Passive Diffusion and Sediment Sampling Work Plan - Operable Unit 3

Kerr-McGee Chemical Corp – Navassa Superfund Site

Navassa, North Carolina

EPA ID #NCD980557805

Prepared for:

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Acronyms and Abbreviations

BERA	baseline ecological risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm	centimeter
DNAPL	dense non-aqueous phase liquid
DQO	data quality objective
EarthCon	EarthCon Consultants of North Carolina, P.C.
EC50	effect concentration using 50 percent of organisms
ft bgs	foot/feet below ground surface
GPS	global positioning system
NAPL	non-aqueous phase liquid
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbons
PCP	pentachlorophenol
PDS	passive diffusion samplers
PE	polyethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
Ramboll	Ramboll US Corporation
RI	remedial investigation
SESD	Science and Ecosystem Support Division
SPME	solid phase microextraction
SRI	Supplemental Remedial Investigation
TOC	total organic carbon
TU	toxic unit
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This 2020 Operable Unit 3 (OU3) Passive Diffusion and Sediment Sampling Work Plan presents the technical approach for the deployment of passive diffusion samplers (PDS) and the collection of additional Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site characterization data to support a remedial alternative evaluation at the Kerr-McGee Chemical Corp – Navassa Superfund Site [U.S. Environmental Protection Agency (USEPA) ID# NCD980557805], referred to herein as the Site, located in Navassa, North Carolina (Figure 1-1). This Work Plan is being submitted by EarthCon Consultants of North Carolina, P.C. (EarthCon) and Ramboll US Corporation (Ramboll) on behalf of Greenfield Environmental Multistate Trust LLC, not individually but solely in its representative capacity as Trustee of the Multistate Environmental Response Trust (the Multistate Trust).

The Site operated as a creosote-based wood treating facility from 1936 to 1974. A Site plan showing the property boundary, Process Area, Wood Storage Areas and other prominent Site features is provided as Figure 1-2. Previous investigations have indicated that soil, groundwater, surface water and sediment were impacted by historical Site operations. The objective of this 2020 investigation is to collect sufficient data to inform the remedial/risk management decision for approximately 35-acres of marsh in the southern portion of the Site, referred to herein as the Southern Marsh or OU3.

2.0 INVESTIGATION STATUS

Beginning in the 1980s, multiple parties performed pre-CERCLA environmental investigations at the Site and surrounding areas. Beginning in 2006, remedial investigation (RI) activities were performed, including dense non-aqueous phase liquid (DNAPL) investigations; soil, groundwater, marsh sediment, and surface water sampling activities; and vapor intrusion assessments. A Baseline Ecological Risk Assessment (BERA) report (Ramboll, 2019) was prepared and approved by United States Environmental Protection Agency (USEPA) in March 2019. The conclusion of the BERA was that there are areas in OU3 where adverse impacts to biota are expected. The BERA recommended that additional sediment characterization be conducted at OU3 to refine the areas of ecological risk.

3.0 DATA QUALITY OBJECTIVES

The Site-specific objectives presented in this section have been developed using the USEPA data quality objective (DQO) process, as presented in USEPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006) and *Data Quality Objectives Process for Hazardous Waste Site Investigations* (USEPA, 2000). The DQOs for the investigation are provided in Attachment A.

3.1 Objective 1 - Evaluate Potential Ecological Risks Using *In Situ* PDS to Measure Pore Water Concentrations and Calculate TUs

DQO 1 was developed to determine *in situ* pore water concentrations of polycyclic aromatic hydrocarbons (PAHs) using PDS deployed at locations in OU3 that cover a range of PAH concentrations and in areas of potential groundwater discharge. Attachment A describes the problem statement, the goals, decision inputs, and study boundary for this objective. As described in Attachment A, locations selected for PDS deployment are based on historical sediment results and/or temperature data indicating areas of groundwater discharge. PDS will be deployed at a total of 36 locations. Figure 3-1 and Table 3-1 identify all locations selected for PDS deployment.

Twenty of the locations were selected to cover a range of PAH concentrations within OU3. In addition, 2 background locations[1] were selected for PDS deployment. Drones were flown at night over the Site during low tide on July 14 thru July 16, 2020 to obtain Site-specific thermal imagery (Attachment B). The imagery was reviewed and 52 thermal anomalies indicative of potential areas of groundwater discharge were identified. PDS will be deployed at 11 of the 52 thermal anomaly locations. In addition, 3 of the 20 locations selected to cover the range of PAH concentrations (SD-146, RISD62, and ECO-BG-SD-02) are located near areas where thermal anomalies were detected. Due to the proximity of the thermal anomalies, it was agreed with the Beneficiaries in a meeting on August 6, 2020 to move the 3 sample locations (SD-146, RISD62, and ECO-BG-SD-02) to the thermal anomalies (SD-146B, RISD62B, and TA-1, respectively). As a result, PDS samplers will be deployed at 14 total locations where thermal anomalies were detected that are indicative of potential groundwater discharge areas. In addition, 3 PDS locations were included to provide a complete spatial coverage along the northern edge of the marsh in the area immediately adjacent to the uplands where potential groundwater discharge may occur. For the purposes of this work plan, these 3 locations and the 14 locations situated at locations of thermal anomalies are referred to as “locations of potential groundwater discharge.”

In situ PDS will be used to collect Site-specific alkylated and non-alkylated PAH data for pore water and that data will be used to evaluate potential ecological risk to benthic organisms following the approach outlined in the 2017 USEPA guidance document “Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-Ionic Contaminants.” Toxic units (TUs) will be calculated with *in situ* PDS pore water results and the USEPA 2017 guidance using 28-day 50 percent of organisms (EC50s), as discussed in the February 13, 2020 meeting with USEPA. The additional data will be used to further characterize the ecological risks from exposure to sediment in OU3 and to determine if

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[1] Although the DQO in Attachment A indicated that the background areas would be those described in the BERA, the two background locations presented in this Work Plan are new locations that have not been sampled previously.

sediments are attenuating the toxicity of PAHs such that there are low chronic impacts to the biota in the marsh due to low contaminant bioavailability. The decision rules and the decision error limits for this objective are described in Attachment A.

3.2 Objective 2 - Develop a Correlation Between Pore Water Data Collected by *Ex Situ* Solid Phase Microextraction (SPME) and *In Situ* PDS

DQO 2 was developed to establish a correlation between *in situ* PDS pore water results obtained in DQO 1 with bulk sediment and *ex situ* solid phase microextraction pore water results. To date, bulk sediment and *ex situ* SPME pore water results are available for OU3. To allow for the continued use of the broader OU3 database to characterize OU3 and to evaluate long-term changes, the establishment of a correlation between the two methods is needed. Attachment A describes the problem statement, the goals, decision inputs, and study boundary for DQO 2. As described in Attachment A, no additional PDS deployment is planned for DQO 2 beyond that described in DQO 1. The new data inputs to the decision for DQO 2 is SPME pore water analysis and sediment chemistry analysis for alkylated and nonalkylated PAHs and total organic carbon (TOC) from sediment collected from 13 of the PDS locations identified in Figure 3-1 and Table 3-1, and the two background locations for a total of 15 locations. Table 3-1 identifies the locations targeted for SPME sampling.

The data from DQO 2 will be used to determine if there is a correlation between the two pore water analysis methods (PDS and SPME). If there is a correlation between the two pore water analysis methods (PDS and SPME), then the correlation will be used on the historical dataset so that a broader dataset can be used to characterize OU3 and to inform the OU3 conceptual site model. If there is not a correlation between the two pore water analysis methods, then the use of data via PDS or SPME will be discussed with the Beneficiaries with the understanding that the Beneficiaries would like PDS data to be used to determine remedial goals, if any. The decision rules and the decision error limits for this objective are described in Attachment A.

As agreed with the Beneficiaries in an email dated August 11, 2020, sediment samples will also be collected at each of the thermal anomaly areas where a PDS is deployed. The sediment samples will be analyzed for alkylated and nonalkylated PAHs and total organic carbon (TOC). Pore water analysis using SPME will not be conducted on these samples. The results from the bulk sediment chemistry analysis will help provide context for the PDS results.

4.0 PROPOSED DATA COLLECTION ACTIVITIES

This section provides a summary of the proposed data collection activities associated with OU3. The data collection activities include the collection of pore water data using *in situ* PDS and the collection of sediment for bulk chemistry and SPME pore water analysis within OU3 and two background locations. A summary of the proposed samples for each objective is provided in Table 4-1.

4.1 *In situ* Pore Water Sampling using PDS for DQO 1

The objective of the *in situ* pore water sampling is to determine if sediments at OU3 are attenuating the toxicity of PAHs such that there are only low chronic impacts to the biota at OU3 due to low contaminant bioavailability. To that end, PDS will be deployed at 20 locations within OU3 and two background locations for a total of 22 locations. Four of these locations are situated at thermal anomalies indicative of groundwater discharge. PDS will also be deployed at 14 additional locations within OU3 and 1 location west of OU3 determined to be areas of potential groundwater discharge. PDS locations are shown on Figure 3-1 and listed in Table 3-1.

Three replicate PDS will be placed at each of the 36 locations for a total of 108 PDS samples. The PDS will be deployed to a depth 0 to 6 inches below ground surface (ft bgs) for a period of four weeks. *In situ* PDS will be deployed at that depth because this interval most closely reflects the biologically active zone of a marsh environment (USEPA, 2015). The PDS used for the project will be SiREM's SP3 samplers (or similar PDS device). SP3 is a polyethylene (PE)-based passive sampler used for the quantification of hydrophobic PAHs in pore water. The sampler consists of a 4 x 10-centimeter (cm) sheet of low-density PE ("membrane") encased in a mesh envelope. The membrane is attached to a steel backing which is then inserted into the sediment (Figure 3-2). The samplers will be deployed and retrieved using the method outlined in Appendix A, SP3 Sampler Deployment and Retrieval in Attachment A. Once the PDS are retrieved, they will be analyzed for alkylated and nonalkylated PAHs by a modified USEPA Method 8270M (Table 4-1).

Based on sediment data collected for OU3, the concentration of PAHs in marsh sediment at OU3 is highly variable. Given the small size of the 4 x 10 cm membrane which is being inserted into the sediment to characterize a given location (similar to that of a grab sample), the decision was made to use three replicates per location to characterize any variability at a given location.

Although the primary objective of DQO 1 is to quantify the bioavailable fraction of alkylated and nonalkylated PAHS, pentachlorophenol (PCP) may also be analyzed pending the results of a separate upland investigation. If it is agreed with the Beneficiaries that PCP is to be analyzed, then the analytical laboratory will be notified two weeks after PDS deployment, if not sooner, and PCP will also be analyzed using the modified USEPA Method 8270M (Table 4-1).

4.2 Sediment Sampling for DQO 2

The objective of the sediment sampling for DQO 2 is to establish a correlation between *in situ* PDS and *ex situ* SPME pore water results as pore water data collected to date at OU3 has been collected with *ex situ* SPME. No additional PDS deployment is planned for DQO 2 beyond that outlined in DQO 1; however, sediment will be collected at 13 of the PDS locations and two background locations for bulk sediment chemistry analysis and *ex situ* SPME pore water analysis following PDS retrieval so that the sediment is collected at the same location as PDS deployment. These locations are identified in Table 3-1. Surface sediment samples will be collected at each of the 13 locations to a depth of 0 to 6 inches bgs as this is the depth that most closely reflects the biologically active zone of a marsh environment (USEPA, 2015). Sediment samples will be analyzed for alkylated and nonalkylated PAHs by modified USEPA Method 8270M (Table 4-1). Pore water obtained from the sediment will be analyzed for alkylated and nonalkylated PAHs using *ex situ* SPME and the ASTM Method D7363-13 (Table 4-1).

One composite sediment sample will be collected to represent a given location, and that composite sample will be compared to the average results from the 3 PDS replicates to develop the PDS correlation.

In addition, sediment will be collected for bulk sediment chemistry from all locations of thermal anomalies where PDS were deployed. Sediment samples will be analyzed for alkylated and nonalkylated PAHs by modified USEPA Method 8270M (Table 4-1). In addition, extra sediment will be collected and archived by the analytical laboratory. Pending results of the upland OU1/OU2 soil investigation, these samples may be analyzed for PCP and dioxin/furans using Method 8270SIM and Method 8290A, respectively (Table 4-1).

5.0 FIELD AND LABORATORY PROCEDURES

Field and laboratory procedures are described in the following sections.

5.1 General Field Procedures

Field activities will be conducted in general accordance with the most recent USEPA Region 4 Science and Ecosystem Support Division (SESD) operating procedures (USEPA, 2019), and other procedures described in the Supplemental Remedial Investigation (SRI) Work Plans dated September 2015 (CH2M Hill, 2015) and December 2016 (EarthCon, 2016).

There will be two field deployments at OU3. Tidal charts will be reviewed prior to each sampling event to determine low tide as this is the time period that the marsh can be safely accessed by foot. The sampling time period will be based on low tide and will be approximately four hours (two hours before and after low tide); however, this time period may be adjusted at the discretion of the field team leader (i.e., if tidal conditions are determined at the time of the field event to be different from what is reported). Each sampling team will navigate to a sample location using an Arrow Gold Real-Time Kinematic (RTK) Global Positioning System (GPS) unit (or similar device) and using a network of planks or "mudders" (a special type of boot support designed for walking on mud). The summary of each field deployment is described below.

5.1.1 Specific Field Procedures Associated with DQO 1

During the first day of the field event, one team of two people will conduct a reconnaissance of the PDS locations in areas of potential groundwater discharge as identified by drone imagery. A handheld thermal camera and a sediment temperature probe will be used to evaluate temperature differences in these areas. In addition, conductivity will also be measured using a water quality meter at these locations. PDS locations in areas of potential groundwater discharge may be shifted or additional locations (up to 5) added if the thermal camera and/or sediment temperature probe depicts a significant temperature difference indicating a potential groundwater discharge. GPS coordinates of any new or adjusted location will be recorded along with information as to why it was added or shifted. Temperature and conductivity observations will be recorded on field forms. An example of a field form is provided in Attachment C.

