administration
OU-1	Operable Unit 1
OU-2	Operable Unit 2
PAH	Polycyclic Aromatic Hydrocarbons
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PBT	Persistent Bioaccumulative and Toxic
PCB	Polychlorinated Biphenyl
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limits

QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RBP	Rapid Bioassessment Protocols
RI	Remedial Investigation
SEM	Simultaneously Extracted Metals
SOP	Standard Operating Procedure
SSO	Site Safety Officer
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TU	Toxic Units
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Constituents
WDNR	Wisconsin Department of Natural Resources

8.0 References

Accardi-Dey, D., and Gschwend, P.M. 2002. Assessing the combined roles of natural organic matter and black carbon as sorbents in sediments. *Environ Sci Technol* **36**: 21-29.

American Society of Testing and Materials (ASTM). 2006. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. Method E1706-05 in Annual Book of ASTM Standards. Vol. 11.06, August 2006, Biological Effects and Environmental Fate; Biotechnology. West Conshohocken, PA.

Bode, R.W., M.A. Novak, L.A. Abele. 1990. Biological impairment criteria for flowing waters in New York State. New York State Department of Environmental Conservation, Albany, NY.

Bode, R.W., M.A. Novak, L.A. Abele, D.L. Heitzman, A.J. Smith. 2002. Quality assurance work plan for biological stream monitoring in New York State. New York State Deparment of Environmental Conservation, Albany, NY.

Chapman, P., Wang, F., Germano, J, and Batley, G. 2002. Pore Water Testing and Analysis: the Good, the Bad, and the Ugly., Marine Pollution Bulletin. vol. 44, no5, pp. 359-366

Cole, G.A. 1994. Textbook of Limnology, 4th Ed. Illinois: Waveland Press, Inc.

Dashalakis, K.D., and T.P. O'Connor. 1995. Normalization and elemental sediment contamination in the coastal United States. Environmental Science and Technology, Vol, 29, No. 2, pp. 470-477.ENSR. 2001. Draft Environmental Impact Statement. Empire State Newsprint Project. Article X Case No. 00-F-2057. NYSDEC Project No. 4-3814-00052. December 2001.

ENSR. 2005. Work Plan Hudson River Operable Unit 2 Investigation. BASF Rensselaer, Rensselaer, New York, September 2005.

ENSR. 2007. Draft Site Investigation Report Hudson River Operable Unit 2, BASF Rensselaer, Rensselaer, New York, February 2007.

Ghosh, U., Weber, A.S., Jensen, J.N., and Smith, J.R. 2000. Relationship between PCB desorption equilibrium, kinetics, and availability during land biotreatment. *Environ Sci Technol* **34**: 2542-2548.

Graf, W.H. 1971. Hydraulics of Sediment Transport. McGraw-Hill Book Company. New York. 513 pp.

Gustafsson, O., Haghseta, F., Chan, C., Macfarlane, J., and Gschwend, P.M. 1997. Quantification of the dilute sedimentary soot phase: Implications for PAH speciation and bioavailability. *Environ Sci Technol* **31**: 203-209.

Hemond, H. F. and E. J. Fechner. 1994. Chemical Fate and Transport in the Environment. Academic Press, San Diego, CA. 338 pp.

Hynes, H.B.N. 1960. The Biology of Polluted Waters. Liverpool: Liverpool University Press.

Jones, D.S. G.W. Suter, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. Document ES/ER/TM-95/R4.

Jonker, M.T.O. and Smedes, F. 2000. Preferential Sorption of Planar Contaminants in Sediments from Lake Ketelmeer, The Netherlands. Environ. Sci. Technol. 34: 1620-1625.

Klamer, J.C., W.J.M. Hegeman, and F. Smedes. 1990. "Comparison of Grain Size Correction Procedures for Organic Micropollutants and Heavy Metals in Marine Sediments." Hydrobiologia, 208: 213-220.

Kleineidam, S., Schuth, C. and Grathwohl, P. 2002. Solubility-Normalized Combined Adsorption-Partitioning Sorption Isotherms for Organic Pollutants. Environ. Sci. Technol. 36: 4689-4697.

Khalil, M.F.; Ghosh, U.; and Kreitinger , J.P. 2006. Role of weathered coal tar pitch in the partitioning of polycyclic aromatic hydrocarbons in manufactured gas plant site sediments. *Environmental Science and Technology*, 40: 5681-5687.

Kreitinger, J. P.; Neuhauser, E. F.; Doherty, F. G.; Hawthorne, S. B. 2007. Greatly reduced toxicity of PAHs to *Hyalella azteca* in sediments from manufactured gas plant sites. Environmental Toxicology and Chemistry. Volume 26: 1146-1157.

Luthy, R.G., G.R. Aiken, M.L. Brusseau, S.D. Cunningham, P.M. Gschwend, J.J. Pingnatello, M. Reihnard, S.J. Traina, W.J. Weber, Jr., and J.C. Wentall. 1997. Sequestration of Hydrophobic Organic Contaminants by Geosorbents, Envir. Sci. Tech., 31L 3341-3347.

Michelson, T.C. and K. Bragdon-Cook. 1993. Organic Carbon Normalization for Sediment Data. Technical Information Memo, Washington State Department of Ecology.

NRC, (ed.). 2003. Bioavailability of contaminants in soils and sediments: Processes, tools and applications, pp. 1-432. The National Academies Press, Washington, D.C.

NYSDEC. 1998. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Division of Water. Technical and Operational Guidance Series 1.1.1. June 1998.

NYSDEC. 1999a. Technical Guidance for Screening Contaminated Sediments. Division of Fish, Wildlife and Marine Resources.

NYSDEC. 1999b. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Division of Water. Technical and Operational Guidance Series 1.1.1. Errata Sheet. January 1999.

NYSDEC. 2000a. Hudson River Submerged Aquatic Vegetation Factsheet. Prepared by NY Sea Grant and NY State Department of Environmental Conservation.

NYSDEC. 2000b. Hudson River Sediment and Biological Survey. Division of Water, Bureau of Watershed Assessment and Research. November 2000.

NYSDEC. 2000c. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations. Division of Water. Technical and Operational Guidance Series 1.1.1. Addendum. March 2000.

Odum, E. P. 1971. Fundamentals of ecology. Third Edition. W. B. Saunders Company, Philadelphia, London, Toronto. 574 pages.

Power, E., and P. Chapman. 1992. "Assessing Sediment Quality." In: G.A. Burton (ed.), Sediment Toxicity Assessment. Lewis Publishers, Chelsea, MI. pp. 1-18.

Roux Associates, Inc. (Roux). 2000. Remedial Investigation (RI) and Supplemental Remedial Investigation (SRI) Report, BASF Rensselaer, Rensselaer, New York, November 2000.

Roux. 2001. Additional Remedial Investigation Activities, BASF Rensselaer, Rensselaer, New York, August 3.

Roux. 2004a. Offsite Investigation Report for Hudson River Sediments, BASF Rensselaer, Rensselaer, New York," August.

Roux. 2004b. Offsite Investigation for Soil Gas and Groundwater, Operable Unit 2. BASF Rensselaer, Rensselaer, New York.

Stout, S.A., A.D. Uhler, and S.D. Emsbo-Mattingly. 2004. Comparative evaluation of background anthropogenic hydrocarbons in surficial sediments from nine urban waterways. *Environ. Sci. Technol.* 38:2987-2994. Section 2.1.3

Stroo, H.F., Jensen, R., Loehr, R.C., Nakles, D.V., Fairbrother, A., Liban, C.B., 2000. Environmentally Acceptable Endpoints for PAHs at a Manufactured Gas Plant Site. Environ. Sci. Technol. 34, pp. 3831-3836.

Suter, G.W. and C.L. Tsao, 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-96/R2.

USEPA. 1994. Briefing Report to the Science Advisory Board on the Equilibrium Partitioning Approach for Predicting Metal Bioavailability in Sediments and the Derivation of Sediment Quality Criteria for Metals. December 1994. USEPA. Office of Water and Office of Research and Development, EPA-822-D-94-002.

USEPA. 1999. Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish Second Edition. Office of Water. EPA 841-B-99-002.

USEPA. 2000a. Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance. Office of Water. EPA-822-B-00-024.

USEPA. 2000b. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates: Second Edition. EPA-600/R-99/064.

USEPA. 2001. Method for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis: Technical Manual. EPA-823-B-01-002. October 2001.

