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Downstream Areas Data Assessment Report

Mayflower Pipeline Incident Response
Mayflower, Arkansas

December 2013

Revision 3

ARCADIS

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Acronyms and Abbreviations

ADEQ	Arkansas Department of Environmental Quality
AGFC	Arkansas Game and Fish Commission
ARCADIS	ARCADIS U.S., Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
bss	below sediment surface
DARSP	Downstream Areas Remedial Sampling Plan
DTI	Dakota Technologies, Inc.
EcoSSLs	Ecological Soil Screening Levels
EMPCo	ExxonMobil Pipeline Company
ESV	ecological screening value
FOD	frequency of detection
GPS	global positioning system
HMW	high molecular weight
LIDAR	Laser Imaging, Detection, and Ranging
LIF	laser-induced fluorescence
LMW	low molecular weight
µg/kg	micrograms per kilogram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum of 1983
NAPL	nonaqueous phase liquid

NAVD88	North American Vertical Datum of 1988
NGS	National Geochemical Survey
PAH	polycyclic aromatic hydrocarbon
PID	photoionization detector
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
report	Downstream Areas Data Assessment Report
RPD	relative percent difference
SDG	sample delivery group
site	Mayflower Pipeline Incident Response located in Mayflower, Arkansas
SOP	Standard Operating Procedure
SPE	solid-phase extraction
TCE	trichloroethene
TEH	total extractable hydrocarbons
TOC	total organic carbon
TSS	total suspended solids
TU	toxic unit
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UTL	upper tolerance level
VOC	volatile organic compound

Executive Summary

Introduction

This Downstream Areas Data Assessment Report for the Mayflower Pipeline Incident Response located in Mayflower, Arkansas presents the results of environmental sampling conducted in accordance with the Downstream Areas Remedial Sampling Plan (DARSP), which was approved by the Arkansas Department of Environmental Quality (ADEQ) on July 12, 2013. The DARSP was designed to evaluate soil, sediment, and surface water conditions following the emergency response actions that were implemented immediately after a release of Wabasca heavy crude oil from the Pegasus Pipeline. Sampling and investigation work targeted three general areas downstream of the release location as shown on Figure 1-1 (drainage ways, Dawson Cove, and Lake Conway), as well as background locations in the drainage ways and Lake Conway to meet the primary objectives:

- Characterize current soil, sediment, and surface water quality.
- Compare analytical results for soil, sediment, and surface water to established quantitative risk-based screening levels.
- Develop a preliminary assessment of background soil and sediment quality in Lake Conway and in the drainage ways.

Sampling Program

Soil, sediment, and surface water sampling activities were completed between July and August 2013; additional activities included a topographic survey in Dawson Cove and a depositional assessment in Lake Conway. These key findings are summarized below.

Sediment and Soil Sampling

A total of 99 soil samples and 178 sediment samples were collected from 83 locations and submitted for laboratory analysis. In addition, six background soil samples and 12 background sediment samples were collected from 18 locations and submitted for laboratory analysis. Samples were collected from the drainage ways, Lake Conway, Dawson Cove and background locations. Out of the 101 sampling locations, 18 were background locations. Samples were analyzed for polycyclic aromatic hydrocarbons

(PAHs), volatile organic compounds (VOCs), and metals; surface samples were also analyzed for grain size, black carbon, and total organic carbon.

Surface Water Sampling

Over 2,180 samples have been collected as part of a daily surface water monitoring program focused primarily on Lake Conway, but also including locations in the drainage ways and Dawson Cove, since March 29, 2013. In August 2013, six surface water samples were also collected from the drainage ways and Dawson Cove as part of a one-time event for the DARSP activities. Surface water samples were analyzed for PAHs, VOCs, total metals, dissolved metals, and oil and grease. The DARSP surface water samples were also analyzed for total suspended solids.

Data Evaluation

The data collected as part of this program were compared to ecological screening values (ESVs) and background concentrations in accordance with the approach described in the DARSP. The ESVs are concentrations below which risk to ecological receptors is considered *de minimus*. Concentrations above ESVs do not necessarily imply that ecological risk exists; only that further evaluation is warranted.

Analytical data were compared to ESVs, Equilibrium Partitioning Sediment Benchmark Toxic Units (TUs), and background concentrations as described in the DARSP. Based on direction from the ADEQ, the risk screening process is focused on ecological risks.

The screening approach consisted of the following:

- Evaluate whether the analyte was associated with the crude oil at concentrations that could have resulted in the observed concentrations in the sampling media.

- Compare detected concentrations of metals to Arkansas background, and if the concentrations are above Arkansas background, compare to ESVs.

- Compare detected concentrations of VOCs to ESVs.

- Compare detected concentrations of PAHs to ESVs, and evaluate TUs for PAH mixtures in sediment and DARSP surface water samples. The TU value is used to evaluate whether concentrations of PAHs in sediment are acceptable for the protection of benthic organisms and whether concentrations of PAHs in surface water are acceptable for the protection of aquatic organisms.

Topographic survey data from Dawson Cove were used to identify the transitional area associated with seasonal fluctuations in Lake Conway. Sample data from this transitional area were screened against both sediment and soil screening values.

Results of Data Evaluation

The data evaluation process eliminated a number of constituents from further consideration because they were not associated with crude oil, were below the ESVs, or were indicative of background conditions. The following provides a summary of soil and sediment findings by area, and a summary of the overall surface water sampling results.

Drainage Ways Soil and Sediment Results

A total of 45 soil samples were collected at 15 locations along the banks of the drainage ways. Based on the screening results, 42 of the 45 soil samples do not require further evaluation. Further evaluation is warranted at three soil samples that had an individual analyte or PAH summation above the ESV.

A total of 35 sediment samples were collected at 13 locations in the drainage ways. Based on the screening approach, sediment in the drainage ways does not warrant further evaluation.

Dawson Cove Soil and Sediment Results

A total of 54 soil samples were collected at 15 locations in Dawson Cove. Based on the screening results, concentrations in 50 of 54 soil samples were at levels that do not require further evaluation. Four samples had a PAH summation above the ESV, indicating that further evaluation is warranted.

A total of 125 sediment samples were collected at 34 locations in Dawson Cove. Based on the screening results, concentrations in 118 of 125 sediment samples were at levels that do not require further evaluation. Seven samples had select analytes above the ESV, indicating that further evaluation is warranted.

Lake Conway Sediment Results

A total of 18 sediment samples were collected at six locations in Lake Conway. Based on the screening results, sediments in Lake Conway do not warrant further evaluation.

Surface Water Results

Over 2,180 surface water samples have been collected to date as part of a daily surface water monitoring program focused primarily on Lake Conway, but also including locations in the drainage ways and Dawson Cove. The data evaluation results for recent surface water samples indicate that no further action is warranted, however, monitoring on a reduced scale will continue.

Recommended Path Forward

Soil and Sediment

Further evaluation is warranted based on sampling results for soil at three locations within the drainage ways, and for soil and sediment at eight locations within Dawson Cove. ExxonMobil will develop a plan for items that warrant further evaluation and review the approach with the ADEQ before proceeding.

As requested by the ADEQ, ExxonMobil will re-sample the six Lake Conway sediment locations using the same procedures and analyses described in the DARSP.

Surface Water

Based on the surface water evaluation, continued surface water sampling is recommended on a weekly frequency at 13 locations and for PAHs only.

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) has prepared this Downstream Areas Data Assessment Report (report) for ExxonMobil Environmental Services Company on behalf of ExxonMobil Pipeline Company (EMPCo) for the Mayflower Pipeline Incident Response located in Mayflower, Arkansas (the site). For the purposes of this report, the site consists of areas located downstream from the residential neighborhood affected by the incident. This report presents the results of environmental sampling conducted under the Downstream Areas Remedial Sampling Plan (DARSP; ARCADIS 2013), which was approved by the Arkansas Department of Environmental Quality (ADEQ) on July 12, 2013. ARCADIS conducted the sampling activities in July and August 2013 in the areas shown on Figure 1-1.

ARCADIS submitted the Downstream Areas Data Assessment Report to the ADEQ on October 11, 2013. A revised report (Revision 1) was submitted on November 1, 2013, to incorporate comments received by ADEQ and the Arkansas Game and Fish Commission (AGFC) on October 24, 2013. The next revised report (Revision 2) was submitted on November 8, 2013, to incorporate the final laboratory data validation results. This revised report (Revision 3) is submitted to incorporate a second round of comments received by ADEQ and AGFC on November 19, 2013.

1.1 Background

On March 29, 2013, a breach in a pipeline operated by EMPCo (the 20-inch Pegasus Pipeline) released crude oil into a residential neighborhood in Mayflower, Arkansas. The crude oil was identified to be Wabasca heavy crude oil. An emergency response action was implemented immediately to mitigate the release, and removed a substantial amount of the crude oil. The area addressed by the DARSP (ARCADIS 2013) includes a drainage way that leads from a residential neighborhood near the Pegasus Pipeline release point to a shallow drainage swale along North Main Street, which then flows east under Highway 365 and Interstate 40 into a marsh known as Dawson Cove (Figure 1-1). Dawson Cove is separated from Lake Conway by Highway 89, with water conveyed between the cove and Lake Conway by two culverts beneath the highway.

The DARSP (ARCADIS 2013) was designed to evaluate the current conditions in soil, sediment, and surface water following the response actions. Specifically, the DARSP defines five operational areas where sediment, soil, and surface water samples were collected in July and August 2013 (Figure 1-1). These areas are in sequence from upstream to downstream and are described below:

- 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 – marsh located between I-40 and a sub-area labeled for purposes of the response as Division B-On Water
- Subsection B-On Water – open water area located between Division B-Dawson Cove and the Highway 89 bridge

In addition to these five areas, sediment sampling was conducted at locations in Lake Conway, north of Highway 89, to verify that sediments in Lake Conway have not been affected by the Mayflower Pipeline release. Lastly, background locations were targeted for soil and sediment sampling to characterize soil and sediment unaffected by the crude oil release; these samples were obtained from drainage ways upstream of the release area and distant locations within Lake Conway (see Figure 1-2).

The following terms are used in this report to describe the three general areas downstream of the release point where post-response conditions were assessed:

- *Drainage ways*. Subsections A-Main, A-365W, and A-365E, which are the shallow drainage ditches from the neighborhood to Dawson Cove
- *Dawson Cove*. Subsections B-Dawson Cove and B-On-Water
- *Lake Conway*. Lake Conway (not including Dawson Cove)

Samples were classified as soil or sediment based on their location. In the drainage ways, samples from along the banks were classified as soil and locations within the flow channel were classified as sediment, regardless of whether there was water present at the time of sampling. In Dawson Cove, where water levels fluctuate seasonally, locations submerged at the time of sampling were classified as sediment, and those not submerged were classified as soil. For risk screening purposes, data for samples in the transitional zone between seasonal high and low water levels were screened as both soil and sediment.

1.2 Objectives

The data generated as part of the DARSP (ARCADIS 2013) sampling activities the primary objectives:

- Characterize current soil, sediment, and surface water quality.
- Compare analytical results for soil, sediment, and surface water to established quantitative risk-based screening levels.
- Develop a preliminary assessment of background soil and sediment quality in Lake Conway and in the drainage ways.

Details of the field sampling effort, including the specific methodologies and analyses, are discussed further in Section 2.

1.3 Report Organization

The remainder of this report is organized into the following sections:

2 – Summary of Sampling Program	Summarizes the sampling activities that were conducted for soil, sediment, and surface water (including background locations); Dart sampling in soil and sediment; and assessing sediment depositional layers in Lake Conway.
3 – Topographic Survey	Discusses the topographical survey activities conducted at the site and the water levels in Lake Conway and Dawson Cove.
4 – Data Quality and Data Management	Describes the data reviews that were performed to evaluate the data quality, and the management and handling of the data.
5 – Data Evaluation Methods	Presents the screening approach and data evaluation process used to compare the data collected as part of this program to applicable screening values.

6 – Soil Sampling Evaluation and Results	Discusses the analytical results and data analysis for soil samples collected in the drainage ways and Dawson Cove.
7 – Sediment Sampling Evaluation and Results	Discusses the analytical results and data analysis for the sediment sampling in the drainage ways, Dawson Cove and Lake Conway.
8 – Surface Water Sampling Evaluation and Results	Summarizes the analytical results and data analysis for surface water samples collected from the drainage ways, Dawson Cove, and Lake Conway.
9 – Summary of Analytical Findings	Presents a summary of the screening results for each area of the site and a recommended path forward.
10 – References	Lists the references cited throughout this report.

Tables and figures are also included to provide further detail, as appropriate, and a series of appendices has been compiled to provide supporting data for the discussions included in the main text. The appendices are as follows:

- Appendix A – Field Notes
- Appendix B – Sediment and Soil Photo Logs
- Appendix C – Lake Conway Depositional Layer Assessment Photographs
- Appendix D - Topographic Survey Data and Channel Cross-Sections
- Appendix E – Dart Sampling and Laser-Induced Flourescence Results
- Appendix F – Analytical Data Tables
- Appendix G – Laboratory Reports
- Appendix H – Box Plots
- Appendix I – Ecological Effects Evaluation
- Appendix J – Toxic Unit Calculations
- Appendix K – Analytical Data Tables – Detected Analytes Only

2. Summary of Sampling Program

The DARSP activities occurred during three primary mobilizations in July and August 2013. A topographic survey and utility clearance were conducted between July 15 and 20, 2013, with additional survey activities completed as needed in August 2013. Soil, sediment, and surface water sampling associated with DARSP was conducted between July 27 and August 16, 2013, and included Dart sampling in soil and sediment. An assessment of sediment depositional layers in Lake Conway was conducted between August 27 and 29, 2013. Dart sampling is described in the DARSP (ARCADIS 2013), and involves the temporary deployment of an adsorbent fiber into the soil or sediment, followed by laboratory observation for light fluorescence, which indicates the presence of polycyclic aromatic hydrocarbons (PAHs). Field notes from the sampling activities described in this section are presented in Appendix A.

2.1 Topographic Survey

The topographic survey conducted in accordance with the DARSP (ARCADIS 2013) included a total of 13 topographic cross sections in the drainage ways and 16 topographic/bathymetric cross sections in Dawson Cove at approximately 300-foot intervals. The survey was conducted using a real-time kinematic global positioning system (GPS). Coordinates were recorded in North American Datum of 1983 (NAD83) and elevations in North American Vertical Datum of 1988 (NAVD88).

In addition to the survey activities, a staff gage was installed on July 18, 2013 in Dawson Cove near the culverts beneath Highway 89 and the gage was read daily to record water levels.

2.2 Soil Sampling

Soil samples were collected at a total of 30 locations in the drainage ways and in Dawson Cove. Background soil samples were collected at six locations adjacent to Lake Conway. Sample locations were surveyed using a handheld GPS unit and soil samples were collected using hand auger or hand trowel techniques according to the process outlined in Section 2.5.2 of the DARSP (ARCADIS 2013). Soil sample locations along the drainage ways and in Dawson Cove are shown on Figures 2-1, 2-2, and 2-3. Background soil sampling locations are shown on Figure 2-5.

Surface soil samples (0 to 0.5 foot below ground surface [bgs]) were collected as five-point composite samples, except in drainage way A-365E, where only one core sample was collected due to the steep slope of the banks. Appendix B (B-1 through B-39) presents photos of the ground conditions at the composite sample locations. Shallow subsurface soil samples (0.5 to 1 foot and 1 to 1.5 feet bgs) were collected using a hand auger at the center of each composite grid. At three soil sampling locations in Dawson Cove, a hand auger was used to collect deep soil cores to a target depth or refusal, with a goal of at least 3 feet.

Samples were collected and processed according to the Standard Operating Procedures (SOPs) in Attachment A of the DARSP (ARCADIS 2013). At each sample location, soil to be analyzed for volatile organic compounds (VOCs) was collected from the center sample point only. After the VOC sample kits were filled for the surface soil, the soil was placed in aluminum pans designated for each sample depth interval and the VOC sample kits were filled for the subsurface soil. At a secondary location, each sample interval was screened with a photoionization detector (PID), photographed, described according to Unified Soil Classification System, homogenized, and placed into soil chemistry jars. Tables 2-1 and 2-2 summarize the soil and background soil sampling locations, and include core depths, sample depth intervals, and the number of samples sent for laboratory analysis. Appendix B (B-1 through B-39) presents photos of the soil samples.

Ninety-nine soil samples and six duplicate samples were submitted for laboratory analysis, including 30 surface soil samples (26 from five-point composite sampling grids) and 69 subsurface samples. Surface soil samples from six background locations (six samples) were also submitted for analysis. Soil samples were analyzed for VOCs, PAHs (two- to six-ring PAHs including Priority Pollutant PAHs and two- to four-ring PAH alkyl groups), and metals (eight Resource Conservation and Recovery Act [RCRA] metals, plus nickel and vanadium)[1]; Table 2-3 lists the individual analytes. Surface soil samples were also analyzed for grain size, black carbon, and total organic carbon (TOC). The soil samples submitted for analysis and associated laboratory methods are summarized in Table 2-4.

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[1] The nine deep subsurface soil samples (deeper than 1.5 feet bgs) were held for possible future analysis of metals and/or PAHs. Due to short holding times for VOC analysis, the samples were analyzed for moisture content and VOCs.

Some soil sample locations targeted in the DARSP (ARCADIS 2013) were adjusted or reclassified based on site conditions at the time of sampling. Variations from the DARSP are described below:

- Two soil sample grids along Main St (SO-DA-001 and SO-DA-002) were enlarged slightly to accommodate an adequate buffer around a shallow buried utility line.