Following the site reconnaissance, two teams of two people will deploy the PDS. The field team will be equipped with an Arrow Gold Real-Time Kinematic (RTK) GPS unit (or similar device), which has a subfoot accuracy. Sample coordinates for locations for PDS deployment will be uploaded to the GPS unit. Table 3-1 provides the coordinates for the 36 locations where PDS will be deployed. At each proposed PDS deployment location, sediment temperature will be collected prior to deployment. In addition, photos of the PDS location will be taken in both the visible and infrared spectrum. Conductivity measurements will be collected at the locations of potential groundwater discharge.

Three replicate PDS will be placed at each of the 36 locations (for a total of 108 PDS samples, not including any additional locations, up to 5, added at the time of the field effort. The PDS used for the project will be SiREM's SP3 samplers (or similar PDS device). The samplers will be deployed using the method outlined in Appendix A of the DQO table (Attachment A), SP3 Sampler Deployment and Retrieval. The replicates will be placed in a triangular pattern inches apart to measure variability at a given sample location (Figure 5-1). Each location will be marked with a polyvinyl chloride (PVC) pipe for future identification for retrieving the PDS and sediment collection efforts for DQO 2. PDS will be deployed for 4 weeks. After 4 weeks, the PDS will be retrieved using the method outlined in Appendix A of the DQO table (Attachment A) and submitted for analysis of alkylated and nonalkylated PAHs (and potentially PCP), resulting in a total of 108 samples analyzed (Table 4-1). Retrieval of PDS will occur concurrent with the field activity associated with DQO 2.

The locations for PDS deployment were selected to cover a range of PAH concentrations based on historical analytical results and thermal imagery data indicating groundwater discharge. Based on data collected at OU3 to date and field observations, it is known that sediment heterogeneity and spatial variability exist at OU3. In an effort to quantify the variability at any given location, three PDS will be deployed at each location. For those samples selected to cover a range of PAH concentrations, it is possible that the target PAH range may not be achieved due to the previously described sediment heterogeneity, the approximately 16-year period over which the sediment data were collected, and unknown accuracy of the GPS coordinates. If visual or olfactory observations at the time of deployment at these locations indicate staining or creosote odor in the area of deployment, then the following adjustments will be made to PDS deployment locations (these adjustments will not be made to those locations selected at areas of thermal anomalies and the 3 locations along the northern edge of the marsh identified as potential groundwater discharge areas):

- If the target TU range is low (e.g., <1, 1-5, and 5-10 TU range), then the PDS at these locations will be deployed away from the odor or staining and towards areas of expected lower concentrations. Any adjustments made to a proposed location for PDS deployment will be recorded.
- If the target TU range is between 10 to 40 TUs, then the PDS will be deployed at the original coordinates provided in Table 3-1.
- If the target TU range is >40, then the PDS locations will be biased towards the area noted to have creosote odor or visual creosote staining. Any adjustments made to a proposed location for PDS deployment will be recorded.

In addition to moving a location based on visual or olfactory observations, the ease of collecting sediment for DQO 2 will also be assessed when deploying PDS at each location. If it is determined that the collection of sediment at that location will be difficult, then the PDS location will be moved to an adjacent area where sediment collection can occur, and the new location will be recorded.

5.1.2 Specific Field Procedures Associated with DQO 2

One team of two people will collect the sediment samples required for DQO 2. The sediment samples will be collected at the same time as the PDS are retrieved. The team will be equipped with an Arrow Gold RTK GPS unit. Sample coordinates for locations used during PDS deployment will be uploaded to the GPS unit. Although PDS locations will be marked with PVC for ease of reference, the team will also have a GPS unit in case the PVC markers are not present at the time of the sampling event. The team will navigate to the PDS deployment location, retrieve the PDS following the protocol outlined Appendix A of the DQO table (Attachment A), and then collect the sediment from the exact location of PDS deployment. Sediment will be collected from each of the 3 replicates to a depth of 6 inches (Figure 5-1). Although the sediment will be collected to a depth of 6 inches, the hole will be narrow at the point of collection (approximately 1.5 inches wide at most) to obtain 8 ounces per PDS deployment for a total composite volume of 24 ounces per location. The sediment will be collected and homogenized in a decontaminated stainless-steel bowl before being placed directly into laboratory supplied sample containers.

Sediment collection in a marsh environment has multiple variables that affect the ease at which samples can be collected and the tools that are best suited for sample collection. Ramboll has performed sampling in OU3 in the past, which allows some experience and expectations for the methods that may be most successful. Therefore, a variety of sampling tools will be available at the time of sampling to offer the most flexibility and opportunity for successful sampling (e.g., hand saw, shovel). Given that only surface sediment samples will be collected (i.e., the upper 6 inches bgs), the primary tool for collection is expected to be a stainless steel spade or trowel as it is the most direct sampling method for surficial samples and has been successfully used in the past especially within the marsh mat areas.

As ease of sediment sampling will be assessed during PDS deployment, there will be no need to adjust the sediment sample location.

5.2 Field Photographs and Field Observations

Photographs will be taken of each location during field activities associated with DQO 1 and DQO 2. Any adjustments made to the location of PDS deployment (DQO 1) or sediment collection (DQO 2) will be recorded on field forms as well as other information such as, but not limited to, the following: sample ID; coordinates; weather; chemistry analysis; date; time; and other miscellaneous notes. In particular, the field team will record observations of creosote sheen, potential creosote odors, and biological organisms, if present. In addition, the field team will record information about the presence and density of marsh mat associated with a particular sample. An example of a field form that may be used is included in Attachment C.

5.3 Sample Shipment

Samples will be placed on ice in a cooler. Sample handling will occur under standard chain of custody, packaging, and shipping protocols, as described in the SRI Work Plans dated September 2015 (CH2M Hill, 2015) and December 2016 (EarthCon, 2016).

5.4 Equipment Decontamination

Reusable sampling equipment will be decontaminated before and immediately after each use as described in the USEPA Region 4 SESD operating procedure (USEPA, 2019), SESDPROC-205. Solids and liquids generated by decontamination operations will be containerized in 55-gallon drums and disposed of off-Site in accordance with the SRI Waste Management Plan dated September 2015 (CH2M Hill, 2015).

5.5 PDS and Sediment Sample Analysis

For DQO 1, a total of 108 PDS will be collected from OU3 (including PDS located at two background locations). Table 3-1 and Figure 3-1 identifies the locations selected for PDS deployment. The PDS will be analyzed for alkylated and nonalkylated PAHs by a modified USEPA Method 8270M. For DQO 2, 15 sediment samples will be collected and analyzed for alkylated and nonalkylated PAHs in sediment and pore water by a modified USEPA Method 8270M and ASTM Method D7363-13, respectively. In addition, sediment for bulk sediment chemistry analysis for alkylated and nonalkylated PAHs will be collected at all of the thermal anomaly areas for which PDS is deployed for a total of 11 additional samples. A summary of the samples collected, and laboratory analyses is provided in Table 4-1. A summary of the laboratory detection limits is provided in Attachment D.

5.6 Quality Control

Field quality control samples will be collected as follows for PDS samples collected for DQO 1 (Table 4-1):

- Three replicate PDS will be placed at each sample location
- Field blank PDS will be used to confirm performance reference compounds, sampling rates, and to assess background contamination during shipping. There will be at least three field blanks and each performance reference compound should have a coefficient of variation of <10%.

Field quality control samples will be collected as follows for sediment samples collected for DQO 2 (Table 4-1):

- Field duplicates will be collected at a rate of 1 per 10 samples
- Matrix spike/matrix spike duplicates will be collected at a rate of 1 per 20 samples
- Field blanks will be collected at a rate of one per week
- Equipment blanks will be collected at a rate of one blank per reusable equipment (stainless steel trowels, hand augers, etc.) per media, per 20 samples collected; or one per week, whichever is more frequent

Laboratory analyses and reporting will be conducted in accordance with the SRI Quality Assurance Project Plan dated September 2015 (CH2M Hill, 2015). Table 4-1 provides a summary of the QC samples to be collected.

PDS replicates for each location will be compared. If there are no significant differences between the replicates, then the results of the replicates will be averaged to represent the concentrations for that location. If there are significant differences between the replicates, then the results will be discussed with the Beneficiaries to determine the best way to handle the results; however, one course of action would be to treat the significantly different replicate as an independent sample for the objectives of OU-1.

5.7 Investigation-derived Waste Sampling and Management

The following waste streams may be generated during this investigation:

- Used personal protective equipment (PPE), trash, and sampling materials; and,
- Decontamination fluids.

Used PPE, trash, and sampling materials will be placed in a 55-gallon drum pending off-Site disposal. Investigation-derived waste will be managed in accordance with the SRI Waste Management Plan dated September 2015 (CH2M Hill, 2015).

6.0 REPORTING

A technical memorandum will be submitted to document the PDS and sediment sampling activities and will include photographs and field notes. Once the PDS and SPME results are finalized, the following actions will be implemented:

- TUs for PDS and SPME pore water results will be calculated based on the 2017 USEPA Guidance Document “Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-Ionic Contaminants.”

- A correlation between the two methods will be developed which will include mapping of marsh conditions based on the correlation and results.

- Results will be discussed with the Beneficiaries to decide on the next course of action, if any, for OU3.

- The results of this investigation, along with the data collected in May 2018 will be incorporated into a Draft BERA Addendum which will present the results of the risk re-characterization of OU3.

7.0 IMPLEMENTATION SCHEDULE

The following presents a summary of the approximate duration and constraints for implementation of field activities scheduled:

Task Name	Estimated Duration	Notes
Initial PDS Deployment	5 days	Occurrence of field activity depends on government restrictions and/or safety concerns due to global pandemic (COVID-19).
PDS Deployment Period	30 days	
PDS Retrieval/ Sediment Sampling	5 days	Sediment sampling will occur concurrent with PDS retrieval.
Laboratory Analysis	15 days	
Data Validation	20 days	
Draft BERA Addendum	35 days	

8.0 REFERENCES

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EarthCon, 2016. Supplemental Remedial Investigation Work Plan Addendum No. 3, Kerr-McGee Chemical Corporation Site – Navassa, NC, EarthCon Consultants of North Carolina, P.C., December 2016.

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USEPA, 2019. Field Branches Quality System and Technical Procedures, Region 4: Laboratory and Field Operations. Standard Operating Procedures available online: http://www.epa.gov/region4/sesd/fbqstp/.

TABLES

Table 3-1: Proposed Marsh Sampling Locations for Passive Diffusion and Sediment Sampling

Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

Proposed Location	Σ34 PAH TU	Σ17 PAH	% TOC	GPS Coordinates (3200 NC State Plane (2011) US Survey Feet NAD83)		Thermal Anomaly	PDS	Bulk Sediment Chemistry	SPME	Notes
	(unitless)	(mg/kg)	(%)	Northing	Easting					
Locations for SPME/PDS Correlation in OU3:										
SD11	260	2.21E+04	24.11	182367.674	2302928.124	--	x	x	x	Has duplicate with TU of 230
SD15	56	7.51E+03	27.3	182463.201	2303136.526	--	x			
SD10	26	3.39E+03	26.4	182317.26	2302814.731	--	x	x	x	
SD21	26	1.55E+03	20.0	182216	2302888	--	x	x	x	
SD53	23	1.87E+03	20	182368	2303119	--	x	x	x	
SD-44	19	2.09E+03	25	182200.841	2302765.492	--	x	x	x	
SD-120	15	1.36E+03	18.5	182447.59	2303073.001	--	x	x	x	
SD-149	14	1.36E+03	20.8	182173.791	2302808.361	--	x			
SD08	13	8.08E+02	15	182285.814	2302625.449	--	x	x	x	Has duplicate with TU of 4
SD41	9.7	8.08E+02	18.48	182113.845	2302641.314	--	x	x	x	
SD-111	8.2	7.26E+02	28.3	182273.3832	2302658.09	--	x			
RISD62B (formerly RISD62)	6.7	5.21E+02	17	182191.2241	2303007.039	x	x	x	x	Original location (RISD62) moved approximately 11 feet to align with TA10. Assumed concentrations would be similar to RISD62. RISD62 also has a duplicate with TU of 4.
SD-134	6.6	1.10E+03	28.4	182161.824	2302650.7	--	x			
SD-110	5.1	6.54E+02	27.4	182254.0268	2302611.988	--	x			
SD54	4.6	4.55E+02	21.3	182266	2303274	--	x			
SD113	4	6.56E+02	33.3	182312.0959	2302750.292	--	x	x	x	
SD49	3	3.02E+02	19	182073	2302960	--	x			Has duplicate with TU of 2.8
SD45	2.1	3.20E+02	29.83	182027.3675	2302729.439	--	x	x	x	Adjacent to Eco-SD-M4 (TU of 1.3)
SD-146B (formerly SD-146)	1	1.15E+02	21.6	182119.6215	2302696.815	x	x			Original location (SD-146) moved approximately 27 feet to align with TA2/TA3. Assumed concentrations would be similar to SD-146.
SD-125	0.61	1.05E+02	23.8	182265.9945	2302769.649	--	x	x	x	
PDS1	--	--	--	182520.8579	2303289.459	--	x			Approximately 163 feet east of SD15.
PDS2	--	--	--	182312.5693	2302502.181	--	x			Adjacent to piezometers PZ-D-01 and PZ-D-02.
PDS3	--	--	--	182385.2857	2302362.395	--	x			Adjacent to piezometers PZ-B-01 and PZ-B-02.
						Total Locations for PDS:	23			
Thermal Anomaly Areas Evaluated Within OU3:										
TA2	--	--	--	182123	2302690	x	x	x		TA2 and TA3 are co-located with SD-146B. Only one of these will be sampled during the field effort for SD-146B.
TA3	--	--	--	182116	2302705					
TA4	--	--	--	182128	2302745	x	x	x		
TA7	--	--	--	182238	2302875	x	x	x		
TA9	--	--	--	182100	2303011	x	x	x		
TA10	--	--	--	182194	2303008	x	x	x		Thermal anomaly is co-located with RISD62B.
TA11	--	--	--	182381	2303031	x	x	x		

Table 3-1: Proposed Marsh Sampling Locations for Passive Diffusion and Sediment Sampling

Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

Proposed Location	Σ34 PAH TU	Σ17 PAH	% TOC	GPS Coordinates (3200 NC State Plane (2011) US Survey Feet NAD83)		Thermal Anomaly	PDS	Bulk Sediment Chemistry	SPME	Notes
	(unitless)	(mg/kg)	(%)	Northing	Easting					
TA13	--	--	--	182238	2303103	x	x	x		
TA14	--	--	--	182356	2303085	x	x	x		
TA15	--	--	--	182349	2303097	x	x	x		TA15 and TA16 are adjacent thermal anomalies. Only one these will be sampled during the field effort.
TA16	--	--	--	182323	2303116					
TA19	--	--	--	182625	2303386	x	x	x		
TA21	--	--	--	182585	2303423	x	x	x	--	TA21, TA22, and TA23 are adjacent thermal anomalies. Only one these will be sampled during the field effort.
TA22	--	--	--	182582	2303442					
TA23	--	--	--	182569	2303444					
TA28	--	--	--	182530	2303548	x	x	x		

Total Locations for PDS: 12
(Two of the 12 are associated with the SPME PDS Correlation and are counted in that category)

Thermal Anomaly West of OU3:

Proposed Location	Σ34 PAH TU	Σ17 PAH	% TOC	Northing	Easting	Thermal Anomaly	PDS	Bulk Sediment Chemistry	SPME	Notes
TA1	--	--	--	182466	2301857	x	x	x	x	Near Eco-BG-SD-01 (approximately 54 ft. southwest).