USEPA. 2003a. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. EPA/600/R-02/013. USEPA Office of Science and Technology. Washington, DC.

USEPA. 2003b. USEPA Region 5 Ecological Screening Levels. Revision August 2003. Available at: http://www.epa.gov/reg5rcra/ca/edql.htm

USEPA. 2005a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver and Zinc). January 2005. EPA-600-R-02-011. Office of Research and Development.

USEPA. 2005b. Contaminated Sediment Remediation Guidance. EPA-540-R-05-012, OSWER 9355.0-85, December 2005.

van den Berg, G.A., J.P.G. Loch, L.M. van der Heijdt, and J.J.G. Zwolsman. 1998. Vertical distribution of acid-volatile sulfide and simultaneously extracted metals in a recent sedimentation area of the River Meuse in the Netherlands. Environmental Toxicology and Chemistry 17:758-763.

Wall, G.R., K. Riva-Murry, and P.J. Phillips. 1988. Water Quality in the Hudson River Basin. New York and Adjacent States, 1992-95. U.S. Department of the Interior. US Geological Society Circular 1165.

WDNR. 2003. Consensus-based Sediment Quality Guidelines. Recommendations for Use & Application. Interim Guidance. Contaminated Sediment Standing Team, Wisconsin Department of Natural Resources, Madison, WI. Available at (http://dnr.wi.gov/org/aw/rr/technical/cbsqg_interim_final.pdf).

APPENDIX

Appendix A

Ecological Risk Assessment Scope of Work

Contents

List of Tables

List of Figures

1.0 Introduction

An ecological risk assessment (ERA) is being conducted as part of the investigation of the Hudson River Operable Unit 2 (OU-2) investigation of the BASF Corporation (BASF) facility in Rensselaer, New York (Figure 1-1). The ERA provides an evaluation of the potential risks to ecological receptors posed by chemicals of potential concern (COPCs) surficial sediment at the Site.

This document presents the scope of work (i.e., the Work Plan) for the Baseline ERA (BERA) at the Site, which will be conducted in accordance with relevant NYSDEC guidance and regulations. The recent Site Investigation Report (ENSR, 2007) summarized the results of sediment investigation efforts conducted between November 2005 and May 2006 and contained a screening level ecological risk assessment (SLERA) based on readily available site information and sampling data. In the screening level assessment, a preliminary conceptual site model (CSM) was developed for the Site, preliminary data quality objectives (DQOs) were established, available data were screened against ecotoxicological benchmarks and standards, and data gaps were identified. Since the results of the SLERA indicated that a conclusion of "no significant risk" could not be reached for benthic ecological receptors potentially exposed to sediment, the accompanying Work Plan has been developed to outline sampling and analysis data needs.

In accordance with current USEPA and NYSDEC guidance, the BERA will be used to refine the SLERA. The proposed BERA assessment and measurement endpoints are more complex than those that were used in the screening-level assessment and require site-specific data collection, rather than relying primarily on literature values. The BERA will be used to help support risk management decision-making. The BERA will be conducted in accordance with relevant state and federal guidance, including the following:

- NYSDEC Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (NYSDEC, 1994);
- Framework for Ecological Risk Assessment (USEPA, 1992);
- Intermittent "ECO Update" Bulletins of USEPA;
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final) (USEPA, 1997); and
- Guidelines for Ecological Risk Assessment (USEPA, 1998).

In accordance with the EPA guidance and process documents, the principal components of the planned BERA will include:

- Problem Formulation: In this phase, the objectives of the ERA are defined, and a plan for characterizing and analyzing risks is determined. Available information regarding stressors and specific sites is integrated. Products generated through problem formulation include assessment endpoints and CSMs.
- Risk Analysis: During the risk analysis phase of work, data are evaluated to characterize potential ecological exposures and effects.
- Risk Characterization: During risk characterization, exposure and stressor response profiles are integrated through risk estimation. Risk characterization also includes a summary of uncertainties, strengths, and weaknesses associated with the risk assessment.

These three components are conceptually sequential. However, the risk assessment process is frequently iterative, and new information brought forth during the risk characterization phase, for instance, may lead to a review of the problem formulation phase, or additional data collection and analysis. USEPA's Ecological Risk

Assessment Guidance for Superfund (USEPA, 1997) expands the primary components listed above and presents an eight-step process for assessments specific to Superfund sites (Figure 1-2). The basic elements of the eight-step Superfund process, as well as the accompanying scientific/management decision points (SMDPs) are consistent with the three-step framework. SMDPs require meetings between the risk assessors and risk managers at several points during the process to evaluate, re-direct, and ultimately approve the risk assessment at a Superfund site. It is envisioned that SMDP meetings will be scheduled throughout the BERA process at the Site.

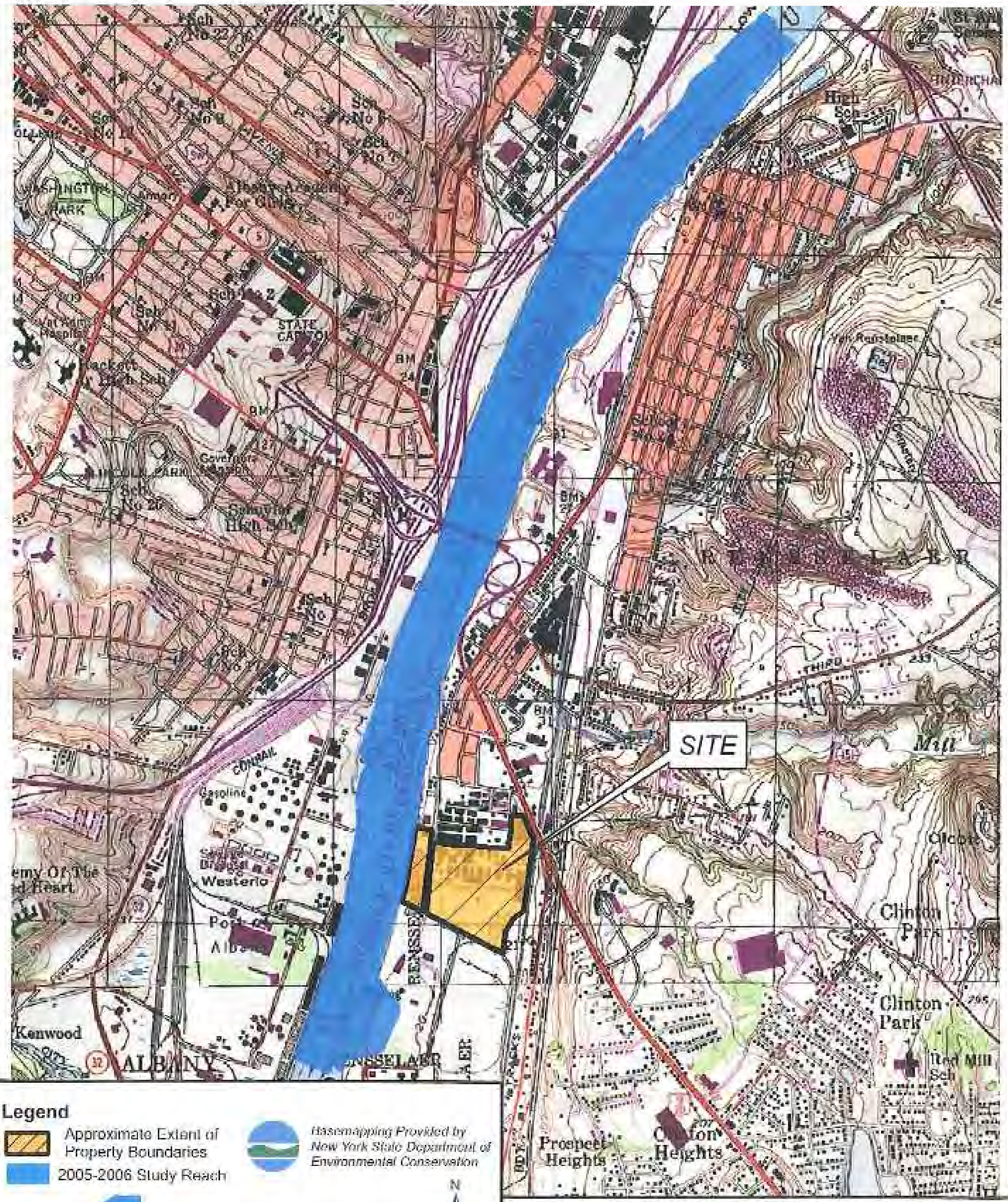
1.1 Site Description

Additional detail regarding the site description, history, and past operations can be found in the Site Investigation Report (ENSR, 2007), as well as in Sections 1 and 2 of the accompanying work plan.

