Howard/White Unit No. 1 Oil Spill

Natural Resource Damage Assessment

PREASSESSMENT PHASE REPORT

April 2003

Howard/White Unit No. 1 Oil Spill NRDA
Obed Wild and Scenic River
Morgan County, Tennessee

PREASSESSMENT PHASE REPORT

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LIST OF ACRONYMS

BMP	Best Management Practices
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
DBH	Diameter Breast Height
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
GC/MS	Gas Chromatography/Mass Spectrometry
IBI	Index of Biotic Integrity
LSU	Louisiana State University
NCBI	North Carolina Biotic Index
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
OC	Oligochaetes and Chironomids
ORNL	Oak Ridge National Laboratory
PAH	Polyaromatic Hydrocarbon
SVOC	Semivolatile Organic Compounds
TDEC	Tennessee Department of Environment and Conservation
TPH-DRO	Total Petroleum Hydrocarbons – Diesel Range Organics
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compounds
WSR	Wild and Scenic River

1.0 INTRODUCTION

1.1 Authorities and Legal Requirements

Under the Oil Pollution Act of 1990 (OPA 90), federal and state natural resource trustees may conduct a Natural Resource Damage Assessment (NRDA) to document the potential injury from an oil spill. On 19 July 2002, the Howard/White Unit No. 1 oil well in Morgan County, Tennessee started to spill oil. Clear Creek, White Creek, and the surrounding vegetation in the Obed Wild and Scenic River (Obed WSR) system were affected during this spill event. The Department of Interior, National Park Service (NPS) and the State of Tennessee are co-Trustees for the damage assessment of this river system. The agencies assisting the Trustees include the U.S. Fish and Wildlife Service (USFWS), the Tennessee Wildlife Resources Agency (TWRA) and the Tennessee Department of Environment and Conservation (TDEC). Preassessment Phase activities for the NRDA include collecting ephemeral data that are necessary for determining the fate and effects of the spilled oil, reviewing the results and analyzing the data, compiling the Administrative Record, and making a determination whether there is injury or potential injury to Trust resources or services potentially affected.

OPA 90 allows for parties responsible for the release of oil to be held liable for the costs associated with the restoration of injured natural resources. In this preliminary assessment of the impacts from the oil spill and subsequent fire, the Trustees will identify if injuries to natural resources or services may have occurred, if these injuries have been addressed by response actions, and if feasible restoration options are available. Ultimately, this report documents the collaborative decision made by the Trustees on whether or not to pursue the assessment and restoration planning phases of the NRDA.

1.2 Site Description

The Obed River watershed, located on the Cumberland Plateau in eastern Tennessee, is part of the 1968 Wild and Scenic Rivers Act, Public Law 90-542 which states: “that certain selected rivers of the nation, with their immediate environments possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of future generations.” On October 12, 1976, an amendment to this Act established the Obed WSR encompassing 45.2 river miles, which includes portions of the Obed and Emory Rivers, as well as Clear Creek and Daddys Creek (Public Law 94-486, sec. 301 3(a), 16 U.S.C.A § 1274 (a) (15)).

The Obed River system and its tributaries are an important habitat area for a number of threatened and endangered species, such as the purple bean mussel (*Villosa perpurpurea*), the Cumberland bean mussel (*Villosa trabalis*), the spotfin chub (*Cyprinella* (=*Hybopsis*) *monacha*) eggert’s sunflower (*Helianthus eggertii*), Virginia spiraea (*Spiraea virginiana*), and Cumberland rosemary (*Conradina verticillata*). It is a popular area for public recreation (whitewater boating, fishing, and swimming) (NPS, 1994). The Clear Creek watershed is an integral component of the State of Tennessee’s Ecoregion Project (Arnwine et al., 2000) for water quality and habitat. Clear Creek is also federally designated critical habitat (Federal Register Volume 42, No. 175) for the federally threatened spotfin chub (*Cyprinella* (=*Hybopsis*) *monacha*). The State of Tennessee has recognized Clear Creek as a Tier II Antidegradation Water and, within the NPS boundary, as a Tier III Outstanding Natural Resource Water (Tennessee Administrative Rule 1200-4-3-.06(3)).

2.0 SUMMARY OF THE OIL SPILL AND FIRE

2.1 Description of Spill Event

On 19 July 2002, the Howard/White Unit No. 1 oil well was being drilled to test for commercial oil production from the geologic formation called the Nashville Group in northeastern Tennessee. The oil well is located in Morgan County on High Point Road, accessible via State Road 62 (Fig. 1). After drilling to a certain depth, oil flow occurred. The pressure of the flow increased and began to spill oil around the well and outside of the containment area at an estimated 200-500 barrels per hour (EPA, 2003). At approximately 2400 hours, the oil well caught fire. The spilled oil had flowed downhill from the wellhead into White Creek, at approximately 0.21 mi above its confluence with Clear Creek, and into Clear Creek, at approximately 0.37 mi above Barnett Bridge. The fire followed both oiled paths, burning the vegetation and the oil-soaked soils (Fig. 2). Some of the large boulders on the slope fractured from the heat of the fire. The oil adjacent to the banks in both creeks caught fire as well. After the initial spill, oil continued to seep from the creek bank into Clear Creek, with sheens continuing to be released as late as April 2003 (Pryor Oil Spill Site Inspection Brief 3, 2003).

2.2 Activities Following Spill

Initial response actions to contain the oil were undertaken by the operator of the well, Pryor Oil Company of Cookeville, Tennessee, and the well drilling firm, Highland Drilling Company, Inc. of Kingston, Tennessee. Response actions were taken over by the U.S. Environmental Protection Agency (EPA) on the evening of 21 July 2002 at 2130 hours, central standard time, with support from the U.S. Coast Guard (USCG) and the EPA support contractors. Two containment ponds were constructed on the north and south side of the wellhead to catch the run-off from the well to White Creek and Clear Creek. Several hours after the oil spill, containment and absorbent booms were deployed at several locations along Clear Creek and White Creek. As of 2 August 2002, the placement of the booms was determined and included these locations (Fig. 3):

A. Point of oil entry in Clear Creek
B. Point of oil entry in White Creek
C. Immediately upstream of Barnett Bridge
D. Downstream (100 yards) of Barnett Bridge
E. Downstream (0.5 miles) of Barnett Bridge
F. Upstream of Jett Bridge, approximately 5 miles downstream of the spill event

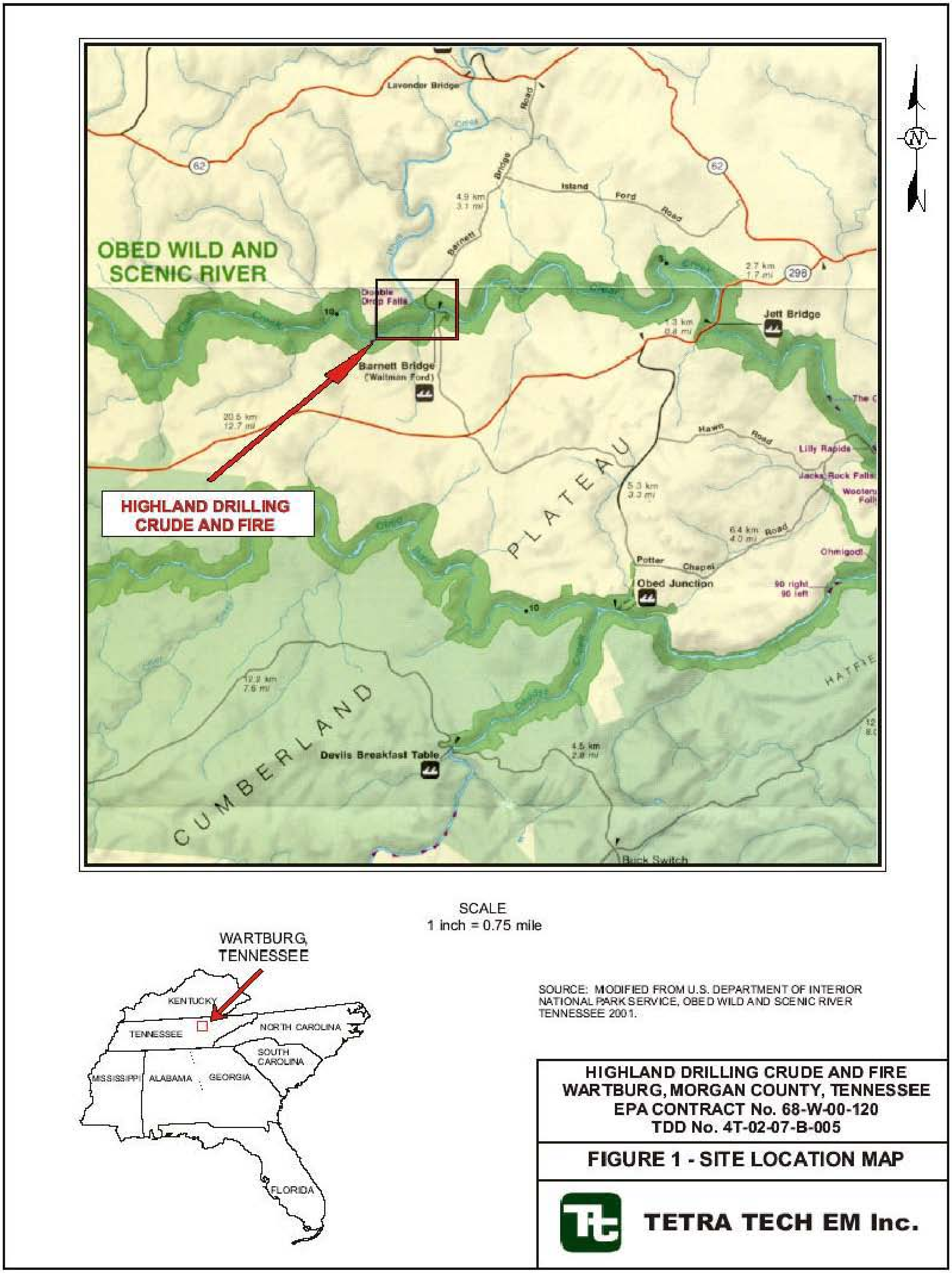


Figure 1. Location of the Howard/White Unit No. 1 oil spill and fire (EPA, 2002).

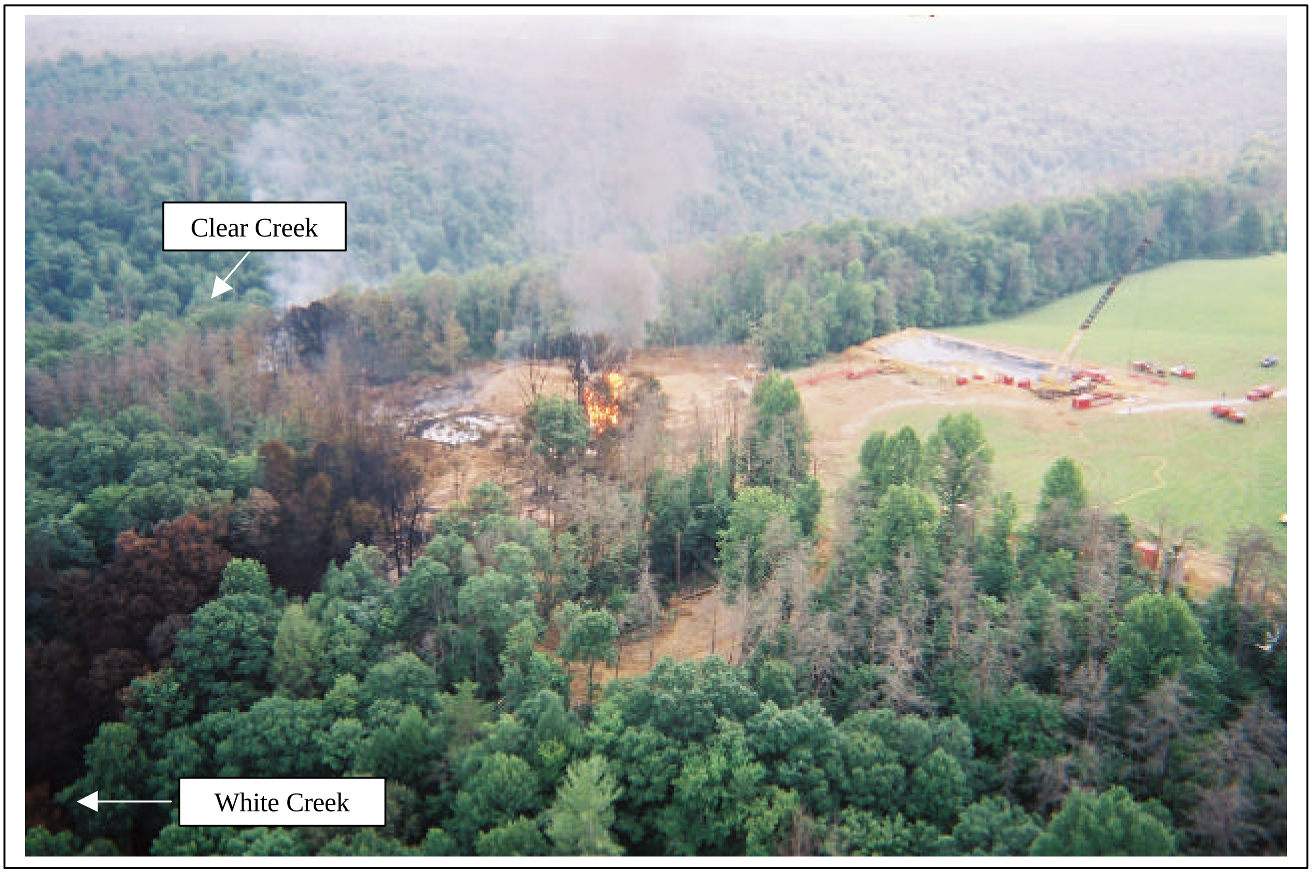


Figure 2. Burned forest paths leading to Clear Creek and White Creek.

During the response actions, oil seeping from the bank of Clear Creek was recovered using containment booms and a drum skimmer. As of February 2003, all containment and absorbent booms have been removed, except at the point of oil entry in Clear Creek.

NPS posted “Do Not Come in Contact with Water” signs at both Jett and Barnett Bridges. On 23 July Clear Creek was officially closed to public use from Double Drop Falls to Jett Bridge (approximately 6 miles) (Appendix A). The closure was implemented due to public health and safety concerns. A cautionary warning was issued to the public against recreating on the water from Jett Bridge to Nemo Bridge. Responders were able to stop the release of oil from the well and extinguished all fires by 25 July 2002. The well was capped on 26 July 2002. An emergency access road was widened and stabilized near Barnett Bridge to allow vacuum trucks access to the area in order to remove spilled product from the creeks. Oil-saturated soil was removed from the top of the slope above the cliff face on Clear Creek from 27 July – 2 August 2002. The soil was excavated and temporarily placed in the containment pond on site. Straw was placed on the slope below the cliff face to reduce erosion and run-off of oily sediments into Clear Creek. The removal actions did not include complete restoration of the damaged areas downslope of the well or complete removal of the access road near Barnett Bridge. Pryor Oil Company is currently producing oil and gas from the well.

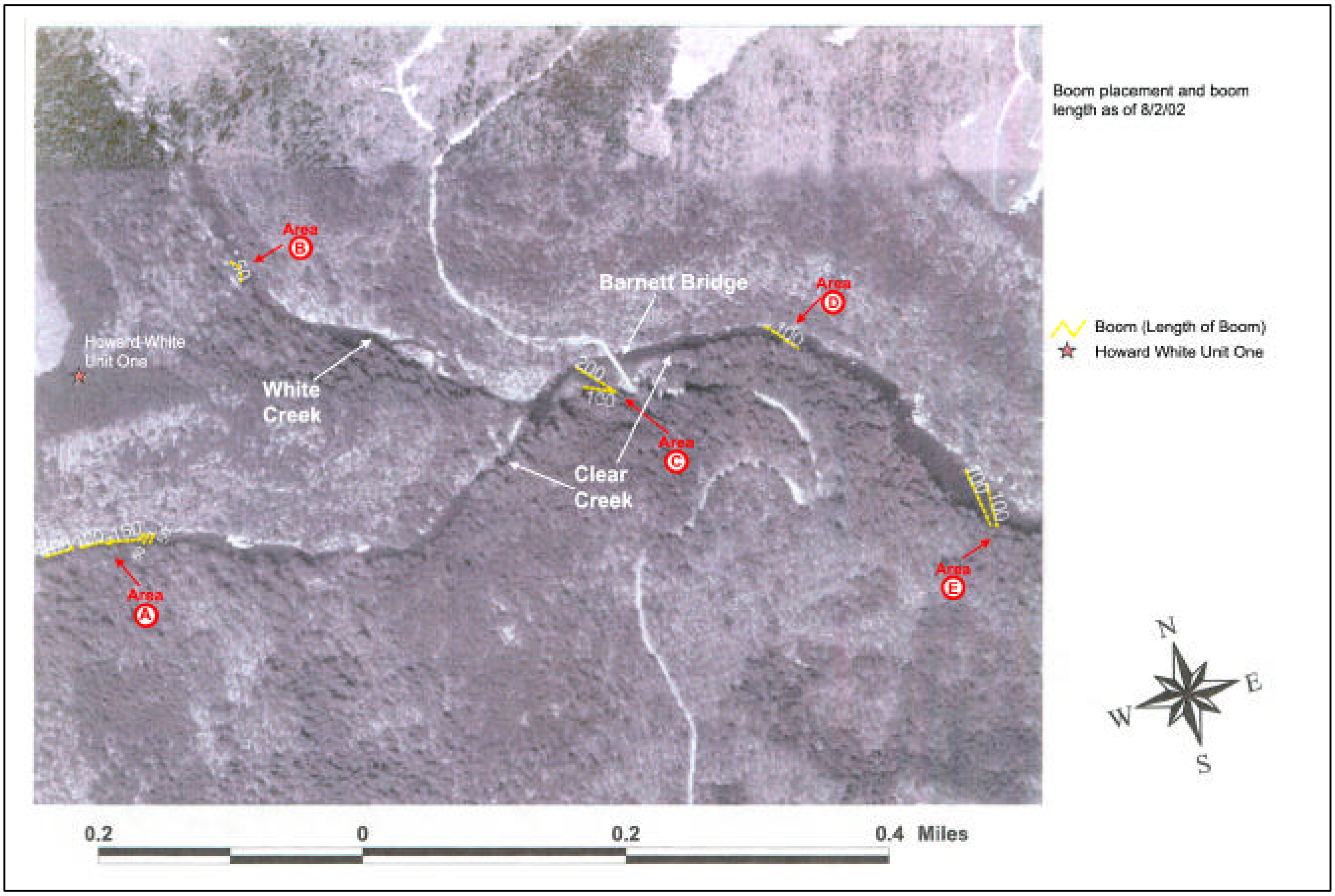


Figure 3. Boom locations in Clear Creek and White Creek (Rob Wachal, pers. comm.).

2.3 Oil Characteristics

The oil released from the well was described as being a light crude oil (API gravity at 60°F = 38.1) with low to medium viscosity. It was yellow to red in color and spread quickly into thin slicks. The oil had a high paraffin (wax) content, and the waxy components tended to separate, forming both a yellow waxy material and a green substance similar in appearance to axle grease. Previous to the spill, Pryor Oil Company collected samples of the oil directly from the well. On 23 July 2002 Tetra Tech EM, Inc., an EPA contractor, collected oil samples from the burned oil, from the collection boom, and just upstream of Barnett Bridge. Reference oil samples were used to provide a "fingerprint" of the oil being released from the well and to characterize it's weathering over time. USFWS sent the reference oil samples to the Louisiana State University Aquatic/Industrial Toxicology Laboratory (LSU, Baton Rouge, Louisiana) to use gas chromatography/mass spectrometry (GC/MS) to analyze the oil samples for n-alkanes and polyaromatic hydrocarbons (PAHs). The PAHs in the "spill reference" samples are shown in Figure 4. The three samples from the oil well, burned oil, and collection boom are similar in composition. These samples represent the PAH distribution or fingerprint in the fresh oil. The naphthalenes comprise about 50 percent of the total PAHs. The relative amount of naphthalenes

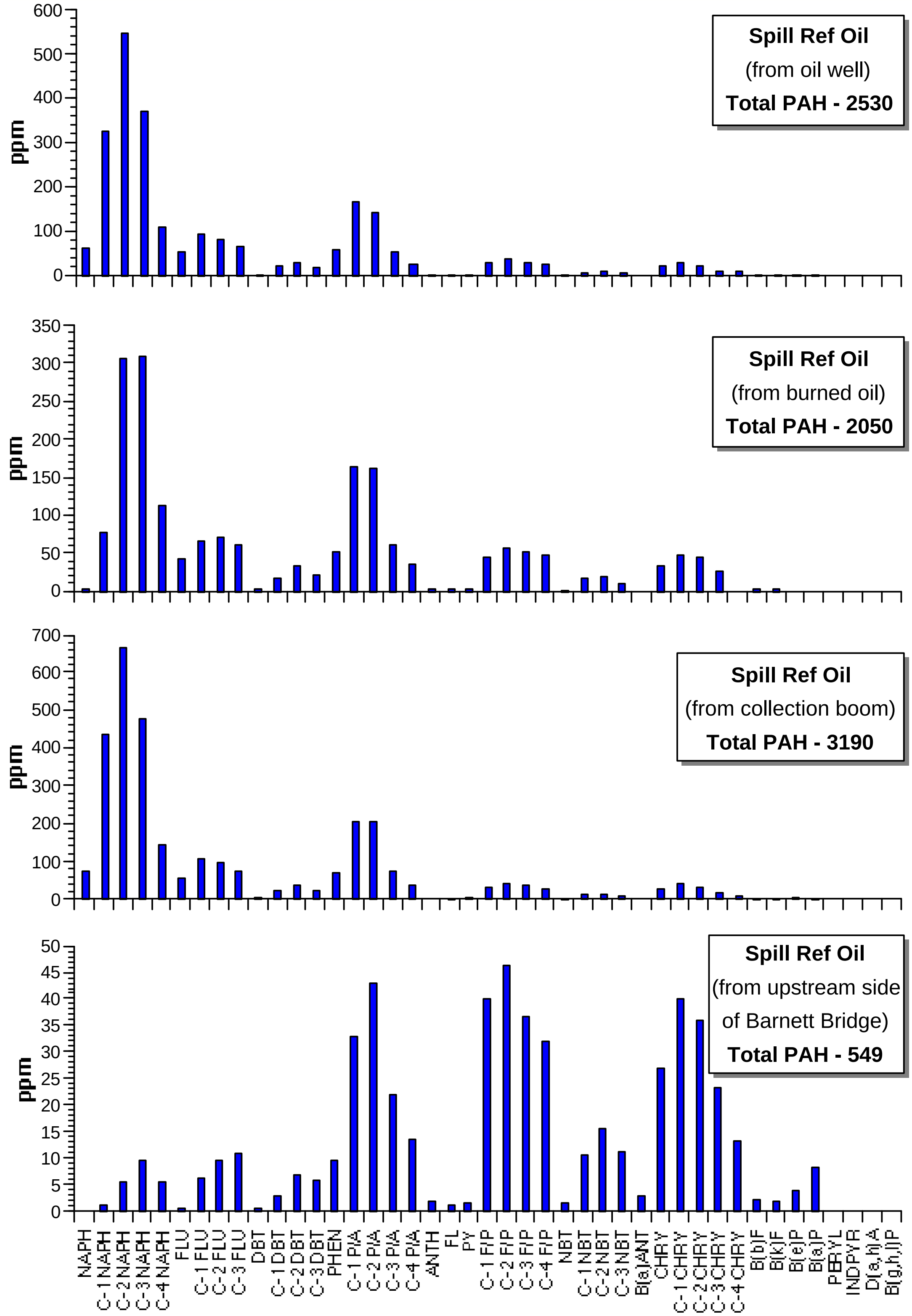


Figure 4. PAH levels from the four spill "reference" oils (chart generated from LSU data). The bottom sample from the water surface shows evidence of weathering by evaporation and dissolution.

is important since these compounds are thought to have the most bioavailability because they are the most soluble, and they have the highest acute toxicity of all PAHs (Meador et al., 1995). They are also the most rapidly degraded of the PAHs, so they can be used to track the rate of weathering of oil remaining in the environment. For example, the oil sample from Barnett Bridge (lowest plot in Fig. 4) shows a significant amount of weathering from both evaporation and dissolution of the lighter PAHs. It also indicates minor microbial degradation of the oil in this sample, since there is little change in the patterns of the alkylated compounds for the three-ringed PAHs, such as phenanthrene.

2.4 Impacted Areas

The slope areas, from the oil well down to both White Creek and Clear Creek, were impacted by both oil and fire (Fig. 5). The soils were soaked with oil and the fire burned the surface soil. An area 0.8 hectares (ha) in size was burned from the oil well to Clear Creek, of which 0.3 ha is Obed WSR property (Fig. 5). The fire also burned an area estimated to be less than 0.5 ha on the slope from the oil well down to White Creek, however, this area was not part of the Obed WSR property (Kris Stoehr, NPS, pers. comm.).

The oil impacted at least 2 miles of Clear Creek and 0.5 miles of White Creek (EPA, 2002). The day after the spill, there was no visible trace or odor of oil detected at Jett Bridge (Rob Turan, pers. comm.). On 27 July 2002, oil was visible on the water's surface near Barnett Bridge, and oil and paraffin were collecting at the last boom below Barnett Bridge. Paraffin was accumulating along the banks of Clear Creek, and the water was murky from the high sediment load from the heavy rains that occurred during the response (EPA, 2002). Emergent vegetation in the creeks was noticeably oiled, and oil was trapped in some of the vegetation (Fig. 6).

It is not clear how much oil remains in the subsurface between the well and Clear Creek. Oil continues to seep out of the creek bank into Clear Creek as of April 2003. The oil seepage slowed during the winter.

3.0 EPHEMERAL DATA COLLECTION

3.1 Collection Activities

Federal and state agencies were involved in the collection of ephemeral data to determine the extent of injury to Clear Creek and White Creek. NPS, USFWS, TDEC, Oak Ridge National Laboratory, and the Tennessee Valley Authority (TVA) participated in the collection of samples for analysis that began days after the spill and continued for the next six months. A scope of work for ephemeral data collection was compiled by the USFWS, and the rationale for each study conducted under the Preassessment Phase was provided by USFWS (Appendix B and C, respectively).

Figure 5. Photographs of the area of spill and burn on Clear Creek. (Top) Aerial photograph taken on 24 July 2002 looking west and upstream on Clear Creek. The spill and fire spread down the slope (right), also burning part of the vegetation on the opposite side. (Bottom) Burned slope and response actions to contain oil seepages on 24 July 2002.

Figure 6. Oiled vegetation in Clear Creek on 25 July 2002.

Chemical and benthic monitoring of the creeks was necessary for determining the extent of contamination and potential for injury to natural resources and services that had occurred due to the spill. An initial assessment of the fish community structure and a study of the forest community structure were completed in response to the spill event. In addition, a visitor use study was done to address the impacts that the spill had on park visitors. Underwater creek surveys were also conducted during a six-month period post-spill to document qualitative alterations in the habitat or changes in the species present over time. The following sections describe the studies conducted to assess the likelihood of injury to the resources impacted by the oil spill. The resources and services that were evaluated include water, sediment, soil, biota, terrestrial vegetation, and visitor use.