Total Locations for PDS: 1

Background Locations:

Proposed Location	Σ34 PAH TU	Σ17 PAH	% TOC	Northing	Easting	Thermal Anomaly	PDS	Bulk Sediment Chemistry	SPME	Notes
BG-SD-04	--	--	--	182609.0464	2301699.837	--	x	x	x	Reference location west of OU3. Replaces original ECO-BG-SD-01 as a background location.
TA45	--	--	--	182611.9234	2304269.013	x	x	x	x	Reference location east of OU3 that is associated with a thermal anomaly. Replaces original ECO-BG-SD-02 as a background location, which is located approximately 86 feet away.

Total Reference Locations for PDS: 2
Total Locations Overall for PDS Deployment: 36

Minimum Number of Target TUs for SPME Sampling for Determining Relationship between SPME and PDS:

TU Range:	<1	1-5	5-10	10-20	20-40	>40	OU3	West OU3	Reference	Total Samples
# Samples:	1	2	2	3	3	1	12	1	2	15

Passive diffusion samplers (3 at each location) will be deployed at 20 locations in OU3 plus 2 background locations based on historical data so that a wide range of TUs are sampled. Passive diffusion sampers (3 at each location) will also be deployed at 10 locations within OU3 where thermal imagery and 1 location west of OU3 where thermal imagery indicated a potential for groundwater discharge. SPME analysis will be done on a subset of these samples so that a correlation can be developed between the two methods.

Notes:

#	Number
% TOC	Percent total organic carbon
GIS	Geographic Information System
mg/kg	Milligram per kilogram
NC	North Carolina
OU3	Operable Unit 3 or the Navassa Southern Marsh
PAH	Polycyclic aromatic hydrocarbons
SPME	Solid phase microextraction
TU	Toxic unit
Σ	Sum

Table 4-1: Analytical Laboratories, Proposed Laboratory Methods, and Sample Summary
Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

DQO	Analysis	Laboratory	Method	No. Sample Locations (includes 2 reference samples)	No. of PDS units per Location	Total No. of PDS at OU3 from all locations	PDS Blanks	Field Dup-licates	Equip-ment Rinsate Blanks	MS/MSD	Total No. Samples	Sample Volume Needed per Location	Hold Times
1, 2	Sediment Pore Water PAHs and PCP via Passive Diffusion Sampling (34 alkylated and non-alkylated PAH) (a)	SiREM via Test America (or similar)	Modified EPA 8270M	36	3	108	3	N/A	N/A	N/A	111	N/A	Samples extracted within 14 days and extracts analyzed within 30 days following extraction
1, 2	Sediment Pore Water PAHs and PCP via Passive Diffusion Sampling (34 alkylated and non-alkylated PAH) (b)			5	3	15	N/A	N/A	N/A	N/A	15	N/A	
2	Bulk sediment PAHs (34 alkylated and non-alkylated) (c)	META via ESS Laboratory	Modified EPA 8270M (GC/MS/SIM-SCAN)	25	--	--	N/A	1	1	1	28	24 ounces or 0.2 gallons	14 days
2	Sediment Pore Water PAHs via Solid Phase Microextraction (34 alkylated and non-alkylated) (d)		ASTM Method D7363 13	15	--	--	N/A	1	--	N/A	16		28 days
2	Total Organic Carbon (c)		EPA 9060	25	--	--	N/A	1	--	1	27		28 days
--	Bulk sediment PCP and/or dioxin/furan analysis (e)	SGS Orlando (PCPs) and SGS Wilmington (dioxins/furans)	8270SIM (PCPs) 8290A (dioxin/furans)	25	--	--	N/A	1	1	1	28	4 ounces (PCP) 4 ounces (dioxins/ furans)	Samples extracted wthin 30 days and extracts analyzed within 45 days following extraction (Dioxin/furans) Samples extracted within 14 days and extracts analyzed within 40 days following extraction

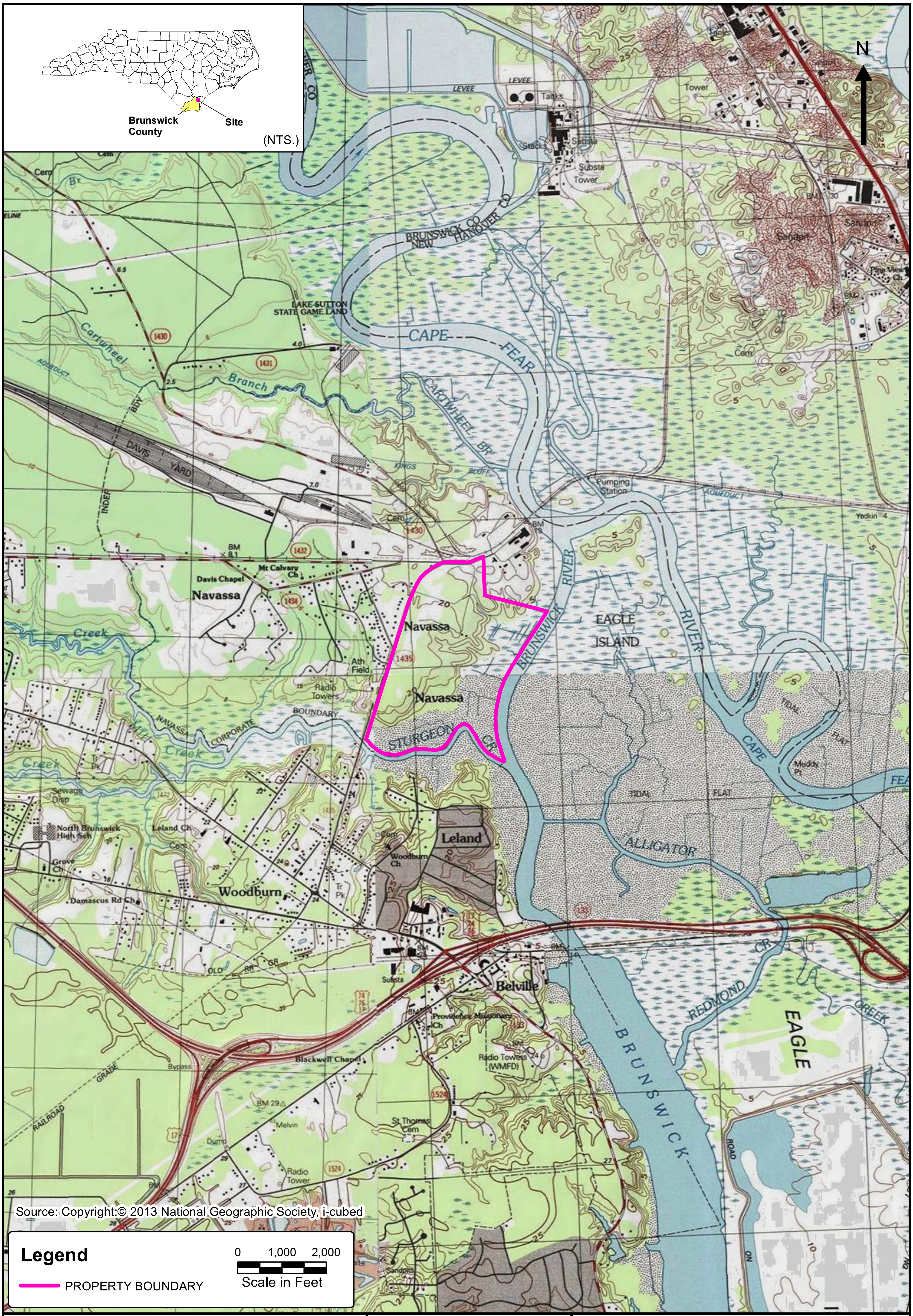
Notes:

(a) Three PDS units will be deployed per location at 20 locations at OU3, 10 locations in areas at OU3 identified as groundwater discharge areas and 1 location west of OU3, and 2 reference locations. In addition, 3 PDS units will also be deployed per location at 3 locations near piezometers in the marsh for a total of 108 PDS units (not including the PDS blanks). Dependent on results from an upland investigation, it may be decided (at a later date) that PCP will also be analyzed.

(b) PDS (up to 15) may be deployed at up to 5 additonal locations at the discretion of the field team if observations made at the time of the field event warrant their deployment for the analysis of PAHs. Dependent on results from an upland investigation, it may be decided (at a later date) that PCP will also be analyzed.
(c) All locations selected for SPME and all locations in areas of thermal anomalies will undergo bulk sediment chemistry and total organic carbon analysis.
(d) 15 locations, including 2 reference locations, will be selected for sediment bulk chemistry and SPME pore water analysis.
(e) Although not part of the DQO, extra sediment will be collected and archived by the analytical laboratory. At the discretion of the Trust and Beneficiaries, they may be analyzed at a later date for PCP and dioxins/furans.

DQO	Data quality objective
EPA	Environmental Protection Agency
N/A	Not applicable either due to sampling method or analysis
No.	Number
OU3	Operable Unit 3 or the Navassa Southern Marsh
PAHs	Polycyclic aromatic hydrocarbons
PCP	Pentachlorophenols
PDS	Passive diffusion sampling unit
SPME	Solid phase microextraction

FIGURES



Source: Copyright:© 2013 National Geographic Society, i-cubed

Legend

PROPERTY BOUNDARY

0 1,000 2,000

Scale in Feet

S:\Premier\Projects\Greenfield Environmental Multistate Trust\KMCC Navassa NC Superfund Site\CAD GIS Data\EARTHCON_GIS\MXDs\Groundwater_Monitoring_2020\Fig 1-1 GMR 2020 Site Location.mxd

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental Response Trust

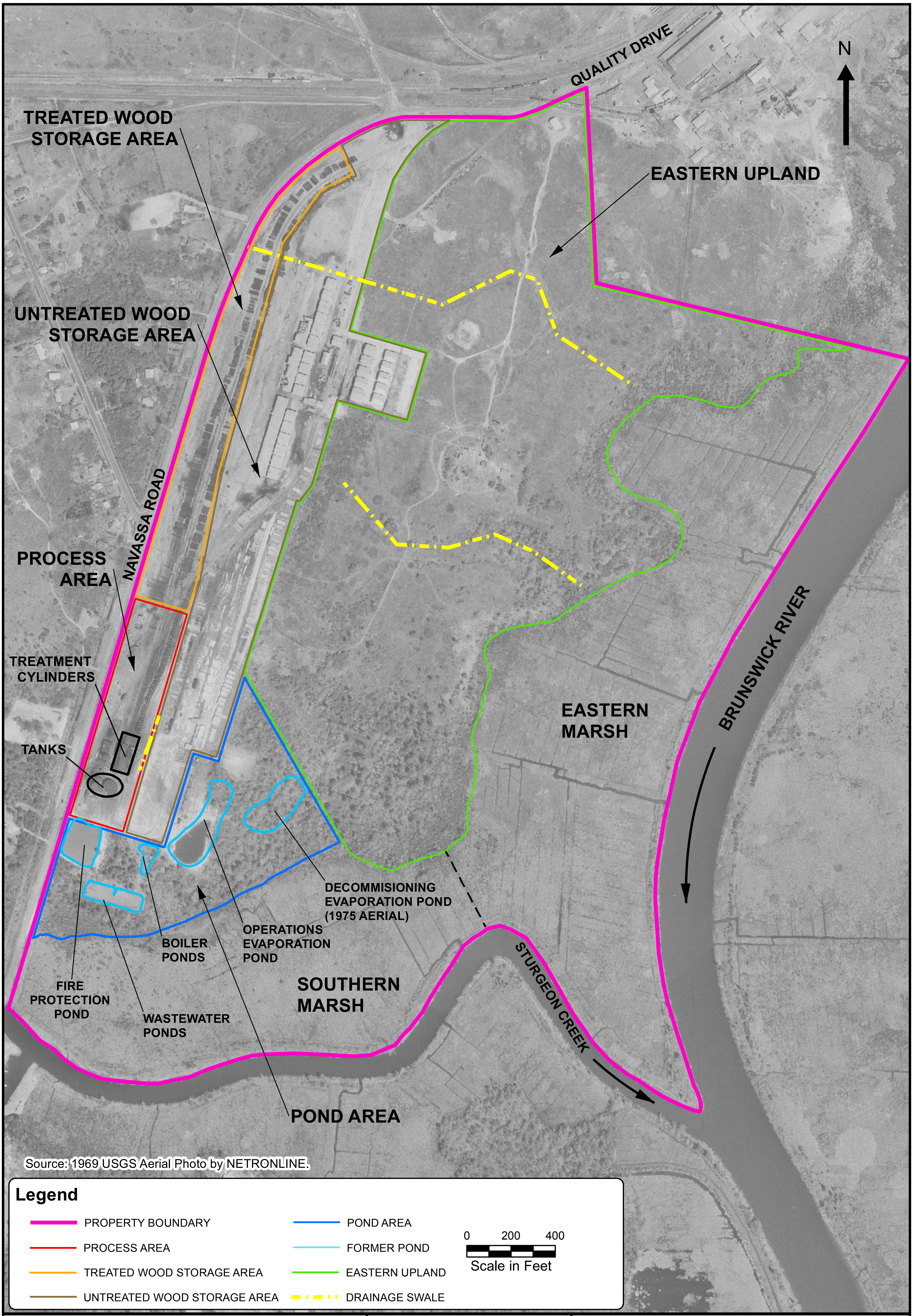
PREPARED BY:

EARTHCON

EARTHCON CONSULTANTS OF NORTH CAROLINA, P.C.