1.2 Document Organization

The remainder of this document is organized in the following manner:

- Section 2 presents additional detail regarding BERA problem formulation;
- Section 3 presents additional detail regarding BERA risk analysis;
- Section 4 presents additional detail regarding BERA risk characterization; and
- Section 5 presents the references cited.



Legend

- Approximate Extent of Property Boundaries
- 2005-2006 Study Reach

Basemapping Provided by New York State Department of Environmental Conservation

NEW YORK — *USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES ALBANY, EAST GREENBUSH, TROY SOUTH AND DELMAR*

N / W / E / S

0 1,500 3,000 6,000 Feet

Site Location

BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

SCALE	DATE	PROJECT NO.
1:24000	02/07	00760-171

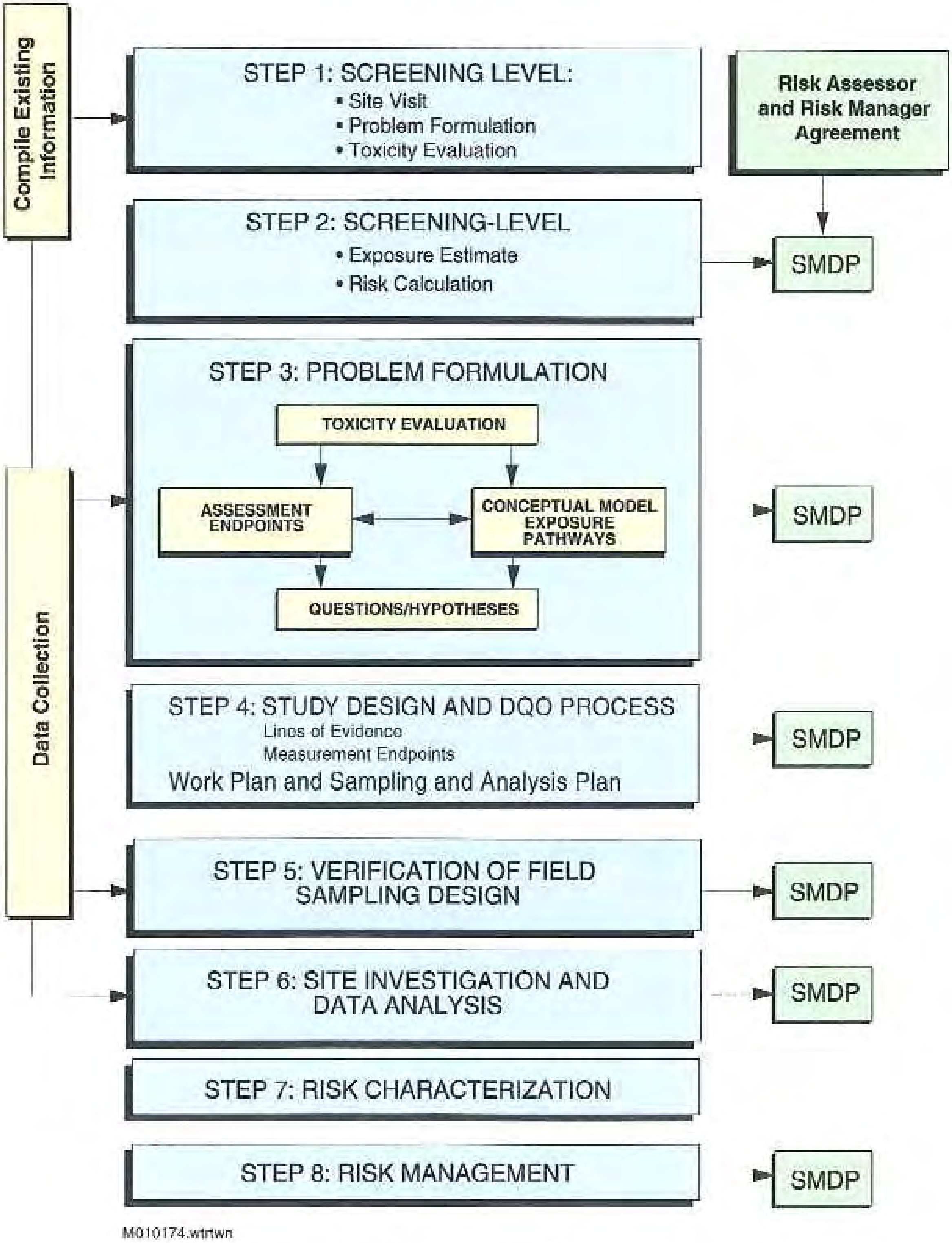
ENSR | AECOM

Figure Number

1-1

J:\Indl_Service\Project Files\BASF-0760\Rensalaer NY\GIS\Projects\MXD_072806\SIR3\Fig1 1 SiteLocus_SIR3.mxd

Figure 1-2 USEPA Eight-Step Ecological Risk Assessment Process



Note: SMDP=Scientific Management Decision Point

2.0 Problem Formulation

In the Site Investigation Report (ENSR, 2007), preliminary COPCs were identified. Table 2-1 presents a summary of the ecological COPCs for the RI/FS at the Site, as determined in the Site Investigation Report. These compounds, and others under consideration in the Human Health Risk Assessment, will be the focus of the sediment media sampling to be conducted in 2007.

Figure 2-1 presents the sampling locations evaluated in the Site Investigation Report (ENSR, 2007). NYSDEC sediment screening criteria were exceeded in surficial sediments through the entire Study Area Concentrations of inorganic compounds and volatile organic compounds (VOCs) in surficial sediment were highest in the muddy sand adjacent to the Site (i.e., the Adjacent Nearshore reach), and metals from at least some sampling locations may be bioavailable to benthic receptors (based on the simultaneously extractable metals (SEM) and acid volatile sulfide (AVS) analyses included in the Site Investigation). Metals concentrations were also elevated above screening criteria in surficial sediments within the muddy sand of the Upper Navigational Channel, immediately downriver of the Site. Screening criteria for some compounds were also exceeded in the Upstream and Adjacent Far Field reaches. The highest observed concentrations of inorganic constituents and VOCs were in the Adjacent Nearshore reach in the deeper sediments, two ft or more below the sediment surface. However, exposure to these sub-surficial sediments is not a complete ecological exposure pathway for ecological receptors as the sediments are situated well below the bioactive zone. Although concentrations of compounds in sediments exceed benchmark screening values, there is currently no indication of any potential risk to the environment. Many of the highest concentrations of compounds are located in sub-surficial sediment, well below the presumed bioactive zone.

In addition, the preliminary macroinvertebrate survey presented in the Site Investigation Report (ENSR, 2007) indicates that there is a similar benthic macroinvertebrate community throughout the entire Study Area (including the Upstream reach, outside any Site-related influence). Although several macroinvertebrate sampling stations were located within the Adjacent Nearshore reach, immediately adjacent to the Site bulkhead, no relationship between proximity to the Site and a decrease in macroinvertebrate community fitness was observed. Likewise, no relationship between increased VOC and/or inorganic compound concentrations and a decrease in macroinvertebrate community fitness was observed. Despite the presence of inorganic and VOC concentrations in excess of screening criteria in surficial sediments, evaluation of the macroinvertebrate data indicates that there is currently no indication of any actual or imminent ecological risk to the environment adjacent to the Site.

The data evaluation indicates that ecological COPCs in the surficial sediments in the Hudson River, particularly in areas of the river immediately adjacent to and downstream of the Site, warrant additional consideration in future sampling efforts. The focus of the recommended sampling is on biological data collection (i.e., toxicity testing, biota sampling, macroinvertebrate surveys) co-located with bulk sediment analytical data and porewater sampling. These data will be used in the BERA to further evaluate the potential for risk of harm to ecological receptors due to exposure to ecological COPCs.