3.2 Water Quality Monitoring

3.2.1 Description of Study

Water quality monitoring of both Clear Creek and White Creek was conducted to document the oil concentrations over time and distance downstream from the release site, as well as to complete a fingerprint analysis to document the source of the oil contamination. On 24 July 2002 and 1 August 2002, Tetra Tech EM, Inc. collected six surface water grab samples from Clear Creek and White Creek (Table 1, Fig. 7). Locations were chosen to represent water quality upstream of the spill site and at the points where the oil was discharged into the creeks. Samples were also collected downstream of the spill site to monitor the spatial extent of exposure. These samples were analyzed for semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), target analyte list metals, and total petroleum hydrocarbons – diesel range organics (TPH-DRO) (EPA, 2003).

NPS and USFWS personnel collected water samples from seven locations along Clear and White Creek on 6 August 2002 to be tested for alkanes and PAHs (Table 1, Fig. 7). The samples were sent to LSU for analysis. The sample locations were chosen for documenting background (control) conditions above the spill impact zone, as well as determining the areal and temporal extent of oil contamination after the discharge of crude oil.

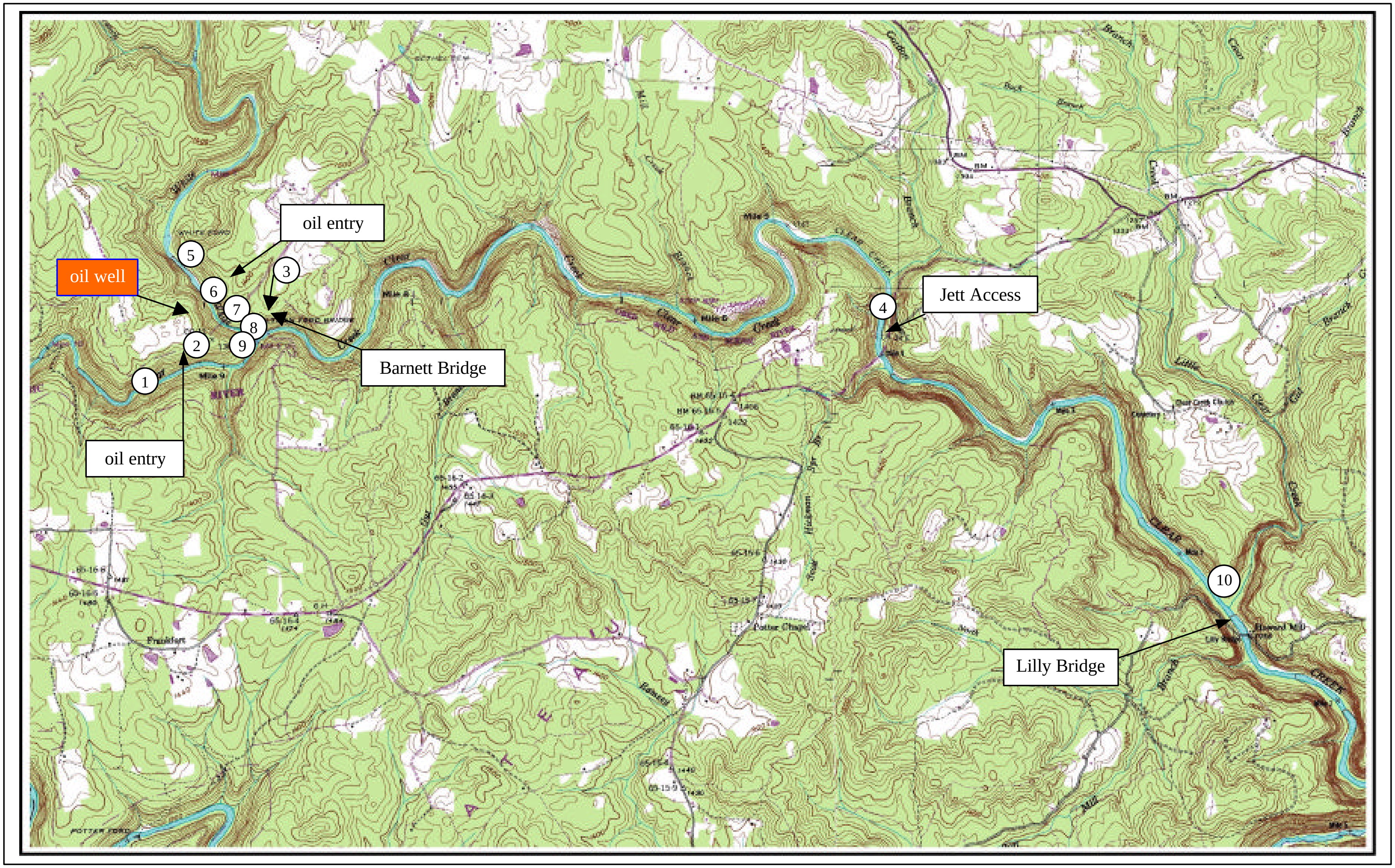
NPS, TDEC and USFWS personnel collected a third round of water samples on 21 and 23 October 2002 (Table 1, Fig. 7). Six samples were submitted to LSU for alkane and PAH analysis, and five samples were sent to the TDEC laboratory for metals and VOC analysis.

3.2.2 Results and Analysis

To determine the extent and degree of oil exposure to water resources within the Obed WSR, VOCs, TPH-DRO, and total PAH levels were analyzed. Of the VOCs measured, the BTEX compounds (benzene, toluene, ethylbenzene, and xylene) are good indicators of the presence and amount of fresh crude oil contamination in Clear and White Creeks. All BTEX measurements were below detection levels, which varied between 1 and 10 ppb, except for the water sample from the 24 July sampling event at the point of oil entry in Clear Creek that contained 4.7 ppm (Table 2). This sample also contained 13,000 ppm TPH-DRO, indicating that the sample included some whole oil rather than just the dissolved fraction. BTEX compounds

Table 1. Water sampling activities from July to October 2002.

LAB	Date	Map ID	Sample ID	Location	Analysis
Tetra Tech	24-Jul-02	1	Clear-SW-BG	Clear Creek - upstream of spill	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	2	Clear-SW-01	Clear Creek - point of oil entry	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	3	Clear-SW-02	Clear Creek - below boom at Barnett Bridge	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	4	Clear-SW-03	Clear Creek - boom upstream from Jett Bridge	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	5	White-SW-BG	White Creek - upstream of spill	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	6	White-SW-01	White Creek - point of oil entry	SVOCs, VOCs, metals, TPH-DRO
LSU	6-Aug-02	1	2N2219-22	Clear Creek - upstream of spill	alkanes, total PAH
	6-Aug-02	2	2N2219-24	Clear Creek - point of oil entry	alkanes, total PAH
	6-Aug-02	3	2N2219-21	Clear Creek - Barnett Bridge	alkanes, total PAH
	6-Aug-02	4	2N2219-23	Clear Creek - Jett Access	alkanes, total PAH
	6-Aug-02	5	2N2219-10	White Creek - upstream of spill	alkanes, total PAH
	6-Aug-02	6	2N2219-11	White Creek - point of oil entry	alkanes, total PAH
	6-Aug-02	7	2N2219-12	White Creek - downstream at point bar	alkanes, total PAH
LSU	21-Oct-02	1	2N2296-01	Clear Creek - upstream of spill	alkanes, total PAH
	21-Oct-02	3	2N2296-03	Clear Creek - Barnett Bridge	alkanes, total PAH
	21-Oct-02	4	2N2296-05	Clear Creek - Jett Access	alkanes, total PAH
	23-Oct-02	10	2N2297-04	Clear Creek - Lilly Bridge	alkanes, total PAH
	21-Oct-02	5	2N2296-02	White Creek - upstream of spill	alkanes, total PAH
	21-Oct-02	8	2N2296-04	White Creek - downstream at mouth	alkanes, total PAH
TN State Lab	21-Oct-02	1	0210146-01C	Clear Creek - upstream of spill	metals, VOCs
	21-Oct-02	9	0210146-03C	Clear Creek - above confluence with White Creek	metals, VOCs
	21-Oct-02	4	0210146-05A	Clear Creek - Jett Access	VOCs
	21-Oct-02	5	0210146-02A	White Creek - upstream of spill	VOCs
	21-Oct-02	8	0210146-04A	White Creek - downstream of spill at mouth	VOCs



(#): Represents Map ID found in Table 1. Each number symbol represents a sample location; multiple sample events were conducted at the same location.

Figure 7. Water sample locations in Clear Creek and White Creek.

Table 2. BTEX and TPH-DRO concentrations in water samples collected in July, August, and October 2002. nd = not detected. NA = not analyzed.

Map ID	Month/Year	Location	BTEX (ppm)	TPH-DRO (ppm)
1	Jul-02	Clear Creek - upstream of spill	nd	0.04
2	Jul-02	Clear Creek - point of oil entry	4.7	13000
3	Aug-02	Clear Creek - boom at Barnett Bridge	nd	0.14
4	Aug-02	Clear Creek - boom at Jett Bridge	nd	nd
5	Jul-02	White Creek - upstream of spill	nd	0.06
6	Jul-02	White Creek - point of oil entry	nd	0.07
1	Oct-02	Clear Creek - upstream of spill	nd	NA
9	Oct-02	Clear Creek - above confluence with White Creek	0.0005	NA
4	Oct-02	Clear Creek - Jett Access	nd	NA
5	Oct-02	White Creek - upstream of spill	nd	NA
8	Oct-02	White Creek - downstream of spill at mouth	0.0008	NA

were not detected in the background sample or in downstream samples from Clear Creek during the July and August sampling event. BTEX compounds were also not detected in any of the July water samples from White Creek. The October water samples contained low levels of BTEX, with 0.0005 ppm downstream of the spill site in Clear Creek and 0.0008 ppm at the mouth of White Creek (Table 2). BTEX was not detected in any of the background sites for Clear Creek or White Creek from the October sampling effort. These data indicate that the oil spill did result in impacts to water quality in Clear Creek and White Creek, and that low levels of exposure to VOCs continued for at least four months after the initial release.

Background levels of TPH-DRO in Clear Creek and White Creek in July were 0.04-0.06 ppm, (Table 2). It should be noted that this analytical method can include natural hydrocarbons such as plant waxes, not just petroleum products. The water sample taken at the point of oil entry into Clear Creek contained 13,000 ppm (Table 2), however, this was likely caused by collection of floating oil slicks in the surface water sample and does not represent the soluble fraction. The water sample collected on 1 August at the boom at Barnett Bridge, downstream of the spill site in Clear Creek, contained 0.14 ppm. This concentration is nearly four times background levels in Clear Creek.

PAHs were measured in water samples collected in August and October from Clear Creek and White Creek. PAH compounds were not detected in the upstream water samples from Clear or White Creek from either period (Fig. 8A – 8B). The water sample from the containment boom at the point of oil entry and the sample taken near the boom at Barnett Bridge on Clear Creek contained extremely high PAH concentrations (24,100 and 278 ppm, respectively) (Fig. 8A). These concentrations indicate that the sample included some floating oil. The oil sample from the boom at the point of oil entry appeared to be very fresh oil with a PAH pattern that closely matched the oil from the well, indicating that fresh oil continued to seep out of the creek bank in late August. PAHs were not detectable in the October water samples from Clear Creek or White Creek. The detection level for individual PAHs was 0.001 ppm.

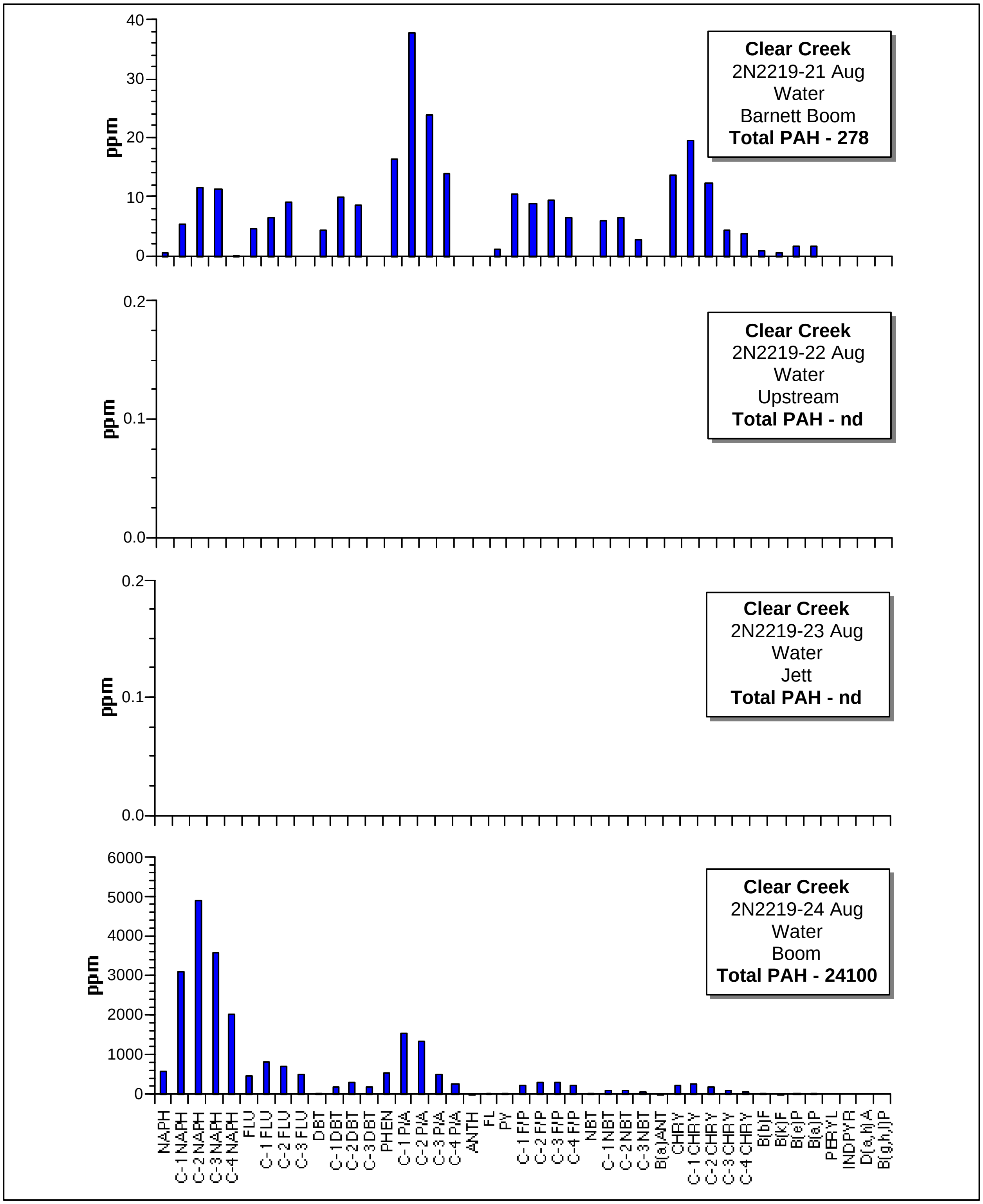


Figure 8A. PAH concentrations (in ppm) in water samples from Clear Creek (August 2002) (chart generated from LSU data). The top and bottom plots are samples that include floating oil and match the reference oils in Figure 4. The middle two plots are upstream of the spill site and at Jett Bridge, greater than 5 miles below the spill site. Both show no evidence of contamination.

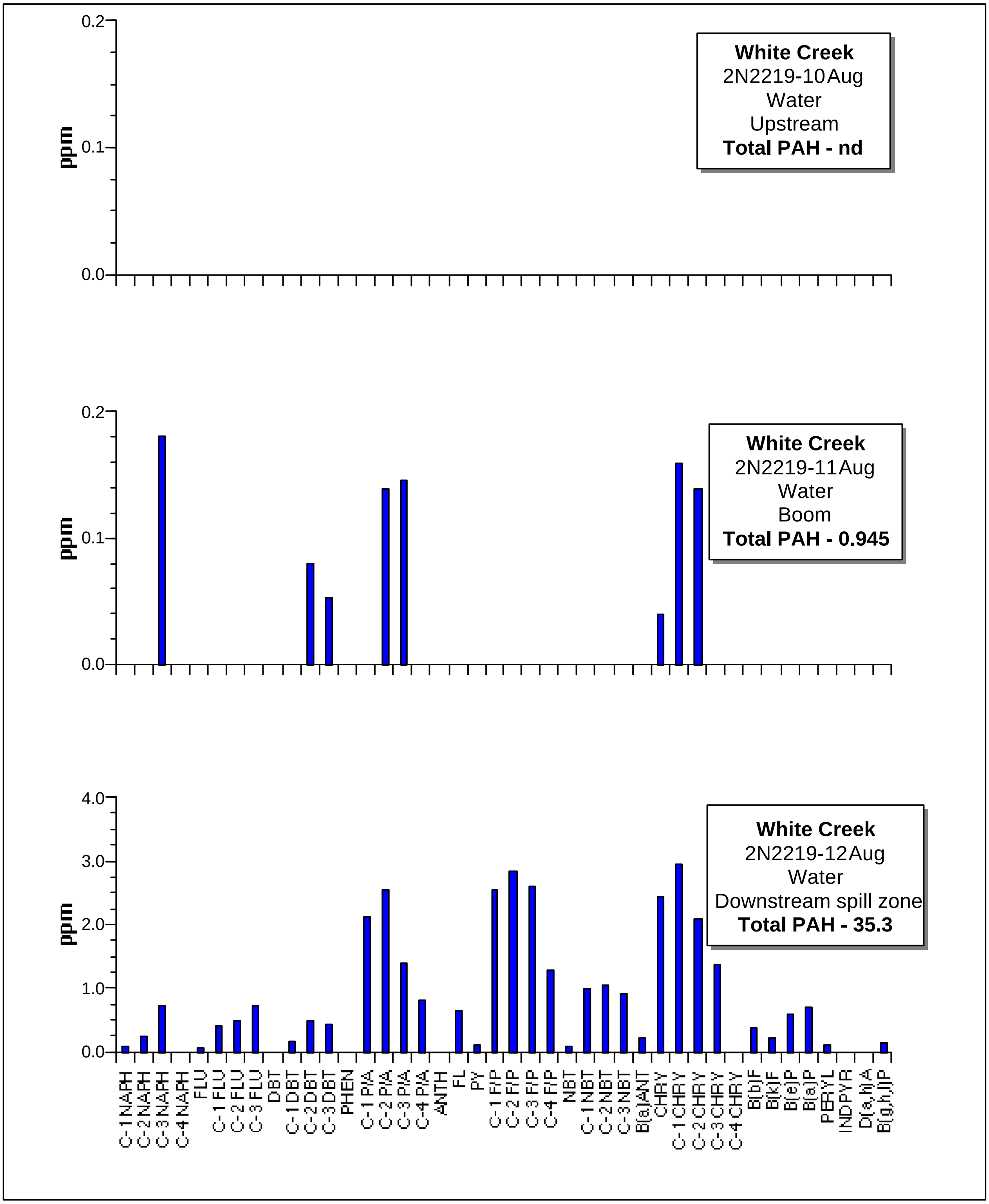


Figure 8B. PAH concentrations (in ppm) in water samples from White Creek (August 2002) (chart generated from LSU data). The top plot shows clean water upstream; the middle plot shows slight contamination at the spill site; bottom plot is a sample with floating oil that matches the reference oil.

The analyses of dissolved metals in the water samples taken in July and August showed no differences between upstream or downstream metal concentrations with the exception of manganese. The upstream concentration from Clear Creek contained 21 ppb, however the downstream sample contained a higher concentration at 110 ppb. The analyses of dissolved metals in the water samples taken in October showed no differences between upstream and downstream concentrations of magnesium, sodium, zinc, and calcium, but substantial increases for the following metals:

Metal	Upstream (ppb)	Barnett Bridge (ppb)
Aluminum	<100	135
Iron	56	154
Manganese	0	77

There are several possible explanations for the increases in these metals: 1) seepage of fluids that tend to increase the dissolution of these metals from the bedrock; 2) mobilization of these metals in runoff as a result from clays, ashes, or metal oxide/hydroxides released by the physical disturbance of the site during the burn and cleanup activities; and 3) changes in the acidity and alkalinity (pH) or oxidation-reduction potential (Eh) in the site soils as a result of the oil and burn. Other metals that might be associated with saline solutions from the oil reservoir, such as sodium, calcium, and magnesium, did not increase downstream of the spill site.

In summary, there were impacts to water quality resulting from the oil spill and fire, from the point of release on each creek and extending at least to Barnett Bridge. Continued oil releases from the spill site through April 2003 have been a source of chronic exposures to aquatic resources. The temporal and downstream extents of water-quality impacts have not been determined.

3.2.3 Potential Long-term Impacts to Water Quality

The continued release of oil from the spill site into Clear Creek through April 2003 indicates that mobile oil remains between the well and the creek. Neither the source nor the volume of the remaining oil is known. The oil is possibly flowing towards the creek through the subsoil and fractured bedrock. There is concern that the oil seepage could continue for years, as has been observed at other spills in porous and fractured substrates. If the amount of oil seepage into Clear Creek does increase as the weather warms, and does not eventually decrease, the source and volume of oil will have to be evaluated.

3.3 Sediment Quality Monitoring

3.3.1 Description of Study

On 24-25 July and 1 August 2002, Tetra Tech EM, Inc. collected six sediment samples from Clear Creek and White Creek (Table 3, Fig. 9). The locations sampled represent unaffected upstream or background sites, points of oil entry into the creeks, and downstream sites. These samples were analyzed for SVOCs, VOCs, metals, and TPH-DRO (EPA, 2003).

NPS and USFWS personnel collected sediment samples from three locations along Clear Creek and White Creek on 6 August 2002 to be tested for alkanes and PAHs (Table 3, Fig. 9). NPS, TDEC, and USFWS personnel conducted a third round of sediment sampling on 21 October 2002 (Table 3, Fig. 9). Six samples were submitted to LSU for alkane and PAH analysis, and five samples were sent to the TDEC laboratory for metals and VOC analysis.

3.3.2 Results and Analysis

To determine the extent and degree of sediment contamination from the oil spill in Clear Creek and White Creek, VOCs, TPH-DRO, and total PAH were analyzed. Of the VOCs tested, the BTEX compounds are good indicators of the presence and amount of fresh crude oil contamination in sediments. Neither Clear Creek nor White Creek contained detectable levels of BTEX in sediment samples collected in August or October 2002 (Table 4). BTEX compounds are highly volatile and tend to rapidly evaporate from surface soils (NRC, 2003).

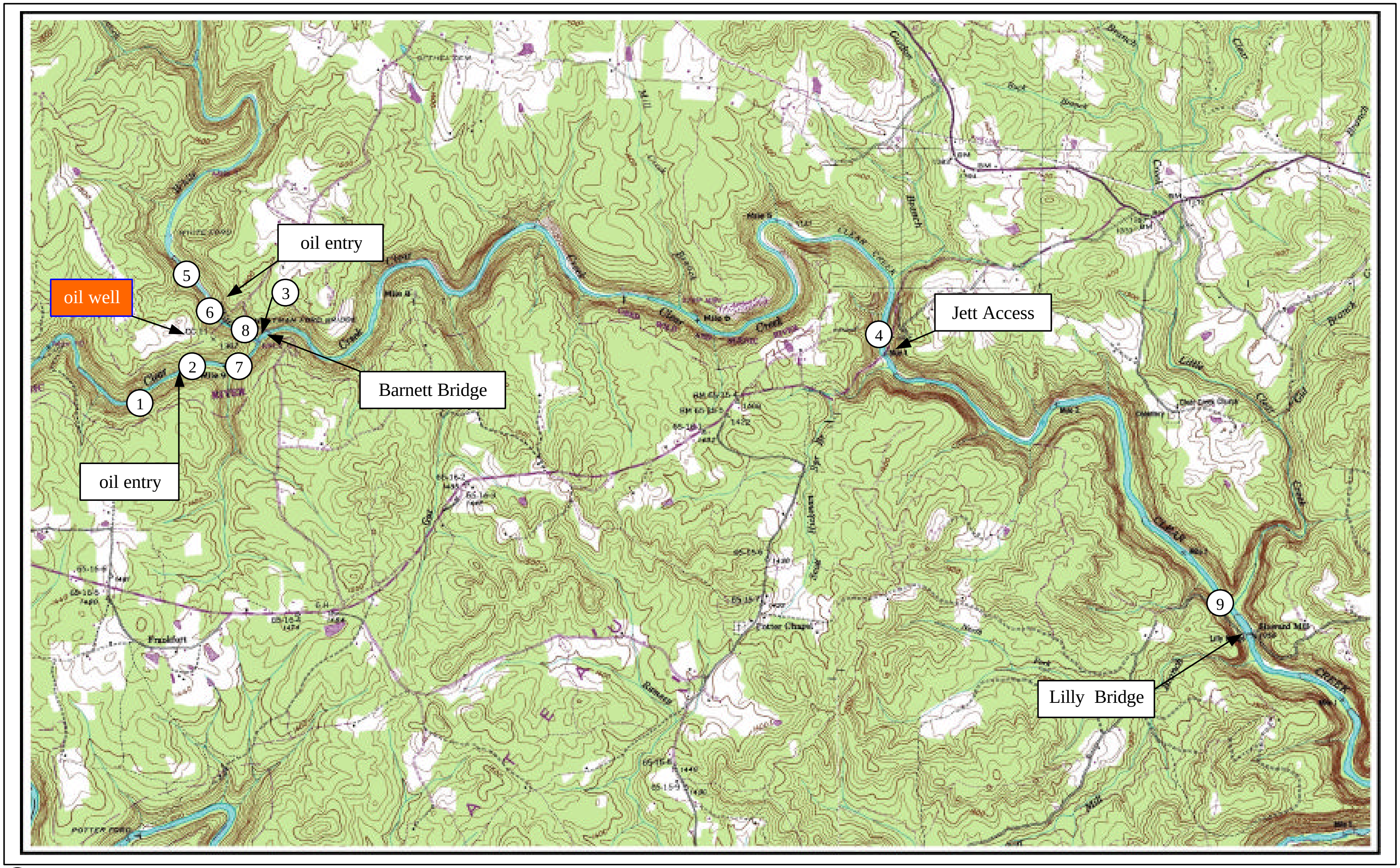
The TPH-DRO concentrations in sediment samples collected in July and August were elevated compared to background samples taken upstream of the spill site. The upstream sediment sample from Clear Creek contained 8 ppm and the White Creek sample contained 0.06 ppm (Table 4). The sediments collected at the point of oil entry for both Clear and White Creek contained 11 ppm TPH-DRO, sediments above Barnett Bridge contained 41 ppm, while further downstream near Jett Bridge sediments contained 21 ppm. The downstream concentrations at Barnett Bridge were at least three times the concentrations upstream of the spill site. The sampling station at Barnett Bridge is upstream of the bridge crossing, so direct runoff from the roadway would not be a factor.

The PAH concentrations and patterns in the sediment samples from Clear Creek and White Creek are shown in Figure 10. In August, the background concentration of PAHs in Clear Creek was 0.06 ppm, and the PAH pattern indicated low levels of contamination by a mix of pyrogenic hydrocarbons (derived from the combustion of fossil fuels) as well as petrogenic hydrocarbons (unburned petroleum products) (Sauer and Uhler, 1994). Background PAHs are associated with highway runoff and other kinds of oil-related activities in the watershed, such as hydrostatic testing of natural gas/oil flow lines and leakage from existing tank batteries/collection lines.

