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Downstream Areas Remedial Sampling Plan

Mayflower Pipeline Incident
Mayflower, Arkansas

July 2013

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Prepared for:

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Tables

Figures

Attachments

List of Acronyms and Abbreviations

ARCADIS	ARCADIS U.S., Inc.
ASTM	ASTM International
BC	black carbon
bgs	below ground surface
bss	below sediment surface
ESB	Equilibrium Partitioning Sediment Benchmark
ESBTUFCV (or TU)	Equilibrium Partitioning Sediment Benchmark Toxic Unit
ESV	Ecological Screening Value
FCV	final chronic value
f_{oc}	fraction of organic carbon
HASP	Health and Safety Plan
HI	hazard index
I-40	Interstate 40
ID	identification
kg	kilogram
NAD83	North American Datum of 1983
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Unit
PAH	polycyclic aromatic hydrocarbon
PID	photo ionization detector
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
sampling plan	Downstream Areas Remedial Sampling Plan
SIM	Select Ion Monitoring
SOP	Standard Operating Procedure
SPI	Sediment Profiling Imagery
SQuiRT	Screening Quick Reference Table
TOC	total organic carbon
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1. Introduction

On March 29, 2013, a breach in the 20-inch Pegasus Pipeline in Mayflower, Arkansas, led to a crude oil release near the town of Mayflower, Arkansas. The site location is shown on Figure 1. This Downstream Areas Remedial Sampling Plan (sampling plan) establishes the sampling locations and the sampling and laboratory analysis methods for characterization of sediment, soil, and surface water in five areas affected by the Mayflower Pipeline Incident and at background locations, as well as to supplement a remedial evaluation. This sampling plan was prepared to fulfill the sampling objectives presented below.

The general objectives of the sampling program include collection of sediment, soil, and surface water samples to assess the post-response conditions in five areas (Figure 1):

- Subsection A-Main – Shallow Ditch Along North Main Street
- Subsection A-365W – Shallow Ditch Between North Main Street and Highway 365
- Subsection A-365E – Shallow Ditch Between Highway 365 and Interstate 40 (I-40)
- Subsection B-Dawson Cove – Open Marsh Area Located Between I-40 and Division B-On Water
- Subsection B-On Water – Open Water Area Located Between Division B-Dawson Cove and Highway 89 Bridge

In addition, sediment sampling will be conducted at selected locations in Lake Conway north of Highway 89 to confirm that sediments have not been affected by the Mayflower Pipeline release in the main portion of Lake Conway. It should be noted that a separate surface water monitoring program (Attachment B) is in place for Lake Conway; surface water will continue to be addressed under that program.

The objectives of this sampling program are to evaluate post-response sediment, soil, and surface water quality in visually impacted areas downstream of the location of the Mayflower Pipeline Incident and to collect background samples. Survey data will also be collected as part of this sampling program. A sediment, soil, and surface water assessment sampling program will be conducted in the above-referenced areas to generate preliminary quantitative sampling results and to provide data necessary for comparison to established quantitative screening levels. Analytical data generated from this sampling program will be evaluated to establish the current sediment, soil, and surface water quality following the recently completed Mayflower Pipeline Incident response efforts, and to determine whether additional sampling is needed. It is anticipated that the analytical results from this initial assessment sampling program will be used to guide subsequent sampling efforts during a second field effort, if needed, to fill in analytical data gaps. Sampling will also be performed to preliminarily characterize background sediment and soil conditions in Lake Conway. In addition, background sediment sampling will be conducted along the drainage way flow path upstream of the oil-impacted areas.

2. Sampling Methodology

The following sampling methodology was developed to generate sediment, soil, and surface water analytical data representative of sediment, soil, and surface water quality conditions, and other pertinent information following the Mayflower Pipeline Incident. For the purposes of this sampling plan, sediment refers to submerged material below the normal water line, soil refers to bank and floodplain material above the normal water line, and surface water refers to water flowing in the drainage features. Sediment and soil sampling locations along the A-Main ditch and the creek leading to the cove will be established based on the edge of water at the time of the sampling as the apparent location of the edge of water. The sample collection techniques for sediments, soils, and surface water will follow the methods presented in the Standard Operating Procedures (SOPs) for Sediment Sampling, Soil Sampling, and Surface Water Sampling (Attachment A), unless otherwise described in this sampling plan.

2.1 Collection of Background Information

The following background items will be obtained to the extent they are available to facilitate finalizing sampling methodology and locations:

- Property ownership maps
- Locations and depths of subsurface utilities crossing the drainage way or Dawson Cove
- Lake level variations in Lake Conway, which likely govern water levels and flooding frequency of the marsh in B-Dawson Cove
- Water depths and bathymetric transects across the creeks, marsh channel, and cove
- Floodplain topographic elevation data
- Pre-incident stream and marsh conditions (for example, the extent of woody debris and other important features)
- Shoreline and creek channel position in the B-Dawson Cove area

2.2 Access for Sampling

Prior to collection of the samples identified in this plan, ExxonMobil Pipeline Company will attempt to secure any necessary legal access agreements with property owners to allow collection and analysis of samples. The sampling schedule may be affected by the timing of completing access agreements.

2.3 Survey

Sample locations will be established by survey using the North American Datum of 1983 (NAD83) coordinate system, and ground surface and top of sediment elevations will be surveyed using the North American Vertical Datum of 1998 system. Survey activities will include the current drainage way centerline and the current creek channel top of bank position in the Dawson Cove area, as well as topographic/ bathymetric cross sections at approximately 200- to 500-foot intervals, depending on position along the site. The survey data will be used to prepare a current topographic map of the sampling areas.

2.4 Sediment Sampling

This section describes the methodology for sediment sample location selection and sediment collection techniques. Table 1 summarizes the sampling described in this sampling plan.

2.4.1 Sediment Sample Location Selection

Sediment sample locations in the five segments located within Divisions A and B were established within the area affected by crude oil from the Mayflower Pipeline Incident (Figure 1). The proposed sediment sampling locations are summarized in Table 1 and shown on Figures 2 through 6. The sampling approach for each of these segments is described below:

- Division A-Main – Shallow Ditch Along North Main Street: Sediment core samples will be collected to a depth of 12 inches or to refusal from four locations spaced equally along the centerline of the creek as shown on Figure 2.
- Division A-365W – Shallow Ditch Between North Main Street and Highway 365: Sediment core samples will be collected to a depth of 18 inches or to refusal from five locations spaced equally along the centerline of the creek and at distances from the left bank alternating between one-thirds and two-thirds of the creek channel width as shown on Figure 3.
- Division A-365E – Shallow Ditch Between Highway 365 and I-40: Sediment core samples will be collected to a depth of 18 inches or to refusal from four locations spaced equally along the centerline of the creek and at distances from the left bank alternating between one-third and two-thirds of the creek channel width as shown on Figure 3.
- Division B-Dawson Cove – Open Marsh Area Located Between I-40 and Division B-On Water: Along the main creek channel, sediment core samples will be collected to a depth of 18 inches or to refusal from up to eight locations spaced approximately 200 feet along the centerline of the creek and at distances from the left bank alternating between one-third and two-thirds of the creek channel width as shown on Figure 4.
- Division B-On Water – Open Water Area Located Between Division B-Dawson Cove and the Highway 89 Bridge. This segment will be divided into an Upper B-On Water sampling unit and a Lower B-On Water sampling unit:
  - The Upper B-On Water unit will be more intensively sampled because it has a higher potential for impact by oil near the point the creek enters the cove. In this area, eight sediment cores will be

collected to a depth of at least 18 inches at positions on a 150-foot sampling grid as shown on Figure 5 (one sample was repositioned from grid nodes to sample sediments along the eastern shore). At six of these locations, sediment cores will be collected by hand-driving lexan cores to a depth of 4 feet below sediment surface (bss), or to refusal with a goal of at least 3 feet bss (locations for deep sediment cores are also shown on Figure 5). At the two remaining locations, the sediment cores will be collected to a depth of at least 18 inches.

– In the Lower B-On Water unit, samples will be collected at seven locations distributed along the cove alternating to either side of a north-south centerline through the cove as shown on Figure 5. At three of these locations, deep sediment cores will be collected by hand-driving lexan cores to 4 feet bss, or to refusal with a goal of at least 3 feet bss (locations for deep sediment cores are also shown on Figure 5). At the other locations, the sediment core will be collected to a depth of at least 18 inches.

At a subset of five of the sediment core locations from the Upper B-On Water sampling unit, Dart samplers will be installed to provide information on the sediment PAH depth profile and for comparison to surface sediment PAH analytical results. The Dart technology provides a semi-quantitative measurement of total PAH content of the sediments and a continuous vertical profile of relative PAH presence. Prior to the use of Dart samplers in the field, a small (30 to 40 milliliter) sample of crude oil will be evaluated by Dakota Technologies to determine the effectiveness of the Dart samplers, based on strength of the relative fluorescence of the site-specific material. The Dart sampling procedure is described in Attachment C. The Dart sampling technique may be used, if needed, in lieu of core sample analyses for further delineation if sampling of additional locations beyond those addressed in this sampling plan is needed.

Two sediment sampling locations will be located immediately downgradient of the Dawson Cove outlet culvert under Highway 89. Sediment samples collected near the culvert are expected to be representative of localized sediment conditions, and not of Lake Conway as a whole. In Lake Conway, four sediment sampling locations were selected to provide data representative of sediments near the inflow to the lake under Highway 89 that drains the Division B-On Water area. Approximate locations are shown on Figure 6.

Background surface sediment (0 to 6 inches) samples will be collected in Lake Conway and the drainage ways upstream of the oil-impacted areas. In Lake Conway, six background surface sediment samples will be collected at locations shown on Figure 7 to evaluate background sediment quality along the western shoreline of Lake Conway near Interstate 40 and other developed areas. Six background sediment samples are targeted for collection along the flow path of the drainage way upstream of the oil-impacted areas to preliminarily assess background conditions at locations shown on Figure 8. The intent is to sample locations that are frequently inundated and thus represent "sediment" along the drainage path; however, it is unknown whether these locations will contain standing water at the time of sampling.

Actual sample locations will be determined in the field based on access, safety considerations, and the presence/distribution of sediments observed at or near the proposed locations. Deviations from the locations proposed in this plan will be documented in a field notebook or field log sheet. If it is determined in the field that a location is unsafe, that location will not be sampled. Sediment sampling will occur when it is determined that it is safe to perform sediment sampling. If warranted based on safety considerations, the sample location may be moved to a location that is safe to sample, the sample location may be attempted at a later date, or the location may not be sampled.

2.4.2 Sediment Sample Collection

Because the sediment samples are deeper than 6 inches, utility clearance will be completed prior to sampling. Sample crews will navigate to the target sediment sampling area using the coordinates established for the approximate midpoint of the target sample locations shown on Figures 2 through 8 prior to going into the field. Upon arrival at the target sediment sample area, a sediment core sample will be collected by hand driving a 3-inch-diameter lexan core tube to a depth of at least 18 inches bss, or to refusal if less than 18 inches of sediment is present. For those locations where a deep sediment core is planned, the core tube will be hand-driven to a depth of 4 feet bss, or to refusal with a goal of at least 3 feet bss. The sample collection procedure includes the following steps:

1. Verify that ExxonMobil Pipeline Company has secured access to the property.
2. Verify that each piece of field equipment is calibrated, if necessary, and inspected to confirm that it is operational (ARCADIS 2013a).
3. Verify that the sampler has been decontaminated in accordance with the Decontamination SOP (Attachment A).
4. Record the sample location coordinates (NAD83 coordinate system). Measure and record the water depth at the sample location.
5. If accessing the target sampling location by wading:
   - Approach the sample location carefully to avoid disturbing sediments that will be sampled. In flowing areas, approach from the downstream direction.
   - Push a 3-inch-diameter core tube into the sediment using manual force to desired depth, or refusal.
   - Seal the top of the core tube to retain capillary pressure within the barrel. Retrieve the core tube and immediately cap the bottom of the tube.
   - Observe the water surface during sampling for evidence of sheen, or other indications of oil impact.
   - Document the appearance and recovery of the sample to confirm acceptability of the sample (see the Sediment Sampling SOP in Attachment A).

If accessing the sample from a boat in the cove area:

- Anchor the boat so as to avoid disturbance of the location being sampled.
- Push a 3-inch-diameter core tube into the sediment using manual force to desired depth, or refusal.
- Seal the top of the core tube to retain capillary pressure within the barrel. Retrieve the core tube and immediately cap the bottom of the tube.
- Observe the water surface during sampling for evidence of sheen, or other indications of oil impact.
- Document the appearance and recovery of the sample to confirm acceptability of the sample (see the Sediment Sampling SOP in Attachment A).

6. Pump the standing surface water from above the recovered sediment, being careful not to disturb the sediment-water interface.

7. Collect sediment recovered from 0 to 6 inches bss or less. Section the remaining deeper sediment into the 6- to 12-inch interval and subsequent 6-inch intervals (12 to 18 inches bss, 18 to 24 inches bss); for deeper cores, the 24- to 36-inch section will also be collected.

8. Immediately collect sediment for analysis of volatile organic compounds (VOCs) using a Terra Core sampler. If sediment texture is not cohesive enough for use of a Terra Core, fill pre-cleaned laboratory-supplied sample jars (see Table 2) with the sample for analysis (analytes are summarized in Section 2.7 and listed in Table 3). Collect these samples prior to the screening or logging steps.

9. Collect a small aliquot (approximately 1 ounce) of sediment representative of the sediment sample and place into a zip-top bag. Perform photo ionization detector (PID) headspace screening as follows:

   - Allow to equilibrate to ambient temperature for approximately 15 minutes.
   - Insert PID tip into the zip-top bag and read PID until the value spikes and then stabilizes.
   - Record the peak value displayed by the PID.
   - The aliquot of sediment used for headspace testing will not be sent for laboratory analysis.

10. Photo-document the grab sample to provide reference for post-processing questions regarding descriptions of color/staining, general texture, recovery, etc. Photographs of the sample will include a view of a dry-erase board marked with the grab sample identification (ID), date, and time. The photograph will also include a view of a tape measure for scale.

11. Describe sediment samples according to the Unified Soil Classification System (USCS) and document any other observations (e.g., color, type of organic materials present, odor, sheen, staining).

12. Homogenize the sediment samples in disposable foil pans or decontaminated stainless steel bowls. Use of these alternative homogenization containers reduces the potential for injury in the case of broken glassware in the field (a potential hazard when mixing samples in glass with a steel mixing spoon) and reduces the potential for cross-contamination by use of dedicated pans or stainless steel, which can be readily decontaminated through standard decontamination methods (see the Decontamination SOP in Attachment A).

13. Fill pre-cleaned laboratory-supplied sample jars (see Table 2) with the sample for analysis (analytes are summarized in Section 2.7 and listed in Table 3). Label sample jars and handle samples in accordance with the Quality Assurance Project Plan (QAPP; ARCADIS 2013), and the Sample Identification and Nomenclature SOP (Attachment A).

2.5 Soil Sampling

This section describes the methodology for soil sample location selection and the soil collection techniques.

2.5.1 Soil Sample Location Selection

Soil sample locations were established for the following segments as summarized in Table 1 and shown on Figures 2, 3, and 4:

- Division A-Main – Concrete Channel West of North Main Street and Shallow Ditch Along North Main Street
- Division A-365W – Shallow Ditch Between North Main Street and Highway 365
- Division A-365E – Shallow Ditch Between Highway 365 and I-40
- Division B-Dawson Cove and Upper B-On Water Area – Bank and floodplain areas affected by response activity: In this area, a total of 28 marsh soil samples will be collected on an approximately 200- by 200-foot sampling grid (some samples will be repositioned slightly to sample within estimated extent of oil-impacted area).

Along the perimeter of Lake Conway, six marsh soil sampling locations were selected to preliminarily assess background soil conditions in coves similar to Dawson Cove (Gold Creek and Stone Dam Creek). Approximate locations are shown in Figure 7.

Actual sample locations will be determined in the field based on access and safety considerations. If the sampling team is approaching a location and determines that the location is unsafe, soil sampling will not be attempted at that location. The sample location may be moved to a location that is safe to sample or the location may not be sampled. Sample locations may be modified to sample areas where response action activities have been completed.

2.5.2 Soil Sample Collection

Soil samples will be 5-point composite surface samples taken from 0 to 6 inches below ground surface (bgs), except the A-356E segment, where one core sample will be collected at each location due to the steepness of the banks and narrow extent of potential oil impacts. Deeper soil samples (up to 18 inches bgs) will be collected at the centroid core location in each composite grid. Field sampling methods will be conducted in accordance with the Soil Sampling SOP (Attachment A).

Utility clearance will be completed prior to sampling, because the soil samples are deeper than 6 inches. Sample crews will travel to the target soil sampling area using Figures 2 through 4 and 7 (coordinates for the approximate centroid of the sampling location will be developed before going into the field). Upon arrival at the target soil sample area, sample crews will stake out a 5-point composite sample target using a centric square or rectangle configuration, except for along the A-365E segment (Figure 3), where due to the steep nature of the banks and defined channel, a single core sample will be collected from midway between the top of bank and edge of water at the time of sampling.

In the A-Main area, a 5- or 10- by 25-foot composite sample layout will be used (see Figure 2) and the axis of the 25-foot dimension will be parallel to the ditch. Along the A-365W segment, a 10- or 15- by 25-foot composite layout will be used (Figure 3). In the B-Dawson Cove and Upper B-On Water segments, a 25- by 25-foot layout will be used (Figure 4), and the axes of the square will be aligned along cardinal directions (north-south and east-west). In the B-Dawson Cove and Upper B-On Water areas, target sample locations may be inundated; in this case, final sample locations may be adjusted in the field to ensure that all locations on the 5-point composite grid target locations can be sampled using the same methods. Sample locations in this area that are waterlogged or otherwise exhibit low cohesiveness due to water content may require the use of sediment sampling procedures, as previously described. Every effort should be used to ensure that all samples from a single 5-point composite have been collected using the same sampling method.

The sampling tools will be decontaminated in accordance with the Decontamination SOP (Attachment A). Soils will be collected and composited as follows:

1. Verify that ExxonMobil Pipeline Company has secured access to the property.

2. Verify that each piece of field equipment is calibrated, if necessary, and inspected to confirm that it is operational (ARCADIS 2013a).

3. Visually inspect the soils in the area of the sample location target coordinates and record the location coordinates for the center sample point (using NAD83 coordinate system). Photograph and document the ground conditions prior to sampling, including observations of oil if present on the soil surface.

4. Collect soil for analysis of VOCs using a Terra Core sampler from the center sample point. If free residual crude oil is present on the surface or oiled vegetation is present on the surface; the free oil and/or oiled vegetation will be first photo-documented and described, but then carefully scraped away to expose the soil surface prior to collecting the soil sample. If oiled vegetation is present at the sampling locations, it will be removed, and handled and disposed of as "Oily Solids: Vegetation, Wood Chips, Debris, and Soil" in accordance with the Waste Disposal Plan (ExxonMobil Pipeline Company 2013).

5. Use a decontaminated trowel to dig and collect soil from an area approximately 2 inches in diameter to a depth of 6 inches bgs. Place soil aliquots from each of the five sample locations to be composited into a decontaminated stainless steel bowl or disposable foil pan.

6. Collect a small aliquot (approximately 1 ounce) of soil representative of the soil sample and place into a zip-top bag. Perform PID headspace screening as follows:

   – Allow to equilibrate to ambient temperature for approximately 15 minutes.
   – Insert "sniffer" of a PID into the zip-top bag and read PID until the value spikes and then stabilizes.
   – Record the peak value displayed by the PID.
   – The aliquot of soil used for headspace testing will not be sent for laboratory analysis.

7. Homogenize the sample in a decontaminated stainless steel bowl or disposable foil pan with a stainless steel mixing spoon until the soil is of uniform color.

8. Photo-document the sample to provide reference for post-processing questions regarding descriptions of color/staining, general texture, recovery, etc. Photographs of the sample will include a view of a dry-erase board marked with the grab sample ID, date, and time. The photograph will also include a view of a tape measure for scale.

9. Describe soil samples according to the USCS and document any other observations (e.g., color, type of organic materials present, odor, sheen, staining).

10. Fill pre-cleaned laboratory-supplied sample jars with sample for analysis (analytes are summarized in Section 2.7 and listed in Table 3). Label and handle samples in accordance with the QAPP (ARCADIS 2013b) and the Sample Identification and Nomenclature SOP (Attachment A).

In addition to the composited surface soil sample, a core will be collected from the centroid location, logged, and sampled to characterize subsurface soils. The core will be collected using manually operated macro-core or hand auger equipment. Cores will be collected from ground surface to a target depth of at least 18 inches bgs. Soils will be logged and screened as described above. Cores will be segmented into 6-inch depth interval segments (0 to 6, 6 to 12, and 12 to 18 inches). At five locations, a deep core will be collected to a depth of 36 inches, or refusal and samples from the 18- to 24-inch and 24- to 36-inch depth interval will be submitted for analysis, but archived at the laboratory pending results of the shallower samples. If the bottom-most sample exceeds screening criteria, these deeper samples will also be submitted for analysis. Dart samplers also will be installed at these same five locations for PAH profile analysis (Figure 4). The target Dart insertion depth is 4 feet below the ground or sediment surface.

2.6 Surface Water Sampling

This section describes the methodology for surface water sample location selection and the surface water collection techniques. The objectives of this surface water sampling event are to evaluate post-response surface water quality in impacted areas downstream of the location of the Mayflower Pipeline Incident. A separate Surface Water Sampling and Analysis Plan (Attachment B) is in place for Lake Conway and surface water will continue to be addressed under that program. The Surface Water Sampling and Analysis Plan will provide data to monitor concentrations as well as characterize spatial and temporal variability in surface water quality to support an assessment, together with other data collection, of whether there are any continuing remediation needs. The Surface Water Sampling and Analysis Plan includes adjustments to previous surface water sampling activities based on review of data collected; the adjustments include modifications to sampling locations and sample depth intervals. The plan includes daily sampling during the ongoing active response activities. Samples will be collected from Dawson Cove, Lake Conway and background locations (drainage way and Lake Conway samples). Figure 9 shows the proposed surface water sampling locations. Sampling methods, frequency information, and other details are presented in Attachment B.

2.6.1 Surface Water Sample Location Selection

A surface water sample will be co-located at the approximate midpoint of each of the following segments (see Figure 9) provided that flowing conditions are present:

- Subsection A-Main – Shallow Ditch along North Main Street: One surface water sample will be collected along the midpoint of this subsection. Because the water depth in this ditch is very shallow, the sample will be collected from the surface.
- Subsection A-365W – Shallow Ditch between North Main Street and Highway 365: One surface water sample will be collected along the midpoint of this subsection. Because the water depth in this ditch is very shallow, the sample will be collected from the surface.
- Subsection A-365E – Shallow Ditch between Highway 365 and I-40: One surface water sample will be collected along the midpoint of this subsection. The sample will be collected from mid-depth.

- Subsection B-Dawson Cove – Open Marsh Area located between I-40 and Division B-On Water: A surface water sample will be collected in the approximate midpoint of open water in this area at the time of sampling.

- Subsection B-On Water – Open Water Area Located between Division B-Dawson Cove and Highway 89 Bridge: Two surface water samples will be collected at locations approximately one-third of the distance to Highway 89 and another at about two-thirds of the distance to Highway 89.

Actual sample locations will be determined in the field based on access permission and safety considerations. If it is determined in the field that a location is unsafe, that location will not be sampled. Surface water sampling will occur when it is determined that it is safe to perform. If the sampling team is approaching a location and determines that the location is unsafe, surface water sampling will not be attempted at that location. The sample location may be moved to a location that is safe to sample, the sample location may be attempted at a later date, or the location may not be sampled.

2.6.2 Surface Water Sample Collection

Sampling personnel will access the sample locations by land and boat. If unsafe conditions exist at the location, the location will be adjusted, if possible, to a nearby safe location. Once the sample location and sample method are selected, the sample will be collected as follows:

1. Verify that ExxonMobil Pipeline Company has secured access to property.

2. Verify that each piece of field equipment is calibrated, if necessary, and inspected to confirm that it is operational (ARCADIS 2013a).

3. Verify that the sampler has been decontaminated in accordance with the Decontamination SOP (Attachment A).

4. Record the sample location coordinates. Measure and record the water depth at the sample location.

5. If accessing the target sampling location by boat:

   - Navigate to the proposed sample location and secure the boat to the shoreline and/or deploy anchors.
   - Document water and shoreline conditions at the sampling location. The approximate water depth will be estimated using the boat’s depth finder and/or a metered rod.
   - Collect surface water sample volume, including aliquot for measurement of field water quality parameters described below.
   - Fill sample bottles in accordance with the QAPP.

- Observe the water surface during sampling for evidence of sheen, distressed wildlife, or other indications of oil impact.
- Document appearance and recovery of the sample.

6. If accessing the sample from land:

   - Park vehicle fully out of the roadway and in a location where personnel can safely exit the vehicle. Follow traffic control procedures identified in the project Health and Safety Plan (HASP).
   - Identify safest access point to surface water body. Avoid undercut banks, eroded areas, densely vegetated areas, steep banks, and other slip, trip, and fall hazards.
   - Visually assess and document surface water conditions at the target sample location. Slowly walk/wade to the target sample location, and minimize turbidity to the extent practical.
   - Establish adequate footing. Make use of a spotter and follow HASP requirements for working in and near water.
   - Collect surface water sample volume, including aliquot for measurement of field water quality parameters described below.
   - Fill sample bottles in accordance with the QAPP.
   - Observe the water surface during sampling for evidence of sheen, distressed wildlife, or other indications of oil impact.
   - Document appearance and recovery of the sample.