2.1 Definition of the Geographic Area to be Considered

As described in Section 1 of the Work Plan, for the purposes of this BERA Work Plan (and consistent with the previously issued Hudson River OU-2 Site Investigation Report (ENSR, 2007)), the data gathered from the various historic sampling and analysis activities have been segregated into discrete groupings based on proximity to the Site (Figure 2-1). Much of the remainder of this Work Plan discusses the historic data and the data needs within the context of the following reaches of the river:

Based on the results of the evaluation of ecological COPCs presented in the Site Investigation Report (ENSR, 2007), additional sampling is recommended to further evaluate the measurement endpoints. It is recommended that this sampling include toxicity testing, biota community sampling, and porewater sampling. These additional sampling and evaluation activities are described in the accompanying Work Plan.

2.4 Conceptual Site Model

The end product of the problem formulation step is the development of an ecological CSM. The CSM helps to describe the COPCs origin, fate, transport, exposure pathways, and receptors of concern. A detailed description of the current Site CSM from the recently completed Site Investigation Report (ENSR, 2007) is found in Section 2 of the accompanying Work Plan.

Table 2-2
Receptors and Exposure Pathways
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Exposure Medium	Potential Receptors	Exposure Route	Pathway Evaluation
Sediments	Benthic Macroinvertebrates	Direct Contact	Exposure of benthic macroinvertebrates to COPCs evaluated by comparisons to benchmarks, macroinvertebrate community surveys, evaluation of metals bioavailability, and laboratory toxicity testing.

3.0 Risk Analysis

The risk analysis phase of the BERA will be based on the CSM developed in problem formulation. Risk analysis includes the characterization of potential ecological exposure and effects. The ecological exposure assessment involves the identification of potential exposure pathways and an evaluation of the magnitude of exposure of identified ecological receptors. The ecological effects assessment describes the potential adverse effects associated with the identified COPCs to ecological receptors and reflects the type of assessment endpoints selected (presented in Table 2-3). The methods that will be used to identify and characterize ecological exposure and effects for aquatic and benthic life are described in the following subsections.

An integral part of the BERA is to reduce the uncertainties identified in the SLERA presented in the Site Investigation Report. The uncertainties/data gaps identified in the SLERA will be evaluated for each exposure area individually, as well as for the Site in general. The field activities outlined in the body of this Work Plan are designed to allow the BERA to include:

- Estimates of potential risks from the exposure to site-related ecological COPCs;
- An evaluation of the potential bioavailability of divalent cationic metals and VOCs;
- An evaluation of the site-specific toxicity of sediment to laboratory test organisms; and
- An evaluation of the health of the macroinvertebrate community relative to the Upstream and Western Shoreline reaches of the Hudson River Study Area.

3.1 Selection of COPCs

COPCs for evaluation in the BERA were selected on a site-specific basis, as outlined above. Selection of these constituents included a variety of tools, including:

- Comparison of Site data to NYSDEC screening values; and
- Background evaluation.

In general, compounds with concentrations in excess of background values and with a maximum concentration in excess of an ecotoxicological screening value were retained as COPCs. Table 2-1 presents a summary of the ecological COPCs.

3.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) will be estimated within each site medium for each COPC in order to evaluate the selected ecological exposure pathways and receptors. These EPCs represent the range of media concentrations that ecological receptors may encounter. When evaluating the results of the various biological and toxicological endpoints (e.g., the site-specific macroinvertebrate community surveys and laboratory toxicity testing data), the EPCs will be the actual concentrations of COPCs detected in the environmental medium evaluated.

All analytical data collected in the 2005 to 2006 field effort and the proposed 2007 field effort will be compiled and tabulated in a database for statistical analysis. The data for each area and medium will be summarized for use in the BERA screening and generation of summary statistics. The following guidance document will be used to develop the summary statistics:

A variety of empirical and theoretical approaches have been adopted to address this concern, including the equilibrium partitioning (EqP) approach used by USEPA in their Equilibrium Sediment Guidelines (ESGs) (USEPA, 2003) and by NYSDEC (1999) when establishing some of their sediment quality criteria. The EqP approach, in essence, provides an estimate of pore water concentrations through relatively simplistic estimates of bulk sediment/pore water portioning dynamics.

Recent literature has also suggested that, while the EqP approach is clearly valid, it can be refined through direct measurement of pore water and/or developing a better understanding of the types of organic carbon and their relative partitioning characteristics; much of this literature has focused on lampblack, an amorphous sooty material commonly found in urban river sediments that has the potential to tightly bind a variety of aromatic hydrocarbons (e.g., see Stroo et al., 2000). This literature has suggested that evaluation of pore water as a primary measure of sediment quality can provide valuable insight into sediment quality, fate and transport, and risk evaluations. Although there are clearly some uncertainties associated with sampling, analysis, and evaluation of pore water data, it is generally recognized that, for at least some organisms associated with sediment, pore water is a primary exposure medium and that evaluation of pore water data can provide useful information regarding ecological exposure and risk. Uncertainties associated with evaluation of pore water include the following, as summarized by Chapman et al., 2002: " . . .pore water is not the only exposure route; pore water tests lack chemical or biological realism; their sensitivity relative to other tests may be meaningless due to manipulation and laboratory artifacts; many sediment and surface dwelling organisms are not directly influenced by pore water." None-the-less, reviewers such as Chapman et al., (2002) and USEPA (2003) conclude that sampling and analysis of sediment pore water can be an effective means to evaluate sediment quality as long as these uncertainties are understood by risk managers.

In order to better understand the potential bioavailability of organic compounds in sediment, pore water samples will be collected from a sub-set of the surficial and sub-surficial sediment samples. (As in the Site Investigation (ENSR, 2007), concentrations of inorganic constituents in pore water will be estimated using EqP theory, including SEM, AVS, and TOC data.). The pore water sampling stations for the investigation are co-located with surficial samples obtained for toxicological and biological investigations, thereby providing additional insight into responses by benthic organisms exposed to COPCs. Pore water samples will be evaluated for the organic constituents, as well as for factors which may influence the concentration of these constituents in pore water (i.e., DOC and TOC).

3.3.2 Toxicity Testing

Laboratory toxicity tests with macroinvertebrates will be conducted at sampling locations co-located with bulk sediment analytical sampling locations. At a minimum, VOCs, inorganic constituents, TOC, and grain size will be analyzed in each sample selected for toxicity testing. In addition to the above-described theoretical measurements (i.e., the equilibrium partitioning methods), these tests will also be used to evaluate site-specific bioavailability of chemical stressors at the Site.

The benchmark screening results of the SLERA indicated potential risks to ecological receptors through direct exposure to sediment, primarily associated with exposure to metals and VOCs. To evaluate whether or not direct exposures to sediments have the potential to cause toxicity to ecological receptors, chronic duration laboratory toxicity tests are planned. All toxicity tests will be conducted under specified laboratory conditions using whole environmental media only (e.g., no dilution series toxicity testing is planned).

The bioavailability of chemicals is dependent on a number of factors, which are both site-specific and medium-specific. Although many of these factors can be estimated using equilibrium partitioning techniques, it is difficult to account for all the physical and chemical properties which could potentially affect bioavailability. Laboratory toxicity tests can be used to help estimate the potential adverse effects of target chemicals on ecological receptors. These tests can be used to demonstrate the reaction of selected organisms to the combination of physical and chemical characteristics in an environmental medium.

2.0 Problem Formulation

In the Site Investigation Report (ENSR, 2007), preliminary COPCs were identified. Table 2-1 presents a summary of the ecological COPCs for the RI/FS at the Site, as determined in the Site Investigation Report. These compounds, and others under consideration in the Human Health Risk Assessment, will be the focus of the sediment media sampling to be conducted in 2007.

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- The **Upstream** data set includes samples collected upstream of the influence of the Site (i.e., this data set serves as the Reference Conditions data set). It is assumed that the data from this reach of the river are uninfluenced by Site conditions.
- The **Adjacent Nearshore** data set includes samples located within a band of muddy sand immediately adjacent to and west of the Site. This band of muddy sand extends from approximately 90 to 185 ft west of the Site bulkhead before transitioning to coarser-grained material (i.e., the Adjacent Far Field).
- The **Adjacent Far Field** data set includes samples collected in the more coarse-grained sediment located to the west of the muddy sand samples in the Adjacent Nearshore sampling reach. The Adjacent Far Field data set is within the same river reach as the Site, but may not be influenced by the Site.
- The **Upper Navigational Channel** data set includes samples collected immediately downstream of the Site, in a depositional environment that is co-located with what is understood to be the northernmost extent of an area where New York State has reportedly conducted periodic navigational dredging to maintain depth for shipping purposes. It is recognized that the deepwater navigational channel of the river continues north of the Site; however, navigational dredging is not known to occur beyond this point.
- The **Downstream** data set includes samples collected downstream of the Adjacent Nearshore reach of the river, approximately 1,800 feet downstream from the southerly Site outfall owned by the City of Rensselaer. These samples are also located within the dredged navigational channel.