SITE LOCATION
PDS and Sediment Sampling Work Plan
Operable Unit 3
Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

DRAWN	CHECKED	DATE	FIGURE
HVP	CDN	APR 2020	1-1



S:\Premier\Projects\Greenfield Environmental Multistate Trust\KMCC Navassa NC Superfund Site\CAD GIS Data\EARTHCON_GIS\MXDs\Fig 1-2 Navassa Historical Site Plan.mxd

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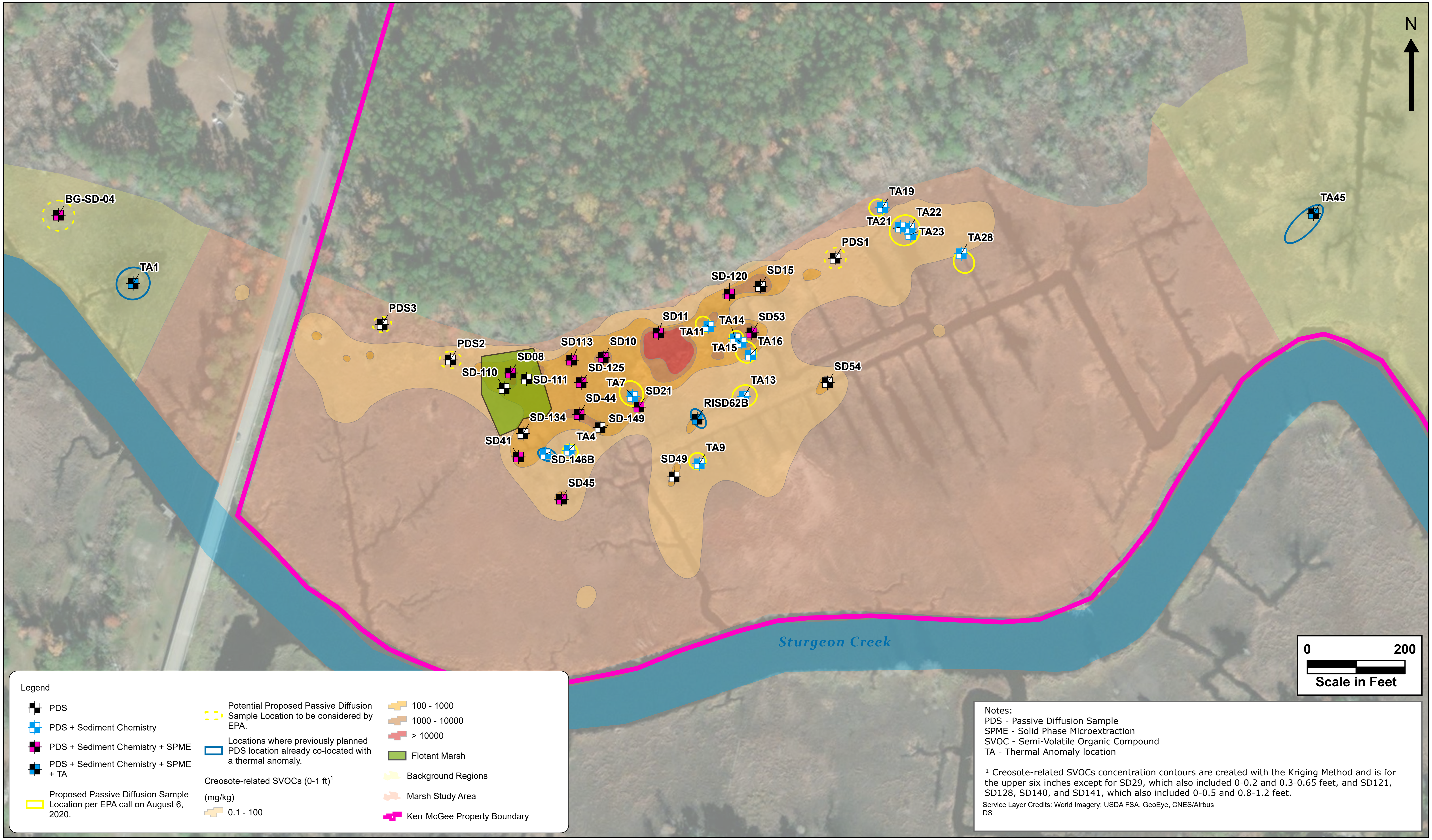
Trustee of the Multistate Environmental Response Trust

PREPARED BY:
EARTHCON®
EARTHCON CONSULTANTS OF NORTH CAROLINA, P.C.

SITE PLAN
PDS and Sediment Sampling Work Plan
Operable Unit 3
Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

DRAWN	CHECKED	DATE	FIGURE
HVP	CDN	APR 2020	1-2



Notes:
PDS - Passive Diffusion Sample
SPME - Solid Phase Microextraction
SVOC - Semi-Volatile Organic Compound
TA - Thermal Anomaly location

[1] Creosote-related SVOCs concentration contours are created with the Kriging Method and is for the upper six inches except for SD29, which also included 0-0.2 and 0.3-0.65 feet, and SD121, SD128, SD140, and SD141, which also included 0-0.5 and 0.8-1.2 feet.

Service Layer Credits: World Imagery: USDA FSA, GeoEye, CNES/Airbus DS

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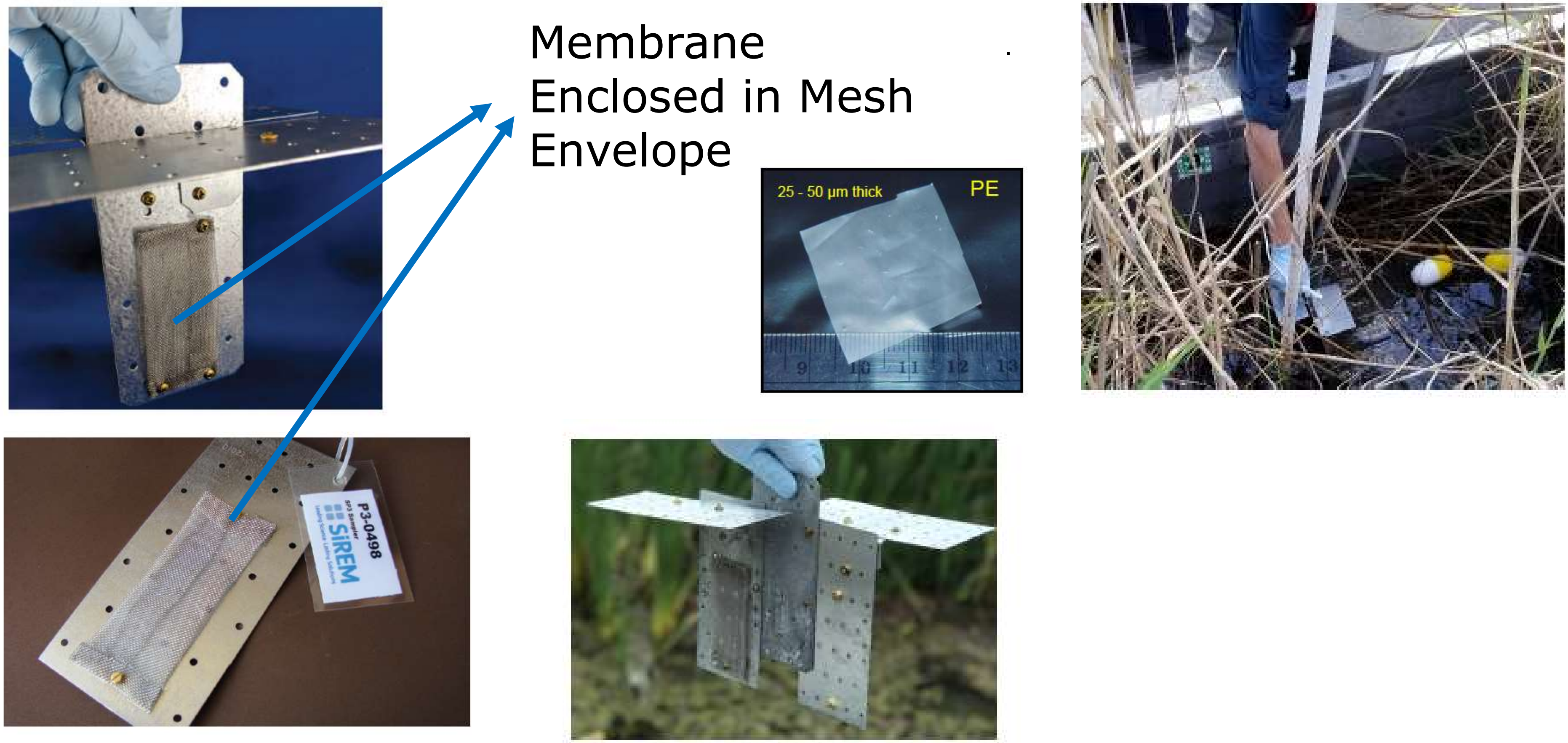
RAMBOLL

Map Design: SAO, Date: 8/13/2020

Proposed Locations for PDS Deployment and SPME Sampling
2020 Investigation Work Plan Addendum
Kerr-McGee Chemical Corporation Superfund Site
Navassa, North Carolina

FIGURE
3-1

Project: 1690004090-007



The SP3 PDS consists of a 4 × 10 centimeter (cm) sheet of thin low density polyethylene (PE) housed in a stainless steel mesh envelope attached to a galvanized steel support plate labeled with a tag containing a unique numerical identifier. The unit is deployed for approximately 4 weeks, retrieved, and then the membrane is analyzed for polycyclic aromatic hydrocarbons.

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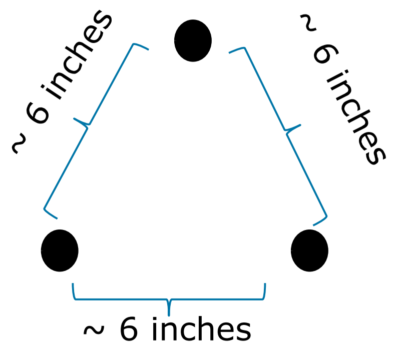
EXAMPLE OF PASSIVE DIFFUSION SAMPLERS

Kerr-McGee Chemical Corp Navassa Superfund Site
Navassa, North Carolina

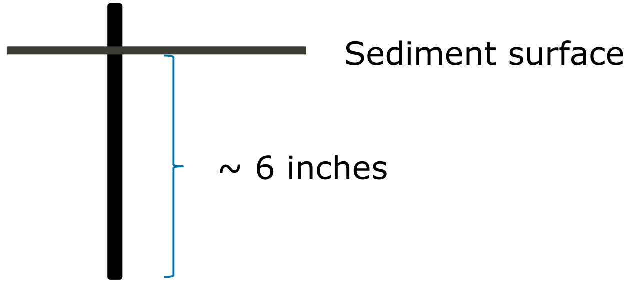
FIGURE
3-2

Project 07-40888A

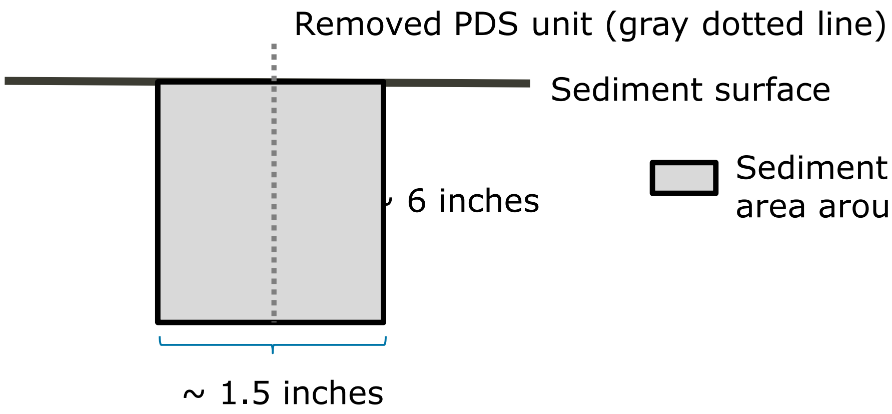


● Passive diffusion sampler

Deployment



Sediment collection after PDS retrieval



▭ Sediment collection area around PDS

PDS will be deployed for approximately 4 weeks. Three replicates will be spaced in a triangular pattern approximately six inches apart at each location. Once the PDS is retrieved, sediment will be collected at each replicate location. For solid-phase microextraction analysis, only 24 ounces (~42 cubic inches) is needed. Therefore, at the location of PDS deployment, sediment will be collected to a vertical extent (depth) of 6 inches and to a horizontal extent of 1.5 inches to ensure that sufficient sediment is collected. Sediment at each replicate will be composited and a composite sample will be collected to represent a PDS location.