- Thirteen soil locations in Dawson Cove, including two targeted for deep cores and Dart sampling, were reclassified in the field as sediment matrix samples when the locations were found to be inundated with water.

- The two background locations farthest north in Lake Conway were relocated from the west side of I-40 to the east side of I-40 due to restricted access from a construction site near the original target locations.

2.3 Sediment Sampling

Sediment samples were collected at 53 locations within the drainage ways, Dawson Cove, and Lake Conway. Sediment sample locations are shown on Figures 2-1 through 2-4. Background sediment samples were collected from six distant locations in Lake Conway upstream of the generalized flow path from Dawson Cove to the Lake Conway dam (see Figure 2-5) and six locations in shallow ditches upstream of the primary drainage path from the residential area to Dawson Cove (see Figure 2-6). At most locations, sediment samples were collected by hand driving a 3-inch-diameter Lexan core tube. Where shallow utilities or minimal water was present, hand trowel or hand auger techniques were used. Sediment was collected to a depth of 12 or 18 inches, except at a subset of 9 sediment sample locations where cores were pushed to a depth of up to 3 to 4 feet. Tables 2-5 and 2-6 summarize the sediment and background sediment sampling locations and include core recovery depths, number of samples sent for analysis, and number of samples currently on hold at the laboratories. Appendix B (B-40 through B-104) presents photos and descriptions of each sediment core.

Samples were collected and processed according to the SOPs in Attachment A of the DARSP (ARCADIS 2013). Sediment cores collected with Lexan tubes were photographed and then cut open length-wise using electric shears. The open core was then sectioned into a surface sample (0 to 0.5 foot bgs) and subsurface sampling intervals (0.5 to 1 foot, 1 to 1.5 feet, 1.5 to 2 feet bgs; and subsequent 1-foot intervals). From the open core, VOC sample kits were filled, and the sediment was screened with a PID, photographed, and described. Each sample interval was then homogenized in an aluminum pan and placed into sediment chemistry jars. Sediment collected using hand trowel or hand auger techniques were processed in the same manner as the soil samples described in Section 2.2.

A total of 178 sediment samples (eight of these had duplicate samples) were submitted for laboratory analysis from the area of interest, including 53 surface sediment samples and 125 subsurface samples (in addition to the duplicates). Surface sediment samples from 12 background locations (12 samples, plus one duplicate sample) were also submitted for analysis. All sediment samples were analyzed for VOCs, PAHs (two- to six-ring PAHs including Priority Pollutant PAHs and 2- to 4-ring PAH alkyl groups)[2], and total metals (RCRA 8 metals, plus nickel and vanadium)[3]; Table 2-3 lists the individual analytes. Surface sediment samples were also analyzed for total extractable hydrocarbons (TEH), grain size, black carbon, and TOC. Table 2-4 summarizes the sediment samples submitted for analysis and the associated laboratory methods.

Some sediment sample locations targeted in the DARSP (ARCADIS 2013) were adjusted or the sample methodology was modified based on site conditions at the time of sampling. Variations from the DARSP are described below:

- Thirteen sample locations (initially planned as soil) in Dawson Cove were classified in the field as sediment after observing that the locations were inundated with water.

- One background location farthest north in Lake Conway was relocated from the west side of I-40 to the east side of I-40 due to restricted access from a construction site near the original target locations.

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[2] Up to 88 individual PAH compounds were analyzed in the surface sediment samples; however, many of these compounds, primarily heterocyclic PAHs, were analyzed for forensic (i.e., source identification) purposes, and are not included for risk screening evaluations.

[3] The 26 deep subsurface soil samples (deeper than 1.5 feet bgs) were held for possible future analysis of metals and/or PAHs. Due to short holding times for VOC analysis, the samples were analyzed for moisture content and VOCs.

- Hand trowels were used instead of Lexan core tubes to collect sediment samples from drainage ways where shallow utilities were present (sediment sample locations along North Main St. and two background drainage way locations [SED-DA-BG-001 and SED-DA-BG-002]).

- Hand augers were used instead of Lexan core tubes to collect sediment samples from drainage ways where minimal water was present and the consolidated nature of the materials resulted in inadequate recovery using the Lexan tube technique (locations SED-DA-005 through SED-DA-008, and SED-DA-010 through SED-DA-013 and one background drainage way location SED-DA-BG-003).

2.4 Soil and Sediment Dart Samplers

Dart samplers were installed at deep core locations (three soil and seven sediment) in Dawson Cove to provide a profile of relative PAH concentration versus depth in soil or sediment. Dart locations are identified in Tables 2-1 and 2-5.

Dart samplers were provided by Dakota Technologies, Inc. (DTI) and were installed according to the SOP and Sampling Approach included in Attachments A and C of the DARSP, respectively (ARCADIS 2013). Dart sampling is a passive sampling technique that evaluates the presence of polycyclic aromatic hydrocarbons (PAHs) present in crude oil. Darts were installed by hand to a depth of approximately 4 feet using a modified slide hammer. Darts were left in place for 48 hours to equilibrate with the surrounding PAH concentrations, allowing PAHs to sorb into the solid-phase extraction coating of the Dart fiber. After 48 hours, Darts were retrieved, wiped clean of any large pieces of residual soil or sediment, wrapped in aluminum foil, and shipped to DTI for reading. The Darts were run through a laser-induced fluorescence (LIF) reader to create a graphical log of florescence response that correlates to the total available PAH content of the soil or sediment versus depth. Results of the Dart readings are included in Appendix E.

2.5 Surface Water Sampling

This section summarizes the daily sampling program for surface water samples collected since March 29, 2013, and six surface water samples collected as part of the DARSP activities. The daily surface water monitoring program focused primarily on Lake Conway, but also including locations in the drainage ways and Dawson Cove. The six surface water samples collected as part of the DARSP activities on August 13 and 15, 2013, focused on the drainage ways and Dawson Cove.

2.5.1 Daily Surface Water Sampling Program

Daily surface water sampling was conducted in drainage ways, Lake Conway, and Dawson Cove in accordance with the Surface Water Sampling and Analysis Plan (Attachment B of the DARSP; ARCADIS 2013). Surface water samples were collected from historical and current sample locations between March 29 and September 6, 2013 (see Figure 2-6). Samples were collected as grab samples from surface and/or midpoint of the water column from each location. Current surface water sampling program includes daily sampling at following 13 locations:

Surface Water Monitoring Locations	**Location ID**	**Depth Interval (feet)**
Locations accessed by foot		
Background drainage way (when flowing)	WS-BKG-002	Surface
Drainage way along North Main Street (when flowing)	WS-008	Surface
Dawson Cove	WS-007	0.5-1.0
Lake Conway near Dawson Cove	WS-001	0.5-1.0
	WS-006	0.5-1.0
Lake Conway downstream from Dawson Cove	WS-002	Surface
Lake Conway Dam	WS-003	Surface
Lake Conway background	WS-005	Surface
Palarm Creek	WS-018	Surface
Locations accessed by boat		
Lake Conway near Dawson Cove	WS-010	1.5-2.0, 80% of water depth
Lake Conway downstream from Dawson Cove	WS-011	1.5-2.0, 80% of water depth
	WS-012	1.5-2.0, 80% of water depth
Lake Conway north of Dawson Cove	WS-014	1.5-2.0, 80% of water depth

These samples were analyzed for VOCs, PAHs (Priority Pollutant PAHs), total metals (RCRA 8 metals plus nickel, vanadium, calcium, and magnesium), dissolved metals (RCRA 8 metals plus nickel and vanadium), and oil and grease (Table 2-8). At each sample location, pH, conductivity, temperature, turbidity, and dissolved oxygen were measured.

2.5.2 One-time Surface Water Sampling Event

On August 13 to 15, 2013, surface water samples were collected from the drainage ways and Dawson Cove at the locations shown on Figure 2-8 and summarized in Table 2-7.

Samples were collected as grab samples from six locations (six samples, plus one duplicate sample) (Figure 2-8). Samples in the drainage ways were collected from the surface of the flowing water. Samples in Dawson Cove were collected from the midpoint of the water column.

The samples were submitted for analysis of VOCs, PAHs (Priority Pollutant PAHs and 2- to 4-ring PAH alkyl groups)[4], total metals (RCRA 8 metals plus nickel, vanadium, calcium, and magnesium), dissolved metals (RCRA 8 metals plus nickel and vanadium), total suspended solids (TSS), and oil and grease (Table 2-8). Field parameters including pH, conductivity, temperature, turbidity, and dissolved oxygen were measured in the field at each sample location using a water quality probe (YSI 556).

2.6 Lake Conway Depositional Layer Assessment

A visual assessment of the near-surface sediment stratigraphic profile was performed to evaluate the potential presence of newly deposited sediment layers that may be associated with the emergency response at 12 locations in Lake Conway and at four distant background locations in Lake Conway. Depositional layer assessment locations are shown on Figure 2-9 and summarized in Tables 2-9 and 2-10. Sediment sample photographs from this effort are presented in Appendix C.

The near-surface sediment stratigraphy was visually inspected by a geologist using core samples obtained with 3-inch-diameter clear, colorless Lexan tubes pushed by hand approximately 8 inches into the sediment, which were then capped and brought to the surface. This approach was used in lieu of the box core technique due to field limitations in the deployment and operation of the box corer device. Field

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[4] Up to 88 individual PAH compounds were analyzed in the surface water samples; however, many of these compounds, primarily heterocyclic PAHs, were analyzed for forensic (i.e., source identification) purposes, and are not included for risk screening evaluations.

experimentation showed that high-quality samples were obtained using the Lexan tube technique. If a box core had been used, the sediment column would subsequently have been carefully subsampled with a Lexan core tube for inspection. This sampling approach was consistent with the DARSP (ARCADIS 2013), which stated the depositional layer assessment will be performed with a Sediment Profiling Imagery approach, a box core, or other sampling device.

Once the core was obtained by direct-push method, the Lexan tube was wiped clean and visually inspected and photographed on the deck of the sampling boat. The inspection was performed immediately upon recovery to avoid alteration of the sediment-water interface or any near-surface depositional layer during transport or storage of the cores. Following the visual inspection, the sediment was extruded into an aluminum pan for visual classification and description of sediment grain size distribution.

3. Topographic Survey

ARCADIS conducted topographical survey activities in July and August 2013 to support the development of topographic cross sections and maps of the drainage ways and Dawson Cove in accordance with the DARSP (ARCADIS 2013). The survey included the following points:

- Ground surface and top of sediment elevations along 29 transects throughout the survey area.
- Points defining channel cross sections (including top of bank, top of sediment, and channel centerline) along transects in reaches A-Main, A-365W, and A-365E; and the creek channel at the west end of Dawson Cove, where a defined channel exists.
- Points defining the boundary of heavily vegetated areas in Dawson Cove at the time of the survey, on transects established in this area.

Coordinates (recorded in NAD83) and elevations (feet; NAVD88) for each survey point, as well as the channel cross sections, are provided in Appendix D (see Figures D-1 through D-6 in Appendix D). All survey points are shown on Figure 3-1.

In addition to the activities described above, a pre-existing Laser Imaging, Detection, and Ranging (LIDAR) dataset was obtained from the United States Department of Agriculture (USDA) to assist with topographic mapping of the area adjacent to the cove. This dataset was acquired for the Lake Conway watershed from January 13 to May 10, 2012 under leaf-off conditions, and was available as bare-earth digital elevation models at a nominal horizontal resolution of 0.5 meter. The root mean square error vertical precision of these data is reported to be within 9.25 centimeters (USDA 2012). These data were converted to feet (NAVD88) to develop a topographic map of adjacent portions of the study area not included in the topographic survey activities (as shown on Figure 3-2).

To create the topographic map, survey data collected during field activities were interpolated by the Inverse Distance Weighting method using an optimized power term to develop a digital elevation model for the area shown on Figure 3-1. This interpolation used all survey points except those within the creek channel on the west end of Dawson Cove (see Figure 3-1). The interpolation was not used to map the topography of the channel due to the sinuous and localized nature of the channel (see cross sections in Appendix D). Where needed, the LIDAR data were used to set boundary elevations to perform the interpolation (see Figure 3-2). Based on the resulting interpolated topography, a contour map was generated for the Dawson Cove area, as shown on Figure 3-3.

3.1 Water Levels in Lake Conway and Dawson Cove

From April 15 through November 15, the water surface elevation in Lake Conway is controlled by the dam elevation, which is at approximately 262.87 feet (NAVD88). During winter, November 15 through April 15, the lake level is lowered to an elevation of approximately 261.87 feet (NAVD88) for flood control purposes. These elevations are specified in the Lake Conway Management Plan (AGFC and Lake Conway Citizen Advisory Committee 2003); however, actual water surface elevations appear to vary as discussed below.

Water surface elevations from February 18, 2008 through September 16, 2013, as recorded by the AGFC at the staff gauge at the Mayflower Enforcement Training Center, are shown on Figure 3-4. During this data collection period, Lake Conway water levels fluctuated between approximately 261.07 and 268.32 feet (NAVD88). The average and median summer levels were 262.64 and 262.70 feet (NAVD88), respectively. During winter, the average and median levels were approximately 262.41 and 262.22 feet, respectively. Short-term water level fluctuations occur due to heavy precipitation events (Figure 3-4).

Water levels in Dawson Cove fluctuate in response to fluctuations in Lake Conway, except when water levels in Lake Conway drop below the controlling elevations of the two culverts (each culvert is 48 inches in diameter) that convey water flow beneath Highway 89 (Figure 3-1). The minimum water surface elevation where Dawson Cove and Lake Conway are in direct communication is 262.2 feet (NAVD88); this is the lower invert elevation at the north (upslope) ends of the culverts beneath Highway 89. Due to the controlling effect of the culverts (invert elevation of 262.2 feet [NAVD88]), normal seasonal water levels in Dawson Cove are 262.2 feet (NAVD88) during winter (or possibly lower) and 262.87 feet (NAVD88) during summer, as controlled by the Lake Conway dam. Figure 3-3 indicates the approximate edge-of-water position in Dawson Cove that corresponds to these elevations.

4. Data Quality and Data Management

This section describes the reviews performed to evaluate the quality of data received from the analytical laboratories, and the management and handling of these data. Field activities and data quality reviews were completed in accordance with the quality assurance (QA)/quality control (QC) procedures established for the project.

4.1 Field Quality Control Samples

Field QC samples were collected during implementation, in accordance with the DARSP (ARCADIS 2013):

- *Soil.* ARCADIS collected seven matrix spike (MS) and matrix spike duplicate (MSD) samples and six field duplicate samples. Field duplicate samples were analyzed for the surface soil analyte list, with the exception of grain size. To verify the effectiveness of field decontamination procedures, six equipment rinsate blanks were collected by rinsing laboratory-supplied deionized water over decontaminated field equipment (e.g., stainless steel hand auger). Ten trip blanks (one per cooler containing samples to be analyzed for VOCs) were analyzed to assess whether samples were affected by non-site-related VOCs during storage and transport.

- *Sediment.* ARCADIS collected 10 MS/MSD samples and ten field duplicate samples. Field duplicate samples were analyzed for the surface sediment analyte list, with the exception of grain size. These samples were collected using dedicated, disposable equipment (e.g., the Lexan core tubes and disposable aluminum pans and plastic scoops used for sample homogenization). To confirm the cleanliness of the dedicated equipment, nine equipment rinsate blanks were collected by pouring laboratory-supplied deionized water over the unused equipment. Fifteen trip blanks (one per cooler containing samples to be analyzed for VOCs) were included to assess whether samples were affected by non-site-related VOCs during storage and transport.

- *Surface Water.* ARCADIS collected one MS/MSD sample and one field duplicate sample. To verify the effectiveness of field decontamination procedures, equipment rinsate blanks are collected daily as part of the ongoing surface water sampling program; a separate equipment rinsate blank was not required for these surface water samples.

One sample of laboratory-supplied deionized water used for equipment rinsate blanks was analyzed for forensic-level PAHs to evaluate the presence of analytes in the laboratory-supplied water. The QA/QC samples are presented in Table 4-1.

4.2 Data Verification and Validation

Laboratory data packages were checked for completeness to confirm that the deliverable requirements specified to each laboratory for this project were met.

Data validation is a standardized review process for judging the analytical quality and utility of a discrete set of laboratory results, and is used to confirm that data of known and documented quality are used for the project. It involves a systematic evaluation of data to ascertain its completeness, correctness, and consistency. Validation procedures were consistent with the U.S. Environmental Protection Agency (USEPA) Contract Laboratory Program National Functional Guidelines for Organic Data Review (1999) and USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (2004).

A tiered validation approach was used for the dataset presented in this report, and Tier II validation was performed on 100 percent of the data generated. A Tier III validation was performed on one sample delivery group (SDG) per medium per parameter group, or approximately 10 percent of the data. Each of these tiers is described below.

Tier II data validation was performed on all SDGs and included review of the following:

- Chain of custody completeness
- Holding times
- Laboratory control samples/laboratory fortified blank recoveries
- Surrogate recoveries
- MS, MSD recoveries, and relative percent difference (RPD)
- Field duplicate RPD
- Method blanks, trip blanks, and field/equipment blanks

Tier III data validation was performed on 10 percent of the data packages. This level of evaluation involves the review of calculations, compound identification, and/or potential transcription errors. Tier III evaluation includes the parameters listed above for Tier II evaluation, in addition (but not limited) to the following:

- Detection limit records
- Instrument calibration records
- Continuing calibration records
- Gas chromatography/mass spectrometry instrument tune records
- Internal standard records
- Target compound calculated results

At the completion of the Tier II and Tier III data validation process, a data validation summary report was prepared specifying suitable uses for the data (see Appendix G). The data validation qualifiers were entered into the database through the use of a web-based validation form.