An additional river reach, identified as the **Western Shoreline**, has been included in the proposed field sampling and data gathering activities. This data set includes samples collected within the gravelly sand and muddy sand along the western shoreline of the Hudson River across from the Site. It is assumed that the data from this reach of the river represent anthropogenic urban background conditions.

2.2 Selection of Specific Receptors and Exposure Pathways

In accordance with NYSDEC guidance, potential ecological receptors occurring at the Site and potentially complete ecological exposure pathways will be evaluated. Each exposure pathway includes a potential source of COPC, an environmental medium, and a potential exposure route. In accordance with agency guidance, incomplete routes of exposure will not be evaluated in the BERA. This approach is used to focus the risk evaluation on exposure pathways that are considered to be potentially complete and for which there are adequate data pertaining to the receptors, exposure, and toxicity for completion of the risk analysis. Table 2-2 presents a summary of the receptors and exposure pathways to be evaluated in the BERA.

2.3 Selection of Biological Endpoints to be Assessed

Risk assessment endpoints to be assessed at the Site include measurement and assessment endpoints. According to USEPA (USEPA, 1998), assessment endpoints are formal expressions of the actual environmental value to be protected. They usually describe potential adverse effects to long-term persistence, abundance, or production of populations of key species or key habitats. Measurement endpoints are the physical, chemical, or biological aspects of the ecological system that are measured to approximate or represent assessment endpoints. Measurement endpoints are often stressor-specific and are used to evaluate the assessment endpoint with respect to potential ecological risks. Since each measurement endpoint has intrinsic and extrinsic strengths and limitations, several measurement endpoints will be used to evaluate each assessment endpoint. The measurement and assessment endpoints to be evaluated in the BERA are presented in Table 2-3.

Based on the results of the evaluation of ecological COPCs presented in the Site Investigation Report (ENSR, 2007), additional sampling is recommended to further evaluate the measurement endpoints. It is recommended that this sampling include toxicity testing, biota community sampling, and porewater sampling. These additional sampling and evaluation activities are described in the accompanying Work Plan.

2.4 Conceptual Site Model

The end product of the problem formulation step is the development of an ecological CSM. The CSM helps to describe the COPCs origin, fate, transport, exposure pathways, and receptors of concern. A detailed description of the current Site CSM from the recently completed Site Investigation Report (ENSR, 2007) is found in Section 2 of the accompanying Work Plan.

Table 2-1
Ecological COPCs - Sediment
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Inorganics	
ALUMINUM	[1]
ANTIMONY	[2]
ARSENIC	[2]
BARIUM	[1]
BERYLLIUM	[1]
CADMIUM	[2]
CHROMIUM, TOTAL	[2]
COBALT	[1]
COPPER	[2]
IRON, TOTAL	[2]
LEAD	[2]
MANGANESE	[2]
MERCURY	[2]
NICKEL	[2]
SELENIUM	[1]
SILVER	[2]
THALLIUM	[1]
VANADIUM	[1]
ZINC	[2]
VOCs	
1,1,1-TRICHLOROETHANE (TCA)	[1]
1,2,4-TRICHLOROBENZENE	[2]
1,2-DICHLOROBENZENE	[2]
1,2-DICHLOROETHANE	[1]
1,2-DICHLOROPROPANE	[1]
1,3-DICHLOROBENZENE	[2]
1,4-DICHLOROBENZENE	[2]
2-BUTANONE (MEK)	[1]
4-METHYL-2-PENTANONE (MIBK)	[1]
ACETONE	[1]
BENZENE	[2]
CARBON DISULFIDE	[1]
CHLOROBENZENE	[2]
CHLOROMETHANE	[1]
CYCLOHEXANE	[1]
ETHYLBENZENE	[2]
ISOPROPYLBENZENE	[2]
M,P-XYLENES	[1]
METHYL ACETATE	[1]
METHYL TERT-BUTYL ETHER	[1]
METHYLCYLOHEXANE	[1]
METHYLENE CHLORIDE	[1]
O-XYLENE	[1]
STYRENE	[1]
TETRACHLOROETHENE (PCE)	[1]
TOLUENE	[2]
TOTAL XYLENES	[2]
TRICHLOROETHYLENE	[1]
TRICHLOROFLUOROMETHANE	[1]

Retained as COPC due to:
[1] Lack of NYSDEC screening value
[2] Exceedance of NYSDEC low effect screening level
Calcium, magnesium, potassium, and sodium were considered essential nutrients and were not retained as COPCs.

Table 2–2
Receptors and Exposure Pathways
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Exposure Medium	Potential Receptors	Exposure Route	Pathway Evaluation
Sediments	Benthic Macroinvertebrates	Direct Contact	Exposure of benthic macroinvertebrates to COPCs evaluated by comparisons to benchmarks, macroinvertebrate community surveys, evaluation of metals bioavailability, and laboratory toxicity testing.

Table 2–3
Measurement and Assessment Endpoints
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Assessment Endpoint *Measurement Endpoint*
Sustainability of a healthy and well-balanced benthic invertebrate community in the Hudson River in the vicinity of the Site which is typical of comparable upstream Hudson River habitats with similar structure, morphology, and hydrology.
a) Characterization of sediment metals bioavailability based on simultaneously extracted metals (SEM)/acid volatile sulfides (AVS) relationships. SEM/AVS ratios greater than 1 in a sediment sample will be considered an indicator of potential bioavailability for divalent cationic metals. The influence of total organic carbon (TOC) will also be considered.
b) Evaluation of pore water VOC data relative to water quality benchmarks. Evaluation of the partitioning of VOCs into pore water, and the presence of VOCs in pore water in excess of water quality benchmarks will be considered indicative of a potential for ecological risk.
c) Comparison of bulk sediment analytical chemistry results to sediment quality benchmarks. Site data in excess of sediment quality benchmarks will be considered indicative of a potential for ecological risks.
d) Bulk sediment invertebrate toxicity tests with insect species will be used to evaluate potential lethal and sub-lethal effects associated with exposure to Site sediment.
e) Field assessment of the benthic macroinvertebrate community present in the Hudson River Study area. Various community composition, abundance, and diversity metrics will be used to evaluate the potential risks associated with exposure to sediment in situ.

3.0 Risk Analysis

The risk analysis phase of the BERA will be based on the CSM developed in problem formulation. Risk analysis includes the characterization of potential ecological exposure and effects. The ecological exposure assessment involves the identification of potential exposure pathways and an evaluation of the magnitude of exposure of identified ecological receptors. The ecological effects assessment describes the potential adverse effects associated with the identified COPCs to ecological receptors and reflects the type of assessment endpoints selected (presented in Table 2-3). The methods that will be used to identify and characterize ecological exposure and effects for aquatic and benthic life are described in the following subsections.

An integral part of the BERA is to reduce the uncertainties identified in the SLERA presented in the Site Investigation Report. The uncertainties/data gaps identified in the SLERA will be evaluated for each exposure area individually, as well as for the Site in general. The field activities outlined in the body of this Work Plan are designed to allow the BERA to include:

- Estimates of potential risks from the exposure to site-related ecological COPCs;
- An evaluation of the potential bioavailability of divalent cationic metals and VOCs;
- An evaluation of the site-specific toxicity of sediment to laboratory test organisms; and
- An evaluation of the health of the macroinvertebrate community relative to the Upstream and Western Shoreline reaches of the Hudson River Study Area.

3.1 Selection of COPCs

COPCs for evaluation in the BERA were selected on a site-specific basis, as outlined above. Selection of these constituents included a variety of tools, including:

- Comparison of Site data to NYSDEC screening values; and
- Background evaluation.

In general, compounds with concentrations in excess of background values and with a maximum concentration in excess of an ecotoxicological screening value were retained as COPCs. Table 2-1 presents a summary of the ecological COPCs.

3.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) will be estimated within each site medium for each COPC in order to evaluate the selected ecological exposure pathways and receptors. These EPCs represent the range of media concentrations that ecological receptors may encounter. When evaluating the results of the various biological and toxicological endpoints (e.g., the site-specific macroinvertebrate community surveys and laboratory toxicity testing data), the EPCs will be the actual concentrations of COPCs detected in the environmental medium evaluated.