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PDS PLACEMENT AND SEDIMENT COLLECTION

Kerr-McGee Chemical Corp Navassa Superfund Site
Navassa, North Carolina

FIGURE
5-1

Project 07-40888A

ATTACHMENT A

Navassa Southern Marsh (OU3) Investigation Data Quality Objectives

Navassa Southern Marsh (OU3) Investigation Data Quality Objectives

Marsh Study Area Strategy

- Quantify potential adverse impacts to biota from creosote in the marsh using passive diffusion samplers (PDS).
- Determine if groundwater is transporting contamination into the marsh at levels that could impact biota by placement of PDS devices in areas of potential groundwater discharging into the marsh identified by infrared imagery, if available.
- Identify site-specific thresholds below which no unacceptable risks are expected through PDS sampling at a range of concentrations and toxic units (TUs).
  - Either calculate remedial goals using USEPA (2017) guidance for PDS or conduct ex-situ toxicity tests and use toxicity test results with PDS results to calculate remedial goals, as appropriate. The remedial goals will be agreed upon with the Beneficiaries.
- Use PDS results and information regarding adverse impacts to biota from PDS (and potentially toxicity testing, if warranted) to monitor future creosote attenuation, as appropriate.

Marsh Study Area Data Quality Objectives (DQOs)

- Objective 1: Estimate pore water concentrations and estimate chronic toxicity using *In Situ* PDS as described in USEPA October 2017 *Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Nonionic Organic Contaminants.*
- Objective 2: Develop a correlation between pore water data collected by *in situ* PDS and *ex situ* solid phase microextraction (SPME) so that the relationship between bulk sediment concentrations and pore water concentrations from the PDS can be consistently applied to the larger sediment dataset for OU3 which is currently normalized to the sum of 34 PAHs based on the SPME pore water relationship (i.e., going forward in OU3, the sum of 34 PAH TUs based on PDS will be used).

Steps Addressed for Each DQO

- Step 1: State the Problem (Problem Definition)
- Step 2: Identify the Goals of the Study
- Step 3: Identify Inputs to the Decision
- Step 4: Define the Study Boundary
- Step 5: Identify Decision Rules
- Step 6: Specify Limits on Decision Errors

Tables

- Table 1: Proposed Marsh Sampling Locations for Passive Diffusion Sampling
- Table 2: Analytical Laboratories, Proposed Laboratory Methods, and Sample Summary

Figure

- Figure 1: BERA Acute Toxicity Test Results Summary
- Figure 2: Proposed Locations for PDS Deployment with PAH Sample Locations

Appendix A

- SP3^{TM} Sampler Deployment and Retrieval

Objective 1
Evaluate Potential Ecological Risks Using *In Situ* Passive Diffusion Samplers (PDS) to Measure Pore Water Concentrations and Calculate TUs

Step 1: State the Problem

The Baseline Ecological Risk Assessment (BERA) included acute toxicity tests that showed low levels of acute toxicity for sediments containing up to approximately 4,000 milligrams per kilogram (mg/kg) of polycyclic aromatic hydrocarbons (PAH) with a toxic unit (TU) of approximately 40[1]. Based on the results of the acute toxicity test, the no observed effect threshold was estimated to be between 2.6 and 42 as shown in Figure 1. Based on the TU results shown in Figure 1, and uncertainties with sediment variability and acute toxicity testing, the no observed effect threshold was estimated to be between 1 to 40. This is consistent with results presented in the USEPA 2017 guidance.

For OU3, it is possible that sediments are attenuating the toxicity of PAHs and that there are low chronic impacts to the biota in the marsh due to low contaminant bioavailability. To test this hypothesis, the Beneficiaries have requested that *in situ* PDS be used to measure pore water concentrations in the Southern Marsh [Operable Unit 3 (OU3) or Marsh Study Area]. As agreed upon in a meeting with the Beneficiaries on February 13, 2020, these locations will be representative of the full range of PAH concentrations in OU3 with a focus on areas with expected TUs between 1 and 40, the range where the no observed effect threshold is expected to occur; however, locations will also include some of the more heavily impacted PAH areas of OU3.

Creosote non-aqueous phase liquid (NAPL) is present in aquifer material, and groundwater discharging through the NAPL and into the marsh could potentially be a source of PAHs to the marsh at that location. As a result, groundwater discharge areas may have elevated pore water and surface water PAH concentrations. PDS devices will also be placed in areas of groundwater upwelling identified using infrared imagery, if this information is available. If present, these additional areas, as well as downgradient adjacent areas, will be targeted for deployment of PDS.

Historical sediment data collected to date at OU3 along with temperature data from infrared imagery will be used to determine initial PDS deployment locations at OU3. The locations will be agreed upon with the Beneficiaries prior to the deployment of PDS.

Problem Definition: Results from *in situ* PDS are needed to determine pore water concentrations of PAHs and TUs (determined by *in situ* PDS) in OU3 at locations selected based on historical sediment results, visual observations of NAPL, and temperature data indicating areas of groundwater discharge.

Step 2: Identify the Goals of the Study

- Obtain site-specific alkylated and non-alkylated PAH data for pore water collected using *in situ* PDS deployed at locations in OU3 that cover a range of PAH concentrations, including those identified in the BERA as potential areas of ecological risk.
- Obtain site-specific information using PDS in OU3 in areas where potential groundwater upwelling is occurring based on infrared imagery when available.
- Use *in situ* PDS results to evaluate potential ecological risk to benthic organisms following the approach outlined in the 2017 USEPA guidance document "Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-Ionic Contaminants."
- Use *in situ* PDS pore water concentrations to calculate total TUs.
- Present all sediment data for OU3 in terms of the sum of 34 PAH TUs based on PDS sampling results (including where appropriate for the larger dataset, PDS TUs from the SPME and PDS relationship).

---

[1] The parent sample tested in the toxicity test had a TU of 42 and the duplicate sample had a TU of 40. As a conservative measure, the TU of 40 was assumed to also have acute levels of toxicity although the duplicate sample was not tested in the acute toxicity test.

- Based upon discussions held during the February 13, 2020 meeting with USEPA, calculate TUs for OU3 using the USEPA 2017 guidance Appendix A, Table 2 using 50 percent of organisms (EC50s).

Principal study question to be addressed:
Do PAH concentrations in pore water samples collected using *in situ* PDS indicate that there are areas of potential ecological risk at OU3 for which additional investigative work is warranted?

Specify the decision statement:
When the total TU exceeds 1.0, then unacceptable risks to benthic organisms are anticipated at a given location if the TU is based on USEPA 2017 Appendix A, Table 2. The location would then be a candidate for *ex situ* chronic toxicity testing or for remedial goal development.

When the total TU is equal to or less than 1.0, then there is low potential risk to benthic organisms, particularly TUs less than 1.0 calculated using the final chronic values (FCVs) based on the 5th percentile value of the species sensitivity distribution (SSD).

Step 3: Identify Inputs to the Decision

Type of information needed for DQO 1:

(1) Collect PDS pore water data from 22 locations in OU3. Previous data was used to select 20 locations in OU3 that reflect a range of PAH concentrations (based on the 17 priority pollutant PAHs; hereafter referenced as "Σ17 PAHs") and estimated TU values for the 34 alkylated and nonalkylated PAHs (hereafter referenced as Σ34 PAHs). These areas will cover a range of PAH concentrations, estimated TU values, total organic carbon (TOC) concentrations, and areas of potential groundwater upwelling. As agreed upon with the Beneficiaries in a meeting on February 13, 2020, the sample locations will include a range of PAH concentrations with a focus on locations with anticipated TUs between 1 and 40, which is the range where the no adverse effect threshold to benthic organisms is expected to occur (Figure 1). The sample locations will also include locations in the more heavily impacted areas of the marsh and/or where creosote is observed during the sampling event. The proposed locations, along with their associated range of concentrations and TU values, are provided in Table 1 and are shown on Figure 2. The locations will consider the results of infrared imagery, if available. PDS will also be deployed at two reference locations described in the BERA.

(2) Locations of potential groundwater upwelling will be determined in a separate investigative effort using infrared imagery. PDS will be deployed at up to 10 additional locations to evaluate pore water concentrations in areas of potential groundwater upwelling based on the infrared imagery. The final number and locations of PDS pore water samples from areas of potential groundwater upwelling will be decided pending discussion with the Beneficiaries prior to PDS deployment.

Identification of sampling and analysis methods:

(1) PDS Deployment and Retrieval: Three replicate PDS will be placed at each of the 22 locations (for a total of 66 PDS samples) based on PAH concentrations from the BERA. Three replicate PDS will also be placed at up to 10 additional locations from potential areas of groundwater upwelling (for a maximum of 30 additional PDS samples). The replicates will be placed in a triangular pattern inches apart to measure variability at a given sample location. Each location will be georeferenced using a GPS unit, and marked with a polyvinyl chloride (PVC) pipe for future identification for sediment collection efforts. PDS will be deployed for 4 weeks before retrieval. After retrieval, the PDS will be submitted for analysis of ∑34 PAHs, resulting in a total of up to 96 samples analyzed (Table 2, Figure 2). The PDS used for the project will be SiREM's SP3 samplers (or similar PDS device). SP3 is a polyethylene-based passive sampler used for the quantification of hydrophobic PAHs in pore water. The samplers will be deployed and retrieved using the method outlined in Appendix A, SP3 Sampler Deployment and Retrieval.

(2) PDS sample analysis: Methods, sample volumes, and holding times are identified on Table 2.

(3) Evaluation of Results: *In situ* pore water concentrations will be used to calculate total TU following the approach outlined in the 2017 USEPA Guidance Document "Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-Ionic Contaminants" to determine if there are any areas of potential ecological risk to benthic organisms including the areas of groundwater upwelling, if present.

Lab performance and target sample selection:

(1) The action levels to evaluate lab performance are specified by the methods and will include use of performance reference compounds as field blanks (Appendix A) in addition to the 4-week equilibration time.

Step 4: Define the Study Boundary

Specifying the study boundary, sample depths, and practical constraints:
The study boundary consists of the approximately 35-acre OU3, as described in the BERA. PDS will be deployed within the sediment at OU3, with the exceptions of two locations at reference areas. Reference sample locations were identified and agreed upon with the Beneficiaries for the BERA. Proposed sample locations are shown on Figure 2.

In situ PDS will be deployed to a depth of 0 to 6 inches below ground surface (bgs) because this interval most closely reflects the biologically active zone of a marsh environment (USEPA, 2015). Locations will be determined by historical results, visual observations of NAPL, and temperature data indicating groundwater discharge, if present. The temporal boundaries for sample collection are the periods of low tide at OU3. Low tide is when the marsh is exposed and can be safely accessed by field personnel.

Step 5: Identify Decision Rules

When the total TU exceeds 1.0 based on USEPA (2017) TU calculations using Appendix A, Table 2, unacceptable risks to benthic organisms are anticipated at that location. The location would then be a candidate for *ex situ* chronic toxicity testing or for remedial goal development. A meeting will be scheduled between the Multistate Trust and the Beneficiaries to discuss.

When the total TU is equal to or less than 1.0, then there is low potential risk to benthic organisms.

Step 6: Specify Limits on Decision Errors

Setting baseline and alternative conditions:
The Beneficiaries would like to use sediment pore water data collected from *in situ* PDS to determine if there are potential ecological risks to benthic organisms at OU3. If results from samples collected with *in situ* PDS indicate that ecological risk is present at OU3, then additional investigative efforts including toxicity testing may be warranted pending discussion with the Beneficiaries. If results from *in situ* PDS indicate that there is no ecological risk to benthic organisms at OU3, then no further investigative work to characterize OU3 is needed. The need for additional work in OU3 will be discussed with the Beneficiaries upon review of the PDS results.

Specifying performance or acceptance criteria:

- Field blank PDS will be used to confirm performance reference compounds, sampling rates, and to assess background contamination during shipping. There will be at least three field blanks and each performance reference compound should have a coefficient of variation of <10%.
- Performance criteria for pore water chemistry for Σ34 PAHs will be based on a modified EPA 8270 Method.
- The internal standard acceptance criteria for the recovery of deuterated PAHs will be from 30 to 120%.

Specifying the Uncertainty:
There are uncertainties with every test method, but efforts are proposed to reduce the uncertainties including:

- Sediment heterogeneity and spatial variability exist at the marsh. In an effort to quantify the variability at any given location, three PDS will be deployed at each location.
- The pore water analyses will be performed using standard laboratory methods and quality control protocols to limit analytical uncertainties.

References

USEPA, 2015. Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments (EPA/600/R-15/176). Cincinnati, Ohio: USEPA, Office of Research and Development, National Center for Environmental Assessment. Ecological Risk Assessment Support Center. October.

USEPA, 2017. Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-Ionic Contaminants (EPA/600/R-15/289). Duluth, Minnesota: USEPA, Office of Research and Development, National Center for Environmental Effects Research Laboratory. October.

Objective 2
Develop a Correlation Between Pore Water Data Collected by *Ex Situ* SPME and *In Situ* PDS

Step 1: State the Problem

The Beneficiaries stated that data collected from *in situ* PDS will be integrated into the existing conceptual site model (CSM) for the Southern Marsh (OU3 or Marsh Study Area) and used to evaluate long-term changes in the marsh. To date, bulk sediment and SPME pore water data are available for OU3. The establishment of a correlation between PDS and SPME results is needed to allow continued use of the broader OU3 dataset to characterize OU3 and to evaluate long-term changes.

Problem Definition: A correlation needs to be established between *ex situ* SPME and *in situ* PDS to allow for a conversion of historical ex situ SPME data to in situ PDS so that a broader dataset is available to inform the OU3 CSM and to evaluate long-term changes in the marsh.