2.6.3 Measurement of Surface Water Quality Field Parameters

In conjunction with the collection of the surface water samples for laboratory analysis, surface water quality field parameters will be measured ex-situ at each surface water sample location. Water quality parameters will be measured in accordance with the sampling requirements and quality assurance requirements contained in the surface water sample collection SOP (Attachment A). The following equipment will be used to measure field parameters:

- pH meter
- Conductivity meter
- Thermometer
- Turbidity meter
- Dissolved oxygen meter

Surface water quality parameters will be measured at each sample location. Surface water quality parameters will be monitored and recorded to confirm that surface water quality is stable and worker-related disturbances are not affecting water quality (e.g., turbidity) prior to collecting samples. Field parameter stability will be established as:

- pH stable +/-1 standard unit
- Conductivity stable +/-10% of previous measurement
- Temperature stable +/-1 degree Celsius
- Turbidity stable +/-10% Nephelometric Turbidity Unit (NTU) (or +/- NTU if turbidity is less than 10 NTU)

2.7 Sample Analysis

The list of laboratory analytes for soil, sediment and surface water are described in this section. The PAH analyses will be completed by B&B Laboratories in College Station, Texas. The BC and TOC analyses will be completed by ALS Environmental in Tucson, Arizona. All other analyses will be completed by Lancaster Laboratories in Lancaster, Pennsylvania. The sample containers, sample volumes, and sample preservation methods for these sample analyses are summarized in Table 2. Analytes are listed in Table 3.

2.7.1 Sediment Sample Analysis

Sediment samples will be analyzed for the following parameters:

- VOCs by USEPA Method 8260
- 44 PAHs, including two- to six-ring priority pollutant PAHs and substituted/alkylated PAHs (see Table 3 for analyte list) by Modified USEPA Method 8270 Select Ion Monitoring (SIM)
- Total metals (eight Resource Conservation and Recovery Act [RCRA] metals plus nickel and vanadium) by USEPA Method 6010/7471 (mercury)
- Surface samples (0 to 6 inches) will be analyzed for Total Extractable Hydrocarbons by Modified USEPA Method 8015
- Surface samples (0 to 6 inches) will also be analyzed for grain size by ASTM International (ASTM) D422, BC by Gustafsson et al. (2001), and TOC by Lloyd Kahn method

In addition, sediment samples will be frozen and archived for up to 1 year for the analysis of additional analytical parameters or biomarkers, if needed. Biomarkers may be beneficial to help identify the extent of the oil spill because there are other potential sources of oil to Lake Conway (e.g., highway runoff). Steranes and hopanes (two classes of biomarkers) are components of oil derived from the cell membranes of eukaryotes (steranes, mainly from plants and algae) and prokaryotes (triterpanes/hopanes, mainly from bacteria). The biomarkers are present in oils in different ratios depending on the origin of the source rock and would be expected in naturally occurring oil-containing sediments, or in oil present due to releases unrelated to the spill. Ratios of these biomarkers can give an indication of the source of the oil, similar to a fingerprinting analysis. Thus, oil present in sediments naturally or due to unrelated releases could, in theory, be distinguished from the fresh crude present due to the spill. However, oil source identification is typically successful using standard PAH fingerprinting which can be accomplished using the proposed analytical plan. It is not certain that biomarker analysis would be beneficial in this case. The archive samples could be analyzed for biomarkers pending the results of the proposed analytical analysis and evaluation.

2.7.2 Soil Sample Analysis

Soil samples will be analyzed for the following parameters:

- VOCs by USEPA Method 8260
- Two- to six-ring PAHs including priority pollutant PAHs and 2- to 4-ring PAH alkyl groups (Modified USEPA Method 8270 SIM
- Total metals (eight RCRA metals plus nickel and vanadium) by USEPA Method 6010/7471 (mercury)
- Surface samples (0 to 6 inches) will also be analyzed for grain size by ASTM D422, BC by Gustafsson et al. (2001) and TOC by Lloyd Kahn method

In addition, soil samples will be frozen and archived for up to 1 year for the analysis of additional parameters or biomarkers, if needed.

2.7.3 Surface Water Sample Analysis

Surface water samples will be analyzed at the laboratory for the following parameters:

- VOCs by USEPA Method 8260
- Two- to six-ring PAHs including priority pollutant PAHs and 2- to 4-ring PAH alkyl groups by Modified USEPA Method 8270 SIM

- Total metals (8 RCRA metals plus nickel, vanadium, calcium, magnesium for Ca-Mg Hardness calculation) by USEPA Method 6010/7470 (mercury)

- Dissolved metals (8 RCRA metals plus nickel, vanadium) by USEPA Method 6010/7470 (mercury)

- Total suspended solids (TSS) by Standard Method 2540 D-1997

- Oil and grease (HEM) by USEPA Method 1664A

2.8 Sediment Deposition Evaluation

Surface sediment inspection and photography will be used to characterize sediment types, evaluate the presence of any discernible new surficial depositional layers, and to map changes in visual characteristics of the sediment surface of Lake Conway in the area of observation.

The visual observation of sediment depositional layers will use either a Sediment Profiling Imagery (SPI) approach, a box corer, or other sampling device capable of collecting a sediment sample suitable for visual inspection. SPI images are obtained in-situ by a device that inserts a viewing lense vertically into the sediment and photographs the near-surface sediment conditions. The SPI can be used to measure and qualitatively evaluate a variety of physical, chemical, and biological parameters including:

- Grain size

- Surface boundary roughness

- Depth of apparent redox potential discontinuity

- Erosional or depositional features

- Subsurface methane gas pockets

- Observation of benthic organisms

The images will provide additional information to assist in evaluating both the presence and extent of recent sediment deposition that may be associated with spill response activities. SPI activities will be conducted according to the SPI SOP in Attachment A, subject to availability of SPI camera equipment and scheduling requirements. The use of hand-deployed SPI equipment is typically limited to areas where water depth is less than 6 feet, but where locations may either by accessible by wading from shore or by a pontoon boat (hand deployment from a jon boat is not recommended due to safety considerations). If the SPI camera equipment is unobtainable on an acceptable schedule, a box corer will be used and the photographs will be obtained after opening the box core samples. The box corer technique has a disadvantage in that the sediments are typically significantly disturbed by the sample collection itself which may mix or alter the sediments. Due to their size, box corers also require deployment from a vessel equipped with an appropriately sized winch and associated equipment.

Visual inspection will be conducted in Lake Conway at approximately 12 locations with three photos at each location, including three locations within 150 feet of Highway 89 culvert (Figure 10). In addition, SPI images will be collected at the background sediment locations (Figure 7) to provide a representation of the degree of variability in sediment type and texture within Lake Conway. Depending upon the results of this survey, SPI images may be used to select sediment core locations for collection and analysis during a second field effort.

3. Laboratory Sample Quality Assurance

Sample and analytical quality assurance for laboratory samples will be achieved through compliance with the project QAPP (ARCADIS 2013). In accordance with this sampling plan, the following quality assurance samples will be collected during implementation of this sampling plan:

- One field duplicate sample per 20 field samples collected per medium (i.e., one per 20 soil samples and one per 20 sediment samples). Field duplicate samples will be sequentially numbered as any other sample, and for purposes of laboratory analysis and chain-of-custody, there will be no identifying markers of duplicate samples.
- One matrix spike/matrix spike duplicate per 20 field samples collected per medium.
- One rinsate blank sample per day on decontaminated, non-dedicated sampling equipment (e.g., spoons and stainless steel bowls used for sample homogenization, hand auger).
- One trip blank per cooler containing samples that will be analyzed for VOCs.

4. Reporting

A data report will be prepared to document the sediment, soil, and surface water sampling activities and summarize field and analytical data. The report will include relevant tables and figures to present the data collected. The data will be evaluated and compared to ecological screening values (ESVs) as appropriate, consistent with USEPA risk assessment guidance and described in the following sections. Survey data will be used in association with stormwater runoff estimates and Lake Conway water level history to identify areas frequently inundated on a seasonal basis.

The data evaluation will focus on the protection of potential ecological receptors in both the aquatic and terrestrial environments. Future human exposure associated with recreational use may be possible after remediation is complete. Based on agreement with the agencies, initial data evaluation will focus on the ecological receptors but human exposures are evaluated as well due to the ecological endpoints being protective of potential human receptors as well.

Based on these evaluations, follow-up sediment, soil, and surface water investigations may be warranted. If additional data collection needs are identified, supplemental data collection plans will be prepared.

4.1.1 Sediment Data Evaluation

The data report will include comparison of sample analytical results to relevant ESVs. Sediment ESVs will be obtained from the following sources in order of hierarchy:

1. USEPA Region IV Sediment Screening Levels (USEPA 2001)
2. USEPA Region III Freshwater Sediment Screening Values (USEPA 2006)
3. USEPA Region V Screening Values (USEPA 2003a)
4. USEPA ECOTOX Thresholds (USEPA 2013b)
5. National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs; Buchman 2008)
6. Canadian Council of Ministers of the Environment (CCME 2008)
7. Other sources

Sediment data will also be compared to sediment background concentrations from samples collected in the drainage way upstream of the oil-impacted areas and in Lake Conway.

Ecological toxicity of PAHs to sediment organisms (which occur as mixtures rather than individual constituents) results from cumulative effects of the various PAHs in a mixture. Therefore, toxicity of PAHs to ecological endpoints is evaluated as a mixture. The evaluation is done differently depending on the medium in which the PAHs are present. For sediment, the USEPA (2003b) developed guidance for evaluating the toxicity of PAH mixtures, which also considers their bioavailability: Procedures for Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. The guidance presents final chronic values (FCVs) that are defensible, numerical, and constituent-specific concentration limits of PAHs applicable across a range of sediment types and that can be used to assess the extent of ecological risks of contaminated sediments, determine pollution control, and identify, prioritize, and implement appropriate cleanup levels (USEPA 2003b).

To evaluate the combined toxic contributions of PAHs in a mixture, the sum of the quotients of the measured PAH concentrations in sediment pore water (normalized to organic carbon, PAH_n) to the FCVs for each individual PAH is calculated. FCVs are presented for 34 PAHs, including alkylated and parent PAHs, which will be among the constituents analyzed for at the site as noted in Table 3. The quotient is called an Equilibrium Partitioning Sediment Benchmark Toxic Unit (ESBTUFCV or TU) and the summation as represented by ESBTUFCV (total TU) is analogous to a hazard index (HI).

$$TU = \frac{[PAH_1]}{FCV_1} + \frac{[PAH_2]}{FCV_2} + \ldots + \frac{[PAH_n]}{FCV_n}$$

If the HI (total TUs) is equal to or less than one in a given sediment sample, the concentration of the PAH mixture in sediment is acceptable for the protection of benthic organisms. If the HI exceeds one, the concentration of the PAH mixture in the sediment may not be acceptable for the protection of benthic organisms. The ESB TU evaluation will be conducted for aquatic sediment sample results along with comparison of results to approximate screening criteria.

Because PAHs bind to organic carbon in sediment, to estimate the PAH concentration in porewater (C_{pw}), the concentration in sediment (C_{sed}) has to be normalized to that of organic carbon. The USEPA guidance (2003b) describes the method for a one-carbon partitioning model that incorporates TOC. TOC is a measure of natural organic carbon such as vegetative debris, humic and fulvic acids, and decayed remains of plants and animals. Sediment TOC is quantified as the fraction of organic carbon (f_{OC}) in sediment. The one-carbon partitioning model is shown in the equation below (USEPA 2003b).

$$[PAH] \text{ or } C_{pw} = C_{sed} / f_{OC}$$

However, the guidance (USEPA 2003b) also recognized that various types of carbon have differing capacity for binding PAHs and other narcotic chemicals. One such type of carbon that has been shown to have a significant binding capacity is BC (anthropogenic carbon) such as coke, charcoal, and soot, which are known to have extremely high sorption capacities (Accardi-Dey and Gschwend 2002 and 2003, Burgess 2009, Ghosh 2007, Hauck et al. 2007, Hawthorne et al. 2007, Interstate Technology Regulatory Council 2011, Lohmann et al. 2005). Whereas the natural organic matter partitioning model discussed above (USEPA 2003b) is still used widely in developing sediment quality guidelines for PAHs based on FCVs of PAHs in the equilibrium water phase, the presence of BC in sediments may make this approach overly conservative. Therefore, a two-carbon model can also be used to better estimate the C_{pw} using the following relationship from Accardi-Dey and Gschwend (2002), which is used iteratively, to estimate the freely dissolved PAH concentration by solving for C_{pw}.

$$C_{sed}/C_{pw} = f_{OC} \times K_{OC} + f_{BC} \times K_{BC} C_{pw}^{\,n-1}$$

Where:

C_{sed} = Concentration of each individual PAH in sediment (micrograms per kilogram [kg] dry weight; measured value)

C_{pw} = Concentration of freely dissolved PAH in pore water (micrograms per liter; estimated value)

f_{OC} = Fraction of organic carbon exclusive of in sediment (kg organic carbon per kg dry weight); f_{OC} exclusive of BC is calculated from the difference between TOC and BC (measured values)

f_{BC} = Fraction of BC in sediment (kg BC per kg dry weight; measured value)

K_{BC} = BC – pore water partition coefficient for each individual PAH (liters per kg BC; Koelmans et al. 2006) [1]

K_{OC} = Organic carbon – water partition coefficient for each individual PAH (liter per kg organic carbon; USEPA 2003b)

n = Freundlich coefficient for sorption to BC (unitless) (0.7; Hauck et al. 2007)

Once C_{pw} is determined for each PAH in a sediment sample using sample specific measures of organic carbon, then the PAH-specific C_{pw} is divided by its respective FCV (USEPA 2003b) to calculate a PAH-specific TU. The TU for a PAH mixture in each sample is then determined by summing the PAH-specific TUs.

The report will include a presentation of Dart sample PAH depth profiles and comparison of the Dart samples and the analytical data to evaluate potential suitability of Dart as a PAH delineation technique in the event that additional information is needed. The report will also include an analysis of the sediment deposition inspection and photography, which will characterize sediment types, evaluate the presence of any discernible new surficial depositional layers, and to map changes in visual characteristics of the sediment surface of Lake Conway in the area of observation.

4.1.2 Soil Data Evaluation

The data report will include comparison of the soil sample analytical results to relevant soil ESVs. Soil ESVs will be obtained from the following sources in order of hierarchy:

1. USEPA Ecological Soil Screening Levels (USEPA 2013a), including those for PAHs (USEPA 2007)
2. USEPA Region IV Screening Values (USEPA 2011)
3. USEPA Region V Screening Values (USEPA 2003a)
4. NOAA SQuiRTs (Buchman 2008)

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[1] PAH-specific K_{BC}s will be calculated based on a regression equation from Koelmans et al. 2006 ($LogK_{BC}$ = 0.6997$LogK_{ow}$ + 2.8219). This regression equation was selected because it was derived using values from various laboratory and field studies obtained from the literature.

5. CCME (2008)
6. Other sources

In addition, soil concentrations will be compared to concentrations from background samples collected in marsh areas around Lake Conway and values for the protection of human health such as the latest version of the USEPA Regional Screening Level values (USEPA 2012). Other pertinent and appropriate soil screening values may also be used.

To evaluate the combined toxic contributions of PAHs for soil, the USEPA guidance (2007) recommends grouping the PAHs based on molecular weight: low molecule weight PAHs and high molecule weight PAHs and then comparing the sums to applicable screening levels.

4.1.3 Surface Water Data Evaluation

Individual surface water sample results will be compared initially to the *Arkansas Pollution Control and Ecology Commission Regulation No. 2* Standards dated August 26, 2011. In addition, the data report will include comparison of the surface water analytical results to other relevant surface water ESVs, to be obtained from the following sources in order of hierarchy:

1. USEPA National Recommended Water Quality Criteria for Freshwater Aquatic Life Chronic Continuous Criteria (USEPA 2013c)
2. USEPA Region IV Screening Values (USEPA 2001)
3. USEPA Region III Freshwater Screening Values (USEPA 2006)
4. USEPA Region V Screening Values (USEPA 2003a)
5. NOAA SQuiRTs (Buchman 2008)
6. CCME (2008)
7. Oak Ridge National Laboratory (Suter and Tsao 1996)
8. Other sources

To evaluate the combined toxic contributions of PAHs in a mixture, the sum of the quotients of the measured PAH concentrations in surface water to the FCVs for each individual PAH is calculated. FCVs are presented for 34 PAHs, including alkylated and parent PAHs, which will be among those analyzed for at the site as noted in Table 3.

5. Schedule

This sampling plan will be implemented upon approval by the Arkansas Department of Environmental Quality and other agencies. Maintenance activities will continue for the A-Main, A-365E, A-365W, and Dawson Cove areas. These activities include:

- A-Main, A-365E and A-365W areas: maintenance and monitoring of the sorbent boom and pads as needed
- Dawson Cove: maintaining the north and south shorelines (using conservative measures) and repositioning and maintaining hard boom, curtain boom, and absorbent boom as needed in Dawson Cove; and assisting the wildlife group as required.

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Tables

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 1 - Sampling Approach Summary

Area	Sampling Approach	Approximate Number of Sample Locations and Estimated Total Number of Samples (in parentheses)		
		Sediment	Soil	Surface Water
A-Main	Up to four 1-foot sediment cores will be collected at unbiased locations evenly distributed along the centerline of the ditch. The surface interval (0 to 6 inches) and subsurface interval (6 to 12 inches) samples will be submitted for analysis. Soil cores will be collected from areas adjacent to each sediment core and on alternating sides of the ditch above the water line. Along North Main Street, five cores will be collected from up to four grids approximately 10 feet by 25 feet in size and will be used to form a 5-point composite. The width of the grid will depend on the available width of the bank. Two additional sampling grids will be established adjacent to the concrete channel located west of North Main Street. The surface (0- to 6-inch) interval of each core will be composited and submitted for analysis. At the centroid core location, the subsurface intervals (6 to 12 inches and 12 to 18 inches) will also be submitted to the laboratory for analysis.	4 (8)	6 (18)	1
A-365W	Up to five 1.5-foot sediment cores will be collected at unbiased locations evenly distributed along the length of the ditch. The core locations will alternate one-third of the distance from either the north or south bank. Three 6-inch-depth interval samples (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. Soil cores will be collected from areas adjacent to each sediment core and on alternating sides of the ditch above the water line. Five cores will be collected from up to five grids approximately 15 feet by 25 feet in size and will be used to form a 5-point composite. The surface (0- to 6-inch) interval of each core will be composited and submitted for analysis. At the centroid core location, the subsurface intervals (6 to 12 inches and 12 to 18 inches) will also be submitted to the laboratory for analysis. One surface water sample will be collected at the midpoint of this subsection.	5 (15)	5 (15)	1

ExxonMobil Pipeline Company

Mayflower Pipeline Incident, Mayflower, Arkansas

Downstream Areas Remedial Sampling Plan

Table 1 - Sampling Approach Summary

Area	Sampling Approach	Approximate Number of Sample Locations and Estimated Total Number of Samples (in parentheses)		
		Sediment	Soil	Surface Water
A-365E	Up to four 1.5-foot sediment cores will be collected at unbiased locations evenly distributed along the length of the ditch. The core locations would alternate one-third of the distance from either the north or south bank. The three interval samples (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. Soil cores will be collected from areas adjacent to each sediment core and on alternating sides of the ditch. Due to the geometry of the ditch, four 18-inch cores will be collected from the midpoint of the bank, but additional surface compositing will not be completed. The three interval samples (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. One surface water sample will be collected at the midpoint of this subsection.	4 (12)	4 (12)	1
B-Dawson Cove	Up to eight 1.5-foot sediment cores will be collected at unbiased locations distributed approximately 200-foot intervals along the length of the main channel. The core locations would alternate one-third of the distance from either the north or south bank. The three interval samples (0 to 6 inches, 6 to 12 inches, and 12 to18 inches) will be submitted for analysis. Marsh samples will be collected using 5-point composites centered on a 200-foot sample grid, yielding approximately 14 composite samples from this subsection. For each composite, five cores will be collected from a grid approximately 25 feet by 25 feet in size. The surface (0- to 6-inch) interval of each core will be composited and submitted for analysis, and the subsurface (6- to 12-inch, 12- to 18-inch, 18- to 24-inch, and 24- to 36-inch) interval of the centroid core will also be submitted to the laboratory; however, the 18- to 24-inch and 24- to 36-inch depth intervals will be analyzed only if the bottom-most sample exceeds screening criteria. Four marsh soil locations will be targeted for co-located Dart analysis. One surface water sample will be collected from approximately the middle of open standing water at the time of sampling in this subsection.	8 (24)	14 (42) + 4 Dart	1

ExxonMobil Pipeline Company

Mayflower Pipeline Incident, Mayflower, Arkansas

Downstream Areas Remedial Sampling Plan

Table 1 - Sampling Approach Summary

Area	Sampling Approach	Approximate Number of Sample Locations and Estimated Total Number of Samples (in parentheses)		
		Sediment	Soil	Surface Water
Upper B-On Water	Eight sediment cores will be collected at locations on a 150-foot sampling grid in the southernmost portion of this subsection. Six of these sediment cores will be analyzed to a target depth of at least 3 feet and up to 4 feet (or refusal), and five locations are targeted for co-located Dart analysis. The interval samples (0 to 6 inches, 6 to 12 inches, 12 to 18 inches, 18 to 24 inches, and 24 to 36 inches) will be submitted for analysis; however, the 18- to 24- and 24- to 36-inch depth intervals will be analyzed only if the bottom-most sample exceeds screening criteria. In the two remaining sediment cores, the three interval samples (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. Fourteen marsh samples will be collected using 5-point composites centered on a 200-foot sample grid. For each composite, five cores will be collected from a grid approximately 25 feet by 25 feet in size. The surface (0- to 6-inch) interval of each core will be composited and submitted for analysis, and the subsurface (6- to 12-inch, 12- to 18-inch, 18- to 24-inch, and 24- to 36-inch) interval of the centroid core will also be submitted to the laboratory; however, the 18- to 24-inch and 24- to 36-inch depth intervals will be analyzed only if the bottom-most sample exceeds screening criteria. One marsh soil location will be targeted for co-located Dart analysis. Locations selected for this analysis will be analyzed to depth of refusal in 1-foot increments. Two surface water samples will be collected at locations approximately one-third and two-thirds of the longitudinal distance of the main creek channel along the subsection.	8 (24) + 5 Dart	14 (42) + 1 Dart	2

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 1 - Sampling Approach Summary

Area	Sampling Approach	Approximate Number of Sample Locations and Estimated Total Number of Samples (in parentheses)		
		Sediment	Soil	Surface Water
Lower B-On Water	In the northern "lower" portion of this subsection, seven sediment cores will be collected at unbiased locations evenly distributed along the axis of the open water. Three of these sediment cores will be analyzed to a target depth of at least 3 feet and up to 4 feet (or refusal). The interval samples (0 to 6 inches, 6 to 12 inches, 12 to 18 inches, 18 to 24 inches, and 24 to 36 inches) will be submitted for analysis; however, the 18- to 24- and 24- to 36-inch depth intervals will be analyzed only if the bottom-most sample exceeds screening criteria. At the other four locations, the three interval samples (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. Surface water samples in the B-On Water area will be collected as described above in "Upper B-On Water."	7 (21)	n/a	see above
Lake Conway Near Highway 89 Culvert	Six 1.5-foot sediment samples will be collected near the culvert. The three intervals (0 to 6 inches, 6 to 12 inches, and 12 to 18 inches) will be submitted for analysis. Response activities are under way that include the collection of surface water samples at approved sample locations; these are expected to continue. Therefore, no additional samples are currently proposed in this sampling plan.	6 (18)	n/a	(Will be collected under existing Lake Conway Sampling Plan)
Lake Conway Background Samples	Six surface sediment samples (0 to 6 inches) will be collected along the shoreline of Lake Conway and submitted for analysis. Three marsh samples will be collected using 5-point composites. For each composite, five cores will be collected from a grid approximately 25 feet by 25 feet in size. The surface (0- to 6-inch) interval of each core will be composited and submitted for analysis. Response activities are under way that include the collection of surface water samples at approved sample locations; these are expected to continue. Therefore, no additional samples are currently proposed in this sampling plan.	6 (6)	6 (6)	(Will be collected under existing Lake Conway Sampling Plan)

ExxonMobil Pipeline Company

Mayflower Pipeline Incident, Mayflower, Arkansas

Downstream Areas Remedial Sampling Plan

Table 1 - Sampling Approach Summary

Area	Sampling Approach	Approximate Number of Sample Locations and Estimated Total Number of Samples (in parentheses)		
		Sediment	Soil	Surface Water
Drainage Background Samples	Surface sediment samples (0 to 6 inches) will be collected from six locations in the drainage way: 1) three along the A-Main ditch upstream of the crude oil-impacted area; 2) one along the creek upstream of the confluence with the A-Main ditch; and 3) two at a stormwater ditch along Highway 89 prior to its confluence with the crude oil-impacted area.	6 (6)	n/a	n/a
	Total (not including QA/QC samples):	**54 (134) + 5 Dart**	**49 (135) + 5 Dart**	**6**

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 2 - Sample Containers, Analytical Methods, Hold Times, and Preservation Methods

Parameter	Sample Containers	Analytical Methods	Preservation Methods	Hold Times [1]
Sediment				
Volatile Organic Compounds	Collect with Terra Core 3 x 40 ml VOA vials	8260 [2]	2 vials Sodium Bisulfate; 1 vial Methanol; Cool to <6°C	14 days to analysis
	1 - 2 oz wide-mouth glass jar	8260 [2]	Cool to <6°C	48 hours to extraction for preservation; 14 days to analysis
Polycyclic Aromatic Hydrocarbons	1 - 8 oz glass jar with Teflon®-lined lid	Modified 8270 SIM [4]	Cool to <6°C	14 days to extraction
Total Extractable Hydrocarbons		Modified 8015 [4]		40 days to analysis
Total Metals (except Mercury)	1 - 4 oz wide-mouth glass jar	6010 [2]	Cool to <6°C	180 days to analysis
Mercury		7471 [2]		28 days to analysis
Grain Size	Large Ziploc® bag	ASTM - D422	NS	NS
Total Organic Carbon	1 - 8 oz glass jar	Lloyd Kahn	Cool to <6°C	28 days to analysis
Black Carbon		Gustafsson		
Archive [3]	1 - 8 oz glass jar with Teflon®-lined lid	TBD	Frozen at approximately -10°C	1 year
Soil				
Volatile Organic Compounds	Collect with Terra Core 3 x 40 ml VOA vials	8260 [2]	2 vials Sodium Bisulfate; 1 vial Methanol; Cool to <6°C	14 days to analysis
Polycyclic Aromatic Hydrocarbons	1 - 4 oz glass jar with Teflon®-lined lid	Modified 8270 SIM [4]	Cool to <6°C	14 days to extraction
				40 days to analysis
Total Metals (except Mercury)	1 - 4 oz glass jar with Teflon®-lined lid	6010 [2]	Cool to <6°C	180 days to analysis
Mercury		7471 [2]		28 days to analysis
Grain Size	Large Ziploc® bag	ASTM - D422	NS	NS
Total Organic Carbon	1 - 8 oz glass jar	Lloyd Kahn	Cool to <6°C	28 days to analysis
Black Carbon		Gustafsson		
Archive [3]	1 - 8 oz glass jar with Teflon®-lined lid	TBD	Frozen at approximately -10°C	1 year
Surface Water				
Volatile Organic Compounds	3 - 40 ml glass vials	8260 [2]	HCl pH <2; Cool to <6°C	14 days to analysis
Polycyclic Aromatic Hydrocarbons	2 - 250 ml amber glass bottles with Teflon®-lined lid	Modified 8270 SIM [4]	Cool to <6°C	7 days to extraction
				40 days to analysis
Total Metals (except Mercury)	1 - 500 ml plastic bottle	6010 [2]	HNO_3 to pH<2 Cool to <6°C	180 days to analysis
Total Mercury		7470 [2]		28 days to analysis
Dissolved Metals (except Mercury)	1 - 500 ml plastic bottle (lab filtered)	6010 [2]	Cool to <6°C	180 days to analysis
Dissolved Mercury		7470 [2]		28 days to analysis
Total Suspended Solids	500 ml plastic bottle	SM 2540 D-1997 [2]	Cool to <6°C	7 days to analysis
Oil & Grease (HEM)	2 - 1 liter glass bottles with Teflon®-lined lid	1664A [2]	HCl to pH <2; Cool to <6°C	28 days to analysis

Notes:

[1] All holding times are from sample collection date.