4.3 Data Usability

The decision on whether data are usable is based on the validation results. Following validation, the data were flagged (i.e., qualified) as appropriate, and any data use restrictions were noted. The USEPA guidance identifies a goal that 90 percent of the data points will not be rejected or deemed unusable. The goal of at least 90 percent useable data was met under the scope of the DARSP (ARCADIS 2013). Therefore, the data are acceptable for use as qualified.

The notable data restrictions following data validation include:

- Many data results for perylene were not recoverable because the associated surrogate failed.

For each analyte that was detected in crude oil (discussed in Section 5), the final reporting limit and the method detection limit in the soil and sediment sampling results were compared to applicable screening level (presented in Section 5; Table

4-2 and 4-3). For most analytes, except selenium, the majority of the reporting limits and all of the method detection limits are below the applicable screening. The selenium reporting limit in soil/sediment (ranged from 2 to 18 milligrams per kilogram [mg/kg]) was above the applicable screening levels (1.7 mg/kg in soil and 2 mg/kg in sediment); however, the selenium method detection limit was less than the applicable screening levels in at least 76 percent of the soil samples and 81% of the sediment samples. Therefore, the selenium data are considered useable.

4.4 Data Management

This section refers to key data handling procedures used to develop this report.

4.4.1 Duplicates

Sections 6, 7, and 8 focus on parent samples and do not include duplicate results. Duplicate results are reported in the data tables, but are excluded in statistical evaluations or graphical representation, unless a duplicate result affects the screening evaluation at a location (e.g., the field duplicate exceeds the screening levels where the parent sample does not). In those cases, the duplicate result is noted in the discussion.

4.4.2 Calculated Totals

The data assessment included calculating total concentrations of PAH compounds, grouped by high molecular weight (HMW) and low molecular weight (LMW), as needed, for ecological risk screening. These specific summations and USEPA guidance are discussed in Section 5. In all summations and calculations, non-detect samples for individual analytes in a compound group are treated as zero values. Because PAH lists vary depending on the screening evaluation, laboratory-calculated total PAHs were not included in the data assessment, but are provided in the laboratory reports.

5. Data Evaluation Methods

The data collected as part of this program were compared to background concentrations and ecological screening values (ESVs) in accordance with the hierarchy recommended by the ADEQ and the approach described in the DARSP (ARCADIS 2013). Based on direction from the ADEQ, the risk screening process is focused on ecological risks (ARCADIS 2013). Human exposure to constituents in soil and sediment at the site is possible, but unlikely to be significant due to site conditions; in particular, the dense vegetation that develops naturally along the drainage way and in Dawson Cove limits direct human exposure to site media. More details regarding the risk screening process, including applicable USPEA guidance, is included in Appendix I.

The screening approach used for soil and sediment samples is illustrated on Figure 5-1, and includes the following steps:

1. *Evaluate whether the analyte was associated with the crude oil at concentrations that could have resulted in the observed concentrations in soil and sediment (Sections 5.1 and 5.3).* Analytes were screened out in this first step because they were not detected in crude oil samples or were only present at low concentrations in crude oil samples (i.e., below Arkansas background concentrations).

2. *Compare detected concentrations of VOCs to ESVs.* Concentrations of crude-oil-related VOCs detected above ESVs are highlighted in the data tables and on the figures. These values were compared to site background concentrations to evaluate whether the detections above the ESVs are comparable with site background concentrations (Section 5.4).

3. *Compare detected concentrations of PAHs to ESVs, and then evaluate toxic unit (TUs) for PAH mixtures.* Concentrations of PAHs detected above ESVs are highlighted in the data tables and on the figures. To evaluate whether the detections above the ESVs in soil are comparable with site background concentrations (Section 5.4), concentrations of PAHs in soil were compared to site background concentrations. For sediment samples, the samples with concentrations above an ESV were then evaluated using Equilibrium Sediment Benchmark Toxic Units (TU; Section 5.2.2) to identify potential risk based on the mixture of PAHs.

4. *Compare detected concentrations of metals to Arkansas background concentrations and ESVs*. Concentrations of metals above both Arkansas background concentrations and ESVs are highlighted in the data tables and on the figures. These values were then compared to site background concentrations to evaluate whether the detections above both Arkansas background and ESVs are comparable with site background concentrations (Section 5.4).

The screening approach used for surface water samples is illustrated on Figure 5-2. Similar to the soil and sediment screen, the first step evaluated whether the analyte was associated with crude oil at concentrations that could have resulted in the observed concentrations in surface water (Section 5.1). Then, the concentrations of detected analytes were compared to surface water ESVs. Concentrations of analytes detected above the ESVs are highlighted in the data tables and on the figures.

This section describes the data evaluation process, including:

- Measured concentrations of constituents in crude oil
- ESVs for soil, sediment, and surface water
- Toxic units (TUs) for PAHs in sediment and surface water
- Arkansas background concentrations for soil and sediment
- Site background concentrations for soil and sediment

5.1 Crude Oil Comparison

Two bulk samples of crude oil from the Pegasus pipeline were collected along with samples split with the USEPA on April 5, 2013, and analyzed for VOCs, PAHs, TEH, and metals. Crude oil sample results used for data screening in this report are presented in Table 5-1 and the laboratory reports are included in Appendix G. The results by chemical class are summarized below:

- *VOCs*. Twelve of the VOCs analyzed in soil, sediment, and surface water samples were detected in crude oil samples. The remaining VOCs were not detected in site media and are not typical petroleum hydrocarbon constituents.

- *PAHs*. All but two PAHs (benzo(a)fluoranthene and 18a-oleanane) analyzed in soil, sediment, and surface water samples were also detected in crude oil samples.

- *Metals*. Cadmium, lead, and mercury were not detected in crude oil samples.

The following sections describe the ESVs that were identified for the detected VOCs, PAHs, and metals. For analytes that were detected in site soil, sediment, and surface water samples collected under the DARSP (ARCADIS 2013), but were not detected in crude oil samples, the data and associated ESVs are presented, if available, for completeness; however, the analytes were not evaluated further.

5.2 Ecological Screening Values and Toxic Units

The ESVs used to evaluate the data in this report were identified and included in the DARSP (ARCADIS 2013). In addition, a TU approach was employed for evaluation of PAHs, also in accordance with the DARSP (ARCADIS 2013). The following sections summarize ESVs and TUs, and their application for screening site media.

5.2.1 Identification of Ecological Screening Values

The data evaluation involves comparing soil, sediment, and surface water analytical results to ESVs. As defined by the USEPA's ecological risk assessment guidance, (USEPA 1997, 1998), ESVs are constituent concentrations in environmental media below which risk to ecological receptors exposed to those media is considered *de minimus* (i.e., if there are no exceedances of the ESV, then the constituent being screened is eliminated from any further ecological risk evaluation). However, the reverse is not true; concentrations exceeding ESVs do not necessarily imply that ecological risk exists, only that further ecological risk evaluation may be warranted. A hierarchy was used to develop the list of ESVs, because any given source of ESVs typically does not contain ESVs for all of the analytes that are evaluated in this report. The DARSP (ARCADIS 2013) described the hierarchy for the ESVs; the hierarchy is also presented in Appendix I. Table 5-2 lists the ESVs for soil, sediment, and surface water, including the literature source for each value.

Soil and sediment ESVs also include values for PAHs grouped and summed based on their molecular weight: LMW PAH summations include PAHs with three or fewer benzene rings, and HMW PAH summations include PAHs with four or more benzene rings. To evaluate the potential risks of multiple PAH, an additive approach was used (USEPA 2003). Consistent with USEPA guidance (USEPA 2001a, 2007a, 2009), PAHs were grouped and summed based on their molecular weight; however, USEPA guidance does not specify which PAHs should be included in PAH summations, which may vary due to site-specific conditions. Summation of PAHs for soil and sediment samples is further discussed below.

5.2.2 Total Polycyclic Aromatic Hydrocarbon Summations for Soil and Sediment

The rationale for PAH screening is presented in greater detail in Appendix I. The specific summations conducted for this screening evaluation for soil and sediment are discussed below:

- *Soil*. Soil ESVs for LMW and HMW PAHs were obtained from the USEPA's Ecological Soil Screening Levels (EcoSSLs; USEPA 2007a); the USEPA's EcoSSLs do not provide soil screening levels for individual PAHs. The USEPA's soil ESVs for both LMW and HMW PAHs were developed based on toxicity studies for a single PAH compound and can be applied for one PAH compound or for a summation of multiple PAHs (USEPA 2007a). USEPA guidance (USEPA 2007a) does not specify which PAHs should be included in PAH summations for comparison to the ESV. For this report, 38 PAHs[5] were used in the summations for the initial soil screening (Table 5-3). These 38 PAHs are hereafter referred to as the "long list of PAHs."

- *Sediment*. Sediment ESVs for PAHs were obtained from the USEPA's Region 4 sediment screening values (USEPA 2001a). Several uncertainties are associated with these ESVs as well as the PAH summations, both of which are important to consider in the screening evaluation. A brief description is included here and additional information is presented in Appendix I.

  The sediment ESV for LMW PAHs is based on the laboratory practical quantitation limit for PAHs, which is not a risk-based value (USEPA 2001a). The sediment ESV for HMW PAHs is based on a threshold effect level using six PAHs in a marine toxicity study (other PAHs may also have been present, but were not analyzed for) and thus has uncertainty with respect to application to freshwater and PAH mixtures that include other PAHs. USEPA guidance (USEPA 2001a, 2007a, 2009)

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[5] The long list of PAHs for soil includes 16 priority pollutant PAHs, two additional non-alkylated PAHs (benzo(e)pyrene and perylene), and 20 alkylated PAHs (Table 5-3).

does not specify which individual PAHs should be included in the summations for comparison to the ESV; therefore, PAHs were summed in two ways for comparison to ESVs: 1) an initial conservative approach was conducted using the long list of PAHs[6] for the summations and 2) a more typical approach summed the priority pollutant PAHs plus 1-methlynaphthelene and 2-methlynaphthelene for a total of 18 PAHs (referred to hereafter as "priority+2 list"). This list is summarized in Table 5-3.

5.2.3 Toxic Unit Calculation

The cumulative toxicity of PAHs in sediment was also evaluated consistent with USEPA guidance (USEPA 2003). The concept of equilibrium partitioning of PAHs with organic carbon holds that sediment toxicity is attributable to the concentration of a constituent that is dissolved in the interstitial pore water, and therefore, biologically available. The TU value is used to evaluate whether concentrations of PAHs in sediment are acceptable for the protection of benthic organisms and whether concentrations of PAHs in pore water and surface water are acceptable for the protection of aquatic invertebrates.

The guidance presents methods for estimating the TU of a mixture of up to 34 PAHs (Table 5-3) in surface sediment. The TU is a conservative screening metric with respect to overall ecological risk because it provides a protective benchmark for the organisms that are most closely associated with the sediments and most highly exposed to chemicals in the sediments.

If the sample TU is 1 or less in a given sediment sample, the concentration of the PAH mixture in sediment is considered acceptable for the protection of benthic organisms. If the TU is greater than 1, further evaluation is recommended.

Several models are available to estimate PAH pore water concentrations (USEPA 2012). In this evaluation, the TU for each sample was calculated using simple model, referred to as the one-carbon model (USEPA 2003). Generally, if a TU for a sediment

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[6] The long list of PAHs for sediment included 16 priority pollutant PAHs, four additional non-alkylated PAHs (benzo(a)fluoranthene, benzo(b)fluorene, benzo(e)pyrene, and perylene) and 20 alkylated PAHs. Benzo(a)flouranthene and benzo(b)fluorene were only measured in surface sediment samples.

sample exceeds a value of 1 and black carbon is detected in the sample, a more rigorous two-carbon model could be used to recalculate the TU for that sample (USEPA 2012). The two-carbon model was used for one sample in this evaluation (because the other TU values using the one-carbon model were 1 or less; see Section 7). An example calculation for one sediment sample is included in Appendix I, along with a more detailed description of the methods.

A TU approach was also used to assess the cumulative effects of PAHs in surface water using criteria established by the USEPA for up to 34 PAHs (USEPA 2003). The method used in the evaluation of surface water is described in detail in Appendix I and a sample calculation is also provided.

5.3 Arkansas Background Metals Concentrations in Soil and Sediment

The U.S. Geological Survey (USGS) along with other federal and state government agencies, industry, and academia, is currently conducting the National Geochemical Survey (NGS) to produce a body of geochemical data for the United States (Arkansas Geological Survey 2013). The NGS incorporates geochemical data from a variety of sources, including existing data in USGS databases, re-analyses of samples in USGS archives, and analyses of newly collected samples (Arkansas Geological Survey 2013). In Arkansas, 348 soil samples[7] and 605 stream sediment samples were collected and analyzed between 2003 and 2004. For this project, these data were accessed through the USGS website (USGS 2013).

Based on USEPA guidance (USEPA 2007b), the Arkansas background concentrations can be considered in the screening evaluation. The available data were compiled and a 95% Upper Tolerance Limit[8] (UTL) was calculated for each of the metals evaluated.

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[7] Based on discussions with J Michael Howard with Arkansas Geological Survey (pers. com. July 3, 2013), Arkansas was divided into 100-square-kilometer grids. One location per grid was selected using a random number generator. Samples were collected at 0 to 0.5 foot and 1.5 to 2 feet bgs; the data were combined for statistical evaluation.

[8] Tolerance limits are the estimated range that contains a certain percentage of each individual measurement in the population, with the upper range referred to as the UTL. Because tolerance limits are based upon only a sample of the entire population, 100 percent confidence is not possible. Therefore, two different proportions are associated with the tolerance limits: a degree of

Table 5-4 presents the 95% UTL for soil and sediment (herein referred to as “Arkansas background”) for arsenic, barium, chromium, lead, mercury, nickel, selenium, and vanadium.

Each of these Arkansas background concentrations (95% UTL) was compared to the concentration detected in the site-specific crude oil samples (see Table 5-5). Cadmium, lead, and mercury were not detected in the crude oil, as discussed in Section 5.1. For arsenic, barium, and chromium, the range of concentrations in crude oil was less than the Arkansas soil and sediment background value. And in addition, the range of vanadium concentrations in crude oil is less than the Arkansas soil background value. Therefore, crude oil concentrations of these metals likely do not pose concerns relative to media-specific background; however concentrations of these metals are still screened against ESVs as presented in Section 5.2.

5.4 Site Background Concentrations in Soil and Sediment

Site background soil and sediment samples were collected from three general areas in accordance with the DARSP (ARCADIS 2013) to generate an additional, local background dataset. The site background samples were analyzed for VOCs, PAHs (full list of 88), total metals (RCRA 8 metals, plus nickel and vanadium), TEH, grain size, black carbon, and TOC. Although the local dataset is limited, it provides an indication of background associated with local or regional sources that may not be presented in the state-wide background study (e.g., sources with direct tributary or runoff inputs to the drainage ways and Dawson Cove, or Lake Conway). The following site background datasets were developed through sampling:

- Site background soil locations (Figures 5-3.1 and 5-3.2)
- Site background sediment locations in drainage ways (Figures 5-4.1 and 5-4.2)
- Site background sediment locations in Lake Conway (Figures 5-5.1 and 5-5.2)

Table 5-6 shows the summary statistics for the site-specific background sampling results. Key observations for the background sampling results include:

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confidence, and a percent coverage. For this site, with 90 percent coverage, 95 percent of the population will be equal to or less then the calculated 95% UTL concentration.

VOCs. Three VOCs (acetone, 2-butanone, and trichloroethene [TCE]) were detected in site-specific background samples for both sediment and soil; however, they were not detected in crude oil and are not crude oil-related constituents. Therefore they were eliminated from further consideration, but are discussed below:

- Acetone was detected in all background soil and sediment samples, and may be present from laboratory, anthropogenic, and natural sources. Acetone is a common laboratory contaminant, but based on the data validation, the detection of acetone is not attributed to laboratory contamination. However, acetone concentrations may be a result of interferences due to sample preservation by acidification for USEPA Method 5035 for extraction of VOCs (USEPA 2002). USEPA has recognized that acidification of certain soils with sodium bisulfate may produce a false positive acetone artifact of 100 to 200 micrograms per kilogram (µg/kg) or even higher concentrations (USEPA 2002). In addition, samples that contain aluminum silicates may act as a catalyst in the conversion of methanol to acetone (Texas Natural Resource Conservation Commission 2002). Acetone is a manufactured chemical, but also occurs naturally in plants, trees, gas from volcanoes, and forest fires (Agency for Toxic Substances and Disease Registry [ATSDR] 1994, Delaware Health and Social Services 2009). It is estimated that 77 percent of acetone in the environment is from natural sources, including forest fires (Environment Canada 2013). Acetone is an oxidation product of natural humic substances, and is excreted as a metabolic by-product from many organisms, including mammals, plants, and microorganisms (Environment Canada 2013). Because oxidation of humic substances can result in acetone production, soil and sediment with high organic content can contain natural acetone concentrations (ATSDR 1994, Environment Canada 2013).