Step 2: Identify the Goals of the Study

- Obtain site-specific data for ∑34 PAHs for pore water using PDS and SPME methods and for sediment collected from locations selected to cover a specified range of concentrations and TUs within OU3.
- Use the data to determine if a correlation between the PDS and SPME results can be established.
- Apply the correlation to the larger set of historical data for a single approach to OU3 marsh characterization so that the larger historical dataset can be normalized to the new PDS results for the ∑34 PAHs.

Principal study question to be addressed:

Is there a correlation between the two pore water analysis methods (PDS and SPME) that can be identified and applied to the existing, extensive sediment and SPME OU3 dataset?

Specify the decision statement:

If there is a correlation between the two pore water analysis methods (PDS and SPME) then the correlation will be used on the historical dataset so that a broader dataset can be used to characterize OU3 and to inform the OU3 CSM.

If there is not a correlation between the two pore water analysis methods, then the use of data via PDS or SPME will be discussed with the Beneficiaries with the understanding that the Beneficiaries would like PDS data to be used to determine remedial goals, if any.

Step 3: Identify Inputs to the Decision

Type of information needed for DQO 2:

(1) As described for DQO 1, previous data collected for the Southern Marsh was used to select 20 locations that reflect a range of Σ34 PAH TUs for the deployment of PDS. The two reference areas identified in DQO 1 will also be used for DQO 2 for a total of 22 locations. No additional PDS deployment is planned for DQO 2 beyond that described in DQO 1. The new data inputs to the decision for DQO 2, beyond those provided in DQO 1, is related to sediment collection from 12 of the 20 OU3 locations, and the two reference locations for a total of 14 locations for sediment and SPME pore water analysis of Σ34 PAHs and TOC (Table 2). These locations are presented on Figure 2.

Identification of sampling and analysis methods:

(1) Field Collection: Concurrent with and upon removal of the PDS devices for DQO 1, collect sufficient sediment volume (approximately 24 ounces) from a minimum of 12 locations in OU3 and from two reference locations for a total of 14 locations (minimum). Sediment samples will be collected to a depth of 6 inches using a stainless-steel spade or other equivalent method.
(2) Homogenization: Sediment from each location will be homogenized in the field, and then packaged for shipment to the analytical laboratory for sediment and SPME pore water analysis of Σ34 PAHs, and TOC. The proposed number of samples and test methods are provided in Table 2.

Lab performance and target sample selection:

(1) The action levels to evaluate lab performance are specified by the methods.

Step 4: Define the Study Boundary

Specifying the study boundary, sample depths, and practical constraints:

The study boundary consists of the approximately 35-acre OU3 marsh, as described in the BERA. Sediment samples will be collected from OU3, except for the two sediment samples to be collected from reference locations. Reference sample locations were identified and agreed upon with the Beneficiaries for the BERA.

The temporal boundaries for sample collection are the periods of low tide at OU3. Low tide is when the marsh is exposed and can be safely accessed by field personnel.

Step 5: Identify Decision Rules

If a correlation can be developed between PDS and SPME pore water analysis, then the correlation will be applied to the larger, existing sediment dataset to normalize it to the PDS results.

If a correlation cannot be established between PDS and SPME pore water analysis, then use of data via PDS or SPME will be discussed with the Beneficiaries with the understanding that the Beneficiaries would like PDS data to be used to determine remedial goals, if any.

Step 6: Specify Limits on Decision Errors

Setting baseline and alternative conditions:

The Beneficiaries would like to use data on sediment pore water concentrations collected using PDS to inform the existing OU3 CSM and as a monitoring tool to evaluate long-term changes in the marsh.

Specifying performance or acceptance criteria:

- Performance criteria between field duplicates, laboratory sample duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples will be based on the 2015 QAPP (CH2M Hill, 2015).
- Performance criteria for pore water chemistry for Σ34 PAHs will be based on a modified EPA 8270 Method.
- Field blank PDS will be used to confirm performance reference compounds, sampling rates, and to assess background contamination during shipping. There will be at least three field blanks and each performance reference compound should have a coefficient of variation of <10%.
- The internal standard acceptance criteria for the recovery of deuterated PAHs will be from 30 to 120%.

Specifying the Uncertainty:

There are uncertainties with both approaches (PDS and SPME). To the extent uncertainty affects the correlation, those will be identified as part of the correlation analysis.

References

CH2M Hill, 2015. Quality Assurance Project Plan, Kerr-McGee Chemical Corporation Site – Navassa, NC, EPA ID #NCD980557805. Prepared for Greenfield Environmental Multistate Trust, LLC, Trustee of the Multistate Environmental Response Trust. September.

USEPA, 2015. Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments (EPA/600/R-15/176). Cincinnati, Ohio: USEPA, Office of Research and Development, National Center for Environmental Assessment. Ecological Risk Assessment Support Center. October.

TABLES

Table 1: Proposed Marsh Sampling Locations for Passive Diffusion Sampling
Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

Proposed Location	Σ34 PAH TU	Σ17 PAH	% TOC	GPS Coordinates (3200 NC State Plane (2011) US Survey Feet NAD83)		Notes
	(unitless)	(mg/kg)	(%)	Northing	Easting	
OU3:						
🟩 SD11	260	2.21E+04	24.11	182367.674	2302928.124	Has duplicate with TU of 230
🟩 SD15	56	7.51E+03	27.3	182463.201	2303136.526	
🟩 SD10	26	3.39E+03	26.4	182317.26	2302814.731	
🟩 SD21	26	1.55E+03	20.0	182216	2302888	
🟩 SD53	23	1.87E+03	20	182368	2303119	
🟩 SD-44	19	2.09E+03	25	182200.841	2302765.492	
🟩 SD-120	15	1.36E+03	18.5	182447.59	2303073.001	
SD-149	14	1.36E+03	20.8	182173.791	2302808.361	
🟩 SD08	13	8.08E+02	15	182285.814	2302625.449	Has duplicate with TU of 4
🟩 SD41	9.7	8.08E+02	18.48	182113.845	2302641.314	
SD-111	8.2	7.26E+02	28.3	182273.3832	2302658.09	
🟩 RISD62	6.7	5.21E+02	17	182184.62	2302997.45	Has duplicate with TU of 4
SD-134	6.6	1.10E+03	28.4	182161.824	2302650.7	
SD-110	5.1	6.54E+02	27.4	182254.0268	2302611.988	
SD54	4.6	4.55E+02	21.3	182266	2303274	
🟩 SD113	4	6.56E+02	33.3	182312.0959	2302750.292	
SD49	3	3.02E+02	19	182073	2302960	Has duplicate with TU of 2.8
🟩 SD45	2.1	3.20E+02	29.83	182027.3675	2302729.439	Adjacent to Eco-SD-M4 (TU of 1.3)
SD-146	1	1.15E+02	21.6	182115.7228	2302670.057	
🟩 SD-125	0.61	1.05E+02	23.8	182265.9945	2302769.649	
Reference Locations:						
🟩 ECO-BG-SD-01	0.23	3.93E+00	21.66	182510.812	2301886.746	West of site
🟩 ECO-BG-SD-02	0.23	1.75E+00	26.12	182575.52	2304240.201	East of site

Target TUs for Passive Diffusion Sampling (PDS):

TU Range:	<1	1-5	5-10	10-20	20-40	>40	OU3	Reference	Total Samples
# Samples:	1	5	5	4	3	2	20	2	22

Minimum Number of Target TUs for SPME Sampling for Determining Relationship between SPME and PDS:

TU Range:	<1	1-5	5-10	10-20	20-40	>40	OU3	Reference	Total Samples
# Samples:	1	2	2	3	3	1	12	2	14

Passive diffusion samplers (3 at each location) will be deployed at all locations plus 2 background locations so that a wide range of TUs are sampled. A minimum of 12 of these locations plus 2 background locations will also have SPME analysis done on samples so that a correlation can be developed between the two methods.

Notes:

#	Number
% TOC	Percent total organic carbon
GIS	Geographic Information System
mg/kg	Milligram per kilogram
NC	North Carolina
OU3	Operable Unit 3 or the Navassa Southern Marsh
PAH	Polycyclic aromatic hydrocarbons
SPME	Solid phase microextraction
TU	Toxic unit
Σ	Sum

🟩 Location targeted for SPME sampling.

Table 2: Analytical Laboratories, Proposed Laboratory Methods, and Sample Summary
Kerr-McGee Chemical Corp - Navassa Superfund Site
Navassa, North Carolina

DQO	Analysis	Laboratory	Method	No. Sample Locations (includes 2 reference samples)	No. of PDS units per Location	Total No. of PDS at OU3 from all locations	PDS Blanks	Field Dup-licates	Equip-ment Rinsate Blanks	MS/MSD	Total No. Samples	Sample Volume Needed per Location	Hold Times
1, 2	Sediment Pore Water PAHs via Passive Diffusion Sampling (34 alkylated and non-alkylated) (a)	SiREM via Test America (or similar)	Modified EPA 8270M	32	3	96	3	N/A	N/A	N/A	99	N/A	Samples extracted within 14 days and extracts analyzed within 30 days following extraction
2	Bulk sediment PAHs (34 alkylated and non-alkylated) (b)	META via ESS Laboratory	Modified EPA 8270M (GC/MS/SIM-SCAN)	14	--		N/A	1	1	1	17	24 ounces or 0.2 gallons	14 days
2	Sediment Pore Water PAHs via Solid Phase Microextraction (34 alkylated and non-alkylated) (b)		ASTM Method D7363 13	14	--		N/A	1	--	N/A	15		28 days
2	Total Organic Carbon (b)		EPA 9060	14	--		N/A	1	--	1	16		28 days

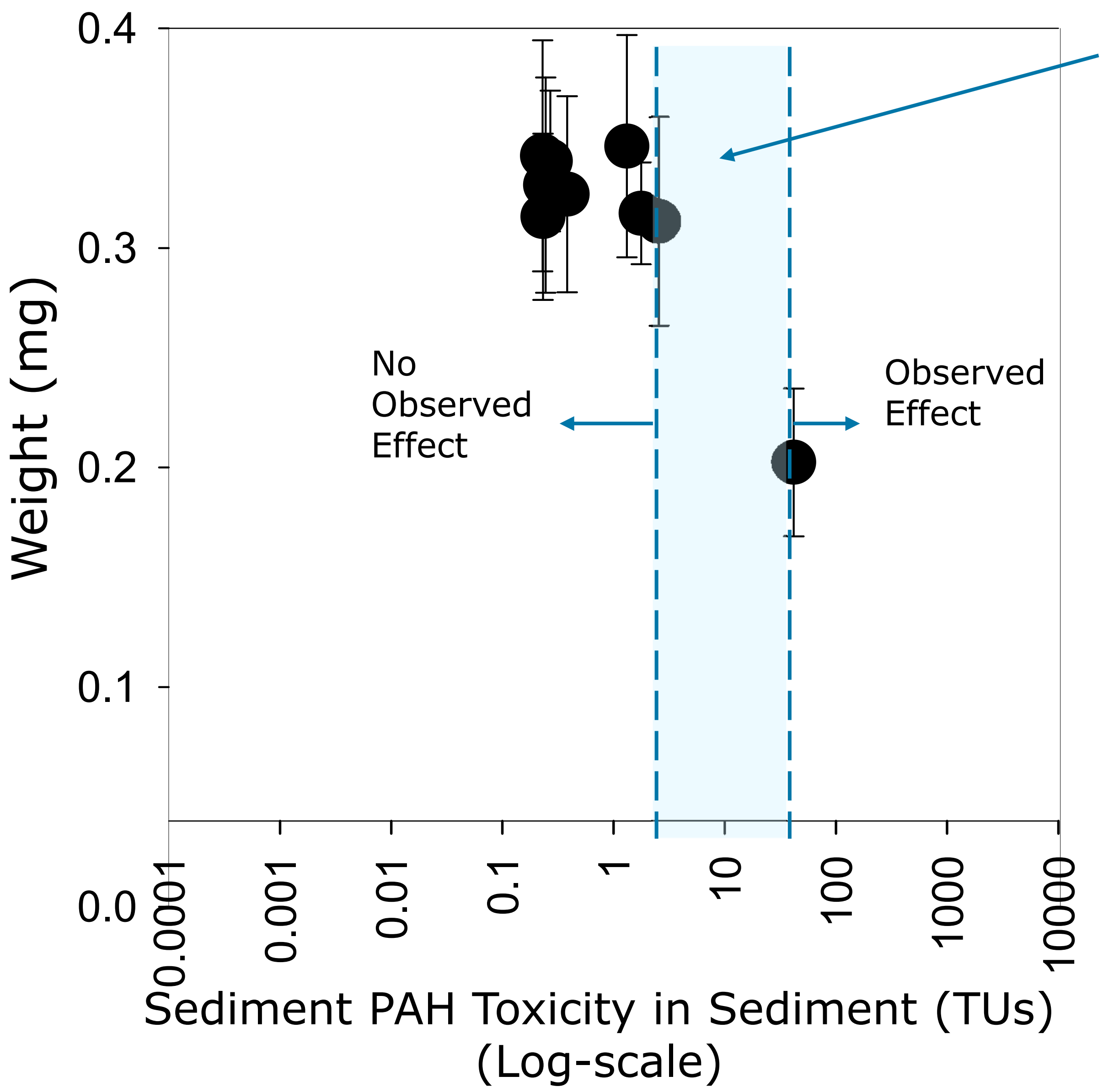
Notes:

(a) Three PDS units will be deployed per location at 20 locations at OU3, and up to 10 locations in areas at OU3 identified as groundwater discharge areas. In addition, 3 PDS units will also be deployed per location at 2 reference locations for 96 PDS units.

(b) A minimum of 14 locations, including 2 reference locations, will be selected for sediment bulk chemistry and SPME pore water analysis.

DQO	Data quality objective
EPA	Environmental Protection Agency
N/A	Not applicable either due to sampling method or analysis
No.	Number
OU3	Operable Unit 3 or the Navassa Southern Marsh
PAHs	Polycyclic aromatic hydrocarbons
PDS	Passive diffusion sampling unit
SPME	Solid phase microextraction

FIGURES



Transition Area (blue shaded area) where the No Effect Threshold is located.