[2] USEPA. Office of Solid Waste and Emergency Response. *Test Methods for Evaluating Solid Waste. SW-846 3rd ed. Update IV Washington, D.C. 1996.*

[3] Additional analytical parameters or biomarkers may be added based on the results.

[4] Refer to Table 3 for the list of analytes included in Modified 8270 SIM and Modified 8015.

All sediments and soils to be reported in dry weight.

°C - degrees Celsius
HCl - hydrogen chloride
HNO_3 - nitric acid
oz - ounce
ml - milliliter
NS - not specified

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 3 - List of Laboratory Analytes

Analyte	CAS Number
Volatile Organic Compounds (Method 8260)	
1,1,1,2-Tetrachloroethane	630-20-6
1,1,1-Trichloroethane	71-55-6
1,1,2,2-Tetrachloroethane	79-34-5
1,1,2-Trichloroethane	79-00-5
1,1,2-Trichlorotrifluoroethane	76-13-1
1,1-Dichloroethane	75-34-3
1,1-Dichloroethene	75-35-4
1,1-Dichloropropene	563-58-6
1,2,3-Trichlorobenzene	87-61-6
1,2,3-Trichloropropane	96-18-4
1,2,4-Trichlorobenzene	120-82-1
1,2,4-Trimethylbenzene	95-63-6
1,2-Dibromo-3-chloropropane	96-12-8
1,2-Dibromoethane (EDB)	106-93-4
1,2-Dichlorobenzene	95-50-1
1,2-Dichloroethane	107-06-2
1,2-Dichloropropane	78-87-5
1,3,5-Trimethylbenzene	108-67-8
1,3-Dichlorobenzene	541-73-1
1,3-Dichloropropane	142-28-9
1,4-Dichlorobenzene	106-46-7
2,2-Dichloropropane	594-20-7
2-Butanone (MEK)	78-93-3
2-Chlorotoluene	95-49-8
4-Chlorotoluene	106-43-4
4-Methyl-2-pentanone (MIBK)	108-10-1
Acetone	67-64-1
Allyl chloride	107-05-1
Benzene	71-43-2
Bromobenzene	108-86-1
Bromochloromethane	74-97-5
Bromodichloromethane	75-27-4
Bromoform	75-25-2
Bromomethane	74-83-9
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroethane	75-00-3

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 3 - List of Laboratory Analytes

Analyte	CAS Number
Volatile Organic Compounds (Method 8260)	
Chloroform	67-66-3
Chloromethane	74-87-3
cis-1,2-Dichloroethene	156-59-2
cis-1,3-Dichloropropene	10061-01-5
Dibromochloromethane	124-48-1
Dibromomethane	74-95-3
Dichlorodifluoromethane	75-71-8
Dichlorofluoromethane	75-43-4
Diethyl ether (Ethyl ether)	60-29-7
Ethylbenzene	100-41-4
Hexachloro-1,3-butadiene	87-68-3
Isopropylbenzene (Cumene)	98-82-8
Methylene Chloride	75-09-2
Methyl-tert-butyl ether	1634-04-4
Naphthalene	91-20-3
n-Butylbenzene	104-51-8
n-Propylbenzene	103-65-1
p-Isopropyltoluene	99-87-6
sec-Butylbenzene	135-98-8
Styrene	100-42-5
tert-Butylbenzene	98-06-6
Tetrachloroethene	127-18-4
Tetrahydrofuran	109-99-9
Toluene	108-88-3
trans-1,2-Dichloroethene	156-60-5
trans-1,3-Dichloropropene	10061-02-6
Trichloroethene	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl chloride	75-01-4
Xylene (Total)	1330-20-7
Pyrene	129-00-0

Table 3 - List of Laboratory Analytes

Analyte	CAS Number
Polycyclic Aromatic Compounds (PAHs) (Modified Method 8270 SIM) [1]	
Unsubstituted	
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Anthracene	120-12-7
Benzo(g,h,i)perylene	191-24-2
Benzo[a]anthracene	56-55-3
Benzo[a]pyrene	50-32-8
Benzo[b]fluoranthene	205-99-2
Benzo[e]pyrene	192-97-2
Benzo[k]fluoranthene	207-08-9
Chrysene	218-01-9
Dibenz(a,h)anthracene	53-70-3
Dibenzothiophene	132-65-0
Fluoranthene	206-44-0
Fluorene	86-73-7
Indeno[1,2,3-cd]pyrene	193-39-5
Naphthalene	91-20-3
Perylene	198-55-0
Phenanthrene	85-01-8
Pyrene	129-00-0
Alkylated	
1-Methylnaphthalene	90-12-0
2-Methylnaphthalene	91-57-6
C1-Benzanthrene/chrysenes	--
C1-Dibenzothiophene	--
C1-Fluoranthenes/Pyrenes	--
C1-Fluorenes	--
C1-Phenanthrenes/Anthracenes	--
C2-Benzanthrene/chrysenes	--
C2-Dibenzothiophene	--
C2-Fluoranthenes/Pyrenes	--
C2-Fluorenes	--
C2-Naphthalenes	--
C2-Phenanthrenes/Anthracenes	--
C3-Benzanthrene/chrysenes	--
C3-Dibenzothiophene	--
C3-Fluoranthenes/Pyrenes	--
C3-Fluorenes	--
C3-Naphthalenes	--
C3-Phenanthrenes/Anthracenes	--
C4-Benzanthrene/chrysenes	--
C4-Dibenzothiophene	--
C4-Fluoranthenes/Pyrenes	--
C4-Naphthalenes	--
C4-Phenanthrenes/Anthracenes	--

ExxonMobil Pipeline Company
Mayflower Pipeline Incident, Mayflower, Arkansas
Downstream Areas Remedial Sampling Plan

Table 3 - List of Laboratory Analytes

Analyte	CAS Number
Total Extractable Hydrocarbon (Modified Method 8015)	
Total Resolveable Hydrocarbons	--
Total Petroleum Hydrocarbons	--
Unresolved Complex Mixture	--
Metals (Method 6010/7471)	
Arsenic	7440-38-2
Barium	7440-39-3
Cadmium	7440-43-9
Chromium	7440-47-3
Lead	7439-92-1
Mercury	7439-97-6
Nickel	7440-02-0
Selenium	7782-49-2
Silver	7440-22-4
Vanadium	7440-62-2

Notes:

1. Additional PAHs may be added for surface sediment sampling in B-On Water, Lake Conway, and background locations. All PAH analyses will be completed by B&B Labs in College Station, TX, an Arkansas Certified lab.

Figures

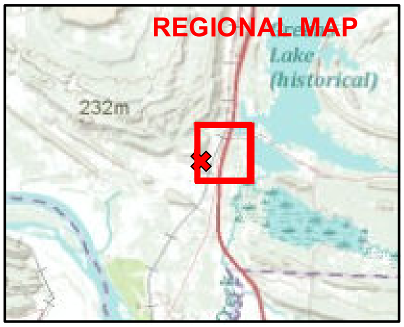
Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_SiteLocation.mxd

Bing Aerial Hybrid Image Source: Bing Online Services, Access date: 4/4/2013, via ArcGIS v. 10. This image is not for re-sale or distribution outside of the use of this PDF.

LEGEND

- Source Point
- Drainage Path
- Operations Areas

REGIONAL MAP



Map Date: 7/3/2013

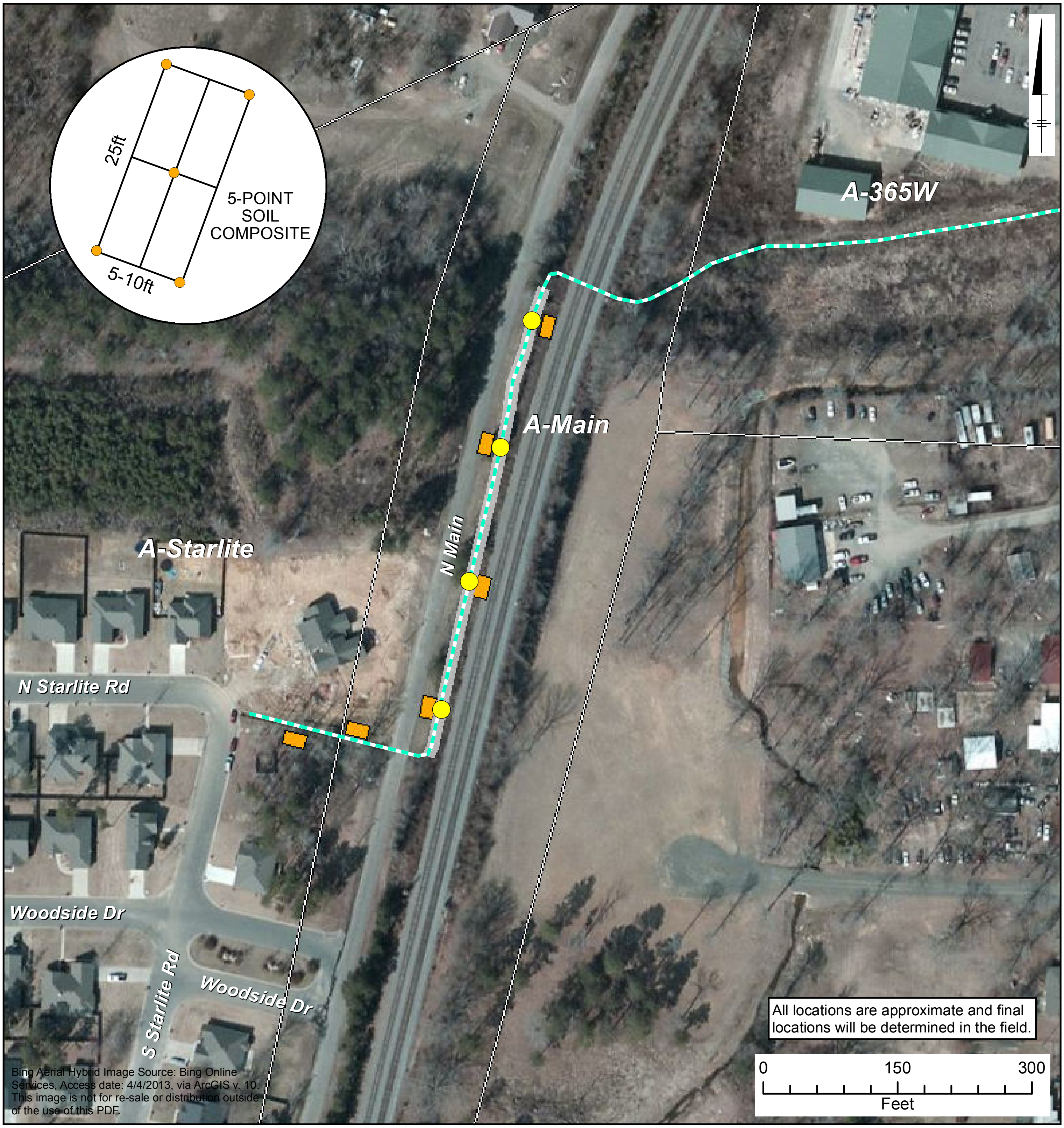
MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

SITE LOCATION MAP

ARCADIS

FIGURE **1**

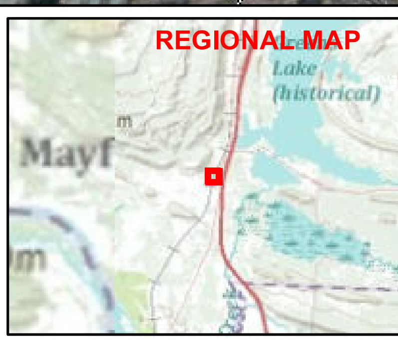
Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_AMain_PropSampling.mxd



LEGEND

- Sediment Sample
- Soil Sample
- Study Area
- Drainage Path
- Operations Areas

Map Date: 7/3/2013



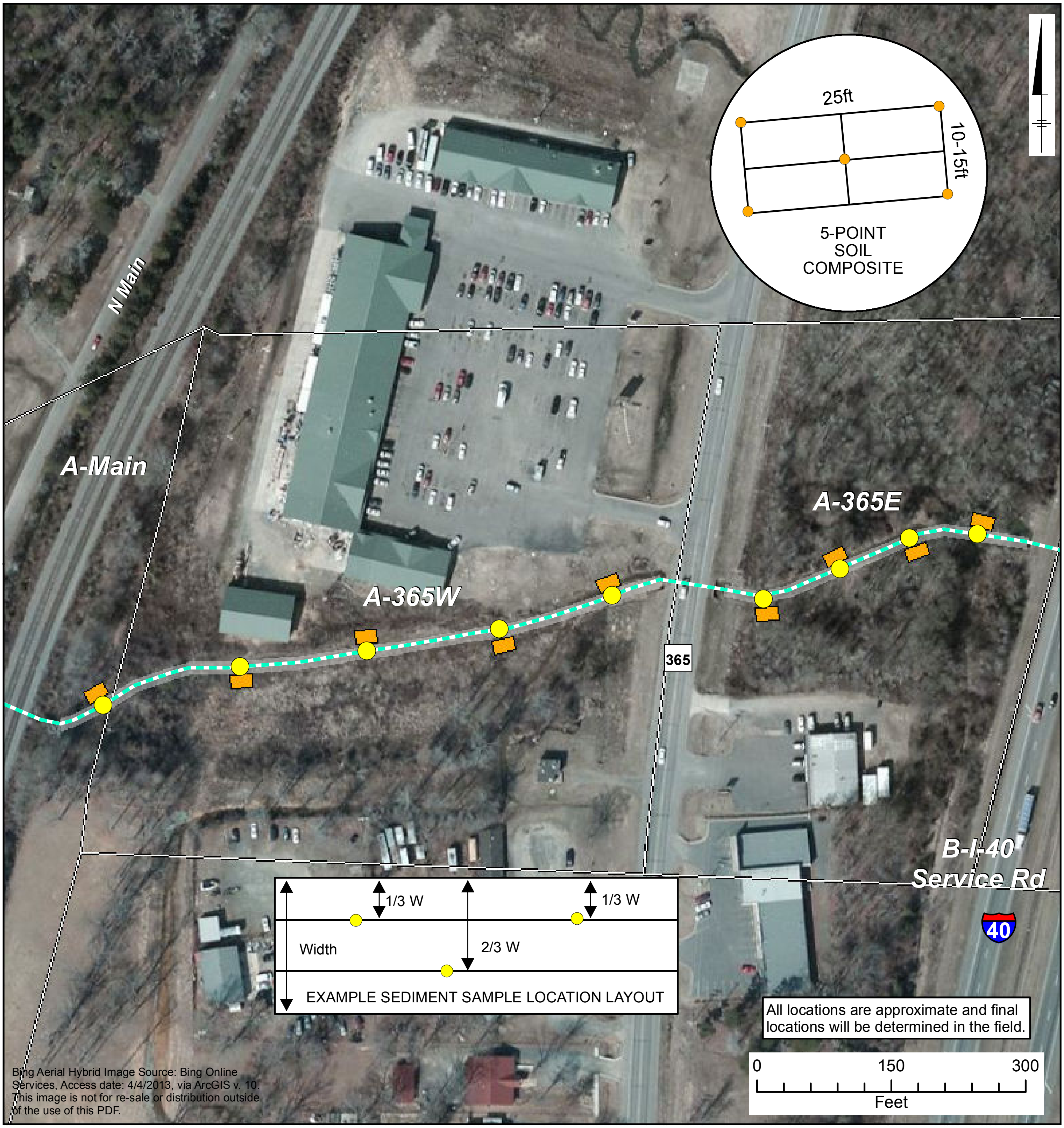
MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SAMPLE LOCATIONS IN A-MAIN

ARCADIS

FIGURE
2

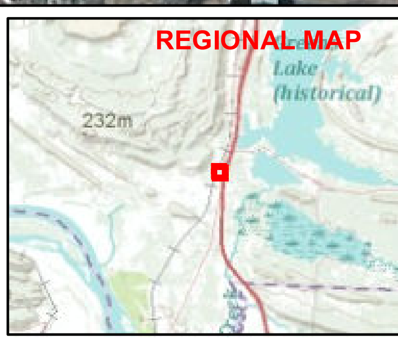
Office: CITRIX Author: MNesta Last Saved By: ssutton
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_A365_PropSampling.mxd



LEGEND

- Sediment Sample
- Soil Sample
- Study Area
- Drainage Path
- Operations Areas

Map Date: 7/3/2013

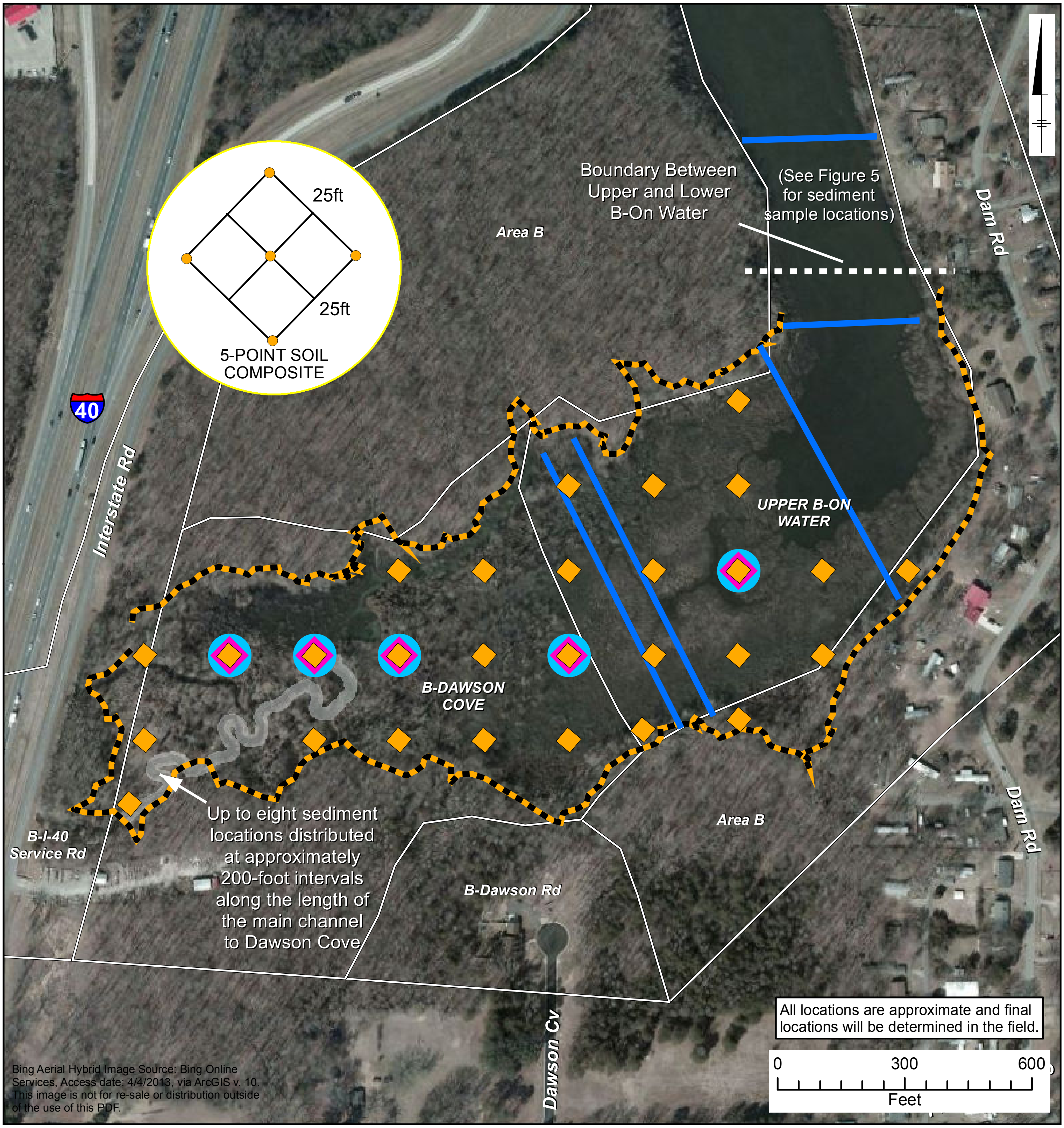


MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SAMPLE LOCATIONS IN A-365E & A-365W

ARCADIS

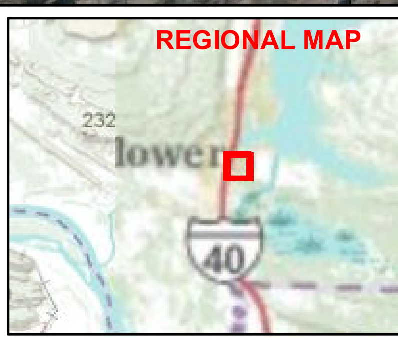
FIGURE
3



LEGEND

- Soil Sample
- Dart Sample Location
- Deep Core Sample Location
- Study Area
- Approximate Oiling Extent
- Operations Areas
- Containment Boom