All analytical data collected in the 2005 to 2006 field effort and the proposed 2007 field effort will be compiled and tabulated in a database for statistical analysis. The data for each area and medium will be summarized for use in the BERA screening and generation of summary statistics. The following guidance document will be used to develop the summary statistics:

- Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Part A (USEPA, 1989).

The steps used to summarize the data by medium are as follows:

Treatment of Duplicates: Data for samples and their duplicates will be averaged before summary statistics were calculated, such that a sample and its duplicate were treated as one sample for calculation of summary statistics (including maximum detection and frequency of detection).

Treatment of Non-Detects:

- Summary statistics will not be calculated for constituents that were not detected in a particular area/medium.
- Where constituents were detected in some samples and not in others in a particular area/medium, ½ the reported sample quantitation limit (SQL) will be used as a proxy concentration for the samples reported as nondetect (USEPA, 1989).
- For all non-detects for which ½ the SQL is calculated, ½ the SQL will be compared to the maximum detected concentration for that area and medium. Where ½ the SQL is greater than the maximum detected concentration in a particular area/medium, the SQL value will not be used in the calculation of summary statistics for that constituent in that area and medium (USEPA, 1989).

Frequency of Detection: The frequency of detection will be reported as a ratio and a percentage based on the total number of samples analyzed and the number of samples reported as detected for a specific constituent. The number of samples used to calculate statistics reflects the treatment of non-detects described above.

Maximum Detected Concentration: This is the maximum detected concentration for each constituent/area/medium combination, after duplicates have been averaged.

Average Concentration: This is the arithmetic mean concentration for each constituent/area/medium combination, after duplicates have been averaged and non-detects have been evaluated.

Figure 3-1 depicts the proposed sampling locations for the BERA program. These sampling locations were selected to represent the spatial and chemical concentration variability present at the site.

3.3 Bioavailability of COPCs

The presence of COPCs in environmental matrices (e.g., sediment or surface water) at concentrations which exceed benchmark screening values does not necessarily constitute ecological risk. For instance, certain COPCs may not be absorbed into an organism's system following ingestion, or may not be absorbed through direct contact due to the chemical form of the COPCs. The bioavailability of certain inorganic and organic COPCs based on the chemical makeup of the media and the particular COPCs will be evaluated. Several specific techniques, described below, will be used to evaluate the potential site-specific bioavailability of COPCs in the sediments.

3.3.1 Interstitial Pore Water Analysis and Equilibrium Partitioning

USEPA (2001; 2003) and others have long recognized that the concentration of a number of organic and inorganic constituents in sediment interstitial water (i.e., pore water) is a better estimate of the potential for ecological risk than bulk sediment concentrations. Pore water (or interstitial water) can be defined as the water occupying the spaces between sediment particles (USEPA, 2001).

A variety of empirical and theoretical approaches have been adopted to address this concern, including the equilibrium partitioning (EqP) approach used by USEPA in their Equilibrium Sediment Guidelines (ESGs) (USEPA, 2003) and by NYSDEC (1999) when establishing some of their sediment quality criteria. The EqP approach, in essence, provides an estimate of pore water concentrations through relatively simplistic estimates of bulk sediment/pore water portioning dynamics.

Recent literature has also suggested that, while the EqP approach is clearly valid, it can be refined through direct measurement of pore water and/or developing a better understanding of the types of organic carbon and their relative partitioning characteristics; much of this literature has focused on lampblack, an amorphous sooty material commonly found in urban river sediments that has the potential to tightly bind a variety of aromatic hydrocarbons (e.g., see Stroo et al., 2000). This literature has suggested that evaluation of pore water as a primary measure of sediment quality can provide valuable insight into sediment quality, fate and transport, and risk evaluations. Although there are clearly some uncertainties associated with sampling, analysis, and evaluation of pore water data, it is generally recognized that, for at least some organisms associated with sediment, pore water is a primary exposure medium and that evaluation of pore water data can provide useful information regarding ecological exposure and risk. Uncertainties associated with evaluation of pore water include the following, as summarized by Chapman et al., 2002: "...pore water is not the only exposure route; pore water tests lack chemical or biological realism; their sensitivity relative to other tests may be meaningless due to manipulation and laboratory artifacts; many sediment and surface dwelling organisms are not directly influenced by pore water." None-the-less, reviewers such as Chapman et al., (2002) and USEPA (2003) conclude that sampling and analysis of sediment pore water can be an effective means to evaluate sediment quality as long as these uncertainties are understood by risk managers.

In order to better understand the potential bioavailability of organic compounds in sediment, pore water samples will be collected from a sub-set of the surficial and sub-surficial sediment samples. (As in the Site Investigation (ENSR, 2007), concentrations of inorganic constituents in pore water will be estimated using EqP theory, including SEM, AVS, and TOC data.). The pore water sampling stations for the investigation are co-located with surficial samples obtained for toxicological and biological investigations, thereby providing additional insight into responses by benthic organisms exposed to COPCs. Pore water samples will be evaluated for the organic constituents, as well as for factors which may influence the concentration of these constituents in pore water (i.e., DOC and TOC).

3.3.2 Toxicity Testing

Laboratory toxicity tests with macroinvertebrates will be conducted at sampling locations co-located with bulk sediment analytical sampling locations. At a minimum, VOCs, inorganic constituents, TOC, and grain size will be analyzed in each sample selected for toxicity testing. In addition to the above-described theoretical measurements (i.e., the equilibrium partitioning methods), these tests will also be used to evaluate site-specific bioavailability of chemical stressors at the Site.

The benchmark screening results of the SLERA indicated potential risks to ecological receptors through direct exposure to sediment, primarily associated with exposure to metals and VOCs. To evaluate whether or not direct exposures to sediments have the potential to cause toxicity to ecological receptors, chronic duration laboratory toxicity tests are planned. All toxicity tests will be conducted under specified laboratory conditions using whole environmental media only (e.g., no dilution series toxicity testing is planned).

The bioavailability of chemicals is dependent on a number of factors, which are both site-specific and medium-specific. Although many of these factors can be estimated using equilibrium partitioning techniques, it is difficult to account for all the physical and chemical properties which could potentially affect bioavailability. Laboratory toxicity tests can be used to help estimate the potential adverse effects of target chemicals on ecological receptors. These tests can be used to demonstrate the reaction of selected organisms to the combination of physical and chemical characteristics in an environmental medium.

Although the results of toxicity tests can be used to evaluate potential effects that might occur to aquatic receptors in situ, it is important to recognize that:

- Mobile organisms may be able to avoid prolonged exposure to contaminated media.
- Although the tests are designed to predict adverse effects on biological communities based on chronic exposures, they are not multi-generation chronic tests, in that they do not consider population effects by assessing potential effects over several generations during the test period.
- Toxicity to organisms in situ may be dependent upon physical characteristics and equilibrium partitioning that are not replicated under laboratory conditions (USEPA, 1993).
- The species used in toxicity testing programs are typically chosen to be representative and protective of the organisms, which may be found on site, but the use of surrogate species cannot precisely predict the health of ecological communities on site.

Chronic laboratory toxicity test sampling stations will be co-located with the sediment analytical chemistry stations, allowing for a detailed evaluation of the co-occurring data in the ecological risk assessment.

The results of the laboratory toxicity tests will be compared to the results of both laboratory control tests and tests conducted with samples collected from the background stations. Standardized statistical tests, such as analysis of variance (ANOVA) will be conducted to determine if significant differences in survival, growth, or other measured response are observed. Samples of environmental media for toxicity testing will be collected concurrently with samples for analytical chemistry, thereby allowing for co-evaluation of chemical, physical, and toxicological stressors. Attempts will be made to relate the results of the toxicity-testing program with measured concentrations of target chemicals to develop potential associations between observed toxicity and chemical concentrations.

Short term chronic sediment toxicity tests will be conducted to assess the toxicity of sediments to invertebrate organisms at the Site. The objective of the sediment toxicity tests will be to obtain laboratory data to evaluate potential ecological risks to invertebrate receptors. Based on the results of the macroinvertebrate survey evaluated in the Site Investigation Report (ENSR, 2007), the midge (*Chironomus tentans*) has been selected as the invertebrate species for sediment toxicity testing. This species is more likely than other possible test organisms (i.e., the amphipod *Hyalella azteca*) to be found within the Hudson River Study Area. As described in the accompanying Work Plan, survival, growth, and emergence studies will be conducted to provide an indication of the spatial distribution of potential invertebrate toxicity.