Sediment TUs (log scale). Black circles are the mean, error bars are ± one standard deviation.

Results are from the 10-day acute toxicity test with *Hyallela azteca.* as presented in the BERA. As shown to the left, the lowest mean weight occurred at a TU of 42, collected at ECO-SD-M2, which also had the highest PAH concentration and PAH TU. This mean weight was significantly different from background samples. The second highest TU of 2.6, collected at ECO-SD-M1, was not statistically different from background samples indicating that the no effect threshold is somewhere between 2.6 and 42, as indicated by the blue shaded area to the left.

Based on these results, and uncertainties with sediment variability and acute toxicity testing, for the OU-3 Data Quality Objectives discussion, it is assumed that the threshold for no adverse effects is somewhere between 1 and 40.

The duplicate sample collected at location ECO-SD-M2 did not undergo toxicity testing and its TU data (TU 40) is not presented in this graphic.

BERA = Baseline ecological risk assessment
mg = Milligram
PAH = Polycyclic aromatic hydrocarbons
TU = Toxic unit

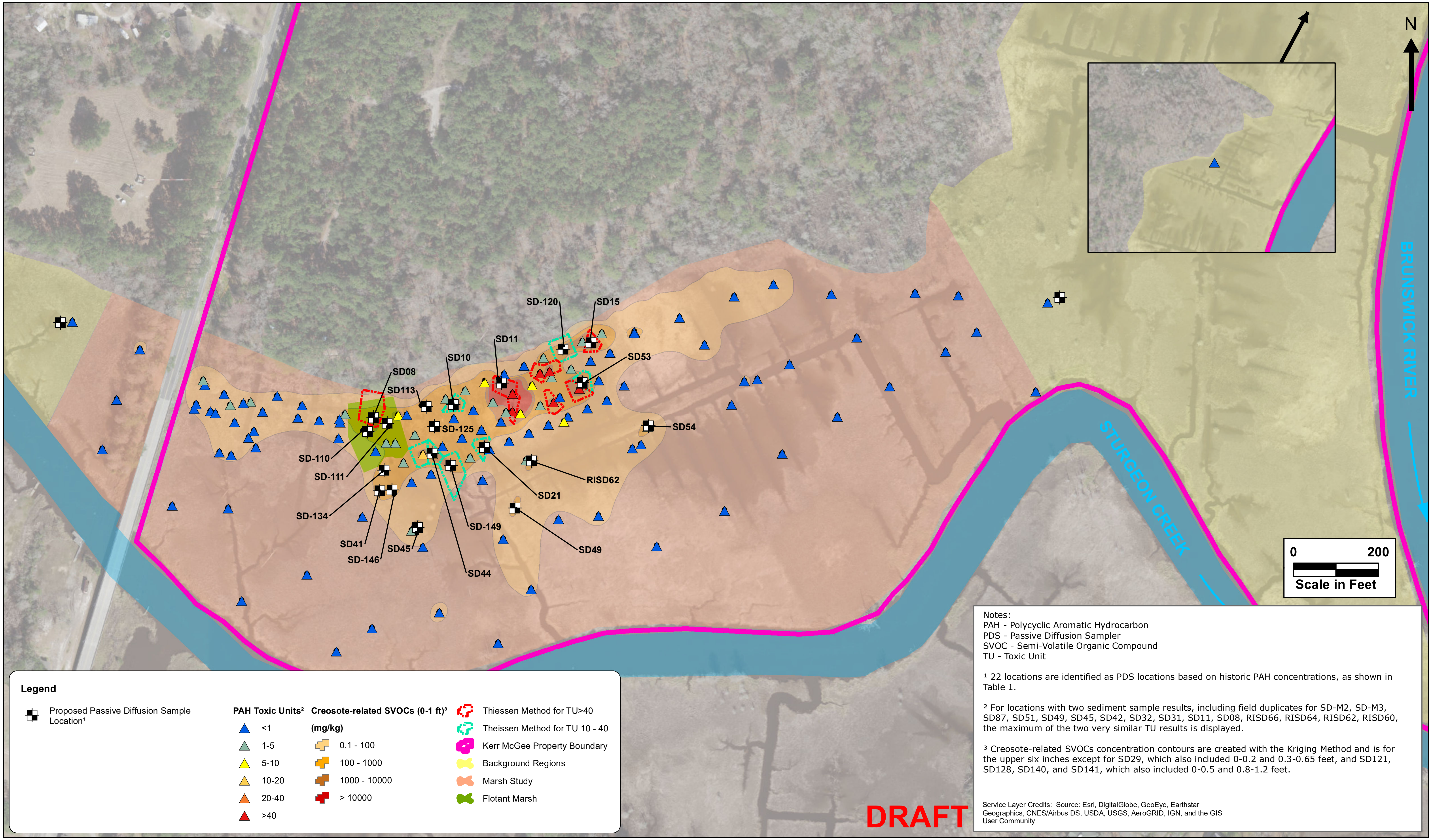
Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental
Response Trust

BERA ACUTE TOXICITY TEST RESULTS SUMMARY

Kerr-McGee Chemical Corp Navassa Superfund Site
Navassa, North Carolina

FIGURE
1

Project 07-40888A



Legend

- ⊞ Proposed Passive Diffusion Sample Location[1]

PAH Toxic Units[2]

- ▲ <1
- ▲ 1-5
- ▲ 5-10
- ▲ 10-20
- ▲ 20-40
- ▲ >40

Creosote-related SVOCs (0-1 ft)[3] (mg/kg)

- ▨ 0.1 - 100
- ▨ 100 - 1000
- ▨ 1000 - 10000
- ▨ > 10000

- ▨ Thiessen Method for TU>40
- ▨ Theissen Method for TU 10 - 40
- ▨ Kerr McGee Property Boundary
- ▨ Background Regions
- ▨ Marsh Study
- ▨ Flotant Marsh

Notes:
PAH - Polycyclic Aromatic Hydrocarbon
PDS - Passive Diffusion Sampler
SVOC - Semi-Volatile Organic Compound
TU - Toxic Unit

[1] 22 locations are identified as PDS locations based on historic PAH concentrations, as shown in Table 1.

[2] For locations with two sediment sample results, including field duplicates for SD-M2, SD-M3, SD87, SD51, SD49, SD45, SD42, SD32, SD31, SD11, SD08, RISD66, RISD64, RISD62, RISD60, the maximum of the two very similar TU results is displayed.

[3] Creosote-related SVOCs concentration contours are created with the Kriging Method and is for the upper six inches except for SD29, which also included 0-0.2 and 0.3-0.65 feet, and SD121, SD128, SD140, and SD141, which also included 0-0.5 and 0.8-1.2 feet.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Greenfield Environmental Multistate Trust, LLC
Trustee of the Multistate Environmental
Response Trust

EARTHCON

RAMBOLL

Map Design: AGK, Date: 12/3/2019

Proposed Locations for PDS Deployment with PAH Sample Locations

Kerr-McGee Chemical Corp Navassa Superfund Site
Navassa, North Carolina

FIGURE
2

Project: 1690004090-001

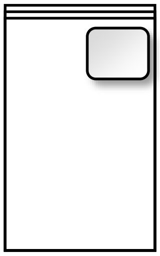
APPENDIX

SiREM
130 Stone Rd. W
Guelph, ON N1G 3Z2
(519) 822-2265

SP3™ Sampler Deployment and Retrieval

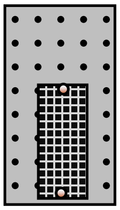
Deployment

1. The SP3™ samplers are shipped in a cooler at 4°C or lower. Each SP3™ sampler is stored in an opaque Ziploc bag and the opaque bag is stored inside a large clear plastic Ziploc bag.



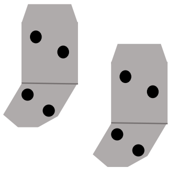
Clear Ziploc Bag

Opaque Ziploc Bag

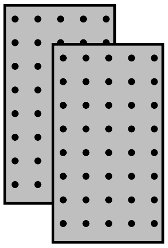


SP3™ Sampler

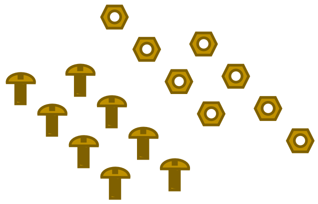
2. Also included in the cooler are bags of pre-cleaned wing brackets, landing wings and screws and nuts used to attach the landing wings to the SP3™.



Wing Brackets

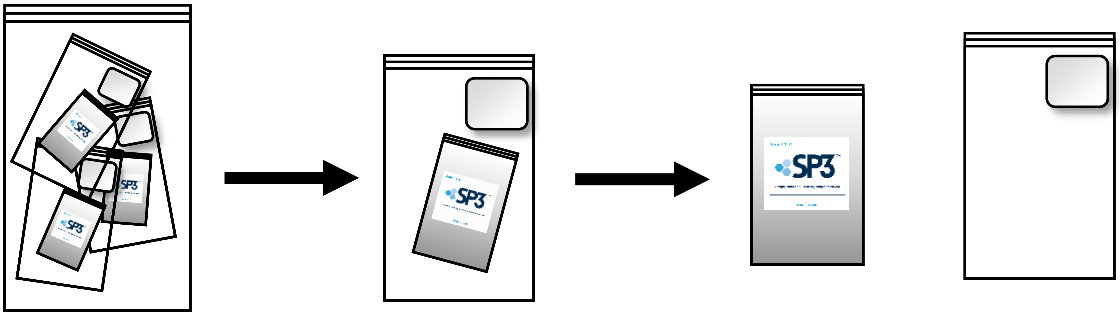


Landing Wings

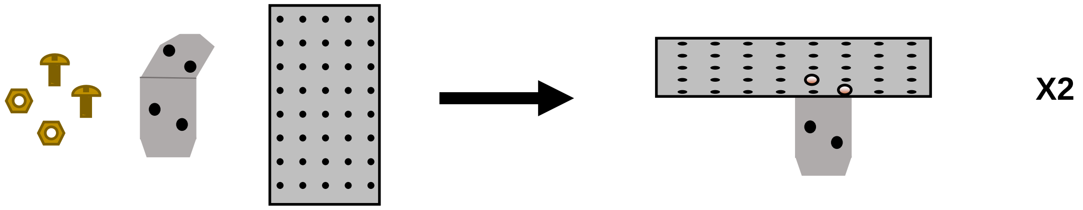


Screws and Nuts

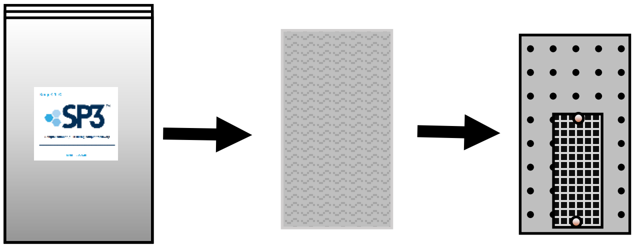
3. Keep the SP3™ samplers cool (4°C or lower) and in the dark prior to use.
4. No more than 30 minutes prior to deployment, remove a single bagged SP3™ sampler from the large bag of samplers or cooler. Then remove the labeled opaque Ziploc sampler bag from the clear plastic Ziploc bag (keep Ziploc bag for next step).

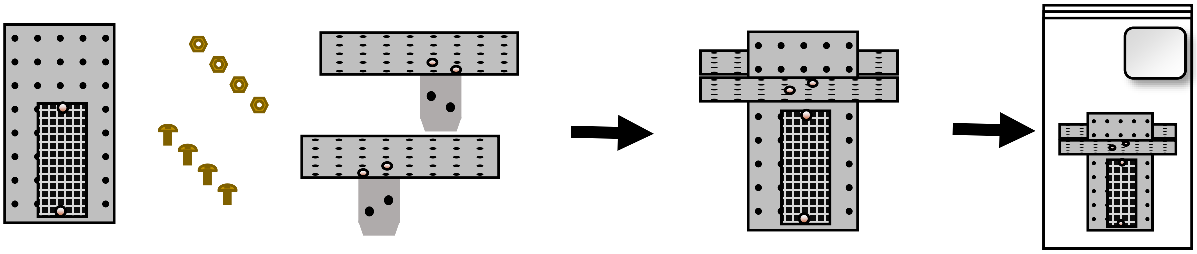


5. Prepare the landing wing apparatus by screwing the wing bracket to the landing wings:

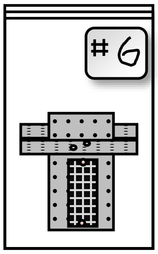


6. Remove the SP3™ sampler from the opaque Ziploc sample bag (keep bag for re-use upon retrieval). Unwrap the aluminum foil around the sample and attach the prepared wing assemblies to the top of the plate (the end of the plate that will remain above the sediment surface when deployed [see below]) using the two screws per wing apparatus. Place the entire SP3™ sampler in the original clear Ziploc bag, and seal bag.