The sample collected at Barnett Bridge contained 0.81 ppm PAHs, and the PAH pattern indicated a match with the oil from the well. In October, the upstream sample for Clear Creek contained 0.18 ppm PAH, while the sample collected at Barnett Bridge contained 0.27 ppm. Neither October sample matched the reference oil PAH pattern. The other sediment samples collected from Clear Creek did not show detectable levels of PAHs. White Creek had low levels of PAHs in the background samples (0.094 and 0.06 ppm for August and October, respectively), and no match to the PAH pattern in the reference oil. The October sediment sample from the mouth of White Creek showed no detectable PAHs. The detection level for individual PAHs was 0.001 ppm.

Table 3. Sediment sampling activities from July to October 2002.

LAB	Date	Map ID	Sample ID	Location	Analysis
Tetra Tech	24-Jul-02	1	Clear-SD-BG	Clear Creek - upstream of spill	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	2	Clear-SD-01	Clear Creek - point of oil entry	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	3	Clear-SD-02	Clear Creek - boom at Barnett Bridge	SVOCs, VOCs, metals, TPH-DRO
	25-Jul-02	4	Clear-SD-03	Clear Creek - boom at Jett Bridge	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	5	White-SD-BG	White Creek - upstream of spill	SVOCs, VOCs, metals, TPH-DRO
	24-Jul-02	6	White-SD-01	White Creek - point of oil entry	SVOCs, VOCs, metals, TPH-DRO
LSU	6-Aug-02	1	2N2219-18	Clear Creek - upstream of spill	alkanes, total PAH
	6-Aug-02	3	2N2219-17	Clear Creek - Barnett Bridge	alkanes, total PAH
	6-Aug-02	5	2N2219-08	White Creek - upstream of spill	alkanes, total PAH
LSU	21-Oct-02	1	2N2296-06	Clear Creek - upstream of spill	alkanes, total PAH
	21-Oct-02	3	2N2296-08	Clear Creek - Barnett Bridge	alkanes, total PAH
	21-Oct-02	4	2N2296-10	Clear Creek - Jett Access	alkanes, total PAH
	21-Oct-02	9	2N2297-03	Clear Creek - Lilly Bridge	alkanes, total PAH
	21-Oct-02	5	2N2296-07	White Creek - upstream of spill	alkanes, total PAH
	21-Oct-02	8	2N2296-09	White Creek - downstream of spill at mouth	alkanes, total PAH
TN State Lab	21-Oct-02	1	0210147-01C	Clear Creek - upstream of spill	metals, VOCs
	21-Oct-02	7	0210147-03C	Clear Creek - above confluence with White Creek	metals, VOCs
	21-Oct-02	4	0210147-05A	Clear Creek - Jett Access	metals, VOCs
	21-Oct-02	5	0210147-02A	White Creek - upstream of spill	metals, VOCs
	21-Oct-02	8	0210147-04A	White Creek - downstream of spill at mouth	metals, VOCs



#: Represents Map ID found in Table 3. One number may represent different samples collected on different dates in the same location

Figure 9. Sediment sample locations in Clear Creek and White Creek.

Table 4. BTEX and TPH-DRO concentrations in sediment samples collected in July, August, and October 2002. nd = not detected. NA = not analyzed.

Map ID	Month/Year	Location	BTEX (ppb)	TPH-DRO (ppm)
1	Jul-02	Clear Creek - upstream of spill	nd	8
2	Jul-02	Clear Creek - point of oil entry	nd	11
3	Aug-02	Clear Creek - boom at Barnett Bridge	nd	41
4	Jul-02	Clear Creek - boom at Jett Bridge	nd	21
5	Jul-02	White Creek - upstream of spill	nd	0.06
6	Jul-02	White Creek - point of oil entry	nd	11
1	Oct-02	Clear Creek - upstream of spill	nd	NA
7	Oct-02	Clear Creek - above confluence with White Creek	nd	NA
4	Oct-02	Clear Creek - Jett Access	nd	NA
5	Oct-02	White Creek - upstream of spill	nd	NA
8	Oct-02	White Creek - downstream of spill at mouth	nd	NA

These PAH concentrations can be compared to toxicity thresholds for PAHs in freshwater sediments. The Threshold Effects Level (TEL) is the concentration below which adverse biological effects are expected to occur only rarely (Buckman, 1999). The Probable Effects Level (PEL) is the concentration above which adverse effects are frequently expected. Freshwater TEL/PELs are based on benthic community metrics and toxicity test results. Based on the bioassay of the amphipod *Hyalella azteca* the TELs and PELs for different PAH compounds and groups of compounds are listed below (Buckman, 1999) and compared with the values in the August sample at Barnett Bridge:

PAH	TEL (ppm)	PEL (ppm)	Barnett Bridge August (ppm)
Naphthalene	0.015	-	0.212
Phenanthrene	0.019	0.515	0.180
2/3-ringed PAHs	0.0771	-	0.50
Total PAH	0.264	-	0.81

Most of the sediments were above the TEL but below the PEL, so there is some potential for toxic effects to benthic macroinvertebrates at these sites.

In summary, sediments in Clear Creek showed evidence of contamination from the oil spill, with elevated TPH concentrations in sediments from the point of entry site to Barnett Bridge. It is uncertain as to whether or not the elevated TPH concentrations are due solely to the spill. Sediments above Barnett Bridge were contaminated with PAHs in August at levels above those that are likely to cause impacts to benthic communities. Oil continued to enter the creek from seepage at the creek bank for several months, and the Trustees are concerned about the potential for renewed oil seepage during the upcoming warmer months when increased soil temperatures could lower the viscosity of residual paraffin-rich oils.

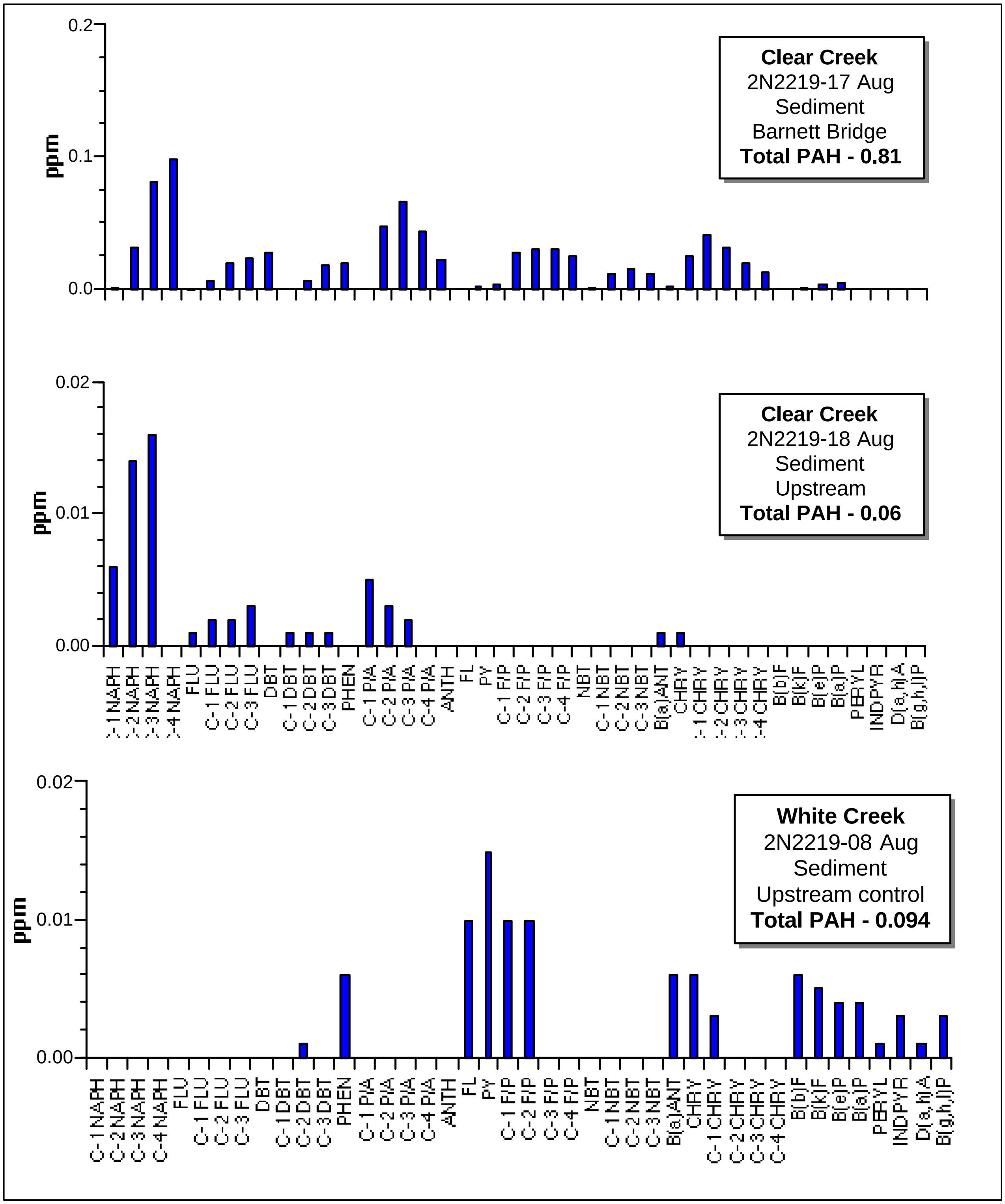


Figure 10A. PAH concentrations (in ppm) in sediment samples from Clear Creek and White Creek (August 2002) (chart generated from LSU data). The bottom plots reflect the low background of PAHs in the sediments in each creek. The top plot is sediment from above Barnett Bridge with low levels (0.81 ppm) of PAHs that match the reference oil.

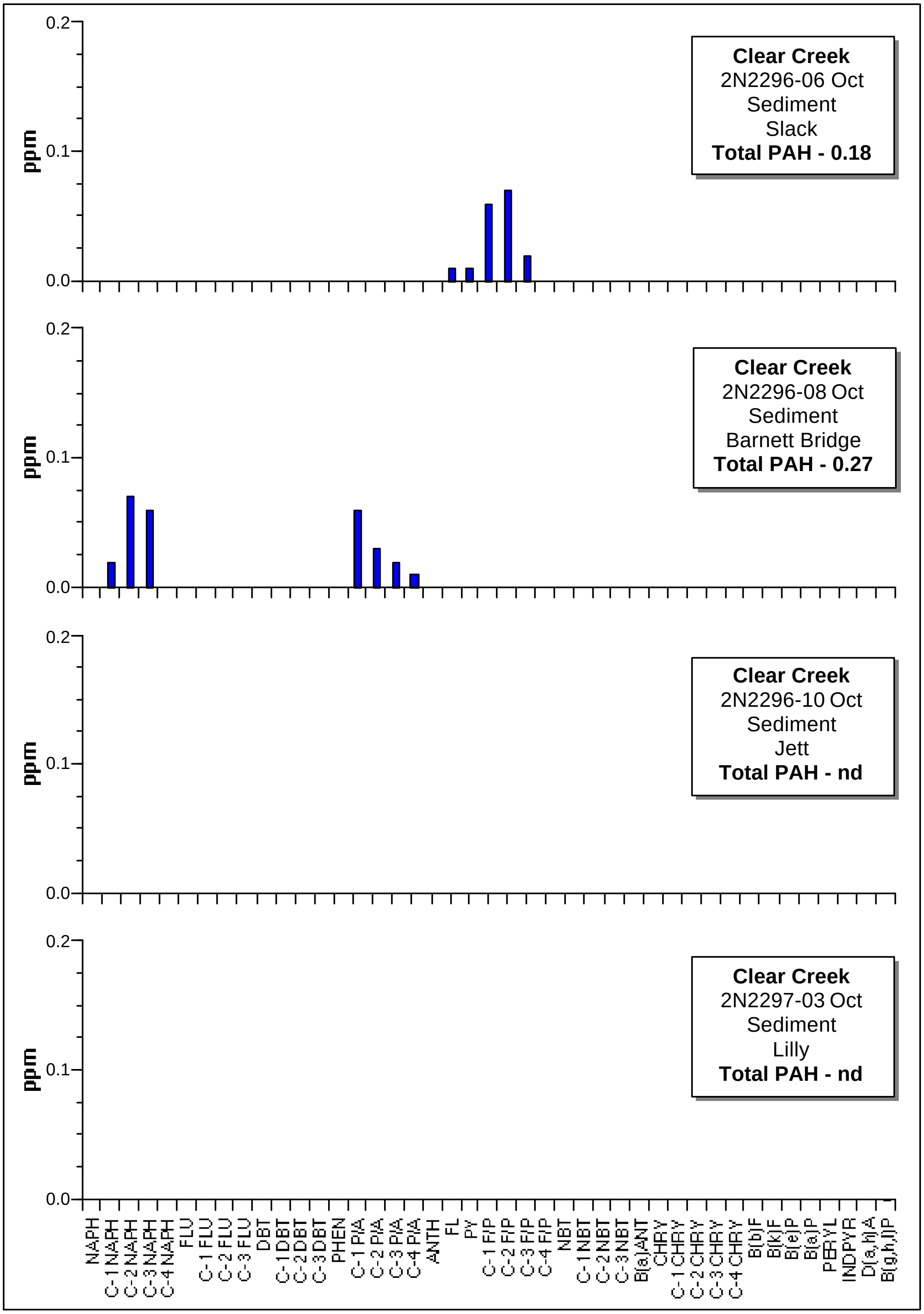


Figure 10B. PAH concentrations in sediment samples collected in Clear Creek (October 2002) (chart generated from LSU data). All samples had low or non-detectable PAHs that did not match the reference oil.

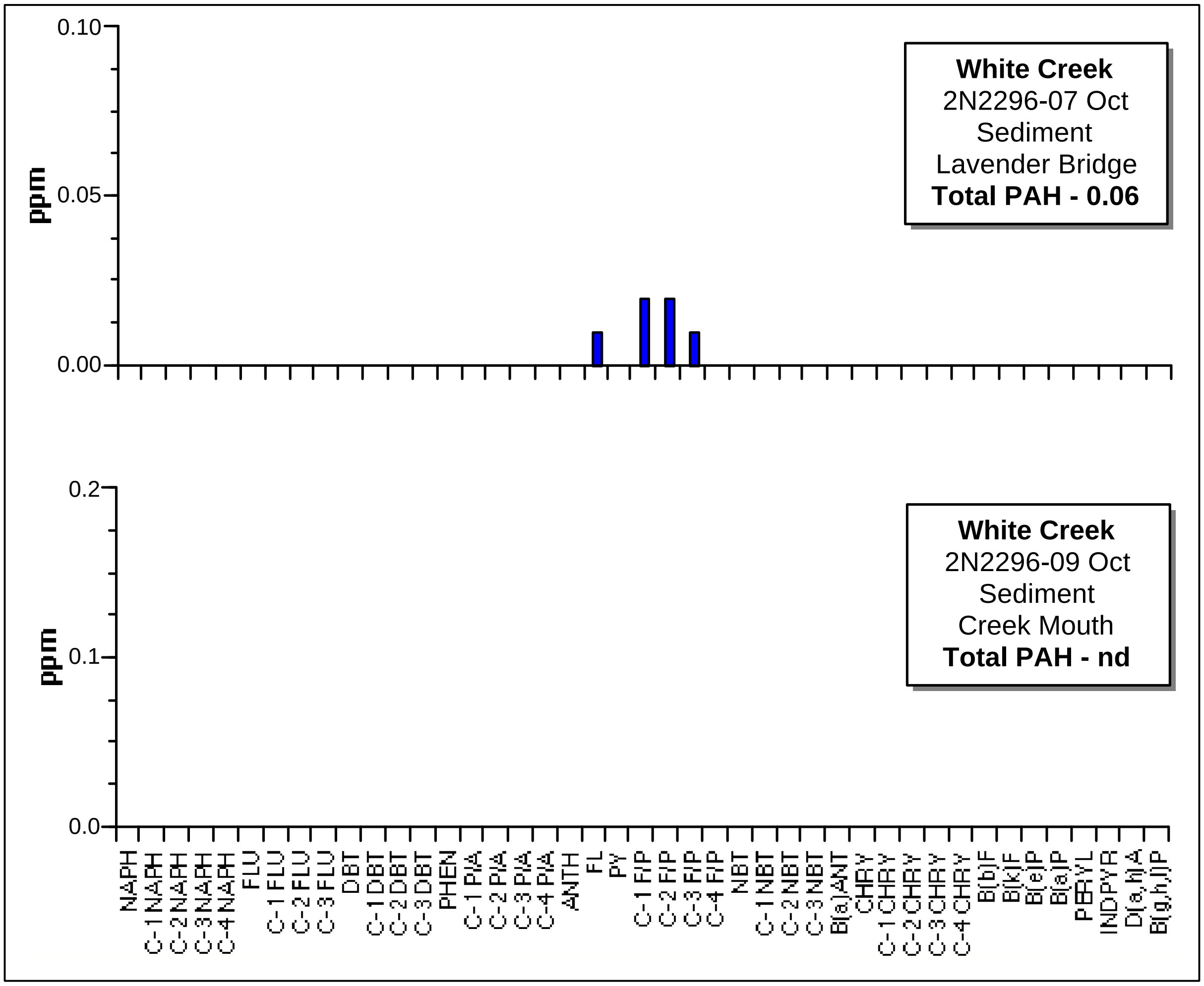


Figure 10C. PAH concentrations (in ppm) in sediment samples collected in White Creek (October 2002) (chart generated from LSU data). All samples had low or non-detectable PAHs that did not match the reference oil.

3.4 Impacts to Soil

3.4.1 Description of Study

NPS, USFWS and Tetra Tech EM, Inc. developed a sampling strategy for collecting soil samples around the well area above the park boundary and within the burned paths leading to Clear Creek and White Creek. Tetra Tech EM, Inc. personnel collected ten soil samples on 26 July and 1 August, and USFWS collected eight soil samples on 6 August 2002 (Table 5, Fig. 11). The samples included a reference site located in the woods southwest of the well, as well as samples between the well and the cliff. Samples were collected between the cliff edge and Clear Creek, as well as in the area between the cliff edge and White Creek. The samples were analyzed for SVOCs, VOCs, metals, and TPH-DRO (EPA, 2003).

NPS personnel collected eight soil samples from five locations distributed throughout the burned forest community on 4 February 2003 (Table 5, Fig. 11). A shallow trench was dug with a hand shovel and samples were taken along the trench to document changes in fire severity and oil saturation. Soil was taken from the oil saturated dark surface layer, as well as from a subsurface layer below the dark surface layer. In two locations, the soil formed a thin layer on top of rock thus only surface samples were collected. These February 2003 soil samples were sent to LSU for PAH analysis.

3.4.2 Results and Analysis

To determine the injury to the soil within Obed WSR property, VOCs, TPH-DRO, and total PAH levels were analyzed. Of the VOCs tested, the BTEX compounds are good indicators of the presence and amount of fresh crude oil contamination. The soils between the well and the edge of the cliff on the Clear Creek side contained between 4 and 95 ppm BTEX and between 31,000 and 43,000 ppm TPH-DRO (Table 6). The soil on the White Creek side of the well contained 2 and 189 ppm BTEX and 22,000 and 30,000 ppm TPH-DRO (Table 6). These concentrations are substantially above background levels for both BTEX and TPH-DRO (0 and 290 ppm, respectively). The soil samples taken from the slopes between the cliff edge and Clear and White Creek contained lower BTEX levels than those samples taken above the cliff, however the TPH-DRO levels increased in this area as compared to samples taken above the cliff for both creeks (Table 6).

Figure 12A and B shows the PAH concentrations and patterns in soil samples collected shortly after the spill. PAH concentrations in the range of 95 to 327 ppm were detected in the outcrop or slope soils leading to Clear Creek (Fig. 12A). The PAH pattern in these samples matched the fresh reference oil and showed a lack of significant microbial degradation of the oil one month after the initial release. PAH concentrations in soils adjacent to White Creek were much lower (1-2.6 ppm) and showed evidence of significant weathering (Fig. 12B).

PAH concentrations in soil samples adjacent to Clear Creek collected in February 2003 ranged from 35-226 ppm, slightly lower than the August 2002 samples (Appendix D-1, Table D-6). The PAH pattern showed some evidence of microbial degradation (Fig. 12C). However, the oil in the soil samples is characterized as slightly weathered.

Table 5. Soil sampling activities from July 2002 to February 2003.

LAB	Date	Map ID	Sample ID	Location	Analysis
Tetra Tech	26-Jul-02	Highland-SS-BG	Highland-SS-BG	woods southwest of well	SVOCs, VOCs, metals, TPH-DRO
	26-Jul-02	Highland-SS-01	Highland-SS-01	between well and edge of cliff (Clear Creek side)	SVOCs, VOCs, metals, TPH-DRO
	26-Jul-02	Highland-SS-02	Highland-SS-02	between well and edge of cliff (Clear Creek side)	SVOCs, VOCs, metals, TPH-DRO
	26-Jul-02	Highland-SS-03	Highland-SS-03	between well and edge of cliff (Clear Creek side)	SVOCs, VOCs, metals, TPH-DRO
	26-Jul-02	Highland-SS-04	Highland-SS-04	between well and edge of cliff (White Creek side)	SVOCs, VOCs, metals, TPH-DRO
	26-Jul-02	Highland-SS-05	Highland-SS-05	between well and edge of cliff (White Creek side)	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	Highland-SS-06	Highland-SS-06	below cliff edge (Clear Creek side)	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	Highland-SS-07	Highland-SS-07	below cliff edge (Clear Creek side)	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	Highland-SS-08	Highland-SS-08	below cliff edge (White Creek side)	SVOCs, VOCs, metals, TPH-DRO
	1-Aug-02	Highland-SS-09	Highland-SS-09	below cliff edge (White Creek side)	SVOCs, VOCs, metals, TPH-DRO
LSU	1-Aug-02	1	2N2219-19	Clear Creek - upstream	alkanes, PAHs
	6-Aug-02	2	2N2219-15	Clear Creek – below outcrop	alkanes, PAHs
	6-Aug-02	3	2N2219-20	Clear Creek - burned slope	alkanes, PAHs
	1-Aug-02	4	2N2219-16	Clear Creek - below outcrop, downstream	alkanes, PAHs
	6-Aug-02	5	2N2219-05	White Creek - upstream control	alkanes, PAHs
	1-Aug-02	6	2N2219-06	White Creek - burned area at spring	alkanes, PAHs
	1-Aug-02	7	2N2219-07	White Creek - below outcrop	alkanes, PAHs
	6-Aug-02	8	2N2219-09	White Creek - burned slope	alkanes, PAHs
LSU	4-Feb-03	9	2N3037-01	~10 m from Clear Creek	PAHs
	4-Feb-03	10	2N3037-02	midslope, 1-3 cm in depth	PAHs
	4-Feb-03	10	2N3037-03	midslope, subsurface sample	PAHs
	4-Feb-03	11	2N3037-04	surface sample	PAHs
	4-Feb-03	11	2N3037-05	subsurface sample	PAHs
	4-Feb-03	12	2N3037-06	~10 m below straw bales, surface sample	PAHs
	4-Feb-03	12	2N3037-07	11 m below straw bales, subsurface sample	PAHs
	4-Feb-03	13	2N3037-08	10-12 m below upper rock wall, near well head	PAHs

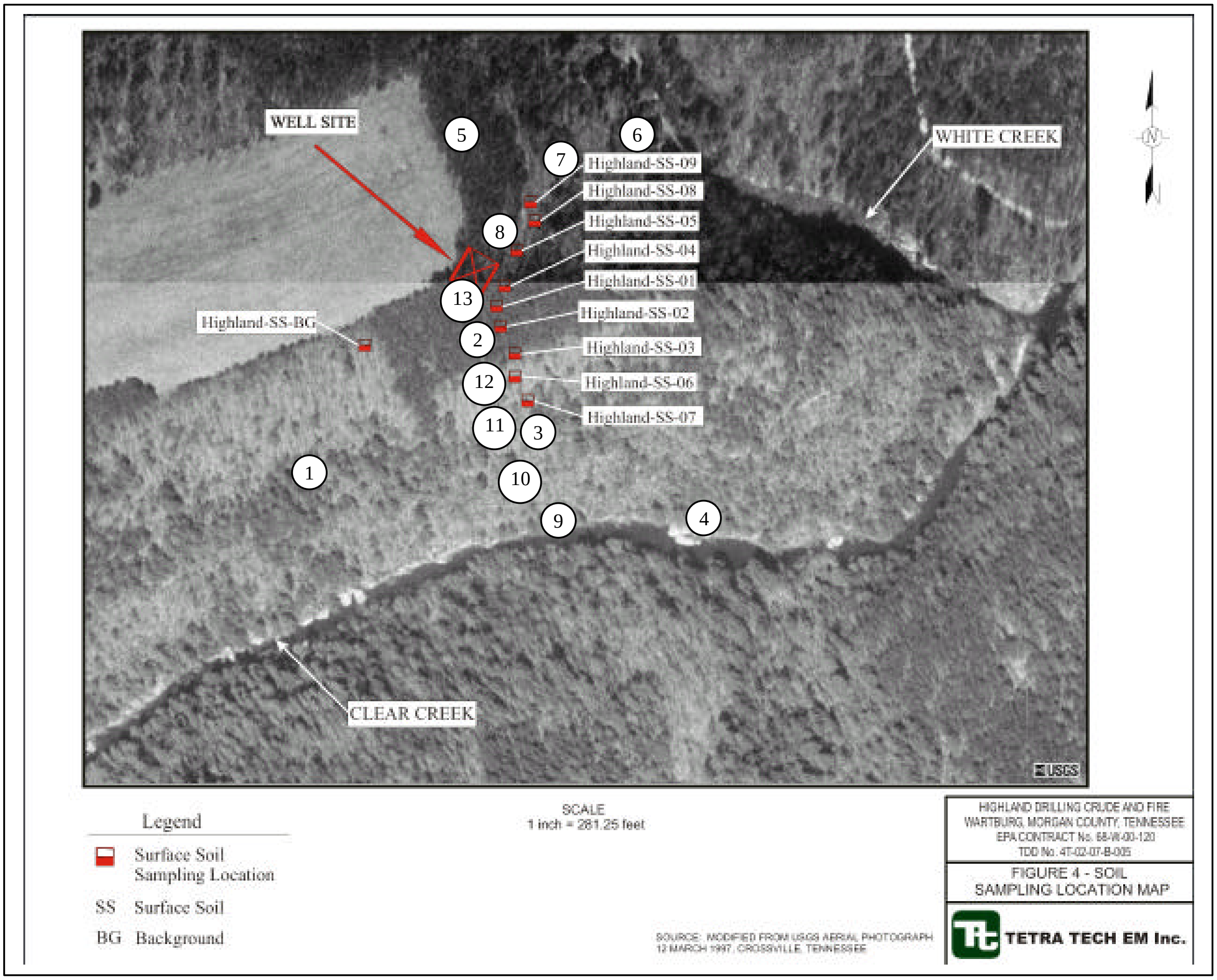


Figure 11. Soil sample locations. Refer to Table 5 for the sample descriptions.

Table 6. BTEX and TPH-DRO concentrations in soil samples collected in July/August 2002.