REGIONAL MAP



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SAMPLE LOCATIONS IN B-DAWSON COVE AND UPPER B-ON WATER

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FIGURE 4

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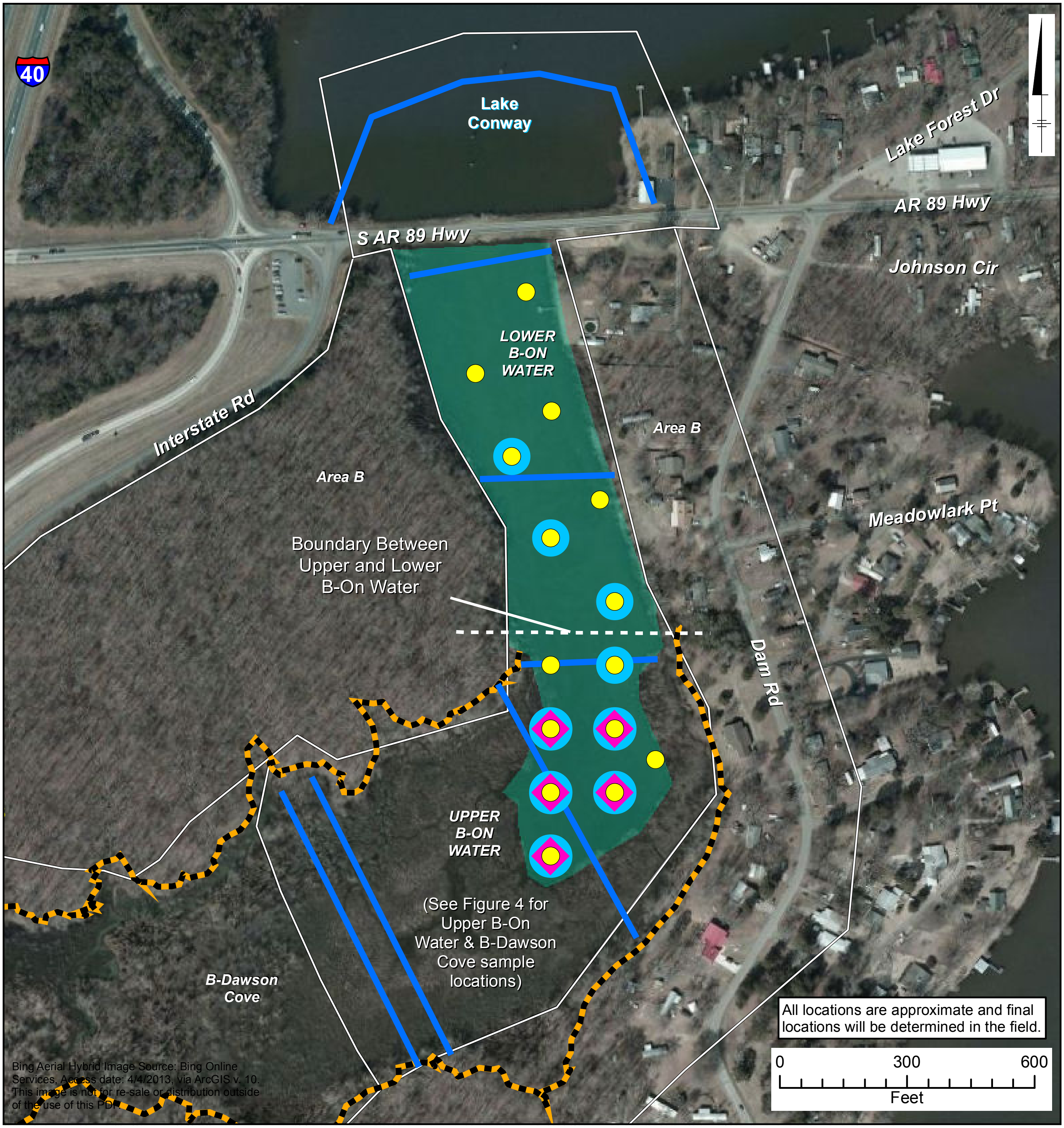
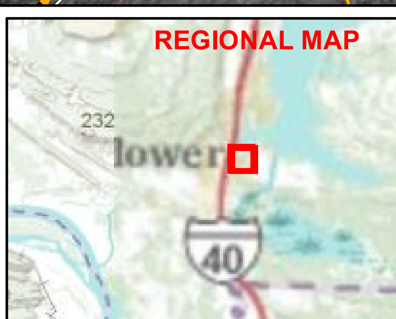
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_BOnWater_PropSampling.mxd



LEGEND

- Sediment Sample
- Dart Sample Location
- Deep Core Sample Location
- Operations Areas
- Approximate Oiling Extent
- Containment Boom

Map Date: 7/3/2013



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SAMPLE LOCATIONS IN B-ON WATER

ARCADIS

FIGURE 5

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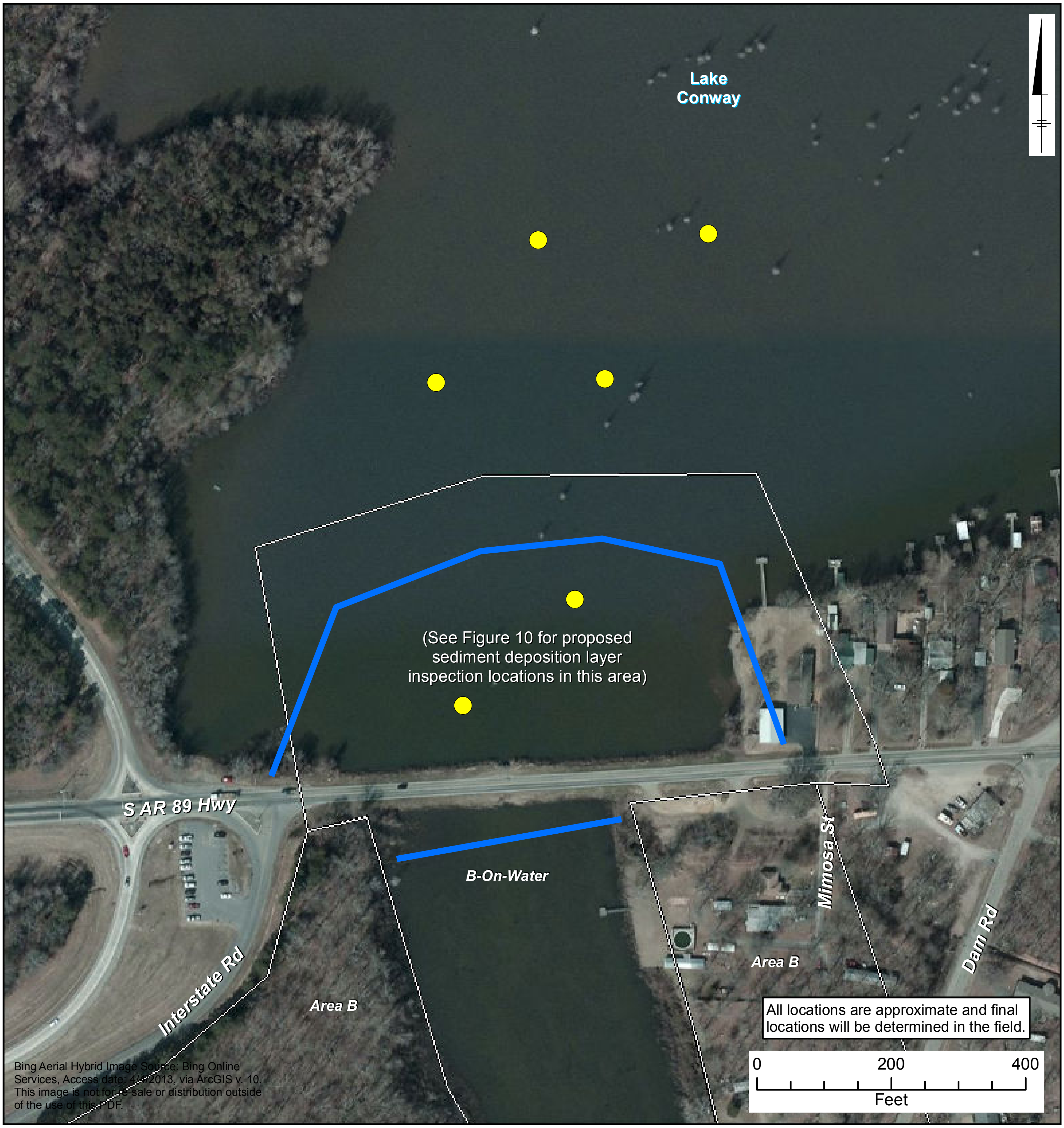
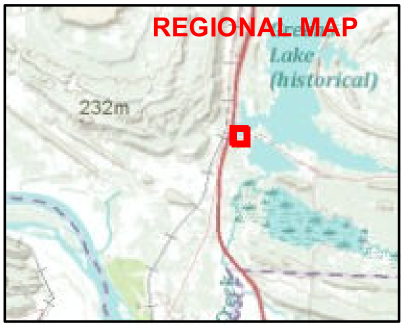
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_LakeConway_PropSampling.mxd



LEGEND
- Sediment Sample
- Containment Boom
- Operations Areas

Map Date: 7/3/2013

REGIONAL MAP



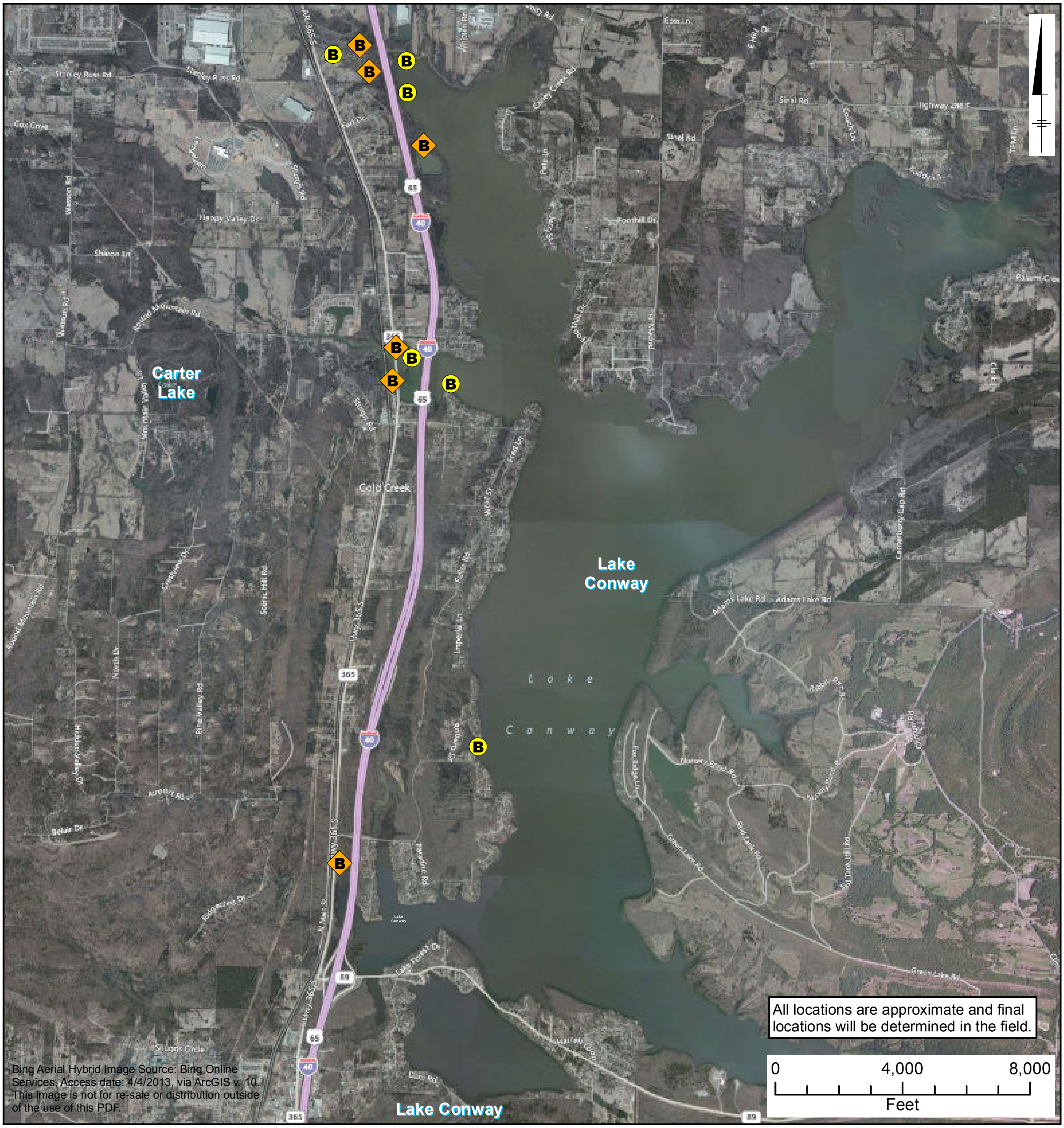
MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED LAKE CONWAY SEDIMENT SAMPLES

ARCADIS

FIGURE
6

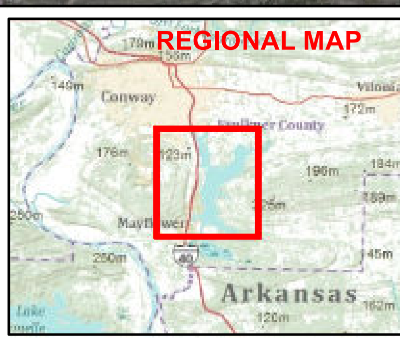
Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_LakeConway_PropSamplingBkgr.mxd



LEGEND

- B Background Sediment Samples
- B Background Soil Samples

Map Date: 7/3/2013



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED LAKE CONWAY BACKGROUND SEDIMENT AND SOIL SAMPLES

ARCADIS

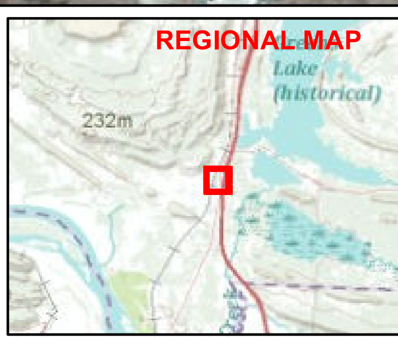
FIGURE
7

Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_DrainageWay_PropSamplingBkgr.mxd

LEGEND

- (B) Background Sediment Sample
- Drainage Path
- Operations Areas

Map Date: 7/3/2013



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED DRAINAGE WAY BACKGROUND SEDIMENT SAMPLES

ARCADIS

FIGURE 8

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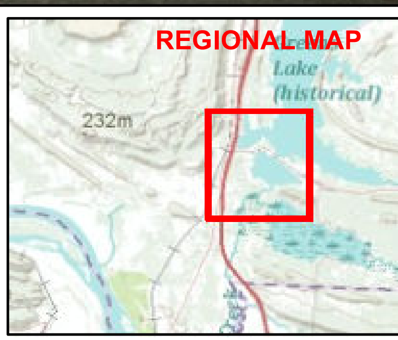
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_WS_PropSampling20130711.mxd

NOTE:
- All locations are approximate and final locations will be determined in the field.
- One-time surface water sample locations are described in the Downstream Areas Remedial Sampling Plan. Ongoing surface water sample locations are included in the Surface Water Sampling and Analysis Plan.

LEGEND

- One-time Surface Water Sample
- Ongoing Surface Water Sample Locations Accessed by Foot
- Ongoing Surface Water Sample Locations Accessed by Boat
- Drainage Path
- Containment Boom
- Operations Areas

Map Date: 7/11/2013



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SURFACE WATER SAMPLING LOCATIONS

ARCADIS

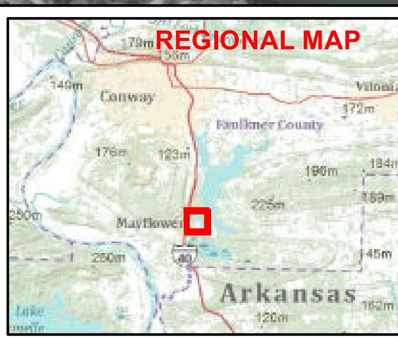
FIGURE
9

Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SEDIMENT\20130524\SED_SPI_CameraLocations.mxd

LEGEND

Sediment Deposition Layer Inspection Locations

Map Date: 7/3/2013



MAYFLOWER PIPELINE INCIDENT
EXXONMOBIL PIPELINE COMPANY
DOWNSTREAM AREAS REMEDIAL SAMPLING PLAN

PROPOSED SEDIMENT DEPOSITION LAYER INSPECTION LOCATIONS

ARCADIS

FIGURE
10

Attachment A

Relevant Standard Operating Procedures

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Infrastructure, environment, facilities

Imagine the result

Sediment Sampling – Shallow Core Tubing

Rev. # 0

Date: December 7, 2011

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection and field screening, logging, and subsequent sampling of sediment collected by core tubing. The general procedures to be utilized in obtaining sediment samples are outlined below.

This SOP should be followed whenever collecting, processing, logging, and sampling sediment using core tubing.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

All field personnel must have the appropriate training required by ARCADIS and ExxonMobil as described in the project Health and Safety Plan (HASP). ARCADIS field sampling personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. In addition to field training each employee must go through boat training, and review the boating and sampling JSA.

III. Equipment List

The following equipment will be needed during sediment sampling activities:

- aluminum boat with outboard motor
- health and safety equipment, as required by the site HASP;
- aluminum foil pan or stainless steel bowl;
- nitrile gloves;
- duct and packing tape;
- Lexan tubing with end caps;
- 1-qt and 1-gallon freezer bags;

- tape measure
- Global Positioning System (GPS);
- lexan core tube;
- garbage bags;
- photoionization detector (PID);
- transport container with ice;
- appropriate sample containers, labels and forms;
- field notebook;
- erasable whiteboard;
- site-specific HASP; and
- digital camera.

IV. Cautions

Field activities associated with sediment sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Always wear a PFD within 10 feet of water, watch for pinch and always have three points of contacts points upon boarding, traversing, and exiting the boat. Know what hazardous substances may be present in the sediment and understand their hazards. Always avoid the temptation to touch sediments with bare hands, detect odors by placing sediments close to your nose, or tasting sediments.

V. Procedure

Sediment Sampling Procedure

1. Identify the proposed sample location in the field notebook along with other appropriate information collected during sediment probing activities. Location, date, time of collection and description or surrounding area along with a photograph will be recorded for each sample.

2. Don personal protective equipment (PPE), as required by the HASP.

3. Probe sediment in the vicinity of the sampling location using a steel rod. If fine grained materials are not encountered, two additional areas per sediment sample location will be probed. Observations of oil impacts (e.g., visible oil or sheen) will be documented.

4. Record sample location with the GPS.

5. Verify the sampler has been decontaminated in accordance with the Decontamination SOP.

6. At each sample location, lower a section of Lexan tube until it reaches the top of sediment. Measure the depth of water.

7. Push the Lexan tube into the sediment by hand until refusal is encountered. Measure the depth of sediment.

8. Seal top of core tube to retain capillary pressure within barrel. Retrieve core tube and immediately cape bottom of tube.

9. Document appearance and recovery of the sample to confirm acceptability of the sample.

10. Pump the standing surface water from above the recovered sediment, being careful not to disturb the sediment-water interface.

11. Document the sampler penetration depth and recovery.

12. Immediately collect sediment for analysis of volatile compounds (i.e., VPH) in an Encore sampler. Collected these samples prior to screening or logging steps.

13. Collect a small aliquot (approximately 1 ounce [oz]) of sediment representative of the sediment sample and place into a zip-top bag. Perform PID headspace screening as follows:

    a. Allow sample to equilibrate to ambient temperature for approximately 15 minutes

    b. Insert ‘sniffer’ of the PID into the zip-top bag and read PID until value spikes and then stabilizes.

    c. Record the peak value displayed by the PID.

d. The aliquot of sediment used for headspace testing will not be sent for laboratory analysis.

14. Photo-document the sample to provide reference for post-processing questions regarding descriptions of color/staining general texture, recovery, etc. Photos will include a view of a dry-erase board marked with the sample identification, date and time. The photo will also include a view of a tape measure for scale.

15. Describe sediment sample according to Unified Soil Classification System (USCS) and document any other observations such as color, type of organic materials present, odor, sheen, staining, etc.

16. Sediment samples will be homogenized in disposable aluminum foil pans or stainless steel bowls, prior to placement into proper laboratory jars.

Field Cleaning Procedure

1. Follow health and safety procedure specified in the HASP.

2. Cleaning of reusable sampling equipment (e.g., Lexan tube, stainless steel bowls) will follow the decontamination procedures presented in the Decontamination SOP.

3. Cleaning will be conducted in plastic containers to collect all decontamination rinsate.

VI. Waste Management

Investigative derived waste (IDW) generated during the sediment sampling activities and disposable equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VII. Data Recording and Management

Upon collection of sediment samples, the sediment sample should be logged in the field log book. Field book scans, chain-of-custody records will be scanned and sent to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The team leaders will retain copies.

Digital photographs of typical sediment types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

VIII. Quality Assurance

Field documentation, data reporting requirements, sampling handling, custody requirements, packing, handling, and shipping requirements along with lab custody procedures, analytical methods, QC requirements, and laboratory specific QAQC requirements are stated in the site-specific Quality Assurance Project Plan.

Infrastructure, environment, facilities

Imagine the result

Soil Sampling – Hand Tools

Rev. # 0

Date: December 7, 2011

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection and field screening, logging, and subsequent sampling of soil collected using hand tools. The general procedures to be utilized in obtaining soil samples are outlined below.

This SOP should be followed whenever collecting, processing, logging, and sampling soil with hand tools.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

All field personnel must have the appropriate training required by ARCADIS and ExxonMobil as described in the project Health and Safety Plan (HASP). ARCADIS field sampling personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following equipment list describes materials that may be needed when carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE), as required by the site Health and Safety Plan (HASP);
- aluminum foil pan or stainless steel bowl;
- stainless steel spoons;
- stainless steel spades
- stainless steel hand auger;
- nitrile gloves;

- packing tape;
- 1-qt and 1-gallon sealable plastic bags;
- tape measure
- Global Positioning System (GPS);
- garbage bags;
- photoionization detector (PID);
- transport container with ice;
- appropriate sample containers, labels and forms;
- field notebook;
- erasable whiteboard;
- site-specific HASP; and
- digital camera.

IV. Cautions

Task specific Job Safety Analysis (JSAs) must be developed to identify site hazards associated with the investigation and reviewed by all field crew members prior to the start of work. Safe Performance Self-Assessment (SPSA) to be performed by employees before performing a new task. Underground utilities will be cleared per the Site Utility Locate SOP.

V. Procedure

Soil sampling may be collected at intervals from the ground surface to various depths. Sample points will be located and documented by surveying, use of a GPS.

1. Identify the proposed sample location in the field notebook along with other appropriate information such as, location, date, time of collection and description of surrounding area along with a photograph will be recorded for each sample.

2. Don personal protective equipment (PPE), as required by the HASP

3. Clear the ground surface of brush, root mat, grass, leaves, or other debris.

4. Use a trowel, spoon, or hand auger to collect a sample of the required depth interval.

5. Use an engineer's ruler to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface.

6. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval. To prevent the hole from collapsing, it may be necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) tubing or pipe to maintain the opening.

7. Collect samples for volatile compounds (i.eVPH) as discrete samples using Encore® samplers.

8. Homogenize samples for other analyses across the required interval or mix them with other discrete grab samples to form a composite sample.

9. Place sample in clean sample container, label with sample identification number, date, and time of collection, and place on ice.

10. Backfill sample holes to grade with native material.

VI. Waste Management

Investigative derived waste (IDW) generated during the soil sampling activities and disposable equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VII. Data Recording and Management

Upon collection of soil samples, the soil sample should be logged in the field log book. Field book scans, chain-of-custody records will be scanned and sent to the ARCADIS

PM at the end of each day unless otherwise directed by the PM. The team leaders will retain copies.

Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

VIII. Quality Assurance

Field documentation, data reporting requirements, sampling handling, custody requirements, packing, handling, and shipping requirements along with lab custody procedures, analytical methods, QC requirements, and laboratory specific QAQC requirements are stated in the site-specific Quality Assurance Project Plan.

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Surface Water Sampling

Rev. #: 2

Rev Date: June 3, 2013

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection of surface water samples using a grab method, discrete depth sampler or peristaltic pump. This SOP should be followed whenever collecting surface water samples.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

III. Equipment List

The following equipment list contains materials that may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE) and other safety equipment, as required in the project Health and Safety Plan (HASP)
- project Quality Assurance Project Plan (QAPP)
- Sampling and Analysis Plan (SAP)
- indelible ink pens
- appropriate sample containers, labels, and forms
- decontamination supplies (see the SOP for Decontamination) including bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern.

- sample packing and shipping materials (see the SOP for Chain-of-Custody, Handling, Packing, and Shipping)

- water-quality (temperature/pH/specific conductivity/ORP/turbidity/dissolved oxygen) meter and flow-through measurement cell. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument
  - Hydrolab Series 3 or Series 4a Multiprobe and Display
  - Horiba U-10 or U-22 Water Quality Monitoring System

- for grab sampling method: pole with polyethylene and/or stainless steel dipper, if applicable

- for discrete depth sampling method: discrete depth samplers (e.g., Kemmerer or Van Dorn samplers)

- for peristaltic pump sampling method: peristaltic pump with appropriate power source, Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used. For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will also be used through the pump apparatus.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate surface water samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field-filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

The ability to safely access the surface water sampling locations should be verified prior to sampling.

Field activities will be performed in accordance with a project-specific HASP, a copy of which will be present onsite during such activities.

Safety hazards associated with sampling surface water include fast-moving water, deep water, and steep slopes close to sampling sites. Extreme caution should be used when approaching sampling sites. Work will be performed in accordance with the project-specific HASP.

V. Procedure

Sampling Method

Surface water samples will be collected from sampling locations sequentially from downstream to upstream to prevent cross-contamination associated with sediment disturbance. Surface water samples will be collected prior to sediment sample collection.

Grab Sample Collection

Personnel conducting surface water sampling using grab sample collection techniques should perform the following:

1. Collect appropriate equipment, cleaned and decontaminated.

2. Obtain appropriate sampling containers.

3. Mobilize to surface water sampling location in accordance with the work plan or SAP.

4. Collect sample by directly lowering the laboratory-supplied sample container into the water and allowing the bottle to partially fill with water. The sampler will hold the bottle immediately below the water surface and allows the bottle to fill with sample. Field

personnel will handle only the portions of the sample containers that do not come in contact with the sample, to avoid contamination. Additionally, care will be taken to avoid exposing samples and sample containers to atmospheric inputs such as dirt or dust.

5. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

6. Transfer surface water samples into laboratory-supplied sample containers to complete the scope described in the SAP. Avoid overfilling sample containers to prevent preservatives, if present, in sample container from being lost.

7. Handle samples in accordance with the SOP for Chain-of-Custody, Handling, Packing, and Shipping

Sample Collection Using a Discrete Depth Sampler (e.g., Kemmerer or Van Dorn)

Personnel conducting surface water sampling using grab sample collection techniques should perform the following:

1. Collect appropriate equipment, cleaned and decontaminated.

2. Obtain appropriate sampling containers.

3. Mobilize to surface water sampling location in accordance with the work plan or SAP.

4. Carefully set the sampling device so that water is allowed to pass through the tube.

5. Lower the pre-set sampling device to the predetermined depth using marked rope or line attached to the device.

6. When at desired depth; send down the messenger, closing the device. Avoid disturbing the bottom.

7. Retrieve sampler and discharge the first 10-20 mL to clear any potential cross-contamination.

8. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

9. Transfer surface water samples into laboratory-supplied sample containers to complete the scope described in the SAP. Avoid overfilling sample containers to prevent preservatives, if present, in sample container from being lost.