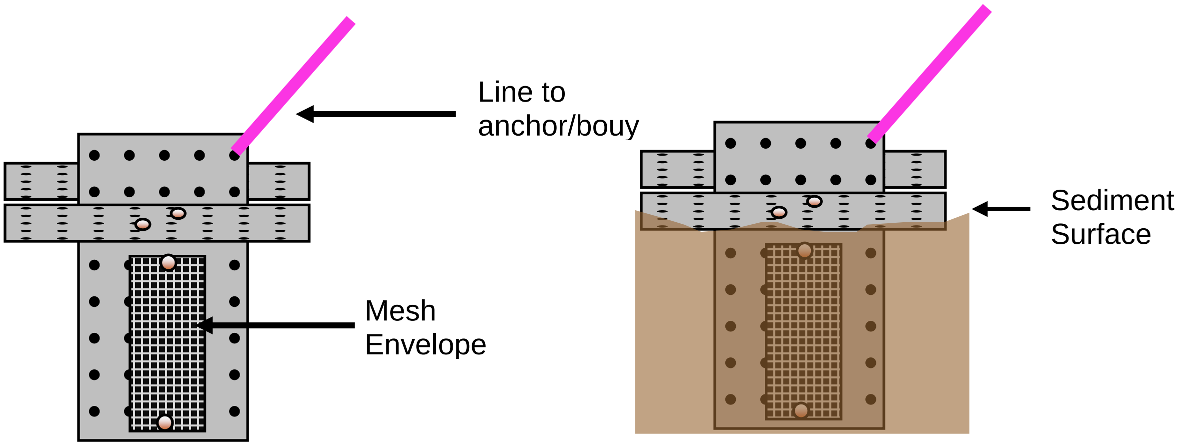


7. It is recommended to mark the sample station at which the sampler will be deployed on the outside label (using a permanent marker or grease pen) so that it can be easily read during deployment.

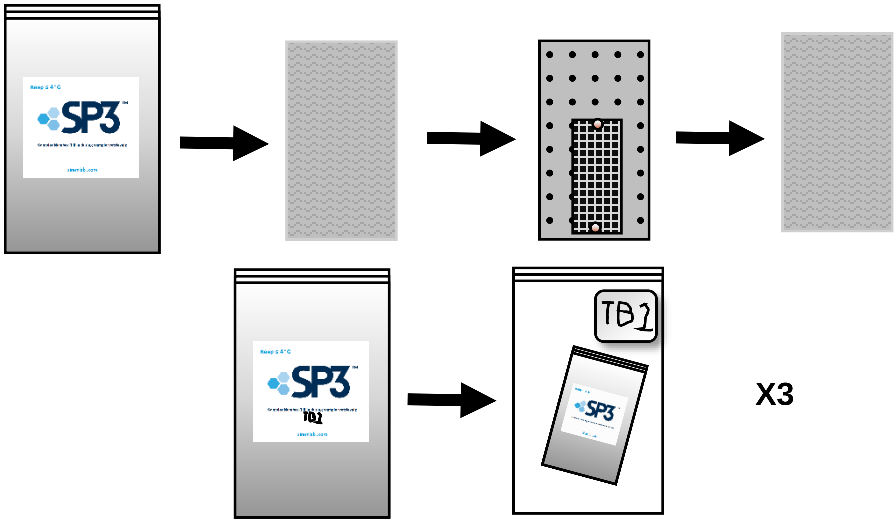


8. Keep the bag out of direct sunlight and heat, to the extent practicable, during the above preparation steps.

9. Provide the bag for deployment to (i.e., push pole technician, SCUBA diver, wader or direct from small boat). Note, multiple bags can be prepared for deployment if multiple samplers will be deployed in a single mobilization. It is acceptable if water enters the bag. Minimize the time the sampler is underwater in the bag, to the extent practicable, up to a maximum time of approximately 30 minutes.
10. At the deployment location, remove the sampler from the plastic bag, attach the sampler to your anchor or bouy line, etc. Insert the sampler plate into the sediment to the desired depth and retain plastic bag, if possible, for re-use after retrieval.



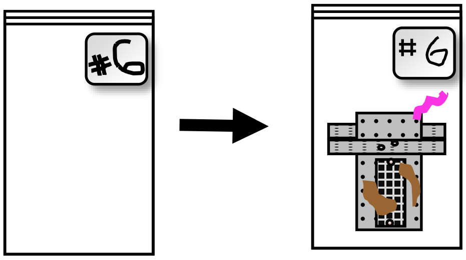
11. If needed, plant a marker flag. Record the GPS co-ordinates of the deployed sampler and date of deployment.
12. Deploy all but three samplers (as needed). The remaining 3 samplers are for Field Blank (FB) use. For each FB sampler, remove the sampler from its labeled opaque Ziploc sampler bag and unwrap it from the aluminum foil. Expose the sampler to air/light/ambient conditions at sampling site for 5-10 minutes (or however long it took to prepare a sampler for deployment). Re-wrap the sampler in aluminum foil and place back in the labeled opaque Ziploc sampler bag, mark label with a unique sample code (e.g., “FB1”), and place in a clear ziploc bag.



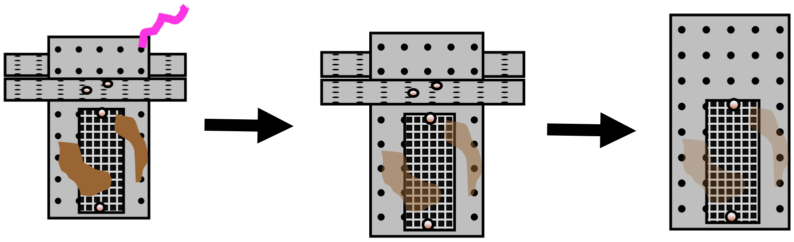
13. For FB samplers, maintain at 4°C or less until they can be shipped to the analytical lab (ideally within 1 to 4 days of deployment).
14. Shipping of FB samplers:
    a. Include ice (double-ziploc bagged) or bagged blue ice packs.
    b. Samplers.
    c. Extra packaging (bubble wrap) as needed.
    d. Chain of custody
        i. Note EPA 1668A for PCB congeners, and/or modified EPA 8270 for PAHs (specify parent PAHs, alkylated PAHs, or both)
        ii. Test America contact is Ryan Henry
    e. Address to ship:
        Test America
        5815 Middlebrook Pike
        Knoxville, TN 37921
        Attn: Sample Receiving, Ryan Henry
        Phone: 865-291-3000
    f. Ship overnight for next morning delivery.

Retrieval

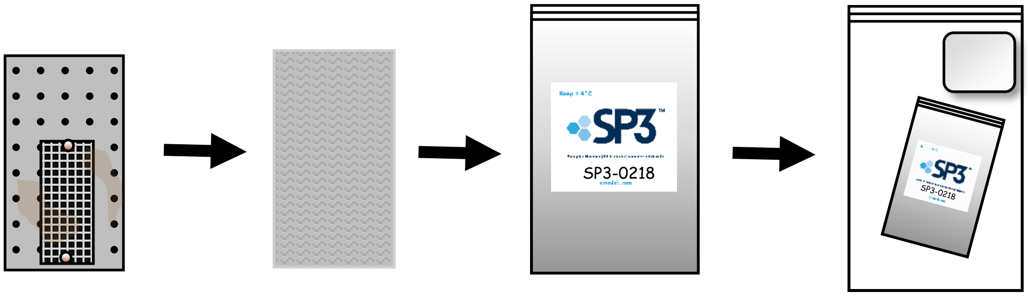
15. Use the original clear Ziploc bag for sample location, retrieve sampler from sediment, place in bag (seal if possible), and return bag to cooler within approximately 20 minutes.



16. Detach any remaining rope from the anchor, wipe off any excess sediment, and remove the wing assembly. Some sediment remaining on the sampler is acceptable.



17. Wrap the sampler in aluminum foil, place the wrapped SP3™ sampler in labeled opaque Ziploc sampler bag, mark label with the unique sample ID (e.g., “SP3-0218”), and place in a Ziploc bag.



18. Place in a cooler with ice/cold packs and maintain cold until shipping; samples can be held for several days as needed as long as they are kept cool (4°C or lower) and dark.

19. Ship the cooler as per the instructions in number 14 described above.

ATTACHMENT B

Thermal Imagery Data

(see file "Final_Figures for EPA_Navassa_20200819.pdf"

ATTACHMENT C

Field Forms

Sampled By:________________
Form Completed By:_________
Date:______________________

FIELD DATA SHEET

Site Name: Navassa Marsh (Sturgeon Creek/Brunswick River)		**Lat:**
Sample Location:	**QA/QC Sample?**	**Long:**
Investigation Purpose: PDS Deployment		
GPS unit: Arrow Gold RTK GPS		**Accuracy:**
Weather:		
Has there been rain the last 7 days?		**Air Temp:**
Habitat Type (% of each habitat type (i.e., mud, rocks, macrophytes):		
How were Samples Collected:		
<u>**Water/Sediment Observations**</u> **Water Odors:** Normal (None) / Petroleum / Fishy / Sewage / Chemical / Other____________________ **Water Surface Oils:** Slick / Sheen / Globs / Flecks / None / Other ____________ **Turbidity (if not measured):** Clear /Slightly Turbid / Turbid / Opaque / Stained / Other____________ **Any biota observed (number/type)?**		
General Comments about Sample Location and Collection:		
Sample IDs:		
Lab Analysis:		
Pictures/Video Identification:		

Field Personnel: _____________________

Date:______________________

TEMPERATURE FIELD SHEET

Location ID	GPS Coordinates		GW Area (a)	Sediment Temp (b)	Notes
	X	Y			

(a) As identified by infrared imagery and Navassa PDS Sediment Sampling Work Plan

(b) Instrument used to measure sediment temperature:

ATTACHMENT D

Laboratory Detection Limits

Detection Limit for ESS Laboratory

ASTM 7363 Compound List and Reporting Limits (all concentrations in µg/L)

	Performance Limit or Reporting Limit	**EDL**
C2-Naphthalenes	0.89	0.3
C3-Naphthalenes	0.33	0.11
C4-Naphthalenes	0.12	0.04
C1-Fluorenes	0.41	0.14
C2-Fluorenes	0.16	0.053
C3-Fluorenes	0.06	0.02
C1-Phenanthrenes/Anthracenes	0.22	0.073
C2-Phenanthrenes/Anthracenes	0.09	0.03
C3-Phenanthrenes/Anthracenes	0.04	0.013
C4-Phenanthrenes/Anthracenes	0.02	0.0067
C1-Fluoranthenes/Pyrenes	0.14	0.047
C1-Chrysenes/Benz(a)anthracenes	0.025	0.0083
C2-Chrysenes/Benz(a)anthracenes	NA	0.005
C3-Chrysenes/Benz(a)anthracenes	NA	0.006
C4-Chrysenes/Benz(a)anthracenes	NA	0.008
Naphthalene	0.8	0.27
2-Methylnaphthalene	0.4	0.13
1-Methylnaphthalene	0.4	0.13
Acenaphthylene	0.2	0.067
Acenaphthene	0.2	0.067
Fluorene	0.12	0.04
Phenanthrene	0.12	0.04
Anthracene	0.12	0.04
Fluoranthene	0.04	0.013
Pyrene	0.04	0.013
Benzo(a)anthracene	0.004	0.0013
Chrysene	0.004	0.0013
Benzo(b)fluoranthene	0.024	0.008
Benzo(k)fluoranthene	0.024	0.008
Benzo(e)pyrene	0.024	0.008
Benzo(a)pyrene	0.024	0.008
Perylene	0.024	0.008
Indeno(1,2,3-cd)pyrene	0.024	0.008
Dibenzo(a,h)anthracene	0.024	0.008
Benzo(g,h,i)perylene	0.024	0.008

SiREM Approximate Method Detection and Reporting Limits for concentrations of freely-dissolved (Cfree) PAHs, as measured using the standard-design SP3^{TM} Sampler, 28-day static deployment period.

Compound	Group	Approximate Freely-dissolved (Cfree) MDL (ng/L)	Approximate Freely-dissolved (Cfree) MRL (ng/L)	Note
Acenaphthene	Priority Pollutant PAH	20	100	1
Acenaphthylene	Priority Pollutant PAH	9	100	1
Anthracene	Priority Pollutant PAH	6	30	1
Benzo(a)anthracene	Priority Pollutant PAH	0.6	2	1
Benzo(a)pyrene	Priority Pollutant PAH	0.2	1	1
Benzo(b)fluoranthene	Priority Pollutant PAH	0.3	1	1
Benzo(ghi)perylene	Priority Pollutant PAH	0.07	0.5	1
Benzo(k)fluoranthene	Priority Pollutant PAH	0.3	1	1
Chrysene	Priority Pollutant PAH	0.4	2	1
Dibenz(a,h)anthracene	Priority Pollutant PAH	0.08	1	1
Fluoranthene	Priority Pollutant PAH	2	7	1
Fluorene	Priority Pollutant PAH	30	60	1
Indeno(1,2,3-cd)pyrene	Priority Pollutant PAH	0.2	0.9	1
Naphthalene	Priority Pollutant PAH	3000	10000	1
Phenanthrene	Priority Pollutant PAH	50	60	1
Pyrene	Priority Pollutant PAH	7	10	1
Benzo(e)pyrene	Other PAH	0.2	1	1
Perylene	Other PAH	0.1	1	1
1-Methylnaphthalene	Alkylated PAH	300	1000	1
2-Methylnaphthalene	Alkylated PAH	700	2000	1
C1-Chrysenes/benz(a)anthracenes	Alkylated PAH	1	1	1
C2-Chrysenes/benz(a)anthracenes	Alkylated PAH	1	1	1
C3-Chrysenes/benz(a)anthracenes	Alkylated PAH	0.7	0.7	1
C4-Chrysenes/benz(a)anthracenes	Alkylated PAH	0.5	0.5	1
C1-Fluoranthenes/pyrenes	Alkylated PAH	3	3	1
C1-Fluorenes	Alkylated PAH	30	30	1
C2-Fluorenes	Alkylated PAH	9	9	1
C3-Fluorenes	Alkylated PAH	4	4	1
C2-Naphthalenes	Alkylated PAH	200	200	1
C3-Naphthalenes	Alkylated PAH	50	50	1
C4-Naphthalenes	Alkylated PAH	10	10	1
C1-Phenanthrenes/anthracenes	Alkylated PAH	10	10	1
C2-Phenanthrenes/anthracenes	Alkylated PAH	4	4	1
C3-Phenanthrenes/anthracenes	Alkylated PAH	2	2	1
C4-Phenanthrenes/anthracenes	Alkylated PAH	1	1	1

Notes

1: Levels are approximate. The ability to quantify Cfree for each analyte, as well as the overall analytical performance of the sampler, is subject to site- and sampler-specific sampling conditions.