Map ID	Month/Year	Location	BTEX (ppm)	TPH-DRO (ppm)
Highland-SS-BG	Jul-02	background - woods southwest of well	0	290
Highland-SS-01	Jul-02	between well and edge of cliff (Clear Creek side)	4	36000
Highland-SS-02	Jul-02	between well and edge of cliff (Clear Creek side)	95	31000
Highland-SS-03	Jul-02	between well and edge of cliff (Clear Creek side)	22	43000
Highland-SS-04	Jul-02	between well and edge of cliff (White Creek side)	189	22000
Highland-SS-05	Jul-02	between well and edge of cliff (White Creek side)	2	30000
Highland-SS-06	Aug-02	below cliff edge (Clear Creek side)	6	160000
Highland-SS-07	Aug-02	below cliff edge (Clear Creek side)	29	89000
Highland-SS-08	Aug-02	below cliff edge (White Creek side)	2	43000
Highland-SS-09	Aug-02	below cliff edge (White Creek side)	0.08	42000

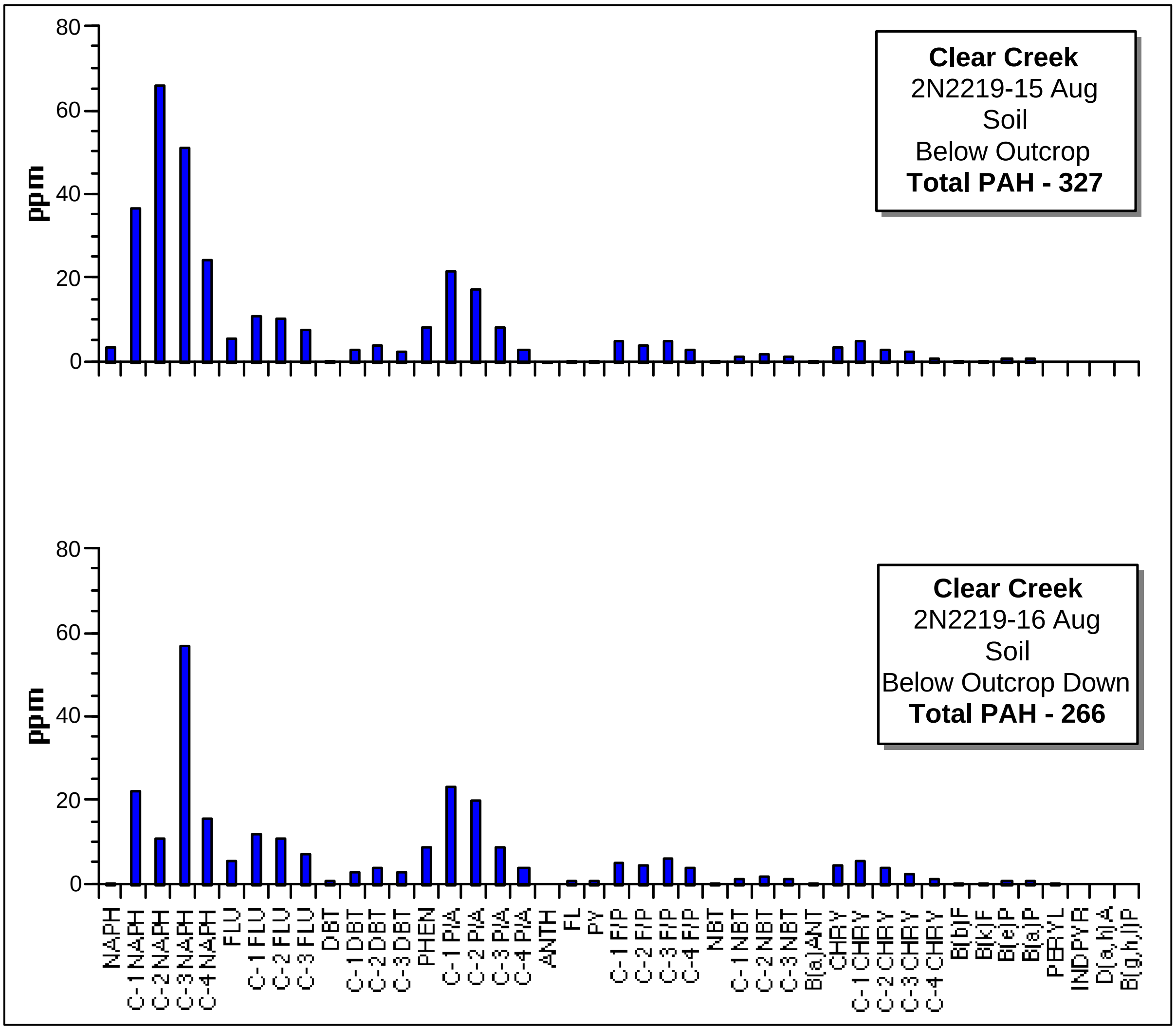


Figure 12A. PAH concentrations (in ppm) in soil samples collected from the slope adjacent to Clear Creek (August 2002) (chart generated from LSU data). Note that the PAH concentrations are high and the oil is only slightly weathered, compared to the reference oils shown in Figure 4.

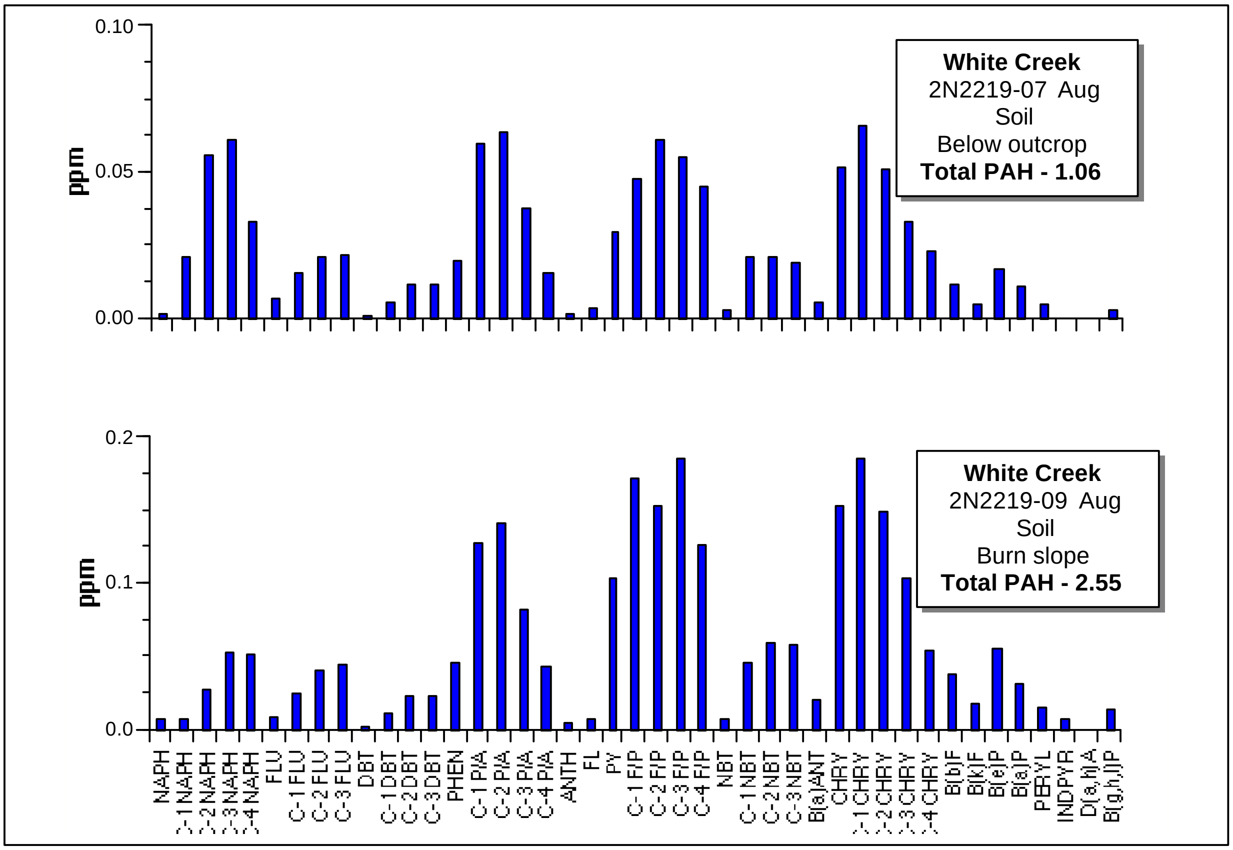


Figure 12B. PAH concentrations (in ppm) in soil samples collected from the slope adjacent to White Creek (August 2002) (chart generated from LSU data). Both samples indicate low levels of PAH contamination and moderate weathering compared to the fresh oil (Fig. 4).

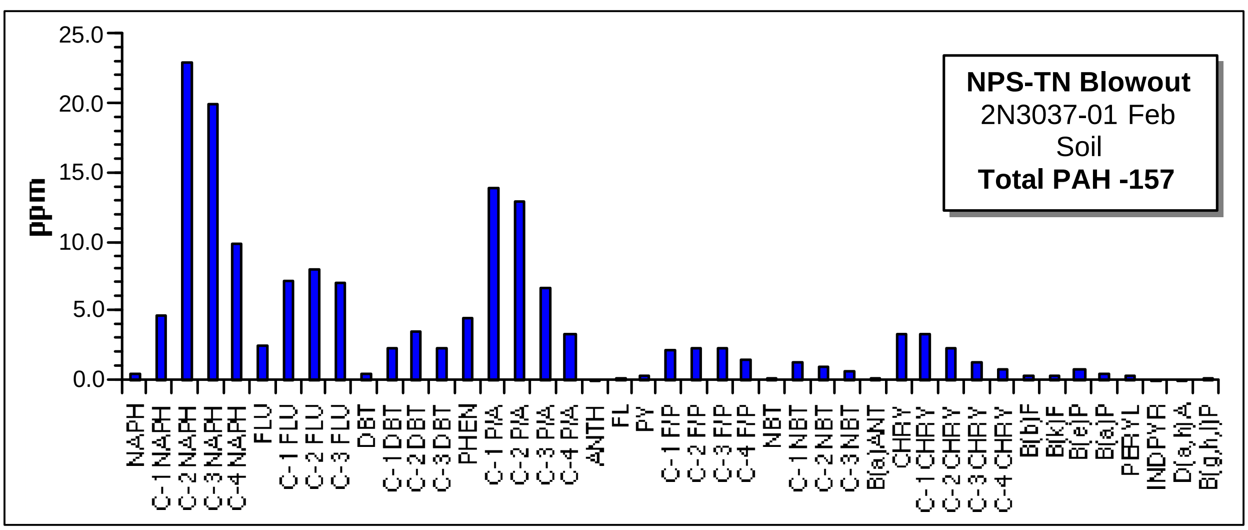


Figure 12C. PAH (in ppm) in a representative heavily oiled soil sample collected from the slope adjacent to Clear Creek (February 2003) (Map ID 9) (chart generated from LSU data). The PAH pattern indicates only slight weathering.

3.5 Impact to Biota

3.5.1 Benthic Algae

3.5.1.1 Description of Study

Benthic algae are important indicators for changes in water quality as they are attached to the substrate and respond rapidly to chemical or physical disturbances within a stream system. Under guidance from the USFWS, Pennington and Associates, Inc. sampled natural substrates and deployed artificial substrates in Clear Creek upstream from the spill site, at Barnett Bridge, and at Jett Access on 21 October 2002 (Table 7). The artificial substrates were removed on 10 December 2002 and sent to TAI Environmental Services, Mobile, Alabama for chlorophyll and ash free dry weight analysis. Pennington and Associates, Inc. (2003) analyzed the samples from the natural substrates for species present, number of individuals per species, and calculation of metrics of biotic integrity.

3.5.1.2 Results and Analysis

Water quality data showed that Clear Creek was very clear and the flow was relatively similar in all three locations sampled. This was determined by measuring physiochemical parameters (pH, specific conduction, dissolved oxygen, and temperature) at each sampling location. A minimum of 13 periphytic algae species were collected from all locations, including 13 diatom (Backillariophyceae), 16 green algae (Chlorophyta) and 2 blue-green algae (Cyanophyta). In October, the natural substrate sampled at Barnett Bridge had the highest number of species (22), followed by the sample taken at Jett Access (21) and upstream of the spill site (19). In December, the highest number of species was found on the artificial tiles placed upstream of the spill site (12), followed by 7 species at Barnett Bridge, and 6 at Jett Access. These data indicate a possible change in the community structure at these sample locations after the spill as a result of the oil exposure. The upstream sample had the highest amount of chlorophyll and ash free dry weight concentrations. The Pollution Tolerance Index (PTI) at the three stations was 2.67 (upstream), 2.35 (Barnett Bridge), and 2.47 at Jett Bridge, indicating relatively unpolluted waters at all locations.

In summary, the natural substrate sampled in October appeared to be similar among all three stations sampled. The December samples analyzed from the artificial substrates indicated a change in the number of species between locations, with the highest number of species found at the upstream location in Clear Creek. These data suggest a change in the algal community as a possible response to the water quality impacts in Clear Creek after the oil spill.

3.5.2 Macroinvertebrates

3.5.2.1 Description of Studies

Impacts to aquatic macroinvertebrates were assessed with three types of studies: 1) mussels were sampled for chemical analysis of tissues to measure the bioavailability of the oil; 2) underwater video surveys; and 3) benthic monitoring was conducted to compare benthic species abundance and diversity between oiled and unoiled areas of Clear Creek.

Table 7. Biota sampling activities in Clear Creek and White Creek, both historical and post-spill.

LAB	Date	MAP ID	Sample	Sample ID	Location	Analysis
LSU	2-Aug-02	1	mussel	2N2219-13	Clear Creek – upstream of spill	alkanes, total PAH
	2-Aug-02	2	mussel	2N2219-14	Clear Creek – at spill site	alkanes, total PAH
	2-Aug-02	3	mussel	2N2219-02	White Creek - upstream	alkanes, total PAH
	2-Aug-02	4	mussel	2N2219-03	White Creek - at spill site	alkanes, total PAH
LSU	23-Oct-02	1	mussel	2N2297-01	Clear Creek - upstream of spill	alkanes, total PAH
	23-Oct-02	5	mussel	2N2297-02	Clear Creek - Barnett Bridge	alkanes, total PAH
	23-Oct-02	5	mussel	2N2297-02MS	Clear Creek - Barnett Bridge (duplicate)	alkanes, total PAH
	23-Oct-02	5	mussel	2N2297-02MSD	Clear Creek - Barnett Bridge (duplicate)	alkanes, total PAH
TVA	22-Jul-96[1]	5	benthos	NA	Clear Creek - Barnett Bridge	EPT[2] score
	23-Jul-96[1]	1	benthos	NA	Clear Creek - upstream of spill	EPT[2] score
	22-Aug-02	5	benthos	NA	Clear Creek - Barnett Bridge	EPT[2] score
	28-Aug-02	1	benthos	NA	Clear Creek - upstream of spill	EPT[2] score
TDEC	12-Sep-96[1]	6	benthos	B9609177-183	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	26-Jun-97[1]	6	benthos	B9707007	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	22-Sep-97[1]	6	benthos	B9712049	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	22-May-98[1]	6	benthos	B9806039	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	2-Sep-98[1]	6	benthos	B9812033	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	26-Apr-99[1]	6	benthos	B9906030	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	23-Jul-02	6	benthos	B0210006	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	8-Oct-02	6	benthos	B0210003	Clear Creek - Jett Access	Benthic Index Score, HAS[3]
	8-Oct-02	5	benthos	B0210005a	Clear Creek - Barnett Bridge	Benthic Index Score, HAS[3]
	8-Oct-02	1	benthos	B0210004	Clear Creek - Upstream of spill	Benthic Index Score, HAS[3]
Pennington & Assoc.	21-Oct-02	1	benthic algae		Clear Creek - upstream of spill	periphyton community survey
	21-Oct-02	5	benthic algae		Clear Creek - Barnett Bridge	periphyton community survey
	21-Oct-02	6	benthic algae		Clear Creek - Jett Access	periphyton community survey

Table 7. Cont.

LAB	Date	MAP ID	Sample	Sample ID	Location	Analysis
LSU	6-Aug-02	28	turtle	2N2219-01	White Creek - near spill site	alkanes, total PAH
	6-Aug-02	29	mallard feather	2N2219-25	Clear Creek - 2nd boom	alkanes, total PAH
TVA, TDEC, ORNL	22-Jul-96[1]	30	fish	na	Clear Creek - Barnett Bridge	IBI score[4]
	23-Jul-96[1]	31	fish	na	Clear Creek - upstream	IBI score[4]
	28-May-98[1]	32	fish	na	Clear Creek - Barnett Bridge	IBI score[4]
	3-Jun-98[1]	33	fish	na	Clear Creek - upstream	IBI score[4]
	22-Aug-02	34	fish	na	Clear Creek - Barnett Bridge	IBI score[4], fish health assessment
	28-Aug-02	35	fish	na	Clear Creek - upstream of spill	IBI score[4], fish health assessment

[1] Previous studies not part of NRDA process
[2] Ephemeroptera, Plecoptera, and Trichoptera
[3] Habitat Assessment Score
[4] Index of Biotic Integrity Score

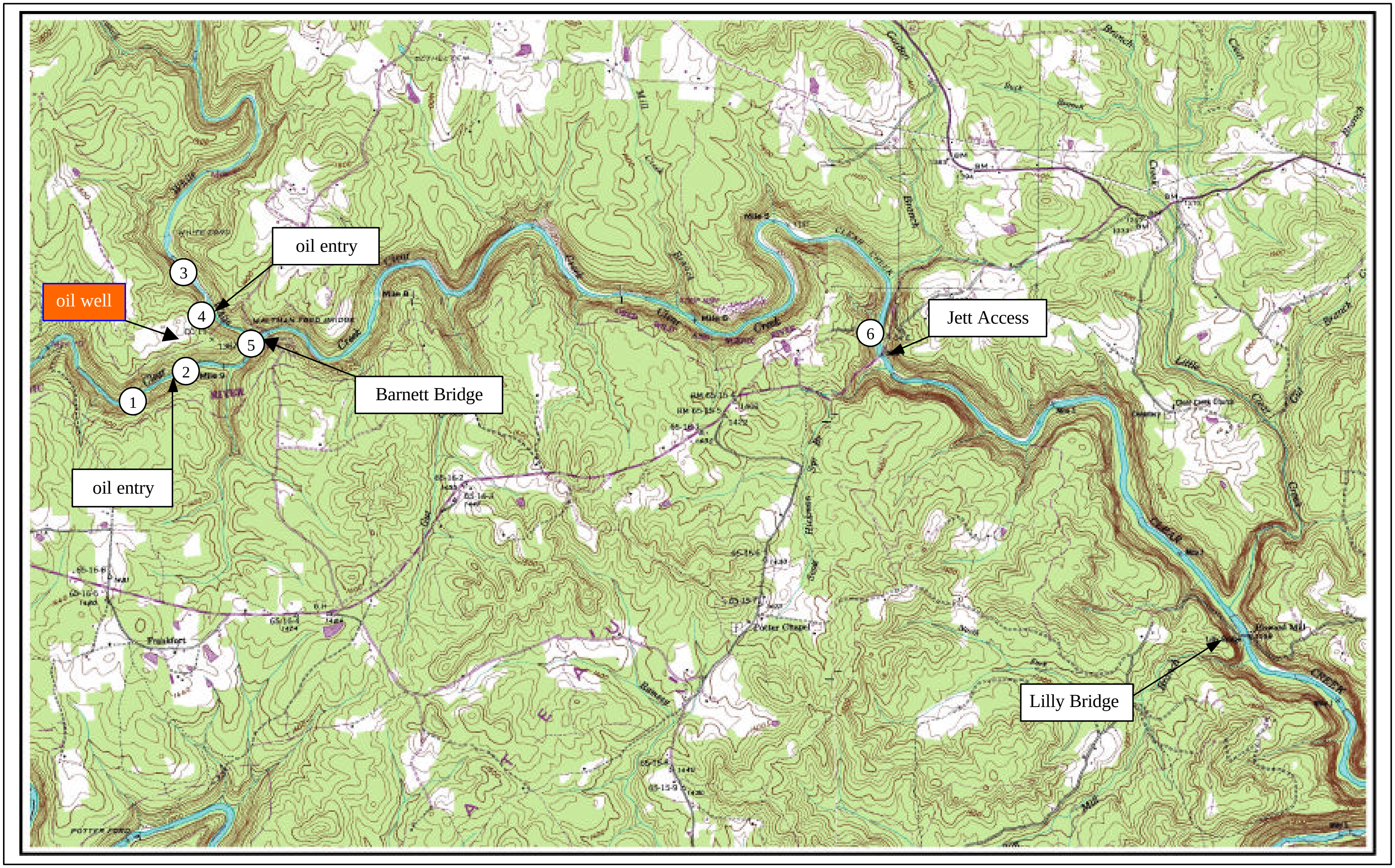


Figure 13. Sampling locations for the biological samples listed in Table 7.

Mussels uptake low molecular weight PAHs quickly, eliminate them over periods of about two weeks, and can be used as “composite” samplers (Yender at al., 2002). Mussels were collected by NPS and USFWS on 2 August 2002 and 23 October 2002 from upstream of the spill site as well as from the point of oil entry into both creeks (Table 7). The tissues were sent to LSU for analysis of alkanes and PAHs.

Underwater stream surveys were conducted by NPS, USFWS, and TWRA personnel on the following dates: 21 August; 3, 11, 18, 25 September; 2, 9, 23 October; and 26 November 2002. The survey began in Clear Creek at Barnett Bridge and continued upstream until just below Hegler Ford. The survey was then re-started at the mouth of White Creek and continued upstream until the videotape ended. The surveyor would not usually pass the point of oil entry into White Creek, so every fourth survey would begin at the mouth of White Creek and continue upstream to the riffle above the point of oil entry.

TDEC-WPC personnel collected benthic samples at Jett Access on 23 July 2002, and at three locations on 8 October 2002: 1) upstream of the spill site; 2) at Barnett Bridge; and 3) at Jett Access (Table 7, Fig. 13). Samples were collected in accordance with TDEC’s accepted protocols for Semi-Quantitative Riffle Kicks (Arnwine, 2002). The preserved samples were sent to the Tennessee Department of Health Aquatic Biology Section for processing, benthic identification, and scoring.

Clear Creek had been sampled previously between 1996 and 1999 as part of the State of Tennessee’s Ecoregion Project (Arnwine et al., 2000) for water quality and habitat. Benthic index scores and habitat assessment scores had already been determined for Clear Creek at Jett Access for the previous sampling events. The benthic index score was based on taxa richness, percent Ephemeroptera, Plecoptera, and Trichoptera (EPT), EPT richness, North Carolina Biotic Index (NCBI), percent Oligochaetes and Chironomids (OC), percent of dominant taxa, and percent of clinger taxa. Scores are recorded based on values developed for each category (i.e., taxa richness, EPT richness) under Bioregion 68a, where Clear Creek is located (Arnwine, 2002). An index of 10 or less is considered to be non-supporting or severely impaired; an index between 10 and 31 is considered to be partially supporting or slightly to moderately impaired; and an index greater than 32 indicates a fully supporting or non-impaired community.

The EPT index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera (EPA, 1989). The index is used to score taxa richness within insect orders that are considered to be pollution sensitive. TVA personnel collected benthic samples on 22 August and 28 August 2002 to determine the EPT index in two locations along Clear Creek, upstream of the spill site and at Barnett Bridge (Table 7). Scores were evaluated and compared to scores assigned to the same locations sampled in July 1996.

The habitat assessment score was determined from scoring selected parameters such as epifaunal substrate, embeddedness, velocity/depth regime, sediment deposition, and channel flow status. This score was used to evaluate the changes in the habitat over several years and to eliminate this parameter as a variable that could cause changes in local taxa. The habitat assessment score was also used to compare different locations that were sampled in the same year. Scores from all five years (1996-99, 2002) were used for comparison for before and after the spill occurred (Table 7).

3.5.2.2 Results and Analysis

The mussels collected in the August sampling effort showed very low levels of PAHs within the tissues (Fig. 14A and 14B), with 0.004 and 0.01 ppm in Clear Creek samples and 0.06 ppm in White Creek samples. The PAH patterns did not match the reference oil. Figure 14A shows that the same PAH and nearly identical concentrations were detected in each duplicate analysis but not in both samples, indicating that the analyses are of good quality. Sources of background PAHs are most likely petroleum and not just by-products of combustion of fossil fuels because: 1) the PAHs detected include both parent and alkylated homologues, whereas PAHs from combustion by-products are dominated by the parent compound; and 2) there are few 4- and 5-ringed PAHs which also dominate in combustion by-products (Sauer and Uhler, 1994).

The October tissue samples from Clear Creek above Barnett Bridge had no detectable PAHs. The mussels collected were young and cooler water temperatures in the Fall might have slowed their feeding rates and thus the uptake of oil.

Only subtle differences were noted in mussel behavior between the oil-impacted sites and the upstream, unoiled sites during the underwater video surveys. It was reported from the August surveys that, near the spill site, mussels were ejecting from the sediments and moving to a different location (seen by a trail left on the substrate by the mussel), possibly indicating that the mussels were trying to relocate into non-polluted sediments. Normally, female mussels would only eject from the sediments in order to release eggs, but breeding for these freshwater mussels does not occur in the summer months. Exposure out of the sediments allows for predation and was observed as abnormal behavior for the mussels in the month of August. This behavior was not seen above the spill site, where all mussels remained buried in the sediment.

Benthic macroinvertebrates collected at Jett Access from 1996 to 1999 and 2002 downstream of the spill site in Clear Creek revealed little variation in benthic index score (Fig. 15A). All samples had a score between 36 and 40, with the sample taken following the spill having a score of 40 and 38 for summer and fall sampling events, respectively. The target index score for Bioregion 68a is 32, therefore the biological condition at Jett Access before and after the spill was considered to be non-impaired. The habitat assessment score was also very similar across all years at Jett Access (Fig. 15B).

The benthic index score calculated from the sample taken at Barnett Bridge in Clear Creek showed more of an impact immediately downstream of the spill site than the scores calculated for the upstream or Jett Access samples (Fig. 15C). A score of 40 (fully supporting) was calculated upstream of the spill site, however downstream of the spill at Barnett Bridge the index score was 20 and considered moderately impaired. The score returned to a higher level (38) at Jett Access. The habitat assessment scores at all sites were very similar in value (176-178) and habitat differences were dismissed as the cause for the decrease in the benthic index score at Barnett Bridge (Fig. 15D). The EPT index, from upstream and downstream of the spill

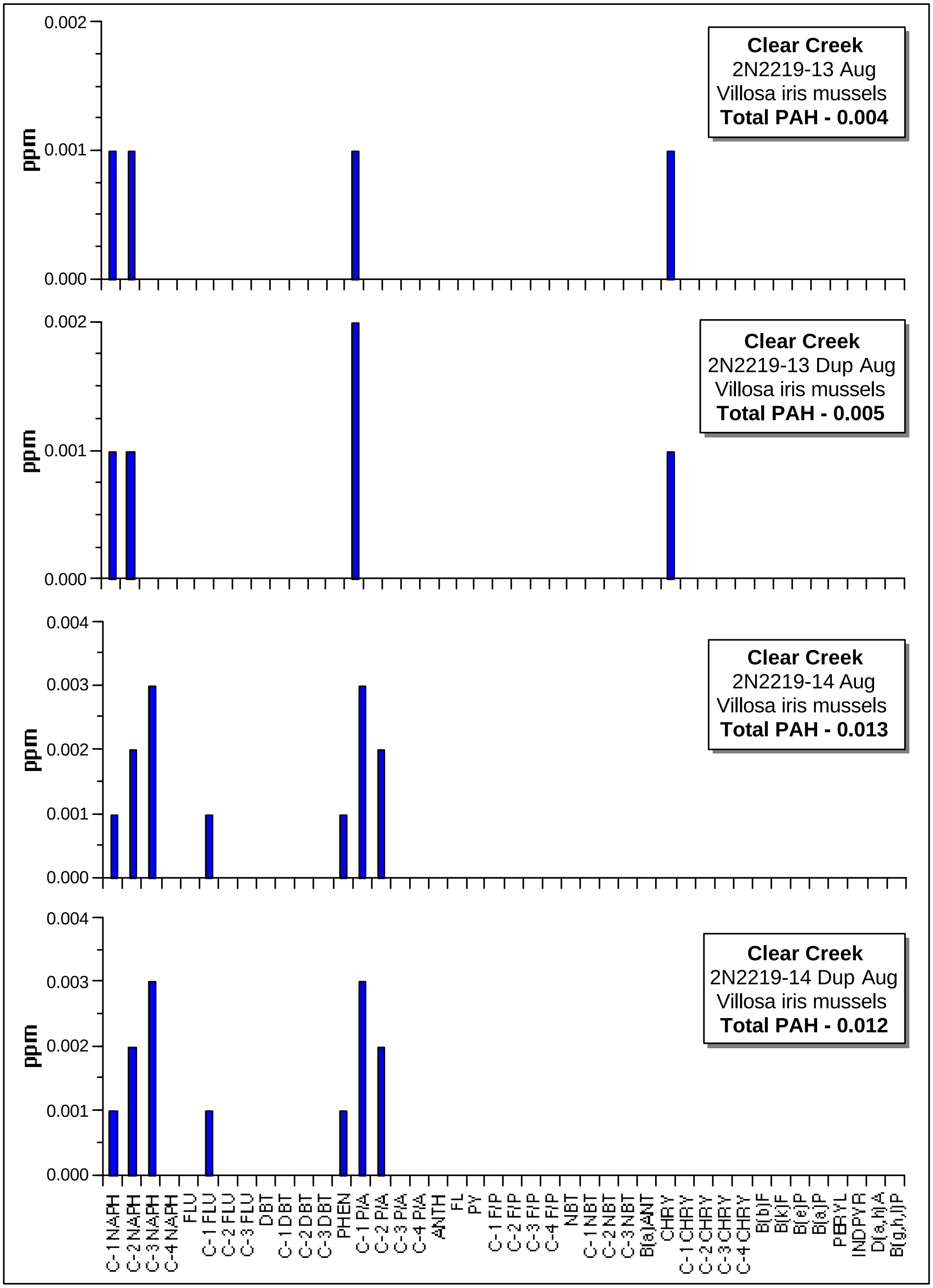


Figure 14A. PAH concentrations (in ppm) in mussels sampled from Clear Creek (August 2002) (chart generated from LSU data). All samples are very low and do not match the reference oil.