10. Handle samples in accordance with the SOP for Chain-of-Custody, Handling, Packing, and Shipping.

Sample Collection Using Peristaltic Pump

Personnel conducting surface water sampling using peristaltic pump collection techniques should perform the following:

1. Surface water will be collected using a peristaltic pump if flow is slow and conventional sampling procedures are impossible without collecting excess suspended sediment in the sample. Note any observations such as color or odors and determine the depth of water. Record the information in the field log book or field log forms.

2. Personnel should be aware that contact with peristaltic pump apparatus (e.g., control knobs) can serve as a source of metals contamination in dissolved metals analyses. Operation of pump controls should be conducted with gloves that do not come into contact with the sample or with materials that contact the sample.

3. Prepare the stream tubing. Based upon the distance to the pump location, cut the desired length of new Tygon tubing with an approved cutting device.

4. Set up the pump. Cut approximately one-foot of new C-Flex tubing from the roll. Remove pump and controller from the transport case. Insert the C-Flex tubing into the pump head by releasing the pump head with the lever on top of the pump head. Close the pump head on the tubing with the lever on top of the pump head. Check to see that the tubing is aligned properly. Attach pump head to the pump controller using the two set screws.

5. Attach the stream tubing and discharge tubing. Attach the stream tubing to the C-Flex using a new plastic connector. Attach a convenient length of Tygon tubing to the C-Flex to serve as the discharge tubing. The discharge tubing may be attached to a flow-through cell for various field measurements. Remove the flow-through cell prior to the collection of surface water samples for laboratory analysis.

6. Connect the power supply. Connect the power cord to the pump unit and the automobile lighter or battery.

7. Start the pump. Set the head direction switch to have flow go in the correct direction for the set up. Turn the pump switch to the ON position and adjust the flow rate with the dial to the desired flow rate.

8. Operate the pump. Operate the pump at the desired flow rate.

9. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

10. Collect surface water samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container.

    - If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to surface water sample collection.
    - Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap.
    - Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the Sampling and Analysis Plan (SAP)).

11. Completion of sampling. At the completion of the sampling at the well, turn off the pump, and remove the tubing from the stream. Drain the tubing according to the project requirements. Remove the C-Flex tubing from the pump head. Discard all tubing and connectors according to project requirements.

12. Disconnect the power. Disconnect the power cord, disassemble pump head from controller and return equipment to the transport case.

13. Secure the well and properly dispose of PPE and disposable equipment.

14. Pack and store samples appropriately for transport to laboratory. Handle samples as described in the SOP for Chain-of-Custody, Handling, Packing, and Shipping.

15. Complete decontamination procedures for flow-through analytical cell, as appropriate.

VI. Waste Management

Investigative derived Waste (IDW) generated during the surface water sampling activities and disposable equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VII. Data Recording and Management

See the SOP for Field Documentation.

VIII. Quality Assurance

Sample quality will be achieved by complying with the procedures outlined in this SOP. Cross-contamination will be prevented by following the protocols described in the SOP for Field Equipment Decontamination. Field activities will be supervised by appropriate experienced field supervisors. Additional quality assurance information is presented in the project-specific Quality Assurance Project Plan.

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Sample Labeling

Rev. #: 0

Rev Date: April 19, 2008

I. Scope

This operating procedure outlines the method used to properly label samples collected.

II. Purpose

The purpose of this procedure is to assure good quality control in field operations and uniformity among different field personnel collecting samples

III. Equipment Needed

The following equipment will be needed during sediment sampling activities:

- Sample labels
- Permanent marker/pen
- Field logs
- Field log book

IV. Procedures

Each sample container will be labeled with a unique sample number that will facilitate tracking and cross referencing of sample information and will be recorded in the field log. The unique sample number will be recorded with the sample location in the field logbook at the time of sample collection. The field logbook will form part of the permanent field record. The sample numbering system to be used is described as follows (the information entered on the sample labels will be printed by the field sampler):

Example: S-LOC(Depth)

Where:

- S – Designates type of sample (S- Soil, SS-Sediment, GW-Groundwater)
- LOC – Designates sample type and location (i.e. MW-monitor well, SB-soil boring, IB – interior boring, CB–catch basin, TG–transformer grab; MW-01, SB-01, CB-01 etc.)
- (Depth) – Designates sample depth (this will only be used for soil and sediment samples) and will be recorded in meters.

To exemplify this:

- a grab groundwater sample from geoprobe boring SB-01 would be labeled as: GW-SB-01;
- a sediment sample from catch basin CB-01, from the 1 foot depth would be labeled as SS-CB-01(0-1);
- a grab water sample from catch basin CB-01, would be labeled as GW-CB-01;
- a soil sample collected from the 1-2 feet interval of interior boring IB-01 would be labeled as: S-IB-01(1-2);
- a grab soil sample collected from the 0-1 feet interval of transformer grab TG-01 would be labeled as: S-TG-01(0-1);
- a groundwater sample from monitor well MW-01 would be labeled GW-MW-01.

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Decontamination of Field Equipment

Rev. #: 1

Rev Date: December 8, 2011

I. Scope and Application

Equipment cleaning/decontamination procedures must confirm that all equipment that contacts a sample during sample collection is free from the analytes of interest and constituents that would interfere with the detection of analytes of interest. Additionally, any equipment used at the site must be cleaned and decontaminated prior to removal and storage. The effectiveness of any cleaning procedure (including all cleaning reagents) must be supported by equipment blanks with reported non-detected values.

The equipment cleaning procedures described in this standard operating procedure (SOP) include pre-field, in the field, and post-field cleaning of sampling tools to be conducted at an established equipment decontamination area (EDA) onsite (as appropriate). Sampling equipment consists of soil sampling tools; well construction materials; groundwater, sediment, and surface water collection devices; water testing instruments; down-hole geophysical instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned after completing each sampling event, between sampling points, and prior to leaving the site. Cleaning procedures for sampling equipment will be monitored by collecting field blank samples as specified in the applicable work plan. Dedicated sampling equipment will not require decontamination.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

III. Equipment List

The following equipment list describes materials that may be needed when carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE) and other safety equipment, as required in the project HASP
- project quality assurance project plan (QAPP)
- Work Plan, or Sampling and Analysis Plan (SAP)
- distilled/deionized water
- non-phosphate detergent such as Luminox (or a non-phosphate solvent based equivalent), Liqui-Nox (or a non-phosphate equivalent), or Alconox (or equivalent). The United States Environmental Protection Agency (USEPA) recommends Luminox (or equivalent) because solvent rinses can be eliminated from the cleaning process. Liquinox (or equivalent; solvent rinses, when applicable, must be performed) and Alconox (or equivalent) may be substituted if the sampling equipment will not be used to collect phosphorus or phosphorus-containing compounds.
- tap water
- steam/pressure washer
- contained decontamination area with secondary containment scrub brushes/bottle brushes
- plastic sheeting
- large heavy-duty garbage bags
- aluminum foil
- spray bottles
- resealable bags
- paper towels/KimWipes

- Handiwipes
- field logbook

IV. Cautions

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium.

If manual drying of equipment is required, use lint-free material (i.e., KimWipes).

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts.

If equipment is damaged to the extent that decontamination is uncertain due to cracks or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination will be performed by a United States Department of Transportation (DOT)-trained individual for cleaning materials shipped by ARCADIS.

Review the material safety data sheets (MSDS) for the cleaning materials, acids, and solvents to be used for decontamination. Avoid use of spray bottles to apply solvent on equipment to minimize potential for introducing vapors into the breathing zone. Work in a well ventilated area and stand upwind while applying solvent to equipment during the decontamination process. Solvent will be applied to the equipment in a manner that minimizes potential for exposure to workers. Follow health and safety procedures outlined in the project HASP.

V . Procedures

A designated area will be established to clean sampling equipment in the field prior to and between sample collections. Equipment cleaning areas will be set up within or adjacent to the specific work area. Equipment to be cleaned in the field may include split spoons, bailers, well pumps, stainless steel bowls, and spatulas.

Cleaning Non-Aqueous Phase Liquid (NAPL) from Sampling Equipment

1. If equipment is very dirty, pre-cleaning with a brush and tap water may be necessary.

2. Wash with non-phosphate detergent and tap water to remove all visible particulate matter and any residual oils or grease.

3. Rinse with tap water to remove the detergent solution.

4. Rinse with reagent-grade methanol.

5. Rinse with tap water.

6. If sampling for polychlorinated biphenyls (PCBs), rinse with hexane. If sampling for volatile organic compounds (VOCs) but not PCBs, rinse with reagent-grade methanol.

7. Rinse with tap water.

8. Triple rinse with distilled water.

9. Collect all rinsate and dispose of in approved storage containers (i.e., DOT-approved, 55-gallon drums).

10. Collect decontamination materials (i.e., plastic sheeting, tubing, gloves, PPE) that have come in contact with used decontamination fluids or sampling equipment and dispose of in approved storage containers.

Cleaning Sampling Equipment (no NAPL)

1. If equipment is very dirty, pre-cleaning with a brush and tap water may be necessary.

2. Wash with non-phosphate detergent and tap water to remove all visible particulate matter.

3. Rinse with tap water to remove the detergent solution.

4. Triple rinse with distilled water.

5. Collect all rinsate and dispose of in approved storage containers (i.e., DOT-approved, 55-gallon drums).

6. Collect decontamination materials (i.e., plastic sheeting, tubing, gloves, PPE) that have come in contact with used decontamination fluids or sampling equipment and dispose of in approved storage containers.

Steam-Cleaning/Pressure Washing Sampling Equipment

1. Place equipment to be washed inside containment area. Don appropriate PPE to prevent splashing/spraying into eyes or onto skin.

2. Confirm that steam cleaner/pressure washer is operating correctly and that burner is heating water.

3. Spray all surfaces of equipment at least twice to remove bulk contaminants (e.g., soil particles) and then to rinse clean surface.

4. Manage wastes in accordance with Section VII, below.

Decontaminating Submersible Pump

Submersible pumps may be used. The pumps will be cleaned and flushed between uses. This cleaning process will consist of the following:

- Wash with an external detergent wash and rinse with tap water.

- Flush potable water through the pump.
  - Use an appropriate container filled with potable water.
  - Run long enough to effectively flush the pump housing and hose. Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock.

- Disconnect the pump from the power source before handling .

- Place on or in clean polyethylene sheeting to avoid contact with the ground surface.

- Manage wastes in accordance with Section VII, below.

VI. Waste Management

Investigative derived Waste (IDW) generated during the sediment sampling activities and disposable equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VII. Data Recording and Management

Equipment cleaning and decontamination will be noted in the field logbook. Information will include the type of equipment cleaned, the location of the decontamination area, and any deviations from this SOP. Specific factors that should be noted include solvent used and source of water.

Any unusual field conditions should be noted if there is potential to impact the efficiency of the decontamination or subsequent sample collection.

An inventory of the solvents brought onsite and used and removed from the site will be maintained in the project files.

Records should be maintained for solvents including lot number and expiration date. Containers of decontamination fluids will be labeled appropriately.

VIII. Quality Assurance

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross-contamination of samples. The equipment blank is prepared by pouring deionized water over the clean and dry tools and collection into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters as those for the field samples collected with the equipment that was cleaned. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

Equipment blanks should be collected at the rate of described in the specific Work Plan or SAP.

IX. References

USEPA Region 9, Field Sampling Guidance #1 230, Sampling Equipment Decontamination.

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Chain-of-Custody, Handling, Packing and Shipping

Rev. #: 2

Rev Date: March 6, 2009

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody, handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to insure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, Department of Transportation (DOT) training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following list provides materials that may be required for each project. Project documents and sample collection requirements should be reviewed prior to initiating field operations:

- indelible ink pens (black or blue);
- polyethylene bags (resealable-type);
- clear packing tape, strapping tape, duct tape;
- chain of custody
- DOT shipping forms, as applicable
- custody seals or tape;
- appropriate sample containers and labels,;
- insulated coolers of adequate size for samples and sufficient ice to maintain 4°C during collection and transfer of samples;
- wet ice;
- cushioning and absorbent material (i.e., bubble wrap or bags);

- temperature blank
- sample return shipping papers and addresses; and
- field notebook.

IV. Cautions

Review project requirements and select appropriate supplies prior to field mobilization.

Insure that appropriate sample containers with applicable preservatives, coolers, and packing material have been supplied by the laboratory.

Understand the offsite transfer requirements for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation. Prior to using air transportation, confirm air shipment is acceptable under DOT and International Air Transport Association (IATA) regulation

Schedule pick-up time for laboratory courier or know location of laboratory/service center and hours of operation.

Understand DOT and IATA shipping requirements and evaluate dangerous goods shipping regulations relative to the samples being collected (i.e. complete an ARCADIS shipping determination). Review the ARCADIS SOPs for shipping, packaging and labeling of dangerous goods. Potential samples requiring compliance with this DOT regulation include:

- Methanol preservation for Volatile Organic Compounds in soil samples
- Non-aqueous phase liquids (NAPL)

V. Health and Safety Considerations

Follow health and safety procedures outlined in the project/site Health and Safety Plan (HASP).

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

Some sample containers contain preservatives.

- The preservatives must be retained in the sample container and should in no instance be rinsed out.

- Preservatives may be corrosive and standard care should be exercised to reduce potential contact to personnel skin or clothing. Follow project safety procedures if spillage is observed.

- If sample container caps are broken discard the bottle. Do not use for sample collection.

VI. Procedure

Chain-of-Custody Procedures

1. Prior to collecting samples, complete the chain-of-custody record header information by filling in the project number, project name, and the name(s) of the sampling technician(s) and other relevant project information. Attachment 1 provides an example chain-o- custody record

2. Chain-of-custody information MUST be printed legibly using indelible ink (black or blue).

3. After sample collection, enter the individual sample information on the chain-of-custody:

    a. Sample Identification indicates the well number or soil location that the sample was collected from. Appropriate values for this field include well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain-of-custody form. DO NOT use the apostrophe or quotes in the sample ID. Sample names may also use the abbreviations “FB,” “TB,” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively. NOTE: The sample nomenclature may be dictated by the project database and require unique identification for each sample collected for the project. Consult the project data management plan for additional information regarding sample identification.

b. List the date of sample collection. The date format to be followed should be mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

c. List the time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. The composite field should be checked if the sample is a composite over a period of time or from several different locations and mixed prior to placing in sample containers.

e. The “Grab”. field should be marked with an “X” if the sample was collected as an individual grab sample. (e.g. monitoring well sample or soil interval).

f. Any sample preservation should be noted.

g. The analytical parameters that the samples are being analyzed for should be written legibly on the diagonal lines. As much detail as possible should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “PCBs” or “Method 8082.” Multiple methods and/or analytical parameters may be combined for each column (e.g., PCBs/VOCs/SVOCs or 8082/8260/8270). These columns should also be used to present project-specific parameter lists (e.g., Appendix IX+3 target analyte list. Each sample that requires a particular parameter analysis will be identified by placing the number of containers in the appropriate analytical parameter column. For metals in particular, indicate which metals are required.

h. Number of containers for each method requested. This information may be included under the parameter or as a total for the sample based on the chain of custody form used.

i. Note which samples should be used for site specific matrix spikes.

j. Indicate any special project requirements.

k. Indicate turnaround time required.

l. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory.

m. If available attach the Laboratory Task Order or Work Authorization forms

n. The remarks field should be used to communicate special analytical requirements to the laboratory. These requirements may be on a per sample basis such as “extract and hold sample until notified,” or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG). Reporting requirements that should be specified in the remarks column include: 1) turnaround time; 2) contact and address where data reports should be sent; 3) name of laboratory project manager; and 4) type of sample preservation used.

o. The “Relinquished By” field should contain the signature of the sampling technician who relinquished custody of the samples to the shipping courier or the analytical laboratory.

p. The “Date” field following the signature block indicates the date the samples were relinquished. The date format should be mm/dd/yyyy (e.g., 03/07/2005).

q. The “Time” field following the signature block indicates the time that the samples were relinquished. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

r. The “Received By” section is signed by sample courier or laboratory representative who received the samples from the sampling technician or it is signed upon laboratory receipt from the overnight courier service.

3. Complete as many chain-of-custody forms as necessary to properly document the collection and transfer of the samples to the analytical laboratory.

4. Upon completing the chain-of-custody forms, forward two copies to the analytical laboratory and retain one copy for the field records.

5. If electronic chain-of-custody forms are utilized, sign the form and make 1 copy for ARCADIS internal records and forward the original with the samples to the laboratory.

Handling Procedures

1. After completing the sample collection procedures, record the following information in the field notebook with indelible ink:

   - project number and site name;
   - sample identification code and other sample identification information, if appropriate;
   - sampling method;
   - date;
   - name of sampler(s);
   - time;
   - location (project reference);
   - location of field duplicates and both sample identifications;
   - locations that field QC samples were collected including equipment blanks, field blanks and additional sample volume for matrix spikes; and
   - any comments.

2. Complete the sample label with the following information in indelible ink:

   - sample type (e.g., surface water);
   - sample identification code and other sample identification information, if applicable;
   - analysis required;
   - date;
   - time sampled; and
   - initials of sampling personnel;

- sample matrix; and
- preservative added, if applicable.

3. Cover the label with clear packing tape to secure the label onto the container and to protect the label from liquid.

4. Confirm that all caps on the sample containers are secure and tightly closed.

5. In some instances it may be necessary to wrap the sample container cap with clear packing tape to prevent it from becoming loose.

6. For some projects individual custody seals may be required. Custody seal evidence tape may be placed on the shipping container or they may be placed on each sample container such that the cooler or cap cannot be opened without breaking the custody seal. The custody seal should be initialed and dated prior to relinquishing the samples.

Packing Procedures

Following collection, samples must be placed on wet ice to initiate cooling to 4°C immediately. Retain samples on ice until ready to pack for shipment to the laboratory.

1. Secure the outside and inside of the drain plug at the bottom of the cooler being used for sample transport with “Duct” tape.

2. Place a new large heavy duty plastic garbage bag inside each cooler

3. Place each sample bottle wrapped in bubble wrap inside the garbage bag. VOC vials may be grouped by sample in individual resealable plastic bags). If a cooler temperature blank is supplied by the laboratory, it should be packaged following the same procedures as the samples. If the laboratory did not include a temperature blank, do not add one. Place 1 to 2 inches of cushioning material (i.e., vermiculite) at the bottom of the cooler.

4. Place the sealed sample containers upright in the cooler.

5. Package ice in large resealable plastic bags and place inside the large garbage bag in the cooler. Samples placed on ice will be cooled to and maintained at a temperature of approximately 4°C.

6. Fill the remaining space in the cooler with cushioning material such as bubble wrap. The cooler must be securely packed and cushioned in an upright position and be surrounded (Note: to comply with 49 CFR 173.4, filled cooler must not exceed 64 pounds).

7. Place the completed chain-of-custody record(s) in a large resealable bag and tape the bag to the inside of the cooler lid.

8. Close the lid of the cooler and fasten with packing tape.

9. Wrap strapping tape around both ends of the cooler.

10. Mark the cooler on the outside with the following information: shipping address, return address, "Fragile, Handle with Care" labels on the top and on one side, and arrows indicating "This Side Up" on two adjacent sides.

11. Place custody seal evidence tape over front right and back left of the cooler lid, initial and date, then cover with clear plastic tape.

Note: Procedure numbers 2, 3, 5, and 6 may be modified in cases where laboratories provide customized shipping coolers. These cooler types are designed so the sample bottles and ice packs fit snugly within preformed styrofoam cushioning and insulating packing material.

Shipping Procedures

1. All samples will be delivered by an express carrier within 48 hours of sample collection. Alternatively, samples may be delivered directly to the laboratory or laboratory service center or a laboratory courier may be used for sample pickup.

2. If parameters with short holding times are required (e.g., VOCs [EnCore™ Sampler], nitrate, nitrite, ortho-phosphate and BOD), sampling personnel will take precautions to ship or deliver samples to the laboratory so that the holding times will not be exceeded.

3. Samples must be maintained at 4°C±2°C until shipment and through receipt at the laboratory

4. All shipments must be in accordance with DOT regulations and ARCADIS dangerous goods shipping SOPs.

5. When the samples are received by the laboratory, laboratory personnel will complete the chain-of-custody by recording the date and time of receipt of samples, measuring and recording the internal temperature of the shipping container, and checking the sample identification numbers on the containers to ensure they correspond with the chain-of-custody forms.

Any deviations between the chain-of-custody and the sample containers, broken containers, or temperature excursions will be communicated to ARCADIS immediately by the laboratory.

VII. Waste Management

Not applicable

VIII. Data Recording and Management

Chain-of-custody records will be transmitted to the ARCADIS PM or designee at the end of each day unless otherwise directed by the ARCADIS PM. The sampling team leader retains copies of the chain-of-custody forms for filing in . the project file. Record retention shall be in accordance with project requirements.

IX. Quality Assurance

Chain-of-custody forms will be legibly completed in accordance with the applicable project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents. A copy of the completed chain-of-custody form will be sent to the ARCADIS Project Manager or designee for review.

X. References

Not Applicable

Attachment 1

ARCADIS
Infrastructure, environment, facilities

ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:		
Contact & Company Name:	Telephone:	
Address:	Fax:	
City State Zip	E-mail Address:	
Project Name/Location (City, State):	Project #:	
Sampler's Printed Name:	Sampler's Signature:	

Preservative								
Filtered (✓)								
# of Containers								
Container Information								

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil; SE - Sediment; NL - NAPL/Oil
W - Water; SL - Sludge; SW - Sample Wipe
T - Tissue; A - Air; Other: ________

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix								REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: ________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

20730826 CofC AR Form 01.12.2007 **Distribution:** **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by BBL**

Imagine the result

Soil Description

Date: May 29, 2013

I. Scope and Application

This standard operating procedure (SOP) describes proper soil description procedures to be followed for soil and sediment logging. This SOP should be followed for all unconsolidated material.

This SOP has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;
- provide geotechnical observations and classifications of subsurface lithology;
- provide information needed to properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This SOP incorporates elements from ASTM D2488, the Unified Soil Classification System.

This SOP does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other ARCADIS SOPS, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

II. Personnel Qualifications

Soil descriptions will be completed only by persons who have been trained in ARCADIS soil description procedures. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist. For sites where soil descriptions have not previously been well documented, soil descriptions should be performed only by trained persons with a degree in geology or a geology-related discipline.

Personnel creating soil descriptions should also be familiar with ASTM D2488.

III. Equipment List

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;

- field book for supplemental notes;
- this SOP for Soil Descriptions and any project-specific SOP (if required);
- USCS soil classification chart;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- equipment and materials required to keep work-area clean and free of debris
- personal protective equipment (PPE), as required by the HASP; and
- hard copy of ASTM D2488 – Standard Practice fo Description and Identification of Soils (Visual-Manual Procedure)
- site-specific HASP
- digital camera.

IV. Cautions

Drilling and drilling-related hazards including subsurface utilities are discussed in other SOPs and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

V. Procedure

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, Lexan or acetate sleeves for dual-tube direct push, etc.

2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.

3. Examine all of each individual soil sample (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:

   - depth interval;
   - principal component with descriptors, as appropriate;
   - amount and identification of minor component(s) with descriptors as appropriate;
   - moisture;
   - consistency/density;
   - color; and
   - additional description or comments (recorded as notes).

The above is described more fully below.

DEPTH

To measure and record the depth below ground level (bgl) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.

2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).

3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.

4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, silt and clay are present, the resultant descriptions should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Silty Sand with Gravel (SM) with interbedded lenses of Sandy Lean Clay (CL) and Elastic Silt (MH), ranging between 1 and 3 inches thick.

Identify the principal component and minor components based on percent weight, using the methods presented below and in accordance with the table below. The percent sample, by weight, of each size fraction should be estimated and recorded to the nearest 5%.

Modifier	Percent of Total Sample by Weight Fraction (%)
Some	30 to 45
Little	14 to 25
Few	5 to 10
Trace	Present, but less than 5

The particle sizes present should be identified using the particle size descriptions shown in the table below. The finer particle sizes may not be visually distinguishable in the field. Therefore, a field assessment of the soil plasticity should be used to distinguish between silts and clays.

Particle	Passing Sieve	Retained on Sieve
Clay *	No. 200	Shows Plasticity
Silt *	No. 200	Nonplastic
Fine Sand	No. 40	No. 200
Medium Sand	No. 10	No. 40
Coarse Sand	No. 4	No. 10
Fine Gravel	3/4"	No. 4
Coarse Gravel	3"	3/4"
Cobbles	12"	3"
Boulder	---	12"

* See ASTM D2488 for further clarification.

Identify components as follows. Remove particles larger than coarse gravel-size from the soil sample. Record the volume estimate of the greater than coarse gravel. Examine the sample fraction of coarse gravel and smaller particles and estimate the percentage by dry weight of the gravel, sand, silt, and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category. Use the volume estimate to inform a dry weight percentage estimate. Note that the recorded sample fraction comprised of particles greater than 3" in dimension will be based on volume percentage while the remainder will be based on dry weight fraction. The sum of the estimated percentages of particle groups should add up to 100%.

PRELIMINARY IDENTIFICATION

Identify sample as fine grained if field logging suggests that more than 50% of the sample by weight would pass the No. 200 sieve. Identify the sample as coarse grained if field logging suggests that more than 50% by weight would be retained on the No. 200 sieve.

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below and ASTM D2488. Figures showing examples of angularity are available in ASTM D2488 and the ARCADIS Soil Description Field Guide.