- 2-Butanone was detected in one-half of the background soil and sediment samples, and may be present from laboratory, anthropogenic, and natural sources. 2-Butanone is a common laboratory contaminant, but based on the data validation, the detection of 2-butanone is not attributed to laboratory contamination. However, 2-butanone concentrations may be a result of interferences or false positive due to sample preservation by acidification for USEPA Method 5035 (USEPA 2002). Some ketones, such as 2-butanone, may react with preservatives under low pH conditions, yielding analytical results not representative of the soil and sediment sampled (USEPA 2002). 2-Butanone is a manufactured chemical and a naturally occurring compound. It is naturally produced in the environment by some trees, and can be released as a result of car and truck exhausts or from decomposition of other organic compounds (ATSDR 1992).

- TCE was detected in one-half of the background soil and sediment samples, and may be present from anthropogenic and natural sources. Primary sources of TCE in the environment are metal cleaning and degreasing operations. It is a chlorinated hydrocarbon and is not associated with crude oil. TCE is also released to the environment by water treatment facilities through volatilization and air-stripping procedures, and by gaseous emissions from landfills. TCE may naturally occur in several temperate, subtropical, and tropical macroalgae and in at least one species of microalgae (ATSDR 1997, USEPA 2001b).

PAHs. Numerous PAH compounds were detected in site-specific soil and sediment background samples. Concentrations of some individual PAHs (in site background sediment samples in the drainage ways and Lake Conway) exceeded ESVs. The HMW PAHs ranged from 5 to 19,500 µg/kg and the LMW PAHs ranged from 19 to 1,190 µg/kg in soil and sediment site background samples. The highest PAH concentrations in site background samples were observed in a drainage way sediment sample collected along Highway 365 (SED-DA-BG-004).

Metals. Metals were commonly detected in the site-specific background soil and sediment samples.

The site background data are compared to the soil and sediment data in Sections 6 and 7, respectively. For analyte concentrations that were above ESVs (and Arkansas background values for metals), but are within the range of site background, it is interpreted that site-specific background conditions contribute to the exceedances of ESVs.

6. Soil Sampling Evaluations and Results

This section discusses the analytical results and data analysis for soil samples collected in the drainage ways and Dawson Cove. Soil samples were submitted for laboratory analysis, as described in Section 2.2. The table below summarizes the number of soil samples (excluding duplicates) collected from each area.

Area	Surface Samples	Subsurface Samples	Deep Subsurface Samples	Total Number of Samples
Drainage Ways	15	30	0	45
Dawson Cove	15	30	9	54

Notes:
"Surface Samples" includes samples from 0 to 0.5 foot bgs.
"Subsurface Samples" includes samples from 0.5 to 1.0 foot and 1.0 to 1.5 feet bgs
"Deep Subsurface Samples" includes samples deeper than 1.5 feet bgs. As discussed in Section 2.2, deep subsurface samples were not analyzed for the full analytical suite.

Table 6-1 summarizes the grain size results for surface soil samples, Table 6-2 presents the drainage ways soil analytical results, and Table 6-3 presents the Dawson Cove soil analytical results.

As described in Section 5, the following data summaries and evaluations were completed:

- Drainage ways and Dawson Cove soil data summary statistics are provided in Tables 6-4 and 6-5.

- Concentrations of key analytes at each of the sample locations are shown for the drainage ways and Dawson Cove on Figures 6-1.1, 6-1.2, 6-2.1, and 6-2.2. These figures present the maximum detections for each key analyte at each location, and the associated sample depth interval at which the maximum detection occurred (i.e., 0 to 0.5 foot bgs, 0.5 to 1.0 foot bgs, or 1.0 to 1.5 feet bgs).

- Box plots for metals and PAHs compare the concentrations in surface soil for drainage ways, Dawson Cove, and site background locations. The box plots are provided in Appendix H, and the comparisons discussed in this section.

- VOCs and PAHs were screened as shown on Figure 5-1. For the analytes detected in soil samples, as well as crude oil, the individual analytes were compared to ESVs (Table 5-2). Total LMW and HMW PAHs (Long List) were calculated according to Table 5-3 and compared to ESVs (Table 5-2).

- Metals were screened in accordance with Figure 5-1, including comparison to ESVs (Table 5-2).

The following subsections discuss the analytical results for physical characteristics and by each chemical class (e.g., metals, PAHs, and VOCs).

6.1 Summary of Grain Size Results

Grain size distribution is determined by measuring the percentages of the sample mass that pass through specifically sized sieves, and results are reported as percent dry weight. A useful measure of grain size is percent silt and clay (defined as the fraction of sediment by weight that passes through a 75-micrometer sieve); this is the fraction that will be examined. Organic chemicals in sediment are preferentially associated with fine-grained particles, which have larger total surface area per unit mass of sediment, and tend to correlate with higher, naturally occurring organic content (USEPA 2005).

Grain size distribution analyses were conducted on surface soil samples from the drainage ways, Dawson Cove, and site background locations, as described below. Grain size data for the drainage ways and Dawson Cove are summarized in Table 6-1; Table 5-6 summarizes grain size data from the background locations.

Area	Number of Surface Samples (0 to 0.5 foot bgs)	Fines Content (Fraction of Silt and Clay)
Drainage Ways	15	58 to 90%
Dawson Cove	15	79 to 97%
Site Background	6	17 to 91%

6.2 Summary of Volatile Organic Compounds in Soil Samples

Soil samples were analyzed for a list of 66 individual VOCs (Table 2-3). Of the 66 VOCs analyzed, 59 were not detected (Tables 6-2 and 6-3). Three detected VOCs (2-butanone, acetone, and trichloroethene) are not associated with the crude oil as discussed in Sections 5.1 and 5.4; therefore, those VOCs are not discussed further in this section. Four VOCs (benzene, p-isopropyltoluene [cymene], isopropylbenzene [cumene], and toluene) were only detected in the drainage way soil samples (Table 6-2). The statistics for each of these detected compounds by area are presented in Tables 6-4 and 6-5, and the frequency of detection (FOD) for crude-oil-related analytes is summarized in the table below.

Analyte	Frequency of Detection		
	Drainage Ways	Dawson Cove	Site Background
Benzene	7% (3/45)	Not detected	Not detected
Isopropylbenzene	7% (3/45)	Not detected	Not detected
p-Isopropyltoluene	9% (4/45)	Not detected	Not detected
Toluene	13% (6/45)	Not detected	Not detected

Three of the four detected VOCs were below soil ESVs in all sampled areas (Tables 6-4 and 6-5). Benzene was detected in three samples in the drainage way; one of these benzene detections was above the 10 µg/kg soil ESV (34 µg/kg in the surface [0 to 0.5-foot] depth interval at location SO-DA-015).

6.3 Summary of Polycyclic Aromatic Hydrocarbon Concentrations in Soil Samples

Figures 6-1.1 and 6-2.1 show the maximum concentrations of total LMW and HMW PAHs (Long List; see Section 5) measured at each soil location for the drainage ways and Dawson Cove, respectively. The statistics for each of the individual PAHs are presented for the drainage ways and Dawson Cove in Tables 6-4 and 6-5. PAHs were detected in all site background soil samples, and in all soil sample locations in the drainage ways and Dawson Cove.

Two drainage way soil samples exceeded the soil ESV for total HMW PAHs (1,100 µg/kg). These exceedances were in the surface (0 to 0.5 foot bgs) interval at sample locations SO-DA-003 and SO-DA-005, with calculated HMW PAH totals of 2,280 and 1,640 µg/kg, respectively. All samples at these locations were below the soil ESV for total LMW PAHs. In addition, concentrations in soil samples upstream and downstream of both of these locations were below the ESVs.

For Dawson Cove soil samples, the total LMW PAHs (Long List) results were below the soil ESVs in all samples, and the total HMW PAHs (Long List) were below the soil ESVs in 41 of 45 samples. In four Dawson Cove soil samples, the total HMW PAHs (Long List) were above the soil ESV of 1,100 µg/kg:

- *SO-DA-019*. The surface sample (0 to 0.5 foot bgs) at this location had a calculated total HMW PAH (Long List) result of 1,180 µg/kg. One subsurface sample (0.5 to 1 foot bgs) also exceeded the soil ESV for total HMW PAHs, with a result of 1,270 µg/kg. In addition, concentrations in adjacent soil samples (SO-DA-018 and SO-DA-021) were below the ESVs.

- *SO-DA-022*. The surface sample (0 to 0.5 foot bgs) at this location had a calculated total HMW PAHs (Long List) result of 1,760 µg/kg. The subsurface samples at this location were below the soil ESV for total HMW PAHs.

- *SO-DA-023*. The surface sample (0 to 0.5 foot bgs) at this location had a calculated total HMW PAHs (Long List) result of 1,220 µg/kg. The subsurface samples at this location were below the soil ESV for total HMW PAHs.

The duplicate of the surface sample (0 to 0.5 foot bgs) at location SO-DA-018 had a calculated total HMW PAHs (Long List) result above the ESV; however, the average of the parent and duplicate concentrations was below the ESV and therefore this sample is not further evaluated.

The total LMW and HMW PAHs (Long List) in surface soil samples are presented on box plots in Appendix H for all three areas. Surface soil results were plotted because maximum total LMW and HMW PAH (Long List) concentrations at each location were most frequently associated with the surface sample (0 to 0.5 foot bgs). Within the drainage ways and Dawson Cove, 72 of 90 samples were within the range of site background soil sample results for LMW PAHs (Long List). For HMW PAHs (Long List), 83 of 90 samples from the drainage ways and Dawson Cove were within the range of results reported for site background soil sample results (see Figure 5-1.1 for background sample locations).

6.4 Summary of Metals Concentrations in Soil Samples

The following subsections discuss metal concentrations and are grouped according to the screening evaluations in Section 5:

- Cadmium, lead, and mercury – the three metals that were not detected in crude oil samples.

- Arsenic, barium, chromium, and vanadium – the four metals that were detected in crude oil samples at concentrations below the Arkansas soil background values (95% UTL).

- Nickel, selenium, and silver – the remaining three metals that samples were analyzed for.

6.4.1 Cadmium, Lead, and Mercury in Soil Samples

As discussed in Section 5.1, cadmium, lead, and mercury were not detected in crude oil samples. However, the detected concentrations of these metals for the soil samples were compared to the ESVs (bolded results in Tables 6-2 and 6-3) and are summarized below.

- *Cadmium.* Concentrations were below the ESV (0.36 mg/kg) in 41 of the 45 drainage way soil samples. In four drainage way soil samples, concentrations were above the ESV. This included all three soil samples at location SO-DA-004, with the highest concentration (0.97 mg/kg) detected in the deepest sample interval, and the surface soil sample at SO-DA-006 (0.64 mg/kg). Cadmium concentrations were below the soil ESV in all Dawson Cove soil samples.

- *Lead.* Concentrations were above the soil ESV (11 mg/kg) in 32 of the 45 drainage way soil samples and in 43 of the 48 Dawson Cove soil samples. For comparison, the lead was not detected in crude oil at a reporting limit of <1.5 mg/kg (Table 5-1) – below the ESV of 11 mg/kg and the Arkansas background value of 29 mg/kg.

- *Mercury.* Concentrations were below the soil ESV (0.1 mg/kg) in all 45 drainage way soil samples and all 48 Dawson Cove soil samples. In addition, all mercury concentrations were below the Arkansas background value of 0.06 mg/kg.

6.4.2 Arsenic, Barium, Chromium, and Vanadium in Soil Samples

As discussed in Section 5.3, arsenic, barium, chromium, and vanadium were not detected in the crude oil samples above their respective Arkansas soil background values. However, the detected concentrations of these metals for all soil samples were compared to the ESVs (bolded results in Tables 6-2 and 6-3) and are summarized below.

- *Arsenic*. Concentrations were below the soil ESV in all drainage way soil samples and in 46 of the 48 Dawson Cove soil samples. In two Dawson Cove soil samples (0.5 to 1.0 foot and 1.0 to 1.5 feet at SO-DA-027), the arsenic concentrations were above the ESV (18 mg/kg); the co-located surface sample was below the ESV. For comparison, the arsenic concentrations detected in crude oil samples were 0.361 and 1.02 mg/kg (Table 5-1) – below the ESV of 18 mg/kg and below the Arkansas background value of 14 mg/kg.

- *Barium*. Concentrations were below the soil ESV of 330 mg/kg in all 45 drainage way soil samples and all 48 Dawson Cove soil samples. For comparison, the barium concentrations detected in crude oil samples were 0.108 and 0.145 mg/kg (Table 5-1) – below the ESV of 330 mg/kg and below the Arkansas background value (95% UTL) of 753 mg/kg.

- *Chromium.* Concentrations were below the soil ESV in 34 of the 45 drainage way soil samples and 39 of the 48 Dawson Cove soil samples. Chromium concentrations were above the ESV (26 mg/kg) in 20 of the 93 drainage way and Dawson Cove soil samples combined. At all locations with chromium concentrations above the ESV (26 mg/kg), the maximum concentrations were detected in a subsurface sample (e.g., 0.5 to 1 foot or 1 to 1.5 feet) and not in the surface sample. For comparison, the chromium concentrations detected in the crude oil samples were 0.229 and 0.278 mg/kg (Table 5-1) – below the ESV of 26 mg/kg and below the Arkansas background value of 69 mg/kg.

- *Vanadium*. Concentrations were above the ESV (7.8 mg/kg) in all drainage way and Dawson Cove soil samples. However, all vanadium concentrations were below the Arkansas background value (95% UTL) of 146 mg/kg.

6.4.3 Nickel, Selenium, and Silver in Soil Samples

Tables 6-4 and 6-5 present the summary statistics for nickel, selenium, and silver. The table below summarizes the FOD, number of samples with concentrations above the Arkansas background and soil ESVs, and number of samples with concentrations above site background.

Analyte	Drainage Way			Dawson Cove		
	FOD	N > AR BKG & ESV	N > Site BKG	FOD	N > AR BKG & ESV	N > Site BKG
Nickel	100% (45/45)	1	1	100% (48/48)	0	0
Selenium	51% (23/45)	4	2	29% (14/48)	3	0
Silver	31% (14/45)	0*	0	8% (4/48)	0*	1

Notes:
FOD = frequency of detection
N > AR BKG & ESV = Number of samples above the Arkansas soil background (95% UTL) and respective soil ESVs.
N > Site BKG = Number of samples above the maximum detection in site background soil samples.
* = Arkansas soil background value not available for this analyte.

These results are discussed below:

- *Nickel*. Figures 6-1.2 and 6-2.2 show the maximum nickel concentrations at each soil sample location and the associated sample depth interval with the maximum detection. Nickel concentrations were below the screening criteria in all Dawson Cove soil samples and in 44 of 45 drainage way soil samples. In one drainage way soil sample, the nickel concentration was above the Arkansas soil background value of 40 mg/kg and the ESV of 38 mg/kg at the deepest sample depth only (SO-DA-006 at 1 to 1.5 feet, 65 mg/kg). This sample was also slightly above the range of site background concentrations (7.9 to 51 mg/kg, Table 5-6). However, nickel was detected in crude oil at concentrations of 50.3 and 50.5 mg/kg (Table 5-1), indicating that crude oil from the Pegasus pipeline would not contribute nickel at the maximum concentration detected in soil. These results indicate that nickel in soil is consistent with background conditions in the area and is not associated with crude oil.

- *Selenium*. Figures 6-1.2 and 6-2.2 show the maximum selenium concentrations at each soil sample location and the associated sample depth interval with the maximum detection. Selenium concentrations were below the screening criteria in 41 of 45 drainage way soil samples. Selenium concentrations in four drainage way samples were above both the Arkansas soil background value of 1.7 mg/kg and the ESV of 0.52 mg/kg, but only two samples had selenium concentrations above the range of site background concentrations (non-detect to 2.5 mg/kg; Table 5-6). Each of those samples was from subsurface depth intervals at locations SO-DA-001 and SO-DA-005 (1 to 1.5 feet bgs and 0.5 to 1 foot bgs, respectively). In Dawson Cove, selenium concentrations were below the screening criteria in 45 of the 48 soil samples. Selenium concentrations in three Dawson Cove samples were above both the Arkansas soil background and the ESV, but none of the samples had selenium detections above the range of site background concentrations (Table 5-6). Although selenium is detected in the crude oil at concentrations of 1.82 and 2.66 mg/kg (Table 5-1) (slightly above the Arkansas soil background value of 1.7 mg/kg), these results indicate that selenium in soil is consistent with background conditions and is not associated with crude oil.

- *Silver*. Figures 6-1.2 and 6-2.2 show the maximum silver concentrations at each soil sample location and the associated sample depth interval with the maximum detection. Silver concentrations were below the soil ESV of 330 mg/kg in all 45 drainage way soil samples and all 48 Dawson Cove soil samples.

6.5 Summary of Total Organic Carbon and Black Carbon

Thirty surface soil samples were analyzed for TOC and black carbon. TOC concentrations range from 0.28 to 3.3 percent in 15 drainage way soil samples and from 0.61 to 2.5 percent in 15 Dawson Cove soil samples. The drainage way and Dawson Cove soil sample TOC concentrations are similar to site background soil TOC concentrations (0.53 to 2.4 percent).

Black carbon was detected in soil samples collected at three drainage way locations, at concentrations ranging from 0.2 to 0.31 percent. Black carbon was not detected in the soil samples collected from Dawson Cove. The concentration ranges of black carbon in drainage way soil samples are similar to site background soils (non-detect to 0.48 percent).