3.3.3 Macroinvertebrate Community and Habitat Survey

To provide a direct assessment of the integrity of the benthic community, a site-specific macroinvertebrate community survey will be conducted. The macroinvertebrate sampling technique is designed after a modified version of the USEPA (1999) Rapid Bioassessment Protocols (RBP) and will incorporate sampling method aspects from the USEPA (2000d) Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance, as well as NYSDEC guidance (Bode et al., 1990; Bode, et al., 2002).

The results of the macroinvertebrate community survey program will provide a direct measure of the health of the site-specific benthic invertebrate community in support of the BERA. Objectives of this task include:

- Determining the abundance of macroinvertebrates at locations associated with near-Site sediment and background sampling stations;
- Assessing the level of taxonomic diversity at selected Site and background sampling locations; and
- Evaluating the macroinvertebrate community structure at near-Site locations and at background sampling stations.

Details of the sampling design and laboratory processing of the data are provided in the accompanying Work Plan.

3.4 Benthic Invertebrate Measurement Endpoints

This section presents a general summary of the field and laboratory measurement endpoints that will be considered in the risk analysis phase of work at the Site. These endpoints were summarized in Table 2-3.

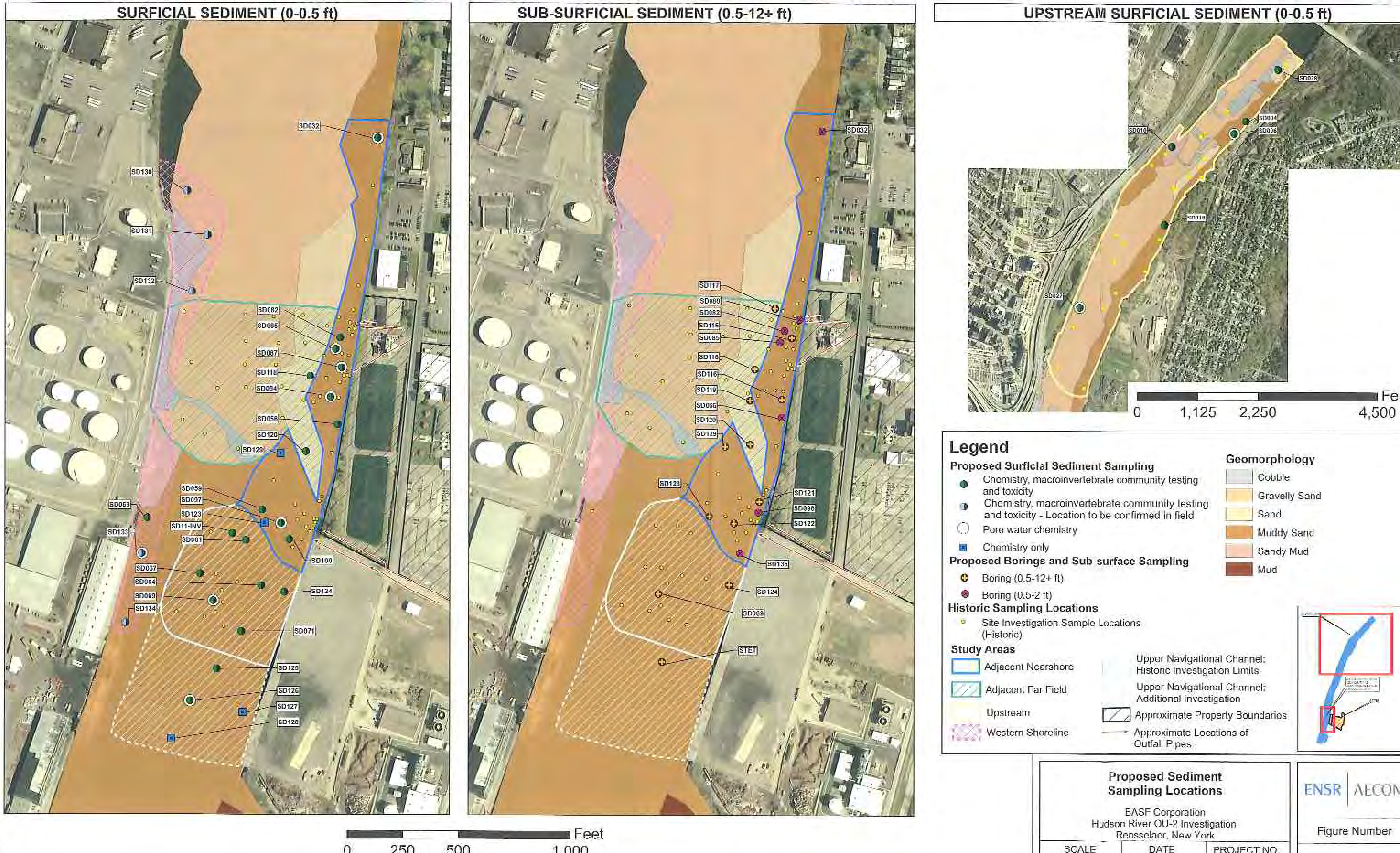
As described above and presented in Table 2-3, several measurement endpoints will be used to evaluate the assessment endpoints developed for benthic invertebrates. These endpoints focus on an analytical chemistry and biological sampling and analysis program. Analytical chemistry analyses, toxicity testing, and benthic macroinvertebrate sampling will be conducted concurrently, allowing for direct evaluation of relationships between biological endpoints and chemical stressors in the BERA.

Sediment analytical parameters will include metals, VOCs, SEM and AVS data, TOC, and grain size. SEM and AVS data will be considered as described in Section 3.3.1. Sediment analytical chemistry analysis results will be compared to NYSDEC benchmark screening values; alternative screening values will be identified as appropriate (e.g., in the absence of NYSDEC screening values for particular constituents).

To evaluate potential exposure to and effects from COPCs in sediment, an early life stage insect species will be exposed to Site sediments in controlled laboratory toxicity tests, as described in Section 3 of the Work Plan. Off-site background or reference stations will be located, sampled, and tested in order to control for site-specific variables, such as grain size in sediment.

The site-specific macroinvertebrate community survey is proposed to provide a direct assessment of the integrity of the benthic community. Benthic macroinvertebrate sampling stations will be co-located with a sub-set of the sediment analytical chemistry and laboratory toxicity testing sampling stations, thereby allowing for detailed evaluation of the co-occurring data in the BERA. The results of the macroinvertebrate community survey program will provide a direct measure of the sustainability of the site-specific benthic invertebrate community in support of the ecological risk assessment.

Additional detail regarding the sediment sampling and analysis program is found in Section 3 of the accompanying Work Plan.



Proposed Sediment Sampling Locations

BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

SCALE	DATE	PROJECT NO.
AS NOTED	06/07	00760-171

ENSR | AECOM

Figure Number

3-1

4.0 Risk Characterization

The results of the environmental risk analysis will be analyzed and interpreted to determine the likelihood of adverse environmental effects, and to determine whether a conclusion of no significant risk can be reached for each assessment endpoint evaluated. The ecological risk characterization will summarize the results of the risk analysis phase of work and will provide interpretation of the ecologically significant findings. Aspects of ecological significance that will be considered to help place the sites into a broader ecological context include the nature and magnitude of effects, the spatial and temporal patterns of effects, and the potential for recovery once a stressor has been removed.

The BERA will integrate a variety of methodologies to assess potential ecological risks. The conclusions regarding overall risk(s) to ecological receptors will be based on a weight-of-evidence approach, which will consider the results of all components of the assessment methodology (i.e., an approach that integrates results of physical, biological, toxicological, and field measurement endpoints to draw risk-based conclusions). The weight-of-evidence components will be designed to provide measures of potential risks for different ecological receptors and exposure pathways.

Individual measurement endpoint results will be evaluated to determine whether or not they support a finding of no significant risk for each assessment endpoint. A useful tool for this sort of evaluation was developed by Menzie et al. (1996). This publication recommends the use of 10 qualitative criteria for weighting ERA measurement endpoints. These criteria, which are summarized below, can be grouped into three broad categories and will be considered in the risk characterization.