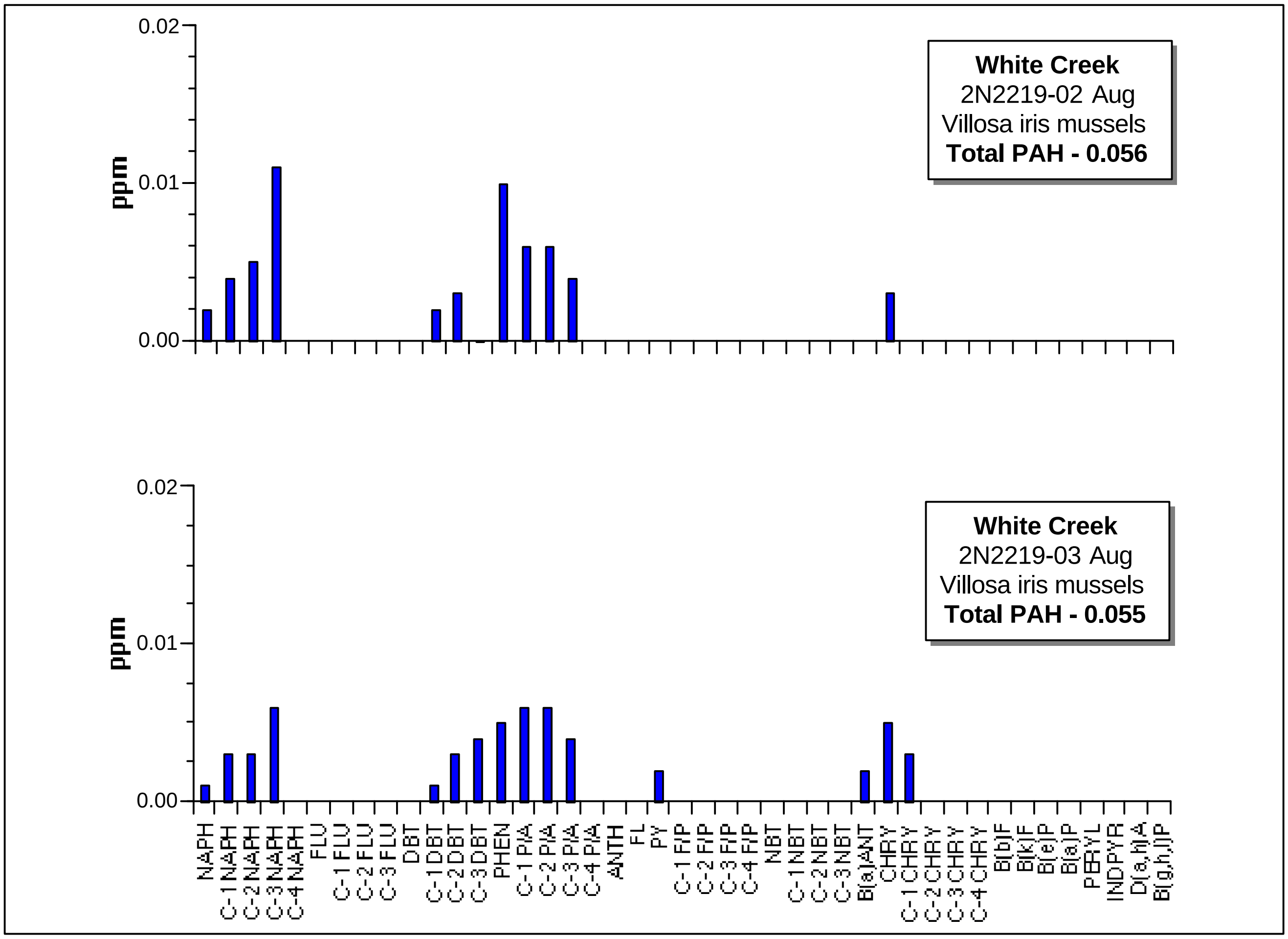


Figure 14B. PAH levels (in ppm) for mussels sampled from White Creek (August 2002) (chart generated from LSU data). All samples are very low and do not match the reference oil.

site in Clear Creek, indicated little change in diversity or abundance of macroinvertebrates between the locations or years sampled (1996 and 2002).

In summary, impacts to the benthic macroinvertebrate communities were detected in Clear Creek in October for the area above Barnett Bridge but not as far downstream as Jett Access. The degradation of benthic community health in Clear Creek dropped to “partially-supporting” whereas it previously was fully supporting and a reference stream. Additional studies are needed to determine the spatial extent and duration of these impacts.

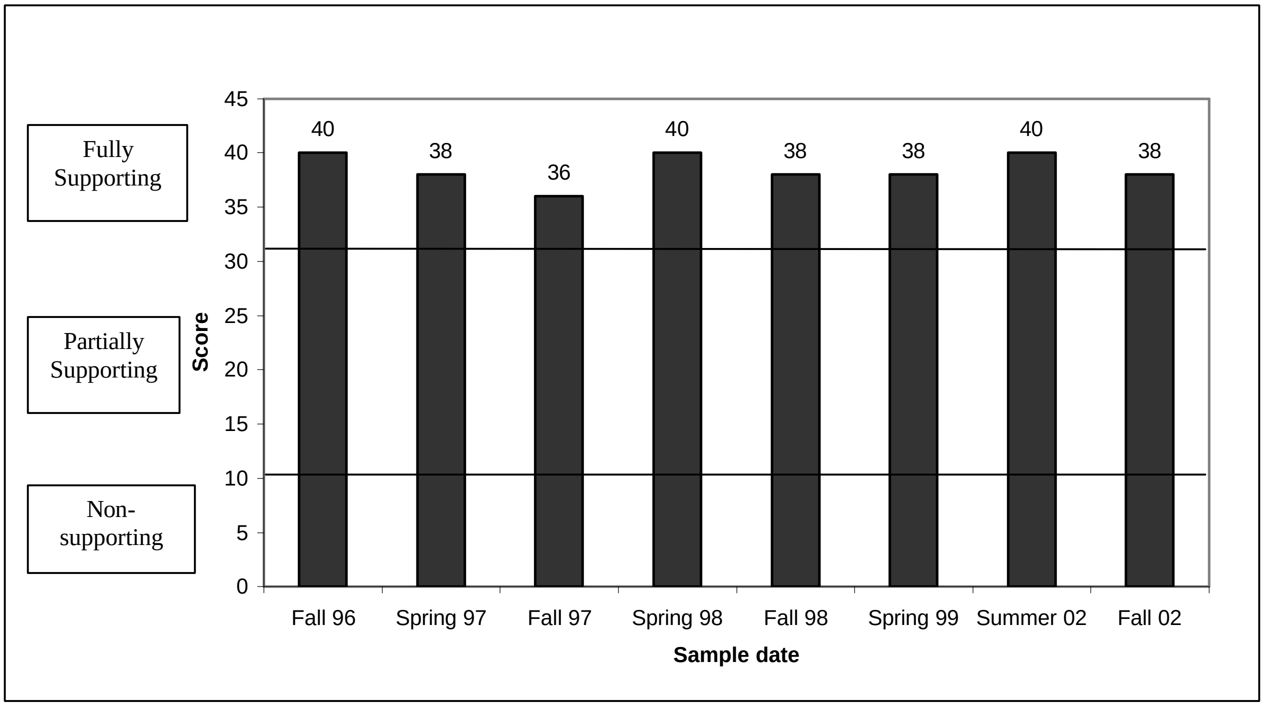


Figure 15A. Benthic index scores for creek benthos near Jett Access (1996-1999, 2002). All sampling periods were within the fully supporting score.

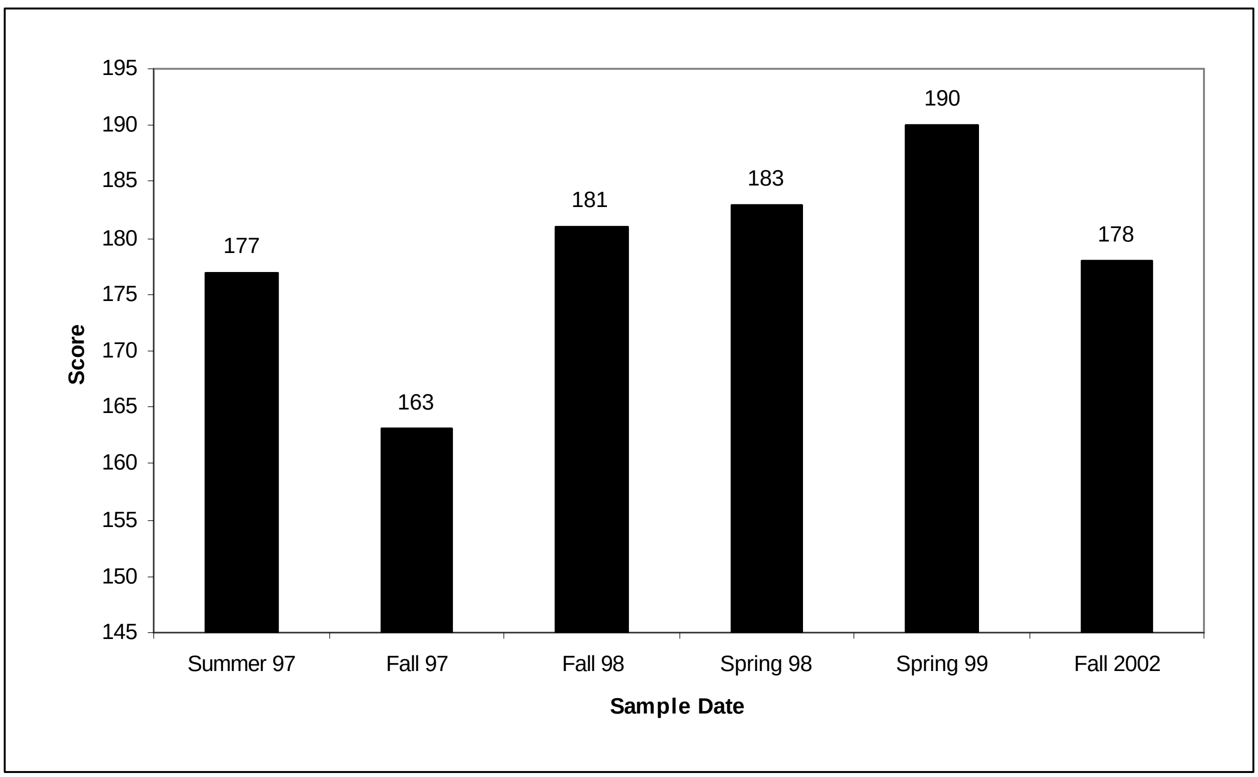


Figure 15B. Habitat assessment scores for creek habitat near Jett Access (1996-1999, 2002).

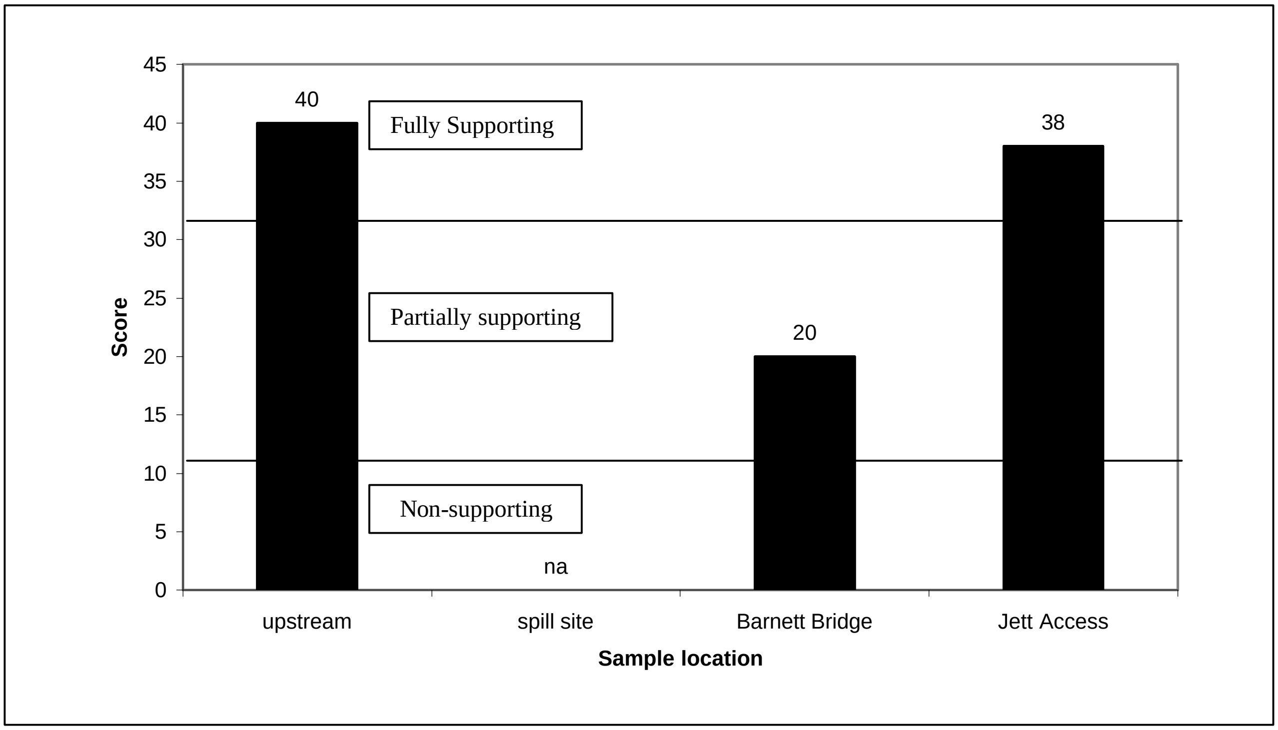


Figure 15C. Benthic index scores upstream and downstream of the spill site (2002). The benthic index score at Barnett Bridge was 50 percent lower than upstream sites.

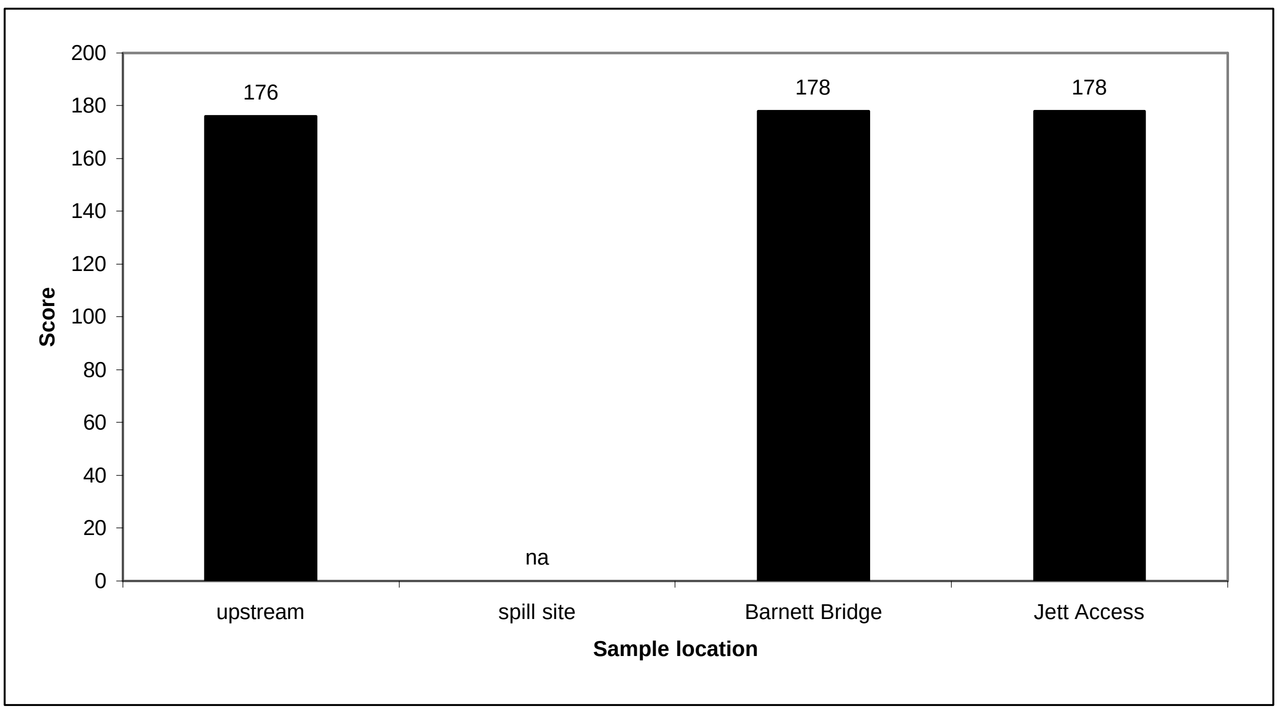


Figure 15D. Habitat assessment scores upstream and downstream of the spill site (2002).

3.5.3 Vertebrates

3.5.3.1 Description of Study

NPS and USFWS personnel collected a juvenile map turtle (*Graptemys geographica*) near the spill site in White Creek and an oily feather from a mallard at the second boom in Clear Creek while collecting samples for various media on 6 August 2002. Both samples were sent to LSU for analysis of alkanes and PAHs (Table 7).

Fish were collected, counted, and observed for anomalies on 22 August 2002 from Clear Creek near Barnett Bridge and on 28 August 2002 at Norris Ford (upstream of spill). TVA and TDEC conducted this study in order to determine the Index of Biotic Integrity (IBI) metric for Clear Creek after the spill event. TVA had previously calculated the IBI for Clear Creek at Barnett Bridge and Norris Ford in 1996 and 1998, allowing time-series comparison of before and after the spill event. The IBI is a fish community assessment where species are assigned to trophic guilds and anomalies are noted in order to obtain a score based on values assigned to the Cumberland Plateau Ecoregion (Barbour et al., 1999).

Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, conducted a preliminary health assessment study using the fish collected by TVA and TDEC in August 2002. ORNL analyzed condition factor indices, feeding and nutrition indicators, and two blood hematological parameters to determine if fish were exposed to PAH compounds.

3.5.3.2 Results and Analysis

The juvenile map turtle collected in White Creek near the spill site showed a level of 0.148 ppm PAH in the tissues, but the PAH pattern did not match the reference oil (Fig. 16). The mallard feather from the 2nd boom in Clear Creek did match the reference oil (Fig. 16).

No fish kills were reported during the oil spill and response. The IBI scores calculated for locations upstream and downstream of the spill site in Clear Creek were compared to scores assigned to the same areas in previous years (Fig. 17). The only decrease observed between sampling times was for the upstream location at Norris Ford. The scores for fish collected at Barnett Bridge, downstream of the spill site, gave no indication of having an impact from the oil spill event. The IBI scores were all rated as good or good/excellent with the exception of the upstream 2002 collection, which was rated fair/good.

The initial data from the fish collections in August 2002 indicated that rock bass may be the species most affected by oil exposure (ORNL, 2003). Rock bass collected near Barnett Bridge in Clear Creek experienced lower visceral-somatic index, liver-somatic index, and reduced feeding index as compared to redbreast sunfish and hogsucker. All three species, rock bass, redbreast sunfish, and hogsucker had higher leukocrit values indicating an impaired immune system. A depressed immune system in fish increases the chance of disease and parasites. Exposure to PAHs can cause a depressed immune system (ORNL, 2003), however, a more comprehensive study would be needed to provide direct evidence of exposure and injury to fish as a result of the spill event.

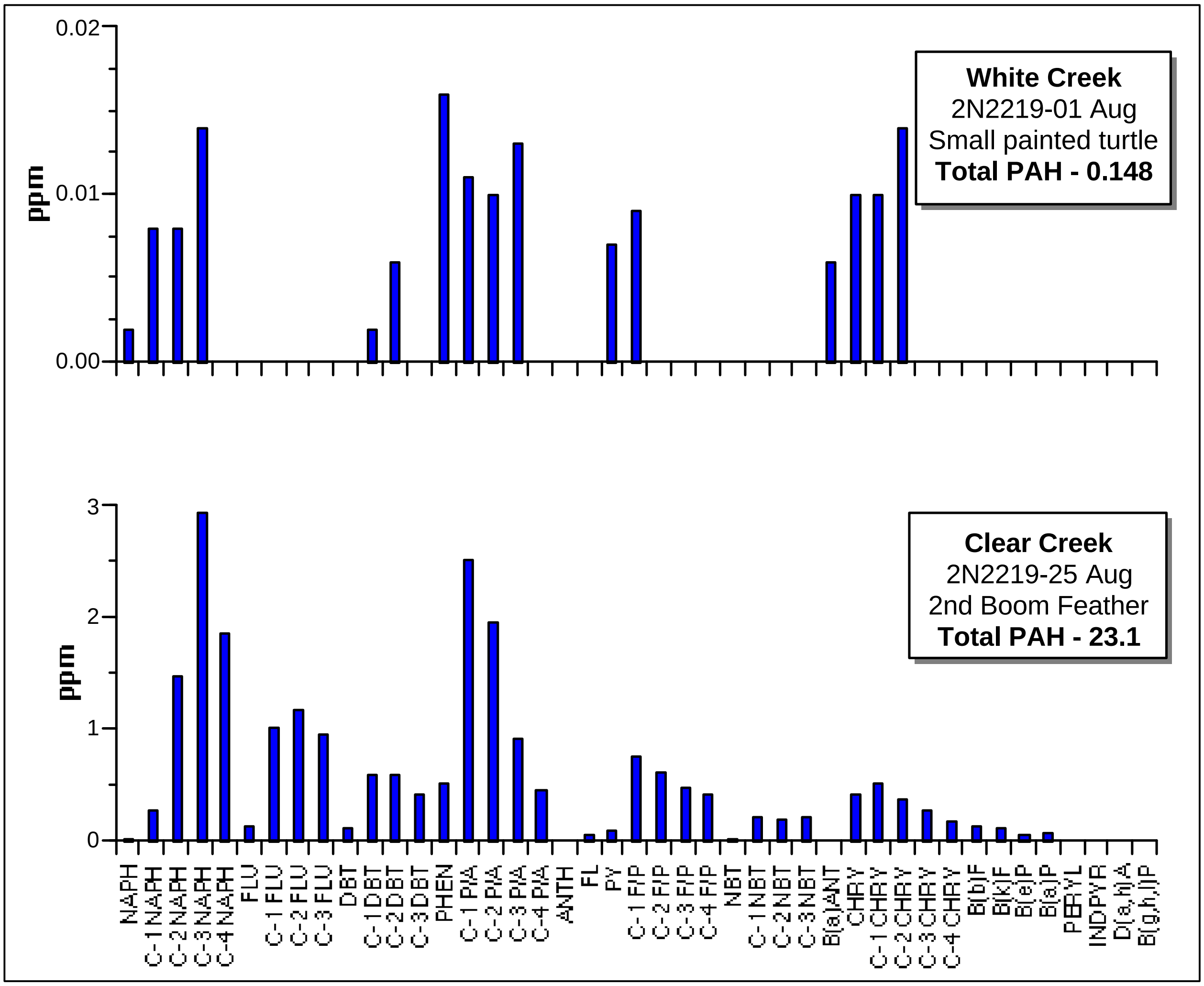


Figure 16. PAH concentrations in vertebrate samples from Clear Creek and White Creek (August 2002) (chart generated from LSU data).

In summary, it is likely that there were no acute impacts to fish communities resulting from the spill. However, there are indications of sub-lethal impacts to fish health that could lead to reduced survival, growth, and reproduction.

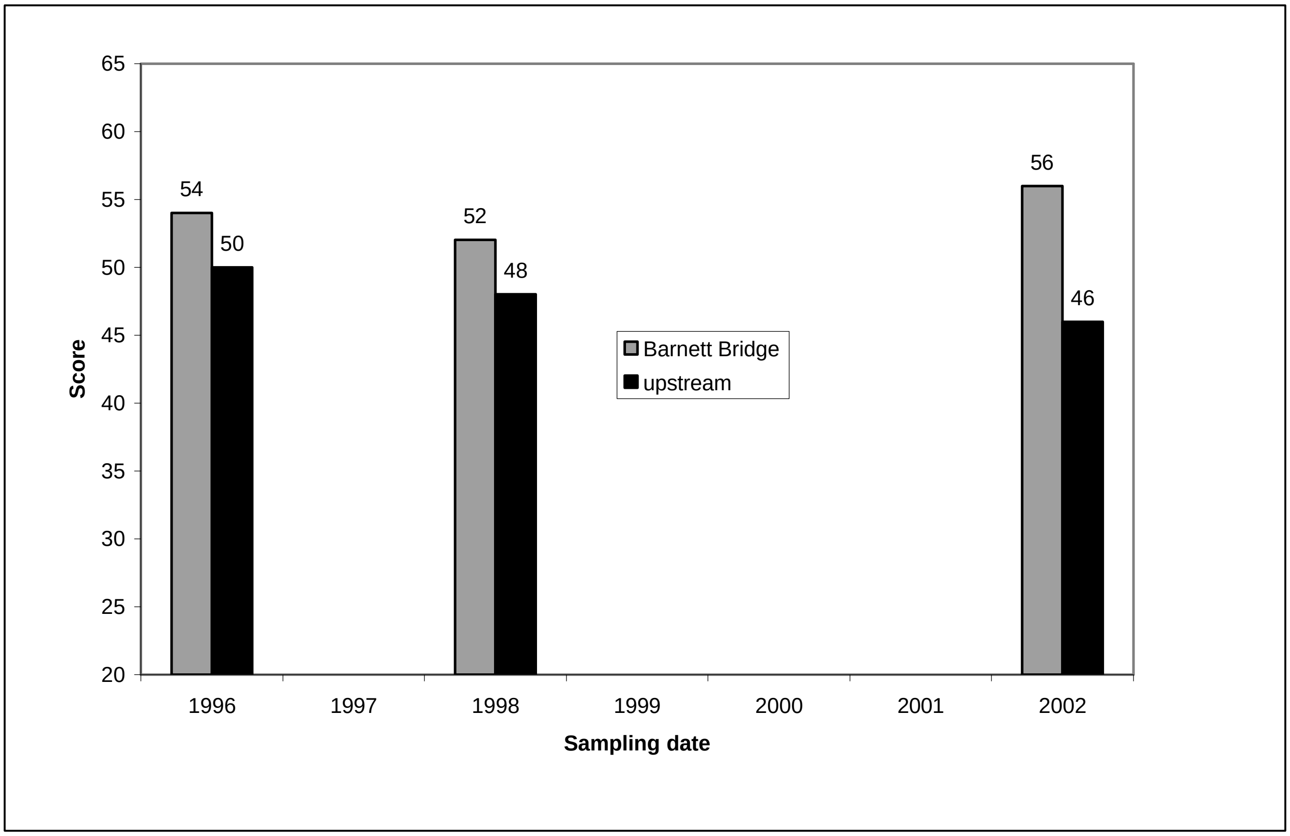


Figure 17. IBI scores for fish collected upstream of the spill site and at Barnett Bridge (downstream of spill site) in Clear Creek.