6.6 Evaluation of Deep Soil Cores for Additional Analysis

In Dawson Cove, deeper samples (1.5 to 2, 2 to 3, and 3 to 4 feet bgs) were collected from three soil locations and held at the laboratory: SO-DA-019, SO-DA-021, and SO-DA-023. A provision of the DARSP (ARCADIS 2013) is that, if the sample collected from at 1 to 1.5 feet bgs “exceeds screening criteria, these deeper samples will also be submitted for analysis.” At all three of these locations, the VOC and PAH concentrations were well below the ESVs in samples collected from 1 to 1.5 feet bgs, and the metals concentrations were below the screening criteria (i.e., not above both the Arkansas background and sediment ESV). In addition, a review of the soil photo logs and sample descriptions (Appendix B) did not indicate any evidence of crude oil (e.g., odor and sheens). Therefore, further analysis of the deeper samples was not warranted.

6.7 Evaluation of Soil Samples in Transitional Area to Screening Criteria

As discussed in Section 3, normal seasonal water levels in Dawson Cove range from 262.2 feet (NAVD88) during winter to 262.87 feet (NAVD88) during summer, as controlled by the Lake Conway Dam and the outlet culvert invert elevation from Dawson Cove. Six soil sample locations in Dawson Cove (SO-DA-023, SO-DA-025, SO-DA-026, SO-DA-027, SO-DA-028, and SO-DA-029) are located within a transitional area that was exposed during the sampling period, but is likely inundated for an extended period of time based on the expected range in seasonal water levels. Therefore, these soil samples were also screened using sediment ESVs, and the results are discussed in Section 7.

6.8 Conclusions

Soil samples were collected at 30 locations in the drainage ways and in Dawson Cove. All soil samples were analyzed for VOCs, PAHs, and metals. Based on the screening results, concentrations in 92 of 99 samples were at levels that do not warrant further evaluation. In the remaining samples, an individual analyte or PAH summation was above the screening criteria. The following presents a summary by chemical class (i.e., VOCs, PAHs, and metals).

VOCs. Crude-oil-related VOC concentrations were either non-detect or below ESVs in all soil samples except for benzene in one sample collected in the drainage way at SO-DA-015. The surface sample (0 to 0.5 feet bgs) at this location had a benzene concentration of 34 µg/kg, which was above the ESV of 10 µg/kg. Benzene was not detected at the upstream soil sample location (SO-DA-014), or in any downstream soil sample locations in Dawson Cove.

PAHs. The total LMW PAH results were below the soil ESVs in all samples. The total HMW PAH were below the soil ESV of 1,100 µg/kg in 93 of 99 samples. The total HMW PAH summation was above the soil ESV in the following locations that warrant further consideration (see Section 9).

Area	Location	Sample Depth	Analyte	Value
Drainage Ways	SO-DA-003	Surface (0 to 0.5 feet bgs)	Total HMW PAH	2,280 µg/kg
	SO-DA-005	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,640 µg/kg
Dawson Cove	SO-DA-019	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,180 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total HMW PAH	1,270 µg/kg
	SO-DA-022	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,760 µg/kg
	SO-DA-023	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,220 µg/kg

Metals. The concentrations of metals are consistent with background conditions in the area and/or are below ESVs based on the screening approach described in Section 5. Therefore, no further assessment of metals concentrations in soils is necessary.

7. Sediment Sampling Evaluation and Results

This section discusses the analytical results and data analysis for the sediment sampling in the drainage ways, Dawson Cove, and Lake Conway. Sediment samples were submitted for laboratory analysis, as described in Section 2.3. The table below summarizes the number of sediment samples (excluding duplicates) collected from each area.

Area	Surface Samples	Subsurface Samples	Deep Subsurface Samples	Total Number of Samples
Drainage Ways	13	22	0	35
Dawson Cove	34	65	26	125
Lake Conway	6	12	0	18

Notes:
"Surface Samples" includes samples from 0 to 0.5 foot bgs.
"Subsurface Samples" includes samples from 0.5 to 1.0 foot and 1.0 to 1.5 feet bgs.
"Deep Subsurface Samples" includes samples deeper than 1.5 feet bgs. As discussed in Section 2.2, deep subsurface samples were not analyzed for the full analytical suite.

Table 7-1 summarizes the grain size results for surface sediment samples, Table 7-2 presents the sediment analytical results for the drainage ways, Table 7-3 presents the sediment analytical results for Dawson Cove, and Table 7-4 presents the sediment analytical results for Lake Conway.

The following data summaries and evaluations were completed:

- Sediment data summary statistics for the drainage ways, Dawson Cove, and Lake Conway are provided in Tables 7-5, 7-6, and 7-7, respectively.

- Concentrations of key analytes at each of the sample locations are shown on Figures 7-1.1 through 7-3.3. These figures present the maximum detections for each key analyte at each location, and the associated sample depth interval at which the maximum detection occurred (i.e., 0 to 0.5 foot bgs, 0.5 to 1.0 foot bgs, or 1.0 to 1.5 feet bgs).

- The VOC and PAH screening was completed following the procedure shown in Figure 5-1. For the analytes detected in the sediment samples, as well as the crude oil, the individual analytes were compared to ESVs (Table 5-2). Total LMW and HMW PAHs (Long List) were calculated according to Table 5-3 and compared to ESVs. The one-carbon model TU calculation was completed for the surface sediments PAHs (provided in Appendix J) and compared to the ESV.

- The metals screening was completed following the procedure shown in Figure 5-1, including comparison to ESVs (Table 5-2).

- Box plots for metals and PAHs compare the concentrations in surface soils for the drainage ways, Dawson Cove, Lake Conway, and site background locations. These box plots are provided in Appendix H.

The following subsections discuss the analytical results for physical characteristics and by each chemical class (e.g., VOCs, PAHs, metals).

7.1 Summary of Grain Size Results

Grain size distribution analyses were conducted on surface sediment samples from the drainage ways, Dawson Cove, Lake Conway, and site background locations. Grain size data for the drainage ways, Dawson Cove, and Lake Conway are presented in Table 7-1; Table 5-6 summarizes grain size data for the background locations. The fines content expressed as a percent of combined silt and clay is summarized in the table below.

Area	Number of Surface Samples (0 to 0.5 foot bgs)	Fines Content (Silt and Clay Fraction)
Drainage Ways	13	26 to 86%
Dawson Cove	34	61 to 99%
Lake Conway	6	77 to 94%
Site Background	12	55 to 99%

7.2 Summary of Volatile Organic Compounds in Sediment Samples

Sediment samples were analyzed for 66 individual VOCs (Table 2-3). Of the 66 VOCs analyzed, 51 were not detected (Tables 7-2, 7-3, and 7-4). Four detected VOCs (2-butanone, acetone, methylene chloride, and trichloroethene) are not associated with the crude oil as discussed in Sections 5.1 and 5.4; therefore, those VOCs are not discussed further in this section. The remaining 11 VOCs were detected in the drainage ways and Dawson Cove, but none of these were detected in Lake Conway. These 11 VOCs were also not detected in site background samples. The statistics for each of these detected compounds are presented by area in Tables 7-5, 7-6, and 7-7, and the FOD is summarized in the table below.

Analyte	**Frequency of Detection**			
	Drainage Ways	**Dawson Cove**	**Lake Conway**	**Site Background**
1,2,4-Trimethylbenzene	Not detected	16% (20/125)	Not detected	Not detected
1,3,5-Trimethylbenzene	6% (2/35)	18% (23/125)	Not detected	Not detected
2-Phenylbutane	Not detected	7% (9/125)	Not detected	Not detected
Benzene	11% (4/35)	8% (10/125)	Not detected	Not detected
Ethylbenzene	3% (1/35)	7% (9/125)	Not detected	Not detected
Isopropylbenzene	Not detected	6% (8/125)	Not detected	Not detected
n-Butylbenzene	Not detected	8% (10/125)	Not detected	Not detected
n-Propylbenzene	Not detected	7% (9/125)	Not detected	Not detected
p-Isopropyltoluene	6% (2/35)	9% (11/125)	Not detected	Not detected
Toluene	3% (1/35)	10% (13/125)	Not detected	Not detected
Xylene (Total)	9% (3/35)	17% (21/125)	Not detected	Not detected

Note: Background statistics include samples from site background locations in the drainage ways and Lake Conway.

Nine of the 11 detected VOCs were below sediment ESVs in all samples (Tables 7-5, 7-6, and 7-7). The two VOCs with detections above the sediment ESV include isopropylbenzene (cumene) and total xylenes. These two VOCs are discussed below:

- *Isopropylbenzene (Cumene)*. Isopropylbenzene was below the sediment ESVs in the drainage ways, and was not detected in Lake Conway or the background locations. In Dawson Cove, isopropylbenzene was below the sediment ESV in 124 of 125 samples. In one subsurface sample (SED-DA-017, 0.5 to 1.0 feet bgs), the isopropylbenzene concentration (280 µg/kg) was above the sediment ESV of 86 µg/kg.

- *Total xylenes*. Total xylenes was below the sediment ESVs in the drainage ways, and was not detected in Lake Conway or the background locations. In Dawson Cove, total xylenes concentrations were below the sediment ESV in 118 of 125 samples. In seven samples, the total xylenes concentration was above the ESV (25 µg/kg) at five locations (SED-DA-015, SED-DA-017, SED-DA-039, SED-DA-045, and SED-DA-048).

7.3 Summary of Polycyclic Aromatic Hydrocarbon Concentrations in Sediment Samples

Figures 7-1.1, 7-2.1, and 7-3.1 show the maximum concentrations of total LMW and HMW PAHs (Priority+2 List and Long List; see Section 5) measured at each sediment location for the drainage ways, Dawson Cove, and Lake Conway, respectively. PAHs were detected in all site background sediment samples, and in all sediment sample locations in the drainage ways, Dawson Cove, and Lake Conway. PAH concentrations in sediment samples collected from the drainage ways, Dawson Cove, and Lake Conway are discussed in Sections 7.3.1, 7.3.2, and 7.3.3.

7.3.1 Summary of Polycyclic Aromatic Hydrocarbon Concentrations in Drainage Ways

The statistics for the individual and total PAHs are presented for the drainage ways in Table 7-5. None of the individual PAHs exceeded their respective ESVs. The FOD for the total LMW and HMW PAHs compared to their respective ESVs is summarized in the table below.

Analyte	Drainage Way		Site Background
	N > ESV	N > Site Bkg	N > ESV
Priority+2 List			
Total HMW PAHs	1	0	3
Total LMW PAHs	0	0	2
Long List			
Total HMW PAHs	2	0	3
Total LMW PAHs	3	2	2
Toxic Unit			
One-Carbon Model TU*	0	0	0

Notes:
N > ESV = Number of samples (excludes duplicates) above the respective sediment ESVs
Site background refers to background sediment locations in the drainage ways.
* Summary for surface sediment samples only. The TU calculations for drainage way sediment samples are provided in Appendix J.

In 33 of 35 samples in the drainage ways, the total HMW and LMW PAHs (both Priority+2 and Long Lists) are below the sediment ESVs. The TUs for the surface sediment samples were all 1.0 or less. In two samples (and one duplicate) in the drainage ways, PAH summations were detected above the ESVs; these samples are discussed below:

- *SED-DA-004*. In the surface sample at this location, the total HMW PAHs (Priority+2 List) and the total HMW and LMW PAHs (Long List) summations were above the sediment ESVs. The one-carbon model TU for the surface sample was 1.0, indicating no unacceptable risk to benthic ecological receptors.

- *SED-DA-006*. In the subsurface sediment sample collected at the 0.5 to 1.0 foot bgs, the total LMW PAHs (Long List) summation was above the sediment ESV. The one-carbon model TU was 1.3 using the TOC value for the surface sample at this location, which was slightly above 1.0. The TU values cannot be evaluated further using the two-carbon model because black carbon was not detected in the surface sample. However, benthic and aquatic receptors are not generally exposed to sediment at depth intervals below the biologically active zone, which is typically about 10 centimeters thick. The 0 to 0.5-foot surface sediment sample interval includes the biologically active zone, and therefore, there is not a complete exposure pathway to subsurface samples at deeper depth intervals. Because it is unlikely that benthic receptors will be exposed to sediments deeper than 0.5 foot, and moreover, the TU value only slightly exceeds 1.0 using the one-carbon model; it is concluded that risks to benthic and aquatic receptors are not expected at this location.

- *SED-DA-007 (Duplicate Sample)*. In the duplicate for the surface sample at this location, the total HMW and LMW PAHs (Long List) summations were above the sediment ESVs. The one-carbon model TU for the surface sample was 0.5, indicating no unacceptable risk to benthic ecological receptors.

Therefore, no further evaluation of PAHs in drainage way sediment is necessary.

7.3.2 Summary of Polycyclic Aromatic Hydrocarbon Concentrations in Dawson Cove

The statistics for the individual and total PAH summations are presented for Dawson Cove in Table 7-6. The individual PAHs were below sediment ESVs in 101 of 105 samples in Dawson Cove; four samples had one or more individual PAHs above the sediment ESV of 330 µg/kg and are described below:

- *SED-DA-015*. The surface sediment sample (0 to 0.5 foot bgs) had a phenanthrene concentration of 331 µg/kg.

- *SED-DA-017*. The subsurface sediment sample (0.5 to 1 foot bgs) had a phenanthrene concentration of 416 µg/kg and a 2-methylnaphthalene concentration of 395 µg/kg.

- *SED-DA-028*. The surface sediment sample (0 to 0.5 foot bgs) had a benzo(b)flouranthene concentration of 386 µg/kg.

- *SED-DA-045*. The surface sediment sample (0 to 0.5 foot bgs) had a phenanthrene concentration of 669 µg/kg.

These samples are evaluated further using the PAH summations and the TU calculation. Total LMW and HMW PAHs compared to their respective ESVs and to the maximum detection in the site background locations are summarized in the table below.

Analyte	**Dawson Cove**		**Site Background**
	N > ESV	**N > Site BKG**	**N > ESV**
Priority+2 List			
Total HMW PAHs	4	2	1
Total LMW PAHs	14	25	0
Long List			
Total HMW PAHs	47	16	5
Total LMW PAHs	47	21	4
Toxic Unit			
One-Carbon Model TU*	1	0	0

Notes:
N > ESV = Number of samples above the respective sediment ESVs.
Site background refers to background sediment locations in Lake Conway.
* Summary for surface sediment samples only. The TU calculations for Dawson Cove sediment samples are provided in Appendix J.

In 52 of 105 samples in Dawson Cove, the total HMW and LMW PAHs (both Priority+2 and Long Lists) were below the sediment ESVs. In the remaining 53 samples (32 surface and 21 subsurface), at least one of the summations was above the sediment ESVs. The TU calculation is applicable to the surface sediment sample concentration, which is where ecological exposures occur. For 31 of the 32 surface sediment samples, the one-carbon model TU was 1.0 or less, indicating no unacceptable risk to benthic ecological receptors. The one-carbon model TU in one surface sediment sample (SED-DA-045) was 1.2, which was slightly above 1.0. The TU was recalculated using the two-carbon model and the result was 0.4, which was below 1.0 (Appendix I,

Table I-2). Therefore, risk to benthic receptors from exposure to PAHs in surface sediments is not expected in Dawson Cove.

The TU was also calculated for the 21 subsurface samples, with at least one of the PAH summations above the sediment ESV, to provide additional information regarding these samples. The TOC value for the surface sample at each location was used for the TU calculation. For 20 of these 21 subsurface samples, the TU was also 1.0 or less, indicating no unacceptable risk to benthic ecological receptors. The TU value for one sample (SED-DA-017, 0.5 to 1 foot) was 1.3, which was slightly above 1.0. The TU value cannot be further evaluated using the two-carbon model because black carbon was not detected in the surface sediment sample at this location. However, benthic and aquatic receptors are not generally exposed to sediment at depth intervals below the biologically active zone, which is typically about 10 centimeters thick. The 0 to 0.5-foot surface sediment sample interval includes the biologically active zone, and therefore, there is not a complete exposure pathway to subsurface samples at deeper depth intervals. Because it is unlikely that benthic receptors will be exposed to sediments deeper than 0.5 foot, and moreover, the TU value only slightly exceeds 1.0 using the one-carbon model; it is concluded that risks to benthic and aquatic receptors are not expected at this location.

Therefore, no further evaluation of PAHs in Dawson Cove sediment is necessary.

7.3.3 Summary of Polycyclic Aromatic Hydrocarbon Concentrations in Lake Conway

The statistics for the individual and total PAHs summations are presented for Lake Conway in Table 7-7. None of the individual PAHs exceeded their respective ESVs. Total LMW and HMW PAHs compared to their respective ESVs are summarized in the table below.

Analyte	**Lake Conway**		**Site Background**
	N > ESV	**N > Site BKG**	**N > ESV**
Priority+2 List			
Total HMW PAHs	0	0	1
Total LMW PAHs	0	0	0
Long List			
Total HMW PAHs	12	0	5
Total LMW PAHs	3	0	4
Toxic Unit			
One-Carbon Model TU*	0	0	0

Notes:
N > ESV = Number of samples above the respective sediment ESVs.
Site background refers to background sediment locations in Lake Conway.
* Summary for surface sediment samples only. The TU calculations for Lake Conway sediment samples are provided in Appendix J.