Description	**Criteria**
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test:

- Select enough material to mold into a ball about ½ inch in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Plasticity tests follow method (ASTM D2488). Results are summarized in the table below.

Description	Criteria
Nonplastic	A 1/8 inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D2488).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

IDENTIFYING FINE-GRAINED SOILS

A sample is classified as fine grained if more than 50% (by weight) of the soil sample is comprised of particles passing the No. 200 sieve. Once the sample has been identified as a fine-grained soil, determine the plasticity of the sample using the procedure described above. If the sample is Nonplastic or has Low plasticity, it should be considered a silt (ML or MH). Samples with medium or high plasticity should be considered clays (CL or CH). Using this information, enter Figure 1 and follow the chart to the appropriate group name based on the minor components.

While in the field it may be difficult to distinguish between CL vs. CH and ML vs. MH. Field personnel should refer to ASTM D2488 for further guidance on distinguishing between these two materials and also make note of borderline samples. These samples can be tested in a laboratory and the precise material can be determined.

Organic soils may also behave as fine grained soils. Figure 1, in tandem with ASTM D2488, should be used to properly identify organic soils.

IDENTIFYING COARSE-GRAINED SOILS

Coarse grained materials are those with more than 50% (by weight) of the material retained on the No. 200 sieve. Once a material has been identified as coarse, it should be further distinguished as either gravel or sand. Gravels contain more gravel, by weight, than sand. Conversely, sands contain more sand, by weight than gravel. After identifying a material as sand or gravel, use the weight fraction of fines present, particle size grading, and other properties to determine the group symbol or name using the attached Figure 2.

If a sample is borderline or should be verified, it should be noted as such and submitted to a laboratory for particle size analysis.

GRADING

Describe coarse grained materials as well-graded or poorly graded based on the criteria presented below from ASTM D2488.

- Well graded: sample comprised of a wide range of particle sizes with significant presence of intermediate particle sizes
- Poorly graded: sample mostly comprised of either a single particle size or a range of particle sizes missing intermediate particle sizes

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. For SPT blow counts the N-value is used. The N-value is the blows per foot for the 6” to 18” interval of a 2.0 in. outside diameter, 1.375 in. inside diameter split spoon advanced by dropping a metallic 140 +/- 2 lb hammer a height of 30 +/- 1 in. onto the drill rods. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6” to12”, the third interval is 12” to 18”, the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- **Odor** - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH “Pocket Guide to Chemical Hazards”, e.g. “pungent” or “sweet” and should not indicate specific chemicals such as “phenol-like” odor or “BTEX” odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts)
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy
- Cementation

- NAPL presence/characteristics, including sheen (based on client-specific guidance)

Description	Criteria
Oil	NAPL lighter than water with varying viscosities.
Sheen	Thin film with no thickness that can range from color of source to iridescent (rainbow) to silver. Sheens can be natural (note natural sheens tend to fragment when disturbed). Describe location, color, extent. Note if the sheen is present only outside or above of the sample (e.g., in the slough) and does not appear to be within the sample.
Staining	Color change of the soil/sediment grains without NAPL presence/ thickness. Stains can also be confused with naturally dark organic soil/ sediment. Describe location, color, extent. To evaluate if staining due to NAPL or just coloration, put sample in plastic bag to see if smearing occurs on bag. If smearing, then trace NAPL is present. If no smearing, then staining is present that is likely not NAPL related.
Blebs	Distinct spots/spheres of NAPL. Describe location, color, extent including the approximate size and number (when in trace amounts, i.e. 1 to 10). To evaluate amount and color further, if needed, put sample in plastic bag to see where and color of smearing on bag.
Partially Saturated	Pore space between soil/sediment grains contains some NAPL but is not saturated with the NAPL. Describe location, color, extent, and relative percentage by number or descriptors (some (25-50%), little (10-25%), trace (less than 10%)).
Saturated	Pore space between soil/sediment grains is entirely saturated with the NAPL. Describe location, color, extent.

- Reaction with HCl (typically used only for special soil conditions)
- Origin, if known (capital letters: LACUSTRINE; FILL; etc.)

EXAMPLE DESCRIPTIONS

51.4 to 54.0’ Clay, some silt, medium to high plasticity; trace small to large pebbles, subround to subangular up to 2” diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0’ Sand, medium to Pebbles, coarse; sub-round to sub-angular; trace silt; poorly sorted; wet; grayish brown (10YR5/2). NOTE: sedimentary, igneous and metamorphic particles.

Unlike the first example where a density of cohesive soils could be estimated, this rotosonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose Sand and Pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth
- Principal Components

    - Particle size (fine sand, silt, etc.)
    - Percent of sample modifiers, based on mass (and, some, little, etc.)
    - Angularity for very coarse sand and larger particles
    - Plasticity for silt and clay
    - Dilatancy for silt and silt-sand mixtures
- Minor Components
    - Particle size (fine sand, silt, etc.)
    - Percent of sample modifiers, based on mass (and, some, little, etc.)
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

VI. Waste Management

Solid investigation-derived wastes (IDWs) such as excess sediment generated through vibracoring activities will be collected into 55 gallon drums and stored onsite pending treatment and/or disposal.

Liquid IDWs such as decant water from vibracores and decontamination liquids will be collected into 55 gallon drums and may be transferred into large-volume polyethylene tanks with secondary containment pending treatment and/or disposal.

Non-aqueous liquid wastes, if generated (i.e., hexane, non-aqueous phase liquid [NAPL], etc), will be segregated and stored in appropriately sized buckets with secondary containment pending disposal.

PPE, soiled disposable items, and other trash will be stored in 55-gallon drums and stored on site pending disposal.

IDW will be collected and stored onsite in United States Department of Transportation (DOT)-compliant 55 gallon drums and/or large-volume tanks with secondary containment. Fifty Five gallon drums and tanks will be labeled with DOT-compliant labels with the following information: drum contents, generator contact information, and date container was filled. IDWs known to be hazardous will be segregated and stored separately from non-hazardous IDWs. Solid IDW will be segregated and stored separately from liquid IDW.

IDW will be sampled as needed for disposal characterization. IDW will be stored onsite pending treatment and/or disposal. IDW may be managed in conjunction with remedial activities..

All IDW will be stored in a secure onsite location pending treatment and disposal and/or discharge.

VII. Data Recording and Management

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. Two examples of standard boring logs are presented below.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

ARCADIS Page _____ of _____

Sample Log

Well/Boring ________________ **Project Name and No.** ________________

Site Location ________________ **Drilling Started** ________ **Drilling Completed** ________

Total Depth Drilled ________ **feet** **Hole Diameter** ______ **inches** **Sampling Interval** ________ **feet**

Length and Diameter of Sampling Device ________ **Type of Sampling Device** ________________

Drilling Method ________ **Drilling Fluid Used** ________________

Drilling Contractor ________ **Driller** ________ **Helper** ________

Prepared By ________________ **Hammer Weight** ________ **Hammer Drop** ________ **inches**

Sample Depth (feet below land surface) From	To	Sample Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 inches	Sample Description	PID (ppm)

http://team/Sites/Offices/North/Northeast Area/Northeast Area Geoscience Forms/Sample Core Log.XLS - Sheet1

VIII. Quality Assurance

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

IX. References

ARCADIS Soil Description Field Guide, 2008 (in progress)

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder"

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48

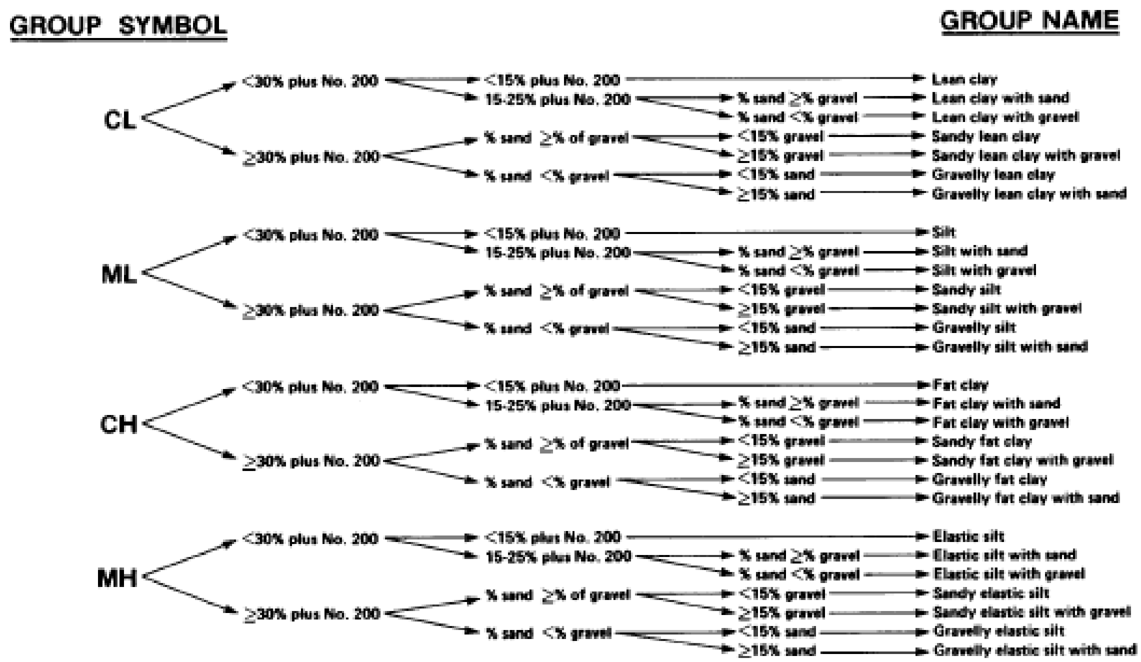
NIOSH Pocket Guide to Chemical Hazards

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63

Figure 1: Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

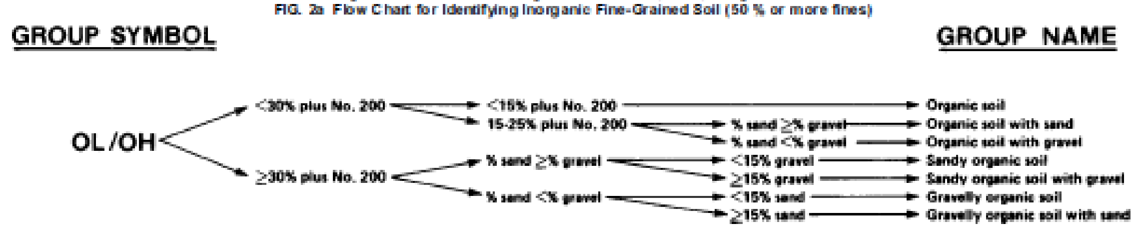
Source: ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 2488



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

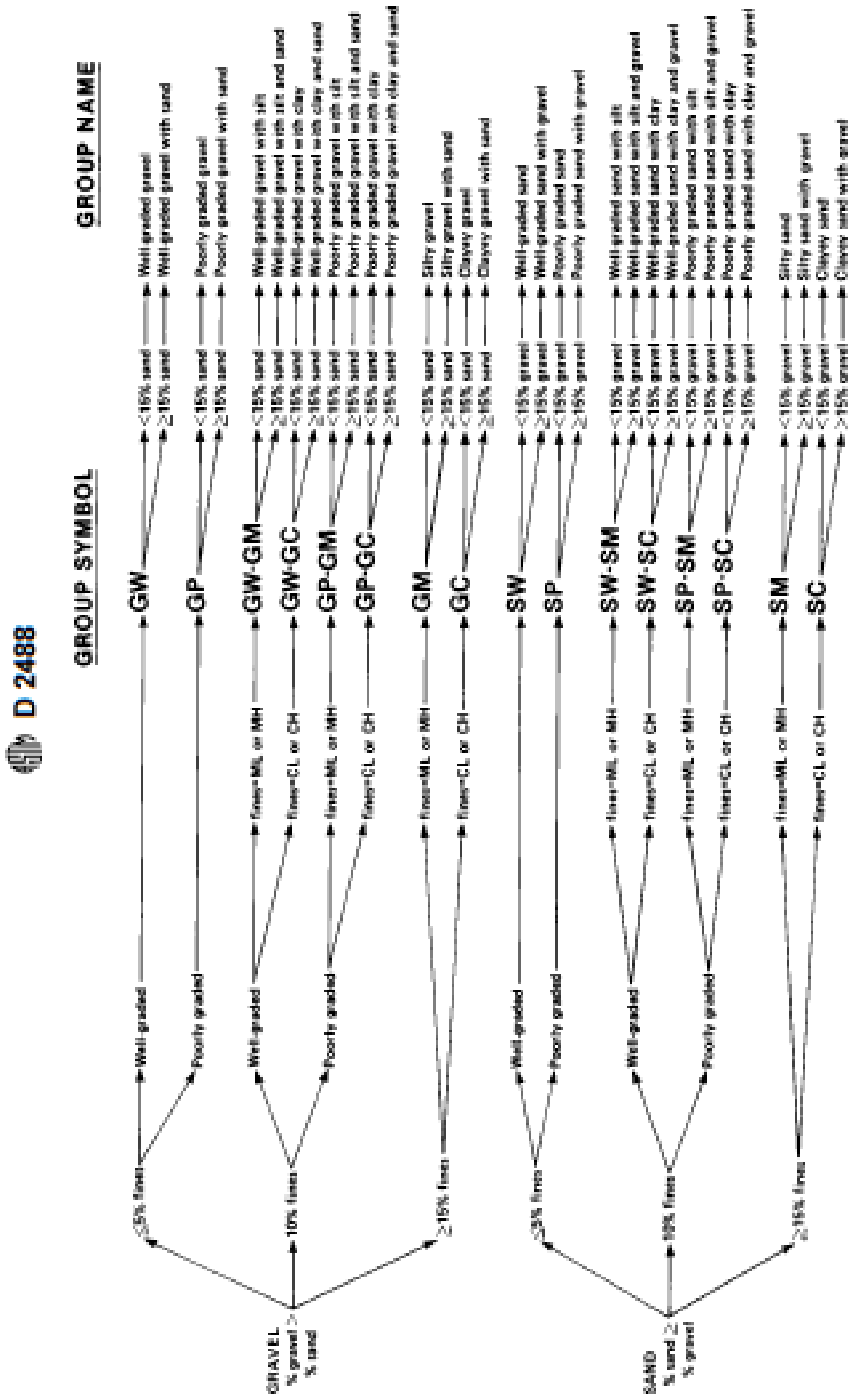


NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

Figure 2: Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Source: ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

I. Scope and Application

The purpose of this document is to define the standard operating procedure (SOP) for documentation of field activities. Appropriate documentation of field activities provides an accurate and comprehensive record of the work performed, sufficient for a technical peer to reconstruct the day's activities and confirm that necessary requirements were met.

This SOP should be followed whenever documenting field activities.

This SOP may change depending upon field conditions or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

All field personnel must have the appropriate training required by ARCADIS and ExxonMobil as described in the project Health and Safety Plan (HASP). ARCADIS field sampling personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following equipment list describes materials that may be needed when carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE) and other safety equipment, as required in the project HASP
- Work Plan or Sampling and Analysis Plan (SAP)
- field notebook
- dry-erase whiteboard with markers
- field forms

- indelible ink pens
- GPS
- camera

IV. Cautions

This section is not applicable.

V. Procedures

General Requirements

Pertinent field information will be recorded in a logbook and/or an appropriate form (as described herein) with a black weather resistant pen. A key that describes each entry is provided for each form. Logbook entries will be factual and observational (i.e., no speculation or opinion), and will not contain any personal information or non-project-related entries. The cover and binding of each logbook will be labeled to identify the operation and dates included within the logbook; each page in the logbook will be consecutively numbered.

A page header will appear on the first page of each day's notes in the logbook, and activities for each day will be recorded on a new page. The page header will include:

- name of author and other personnel onsite (and affiliated organization if applicable)
- date
- time of arrival
- current weather and river stage (if applicable) conditions
- weather forecast for the day

An abbreviated header, limited to the date, will appear at the top of each additional page for the active date. Field forms will require similar header information.

Field activities and other events pertinent to the field activities will be documented in chronological order. Times will be recorded using 24-hour notation for each entry. At a minimum, documentation in a logbook will include the following:

- names of visitor(s) to the work location being documented in the log, including time of arrival and departure, the visitor's affiliation, and reason for visit
- summary of project-related communications, including names of people involved and time
- time at which daily work commences and ceases
- start and stop times of new tasks
- start and stop times of breaks
- safety or other monitoring data, including units with each measurement
- deviations from scope of work
- progress updates
- problems/delays encountered
- unusual events
- signatures or initials of author on every page

A single line will be drawn through incorrect entries and the corrected entry written next to the original strikeout. Strikeouts are to be initialed and dated by the originator.

If there are blank lines on the page at the end of the day's activities, a line will be drawn through the empty space, initialed, and dated, leaving no room for additional entries.

The logbook will cross-reference information documented in the field forms.

Photographs will be identified by the whiteboard with the sample and location ID. At a minimum, the time the photograph was taken, the general location, a brief description, and the photographer's name will be recorded. Additional information may include differential global positioning system coordinates, direction the photographer was facing, and/or weather conditions. If necessary, a common object will be included in the photograph to indicate the scale of the object being documented.

Equipment Decontamination

Documentation of decontamination procedures will be contained in a logbook and will include a list of equipment being decontaminated, a brief description of the procedure and materials used during the process, and the names of the project staff performing the decontamination.

Equipment Calibration and Maintenance

Equipment calibration will be recorded in the field notebook. Instrument information, including the instrument manufacturer, model number, and serial number, will be recorded. Instrument calibration will be performed in accordance with manufacturer's specifications. Values measured during calibration will be recorded in the equipment calibration log. In addition, maintenance, problems and repairs to the equipment will be recorded in the field notebook.

Sample Collection

Documentation of samples will be recorded in the field documents discussed above.

As samples are collected, qualified personnel will describe each sample on the appropriate log form, in the field logbook, and on the chain-of-custody form if samples are to be transmitted to a third party.

Distribution and Maintenance of Field Documentation

Logbooks that are taken offsite from the field offices will be photocopied and filed at the end of each day to mitigate against the loss of historical entries, should the logbook be lost in the field. Scanned and/or copied versions of all the daily field logs and logbook entries will be transmitted daily to the Field Manager, who will perform a daily quality check of the field documents and maintain the backup field documents file.

Electronically-recorded data (i.e., GPS coordinates) will be uploaded to the Field Supervisor on a daily basis.

Field data forms and chain-of-custody tracking logs will be filed once they have been completed and distributed (if necessary), or at the end of each field day.

Upon completion of sampling and transfer of samples to the shipping company or courier, copies of the signed chains of custody will be faxed to the appropriate analytical laboratory contact, and the data validator. Copies of these documents will also be maintained at the field office in a labeled three-ring binder in reverse chronological order.

VI. Waste Management

This section is not applicable.

VII. Data Recording and Management

This section is not applicable.

VIII. Quality Assurance

Entries in the field forms will be double-checked by the samplers to verify the information is correct. Completed field forms will be reviewed periodically by the Investigative Organization and/or Field Coordinator's designee to verify that the requirements are being met.

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Dart Sampler Field Deployment and Retrieval

Rev. #: 0

Rev Date: May 6, 2013

I. Scope and Application

This Standard Operating Procedure (SOP) describes the field deployment, retrieval, and packing procedures for the Dakota Technologies, Inc. Dart Solid Phase Extraction Samplers.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

All field personnel must have the appropriate training required by ARCADIS and the client as described in the project Health and Safety Plan (HASP). ARCADIS field sampling personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. In addition to field training each employee must go through boat training, and review the boating and sampling job safety analyses (JSA).

III. Equipment List

The following equipment will be needed during Dart sampler activities:

- Boat- sized per field conditions (optional)
- Waders (optional)
- Personal Floatation Device (PFD) (optional)
- Dakota Darts, plastic sleeves and shipping box/ tube
- Dakota slide-hammer for Darts
- Rope with flagging or buoys
- Nitrile gloves
- Packing tape
- Tape measure
- Global Positioning System (GPS)
- Garbage bags
- Plastic sheeting
- Paper towel
- Aluminum foil
- Sample labels & marker
- Field notebook & pen

- Erasable whiteboard & marker
- Site-specific HASP
- Digital camera

IV. Cautions

Always wear a PFD within 10 feet of open water, watch for pinch points and always have three points of contact upon boarding, traversing, and exiting the boat. Know what substances may be present in the sediment and understand their hazards.

V. Health and Safety Considerations

Field activities associated with Dart samplers will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

Dart installation, recovery and packing will be performed according to the techniques outlined in the User Manual for Darts (Dakota 2010; provided as an attachment to this SOP) and the procedures described below. Darts may be installed from land, by wading into shallow water or from a boat.

Nitrile gloves should always be worn when handling Darts to avoid the transfer of non-aqueous phase liquids (NAPLs) from hands to the Dart. Also, avoid exposing Darts to other potentially fluorescent NAPLs such as gasoline and diesel fuel.

Dart Installation

1. Wearing clean nitrile gloves, remove Dart from plastic sleeve. (Retain plastic sleeve in a clean location for packing and shipping.) Darts are assembled and ready to deploy.

2. Tie rope/string to top loop of Dart. Attach other end of rope/string to flagging or buoy placed in a visible location so Dart can be located for retrieval.

3. Hold the Dart vertically and insert into the soil/sediment. Push Dart into soil/sediment as far as possible by hand. If necessary, the Dakota-provided slide-hammer may be used to assist in installation. Install Dart until refusal, or until the top of the yellow solid phase extraction (SPE) material covering the Dart is even with the soil/sediment surface.

4. Measure the water depth and the length of the yellow SPE material covering the Dart sticking up out of the soil/sediment (or, if deployment has inadvertently pushed the top loop of the Dart below the soil/sediment surface, estimate how far under the surface the yellow SPE material may have been pushed). Record the location, date, time, Dart stickup (distance from top of soil/sediment to top of yellow SPE material), and water depth in the field book.

5. Locate the installed Dart with GPS.

6. Allow all Darts to equilibrate at least 24 hours (up to 72 hours) before retrieving.

If slide-hammer or other tools are exposed to site contaminants, decontaminate prior to moving to next Dart location.

Dart Recovery

Dart should be removed from soil/sediment 24-72 hours after installation. All Darts installed should be recovered after approximately the same amount of equilibration time.

1. In a level area, lay out plastic sheeting and row of paper towel for Dart processing and packaging. Clean plastic sheeting should be used for each Dart.

2. Wearing clean nitrile gloves, pull the Dart rod straight up out of the soil/sediment. Avoid contact with the yellow SPE material that has been below the soil/sediment surface.

3. Once the rod is clear of the soil/sediment and water, hold it horizontally to prevent any soil, sediment, NAPL, etc. from running down the Dart.

4. Place the Dart on the clean paper towel. Clean the Dart of any major debris/NAPL by wiping across the Dart, not up and down. If the Dart is grossly contaminated with NAPL, let the residual drip/soak off until it will no longer flow or seep.

5. Photograph the Dart.

Dart Packing

1. Wrap the Dart in aluminum foil and place back in plastic sleeve. Label with Dart/location name, date, and stickup length. Store Darts in a dry, dark and cool location. No ice or refrigeration is necessary.

2. Complete Chain of Custody (COC) – include the length of the yellow SPE material that was sticking up out of the soil/sediment.

3. Place Darts and COC in original shipping box/tube, or similar and tape closed. If some Darts are suspected to be more impacted than others (strong odors, NAPL visible on the Dart), then consider shipping Darts in two separate containers to avoid the potential cross-contamination of cleaner Darts. Vapor phase cross-contamination is rare, but possible.

VII. Waste Management

Disposable equipment and personal protective equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VIII. Data Recording and Management

Field measurements related to Dart installation and recovery should be logged in the field log book. Field book scans and COC records will be scanned and sent to the ARCADIS Project Manager at the end of each day unless otherwise directed by the Project Manager. The team leaders will retain copies.

Digital photographs of retrieved Darts and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo information such as location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

IX. Quality Assurance

One Dart per shipping container should be carried to the field as a blank (not installed in any site materials), and sent back to the lab for analysis.

Field documentation, data reporting requirements, sampling handling, custody requirements, packing, handling, and shipping requirements along with lab custody procedures, analytical methods, quality control (QC) requirements, and laboratory specific quality assurance/ quality control (QA/QC) requirements are stated in the site-specific Quality Assurance Project Plan.

X. References

Dakota 2010. User Manual, Darts Field Depolyable Solid Phase Extraction Samplers. Version 2.10.09. Dakota Technologies.

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Sediment Profile Imaging

Rev. # 0

Date: May 30, 2013

I. Scope and Application

This Standard Operating Procedure (SOP) describes the operation of the hand-deployed sediment profile imaging (SPI) system. The general procedures to be utilized in obtaining sediment images are outlined below.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

All field personnel must have the appropriate training required by ARCADIS and ExxonMobil as described in the project Health and Safety Plan (HASP). ARCADIS field personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. In addition to field training each employee must go through boat training, and review the boating and SPI JSA.

III. Equipment List

The following equipment will be needed during SPI survey activities:

- Handheld Ocean Imaging Sediment Profile Camera System (supplied and operated by Germano & Associates, Inc.)
    - 12 v Nicad Battery Packs
    - 12 Kilogram Lead Weights (10 sets)
    - “Mud” Doors
    - Nikon D7000 Camera & Spare body
    - Tool kit
    - Shackles, swivels and hardware
- Global Positioning System (GPS)
- Pontoon Research vessel

- Navigation system
- Field notebook/log and pens
- Health and safety equipment, as required by the site HASP
- Site specific HASP

IV. Cautions

Field activities associated with SPI will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Always wear a PFD within 10 feet of water, watch for pinch points and always have three points of contact upon boarding, traversing, and exiting the boat.