3.6 Terrestrial Vegetation

3.6.1 Description of Study

NPS personnel conducted a study to document impacts to the forest structure by sampling vegetation within the burned site and a nearby reference site (Jenkins, 2003). All field sampling was completed on 3-4 February 2003 and 18 February 2003. At each site, a 0.05 ha plot was established with the long axis placed perpendicular to the slope. The 0.05 ha plot was then divided into five 0.01 ha subplots. The diameter breast height (dbh) and height of all woody stem species greater than or equal to 1.4 m in height were measured within each 0.01 ha subplot. Each tree was assigned a canopy position class (dominant, codominant, intermediate, or suppressed) and a tree condition class (no dieback, 1-25% dieback, 26-50% dieback, 51-75% dieback, >75% dieback, or dead). Basal area and density were calculated for all living and dead woody stems greater than or equal to 2.54 cm dbh. Density was measured for stems less than 2.54 cm dbh. To determine the approximate ages of the overstory trees, three representative trees were cored at both the burned and reference site and the annual rings were counted. Soil samples were collected from five locations throughout the burn unit to be analyzed by LSU for alkanes and PAHs.

3.6.2 Results and Analysis

Chestnut oak (*Quercus prinus*) was the dominant overstory species in the burned area. The survey documented that 81 percent of the chestnut oak and 84 percent of the basal area of the chestnut oak were dead. The majority of the chestnut oaks were over 20 cm dbh. It was estimated that the fire killed 102 of the 108 white pines (*Pinus strobus*) with the majority being less than 15 cm dbh. Only 15 percent of stems in the burned area were living. The reference site had only one large dead tree (26 cm dbh), a yellow pine (*Pinus spp.*), which was killed by southern pine beetles. It appeared that 93 percent of the stems in the reference area were living. The density in the sapling layer (stems <2.54 cm dbh) at the burned site was dramatically reduced. The reference site had over 330 saplings and over 98 percent were alive. Because the sampling occurred during the dormant season, it was sometimes difficult to assess tree condition. It was recommended that a follow-up study be conducted during the 2003 growing season to determine actual mortality.

The measured trees ranged in age from 64 to 205 years at the burned site (eastern hemlock and white oak, respectively), and 53 to 296 at the reference site (white pine and hickory species, respectively). Only six trees were cored to determine age, many more trees in the burned area could be over 200 years old. Only the overstory trees were cored, the stand was uneven-aged and multicohort.

In summary, there was high mortality of the vegetation in the footprint of the area affected by the oil spill and fire. The soil was severely impacted by the oil spill and fire (see *Soil* section above). The oil saturation and fire probably caused the loss of the fine roots, the seed bank, and the sources of vegetative reproduction, which will slow recovery of the burned area. The fine roots are responsible for the uptake of water and nutrients and their loss could greatly impact surviving trees.

3.7 Documentation of Visitor Use Impacts

3.7.1 Description of Study

The first two tasks of the study have been completed. They were intended to document ephemeral data that will permit the later determination of interim lost visitor use. First, the potential impacts of the spill event on park visitors were documented. The response actions, the timing and geographic extent of closures and warnings for Clear Creek, and the appearance of the oil were recorded. This information was researched and compiled into a single document for future economic valuation work (IEc, 2003a). The second task documented the baseline visitation levels of the affected areas from interviews with NPS staff (IEc, 2003b). The third task is currently underway, and is intended to prepare a survey plan to capture ephemeral data resulting from a possible future closure of the river due to the potential for additional discharges of oil.

3.7.2 Results and Analysis

The results of the first two tasks indicate the potential for lost and/or diminished visitor use due to the incident. A determination of whether any significant lost or diminished visitor use occurred will be made at a later date following an analysis of these two documents (IEc, 2003a; IEc, 2003b) and further research into the economic value of such visitor use.

3.8 Other Preassessment Activities

3.8.1 NPS Boundary Determinations

NPS contracted Dickson and Bennett, Inc. of Memphis, Tennessee to conduct a property survey to show the relationship of the Park boundary to the property lines of Elmer Howard and Thomas White, and the relationship of the property boundaries to Clear Creek and White Creek. The Park has a scenic easement over the land of Leonard Slack lying between the property of Elmer Howard and Clear Creek, and on both sides of White Creek on part of the Thomas White property. A copy of the prepared boundary map can be found in the Administrative Record.

3.8.2 Aerial Photography

To document the location of the spill and evaluate the recovery of the injured resources for long-term studies, NPS contracted Tuck Engineering, Inc. to produce aerial photography of the spill area. An infrared orthophoto was also included so that the burned areas could be easily identified. The photographs can be found in the Administrative Record.

4.0 EFFECTIVENESS OF RESPONSE ACTIONS ON RESTORING INJURED RESOURCES

Based on the information obtained during the Preassessment Phase, it is concluded that the response actions have not adequately addressed the injuries to trust resources resulting from the oil spill. For example, oil releases into Clear Creek have continued to date and there is a potential for the releases to increase during the warmer months of 2003. The oil spill caused impacts to aquatic biological resources that have persisted, as summarized in this report. Even if there were no continuing oil releases, the data indicate that the health of the aquatic biological community in Clear Creek was degraded by oil from the oil spill. The response actions alone have not restored the health of the biological community and have not compensated for the lost ecological services provided by the stream biological community. Further studies are needed to determine the full extent of the injury and when the affected ecological services in Clear Creek will return to pre-spill conditions.

In addition, the oil and/or the subsequent fire killed most of the trees and other vegetation on the slope areas affected by the oil spill and burn. The response actions undertaken by EPA and others did not address these injuries. Indeed, response actions under the Oil Pollution Act generally are not intended to address this type of injury. Similarly, soils on the slope and below the cliff face, down hill from the oil well, remain heavily oiled. Some soil samples contain up to 16 percent oil by weight.

Finally, visitor use of the Obed Wild and Scenic River system was affected during the spill and subsequent response activities. The response actions did not restore the lost visitor use of the river system.

In summary, the Trustees have concluded that the response actions have not adequately addressed the injuries to natural resources and other trust resources that resulted from the oil spill.

5.0 FEASIBILITY OF RESTORATION OPTIONS

One of the key considerations in the determination by the Trustees to conduct restoration planning is whether there are feasible restoration options for the injured resources and services. Based on the data collected during the Preassessment Phase, it is likely that there have been impacts to the following:

- Vegetation and soil resources in the footprint of the spill and burn
- Aquatic resources (water quality, sediment quality, benthic macroinvertebrates, benthic algae, and fish) in Clear Creek from the spill site to some distance downstream from Barnett Bridge and in White Creek from the spill site to its confluence with Clear Creek
- Visitor Use

The Trustees have decided that there are feasible primary and compensatory restoration options for those resources and services affected by the oil spill and are currently evaluating these options. These options may include but are not limited to:

- Restoration of the land on NPS property above the cliff face that remains disturbed from the spill, fire, and cleanup actions
- Restoration of the slope below the cliff face extending to the creek where the vegetation and soils were burned
- Restoration of the area affected by the construction of the access road during the spill response at Barnett Bridge
- Implementation of components of the recovery plan for spotfin chub
- Implementation of best management practices along the tributaries to the Obed River system to control sources of non-point pollution that impacts water quality
- Modification of in-stream habitat to improve habitat for benthic communities and fish
- Cleaning up of abandoned oil production and storage facilities within the Obed River watershed
- Improving visitor services consistent with the general management plan for the Obed Unit

The Trustees' agency personnel have experience in implementing many of these kinds of restoration activities, and they have knowledge of the use of the remaining techniques in other cases of oil spill damage restoration. Some of the options include implementation of existing management plans established through a public review process. Others are simple matters of civil engineering and earthmoving activities, or typical horticultural or sylvacultural practices. Therefore, the Trustees conclude that there are feasible restoration options for the affected resources.

6.0 DETERMINATION OF THE NEED TO CONDUCT RESTORATION PLANNING

The determination to conduct restoration planning is based on the following conditions (OPA regulations section 990.42(a)):

- Injuries have resulted, or are likely to result, from the incident;
- Response actions have not adequately addressed, or are not expected to adequately address, the injuries resulting from the incident; and
- Feasible primary and/or compensatory restoration actions exist to address the potential injuries.

Based on the information collected during the Preassessment Phase and presented in the preceding sections of this report, the Trustees have determined that these conditions have been met. Therefore, the Trustees have decided to conduct the Restoration Planning Phase of the natural resource damage assessment for the Howard/White Unit No. 1 oil spill.

7.0 CONSIDERATIONS FOR ADDITIONAL STUDIES TO SUPPORT RESTORATION PLANNING

The studies conducted during the Preassessment Phase have been effective in collecting ephemeral data and providing the information needed by the Trustees to decide whether to continue with damage assessment activities. To complete the Restoration Planning Phase of the process, the Trustees are evaluating additional site-specific, media-specific, and resource-specific studies so that the magnitude and spatial and temporal extent of the injury can be determined. Based on the natural resource injury results available to date, the following focused studies are being considered:

- Determine the presence and extent of continued oil seepage into Clear Creek
- Determine the areal extent of different categories of oil exposure in White Creek and Clear Creek
- Determine the areal and temporal extent of impacts to benthic macroinvertebrates
- Assess impacts to fish health
- Assess impacts to terrestrial vegetation and soils
- Assess impacts to visitor use

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APPENDICES

APPENDIX A. CLEAR CREEK CLOSURE POSTING

IN REPLY REFER TO

United States Department of the Interior

NATIONAL PARK SERVICE
BIG SOUTH FORK
NATIONAL RIVER AND RECREATION AREA
OBED WILD AND SCENIC RIVER
4564 LEATHERWOOD ROAD
ONEIDA, TENNESSEE 37841

RECEIVED

Code of Federal Regulations
Title 36, Chapter 1 Sec. 1.5

Temporary Closure and Restriction imposed
Under the discretionary authority of the Superintendent.

Temporary Closure of Clear Creek

In accordance with regulations and the delegated authority provided in Title 36, Code of Federal Regulations, Chapter 1.5a(1), authorized by Title 16, United States Code, Section 3, the Superintendent has temporarily closed Clear Creek, a tributary of the Obed River within Obed, Wild and Scenic River. This closure will prohibit entering the river from Double Drop Falls to Jett Bridge.

This temporary closure is the result of a significant oil well accident which has dumped several barrels of crude oil into the river. The situation is such that there will be a health and safety effect until the river is cleaned up. This temporary closure will remain in effect until such time as that cleanup is finished.

In addition, a cautionary warning concerning entering the river from Jett Bridge to Nemo Bridge is also being issued.

Kristin A. Stoehr
Kristin A. Stoehr
Unit Manager
Obed Wild and Scenic River

07/23/02
Date

Reed E. Detring
Reed E. Detring
Superintendent
Big South Fork NRRA

07/23/02
Date

APPENDIX B. SCOPE OF WORK FOR EPHEMERAL DATA COLLECTION

SCOPE OF WORK FOR NATURAL RESOURCE DAMAGE ASSESSMENT (NRDA) INITIATE EPHEMERAL DATA COLLECTION AND THE USE OF DATA COLLECTED DURING RESPONSE OPERATIONS FOR THE HIGHLAND DRILLING OILWELL BLOWOUT, MORGAN COUNTY, TENNESSEE
(Revised 11/06/02)

1. Two sampling stations (sites) will be located upstream of hydrocarbon product (oil) entry into Clear Creek and White Creek. These stations will serve as individual control points for the collection of data in un-impacted areas of Clear Creek and White Creek. Additional sites for the assessment of oil impacted areas in Clear Creek and White Creek will be selected based on the consideration of continuing response and removal operations, and the potential accumulation of hydrocarbon products on or in soil, sediment, vegetation, and surface water. Every effort shall be made to select sites where previous samples (data) were collected during the course of response and characterization activities and near fixed (ambient) stations where water quality and biological data have been collected by various Federal and State agencies. As conditions change over time, additional sites may also be evaluated. These sites could include areas downstream in the Obed River watershed.

2. All media sampling activities shall adhere to the guidance (attachment) developed by the National Oceanographic and Atmospheric Administration spill response program provided by Louisiana State University or, depending upon the selected analytical laboratory, U.S. Environmental Protection Agency and State of Tennessee guidance for the collection and analysis of various media samples. This includes sample collection, preparation, interim transport and storage, and shipment to the analytical laboratory.

3. Physicochemical analyses (dissolved oxygen, pH, conductivity, temperature, total dissolved solids, and salinity) of surface water at each site shall be performed simultaneously with sample collection and recorded in field notebooks.

A. Physicochemical data collection shall be accomplished with the use of a Yellow Springs Instrument (YSI) 6000upg multi-probe sonde and 610-DM data logger. Calibration of this instrument will be accomplished with appropriate reference solutions and standards. The calibration of dissolved oxygen will be accomplished with current local barometric pressure readings obtained from the National Weather Service.

B. If significant hydrocarbon product accumulation could potentially foul probes or sensors, this requirement is waived and project personnel will record rationale in field notes.

C. Calibration records will be maintained in the Environmental Contaminants laboratory at the U.S. Fish and Wildlife Service, Tennessee/Kentucky Field Office, in Cookeville, Tennessee.

4. Visual substrate and biota assessments and, if possible, the collection of biota shall be performed at each site during sample collection. These substrate surveys will be recorded on videotape. These visual surveys will be performed periodically regardless of whether samples are collected for analysis.

5. Digital photographs shall be taken at each site. All observations during the course of sampling activities shall be recorded in field notebooks.

6. Samples collected by Department of Interior (DOI) personnel and those samples split with U.S. Environmental Protection Agency contractors shall be assigned an unique DOI sample identification number. Copies of chain of custody records for these samples shall be submitted to the DOI project manager and maintained in NRDA project files. Unverified data provided by other parties shall be maintained in project files, however, this data shall not be utilized in assessment activities until a determination of sample validity is made. Appropriate quality assurance/quality control information should accompany data obtained from all sources.

APPENDIX C. RATIONALE FOR EPHEMERAL DATA COLLECTION

Revised Draft Natural Resource Damage Assessment and Restoration (NRDAR) Pre-Assessment Screen (PAS) Rationale

Introduction/Background

The Wild and Scenic Rivers Act of 1968, Public Law 90-542, declared as policy of the United States: " that certain selected rivers of the nation, with their immediate environments possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife shall be preserved in free-flowing condition and that they and their immediate environments shall be protected for the benefit and enjoyment of future generations." Recognized for it's free-flowing condition, rugged terrain, and pristine waters, the Obed River watershed was included into the Wild and Scenic Rivers System in 1976 and established as a unit of the National Park Service (NPS). Located on the Cumberland Plateau in eastern Tennessee, the Obed Wild and Scenic River corridor is managed cooperatively by the NPS and State of Tennessee. The NPS exercises management responsibilities for the Obed River and its major tributaries, including Clear Creek. Clear Creek is a high-gradient fourth order stream located in Fentress and Morgan Counties, Tennessee.

Through a Memorandum of Understanding, the State of Tennessee's Wildlife Resources Agency (TWRA) manages 5,057 acres within the legislated boundary as a Wildlife Management Area. The Obed is one of only nine Wild and Scenic Rivers authorized in the Southeastern United States. The Obed River flows over 45 miles through some of the most rugged, and undeveloped terrain in eastern Tennessee. Spectacular views of high bluffs, waterfalls, and geologic features are common. Its rugged terrain has allowed the river corridor to remain relatively uninhabited and unimpacted. The Obed WSR's "wild" character and difficult terrain offer visitors a rare opportunity to experience a trace of primitive America. Water resources and riparian environments are the principle resources of the Obed WSR. The waters of the Obed, including Clear Creek, are relatively unpolluted and are considered to be among the highest quality in the state, supporting a rich array of plant and animal life.

These watersheds are part of the U.S. Fish and Wildlife Service's (FWS) Southern Appalachian Ecosystem (FWS 1995). Clear Creek is Federally designated critical habitat (Federal Register Volume 42, No. 175) for the Federally threatened spotfin chub (*Cyprinella* (=*Hybopsis*) *monacha*). One Federally endangered Unionid mussel, the purple bean (*Villosa perpurpurea*), and two Federally threatened plants, Virginia spiraea (*Spiraea virginiana*) and Cumberland rosemary (*Conradina verticillata*) are also known to occur in Clear Creek. The State of Tennessee has recognized Clear Creek as a Tier II antidegradation water and, within the NPS boundary, as a Tier III Outstanding National Resource Water (Tennessee Administrative Rule 1200-4-3-.06(3)).

The Clear Creek watershed is an integral component of the State of Tennessee's Ecoregion Project (Arnwine et al., 2000) for water quality and habitat. A firm understanding of the inherent biological variability and potential of natural streams in a collective region is necessary to establish what the true reference conditions are in a specific watershed. The U.S. Environmental Protection Agency's (EPA) Biocriteria Program suggests that the selection process for candidate reference reach waterbodies should be well documented so that the data defining the reference condition are scientifically defensible. Clear Creek was extensively sampled from 1996 to 1999 in an effort to standardize stream assessments for water quality and habitat and to distinguish regional differences in aquatic communities in Tennessee. Ambient water quality data, macroinvertebrate community structure data, and fish community structure data have been collected by the Tennessee Department of Environment and Conservation (TDEC) as part of this effort. Additional aquatic community and hydrological data have also been collected periodically by NPS, U.S. Geological Survey (USGS), and Tennessee Valley Authority (TVA). Water quality criteria are promulgated and legislatively enacted (Tennessee Rule Chapter 1200-4-3) in the State of Tennessee.

On July 20, 2002, an oil well blowout occurred on the Howard/White Unit No. 1, releasing an undetermined amount of crude oil to Clear Creek and White Creek. Emergency response operations were initiated and the site was Federalized on July 21, 2002, by EPA. During the course of response operations, various media (e.g., water, soil, and sediment) and oil samples were collected by EPA contractors. EPA contractors and TDEC and FWS personnel also collected additional samples on July 25, 2002, to characterize the nature and extent of contamination in the impact areas. At the request of FWS, United States Coast Guard (USCG) personnel initiated fluorometer data collection in control and impact areas on July 26, 2002. Their control sites were in Clear Creek at Hegler Ford and at the U.S. 127 bridge.

Initial results of the data collected by the EPA contractor indicated significant levels of Volatile Organic Compounds (VOCs) and Semi-volatile Organic Compounds (SVOCs), components of crude oil and petroleum products, had been released to terrestrial and aquatic habitats in the Clear Creek watershed. Volatile and semi-volatile organic compounds can be acutely or chronically toxic to a variety of aquatic organisms and terrestrial plant species. These chemicals can cause mortality and elicit a variety of sub-lethal toxic responses that affect normal physiological and reproductive functions, as well as feeding behavior and predator avoidance.

NRDAR Ephemeral Data Collection Activities

A scope of work (SOW)(Appendix B) was prepared for ephemeral data collection activities by the FWS. Water, sediment, and soil samples were collected by NPS and FWS personnel on August 6, 2002, at the following locations (Figure 1):

Station	Location	Latitude/Longitude	
Site 1	White Creek - Upstream Control	36° 07' 27"	84° 47' 57"
Site 2	White Creek at Boom	36° 07' 26"	84° 47' 57"
Site 3	White Creek - Downstream Point Bar	36° 07' 23"	84° 47' 50"
Site 4	Clear Creek - Upstream Control	36° 07' 14"	84° 48' 06"
Site 5	Clear Creek at Containment Booms	36° 07' 15"	84° 48' 02"
Site 6	Clear Creek at White Creek Confluence	36° 07' 15"	84° 47' 54"
Site 7	Clear Creek at Barnett Bridge	36° 07' 21"	84° 47' 42"
Site 8	Clear Creek at Jett Access	36° 07' 17"	84° 44' 45"

These sample locations are beneficial in determining the level of water quality and biological impacts associated with the discharge of crude oil, as well as documenting background (control) conditions above the impact zone. The samples were submitted to Louisiana State University (LSU) for analyses of SVOCs and aliphatic hydrocarbons. Composite biota (mussel) samples and a juvenile map turtle (*Graptemys geographica*) were also collected from control and impact zone sites. The SOW was subsequently modified to include additional data collection and sample analyses activities.

A second water and sediment sample collection effort was conducted on October 21 and 23, 2002. Sample collection activities adhered to the SOW and State of Tennessee guidance. Samples were collected by TDEC, NPS, and FWS at the following locations (Figure 2):

Station	**Location**	**Latitude/Longitude**	
Site 1	Clear Creek at Hegler Ford	36^{o} 07' 18"	84^{o} 48' 48"
Site 2	White Creek at Lavender Bridge	36^{o} 09' 31"	84^{o} 47' 20"
Site 3	Clear Creek above White Creek	36^{o} 07' 20"	84^{o} 47' 45"
Site 4	White Creek at mouth	36^{o} 07' 21"	84^{o} 47' 46"
Site 5	Clear Creek at Jett Access	36^{o} 07' 17"	84^{o} 44' 45"
Site 6	Clear Creek at Lilly Bridge	36^{o} 06' 01"	84^{o} 42' 57"

Additionally, composite biota (mussel) samples were collected from Clear Creek at Hegler Ford (*Villosa iris* (5)) and Clear Creek near the confluence of White Creek (*Villosa iris* (4) and *Lampsilis fasciola* (9)). The samples were submitted to LSU for analyses of SVOCs and aliphatic hydrocarbons. Personnel from TDEC also collected additional water and sediment samples for metals and VOC analyses at the State's Central Laboratory.

Opportunistic sampling activities during response operations included the collection of a juvenile mallard hen (*Anas platyrhynchos*) from Boom 3 at Barnett Bridge on July 27, 2002. This specimen was submitted to the National Wildlife Health Center for necropsy and determination of causative mortality factors. Feathers from the mallard and the whole-body turtle were also submitted to LSU for analyses. NPS personnel collected additional water samples for VOC analyses on September 25, 2002. Analyses of the water samples were performed by the TDEC laboratory in Knoxville, Tennessee.

All of the analytical data received to date are currently being compiled in tabular format and assessed. Additional samples from these sites will be collected in the winter of 2002/2003 during an extended period of low flow and, possibly, during, or shortly after, a typical storm event.

Digital data and imagery were compiled by the FWS for the impact zone and upstream reference sites (control) in the watershed. Data compilation and evaluation includes previous assessments performed by TDEC, NPS, USGS, and TVA, and current physicochemical assessments and analytical results from water, sediment, soil, and biota samples collected during NRDAR ephemeral data collection activities by the Trustee Council.

Additional Data Collection Activities

Benthic Algae

Benthic (attached) algae are sensitive indicators of change in lotic waters, as well as being the primary producers within the stream ecosystem. Because it is attached to the substrate, the benthic algae community integrates physical and chemical disturbances to a stream. Various algae species are sensitive to a variety of the chemical constituents present in the crude oil that was and continues to be discharged to Clear Creek. By using benthic algal data in association with macroinvertebrate and fish data, the biological integrity of Clear Creek and White Creek can be ascertained. Previous assessments of the benthic algal communities in the watershed have not been performed.

A survey of the periphyton community was initiated on October 21, 2002. Natural substrates were sampled and artificial substrates deployed in Clear Creek at Hegler Ford, Barnett Bridge, and Jett. The artificial substrates were removed on December 10, 2002. Sampling is being conducted in adherence with current EPA guidance (Barbour et al. 1999). The analyses will include a determination of species present, enumeration of individuals for each species and number per unit area (density), a determination of biomass (standing crop) using chlorophyll-a content and ash-free weight, and a calculation of metrics of biotic integrity. Initial results should be received in late December 2002. A subsequent survey will likely be performed during the spring/summer of 2003.

Macroinvertebates

Macroinvertebrates are routinely used in water quality assessments in the State of Tennessee (Arnwine 2002). Various macroinvertebrate species are environmental indicators of biological integrity used to describe water quality and sediment conditions and to identify causes of impairment. Various macroinvertebrate species are sensitive to a variety of the chemical constituents present in the crude oil that was and continues to be discharged to Clear Creek. TDEC routinely utilizes macroinvertebrate community data in use-attainment designations for Sections 305 (b) and 303 (d) of the Clean Water Act (CWA) reporting, assessing specific effects of pollutants on water quality. Specific methodologies (e.g., semi-quantitative riffle kicks) have been utilized in Clear Creek since 1996. These methodologies have been periodically refined by field investigators to ensure that the level of characterization performed for a specific taxa is adequate for their data assessment needs.

Macroinvertebrate surveys were conducted by TDEC personnel upstream of the impact zone at Hegler Ford, and at Barnett Bridge and the Jett Access on October 8, 2002. The methodology for sample collection, preservation, and identification adhered to current EPA and State of Tennessee guidance (Arnwine 2002).

An initial qualitative mussel survey was performed by NPS and FWS personnel in Clear Creek and White Creek on July 30, 2002. Transects were established at approximately 50- meter intervals across the stream channels. Visual surveys (snorkel) were conducted across these transects to locate and identify as many specimens as possible. A total of 32 specimens (28 *Villosa iris* and 3 *Lampsilis fasciola*) were collected, identified, and released. All age classes were represented in the collections. Additional substrate and biota surveys, including the use of underwater videography, were performed by NPS, FWS, and TWRA personnel on August 21, September 3, September 11, September 18, September 25, October 2, October 9, October 23, and November 26, 2002. Normal feeding and reproductive behaviors were documented, as well as any unusual mussel behavior and abnormal substrate conditions.

Fish

The evaluation of fish community structure is an important component of biological monitoring. Advantages of using fish as biological indicators include their widespread distribution from small streams to all but the most polluted waters, their utilization of a variety of trophic levels, their stable populations during summer months and the availability of extensive life history information (Karr et al. 1986). The primary goal of evaluating fish community structure is to ensure accurate assessments for CWA and ecoregional reference conditions. A fish Index of Biotic Integrity (IBI) (Barbour 1999) metric is calculated for the sampling event. These types of assessments have been performed in Clear Creek since 1994 and IBI's and other metrics have been calculated by TDEC, USGS, and TVA.