For the 18 sediment samples collected in Lake Conway, the total Priority+2 List HMW and LMW PAHs are below the sediment ESVs. In 12 of 18 samples, one or more of the Long List HMW and LMW PAHs are above the sediment ESVs. The one-carbon model TU was less than 1 in all of the surface samples, indicating no unacceptable risk to benthic ecological receptors. The TU was also calculated for the six subsurface samples, with at least one of the PAH summations above the sediment ESV, to provide additional information regarding these samples, even though benthic receptors will most likely not be exposed to subsurface sediment as they dwell in surface sediment. The TOC value for the surface sample at each location was used for the TU calculation. For all six of these subsurface samples, the TU was also less than 1, indicating no unacceptable risk to benthic ecological receptors.

Therefore, no further evaluation of PAHs in Lake Conway sediment is necessary.

7.4 Summary of Metals Concentrations in Sediment Samples

The following subsections discuss the metals concentrations grouped according to the screening evaluations in Section 5:

- Cadmium, lead, and mercury – the three metals that were not detected in crude oil.
- Arsenic, barium, and chromium – the three metals that were detected in crude oil at concentrations below the Arkansas sediment background values (95% UTL).
- Nickel, selenium, silver, and vanadium – the remaining four metals that samples were analyzed for.

7.4.1 Cadmium, Lead, and Mercury in Sediment Samples

As discussed in Section 5.1, cadmium, lead, and mercury were not detected in the crude oil. However, the detected concentrations of these metals for all sediment samples were compared to the ESVs (bolded results in Tables 7-2, 7-3 and 7-4) and are summarized below.

- *Cadmium*. Concentrations were below the sediment ESV in all 35 drainage way sediment samples, in 100 of the 101 Dawson Cove sediment samples, and in all 18 Lake Conway sediment samples. The detected cadmium concentration of 1.99 mg/kg in one Dawson Cove sediment sample (SED-DA-025) was above the ESV (1 mg/kg).

- *Lead*. Concentrations were below the sediment ESV in all 35 drainage way sediment samples, in 72 of the 101 Dawson Cove sediment samples, and 13 of the 18 Lake Conway sediment samples. The lead concentration was above the sediment ESV (30.2 mg/kg) in 29 of the 101 Dawson Cove samples and in 5 of the 10 Lake Conway samples. For comparison, the lead was not detected in crude oil at a reporting limit of <1.5 mg/kg (Table 5-1) – below the ESV of 30.2 mg/kg and the Arkansas background value of 36 mg/kg.

- *Mercury.* Mercury concentrations were below the sediment ESV in all 35 drainage way sediment samples, in 95 of the 101 Dawson Cove sediment samples, and all 18 Lake Conway sediment samples. Detected mercury concentrations were above the sediment ESV (0.13 mg/kg) in 6 of the 101 Dawson Cove samples, with the highest concentration (0.788 mg/kg) detected in the deepest sample depth interval at location SED-DA-026.

7.4.2 Arsenic, Barium and Chromium in Sediment Samples

As discussed in Section 5.3, arsenic, barium and chromium were not detected in the crude oil above their respective Arkansas sediment background values. However, the detected concentrations of these metals for all sediment samples were compared to the ESVs (bolded results in Tables 7-2, 7-3 and 7-4) and are summarized below.

- *Arsenic*: Concentrations were below the sediment ESV in 22 of the 35 drainage way sediment samples, in 70 of the 101 Dawson Cove sediment samples, and in 13 of the 18 Lake Conway sediment samples. Detected arsenic concentrations were above the ESV (7.24 mg/kg) in the 49 of the 154 sediment samples. For comparison, the arsenic concentrations detected in crude oil samples were 0.361 and 1.02 mg/kg (Table 5-1) – below the ESV of 7.24 mg/kg and below the Arkansas background sediment value of 14 mg/kg.

- *Barium*. A sediment ESV was not available for barium. However, detected barium concentrations in the 154 sediment samples were all less than Arkansas background sediment value of 558 mg/kg.

- *Chromium.* Concentrations were below the sediment ESV in 34 of the 35 drainage way sediment samples, in 98 of the 101 Dawson Cove sediment samples, and in all 18 Lake Conway sediment samples. Chromium concentrations were above the ESV (52.3 mg/kg) in 4 of the 154 sediment samples. For comparison, the chromium concentrations detected in crude oil samples were 0.229 and 0.278 mg/kg (Table 5-1) – below the ESV of 52.3 mg/kg and below the Arkansas background sediment value of 80 mg/kg.

7.4.3 Nickel, Selenium, Silver and Vanadium in Sediment Samples

Tables 7-5, 7-6, and 7-7 present the summary statistics for nickel, selenium, silver, and vanadium. The table below summarizes the FOD and number of samples with concentrations above the Arkansas background and soil ESVs.

Analyte	**Drainage Way**		**Dawson Cove**		**Lake Conway**	
	FOD	**N > AR BKG & ESV**	**FOD**	**N > AR BKG & ESV**	**FOD**	**N > AR BKG & ESV**
Nickel	100% (35/35)	1	100% (101/101)	5	100% (18/18)	0
Selenium	34% (12/35)	5	6% (6/101)	1	17% (3/18)	2
Silver	14% (5/35)	2	1% (1/101)	0	0% (0/18)	0
Vanadium*	100% (35/35)	0	100% (101/101)	0	100% (18/18)	0

Notes:
FOD = Frequency of detection
N > AR BKG & ESV = Number of samples above the Arkansas sediment background (95% UTL) and respective sediments ESVs.
* = No ESV available for vanadium

These results are discussed below:

- *Nickel*. Figures 7-1.3, 7-2.3, and 7-3.3 show the maximum nickel concentrations at each sediment sample location and the associated sample depth interval with the maximum detection. In one drainage way sample, the nickel concentrations was above the both the Arkansas background and the sediment ESV (SED-DA-004 at 0 to 0.5 foot [42.8 mg/kg]), but within the range of site background concentrations (17 to 66 mg/kg; Table 5-6). In four Dawson Cove sediment samples, the nickel concentrations were above both the Arkansas background and the sediment ESVs (SED-DA-020 at 0 to 0.5 foot [38.6 mg/kg], SED-DA-025 0 to 0.5 foot [36.0 mg/kg], SED-DA-026 at 0.5 to 1 foot [74 mg/kg], and SED-DA-029 at 0 to 0.5 foot [61.8 mg/kg]). Three of these samples were within the range of site background concentrations (17 to 66 mg/kg; Table 5-6) and one was slightly above the range of site background concentrations. Nickel was detected in pure crude oil at concentrations of 50.3 and 50.5 mg/kg (see Table 5-1), which are lower than the maximum detected concentrations in sediment; therefore, it is unlikely that the nickel concentrations in sediment are due to crude oil.

- *Selenium*. Figures 7-1.3, 7-2.3, and 7-3.3 show the maximum detected selenium concentrations at each sediment sample location and the associated sample depth interval with the maximum detection. Selenium concentrations were below the ESV in 30 of 35 drainage way sediment samples. Five drainage way sediment samples have selenium concentrations above the ESV. Two of these samples were subsurface samples collected at SED-DA-006 (1 to 1.5 feet bgs [2.03 mg/kg]) and SED-DA-007 (1 to 1.5 feet bgs [3.05 mg/kg]). The other three samples were all collected at different depth intervals at SED-DA-010 (3.39 to 6.11 mg/kg). Selenium concentrations were below the ESV in 100 of the 101 Dawson Cove sediment samples; one subsurface sample was above the ESV (SED-DA-016 at 0.5 to 1 foot bgs [2.93 mg/kg]). In Lake Conway, selenium concentrations were below the ESV in 16 of 18 sediment samples; two surface samples were above the ESV (SED-DA-035 at 2.89 mg/kg and SED-DA-038 at 3.24 mg/kg). Selenium is detected in the crude oil at concentrations of 1.82 and 2.66 mg/kg (see Table 5-1), indicating that crude oil from the Pegasus pipeline would not contribute selenium up to the concentrations detected in sediment, especially in the deeper subsurface sample at SED-DA-010. These results suggest that selenium is consistent with background conditions and is not associated with crude oil.

- *Silver*. Figures 7-1.3, 7-2.3, and 7-3.3 show the maximum silver concentrations at each sediment sample location and the sample depth interval associated with the maximum detection. In two drainage way sediment samples, the silver concentrations were above the sediment ESVs. Both of these samples were subsurface samples at the same location (SED-DA-010 at 0.5 to 1 foot and 1 to 1.5 feet bgs); the associated surface sediment sample at this location was below the sediment ESV. Silver does not have an associated Arkansas background screening level (see Table 5-5). Both sample concentrations (28.7 to 34.3 mg/kg) were above the range of site background concentrations (0.68 to 1.3 mg/kg; Table 5-6). Silver was detected in crude oil at concentrations of 0.600 to 0.613 mg/kg (see Table 5-1) indicating that crude oil from the Pegasus pipeline could not have contributed silver at the concentrations detected in sediment. These results indicate that silver in sediment samples is associated with background sources, and the limited concentrations above the ESV are not associated with crude oil.

- *Vanadium*. A sediment ESV was not available for vanadium. However, vanadium concentrations in 151 of the 154 sediment samples were less than the Arkansas background value of 88 mg/kg (Table 5-4) and vanadium concentrations in all 154 sediment samples were within the range of the Arkansas background sediment samples (4 to 190 mg/kg; Table 5-4).

7.5 Summary of Total Organic Carbon and Black Carbon

Fifty-three surface sediment samples were analyzed for TOC and black carbon to facilitate ecological risk screening, specifically the TU calculations. TOC concentrations range from 0.14 to 1.35 percent in 13 drainage way sediment samples, from 0.17 to 13.3 percent in 34 Dawson Cove sediment samples, and from 2.2 to 5.91 percent in six Lake Conway sediment samples.

Black carbon was detected in sediment samples collected from Dawson Cove (ranging from 0.16 to 0.42 mg/kg) and Lake Conway (ranging from 0.22 to 0.31 mg/kg). Black carbon was not detected in the sediment samples from the drainage way.

7.6 Evaluation of Deep Sediment Cores for Additional Analysis

In Dawson Cove, deeper samples (1.5 to 2, 2 to 3, and 3 to 4 feet) were collected from nine sediment locations and held at the laboratory: SED-DA-018, SED-DA-019, SED-DA-021, SED-DA-022, SED-DA-023, SED-DA-024, SED-DA-026, SED-DA-027, and SED-DA-029. A provision of the DARSP (ARCADIS 2013) is that, if the sample collected from at 1 to 1.5 feet bgs “exceeds screening criteria, these deeper samples will also be submitted for analysis.” At all nine of these locations, the VOC and PAH concentrations were below the ESVs in the in samples collected from 1 to 1.5 feet bgs sample, and the metals concentrations were below the screening criteria (i.e., not above both the Arkansas background and sediment ESV). Therefore, further analysis of the deeper samples was not warranted.

7.7 Evaluation of Soil Samples in Transitional Area to Polycyclic Aromatic Hydrocarbon Screening Criteria

As discussed in Section 3, normal seasonal water levels in Dawson Cove range from 262.2 feet (NAVD88) during winter to 262.87 feet (NAVD88) during summer, as controlled by the Lake Conway Dam and the outlet culvert invert elevation from Dawson Cove. Six soil sample locations in Dawson Cove (SO-DA-023, SO-DA-025, SO-DA-026, SO-DA-027, SO-DA-028, and SO-DA-029) are located within a transitional area that was exposed during the sampling period, but is likely inundated for an extended period of time based on the expected range in seasonal water levels. Therefore, these soil samples were also screened using sediment ESVs. Few analytes at these transitional locations were above sediment ESVs, as summarized below:

- *SO-DA-023*. In the subsurface sample (1 to 1.5 feet bgs) collected at this location, the nickel concentration was 37.7 mg/kg, which was slightly above the Arkansas sediment background of 35 mg/kg (and the sediment ESV of 15.9 mg/kg). Given the depth of this sample, this result indicates that nickel in this sample is consistent with background conditions in the area and is not associated with crude oil.

- *SO-DA-023, SO-DA-025, and SO-DA-027*. In the surface samples (0 to 0.5 foot bgs), the total LMW PAHs (Long List only) concentrations were above the sediment ESV. However, the one-carbon model TU were less than 1, indicating no unacceptable risk to benthic ecological receptors

These locations do not need to be evaluated further based on the sediment screening results.

7.8 Evaluation of the Dart Samplers

ARCADIS conducted Dart sampling at 10 locations in Dawson Cove (three soil locations and seven sediment locations) to qualitatively assess the vertical profile of PAHs and to evaluate the Dart sampling technique for potential future soil and sediment delineation sampling. Dart sampling is a technology developed by DTI that uses solid-phase extraction (SPE) and LIF principles to detect PAHs and PAH-containing nonaqueous phase liquids (NAPLs) in soil and sediment. A Dart sampler consists of a rod coated with an SPE medium, which sorbs PAHs. The sampler is inserted into the soil or sediment, allowed to equilibrate, removed, and analyzed with an LIF reader for PAH/NAPL concentrations as a function of depth[9]. Sampling activities, as well as the outcome of a calibration study for the Darts, are detailed in Appendix E. Sampling results are summarized here.

The Dart readings were compared to the field observations from co-located cores and the total PAH (both Priority+2 List and Long List PAHs) analytical results to evaluate

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[9] Additional information regarding the Dart technology can be found on DTI's website (http://www.dakotatechnologies.com/index.php/Service/Darts.html), and in Attachment C of the Downstream Areas Remedial Sampling Plan (ARCADIS 2013).

the Dart results. As detailed in Appendix E, the Dart sampling method appears to have limited use in quantifying crude-oil-related PAHs in sediment and soil at the site. However, Dart samplers may have some use as a qualitative tool.

7.9 Lake Conway Depositional Assessment Results

In August 28 and 29, 2013, ARCADIS conducted a depositional assessment in Lake Conway to evaluate whether the Mayflower Pipeline Incident Response activities within Dawson Cove, which temporarily increased surface-water turbidity within the cove, produced a discernible deposition of new, surficial sediment within Lake Conway. Such deposition, if any, would be evidenced by a surficial sediment layer and would most likely occur near the Dawson Cove outlet, where Dawson Cove discharges into Lake Conway. This assessment was performed at the request of the Arkansas Game and Fish Commission. The assessment was qualitative, based on visual descriptions of sediment core samples. The assessment was performed in accordance with the DARSP (ARCADIS 2013).

During the Mayflower Pipeline Incident Response activities, a silt curtain was installed, temporarily blocking the outflow from Dawson Cove to Lake Conway. The water level in Dawson Cove was maintained by pumping, as needed, from a temporary structure that was designed to minimize entrainment of sediment.

7.9.1 Sampling Locations

The sediment core locations included in the depositional assessment are shown on Figure 2-8. ARCADIS collected twelve sediment cores (DEP-01 through DEP-12) along a transect in Lake Conway leading from near the outlet of Dawson Cove toward the Highway 89 eastern bridge that crosses Lake Conway (herein referred to as south Lake Conway cores; Figure 2-9). ARCADIS also collected four background sediment cores (BG-008, BG-010, BG-011, and BG-012) for comparison with the south Lake Conway cores. The background samples were collected in the northern area of Lake Conway, where the overall surface water flow direction is toward the south.

The sediment descriptions are presented in Tables 2-9 and 2-10. Photographs of the cores are presented in Appendix C, and stratigraphic profiles are summarized on Figures 7-4.1 and 7-4.2.

7.9.2 Characteristics of South Lake Conway Samples

Sediment cores DEP-01 through DEP-07 were collected closest to the outlet of Dawson Cove (Figure 2-8). These cores were collected to a depth of between 4 to 10 inches below sediment surface (bss). These cores exhibited a surficial sediment layer approximately 0.04 to 0.08 inches thick, composed of brown silt (see Figure 7-4.1). The observation of silt is consistent with the relatively quiescent setting of these samples, within a cove west of the main part of Lake Conway. This brown silt layer was underlain by gray silt, with a thickness of approximately 1 to at least 9 inches, in all of these cores. Brown clay was present below the gray silt in some of these south Lake Conway cores.

Cores DEP-08 through DEP-12 were collected within the main part of Lake Conway. These cores were collected to a depth of between 7 to 9 inches bss. In contrast with the brown silt surficial layer observed at locations DEP-01 though DEP-07, cores DEP-08 through DEP-12 had a surficial layer of gray silt with trace sand, silt with little sand, or sand with some silt (see Figure 7-4.2). The sand content generally increased toward the east; core DEP-12 had the highest sand content. The absence of the brown silt layer at these locations may be related to higher energy within the main part of the lake due to the main flow velocities associated with discharge of Lake Conway near the constriction under the Highway 89 eastern bridge, longer wind fetch, and boat traffic; it is interpreted that higher energy conditions have either prevented the deposition of the surficial brown silt layer or removed it by natural scouring.

7.9.3 Characteristics of Background Samples

Background sediment cores BG-008, BG-010, BG-011, and BG-012 were collected in the northern area of Lake Conway. These cores were collected to a depth of between 6 to 13 inches bss. The general stratigraphy of these background cores was similar to that at the DEP-01 through DEP-12 locations. Three of the four background sediment cores (BG-010 through BG-012) had a surface layer approximately 0.04 to 1 inch thick of brown silt and sand, sand and silt, or sand with some silt, underlain by gray silt with a thickness of approximately 0.5 to at least 8 inches, and then by clay. Two of these background locations (BG-010 and BG-011) had a similar thickness of brown surficial sediment as observed in samples DEP-01 through DEP-07, discussed above (approximately 0.04 to 0.08 inches).

Background sediment core BG-008 contrasted with the other background samples, in that it lacked a brown surficial layer; rather, it contained gray sand and silt, underlain by brown clay. The general stratigraphy of this background core was similar to that at DEP-08 through DEP-12.