V. Procedure

Always don personal protective equipment (PPE), as required by the HASP.

Three replicates will be collected per SPI location with two images per each replicate. The rate of data acquisition will be affected by several variables including but not limited to: efficiency of vessel positioning, weather conditions, water depth, and transit times.

Daily SPI Camera Set Up

1. At the beginning of each survey day, synchronize the time on the data logger mounted on the SPI camera with the navigation system clock.
2. Load Nikon digital SLR camera and a charged battery in the camera housing
3. Fire test shots on the deck at the beginning of each day to verify all internal electronics systems are working according to specifications.
4. Check frame counter at regular intervals during each survey day to make sure that the desired number of replicates has been taken. If images have been missed or the penetration depth is insufficient, then proper adjustments are made (e.g., weight is added to the frame) and additional replicates are taken.

SPI Data Collection

1. Pilot research vessel to the target sampling location. Maximum water depth for hand-deployed SPI equipment from a boat is approximately 6 feet.

2. Once within 20 feet of the target location, deploy the SPI camera.

    a. Carefully lower the SPI camera to the seafloor until it lands on the bottom.

    b. Once on the bottom, an electronic trigger is automatically activated to signal the camera to collect images 5 seconds after contact and 20 seconds after contact.

3. Record a position for the images. (A position should be recorded for each of the three replicate images taken at each SPI location.)

4. Record the following information in the field log:

    a. Time

    b. Date

    c. Station location

    d. Replicate ID - Identify each SPI station replicate by the time recorded in the image file and the corresponding time and position recorded by the navigation system.

    e. Frame count

    f. Water depth

    g. Penetration

    h. Observations on weather conditions, environmental conditions, or other pertinent observations

    i. Sampling crew

    j. Time of arrival at vessel

k. Time of survey commencement

l. Time of survey conclusion

m. Time departing vessel

5. Once the image set is acquired raise the SPI camera off the seafloor and lower again to collect the remaining two replicate image sets. Three replicate images should be taken at each SPI location.

VII. Data Recording and Management

Upon completion of SPI field activities, the images and digital files are used by Germano & Associates, Inc. to complete data processing and analysis. Digital files may also be provided to ARCADIS upon completion of the field activities, prior to data processing by Germano and Associates.

The field book will be scanned and sent to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The team leaders will retain copies.

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Attachment B

Surface Water Sampling and Analysis Plan

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ExxonMobil Pipeline Company

Surface Water Sampling and Analysis Plan

Mayflower Pipeline Incident
Mayflower, Arkansas

July 22, 2013

Figures

Attachments

1. Introduction

On March 29, 2013, a breach in the 20-inch Pegasus Pipeline in Mayflower, Arkansas, led to a crude oil release near the town of Mayflower, Arkansas. An emergency response action has removed visible crude oil and various monitoring activities are being conducted to understand remaining conditions. This Surface Water Sampling and Analysis Plan (SAP) establishes sampling locations, sampling frequency, and laboratory analysis methods for monitoring and characterization of surface water downgradient of the crude oil incident, and at background locations.

Surface water sampling in drainage ways, the Dawson Cove outlet, and Lake Conway has been ongoing since March 30, 2013 (Figure 1). The sampling was conducted in accordance with the Sampling and Analysis Plan prepared by Center for Toxicology and Environmental Health (CTEH 2013) and approved by the Unified Command on April 5, 2013. Surface water sampling locations were added and/or revised based on requests by the Arkansas Department of Environmental Quality (ADEQ) and Arkansas Game and Fish Commission (AGFC).

2. Purpose and Objectives

This SAP was developed to establish the sampling methods and analytical parameters for surface water monitoring downstream of the crude oil incident following the emergency response efforts. The surface water monitoring program will provide data to monitor concentrations as well as characterize spatial and temporal variability in surface water quality to support an assessment, together with other data collection, of whether there are any continuing remediation needs. This SAP includes daily sampling during the currently ongoing active response activities in Dawson Cove, which will continue until a modified frequency is agreed upon with the ADEQ.

3. Surface Water Sampling Locations

3.1 Locations Sampled To-Date

Historical surface water sample locations are shown on Figure 1. The following locations have been sampled downstream of the Incident, where an asterisk (*) indicates locations that have been sampled at both shallow and deeper intervals[1]:

- Drainage way along North Main Street: WS-008
- Dawson Cove outlet, south of Highway 89: WS-004*, WS-007*, WS-009, WS-010*, WS-020, and WS-021
- Dawson Cove outlet, north of Highway 89: WS-001*, WS-006*
- In Lake Conway downstream of Dawson Cove outlet: WS-012*, WS-002, and WS-011*
- At Lake Conway dam: WS-003
- In Palarm Creek: WS-018*
- In Lake Conway north of Dawson Cove: WS-005, WS-013*, WS-014*, WS-015*, WS-016*, and WS-017*
- In stream leading to Dawson Creek: WS-019*
- In background drainage way locations: WS-BKG-001 and WS-BKG-002

The Lake Conway locations are intended to monitor water quality in the lake and provide additional reference locations for comparison. Sample location WS-BKG-001 was used as a background drainage

[1] For sampling near the Dawson Cove outlet, "shallow" samples were collected at the surface and "deeper" samples were collected at the 1.0- to 1.5-feet depth interval. For sampling in Lake Conway, "shallow" samples were collected at the 1.0- to 1.5-feet depth interval and the "deeper" samples were collected at 80% of the water depth (determined in the field).

way sampling location along North Main Street, but became dry. This location was changed to WS-BKG-002 and is located in an upgradient area along North Main Street.

3.2 Proposed Locations

Based on a review of surface water sampling results collected through May 19, 2013, the following sample locations are proposed for ongoing water quality monitoring (Figure 2):

Location	Sample Location ID	Depth Intervals To Be Sampled Per Location (Feet Below Water Surface)
Locations accessed by foot		
Background drainage way	WS-BKG-002	Surface
Drainage way along North Main Street	WS-008	Surface
Dawson Cove outlet	WS-007	0.5-1.0
	WS-006	0.5-1.0
	WS-001	0.5-1.0
Lake Conway downstream of Dawson Cove	WS-002	Surface
Lake Conway Dam	WS-003	Surface
Lake Conway background	WS-005	Surface
Locations accessed by boat		
Dawson Cove outlet	WS-010	1.5-2.0
Lake Conway downstream of Dawson Cove	WS-011	1.5-2.0, 80% water depth*
	WS-012	1.5-2.0, 80% water depth*
Lake Conway north of Dawson Cove	WS-014	1.5-2.0, 80% water depth*
In Palarm Creek	WS-018	1.5-2.0, 80% water depth*

*If the water depth is deep enough to collect a sample at the second depth interval.

4. Sampling Methodology

The methodology presented herein allows for the collection of surface water samples that are representative of surface water quality.

4.1 Sample Collection

Sampling personnel will access the sample locations by land, bridge, and boat. If unsafe conditions exist at the location, the location will be adjusted, if possible, to a nearby safe location. Surface water sampling from land will be conducted as follows, provided that flowing conditions are present:

1. Park vehicle fully out of the roadway and in location where personnel can safely exit the vehicle. Follow traffic control procedures identified in the project Health and Safety Plan (HASP).

2. Verify that ExxonMobil has secured access to the property.

3. Verify that each piece of field equipment is calibrated, if necessary, and inspected to confirm that it is operational. Calibration and checks will be recorded in the sampler's field log book (ARCADIS 2013).

4. If using non-disposable sampling equipment, verify that the equipment has been decontaminated prior to reuse, using an Alconox© or equivalent wash and deionized or distilled water rinse.

5. If accessing the target sample location from land per the Standard Operating Procedure (SOP) included in Attachment A:

   - Park vehicle fully out of the roadway and in a location where personnel can safely exit the vehicle. Follow traffic control procedures identified in the project Health and Safety Plan (HASP).
   - Identify safest access point to surface water body. Avoid undercut banks, eroded areas, densely vegetated areas, steep banks, and other slip, trip, and fall hazards.
   - Visually assess and document surface water conditions at the target sample location. Slowly walk/wade to the target sample location starting from a downstream position and moving upstream towards the sampling location, and minimize turbidity to the extent practicable.
   - Establish adequate footing. Make use of a spotter and follow HASP requirements for working in and near water.
   - Using the grab sample method described in the SOP (Attachment A), collect surface water sample volume, including aliquot for measurement of field water quality parameters described below.
   - Fill sample bottles in accordance with the QAPP (ARCADIS 2013).
   - Observe the water surface during sampling for evidence of sheen, distressed wildlife, or other indications of oil impact.
   - Document appearance of the sample.

6. If accessing the target sampling location by boat per the SOP included in Attachment A:

   - Navigate to the proposed sample location and secure the boat to the shoreline and/or deploy anchors.
   - Document water and shoreline conditions at the sampling location. The approximate water depth will be estimated using the boat's depth finder and/or a metered rod.
   - Using the grab sample method or discrete depth sampler method described in the SOP (Attachment A), collect surface water sample volume, including aliquot for measurement of field water quality parameters described below.

- Fill sample bottles in accordance with the QAPP (ARCADIS 2013).
- Observe the water surface during sampling for evidence of sheen, distressed wildlife, or other indications of oil impact.
- Document appearance of the sample.

4.2 Measurement of Surface Water Quality Field Parameters

In conjunction with the collection of the surface water samples for laboratory analysis, surface water quality field parameters will be measured by lowering the water quality probe into the water at each surface water sample location. Water quality parameters will be measured in accordance with the sampling requirements and quality assurance requirements contained herein. The water quality parameters will be documented in a field notebook or field log sheet. The following equipment will be used to measure field parameters:

- pH meter
- Conductivity meter
- Thermometer
- Turbidity meter
- Dissolved oxygen meter

Surface water quality parameters will be measured at each sample location. Surface water quality parameters will be monitored and recorded to confirm that surface water quality is stable and worker related disturbances are not affecting water quality (e.g., turbidity). Field parameter stability will be established as:

- pH stable +/- 1 standard unit
- Conductivity stable +/- 10% of previous measurement
- Temperature stable +/- 1 degree Celsius
- Turbidity stable +/- 10% NTU (or +/- NTU if turbidity is less than 10 NTU)

5. Sample Analysis

Surface water samples will be collected and submitted to Lancaster Laboratories for analysis for the following compounds:

- Volatile Organic Compounds (VOCs) by USEPA Method 8260
- Polycyclic Aromatic Hydrocarbons (PAHs) by USEPA Method 8270 SIM
- Total metals (8 RCRA metals plus nickel, vanadium, calcium, and magnesium for Ca-Mg Hardness calculation) by USEPA Method 6010/7470 (mercury)
- Dissolved metals (8 RCRA metals plus nickel and vanadium) by USEPA Method 6010/7470 (mercury)
- Oil and grease (HEM) by USEPA Method 1664A

6. Laboratory Sample Quality Assurance

Sample and analytical quality assurance for laboratory samples will be achieved through compliance with the project QAPP (ARCADIS 2013). In accordance with this SAP, the following quality assurance samples will be collected during implementation:

- One field duplicate sample per 20 field samples collected.
- One matrix spike/matrix spike duplicate (MS/MSD) per 20 field samples collected.
- One rinsate blank sample per day on decontaminated non-dedicated sampling equipment.
- One trip blank per cooler containing samples that will be analyzed for VOCs.

7. Surface Water Data Evaluation

Surface water sample results will be compared to the *Arkansas Pollution Control and Ecology Commission Regulation No. 2* Standards (APC&EC Reg. 2 Standards) dated August 26, 2011. When APC&EC Reg. 2 Standards are unavailable for certain compounds, the surface water sample results will be compared to the USEPA National Recommended Water Quality Criteria (2013). The data will be evaluated for summary statistics and any important spatial or temporal trends. If data review and analysis supports modification of this SAP, those proposed modifications will be provided to the Arkansas Department of Environmental Quality (ADEQ) for review and approval prior to implementing any changes.

8. Schedule

The surface water monitoring locations will be sampled daily. The frequency may be reduced at a later date following approval by the ADEQ. Events may be cancelled or rescheduled due to inclement weather.

This SAP will be implemented upon approval by the ADEQ and other agencies.

9. References

ARCADIS U.S., Inc. 2013. ExxonMobil Environmental Services Company. Quality Assurance Project Plan, Pegasus Pipeline Release, Mayflower, Arkansas. April. (Pending submittal.)

Center for Toxicology and Environmental Health, LLC. 2013. Sampling and Analysis Plan, Mayflower Pipeline Incident. Mayflower, Arkansas. Prepared on behalf of ExxonMobil Pipeline Company. Revised April 4.

United States Environmental Protection Agency. 2013. National Recommended Water Quality Criteria. Available at: http://www.epa.gov/waterscience/criteria/.

Figures

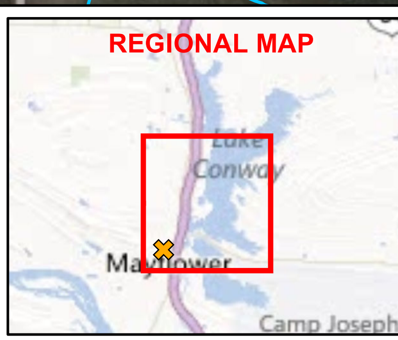
Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SURFACE_WATER\MAYFLOWER_SW_FILTERED_20130531_R2.mxd

LEGEND

- Surface Water Sample Locations
- Source Point
- Parcel Boundary
- Stream/River: Intermittent
- Stream/River: Perennial

***Background location WS-BKG-002 added on 5/9/2013 due to dry condition at location WS-BKG-001.**

Map date: 5/31/2013



EXXONMOBIL PIPELINE COMPANY
MAYFLOWER PIPELINE INCIDENT
MAYFLOWER, ARKANSAS

HISTORICAL SURFACE WATER SAMPLE LOCATIONS

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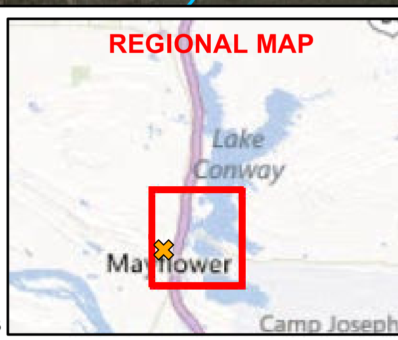
FIGURE
1

Office: CITRIX Author: MNesta
Path: H:\GISPROJECTS_ENV\XOM_MayflowerAK\MXD\SURFACE_WATER\MAYFLOWER_SW_FILTERED_20130711.mxd

LEGEND

- Surface Water Sample Locations Accessed by Foot
- Surface Water Sample Locations Accessed by Boat
- Source Point
- Parcel Boundary
- Stream/River: Intermittent
- Stream/River: Perennial

Map date: 7/11/2013



EXXONMOBIL PIPELINE COMPANY
MAYFLOWER PIPELINE INCIDENT
MAYFLOWER, ARKANSAS

PROPOSED SURFACE WATER SAMPLE LOCATIONS

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FIGURE
2

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Attachment A

Relevant Standard Operating Procedures

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Surface Water Sampling

Rev. #: 2

Rev Date: June 3, 2013

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection of surface water samples using a grab method, discrete depth sampler or peristaltic pump. This SOP should be followed whenever collecting surface water samples.

This SOP may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field personnel will be versed in the relevant SOPs and will possess the skills and experience necessary to successfully complete the desired field work. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

III. Equipment List

The following equipment list contains materials that may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- personal protective equipment (PPE) and other safety equipment, as required in the project Health and Safety Plan (HASP)
- project Quality Assurance Project Plan (QAPP)
- Sampling and Analysis Plan (SAP)
- indelible ink pens
- appropriate sample containers, labels, and forms
- decontamination supplies (see the SOP for Decontamination) including bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern.

- sample packing and shipping materials (see the SOP for Chain-of-Custody, Handling, Packing, and Shipping)

- water-quality (temperature/pH/specific conductivity/ORP/turbidity/dissolved oxygen) meter and flow-through measurement cell. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument
  - Hydrolab Series 3 or Series 4a Multiprobe and Display
  - Horiba U-10 or U-22 Water Quality Monitoring System

- for grab sampling method: pole with polyethylene and/or stainless steel dipper, if applicable

- for discrete depth sampling method: discrete depth samplers (e.g., Kemmerer or Van Dorn samplers)

- for peristaltic pump sampling method: peristaltic pump with appropriate power source, Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used. For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will also be used through the pump apparatus.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate surface water samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field-filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

The ability to safely access the surface water sampling locations should be verified prior to sampling.

Field activities will be performed in accordance with a project-specific HASP, a copy of which will be present onsite during such activities.

Safety hazards associated with sampling surface water include fast-moving water, deep water, and steep slopes close to sampling sites. Extreme caution should be used when approaching sampling sites. Work will be performed in accordance with the project-specific HASP.

V. Procedure

Sampling Method

Surface water samples will be collected from sampling locations sequentially from downstream to upstream to prevent cross-contamination associated with sediment disturbance. Surface water samples will be collected prior to sediment sample collection.

Grab Sample Collection

Personnel conducting surface water sampling using grab sample collection techniques should perform the following:

1. Collect appropriate equipment, cleaned and decontaminated.
2. Obtain appropriate sampling containers.
3. Mobilize to surface water sampling location in accordance with the work plan or SAP.
4. Collect sample by directly lowering the laboratory-supplied sample container into the water and allowing the bottle to partially fill with water. The sampler will hold the bottle immediately below the water surface and allows the bottle to fill with sample. Field

personnel will handle only the portions of the sample containers that do not come in contact with the sample, to avoid contamination. Additionally, care will be taken to avoid exposing samples and sample containers to atmospheric inputs such as dirt or dust.

5. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

6. Transfer surface water samples into laboratory-supplied sample containers to complete the scope described in the SAP. Avoid overfilling sample containers to prevent preservatives, if present, in sample container from being lost.

7. Handle samples in accordance with the SOP for Chain-of-Custody, Handling, Packing, and Shipping

Sample Collection Using a Discrete Depth Sampler (e.g., Kemmerer or Van Dorn)

Personnel conducting surface water sampling using grab sample collection techniques should perform the following:

1. Collect appropriate equipment, cleaned and decontaminated.

2. Obtain appropriate sampling containers.

3. Mobilize to surface water sampling location in accordance with the work plan or SAP.

4. Carefully set the sampling device so that water is allowed to pass through the tube.

5. Lower the pre-set sampling device to the predetermined depth using marked rope or line attached to the device.

6. When at desired depth; send down the messenger, closing the device. Avoid disturbing the bottom.

7. Retrieve sampler and discharge the first 10-20 mL to clear any potential cross-contamination.

8. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

9. Transfer surface water samples into laboratory-supplied sample containers to complete the scope described in the SAP. Avoid overfilling sample containers to prevent preservatives, if present, in sample container from being lost.

10. Handle samples in accordance with the SOP for Chain-of-Custody, Handling, Packing, and Shipping.

Sample Collection Using Peristaltic Pump

Personnel conducting surface water sampling using peristaltic pump collection techniques should perform the following:

1. Surface water will be collected using a peristaltic pump if flow is slow and conventional sampling procedures are impossible without collecting excess suspended sediment in the sample. Note any observations such as color or odors and determine the depth of water. Record the information in the field log book or field log forms.

2. Personnel should be aware that contact with peristaltic pump apparatus (e.g., control knobs) can serve as a source of metals contamination in dissolved metals analyses. Operation of pump controls should be conducted with gloves that do not come into contact with the sample or with materials that contact the sample.

3. Prepare the stream tubing. Based upon the distance to the pump location, cut the desired length of new Tygon tubing with an approved cutting device.

4. Set up the pump. Cut approximately one-foot of new C-Flex tubing from the roll. Remove pump and controller from the transport case. Insert the C-Flex tubing into the pump head by releasing the pump head with the lever on top of the pump head. Close the pump head on the tubing with the lever on top of the pump head. Check to see that the tubing is aligned properly. Attach pump head to the pump controller using the two set screws.

5. Attach the stream tubing and discharge tubing. Attach the stream tubing to the C-Flex using a new plastic connector. Attach a convenient length of Tygon tubing to the C-Flex to serve as the discharge tubing. The discharge tubing may be attached to a flow-through cell for various field measurements. Remove the flow-through cell prior to the collection of surface water samples for laboratory analysis.

6. Connect the power supply. Connect the power cord to the pump unit and the automobile lighter or battery.

7. Start the pump. Set the head direction switch to have flow go in the correct direction for the set up. Turn the pump switch to the ON position and adjust the flow rate with the dial to the desired flow rate.

8. Operate the pump. Operate the pump at the desired flow rate.

9. Measure water quality parameters in accordance with the SOP for Measuring Basic Water Quality Parameters.

10. Collect surface water samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container.

    – If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to surface water sample collection.
    – Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap.
    – Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the Sampling and Analysis Plan (SAP)).

11. Completion of sampling. At the completion of the sampling at the well, turn off the pump, and remove the tubing from the stream. Drain the tubing according to the project requirements. Remove the C-Flex tubing from the pump head. Discard all tubing and connectors according to project requirements.

12. Disconnect the power. Disconnect the power cord, disassemble pump head from controller and return equipment to the transport case.

13. Secure the well and properly dispose of PPE and disposable equipment.

14. Pack and store samples appropriately for transport to laboratory. Handle samples as described in the SOP for Chain-of-Custody, Handling, Packing, and Shipping.

15. Complete decontamination procedures for flow-through analytical cell, as appropriate.

VI. Waste Management

Investigative derived Waste (IDW) generated during the surface water sampling activities and disposable equipment will be transported for offsite disposal in accordance with the site-specific Waste Management Plan.

VII. Data Recording and Management

See the SOP for Field Documentation.

VIII. Quality Assurance

Sample quality will be achieved by complying with the procedures outlined in this SOP. Cross-contamination will be prevented by following the protocols described in the SOP for Field Equipment Decontamination. Field activities will be supervised by appropriate experienced field supervisors. Additional quality assurance information is presented in the project-specific Quality Assurance Project Plan.

ARCADIS

Attachment C

Description of Dart Sampling Approach

User Manual

Darts

Field Deployable
Solid Phase Extraction Samplers

DAKOTA TECHNOLOGIES

Version 2.10.09

2010

Table of Contents

Introduction

The Dart system is designed to quickly and inexpensively screen for polycyclic aromatic hydrocarbons (PAHs) in sediments and similar soft soils, where LIF, traditional soil boring, and other mechanized sampling are difficult, if not impossible.

The Dart sampler is comprised of a continuous rope or rod made from or coated with solid-phase extraction (SPE) media – the same type of materials used in labs for EPA-approved cleanup and pre-concentration of PAHs in traditional grab samples. PAHs are attracted to and sorb into the SPE media. Once the PAHs have migrated into the Dart, they're held within the SPE matrix and remain trapped there almost indefinitely.

The Darts are deployed by hand or manual slide hammer into the sediments, anywhere from 1 to 20 ft deep, depending on soil conditions or survey needs. Once planted, any PAHs that are sorbed to sediment soil particles, dissolved in sediment pore water, or exist as a component of non-aqueous phase liquids in the sediments, will migrate into the Dart sampler. They migrate into the Dart sampler because of the PAHs' high affinity for the SPE material versus its relatively low affinity for water or sediments, generating a considerable concentration gradient. Typically 24 hours of equilibration time is sufficient, after which the Darts are retrieved, packaged, and sent to Dakota Technologies, Inc. (Dakota) for reading. Additional soak times allow more PAHs to sorb. In most environments it does not matter if 24-72 hours soak times are used, but all soak times should be consistent – both with field and lab/validation soak times.

Technicians at Dakota run the Darts through an LIF reader that is very similar to UVOST. The result is an LIF log that looks nearly identical to a UVOST log. Similar to UVOST and TarGOST, the LIF response correlates to the total available PAH content of the sediment vs. depth. A graphical log in JPG format and high-resolution data files are available to the client soon after reading.

In addition, when combined with DGPS position information, the numerical results may be readily visualized with Dakota's 3D conceptual site model service, allowing the client to visualize the big picture of their sediment PAH contamination at a fraction of the cost of traditional sampling/analysis.

The Dart system is particularly well suited for characterization work in shorelines, marshes, or shallow bodies of water, where profiling PAHs sediments has traditionally been difficult and expensive. Research by others also suggests that the Darts will be capable of acting as biological surrogates due to the SPE material's similarity to biological tissues with regard to absorbing biologically available PAHs in sediments, allowing for surveys of biological uptake risk as opposed to total PAH analyses of sediment using aggressive Soxhlet extractions, which often overestimate risk. Dakota is continuing to investigate the efficacy of applying Darts to these and other screening applications.

Overview of Installation

This guide will help you deploy, retrieve, and package the Darts so that there is minimal risk of false positives or crossover contamination from one portion of the Dart to the other. The key physical property behind the Dart concept is that they will quickly soak up oils, greases, PAHs, and nearly all organic solvents. Figure 1 illustrates the desired installation approach. Prior to a detailed and mechanical procedure listing, we'll discuss the basics you'll want to keep in mind during your Dart survey. Finally, we'll walk you through a step-by-step procedure with photos to guide you through the process.