A fish community structure assessment was performed by TVA and TDEC personnel on July 25, 2002. Electroshocking (backpack and boat) techniques were utilized to collect specimens within the immediate reach of Clear Creek at Barnett Bridge and at an upstream control site at the U. S 127 bridge. A fish health assessment (Adams et al. 1993) was also performed by researchers from Oak Ridge National Laboratory. Redbreast sunfish (*Lepomis auritus*), rock bass (*Ambloplites rupestris*), and Northern hogsucker (*Hypentelium nigricans*) were collected. The ORNL methodologies (Adams et al. 2000) have been used successfully throughout the United States to evaluate sub-lethal stress in fish, including exposure from a variety of contaminants. The measurement of a suite of biological responses in fish (e.g., biochemical, physiological, genetic) could provide direct evidence of exposure and sub-lethal injury to fish as a result of the oil spill.

Terrestrial Surveys

A terrestrial survey was completed for the immediate oil spill site (burn area) on September 4, 2002. The burned area and the banks of Clear Creek were visually surveyed by personnel from TDEC, Division of Natural Heritage, for potential impacts and damages resulting from the oil spill, subsequent fire, and emergency response operations. Individual plants and plant communities that were affected were documented in a brief report issued on September 16, 2002. Dominant plant communities in adjacent unaffected areas were also documented.

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APPENDIX D.

ALKANE AND PAH LEVELS FOR WATER, SEDIMENT, SOIL, AND BIOTA

Table D1. n-alkane concentrations from August 2002 sampling effort.

LSU Sample #	2N2219-01	2N2219-02	2N2219-03	2N2219-05	2N2219-08	2N2219-06	2N2219-07	2N2219-09	2N2219-10	2N2219-11	2N2219-12
Site	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK
Sample Description	Small painted turtle	*Villosa iris* mussels	*Villosa iris* mussels	Upstream Control	Upstream Control	Burn area@spring	Below outcrop	Burn slope	Upstream	Boom	Downstream spill zone
Sample Type	Biota	Biota	Biota	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Water	Water	Water
ALKANES	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**
nC-10 Decane	nd	nd	nd	nd	nd	0.484	0.202	0.005	nd	nd	nd
nC-11 Undecane	nd	nd	nd	nd	nd	1.01	0.502	0.012	nd	nd	0.483
nC-12 Dodecane	nd	nd	0.004	nd	nd	1.22	0.732	0.028	nd	nd	0.537
nC-13 Tridecane	0.101	nd	0.003	nd	nd	2.30	1.38	0.100	nd	nd	1.20
nC-14 Tetradecane	0.029	0.008	0.008	nd	nd	1.96	1.26	0.196	nd	nd	2.49
nC-15 Pentadecane	0.094	0.032	0.019	0.002	0.002	1.80	1.12	0.359	0.040	0.311	4.54
nC-16 Hexadecane	0.195	0.060	0.040	0.002	0.004	1.93	1.22	0.776	0.099	0.830	13.0
nC-17 Heptadecane	0.560	0.136	0.018	0.005	0.006	2.63	1.70	1.68	0.117	3.00	44.4
Pristane	0.081	0.052	0.007	nd	nd	0.207	0.127	0.173	nd	0.539	2.75
nC-18 Octadecane	0.289	0.046	0.028	0.003	0.005	1.37	0.919	1.19	0.129	1.48	30.0
Phytane	0.091	0.003	nd	0.003	0.005	0.163	0.123	0.140	0.110	0.506	3.83
nC-19 Nonadecane	0.616	0.019	0.046	0.003	0.009	1.97	1.37	2.00	0.099	4.86	57.4
nC-20 Eicosane	0.336	0.020	0.027	0.003	0.004	0.970	0.738	1.11	0.055	2.68	33.8
nC-21 Heneicosane	0.468	0.017	0.035	0.003	0.008	1.17	0.885	1.34	0.081	3.13	42.7
nC-22 Docosane	0.455	0.018	0.024	0.003	0.007	1.04	0.799	1.31	0.280	3.44	38.8
nC-23 Tricosane	0.635	0.028	0.041	0.009	0.020	1.19	0.979	1.60	1.01	4.57	44.8
nC-24 Tetracosane	0.743	0.031	0.042	0.020	0.028	1.44	1.24	2.01	2.40	6.14	52.9
nC-25 Pentacosane	1.40	0.077	0.086	0.039	0.056	2.59	2.47	5.05	3.91	8.62	112
nC-26 Hexacosane	1.73	0.067	0.083	0.046	0.062	2.98	2.86	5.29	4.56	9.21	123
nC-27 Heptacosane	2.09	0.080	0.116	0.079	0.096	3.30	2.99	6.27	5.01	9.56	147
nC-28 Octacosane	2.18	0.051	0.092	0.053	0.072	3.33	3.17	5.99	4.96	9.01	163
nC-29 Nonacosane	2.36	0.063	0.106	0.076	0.138	3.82	3.61	6.50	4.57	8.38	186
nC-30 Triacontane	2.23	0.040	0.090	0.042	0.064	4.55	3.86	7.93	3.27	5.89	223
nC-31 Hentriacontane	2.69	0.060	0.084	0.048	0.106	5.47	4.13	8.44	2.55	5.09	260
nC-32 Dotriacontane	2.29	0.026	0.124	0.024	0.036	4.31	3.20	7.09	1.49	3.34	219
nC-33 Tritriacontane	2.51	nd	0.056	0.022	0.069	4.50	3.08	6.41	0.69	3.21	243
nC-34 Tetratriacontane	1.37	nd	0.040	nd	0.033	3.80	2.38	4.93	0.81	1.23	181
nC-35 Pentatriacontane	1.41	nd	nd	nd	nd	3.65	2.31	5.38	nd	nd	184
TOTAL ALKANES	**26.9**	**0.933**	**1.22**	**0.484**	**0.830**	**65.2**	**49.3**	**83.3**	**36.2**	**95.0**	**2400**

Table D1. Cont.

Sample #	2N2219-13	2N2219-13DUP	2N2219-14	2N2219-14 DUP	2N2219-25	2N2219-17	2N2219-15	2N2219-16
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	2nd Boom	Barnett Bridge	Below outcrop	Below outcrop-down
Sample Type	Biota	Biota	Biota	Biota	Feather from Mallard	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil
ALKANES	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**
nC-10 Decane	nd	nd	nd	nd	1.37	0.224	467	319
nC-11 Undecane	nd	nd	0.004	0.004	7.70	0.677	955	752
nC-12 Dodecane	nd	nd	0.005	0.004	23.1	1.14	971	1056
nC-13 Tridecane	nd	nd	0.004	0.005	101	2.43	1930	2057
nC-14 Tetradecane	nd	nd	0.006	0.007	216	2.90	1190	1293
nC-15 Pentadecane	0.006	0.005	0.018	0.019	435	2.93	917	1064
nC-16 Hexadecane	0.011	0.018	0.028	0.030	605	3.79	863	1165
nC-17 Heptadecane	0.036	0.037	0.065	0.062	777	4.97	1470	1676
Pristane	0.012	0.012	0.009	0.009	12.9	0.222	17.4	21.9
nC-18 Octadecane	0.011	0.014	0.034	0.035	236	2.54	397	511
Phytane	0.012	0.013	0.016	0.016	7.82	0.376	30.3	33.2
nC-19 Nonadecane	0.005	0.006	0.030	0.029	456	3.02	764	924
nC-20 Eicosane	0.009	0.008	0.015	0.016	91.4	1.20	234	259
nC-21 Heneicosane	0.009	0.007	0.018	0.017	68.1	1.26	200	265
nC-22 Docosane	0.006	0.005	0.008	0.009	47.9	0.885	165	191
nC-23 Tricosane	0.011	0.010	0.015	0.016	50.8	0.908	160	188
nC-24 Tetracosane	0.017	0.017	0.023	0.029	44.4	0.974	173	200
nC-25 Pentacosane	0.041	0.044	0.039	0.040	71.4	1.27	210	241
nC-26 Hexacosane	0.045	0.046	0.041	0.042	68.1	1.15	204	222
nC-27 Heptacosane	0.051	0.051	0.047	0.051	70.7	1.26	231	251
nC-28 Octacosane	0.044	0.042	0.043	0.047	66.4	1.29	239	260
nC-29 Nonacosane	0.048	0.046	0.043	0.046	62.6	1.27	282	274
nC-30 Triacontane	0.026	0.028	0.023	0.027	74.6	1.29	284	260
nC-31 Hentriacontane	0.025	0.025	0.030	0.031	75.6	1.33	324	272
nC-32 Dotriacontane	0.036	0.036	0.048	0.050	60.6	1.04	278	220
nC-33 Tritriacontane	0.012	0.012	0.014	0.014	66.5	1.04	309	258
nC-34 Tetratriacontane	0.019	0.017	0.012	0.012	52.7	0.814	218	187
nC-35 Pentatriacontane	0.018	0.016	nd	nd	50.7	0.841	213	191
TOTAL ALKANES	**0.510**	**0.516**	**0.639**	**0.666**	**3901**	**43.0**	**13700**	**14600**

Table D1. Cont.

Sample #	2N2219-20	2N2219-18	2N2219-19	2N2219-21	2N2219-22	2N2219-23	2N2219-24
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	Burn Slope	Upstream	Upstream	Barnett Boom	Upstream	Jett	Boom
Sample Type	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Water	Water	Water	Water
ALKANES	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**
nC-10 Decane	273	0.031	0.163	35.8	nd	nd	106000
nC-11 Undecane	468	0.077	0.330	73.7	nd	nd	195000
nC-12 Dodecane	430	0.120	0.400	121	nd	nd	149000
nC-13 Tridecane	642	0.270	0.827	295	nd	nd	231000
nC-14 Tetradecane	500	0.258	0.719	265	nd	1.27	115000
nC-15 Pentadecane	482	0.207	0.712	490	3.66	1.84	94500
nC-16 Hexadecane	546	0.247	0.884	805	4.32	2.57	107000
nC-17 Heptadecane	692	0.403	1.32	3157	8.23	4.07	149000
Pristane	4.53	0.022	0.040	46.6	8.50	5.80	1640
nC-18 Octadecane	189	0.110	0.462	1251	1.63	2.73	35600
Phytane	11.2	0.019	0.055	38.1	3.76	0.690	1480
nC-19 Nonadecane	399	0.187	0.779	4304	8.19	6.26	69100
nC-20 Eicosane	87.4	0.074	0.280	1353	3.43	2.46	18500
nC-21 Heneicosane	53.8	0.072	0.298	1142	3.39	2.42	16400
nC-22 Docosane	40.1	0.059	0.203	828	2.54	1.75	12300
nC-23 Tricosane	38.5	0.066	0.220	704	2.47	2.04	12600
nC-24 Tetracosane	39.7	0.081	0.174	633	3.15	2.39	13600
nC-25 Pentacosane	45.2	0.106	0.413	686	4.76	3.61	13500
nC-26 Hexacosane	40.8	0.116	0.285	567	5.30	3.90	14100
nC-27 Heptacosane	40.5	0.140	0.860	483	5.38	5.68	12800
nC-28 Octacosane	41.6	0.123	0.359	381	4.49	4.39	11800
nC-29 Nonacosane	44.2	0.156	2.238	306	4.11	6.68	9700
nC-30 Triacontane	49.9	0.118	0.412	434	5.67	4.24	6690
nC-31 Hentriacontane	54.2	0.145	2.207	485	5.35	5.28	5230
nC-32 Dotriacontane	37.8	0.085	0.174	341	3.39	1.80	3180
nC-33 Tritriacontane	35.5	0.102	0.883	296	0.916	2.36	2460
nC-34 Tetratriacontane	20.4	0.051	nd	239	nd	nd	1060
nC-35 Pentatriacontane	21.9	0.068	nd	242	nd	nd	936
TOTAL ALKANES	**5330**	**3.51**	**15.7**	**20000**	**92.6**	**74.2**	**1410000**

Table D2. PAH concentrations from August 2002 sampling effort.

LSU Sample #	2N2219-01	2N2219-02	2N2219-03	2N2219-05	2N2219-08	2N2219-06	2N2219-07	2N2219-09	2N2219-10	2N2219-11	2N2219-12
Site	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK
Sample Decription	Small painted turtle	*Villosa iris* mussels	*Villosa iris* mussels	Upstream Control	Upstream Control	Burn area@spring	Below outcrop	Burn slope	Upstream	Boom	Downstream spill zone
Sample Type	Biota	Biota	Biota	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Water	Water	Water
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**
Naphthalene	0.002	0.002	0.001	nd	nd	0.010	0.002	0.007	nd	nd	nd
C-1 Naphthalene	0.008	0.004	0.003	nd	nd	0.046	0.021	0.008	nd	nd	0.094
C-2 Naphthalene	0.008	0.005	0.003	nd	nd	0.105	0.056	0.027	nd	nd	0.268
C-3 Naphthalene	0.014	0.011	0.006	nd	nd	0.109	0.061	0.053	nd	0.181	0.740
C-4 Naphthalene	nd	nd	nd	nd	nd	0.052	0.033	0.052	nd	nd	nd
Fluorene	nd	nd	nd	nd	nd	0.014	0.007	0.009	nd	nd	0.076
C-1 Fluorene	nd	nd	nd	nd	nd	0.027	0.016	0.025	nd	nd	0.416
C-2 Fluorene	nd	nd	nd	nd	nd	0.029	0.021	0.041	nd	nd	0.493
C-3 Fluorene	nd	nd	nd	nd	nd	0.027	0.022	0.045	nd	nd	0.749
Dibenzothiophene	nd	nd	nd	nd	nd	0.002	0.001	0.002	nd	nd	nd
C-1 Dibenzothiophene	0.002	0.002	0.001	nd	nd	0.007	0.006	0.012	nd	nd	0.185
C-2 Dibenzothiophene	0.006	0.003	0.003	nd	0.001	0.015	0.012	0.024	nd	0.081	0.487
C-3 Dibenzothiophene	nd	0.000	0.004	nd	nd	0.014	0.012	0.023	nd	0.053	0.436
Phenanthrene	0.016	0.010	0.005	0.004	0.006	0.033	0.020	0.046	nd	nd	nd
C-1 Phenanthrene	0.011	0.006	0.006	nd	nd	0.079	0.060	0.128	nd	nd	2.12
C-2 Phenanthrene	0.010	0.006	0.006	nd	nd	0.081	0.064	0.141	nd	0.140	2.56
C-3 Phenanthrene	0.013	0.004	0.004	nd	nd	0.038	0.038	0.083	nd	0.147	1.40
C-4 Phenanthrene	nd	nd	nd	nd	nd	0.020	0.016	0.044	nd	nd	0.808
Anthracene	nd	nd	nd	nd	nd	0.002	0.002	0.005	nd	nd	nd
Fluoranthene	nd	nd	nd	0.001	0.010	0.003	0.004	0.008	nd	nd	0.658
Pyrene	0.007	nd	0.002	nd	0.015	0.036	0.030	0.104	nd	nd	0.125
C-1 Pyrene	0.009	nd	nd	nd	0.010	0.058	0.048	0.172	nd	nd	2.56
C-2 Pyrene	nd	nd	nd	nd	0.010	0.055	0.061	0.154	nd	nd	2.84
C-3 Pyrene	nd	nd	nd	nd	nd	0.065	0.055	0.185	nd	nd	2.61
C-4 Pyrene	nd	nd	nd	nd	nd	0.045	0.045	0.127	nd	nd	1.29
Napthobenzothiophene	nd	nd	nd	nd	nd	0.002	0.003	0.007	nd	nd	0.089
C-1 NBT	nd	nd	nd	nd	nd	0.020	0.021	0.047	nd	nd	0.995
C-2 NBT	nd	nd	nd	nd	nd	0.020	0.021	0.060	nd	nd	1.06
C-3 NBT	nd	nd	nd	nd	nd	0.017	0.019	0.058	nd	nd	0.920
Benzo (a) Anthracene	0.006	nd	0.002	nd	0.006	0.006	0.006	0.021	nd	nd	0.239
Chrysene	0.010	0.003	0.005	0.001	0.006	0.052	0.052	0.154	nd	0.04	2.45
C-1 Chrysene	0.010	nd	0.003	nd	0.003	0.067	0.066	0.186	nd	0.16	2.95
C-2 Chrysene	0.014	nd	nd	nd	nd	0.058	0.051	0.149	nd	0.14	2.10
C-3 Chrysene	nd	nd	nd	nd	nd	0.042	0.033	0.104	nd	nd	1.37

Table D2. Cont.

LSU Sample #	2N2219-01	2N2219-02	2N2219-03	2N2219-05	2N2219-08	2N2219-06	2N2219-07	2N2219-09	2N2219-10	2N2219-11	2N2219-12
Sample Decription	Small painted turtle	*Villosa iris* mussels	*Villosa iris* mussels	Upstream Control	Upstream Control	Burn area@spring	Below outcrop	Burn slope	Upstream	Boom	Downstream spill zone
Sample Type	Biota	Biota	Biota	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Sediment/ Soil	Water	Water	Water
Site	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK	WHITE CREEK
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**
C-4 Chrysene	nd	nd	nd	nd	nd	0.032	0.023	0.054	nd	nd	nd
Benzo (b) Fluoranthene	nd	nd	nd	nd	0.006	0.016	0.012	0.038	nd	nd	0.385
Benzo (k) Fluoranthene	nd	nd	nd	nd	0.005	0.008	0.005	0.018	nd	nd	0.223
Benzo (e) Pyrene	nd	nd	nd	nd	0.004	0.023	0.017	0.056	nd	nd	0.612
Benzo (a) Pyrene	nd	nd	nd	nd	0.004	0.013	0.011	0.031	nd	nd	0.720
Perylene	nd	nd	nd	nd	0.001	0.007	0.005	0.016	nd	nd	0.119
Indeno (1,2,3 - cd) Pyrene	nd	nd	nd	0.001	0.003	0.003	nd	0.007	nd	nd	nd
Dibenzo (a,h) anthracene	nd	nd	nd	0.002	0.001	nd	nd	nd	nd	nd	nd
Benzo (g,h,i) perylene	nd	nd	nd	nd	0.003	0.004	0.003	0.014	nd	nd	0.144
TOTAL PAHs	**0.148**	**0.056**	**0.055**	**0.009**	**0.094**	**1.37**	**1.06**	**2.55**	**nd**	**0.945**	**35.3**

Table D2. Cont.

Sample #	2N2219-13	2N2219-13DUP	2N2219-14	2N2219-14 DUP	2N2219-25	2N2219-17	2N2219-15	2N2219-16
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	2nd Boom	Barnett Bridge	Below outcrop	Below outcrop-down
Sample Type	Biota	Biota	Biota	Biota	Feather from Mallard	Sediment /Soil	Sediment/ Soil	Sediment /Soil
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**
Naphthalene	0.001	0.001	nd	nd	0.011	0.001	3.58	0.343
C-1 Naphthalene	0.001	0.001	0.001	0.001	0.275	0.031	36.7	22.1
C-2 Naphthalene	nd	nd	0.002	0.002	1.47	0.081	66.4	11.3
C-3 Naphthalene	nd	nd	0.003	0.003	2.95	0.099	51.1	56.8
C-4 Naphthalene	nd	nd	nd	nd	1.86	0.0	24.4	16.1
Fluorene	nd	nd	nd	nd	0.127	0.006	5.64	5.57
C-1 Fluorene	nd	nd	0.001	0.001	1.02	0.020	10.8	12.0
C-2 Fluorene	nd	nd	nd	nd	1.18	0.024	10.3	11.2
C-3 Fluorene	nd	nd	nd	nd	0.963	0.027	7.61	7.37
Dibenzothiophene	nd	nd	nd	nd	0.106	nd	0.595	0.625
C-1 Dibenzothiophene	nd	nd	nd	nd	0.591	0.006	2.83	2.82
C-2 Dibenzothiophene	nd	nd	nd	nd	0.586	0.018	4.31	4.36
C-3 Dibenzothiophene	nd	nd	nd	nd	0.420	0.019	2.67	2.97
Phenanthrene	0.001	0.002	0.001	0.001	0.507	nd	8.63	8.91
C-1 Phenanthrene	nd	nd	0.003	0.003	2.52	0.048	21.5	23.5
C-2 Phenanthrene	nd	nd	0.002	0.002	1.95	0.066	17.7	19.9
C-3 Phenanthrene	nd	nd	nd	nd	0.921	0.044	8.41	8.88
C-4 Phenanthrene	nd	nd	nd	nd	0.463	0.022	3.23	4.02
Anthracene	nd	nd	nd	nd	nd	nd	0.049	nd
Fluoranthene	nd	nd	nd	nd	0.061	0.002	0.509	0.641
Pyrene	nd	nd	nd	nd	0.096	0.003	0.524	0.622
C-1 Pyrene	nd	nd	nd	nd	0.746	0.027	5.34	4.93
C-2 Pyrene	nd	nd	nd	nd	0.621	0.030	4.19	4.74
C-3 Pyrene	nd	nd	nd	nd	0.469	0.030	5.13	6.12
C-4 Pyrene	nd	nd	nd	nd	0.416	0.025	3.06	4.01
Napthobenzothiophene	nd	nd	nd	nd	0.011	0.001	0.183	0.243
C-1 NBT	nd	nd	nd	nd	0.223	0.011	1.61	1.64
C-2 NBT	nd	nd	nd	nd	0.189	0.016	1.73	2.10
C-3 NBT	nd	nd	nd	nd	0.214	0.011	1.21	1.21
Benzo (a) Anthracene	nd	nd	nd	nd	nd	0.002	0.153	0.285
Chrysene	0.001	0.001	nd	nd	0.413	0.025	3.69	4.76
C-1 Chrysene	nd	nd	nd	nd	0.523	0.041	5.25	5.56
C-2 Chrysene	nd	nd	nd	nd	0.372	0.031	3.21	3.89
C-3 Chrysene	nd	nd	nd	nd	0.268	0.019	2.23	2.69

Table D2. Cont.

Sample #	2N2219-13	2N2219-13DUP	2N2219-14	2N2219-14 DUP	2N2219-25	2N2219-17	2N2219-15	2N2219-16
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	*Villosa iris* mussels	2nd Boom	Barnett Bridge	Below outcrop	Below outcrop-down
Sample Type	Biota	Biota	Biota	Biota	Feather from Mallard	Sediment /Soil	Sediment /Soil	Sediment /Soil
C-4 Chrysene	nd	nd	nd	nd	0.167	0.013	1.14	1.25
Benzo (b) Fluoranthene	nd	nd	nd	nd	0.128	nd	0.282	0.460
Benzo (k) Fluoranthene	nd	nd	nd	nd	0.104	0.001	0.308	0.353
Benzo (e) Pyrene	nd	nd	nd	nd	0.063	0.004	0.637	0.842
Benzo (a) Pyrene	nd	nd	nd	nd	0.071	0.005	0.669	0.860
Perylene	nd	nd	nd	nd	nd	nd	nd	0.098
Indeno (1,2,3 - cd) Pyrene	nd	nd	nd	nd	nd	nd	nd	nd
Dibenzo (a,h) anthracene	nd	nd	nd	nd	nd	nd	nd	nd
Benzo (g,h,i) perylene	nd	nd	nd	nd	nd	nd	nd	nd
TOTAL PAHs	**0.004**	**0.005**	**0.013**	**0.012**	**23.1**	**0.810**	**327**	**266**

Table D2. Cont.

Sample #	2N2219-20	2N2219-18	2N2219-19	2N2219-21	2N2219-22	2N2219-23	2N2219-24
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	Burn Slope	Upstream	Upstream	Barnett Boom	Upstream	Jett	Boom
Sample Type	Sediment/Soil	Sediment/Soil	Sediment/Soil	Water	Water	Water	Water
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**	**Conc (ng/mL)**
Naphthalene	1.71	nd	nd	nd	nd	nd	597
C-1 Naphthalene	11.4	0.006	0.024	0.794	nd	nd	3100
C-2 Naphthalene	17.8	0.014	0.047	5.54	nd	nd	4940
C-3 Naphthalene	13.1	0.016	0.043	11.7	nd	nd	3590
C-4 Naphthalene	7.76	nd	nd	11.4	nd	nd	2030
Fluorene	1.74	0.001	nd	0.279	nd	nd	460
C-1 Fluorene	3.97	0.002	nd	4.83	nd	nd	844
C-2 Fluorene	2.77	0.002	nd	6.51	nd	nd	711
C-3 Fluorene	2.43	0.003	nd	9.19	nd	nd	501
Dibenzothiophene	0.075	nd	nd	nd	nd	nd	28.7
C-1 Dibenzothiophene	0.882	0.001	nd	4.58	nd	nd	195
C-2 Dibenzothiophene	1.17	0.001	nd	10.1	nd	nd	301
C-3 Dibenzothiophene	0.732	0.001	nd	8.83	nd	nd	174
Phenanthrene	2.55	nd	nd	nd	nd	nd	551
C-1 Phenanthrene	6.60	0.005	0.024	16.4	nd	nd	1560
C-2 Phenanthrene	5.10	0.003	0.012	37.8	nd	nd	1370
C-3 Phenanthrene	2.13	0.002	0.011	24.0	nd	nd	519
C-4 Phenanthrene	1.10	nd	nd	14.0	nd	nd	268
Anthracene	0.032	nd	nd	nd	nd	nd	3.26
Fluoranthene	0.133	nd	0.048	nd	nd	nd	32.0
Pyrene	0.138	nd	0.048	1.19	nd	nd	35.4
C-1 Pyrene	1.65	nd	0.046	10.6	nd	nd	238
C-2 Pyrene	1.32	nd	nd	8.93	nd	nd	296
C-3 Pyrene	1.39	nd	nd	9.52	nd	nd	289
C-4 Pyrene	0.972	nd	nd	6.65	nd	nd	246
Napthobenzothiophene	0.048	nd	nd	nd	nd	nd	7.62
C-1 NBT	0.338	nd	nd	6.18	nd	nd	93.3
C-2 NBT	0.461	nd	nd	6.62	nd	nd	97.2
C-3 NBT	0.276	nd	nd	2.93	nd	nd	61.0
Benzo (a) Anthracene	0.058	0.001	0.016	nd	nd	nd	0.0
Chrysene	1.17	0.001	0.018	13.9	nd	nd	243
C-1 Chrysene	1.29	nd	nd	19.7	nd	nd	275
C-2 Chrysene	0.911	nd	nd	12.5	nd	nd	202
C-3 Chrysene	0.397	nd	nd	4.48	nd	nd	95.6

Table D2. Cont.

Sample #	2N2219-20	2N2219-18	2N2219-19	2N2219-21	2N2219-22	2N2219-23	2N2219-24
Site	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK	CLEAR CREEK
Sample Decription	Burn Slope	Upstream	Upstream	Barnett Boom	Upstream	Jett	Boom
Sample Type	Sediment/Soil	Sediment/Soil	Sediment/Soil	Water	Water	Water	Water
C-4 Chrysene	0.241	nd	nd	3.98	nd	nd	65.2
Benzo (b) Fluoranthene	0.048	nd	nd	1.00	nd	nd	20.4
Benzo (k) Fluoranthene	0.052	nd	nd	0.751	nd	nd	5.97
Benzo (e) Pyrene	0.159	nd	nd	1.9	nd	nd	38.7
Benzo (a) Pyrene	0.172	nd	nd	1.7	nd	nd	34.3
Perylene	nd	nd	nd	nd	nd	nd	nd
Indeno (1,2,3 - cd) Pyrene	nd	nd	nd	nd	nd	nd	nd
Dibenzo (a,h) anthracene	nd	nd	nd	nd	nd	nd	nd
Benzo (g,h,i) perylene	nd	nd	nd	nd	nd	nd	nd
TOTAL PAHs	**94.3**	**0.060**	**0.340**	**278**	**nd**	**nd**	**24100**

Table D3. n-alkane concentrations from October 2002 sampling effort.