7.9.4 Evaluation of Physical, Chemical, and Biological Parameters

The assessment of whether the Mayflower Pipeline Incident Response activities within Dawson Cove produced a discernible layer of new, surficial sediment in Lake Conway is summarized in Sections 7.9.2 and 7.9.3, and primarily relied on inspection of sediment stratigraphy. This included limited qualitative evaluation of various physical characteristics of the near-surface sediment profile in relation to background samples. While more extensive information about the near-surface sediment conditions and characteristics are available through detailed inspection of sediment profile imagery (as listed in the DARSP), not all of these characteristics are relevant to the evaluation of presence/absence of a new sediment layer in Lake Conway. For completeness with respect to the types of information identified in the DARSP, a brief listing and discussion of these follows.

- *Grain size*. Visual characterization/classification of sediment type and texture is principally based on grain size as discussed in Sections 7.9.2 and 7.9.3.

- *Surface boundary roughness*. Surface boundary roughness at the sediment-water interface governs bottom boundary layer thickness in the water column. Surface boundary roughness is used to represent how flow across that roughness will affect boundary layer flow. The grain size of the sediment together with presence of any larger scale irregular features or objects such as woody debris, rocks, sediment clumps (for example from recently disturbed bed surface or recent deposition of sediment clumps or debris) and other organic matter can affect surface boundary roughness. Surface boundary roughness, as observed through the sediment cores, did not vary to any considerable degree among samples and thus, had limited significance with respect to the depositional layer assessment.

- *Depth of apparent redox potential discontinuity*. The brown silt surficial layer observed in south Lake Conway cores DEP-01 through DEP-07 and background cores BG-010, BG-011, and BG-012 are most likely oxidized sediment. The underlying gray sediment may reflect reduced conditions associated with oxygen consumption via biological decomposition of organic sediment. Diffusion, burrowing organisms, and physical mixing introduce oxygen in the surface sediments. Oxygen is typically rapidly consumed such that the surface oxidized layer is often thin. Oxygen will usually penetrate approximately 2 to 3 millimeters into the sediment by molecular diffusion (Aller 1994). Within a few millimeters of the sediment-water interface organic sediment will often be anoxic, exhibiting a darker color. In a 2004 survey of Lake Conway, dissolved oxygen was present in surface water near the sediment water interface (Shostell and Williams 2007), indicating the potential for oxidized sediment at the sediment water interface, which explains the thin light brown silty surface layer.

- *Erosional or depositional features*. Potential erosional and depositional processes affect the stratigraphy and grain size of the sediments and are discussed in Sections 7.9.2.

- *Subsurface methane gas pockets*. The standard profile of sediment respiration consists of a series of oxidants that are consumed in order of free energy release, that order being: oxygen, nitrate, manganese oxides, iron oxides/hydroxides, sulfate, and carbon dioxide (Berner 1980; Froelich et al. 1979; Stumm and Morgan 1981). Generally, the lower free-energy oxidants will not be utilized until the higher free-energy oxidants have been consumed. The degradation of organic matter using the oxidant carbon dioxide results in the production of methane and other gases which can produce gas pockets or voids in the sediment profile. Gas pockets were not observed to any notable degree in the south Lake Conway cores or in the background cores and thus, have little, if any significance to the depositional assessment.

- *Observation of benthic organisms*. Observation of benthic organisms is listed in Tables 2-9 and 2-10.

7.9.5 Discussion of Results

If a significant depositional event occurred in Lake Conway during the response activities, a surficial sediment layer would be visible in the core stratigraphy, particularly in the area near the Dawson Cove outlet. As discussed above, a very thin (0.04 to 0.08 inches) surficial layer of brown silt was observed in cores DEP-01 through DEP-07. It is possible that this layer was deposited, at least in part, during the response activities. However, two of the four background samples BG-010 and BG-011, also contained a very thin (0.04 to 0.08 inches) surficial layer of brown sediment. The brown surficial layer at DEP-01 through DEP-07 may reflect natural, long term depositional processes. As discussed in Section 5, the analytical results of sediment samples collected from Lake Conway indicate no discernible effect on lake sediments as a result of the Mayflower Pipeline Incident.

7.10 Conclusions

A total of 178 sediment samples were collected at 53 locations within the drainage ways, Dawson Cove, and Lake Conway. Based on the screening results, concentrations in 172 of 178 samples were at levels that do not warrant further evaluation. In the remaining samples, one analyte was above the screening criteria. The following presents a summary, by chemical class (i.e., VOCs, PAHs, and metals).

VOCs. Crude-oil-related VOC concentrations were either non-detect or below ESVs in all sediment samples in the drainage ways and Lake Conway. Total xylenes and isopropylbenzene were detected above ESVs (25.2 µg/kg and 86 µg/kg, respectively) at the following five locations in Dawson Cove that warrant further consideration (see Section 9).

Area	Location	Sample Depth	Analyte	Value
Dawson Cove	SED-DA-015	Surface (0 to 0.5 feet bgs)	Total xylenes	730 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total xylenes	420 µg/kg
	SED-DA-017	Subsurface (0.5 to 1.0 feet bgs)	Isopropylbenzene	280 µg/kg
			Total xylenes	2,600 µg/kg
	SED-DA-039	Subsurface (1.0 to 1.5 feet bgs)	Total xylenes	26 µg/kg
	SED-DA-045	Surface (0 to 0.5 feet bgs)	Total xylenes	110 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total xylenes	61 µg/kg
	SED-DA-048	Surface (0 to 0.5 feet bgs)	Total xylenes	81 µg/kg

PAHs. Fifty-three of the sediment samples collected in the drainage ways and Dawson Cove had individual PAHs and/or PAH summations above ESVs. However, the TU for each surface sample, which accounts for the specific mixture and concentrations of PAHs in pore water and provides a rigorous indication of potential risk to benthic invertebrates, was 1.0 or less in all samples, indicating no unacceptable risk to benthic ecological receptors. Two of the subsurface samples had a TU slightly above 1.0, but because it is unlikely that benthic receptors will be exposed to sediments deeper than 0.5 foot and value only slightly exceeded 1.0 using the one-carbon model, it was concluded that risks to benthic and aquatic receptors are not expected at these locations. Twelve of the 18 samples in Lake Conway had a total LMW PAH (Long List only) summation above the ESV; however, the TU for the samples were well below 1. Therefore, no further assessment of PAHs in sediment in the drainage ways, Dawson Cove, or Lake Conway is necessary.

Metals. Based on the screening approach, the concentrations of metals are consistent with background conditions in the area and/or below ESVs. Therefore, no further assessment of metals concentrations in soils is necessary.

Six soil sample locations in Dawson Cove are located within a transitional area that is seasonally inundated, but was exposed during the sampling period; therefore, these soil samples were also compared to sediment ESVs. The evaluation of PAHs showed no unacceptable risk to benthic ecological receptors, and the metals concentrations were consistent with background conditions in the area and are not associated with crude oil. No further assessment of these locations is necessary, based on the sediment screening results.

The depositional assessment identified a very thin, brown surficial sediment layer at several locations near the Dawson Cove outlet that was similar to that observed at two of the background locations, and therefore, may reflect natural, long-term depositional processes. These results, combined with the analytical results in Lake Conway indicate no further assessment of sediments in Lake Conway is necessary.

8. Surface Water Sampling Evaluation and Results

This section summarizes the analytical results and data analysis for daily surface water samples collected from drainage ways, Lake Conway, and Dawson Cove and six surface water samples collected from the drainage ways and Dawson Cove as part of the DARSP activities.

8.1 Daily Sampling

Over 2,180 surface water samples have been collected from numerous locations in drainage ways, Dawson Cove, and Lake Conway since March 29, 2013. (Figure 2-7; data through September 6, 2013 were available for evaluation). These surface water samples were analyzed for VOCs, PAHs, total metals, dissolved metals, and oil and grease (Table 2-8). Surface water data tables for daily samples are provided in Appendix F. Figures 8-1 through 8-12 present the evaluation of analytical results for these daily surface water samples. Field parameters measured at the sample locations are summarized in Appendix F.

8.1.1 Summary of Volatile Organic Compounds in Daily Surface Water Samples

VOC results for all sampling locations (i.e., drainage ways, Dawson Cove, Lake Conway, and background) are summarized in Figures 8-1 through 8-3. Of the 70 individual VOCs analyzed in approximately 2,185 samples, 48 VOCs were never detected (Appendix F).

Lake Conway

No VOCs were detected at concentrations above associated ESVs in Lake Conway surface water samples (Figure 8-2).

Dawson Cove

Of the 14 VOCs detected in Dawson Cove surface water, only two VOCs were detected at concentrations above their respective ESV since March 29, 2013 (Figure 8-3):

- Benzene was detected at concentrations above the ESV of 53 µg/L in two samples (79.2 and 102 µg/L) collected at Dawson Cove sampling location WS-004S on

April 1 and 2, 2013, respectively. Benzene has not been detected in Dawson Cove surface water samples collected since May 5, 2013.

- Total xylenes were detected at concentrations above the ESV of 13 µg/L in four samples collected at locations WS-004S (13.5 to 59.2 µg/L between April 1 and April 11, 2013) and WS-004D (20 µg/L on April 11, 2013). Total xylenes have not been detected in Dawson Cove surface water samples since May 31, 2013.

Drainage Ways

At drainage way sample location WS-008, only two VOCs were detected at concentrations above their respective ESV since March 29, 2013:

- Total xylenes were detected at concentrations above the ESV of 13 µg/L in four samples collected at WS-008 (52 to 130 µg/L between April 8 and April 13, 2013). Total xylenes have not been detected in WS-008 surface water samples since May 31, 2013.

- Isopropylbenzene was detected at a concentration above the ESV of 2.6 µg/L in one sample (3.7 µg/L) collected at drainage way location WS-008 on April 11, 2013. Isopropylbenzene has not been detected in surface water samples collected at WS-008 since April 16, 2013.

Benzene, isopropylbenzene, and total xylenes have been below their respective ESVs continuously at all surface water monitoring locations since April 13, 2013.

8.1.2 Summary of Polycyclic Aromatic Hydrocarbons in Daily Surface Water Samples

Locations with PAH concentrations above ESVs are shown on Figure 8-4 (all surface water data) and Figure 8-5 (August 5 through September 6, 2013). Summary statistics for samples collected from March 29 through September 6, 2013, and also more recent results for samples collected from August 5 through September 6, 2013 are provided on Figure 8-6 for background surface water sample locations (WS-005, WS-014S, and WS-014D), on Figure 8-7 for Lake Conway samples, and on Figure 8-8 for Dawson Cove samples.

Background (Figure 8-6)

Evaluation of sampling results for WS-005 and WS-014 indicate detections of two PAHs (benzo(a)pyrene and pyrene) above their respective ESVs in background samples collected at WS-005.

- Benzo(a)pyrene was detected at a concentration of 0.019 µg/L above the ESV of 0.015 µg/L in one sample collected at WS-005 on May 7, 2013.

- Pyrene was detected at concentrations above the ESV of 0.025 µg/L in 10 samples collected at WS-005. Pyrene was detected above the Region 5 Alternate ESV of 0.39 µg/L in one sample collected at WS-005 at a concentration of 1.5 µg/L on August 22, 2013.

Lake Conway (Figure 8-7)

Recent sampling results (August 5 through September 6, 2013) indicate detections of four PAHs (anthracene, benzo(a)anthracene, benzo(a)pyrene, and pyrene) above their respective ESVs at select locations, including near the Dawson Cove outlet (WS-001 and WS-006), the Highway 89 bridge (WS-002), and the boat ramp next to the Lake Conway dam (WS-003).

- Anthracene was detected above the ESV of 0.012 µg/L in one sample collected at WS-001D at a concentration of 0.014 µg/L on September 5, 2013.

- Benzo(a)anthracene was detected above the ESV of 0.018 µg/L in three samples (maximum concentration 0.034 µg/L) collected at WS-003 on August 20 and September 4, 2013 and at WS-012D on August 21, 2013. Surface water monitoring locations WS-003 and WS-012D are not located adjacent to the Dawson Cove outlet.

- Benzo(a)pyrene was detected above the ESV of 0.015 µg/L in four samples (maximum concentrations 0.03 µg/L) collected at WS-003 on August 17 and 20 and September 4, 2013 and at WS-012D on August 21, 2013. Benzo(a)pyrene was also detected in background surface water samples at a maximum concentration of 0.019 µg/L. Surface water monitoring locations WS-003 and WS-012D are not located adjacent to the Dawson Cove outlet.

- Pyrene was detected above the ESV of 0.025 µg/L in 46 samples collected at WS-001S, WS-001D, WS-002, WS-003, WS-006S, WS-006D, WS-010S, WS-010D, and WS-012D. Pyrene was detected above the Region 5 Alternate ESV of 0.39 µg/L in one sample collected at WS-002 and two samples collected at WS-006S. The maximum detected pyrene concentration of 1.0 µg/L in Lake Conway samples is less than the maximum detected pyrene concentration of 1.5 µg/L in background surface water samples. Surface water monitoring locations WS-002, WS-003, WS-010, and WS-012 are not located adjacent to the Dawson Cove outlet.

Dawson Cove (Figure 8-8)

Recent sampling results (August 5 through September 6, 2013) indicate detections of four PAHs (anthracene, benzo(a)anthracene, benzo(a)pyrene, and pyrene) above their respective ESVs in Dawson Cove samples.

- Anthracene was detected above the ESV of 0.012 µg/L in 18 samples (maximum concentration of 0.085 µg/L) collected at WS-007S.

- Benzo(a)anthracene was detected above the ESV of 0.018 µg/L in 11 samples (maximum concentration of 0.14 µg/L) collected at WS-007S.

- Benzo(a)pyrene was detected above the ESV of 0.015 µg/L in 18 samples (maximum concentration of 0.13 µg/L) collected at WS-007S.

- Pyrene was detected above the ESV of 0.025 µg/L in 22 samples (maximum concentration of 0.43 µg/L) collected at WS-007S. Only one sample had a concentration above the Region 5 Alternate ESV of 0.39 µg/L. The recent maximum detected concentration of 0.43 µg/L in Dawson Cove surface water is less than the recent maximum detected pyrene concentration of 1.5 µg/L in background surface water.

8.1.3 Summary of Oil and Grease in Daily Surface Water Samples

Oil and grease results for all sampling locations (i.e., drainage ways, Dawson Cove, Lake Conway, and background) are provided on Figure 8-9. A total of 982 samples have been analyzed for oil and grease since March 29, 2013. One sample collected at WS-008 on May 29, 2013 (location in the drainage way along Main Street) had a detected oil and grease concentration of 10.1 mg/L, above the APCEC Reg. 2

guideline of 10 mg/L average but below the APCEC Reg. 2 guideline of 15 mg/L maximum.

8.1.4 Summary of Dissolved Metals in Daily Surface Water Samples

The analysis of metals is focused on recent sampling results because dissolved metals were added to the surface water program on July 15, 2013 for comparison to ESVs which are based on dissolved metals concentrations.

Background (Figure 8-10)

Barium was detected at concentrations ranging from 0.0051 to 0.033 mg/L above the ESV of 0.004 mg/L in all dissolved metals samples collected at Lake Conway background monitoring locations WS-005, WS-014S, and WS-014D.

The barium ESV is a secondary chronic value developed by the USEPA for the Great Lakes Water Quality Initiative, as cited in Suter and Tsao, 1996. Suter and Tsao (1996) have the following comment regarding the ESV for barium:

> "*Background water concentrations should be used as a check for these benchmarks* [i.e., ESVs]. *That is, because some of these benchmarks are quite conservative and because the measured concentrations in ambient water may include forms that are not bioavailable, benchmark concentrations may be lower than background water concentrations. If the background concentrations are valid and represent an uncontaminated state and if exposed site does not contain forms of the chemical that are more bioavailable or toxic than the forms at background sites, then screening benchmarks lower than the background concentration should not be used*."

Based on this comment, barium concentrations for other surface water samples were compared against Lake Conway background concentrations.

Dissolved mercury was detected at a concentration equal to the ESV of 0.00077 mg/L in one background surface water sample collected at WS-014 on July 18, 2013. Dissolved mercury was not detected in any other background surface water samples.

Lake Conway (Figure 8-11)

Four metals, barium, silver, mercury and cadmium, were detected at concentrations above their respective ESVs for dissolved samples:

- Barium concentrations in the Lake Conway samples ranged from 0.0027 to 0.18 mg/L which is similar to the range of dissolved barium, 0.0051 to 0.033 mg/L, detected in background surface water samples. Average barium concentrations in Lake Conway (0.016 mg/L) and background samples (0.013 mg/L) were similar.

- Silver was detected at a concentration above the ESV of 0.0003 mg/L in one Lake Conway dissolved sample collected at WS-012D (0.0022 mg/L) on July 25, 2013. WS-012D is not located adjacent to the Dawson Cove outlet.

- Mercury was detected at a concentration above the ESV of 0.00077 mg/L in one Lake Conway dissolved metals sample collected at WS-012S (0.0011 mg/L) on July 18, 2013. WS-012S is not located adjacent to the Dawson Cove outlet. Mercury was not detected in crude oil.

- Cadmium was detected at a concentration of 0.0026 mg/L above the ESV of 0.00037 mg/L in one Lake Conway sample collected at WS-002 on August 11, 2013. WS-002 is not located adjacent to the Dawson Cove outlet. Cadmium was not detected in crude oil.