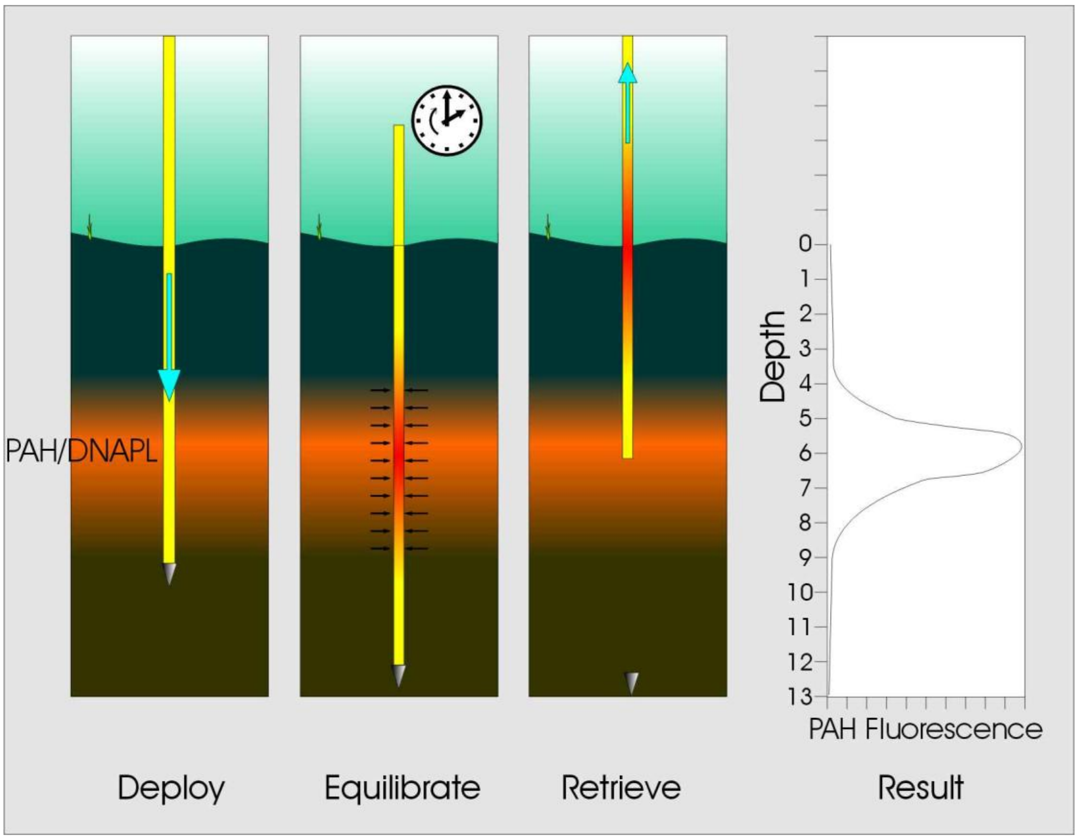


Figure 1. Basic concept behind Dart installation, exposure, and retrieval

Eliminating False Positives

The ability of the Dart to absorb organics is crucial to the Dart's ability to survey for PAH NAPL, but can easily lead to false positives. In order to avoid this, the technician should wear standard nitrile gloves when handling Darts, so as to prevent potentially fluorescent oils from transferring from your hands to the Dart. The Darts can also pick up fluorescent contamination from the delivery tooling if reasonable hygiene precautions aren't followed between insertions. The Darts are shipped in a plastic sleeve that protects the Dart from incidental exposure to grease/oils, but gasoline and diesel might well penetrate the sleeve and expose the Dart to PAHs, so protect the Darts from exposure to fuels/oils. Lastly, storing the Dart so that a PAH-contaminated section is in contact with an uncontaminated section of another Dart can lead to false-positives in the sense that contamination will be assumed to have existed where PAH fluorescence is detected, yet the PAHs came from "hot" regions of another Dart, not the sediments that were in contact with the Dart during the survey. Dakota can supply aluminum foil that should be used to wrap each Dart to protect from this "cross talk".

While Darts can pick up PAHs from relatively dry metal surfaces or dissolved phase (aqueous) fluids, they need a lot of time (days/weeks) to do so. The Darts need true NAPL or high concentrations for faster (<24 hour) transfer. As a result, don't let the good hygiene issue consume your thoughts. As long as one prevents exposure to bare hands and tar/oil from previous installations (including "sheen" on the water's surface), the likelihood of carryover contamination is minimal. Previous studies also have shown that Darts are immune to humics/fulvics from plant material such as sticks, leaves, peat moss, detritus, and high organic soils.

So the basic idea is to assemble, retrieve, and package the Darts without letting anything but that Dart's own particular location sediment come into contact with the Dart. That means that Darts should be handles without letting the Dart touch oil/NAPL from any other source. A few tips include:

- Lay out a clean and level work area or 'base camp' with dirty and clean zones so one doesn't inadvertently expose clean tools/Darts to contaminated surfaces.
- Try to implant Darts by working from suspected clean zones toward suspected hot zones so that effort of cleaning the tooling and degree of contamination of tooling is reduced between clean zones and hot ones. A small degree of inadvertent carryover between two hot Dart locations is not nearly as detrimental as carryover from a hot zone to a pristinely clean zone... leading to a very false-positive.
- Switch gloves A LOT. Take several boxes of cheap nitrile gloves, keep lots of spares in your pockets and when you see tar/oil on your gloves and you need to handle a Dart then switch to new gloves. When in doubt… glove up!
- Use lots of paper towels, tarps, plastic sheeting, or whatever you need to prevent tar/oil carryover.
- Work "upstream" or "upwind" to prevent sheen from previous plantings contaminate the subsequent Darts
- Always use a Dart or two as trip blanks. Take them in the field and back with you and have them analyzed to prove that shipping, storing, reading and other processes did not create positive responses in the Darts

Field Deployment

Assembly

Step 1. Glove up.

Step 2. Inspect plastic sleeve for cleanliness. If it appears contaminated or torn/exposed, either don't use the Dart or note the damage for future reference should a "positive" be found at that section of that Dart.

Step 3. Single Darts (6 foot standard) are assembled and ready to deploy. Simply insert into the sediment by hand. If required, use the "mini-hammer" to assist in delivery.

Figure 2. Hand delivery mini-hammer

Step 4. If the Darts are sectionized versions (for up to 12 ft deep sampling), assemble the two sections by coupling the top and bottom sections together and inserting the pin that holds the two sections together. If necessary, the bottom section can be driven to a convenient working height, the second section added to the first, pinned together, then advance the second Dart section to final depth.

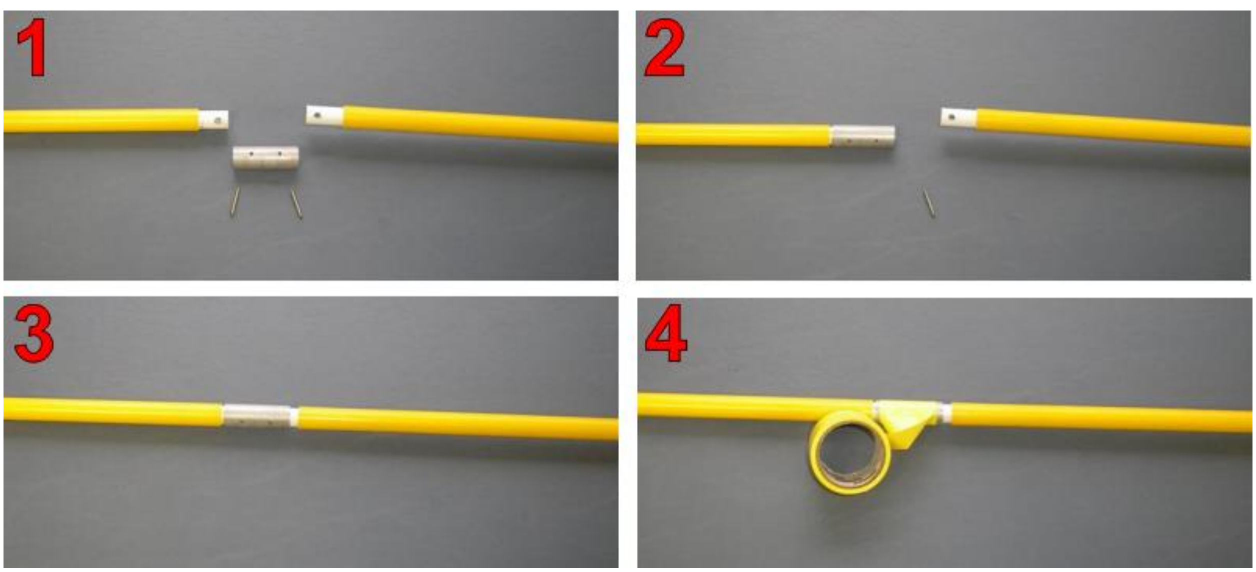


Figure 3. Dart extension coupling

Installation

Step 1. Attempt to deliver the Darts into the subsurface until the yellow SPE material is flush with the surface of the sediment. When delivering from a boat/kayak it may be difficult to determine when flush. Dakota is developing a “planting tool” that should assist with this.

Step 2. Using either static weight (simply pushing) or the mini-slide hammer delivery, insert the Dart and rod assembly to the desired depth. Continue pushing/hammering until the desired depth is achieved. The Dart is built to take some tearing and scarring while still producing valid results.

Step 3. In any event, once the Dart is inserted to desired depth (or you’ve met refusal) make note of how much yellow SPE material is either sticking up out of the sediment or estimate how far under the sediment the yellow may have been inadvertently planted. The Dart readout logs are all “zeroed” using this information, so that the logs correctly show the “surface” of the sediment at 0 ft. Make sure the Dart is accompanied with this information when delivered for reading. Record the location, date, time, Dart stickup (**distance from sediment surface to tagged top end of Dart**), water depth, tag ID #, and any other desired information for the Dart location. Also, be sure to record **desired file name** for the Dart data generated later during analysis in the lab. File names are the default Title used in graphics logs produced in the lab.

Step 4. For water projects, Dakota supplies floating rope/cord and buoys that are useful for recovering the Darts. The only “downside” to these is vandalism or boat traffic. One should consider marking the shore or using separate buoys at a predetermined offset in these cases. Use “sinking rope” on the actual Dart which you can then “fish for” with a grappling line or pole – guided by shoreline or separate buoy marker.

Figure 4. Dart clip, clip applicator, rope, and buoy

Step 5. Allow all the Darts to soak or dwell for approximately the same amount of time, ranging from 24-72 hours. The Dart soak times can vary by up to 6 hours without significantly impacting the survey. Variance beyond this has not been experienced to date, but we’re confident that, if desired, adjustments could be made by doing a limited lab study on site-specific materials to determine a correction factor that can be applied to the Dart logs.

Recovery

24-72 hours after implant, the Darts should be removed from the sediment. The longer the soak time, the more obvious the NAPL or sorbed PAH staining. Although it hasn't necessarily been determined to be an optimal time, 24 hours has been the default soak time used in previous field and lab work. Regardless of how long they've soaked, be sure that they all get pulled after approximately the same amount of soak time as the others.

Step 1. Using clean nitrile gloves to handle the Dart, simply pull the Dart out of the sediment, being very careful not to cross-contaminate the Dart by allowing ooze, mud, NAPL, etc. to run up/down the Dart. The easiest way to accomplish this is the get the Dart Horizontal ASAP. Feel free to handle the stickup portion (the above sediment portion) – even if your glove might be slightly contaminated. Remember that we'll only be reading the below ground surface portion. The stickup end (the handle if you will) won't be included in the log.

Step 2. Once the Dart is retrieved, hold the Dart horizontal and away from other Darts or contaminating surfaces and transport the Dart back to the central location or a clean plastic sheet laid out on the river bank, etc. At this time you might notice a distinct "mudline". If you do, and you trust that this represents the true zero, feel free to mark this location by attaching a strong zip tie to the Dart at that exact location.

Step 3. Clean the Dart of any major debris/mud. If grossly contaminated with tar/oil, lay out some paper towels and let the residual material drip/soak off until it's at a point where you feel it won't flow/seep. It's important to recognize that gross NAPL will continue to source PAHs to that Dart or section of Dart, making that section higher in PAH relative to the other Darts that were exposed to NAPL for only the dwell time. If necessary to wipe lots of mud/debris (rare) then wipe across the Dart – don't scrub back/forth lengthwise as this might smear NAPL up/down the Dart.

Step 4. Wrap the Dart in aluminum foil. If it's necessary/convenient to leave some mud/soil on the Dart, it's best to let the mud dry to the touch so it doesn't flow or smear around a lot while being wrapped or shipped.

Figure 5. Wrapping Dart in foil

Step 5. At this point the Dart is robust and readily handled. Keep the Darts out of direct sunlight or other "hot places". Dry, dark and cool is best but it is not necessary to ice/freeze.

Shipping

Step 1. Ship the Darts back to Dakota for reading. Ship in a container where the Darts are "snug" but won't rub the foil off each other. If you suspect some to be extremely "hot" (strong naphthalene odor) then group the Darts hot with hot and clean with clean if at possible in order to prevent the slight chance of vapor phase cross-contamination in gross contamination conditions (Darts soaked in pure tar/creosote grouped with background Darts). We commonly ship in boxes, hard cardboard shipping tubes, or even Vibracore sampling tubes. The Darts will all be read in one session, using a reference emitter to normalize the response across all Darts for your project. ASCII and JPG images of the logs will be emailed to you shortly after they've been read.

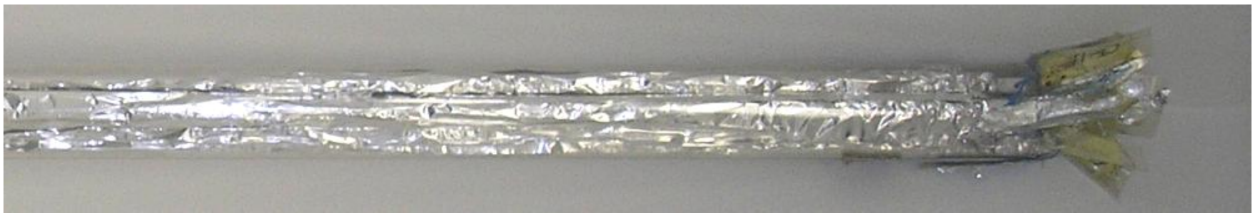


Figure 6. Eight Darts in a 3 inch sample tube

Analysis at Dakota

Instrument

A modified Ultra-Violet Optical Screening Tool (UVOST®) is used to determine the intensity and location of any NAPL staining. The UVOST is a laser-induced fluorescence instrument that has been used for in-situ screening of NAPLs since 1993. Modifications for the purposes of Dart reading include a modified optical arrangement, and the addition of a lathe that rotates the Dart while translating the excitation/emission optics. The benefit of this rotating lathe system is that the Dart is read in a spiral pattern, meaning the Dart reading has maximum coverage and there are no blind areas.

The system developed by Dakota sends excitation light through a fiber optic cable to the Dart reader. The light exits fiber and illuminates the Dart. As the probe is advanced along the Dart, if fluorescent compounds exist (i.e. contaminants) light is emitted. The emission light is transmitted through a fiber back to the instrument for analysis. Dakota's LIF systems monitor four unique bands of this emission in real-time. Responses are indicated on a graph of signal vs. depth. More information on the UVOST and laser-induced fluorescence can be found at our website: www.DakotaTechnologies.com.

Dart Preparation

The Darts are unpackaged from the bulk container and inspected for any damage to the protective layer of packaging, as this may be a sign of potential cross-contamination. A Dart is then unwrapped from its protective layer and any debris is cleaned off the Dart using non-fluorescent water and lint free towels. At all times, personnel handling the Darts wear latex or nitrile gloves that have been proven to be non-fluorescent. Note this cleaning has no impact on the absorbed NAPL due to the affinity of the NAPL for the Dart material over an aqueous solution. The Dart is then loaded into the reading instrument and the optics are aligned to the proper start-depth location on the Dart.

Calibration

A stable reference fluorescent material is positioned in front of the optical assembly and the resulting instrument response is recorded. This reference emitter (RE) measurement is made before every Dart and defines the unit of measurement (%RE = signal / reference * 100). Any day-to-day drift in instrument response (such as that caused by a change in laser excitation energy) is accounted for by consistently using this same RE.

It is possible to generate response curves across a range of concentrations with lab testing. It is done by mixing various concentrations of site-specific NAPL on site-specific soil/sediment, Fisher Scientific sea sand, etc., soaking very short Darts in these mixtures, then analyzing these Darts after the same dwell times as used in the field. The results can later be used to convert the %RE values of field logs to ppm NAPL by weight (or other units if the calibration set of samples is sent to a lab for same analysis as field samples). Example calibration curve figure is shown below. Darker, more organic, and finer grain sediments will yield a lower response as reflected in the figure.

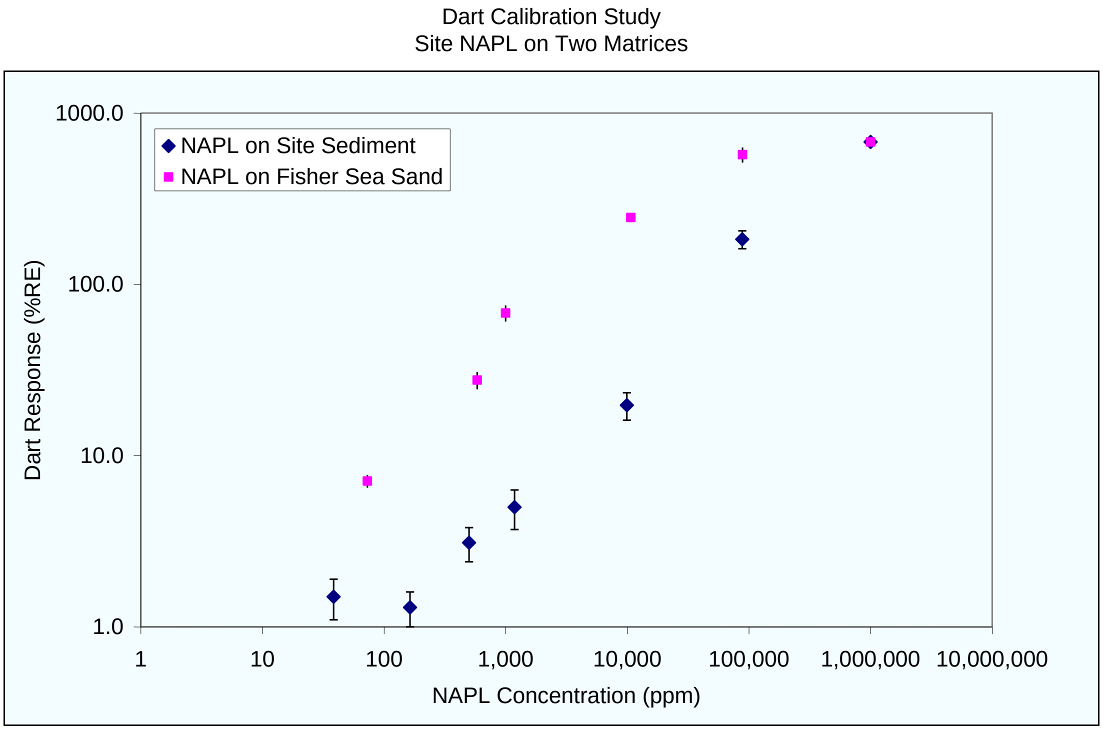


Figure 7. Dart calibration – site NAPL on two different matrices

It is also possible to calibrate the response of both Darts and TarGOST so as to be able to relate the two technologies. In some cases both Darts and TarGOST are used on the same site. Calibrating to both allows a site-wide distribution map to be made with consistency, thereby accounting for the differences between the Dart RE and TarGOST RE (two different REs due to the differing technologies/processes).

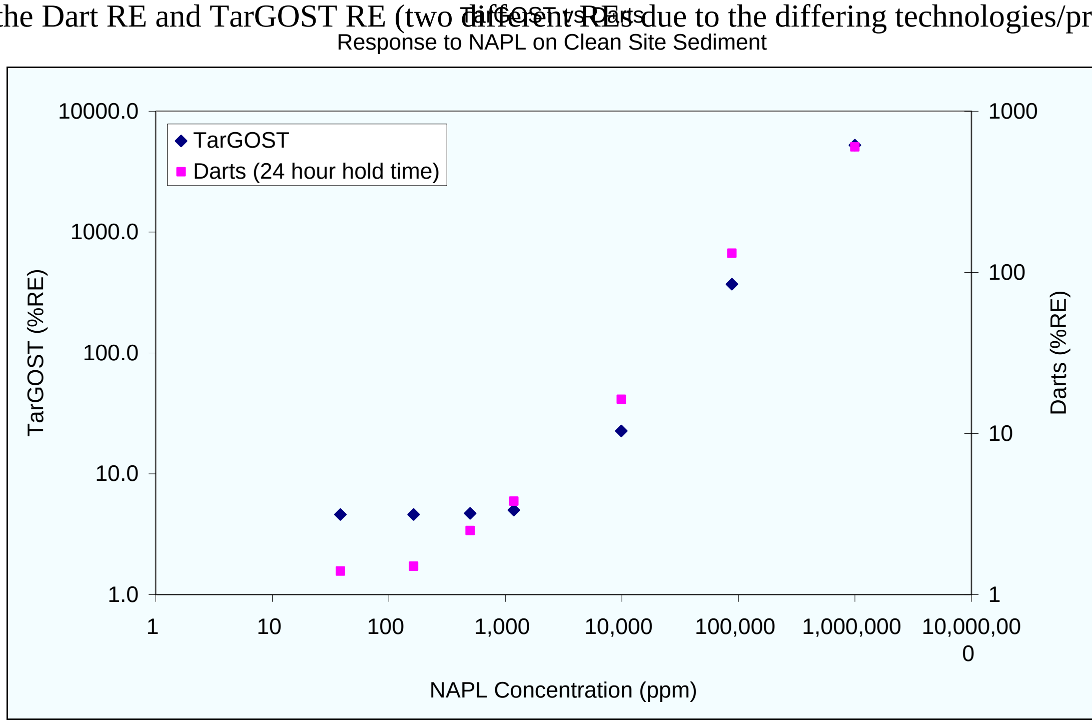


Figure 8. Darts vs. TarGOST – response to NAPL on clean site sediment

Reading

The instrument and related software digitize and record the fluorescence signal at each data point. The instrument is designed to record over ten data points per vertical inch (2.5 cm). Each data point is the average of roughly ¼ inch (0.6 cm) of spiral travel along the Dart.

Manual Inspection

Following the automated Dart reading, a visual inspection of the Dart under black light is performed. Any areas of interest (such as spotting) are noted and correlated with the measured log. In this way, the potential nature of the fluorescence causing material might be better understood by observing the pattern/image left behind.

Data Output

Data is provided in two digital forms: as a text file (essentially depth vs. signal) and as a log image. See below for an example log image and a description of each part of the log.

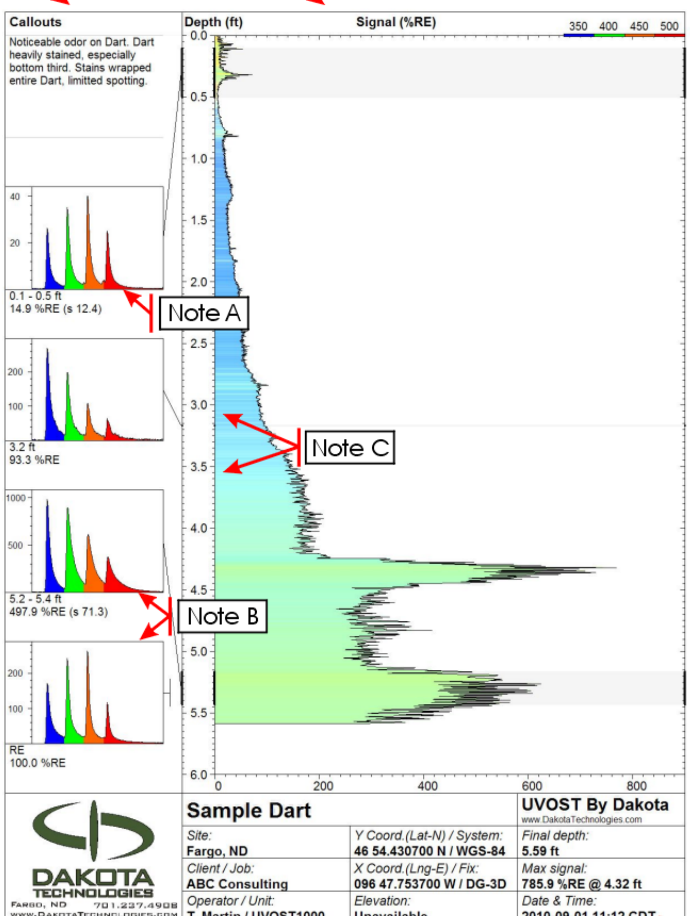
Main Plot :
Signal (total fluorescence) versus depth where signal is relative to the Reference Emitter (RE). The total area of the waveform is divided by the total area of the Reference Emitter yielding the %RE. This %RE scales with the NAPL fluorescence. The fill color is based on relative contribution of each channel's area to the total waveform area (see callout waveform). The channel-to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

Callouts :
Waveforms from selected depths or depth ranges showing the multi-wavelength waveform for that depth.

The four peaks are due to fluorescence at four wavelengths and referred to as “channels”. Each channel is assigned a color.

Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more channels.

Basic waveform statistics and any operator notes are given below the callout.



Info Box :
Contains pertinent log info including name and location.

Note A :
Time is along the x axis. No scale is given, but it is a consistent 320ns wide.
The y axis is in mV and directly corresponds to the amount of light striking the photodetector.

Note B :
These two waveforms are clearly different. The first is weathered diesel from the log itself while the second is the Reference Emitter (a blend of NAPLs) always taken before each log for calibration.

Note C :
Callouts can be a single depth (see 3rd callout) or a range (see 4th callout). The range is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

Reporting

A report is generated that contains an overview of the basic steps followed during the reading and includes a table with the known pertinent info such as Dart ID, retrieval date/time, location, measurement date/time, max signal, and any relevant sample notes.

Storage

Previously read Darts are stored until it is clear that there is no need to reexamine for any reason. The storage process is the same as in the recovery steps detailed earlier.

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