4.1 Strength of Association Between Assessment and Measurement Endpoint

- "Biological relationship between the measurement and assessment endpoint refers to the correlation/applicability of the measurement endpoint with respect to the assessment endpoint."
- "Correlation of stressor to response relates to the ability of the endpoint to demonstrate effects from exposure to the stressor, and the ability to correlate the magnitude of the effect(s) with the degree of exposure."
- "Sensitivity of the measurement endpoint for detecting changes in the assessment endpoint means the ability of the of the measurement endpoint to detect changes in the assessment endpoint caused by the stressor."
- "Utility of the measure for judging environmental harm is the ability to judge results of the study against well-accepted standards, criteria, or objective measures."

4.2 Data Quality

- "Extent to which data quality objectives are met refers to the degree to which data quality objectives are designated that are comprehensive and rigorous, as well as to the extent that they are met."

4.3 Study Design and Execution

- "Site specificity refers to the representativeness of the data, media, species, environmental conditions, and habitat types that are used in the measurement endpoint relative to those present at the site"
- "Temporal and spatial representativeness are important factors in evaluating the appropriateness of the study design"

- "Use of a standard method refers to the extent to which the study follows specific protocols recommended by a recognized scientific authority for conducting the method correctly"
- "Sensitivity of the measurement refers to the ability to detect a response in the measurement endpoint"
- "Quantitativeness relates to the degree to which numbers can be used to describe the magnitude of the response of the measurement endpoint to the stressor."

Weighting factors (e.g., high, medium, low) associated with two of the three broad categories (strength of association, study design) will be assigned following project implementation. Data quality will be considered as a "pass/fail" designation; if data quality for a particular measurement endpoint is inadequate, that measurement endpoint will not be considered in the weight-of-evidence evaluation. A preliminary analysis of these weighting factors relative to the specific endpoints at the Site is presented in Table 4-1. This analysis will be updated as part of the BERA presentation.

The documentation of the risk characterization will include a summary of assumptions, uncertainties (both generic and site-specific), strengths and weaknesses of the analysis phase of work, and justification of conclusions regarding the ecological significance of the estimated (i.e., risk of harm) or actual (i.e., evidence of harm) risks.

The estimation of ecological risks involves a number of assumptions. A primary component of any risk assessment is an estimate or discussion of the uncertainty associated with these assumptions. The BERA for the Site will include examination of uncertainty related to the site-specific risk evaluations, and an analysis of the uncertainties which potentially affect all sites.

All discussions of uncertainty will include examination and review of several aspects of the ERA including, but not limited to, sampling, data quality, study design, selection of indicator species, estimates of exposure, and selection of ecological benchmarks and screening values. The BERA has been designed to supplement the SLERA. The sampling scheme, ecological endpoints, and study design have been developed to fill data gaps and refine the conclusions of the risk assessment. However, a number of assumptions will still be made. The uncertainty section of the BERA will identify these assumptions and will relate them to the potential effects these uncertainties may have on the overall conclusions of the ERA.

The major sources of uncertainty in a risk assessment include the potential for errors in assumptions, analyses, and in making measurements. Another source of uncertainty lies in the variability inherent in the components of the ecosystem being evaluated. A certain amount of uncertainty arising from the study design, analyses, and measurements will be accounted for with the weight-of-evidence evaluation.

Although it is not practical to account for all sources of uncertainty, it is important to identify and address the major elements of uncertainty in the risk evaluation and assessment. Some uncertainties bias the results of the risk assessment towards excessive risk, while others bias towards no significant risk. Once identified, the uncertainties will be classified by this bias, and the overall effects on the risk assessment will be reflected in the conclusions.

The ecological risk characterization will summarize the results of the risk analysis phase of work and will provide interpretation of the ecological significance findings. The ecological risk characterization at the Site will rely on an approach that uses field data, laboratory data, and theoretical methods to provide risk estimates to ecological receptors (i.e., the BERA will provide estimates of potential ecological risks through a weight-of-evidence approach). Aspects of ecological significance that will be considered to help place the Site into a broader ecological context include the nature and magnitude of effects, the spatial and temporal patterns of effects, and the potential for recovery once a stressor has been removed.

Table 4-1
Summary of Ecological Risk Characterization Endpoints
BASF Corporation
Hudson River OU-2 Investigation
Rensselaer, New York

Assessment Endpoint Measurement Endpoint	Type of Measure	Strength of Association	Study Design (a)	Quality of Data
Sustainability of a healthy and well-balanced benthic invertebrate community in the Hudson River in the vicinity of the Site which is typical of comparable upstream Hudson River habitats with similar structure, morphology, and hydrology.		The weight assigned to the strength of association is specific to the relationship between the data and the measurement endpoint. The final weight will be assigned following project implementation.		The quality of the BERA data is specific to the relationship between the data and the measurement endpoints and will be reviewed relative to the BASF OU-2 site-specific DQOs. Data quality will be assigned either a "pass" or "fail" designation following project implementation.
a) Characterization of sediment metals bioavailability based on simultaneously extracted metals (SEM)/acid volatile sulfides (AVS) relationships. SEM/AVS ratios greater than 1 in a sediment sample will be considered an indicator of potential bioavailability for divalent cationic metals. The influence of total organic carbon (TOC) will also be considered.	Indirect		Medium	
b) Evaluation of pore water VOC data relative to water quality benchmarks. Evaluation of the partitioning of VOCs into pore water, and the presence of VOCs in pore water in excess of water quality benchmarks will be considered indicative of a potential for ecological risk.	Indirect		Medium	
c) Comparison of bulk sediment analytical chemistry results to sediment quality benchmarks. Site data in excess of sediment quality benchmarks will be considered indicative of a potential for ecological risks.	Indirect		Low to medium	
d) Bulk sediment invertebrate toxicity tests with insect species will be used to evaluate potential lethal and sub-lethal effects associated with exposure to Site sediment.	Indirect		Medium to high	
e) Field assessment of the benthic macroinvertebrate community present in the Hudson River Study Area. Various community composition, abundance, and diversity metrics will be used to evaluate the potential risks associated with exposure to sediment *in situ*.	Direct		Medium to high	

(a) - The weight given to the study design will be assigned following project implementation. The weights assigned in the table are reflective of anticipated successful implementation of the work plan.

5.0 References

Bode, R.W., M.A. Novak, L.A. Abele. 1990. Biological impairment criteria for flowing waters in New York State. New York State Department of Environmental Conservation, Albany, NY.

Bode, R.W., M.A. Novak, L.A. Abele, D.L. Heitzman, A.J. Smith. 2002. Quality assurance work plan for biological stream monitoring in New York State. New York State Department of Environmental Conservation, Albany, NY.

Chapman, P., Wang, F., Germano, J, and Batley, G. 2002. Pore Water Testing and Analysis: the Good, the Bad, and the Ugly., Marine Pollution Bulletin. Vol. 44, No. 5, pp. 359-366.

Decker, C.D, and R.J. Lewis, 2003. Draft Report Screening Level Ecological Risk Assessment Sixty-One Industrial Park. USEPA Region 4 September 2003.

ENSR, 2007. Draft Site Investigation Report Hudson River Operable Unit 2, BASF Rensselaer, Rensselaer, New York, February 2007.

Menzie, C., M. Hope-Henning, J. Cura, K. Finklestein, J. Gentile, J. Maughan, D.F. Mitchell, S. Petron, B. Potocki, S. Svirsky, and P. Tyler. 1996. 'Special Report of the Massachusetts Weight-of-Evidence Workgroup: A Weight-of-Evidence Approach for Evaluating Ecological Risks.' Human and Ecological Risk Assessment 2:277-304.

NYSDEC. 1999. Technical Guidance for Screening Contaminated Sediments. Division of Fish, Wildlife and Marine Resources.

Stroo, H.F., Jensen, R., Loehr, R.C., Nakles, D.V., Fairbrother, A., Liban, C.B., 2000. Environmentally Acceptable Endpoints for PAHs at a Manufactured Gas Plant Site. Environ. Sci. Technol. 34, pp. 3831-3836.

USEPA. 1989. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002.

USEPA. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001.

USEPA, 1997. Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments (Interim Final). U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response. EPA 540/R-97/006.

USEPA. 1998. Guidelines for Ecological Risk Assessment; Risk Assessment Forum, U.S. Environmental Protection Agency, Washington D.C. EPA/630/R-95/002f. April, 1998.

USEPA, 1999. Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish Second Edition. Office of Water. EPA 841-B-99-002

USEPA, 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. ECO UPDATE. Interim Bulletin Number 12. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response.

USEPA. 2003. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. EPA/600/R-02/013. USEPA Office of Science and Technology. Washington, DC.

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