Dawson Cove (Figure 8-12)

Two metals, barium and silver, were detected at concentrations above their respective ESVs for dissolved samples:

- Barium concentrations in Dawson Cove dissolved samples ranged from 0.0048 to 0.028 mg/L, which is similar to the range of dissolved barium detected in background samples (0.0051 to 0.033 mg/L) and within the range of dissolved barium detected in the Lake Conway samples (0.0027 to 0.18 mg/L). Average barium concentrations in Dawson Cove (0.018 mg/L), Lake Conway samples (0.016 mg/L), and background samples (0.013 mg/L) were similar.

- Silver was detected at concentrations of 0.0022 and 0.0024 mg/L, above the ESV of 0.0003 mg/L, in two dissolved samples collected at WS-007D on July 25 and 26, 2013, respectively. These detected silver concentrations are similar to the silver concentration of 0.0022 mg/L detected in a Lake Conway sample (WS-012D) collected on July 12, 2013. WS-012D is not located adjacent to the Dawson Cove outlet.

Metals in surface water samples collected from Dawson Cove and Lake Conway are derived from background sources. All dissolved metals detected at concentrations above ESVs are detected in background soil samples collected across Arkansas and in the vicinity of the incident. It is likely that soils contribute to the detected concentrations of metals in surface water. Higher concentrations of total metals are typically associated with higher turbidity, indicating contributions of particulate metals to surface water. In addition, higher concentrations of total and dissolved metals in Dawson Cove are associated with periods of limited or no precipitation indicating that evaporation may play a role in controlling concentrations of total and dissolved metals in surface water. Based on the limited detections of dissolved metals above ESVs in Dawson Cove and in Lake Conway surface water samples, metals in surface water are of limited ecological concern.

8.2 One-Time DARSP Surface Water Sampling Event

In support of the DARSP, a one-time surface water sampling event was conducted in mid-August, 2013. Two drainage way surface water samples (WS-022DA and WS-023DA, located in areas North Main Street and west of Highway 365), were collected from the surface of the water column, and the other one drainage way surface water sample (WS-024DA located at east of Highway 365) and three Dawson Cove (WS-025DA, WS-026DA, and WS-027DA) surface water samples were collected from the midpoint of the water column (Figure 2-8). Drainage way surface water samples were collected on August 13, 2013 and the Dawson Cove surface water samples were collected on August 15, 2013. As described in Section 2.5, surface water samples were submitted for laboratory analysis of VOCs, PAHs (2- to 6-ring PAHs including Priority Pollutant PAHs and 2- to 4-ring PAH alkyl groups), oil and grease, total metals (RCRA 8 metals, nickel, vanadium, calcium, and magnesium), dissolved metals (RCRA 8 metals, nickel, and vanadium), hardness, and TSS. Table 8-1 presents the analytical results for surface water samples collected during the one-time sampling event.

This section presents the following data evaluations:

- Individual analytes were screened against their respective ESVs (see Table 5-2 and Table 8-1).

- Total LMW and HMW PAHs were calculated according to Table 5-3 and screened against ESVs (Table 8-2). Additionally, TUs for surface water samples were calculated in accordance with Table 5-3, as shown on Table 8-2.

The following subsections discuss the analytical results by each chemical class (e.g., VOCs, PAHs, and metals).

8.2.1 Summary of Volatile Organic Compounds in DARSP Surface Water Samples

Surface water samples were analyzed for 66 VOCs (see Table 2-8); 61 of these VOCs were not detected in any surface water sample (see Table 8-1). Four detected VOCs (2-butanone, acetone, TCE, and chloroform) were not detected in the crude oil as discussed in Section 5.1; therefore, these four compounds are not evaluated further in this section. Toluene was the only VOC detected in both crude oil and surface water samples. Detected toluene concentrations were below the toluene surface water ESV in all samples.

8.2.2 Summary of Polycyclic Aromatic Hydrocarbons in DARSP Surface Water Samples

Sixteen Priority Pollutant PAHs were detected in drainage way surface water samples (see Tables 8-1 and 8-2). Anthracene was the only PAH compound detected above the ESV of 0.012 µg/L in two drainage way surface water samples (0.01849 µg/L at WS-022DA and 0.02762 µg/L at WS-023DA). The TUs for drainage way surface water samples were 1.0 or less (see Table 8-1).

Priority Pollutant PAHs were not detected in Dawson Cove surface water sample WS-025DA. Fourteen PAHs were detected in surface water sample WS-026DA (Dawson Cove), 16 PAHs were detected in surface water sample WS-024DA (Dawson Cove), and all 20 PAHs were detected in surface water sample WS-027DA (Dawson Cove). Three PAHs (anthracene, benzo(a)anthracene, and benzo(a)pyrene) were detected above their respective ESVs in Dawson Cove surface water sample WS-027DA. The TU for the four Dawson Cove surface water samples ranged from 0.0 at WS-025DA to 1.0 at WS-027DA.

In summary, few PAHs in drainage way and Dawson Cove surface water samples were detected above ESVs, and TU values were 1 or less for all surface water samples, indicating no unacceptable risk to aquatic ecological receptors.

8.2.3 Summary of Oil and Grease in DARSP Surface Water Samples

Oil and grease were not detected in any of the surface water samples collected from the drainage way and Dawson Cove.

8.2.4 Summary of Metals in DARSP Surface Water Samples

Arsenic, cadmium, mercury, selenium, and silver were not detected in any of the drainage way or Dawson Cove dissolved metals or total metals surface water samples. Chromium, lead, and vanadium were not detected in any of the drainage way or Dawson Cove dissolved metals samples. Dissolved nickel was detected in all three drainage way surface water samples (WS-022DA, WS-023DA, and WS-024DA) and one Dawson Cove surface water sample (WS-025DA), but was below the ESV for all samples. Dissolved nickel was not detected in the other two Dawson Cove surface water samples (WS-026DA and WS-027DA).

Dissolved barium was the only constituent detected in drainage way and Dawson Cove surface water samples at concentrations above the surface water ESV of 0.004 milligrams per liter (mg/L). Dissolved barium concentrations ranged from 0.0167 to 0.0215 mg/L in drainage way surface water and from 0.0169 to 0.0223 mg/L in Dawson Cove surface water.

As described in Section 8.1.4, drainage way and Dawson Cove surface water sample dissolved barium concentrations were compared to background Lake Conway dissolved barium concentrations. The background Lake Conway samples were collected in accordance with the Surface Water Sampling and Analysis Plan (Attachment B of the DARSP; ARCADIS 2013). Dissolved barium was detected at concentrations ranging from 0.0051 to 0.033 mg/L in all background Lake Conway surface water samples collected at sampling locations WS-005, WS-014S, and WS-014D from July 15 through September 6, 2013. These results indicate that dissolved barium concentrations in drainage way and Dawson Cove surface water samples were within the range for Lake Conway background. These results demonstrate that dissolved barium concentrations in the drainage way and Dawson Cove surface water are consistent with background conditions.

8.2.5 Summary of Hardness and Total Suspended Solids in DARSP Surface Water Samples

Surface water samples were analyzed for hardness and TSS, and field parameters were measured (Table 8-1). For drainage way surface water samples, hardness concentrations ranged from 18.2 to 30 mg/L and TSS concentrations ranged from and 28.7 to 50 mg/L In Dawson Cove surface water samples, hardness concentrations ranged from 15.8 to 39.8 mg/L and TSS concentrations ranged from 15 to 110 mg/L.

8.3 Surface Water Data Summary

In summary, extensive monitoring of surface water quality has been conducted since March 29, 2013. Through September 6, 2013, more than 2,180 daily surface water samples have been collected from numerous locations in drainage ways, Dawson Cove, and Lake Conway, and six surface water samples were collected from drainage ways and Dawson Cove in support of the DARSP.

For daily surface water samples collected over a five month period from March 29 through September 6, 2013 there have been limited detections of constituents of concern at concentrations above ESVs.

- Only three of 70 VOCs (benzene, isopropylbenzene, and total xylenes) have been detected at concentrations above ESVs in drainage way and Dawson Cove surface water samples. No VOCs have been detected at concentrations above ESVs since April 13, 2013 and no VOCs were detected above ESVs in Lake Conway surface water.

- Only four of 18 PAHs (anthracene, benzo(a)anthracene, benzo(a)pyrene, and pyrene) have been detected at concentrations above their respective ESVs. All four PAHs were detected at concentrations above ESVs in Dawson Cove and Lake Conway surface water samples (including Lake Conway sampling locations not adjacent to the Dawson Cove outlet). Benzo(a)pyrene and pyrene were detected at concentrations above ESVs in background surface water samples. In recent surface water samples collected from August 5 through September 6, 2013, the maximum pyrene concentration of 1.5 µg/L was detected in a surface water sample collected at background Lake Conway monitoring location WS-005.

- Only two of 10 metals (barium and silver) have been detected in dissolved surface water samples at concentrations above ESVs at locations in Dawson Cove samples. Dissolved barium concentrations were above the ESV for all surface water samples, including background samples, and the highest dissolved barium concentrations were detected in Lake Conway surface water samples. Only three of 557 Dawson Cove and Lake Conway dissolved metals samples were above the ESV for silver and dissolved silver concentrations for Dawson Cove (0.0022 and

0.0024 mg/L) and Lake Conway (0.0022 mg/L) samples were similar. Dissolved metals concentrations in all surface water samples are considered to be representative of background conditions.

For the six DARSP surface water samples collected in August 2013, concentrations of toluene (the only VOC present in crude oil and also detected in the surface water samples) were below the ESV and PAH TU results were all 1 or less. Dissolved barium was detected in surface water samples at concentrations above the ESV; however, concentrations were within the range of background Lake Conway concentrations.

Based on the data evaluation, no further action is warranted, however a reduced surface water monitoring program is proposed in Section 9.

9. Summary of Analytical Findings

Three areas downstream of the release location were assessed to determine post-response conditions; these include the drainage ways from the residential area to Dawson Cove, Dawson Cove, and Lake Conway. Soil, sediment, and surface water samples were collected as part of the response. The following provides a summary of soil and sediment findings by area, and a summary of the overall surface water sampling results.

Drainage Ways Soil and Sediment Results

A total of 45 soil samples were collected at 15 locations along the banks of the drainage ways. Based on the screening results, concentrations in 42 of the 45 samples were at levels that do not warrant further evaluation. Crude-oil-related VOC concentrations were either non-detect or below ESVs in all soil samples except for benzene in one sample. Only two samples had PAH summations above the associated soil ESV. The screening of metals results indicates the concentrations in soil were consistent with background conditions in the area and are not associated with crude oil. The following table summarizes the three soil locations along the drainage ways that warrant further evaluation.

Media	Location	Sample Depth	Analyte	Value
Soil	SO-DA-003	Surface (0 to 0.5 feet bgs)	Total HMW PAH	2,280 µg/kg
	SO-DA-005	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,640 µg/kg
	SO-DA-015	Surface (0 to 0.5 feet bgs)	Benzene	34 µg/kg

A total of 35 sediment samples were collected at 13 locations in the drainage ways. Crude-oil-related VOC concentrations were either non-detect or below ESVs in all sediment samples. Several sediment samples in the drainage ways and Dawson Cove had individual PAHs and/or PAH summations above ESVs. However, the TU for each of the surface samples, which accounts for the specific mixture and concentrations of PAHs, was 1.0 or less in all samples. One of the subsurface samples had a TU slightly above 1.0, but because it is unlikely that benthic receptors will be exposed to sediments deeper than 0.5 foot and value only slightly exceeded 1.0 using the one-carbon model, it was concluded that risks to benthic and aquatic receptors are not expected at this location. The metals screening indicated the concentrations in sediment were consistent with background conditions in the area and/or below ESVs.

Based on these results, sediments in the drainage ways do not require further assessment or evaluation.

Dawson Cove Soil and Sediment Results

A total of 54 soil samples were collected at 15 locations in Dawson Cove. Based on the screening results, concentrations in 50 of the 54 samples were at levels that do not warrant further evaluation. Crude-oil-related VOC concentrations were either non-detect or below ESVs in all soil samples. A limited number of samples had detections above the associated soil ESV for Total HMW PAH (Long List). In addition, the metals screening indicated the concentrations in soil were consistent with background conditions in the area and/or below ESVs. The following table summarizes the three soil locations in Dawson Cove that warrant further evaluation based on the outcome of the screening process.

Media	Location	Sample Depth	Analyte	Value
Soil	SO-DA-019	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,180 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total HMW PAH	1,270 µg/kg
	SO-DA-022	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,760 µg/kg
	SO-DA-023	Surface (0 to 0.5 feet bgs)	Total HMW PAH	1,220 µg/kg

A total of 125 sediment samples were collected at 34 locations in Dawson Cove. Based on the screening results, concentrations in 118 of 125 samples were at levels that do not warrant further evaluation. Crude-oil-related VOC concentrations were either non-detect or below ESVs at all sediment sample locations, with the exception of five locations that had concentrations above the ESVs for total xylenes and isopropylbenzene (25.2 and 86 µg/kg, respectively). Fifty-three sediment samples in Dawson Cove had individual PAHs and/or PAH summations above ESVs; however, the TU for each of the surface samples was 1.0 or less. One of the subsurface samples had a TU slightly above 1.0, but because it is unlikely that benthic receptors will be exposed to sediments deeper than 0.5 foot and value only slightly exceeded 1.0 using the one-carbon model, it was concluded that risks to benthic and aquatic receptors are not expected at these locations. The metals screening indicated the concentrations in sediment were consistent with background conditions in the area and/or below ESVs. The following table summarizes the sediment locations in Dawson Cove that warrant further evaluation.

Media	Location	Sample Depth	Analyte	Value
Sediment	SED-DA-015	Surface (0 to 0.5 feet bgs)	Total xylenes	730 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total xylenes	420 µg/kg
	SED-DA-017	Subsurface (0.5 to 1.0 feet bgs)	Isopropylbenzene	280 µg/kg
			Total xylenes	2,600 µg/kg
	SED-DA-039	Subsurface (1.0 to 1.5 feet bgs)	Total xylenes	26 µg/kg
	SED-DA-045	Surface (0 to 0.5 feet bgs)	Total xylenes	110 µg/kg
		Subsurface (0.5 to 1.0 feet bgs)	Total xylenes	61 µg/kg
	SED-DA-048	Surface (0 to 0.5 feet bgs)	Total xylenes	81 µg/kg

Lake Conway Sediment Results

A total of 18 sediment samples were collected at six locations in Lake Conway. Crude-oil-related VOC concentrations were non-detect in all sediment samples. Twelve sediment samples in Lake Conway had individual PAHs and total PAH summations above ESVs; however, the TU for each sample was 1 or less, indicating no unacceptable risk to ecological receptors. The metals screening process indicated the metals concentrations in Lake Conway sediments were consistent with background conditions in the area and/or below ESVs.

Surface Water Results

Over 2,180 surface water samples have been collected to date as part of a daily surface water monitoring program focused primarily on Lake Conway, but also including locations in the drainage ways and Dawson Cove. In August 2013, six surface water samples were also collected from the drainage ways and Dawson Cove as part of a one-time event for the DARSP activities. Detections of crude-oil-related analytes at concentrations above ESVs are limited, as summarized below.

Lake Conway. No VOCs were detected at concentrations above ESVs in Lake Conway surface water samples collected to date. Based on recent sampling results (August 5 through September 6, 2013) four PAHs were very sporadically detected above ESVs near the Dawson Cove outlet and at select locations near the Highway 89 bridge and the boat ramp next to the Lake Conway Dam. Dissolved metals concentrations in surface water samples are considered to be representative of background conditions.

Dawson Cove. No VOCs have been detected above ESVs since April 13, 2013 in Dawson Cove surface water samples. Based on recent sampling results (August 5 through September 6, 2013) four PAHs were detected above ESVs in Dawson Cove. In general, concentrations of PAHs in Dawson Cove surface water have declined with time since early August 2013. Dissolved metals concentrations in surface water samples are considered to be representative of background conditions.

Drainage Ways. No VOCs have been detected above ESVs since April 13, 2013, in drainage way surface water samples. Based on the DARSP sampling results in the drainage ways, only one PAH compound was above the ESV; however, the TU for the drainage ways was 1 or less (see Table 8-1). Dissolved metals concentrations in surface water samples are considered to be representative of background conditions.

Recommended Path Forward

Soil and Sediment Sampling Results. Sampling results indicate that further evaluation may be warranted for soil in at three locations within the drainage ways, and for soil and sediment at eight locations within Dawson Cove. ExxonMobil will discuss the path forward with the ADEQ before proceeding.

As requested by the ADEQ, ExxonMobil will re-sample the six Lake Conway sediment locations (SED-DA-033 through SED-DA-038) using the same procedures and analyses described in the DARSP (ARCADIS 2013).

Surface Water Sampling Results. Based on the data evaluation, continued surface water sampling is recommended. A revised Surface Water Sampling and Analysis Plan was submitted to the ADEQ on November 1, 2013 and reflects the following changes:

- *Frequency*: Weekly

- *Locations*: Drainage Way (WS-008), Dawson Cove (WS-004, WS-007, WS-020), Lake Conway near Dawson Cove (WS-001, WS-006, WS-009, WS-010, WS-021) and Lake Conway (WS-011, WS-012, WS-014, WS-015). The sampling depth interval(s) at each location will be consistent with previous sampling events.

- *Analytes*: PAHs by USEPA Method 8270 SIM, Standard Turnaround Time

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