Sample ID:	SACCW1021-1	SAWCW1021-1	SACCW1021-2	SAWCW1021-2	SACCS1021-3	SACCS1021-1
LSU ID:	2N2296-01	2N2296-02	2N2296-03	2N2296-04	2N2296-05	2N2296-06
Matix:	WATER	WATER	WATER	WATER	WATER	SEDIMENT
Wet Wt.(g) / Volume(ml):	500	500	500	500	500	30.38
	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mg)
Alkane Analyte:						
nC-10 Decane	0.00	0.00	0.00	0.00	0.00	0.00
nC-11 Undecane	0.00	0.00	0.00	0.00	0.00	0.00
nC-12 Dodecane	0.00	0.00	0.00	0.00	0.00	0.00
nC-13 Tridecane	0.00	0.00	1.93	0.00	0.00	0.00
nC-14 Tetradecane	0.00	0.00	4.14	0.00	0.00	0.00
nC-15 Pentadecane	0.00	0.00	5.69	0.00	0.00	0.02
nC-16 Hexadecane	0.00	0.00	8.28	0.90	0.85	0.02
nC-17 Heptadecane	0.00	0.00	10.94	1.64	1.25	0.04
Pristane	0.00	0.00	2.04	0.37	0.42	0.02
nC-18 Octadecane	0.00	0.00	4.64	0.99	1.00	0.02
Phytane	0.00	0.00	1.37	0.47	0.57	0.01
nC-19 Nonadecane	0.00	0.00	7.46	1.07	0.46	0.03
nC-20 Eicosane	0.00	0.00	2.42	0.28	0.14	0.02
nC-21 Heneicosane	0.00	0.00	2.66	0.36	0.14	0.04
nC-22 Docosane	0.21	0.22	2.20	0.36	0.05	0.03
nC-23 Tricosane	0.75	0.76	2.62	0.66	0.08	0.11
nC-24 Tetracosane	2.02	2.21	3.55	1.47	0.15	0.06
nC-25 Pentacosane	4.71	4.71	6.01	2.45	0.15	0.20
nC-26 Hexacosane	5.15	4.92	5.60	2.27	0.15	0.08
nC-27 Heptacosane	4.77	4.46	4.73	1.83	0.15	0.47
nC-28 Octacosane	3.19	2.68	2.67	0.98	0.15	0.11
nC-29 Nonacosane	2.40	1.49	1.48	0.90	0.15	1.97
nC-30 Triacontane	1.42	1.19	0.82	0.83	0.15	0.11
nC-31 Hentriacontane	0.00	0.00	0.00	0.00	0.15	1.45
nC-32 Dotriacontane	0.00	0.00	0.00	0.00	0.15	0.00
nC-33 Tritriacontane	0.00	0.00	0.00	0.00	0.15	0.41
nC-34 Tetratriacontane	0.00	0.00	0.00	0.00	0.15	0.00
nC-35 Pentatriacontane	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ALKANES	**25**	**23**	**81**	**18**	**6.6**	**5.2**

Table D3. Cont.

Sample ID:	SAWCS1021-1	SACCS1021-2	SAWCS1021-2	SACCS1021-3	SCCM1023-1	SACCM1023-2
LSU ID:	**2N2296-07**	**2N2296-08**	**2N2296-09**	**2N2296-10**	**2N2297-01**	**2N2297-02**
Matix:	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**BIOTA**	**BIOTA**
Wet Wt.(g) / Volume(ml):	**30.14**	**30.30**	**30.61**	**30.94**	**14.73**	**33.43**
	Conc. (ng/mg)	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**
Alkane Analyte:						
nC-10 Decane	0.00	0.00	0.00	0.00	0.0	0.00
nC-11 Undecane	0.00	0.00	0.00	0.00	0.00	0.00
nC-12 Dodecane	0.00	0.00	0.00	0.00	0.00	0.00
nC-13 Tridecane	0.00	0.00	0.00	0.00	0.00	0.00
nC-14 Tetradecane	0.00	0.03	0.00	0.00	0.00	0.00
nC-15 Pentadecane	0.00	0.04	0.00	0.00	0.00	0.00
nC-16 Hexadecane	0.01	0.07	0.01	0.01	0.00	0.00
nC-17 Heptadecane	0.03	0.08	0.01	0.03	0.02	0.01
Pristane	0.01	0.09	0.00	0.01	0.01	0.01
nC-18 Octadecane	0.02	0.08	0.01	0.02	0.02	0.01
Phytane	0.01	0.03	0.00	0.01	0.01	0.01
nC-19 Nonadecane	0.01	0.09	0.00	0.01	0.01	0.01
nC-20 Eicosane	0.01	0.07	0.00	0.01	0.01	0.00
nC-21 Heneicosane	0.02	0.11	0.00	0.01	0.00	0.00
nC-22 Docosane	0.01	0.09	0.00	0.01	0.00	0.00
nC-23 Tricosane	0.04	0.14	0.00	0.02	0.01	0.00
nC-24 Tetracosane	0.03	0.12	0.00	0.01	0.01	0.01
nC-25 Pentacosane	0.07	0.18	0.01	0.02	0.01	0.00
nC-26 Hexacosane	0.04	0.11	0.00	0.01	0.00	0.00
nC-27 Heptacosane	0.12	0.36	0.01	0.03	0.00	0.00
nC-28 Octacosane	0.04	0.09	0.00	0.00	0.00	0.00
nC-29 Nonacosane	0.35	1.11	0.00	0.07	0.00	0.00
nC-30 Triacontane	0.03	0.08	0.00	0.00	0.00	0.00
nC-31 Hentriacontane	0.24	1.43	0.00	0.00	0.00	0.00
nC-32 Dotriacontane	0.00	0.00	0.00	0.00	0.00	0.00
nC-33 Tritriacontane	0.04	0.43	0.00	0.00	0.00	0.00
nC-34 Tetratriacontane	0.00	0.00	0.00	0.00	0.00	0.00
nC-35 Pentatriacontane	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ALKANES	**1.10**	**4.84**	**0.07**	**0.27**	**0.10**	**0.06**

Table D3. Cont.

Sample ID:	SACCM1023-2	SACCM1023-2	SACCS1021-1	SACCW1023-1
LSU ID:	**2N2297-02MS**	**2N2297-02MSD**	**2N2297-03**	**2N2297-04**
Matix:	**BIOTA**	**BIOTA**	**SEDIMENT**	**WATER**
Wet Wt.(g) / Volume(ml):	**19.92**	**17.31**	**30.12**	**500**
	Conc. (ng/mg)	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mL)**
Alkane Analyte:				
nC-10 Decane	0.00	0.00	0.00	0.00
nC-11 Undecane	0.00	0.00	0.00	0.00
nC-12 Dodecane	0.00	0.00	0.00	0.00
nC-13 Tridecane	0.00	0.00	0.00	0.00
nC-14 Tetradecane	0.00	0.00	0.00	0.00
nC-15 Pentadecane	0.00	0.00	0.00	0.00
nC-16 Hexadecane	0.01	0.00	0.01	0.01
nC-17 Heptadecane	0.01	0.01	0.04	0.01
Pristane	0.00	0.01	0.01	0.00
nC-18 Octadecane	0.02	0.02	0.03	0.02
Phytane	0.01	0.01	0.02	0.01
nC-19 Nonadecane	0.01	0.01	0.02	0.01
nC-20 Eicosane	0.00	0.00	0.01	0.00
nC-21 Heneicosane	0.01	0.01	0.01	0.01
nC-22 Docosane	0.01	0.01	0.01	0.01
nC-23 Tricosane	0.02	0.02	0.02	0.02
nC-24 Tetracosane	0.02	0.03	0.00	0.02
nC-25 Pentacosane	0.01	0.01	0.02	0.01
nC-26 Hexacosane	0.01	0.01	0.00	0.01
nC-27 Heptacosane	0.00	0.00	0.03	0.00
nC-28 Octacosane	0.00	0.00	0.00	0.00
nC-29 Nonacosane	0.00	0.00	0.04	0.00
nC-30 Triacontane	0.00	0.00	0.00	0.00
nC-31 Hentriacontane	0.00	0.00	0.00	0.00
nC-32 Dotriacontane	0.00	0.00	0.00	0.00
nC-33 Tritriacontane	0.00	0.00	0.00	0.00
nC-34 Tetratriacontane	0.00	0.00	0.00	0.00
nC-35 Pentatriacontane	0.00	0.00	0.00	0.00
TOTAL ALKANES	**0.13**	**0.16**	**0.27**	**0.13**

Table D4. PAH concentrations from October 2002 sampling effort.

Sample ID:	SACCW1021-1	SAWCW1021-1	SACCW1021-2	SAWCW1021-2	SACCS1021-3	SACCS1021-1
LSU ID:	2N2296-01	2N2296-02	2N2296-03	2N2296-04	2N2296-05	2N2296-06
Matix:	WATER	WATER	WATER	WATER	WATER	SEDIMENT
Wet Wt.(g) / Volume(ml):	500	500	500	500	500	30.38
	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mg)
Aromatic Analyte:						
Naphthalene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Naphthalenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Naphthalenes	0.00	0.00	0.00	0.00	0.00	0.00
C3-Naphthalenes	0.00	0.00	0.00	0.00	0.00	0.00
C4-Naphthalenes	0.00	0.00	0.00	0.00	0.00	0.00
Fluorene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
Dibenzothiophene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
Phenanthrene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Phenanthrenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Phenanthrenes	0.00	0.00	0.00	0.00	0.00	0.00
C3-Phenanthrenes	0.00	0.00	0.00	0.00	0.00	0.00
C4-Phenanthrenes	0.00	0.00	0.00	0.00	0.00	0.00
Anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.01
Pyrene	0.00	0.00	0.00	0.00	0.00	0.01
C1- Pyrenes	0.00	0.00	0.00	0.00	0.00	0.06
C2- Pyrenes	0.00	0.00	0.00	0.00	0.00	0.07
C3- Pyrenes	0.00	0.00	0.00	0.00	0.00	0.02
C4- Pyrenes	0.00	0.00	0.00	0.00	0.00	0.00
Naphthobenzothiophene	0.00	0.00	0.00	0.00	0.00	0.00
C-1 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C-2 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C-3 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (a) Anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Chrysene	0.00	0.00	0.00	0.00	0.00	0.00
C1- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C2- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C4- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (b) Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (k) Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (e) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (a) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00

Table D4. Cont.

Sample ID:	SACCW1021-1	SAWCW1021-1	SACCW1021-2	SAWCW1021-2	SACCS1021-3	SACCS1021-1
LSU ID:	2N2296-01	2N2296-02	2N2296-03	2N2296-04	2N2296-05	2N2296-06
Matix:	WATER	WATER	WATER	WATER	WATER	SEDIMENT
Wet Wt.(g) / Volume(ml):	500	500	500	500	500	30.38
	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mL)	Conc. (ng/mg)
Aromatic Analyte:						
Perylene	0.00	0.00	0.00	0.00	0.00	0.00
Indeno (1,2,3 - cd) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00
Dibenzo (a,h) anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (g,h,i) perylene	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL AROMATICS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.18**

Table D4. Cont.

Sample ID:	SAWCS1021-1	SACCS1021-2	SAWCS1021-2	SACCS1021-3	SCCM1023-1	SACCM1023-2
LSU ID:	2N2296-07	2N2296-08	2N2296-09	2N2296-10	2N2297-01	2N2297-02
Matix:	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	BIOTA	BIOTA
Wet Wt.(g) / Volume(ml):	30.14	30.30	30.61	30.94	14.73	33.43
	Conc. (ng/mg)	Conc. (ng/mg)	Conc. (ng/mg)	Conc. (ng/mg)	Conc. (ng/mg)	Conc. (ng/mg)
Aromatic Analyte:						
Naphthalene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Naphthalenes	0.00	0.02	0.00	0.00	0.00	0.00
C2-Naphthalenes	0.00	0.07	0.00	0.00	0.00	0.00
C3-Naphthalenes	0.00	0.06	0.00	0.00	0.00	0.00
C4-Naphthalenes	0.00	0.00	0.00	0.00	0.00	0.00
Fluorene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
Dibenzothiophene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C2-Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
Phenanthrene	0.00	0.00	0.00	0.00	0.00	0.00
C1-Phenanthrenes	0.00	0.06	0.00	0.00	0.00	0.00
C2-Phenanthrenes	0.00	0.03	0.00	0.00	0.00	0.00
C3-Phenanthrenes	0.00	0.02	0.00	0.00	0.00	0.00
C4-Phenanthrenes	0.00	0.01	0.00	0.00	0.00	0.00
Anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Fluoranthene	0.01	0.00	0.00	0.00	0.00	0.00
Pyrene	0.00	0.00	0.00	0.00	0.00	0.00
C1- Pyrenes	0.02	0.00	0.00	0.00	0.00	0.00
C2- Pyrenes	0.02	0.00	0.00	0.00	0.00	0.00
C3- Pyrenes	0.01	0.00	0.00	0.00	0.00	0.00
C4- Pyrenes	0.00	0.00	0.00	0.00	0.00	0.00
Naphthobenzothiophene	0.00	0.00	0.00	0.00	0.00	0.00
C-1 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C-2 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
C-3 Naphthobenzothiophenes	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (a) Anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Chrysene	0.00	0.00	0.00	0.00	0.00	0.00
C1- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C2- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C3- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
C4- Chrysenes	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (b) Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (k) Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (e) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (a) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00

Table D4. Cont.

Sample ID:	SAWCS1021-1	SACCS1021-2	SAWCS1021-2	SACCS1021-3	SCCM1023-1	SACCM1023-2
LSU ID:	**2N2296-07**	**2N2296-08**	**2N2296-09**	**2N2296-10**	**2N2297-01**	**2N2297-02**
Matix:	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**BIOTA**	**BIOTA**
Wet Wt.(g) / Volume(ml):	**30.14**	**30.30**	**30.61**	**30.94**	**14.73**	**33.43**
	Conc. (ng/mg)	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mg)**
Aromatic Analyte:						
Perylene	0.00	0.00	0.00	0.00	0.00	0.00
Indeno (1,2,3 - cd) Pyrene	0.00	0.00	0.00	0.00	0.00	0.00
Dibenzo (a,h) anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo (g,h,i) perylene	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL AROMATICS	**0.06**	**0.27**	**0.00**	**0.00**	**0.00**	**0.00**

Table D4. Cont.

Sample ID:	SACCM1023-2	SACCM1023-2	SACCS1021-1	SACCW1023-1
LSU ID:	**2N2297-02MS**	**2N2297-02MSD**	**2N2297-03**	**2N2297-04**
Matix:	**BIOTA**	**BIOTA**	**SEDIMENT**	**WATER**
Wet Wt.(g) / Volume(ml):	**19.92**	**17.31**	**30.12**	**500**
	Conc. (ng/mg)	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mL)**
Aromatic Analyte:				
Naphthalene	0.00	0.00	0.00	0.00
C1-Naphthalenes	0.00	0.00	0.00	0.00
C2-Naphthalenes	0.00	0.00	0.00	0.00
C3-Naphthalenes	0.00	0.00	0.00	0.00
C4-Naphthalenes	0.00	0.00	0.00	0.00
Fluorene	0.00	0.00	0.00	0.00
C1-Fluorenes	0.00	0.00	0.00	0.00
C2-Fluorenes	0.00	0.00	0.00	0.00
C3- Fluorenes	0.00	0.00	0.00	0.00
Dibenzothiophene	0.00	0.00	0.00	0.00
C1-Dibenzothiophenes	0.00	0.00	0.00	0.00
C2-Dibenzothiophenes	0.00	0.00	0.00	0.00
C3- Dibenzothiophenes	0.00	0.00	0.00	0.00
Phenanthrene	0.48	0.54	0.00	0.48
C1-Phenanthrenes	0.00	0.00	0.00	0.00
C2-Phenanthrenes	0.00	0.00	0.00	0.00
C3-Phenanthrenes	0.00	0.00	0.00	0.00
C4-Phenanthrenes	0.00	0.00	0.00	0.00
Anthracene	0.00	0.00	0.00	0.00
Fluoranthene	0.00	0.00	0.00	0.00
Pyrene	0.00	0.00	0.00	0.00
C1- Pyrenes	0.00	0.00	0.00	0.00
C2- Pyrenes	0.00	0.00	0.00	0.00
C3- Pyrenes	0.00	0.00	0.00	0.00
C4- Pyrenes	0.00	0.00	0.00	0.00
Naphthobenzothiophene	0.00	0.00	0.00	0.00
C-1 Naphthobenzothiophenes	0.00	0.00	0.00	0.00
C-2 Naphthobenzothiophenes	0.00	0.00	0.00	0.00
C-3 Naphthobenzothiophenes	0.00	0.00	0.00	0.00
Benzo (a) Anthracene	0.00	0.00	0.00	0.00
Chrysene	0.00	0.00	0.00	0.00
C1- Chrysenes	0.00	0.00	0.00	0.00
C2- Chrysenes	0.00	0.00	0.00	0.00
C3- Chrysenes	0.00	0.00	0.00	0.00
C4- Chrysenes	0.00	0.00	0.00	0.00
Benzo (b) Fluoranthene	0.00	0.00	0.00	0.00
Benzo (k) Fluoranthene	0.00	0.00	0.00	0.00
Benzo (e) Pyrene	0.00	0.00	0.00	0.00
Benzo (a) Pyrene	0.00	0.00	0.00	0.00

Table D4. Cont.

Sample ID:	SACCM1023-2	SACCM1023-2	SACCS1021-1	SACCW1023-1
LSU ID:	**2N2297-02MS**	**2N2297-02MSD**	**2N2297-03**	**2N2297-04**
Matix:	**BIOTA**	**BIOTA**	**SEDIMENT**	**WATER**
Wet Wt.(g) / Volume(ml):	**19.92**	**17.31**	**30.12**	**500**
	Conc. (ng/mg)	**Conc. (ng/mg)**	**Conc. (ng/mg)**	**Conc. (ng/mL)**
Aromatic Analyte:				
Perylene	0.00	0.00	0.00	0.00
Indeno (1,2,3 - cd) Pyrene	0.00	0.00	0.00	0.00
Dibenzo (a,h) anthracene	0.00	0.00	0.00	0.00
Benzo (g,h,i) perylene	0.00	0.00	0.00	0.00
TOTAL AROMATICS	**0.00**	**0.00**	**0.00**	**0.00**

Table D5. n-alkane concentrations from soil samples collected in February 2003.

LSU Sample #	2N3037-01	2N3037-02	2N3037-03	2N3037-04	2N3037-05	2N3037-06	2N3037-07	2N3037-08	--
Site	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT
Sample Decription	Sample #1: Black area, Depth 6 cm to rock, no duff	Sample #2A: Depth of black 1-3cm, no duff midslope	Sample #2B: No black, below 2A upper midslope	Sample# 3A: Black, no duff-slimy green layer b/n 3A&3B	Sample# 3B: No black, below 3A	Sample #4A: Edge of burn	Sample #4B: Deepest sample	Sample #5: 10-12m below upper rock wall	North Slope Crude
Sample Type	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Calibration Oil
ALKANES	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**
nC-10 Decane	6.3	8.5	46	32	63	12	15	66	2700
nC-11 Undecane	42	31	86	87	83	26	48	74	2600
nC-12 Dodecane	76	43	86	92	92	28	45	80	2400
nC-13 Tridecane	200	91	120	112	110	40	110	150	2300
nC-14 Tetradecane	240	110	100	136	91	38	69	130	2100
nC-15 Pentadecane	270	140	150	396	140	48	75	210	2000
nC-16 Hexadecane	390	300	140	553	150	51	74	290	2200
nC-17 Heptadecane	430	530	250	844	250	130	180	350	2000
Pristane	5.2	9.1	10	25	10	4.1	3.9	4.4	1500
nC-18 Octadecane	190	280	100	507	110	37	49	160	2100
Phytane	16	33	24	37	22	5.9	5.5	18	1300
nC-19 Nonadecane	410	670	180	715	180	115	140	340	2000
nC-20 Eicosane	150	220	83	295	90	30	34	99	2100
nC-21 Heneicosane	140	210	79	220	84	27	29	88	2000
nC-22 Docosane	110	170	58	164	67	21	27	63	1900
nC-23 Tricosane	98	130	52	117	59	21	28	55	1700
nC-24 Tetracosane	87	120	45	100	52	19	24	46	1800
nC-25 Pentacosane	180	300	120	172	120	48	46	88	1800
nC-26 Hexacosane	160	250	97	129	110	41	43	72	1600
nC-27 Heptacosane	150	240	96	150	110	45	41	79	1400
nC-28 Octacosane	130	220	93	133	100	43	39	73	1100
nC-29 Nonacosane	120	190	93	131	98	40	36	70	820
nC-30 Triacontane	300	250	180	325	180	84	87	150	860
nC-31 Hentriacontane	290	260	190	276	180	84	89	160	760
nC-32 Dotriacontane	250	250	170	260	170	80	81	150	560
nC-33 Tritriacontane	220	210	150	228	150	77	76	150	400
nC-34 Tetratriacontane	130	130	100	152	110	62	57	120	320
nC-35 Pentatriacontane	130	110	98	145	100	60	58	97	450
TOTAL ALKANES	***4921***	***5506***	***2996***	***6534***	***3080***	***1318***	***1610***	***3435***	***44770***

Table D6. PAH concentrations from soil samples collected in February 2003.

LSU Sample #	2N3037-01	2N3037-02	2N3037-03	2N3037-04	2N3037-05	2N3037-06	2N3037-07	2N3037-08	--
Site	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT
Sample Decription	Sample #1: Black area, Depth 6 cm to rock, no duff	Sample #2A: Depth of black 1-3cm, no duff midslope	Sample #2B: No black, below 2A upper midslope	Sample# 3A: Black, no duff-slimy green layer b/n 3A&3B	Sample# 3B: No black, below 3A	Sample #4A: Edge of burn	Sample #4B: Deepest sample	Sample #5: 10-12m below upper rock wall	North Slope Crude
Sample Type	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Calibration Oil
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**
Naphthalene	0.42	0.08	0.29	0.60	1.0	0.02	0.37	0.18	600
C-1 Naphthalene	4.6	1.5	3.5	6.4	6.9	0.72	3.3	4.2	1400
C-2 Naphthalene	23	8.8	11	21	14	4.2	6.6	13	1700
C-3 Naphthalene	20	12	10	22	12	4.7	5.3	11	1400
C-4 Naphthalene	10	7.6	5.0	14	5.6	2.2	2.7	6.3	850
Fluorene	2.5	1.9	1.6	4.1	1.7	0.35	0.86	2.0	96
C-1 Fluorene	7.2	5.7	3.5	12	3.6	0.91	1.7	4.7	280
C-2 Fluorene	8.1	8.7	5.0	14	4.6	1.8	2.1	5.3	370
C-3 Fluorene	6.9	8.9	4.0	13	3.9	1.7	1.7	4.7	380
Dibenzothiophene	0.47	0.45	0.20	0.67	0.23	0.10	0.11	0.27	210
C-1 Dibenzothiophene	2.3	2.5	1.2	3.8	1.1	0.45	0.58	1.3	400
C-2 Dibenzothiophene	3.5	4.3	2.0	6.1	1.8	0.85	0.82	2.3	570
C-3 Dibenzothiophene	2.2	2.9	1.3	3.7	1.2	0.55	0.53	1.3	460
Phenanthrene	4.4	4.8	2.2	6.2	2.5	0.83	1.1	2.6	250
C-1 Phenanthrene	14	16	6.8	23	6.6	3.4	3.2	7.6	590
C-2 Phenanthrene	13	16	7.8	21	7.6	3.7	3.7	8.1	660
C-3 Phenanthrene	6.7	8.4	4.0	10	3.6	1.7	1.7	4.1	560
C-4 Phenanthrene	3.3	4.3	1.7	4.9	1.7	0.90	0.90	2.0	290
Anthracene	0.01	0.05	0.03	0.03	0.03	0.00	0.00	0.07	3.3
Fluoranthene	0.10	0.91	0.20	0.49	0.16	0.06	0.05	0.35	7.8
Pyrene	0.31	0.56	0.16	0.56	0.14	0.03	0.04	0.22	18
C-1 Pyrene	2.1	3.5	1.3	4.0	1.1	0.51	0.47	1.5	140
C-2 Pyrene	2.2	3.4	1.4	3.7	1.1	0.63	0.50	1.4	180
C-3 Pyrene	2.2	3.8	1.3	3.6	1.1	0.48	0.45	1.2	210
C-4 Pyrene	1.4	2.8	1.2	2.3	0.86	0.39	0.33	1.1	140
Napthobenzothiophene	0.14	0.25	0.06	0.17	0.04	0.02	0.01	0.06	35
C-1 NBT	1.2	1.7	0.54	1.7	0.52	0.33	0.24	0.62	140
C-2 NBT	0.90	1.7	0.44	1.4	0.36	0.23	0.17	0.44	150
C-3 NBT	0.54	1.2	0.32	0.77	0.26	0.17	0.14	0.36	120
Benzo (a) Anthracene	0.07	0.23	0.11	0.19	0.08	0.01	0.00	0.10	4.6
Chrysene	3.3	5.7	1.6	4.9	1.3	0.74	0.51	1.5	53
C-1 Chrysene	3.3	6.1	1.8	5.3	1.4	0.78	0.57	1.7	130

Table D6. Cont.

LSU Sample #	2N3037-01	2N3037-02	2N3037-03	2N3037-04	2N3037-05	2N3037-06	2N3037-07	2N3037-08	--
Site	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT	NPS-TN BLOWOUT
Sample Decription	Sample #1: Black area, Depth 6 cm to rock, no duff	Sample #2A: Depth of black 1-3cm, no duff midslope	Sample #2B: No black, below 2A upper midslope	Sample# 3A: Black, no duff-slimy green layer b/n 3A&3B	Sample# 3B: No black, below 3A	Sample #4A: Edge of burn	Sample #4B: Deepest sample	Sample #5: 10-12m below upper rock wall	North Slope Crude
Sample Type	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Sediment/Soil	Calibration Oil
PAHs	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**	**Conc (ng/mg)**
C-2 Chrysene	2.2	4.6	1.5	3.7	1.0	0.60	0.43	1.2	150
C-3 Chrysene	1.3	2.2	0.81	1.9	0.57	0.37	0.27	0.58	110
C-4 Chrysene	0.82	2.0	0.60	1.3	0.58	0.24	0.21	0.52	81
Benzo (b) Fluoranthene	0.29	0.64	0.18	0.37	0.10	0.05	0.06	0.10	3.3
Benzo (k) Fluoranthene	0.32	0.66	0.17	0.41	0.14	0.06	0.08	0.12	3.3
Benzo (e) Pyrene	0.71	1.3	0.30	1.0	0.27	0.12	0.10	0.35	12
Benzo (a) Pyrene	0.48	0.86	0.33	0.62	0.25	0.08	0.09	0.36	2.5
Perylene	0.26	0.49	0.18	0.28	0.14	0.05	0.04	0.18	1.9
Indeno (1,2,3 - cd) Pyrene	0.01	0.13	0.02	0.02	0.02	nd	nd	0.02	1.0
Dibenzo (a,h) anthracene	0.01	0.07	0.02	0.03	0.02	nd	nd	0.01	0.92
Benzo (g,h,i) perylene	0.03	0.15	0.04	0.05	0.03	nd	nd	0.04	2.4
TOTAL PAHs	***157***	***160***	***86***	***226***	***92***	***35***	***42***	***95***	***12765***