DAMAGE ASSESSMENT AND RESTORATION PLAN / ENVIRONMENTAL ASSESSMENT

Howard/White Unit No. 1 Oil Spill

PUBLIC REVIEW DRAFT

January 2008

Howard/White Unit No. 1 Oil Spill NRDA
Obed Wild and Scenic River
Morgan County, Tennessee
DAMAGE ASSESSMENT AND RESTORATION PLAN / ENVIRONMENTAL ASSESSMENT

PUBLIC REVIEW DRAFT

Prepared by:
Obed Wild and Scenic River Natural Resource Trustee Council

Including:
U.S. Department of Interior
National Park Service
U.S. Fish and Wildlife Service
Tennessee Department of Environment and Conservation

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AMD	acid mine drainage
BTEX	benzene, toluene, ethylbenzene, xylene
DARP	Damage Assessment and Restoration Plan
dbh	diameter breast height
DOI	Department of the Interior
DSAYs	discounted service acre years
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ft	feet
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system
HEA	Habitat Equivalency Analysis
IBI	Index of Biotic Integrity
LPP	Land Protection Plan
LSU	Louisiana State University
m	meter
NCBI	North Carolina Biotic Index
NEPA	National Environmental Policy Act
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
OC	Oligochaetes and Chironomids
OSLTF	Oil Spill Liability Trust Fund
OPA	Oil Pollution Act of 1990
ORNL	Oak Ridge National Laboratory
PAH	polynuclear aromatic hydrocarbon
RP	Responsible Party
SHPO	State Historic Preservation Office
SQKICK	Semi-Quantitative Riffle Kick
SVOC	semivolatile organic compounds
TDEC	Tennessee Department of Environment and Conservation
TMI	Tennessee Macroinvertebrate Index
TNC	The Nature Conservancy
TPH-DRO	total petroleum hydrocarbons – diesel range organics
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
WSR	Wild and Scenic River

EXECUTIVE SUMMARY

On 19 July 2002, a blowout occurred on the Howard/White Unit No. 1 oil well in Morgan County, Tennessee releasing an undetermined amount of crude oil. The oil flowed down the slope, entering White Creek and Clear Creek, two tributaries of the Obed Wild and Scenic River. The oil caught on fire and burned down both slopes and across Clear Creek. Emergency response operations were initially conducted by the Responsible Party; however, the U.S. Environmental Protection Agency took over operations on 21 July. Since the initial spill, oil has continued to seep out of the bank below the well through July 2007.

The Trustees for this incident include the Department of the Interior (DOI) represented by the National Park Service and the U.S. Fish and Wildlife Service, and the State of Tennessee represented by the Tennessee Department of Environment and Conservation. The Trustees were assisted by the U.S. Geological Survey and the Tennessee Wildlife Resource Agency. During the Preassessment Phase, the Trustees determined that forest vegetation and soils, visitor use, and stream health (as indicated by benthic algae and invertebrates, fisheries, water quality, and sediment quality) had been affected as a result of the oil spill and decided to pursue Injury Assessment and Restoration Scaling.

Injury to forestry resources was determined by a study of the forest structure and chemical analysis of the soils in the burned site and a nearby reference site two years after the spill and fire. Overstory mortality at the burned site was 100%. The soil litter, duff, and surface horizons were burned away, and the soil seed bank was destroyed. Mychorrizae and root systems were killed so that trees could not resprout from their roots following the burn. Based on the rate of biomass accumulation and the age structure of the reference forest, it was estimated that it will take 172 years for the forest to return to pre-spill biomass standing stock. Using the Habitat Equivalency Analysis (HEA), the injury to forestry resources in the 0.74 acre site that was oiled and burned was calculated to be 24.3 discounted service acre years (DSAYs).

Injury to stream services was determined by studies of the benthic macroinvertebrates in the impacted and upstream reference sites, studies of benthic algae, surveys of riparian vegetation, chemical analysis of water and sediments, and studies of the health and integrity of fish populations in impacted versus reference sites in Clear Creek. An important consideration in the injury assessment is the continued release of oil from the spill site as seepage directly into Clear Creek since the spill and as of July 2007. The rate of seepage appears to be controlled by the flow conditions; that is, the seepage rate is higher during low-flow conditions and appears to slow during high-flow conditions. It has not been possible to determine if the oil is still being released from the well itself or from the oil trapped in the vadose zone and fractures in the rocky slope adjacent to the creek. Thus, the Trustees have assumed that the oil seepage will continue for 20 years and follow a pattern of higher seepage during low flows 66% of the time. This pattern of higher seepage rates during low-flow conditions is important because the benthic macroinvertebrate community, as measured using the Tennessee Macroinvetebrate Index (TMI), becomes degraded in the section of stream below the seep during periods of higher seepage, compared to the reference site that is located only a short distance upstream.

The affected sections of Clear Creek and White Creek were divided into three reaches with differing degree and duration of exposure and impact. The Clear Creek Seep Reach extends 1,320 feet from the seep site and is chronically exposed to oil seepage during low-flow conditions. Low-flow conditions were determined to be when the flow at the Obed River gaging station at Lancing, TN for July, August, or September was below 98 cubic feet per second, which is the 70% duration flow exceedance value. The Clear Creek Downstream Reach extends 1,240 feet from the end of the Seep Reach to 500 feet below Barnett Bridge where oil sheens continue to be observed through June 2007, thus it is also chronically exposed, but to lower amounts of oil. The White Creek Reach extends 1,174 feet from the point of oil entry into White Creek to the junction with Clear Creek. White Creek was exposed to oil during the first year of the spill; the amount of chronic oil seepage since then into White Creek was considered to be insufficient to cause injury to benthic resources.

The inputs to the HEA model after the first year were based largely on the TMI scores in the impacted streams versus upstream reference sites and consideration of the life histories of the benthic macroinvertebrates present in the streams. It was assumed that low-flow conditions would occur 66% of the time over the next 20 years. Thus, for years 1-20 the % service loss for the Clear Creek Seep Reach was 50% during low-flow years and 25% during high-flow years. The injury to the 2.41 acres in the Clear Creek Seep Reach was calculated as 16.01 DSAYs. For the Clear Creek Downstream Reach, the % service losses, again based largely on the measured TMI scores in this reach compared to the reference site, was 25% during low-flow years and 10% during high-flow years. The injury to the 2.26 acres in the Clear Creek Downstream Reach was calculated as 8.76 DSAYs. The White Creek Reach recovery curve was based on oil exposure during the first year after the spill and the life histories of the benthic invertebrates. Thus, the service loss in the first year was 25% and full recovery was reached in four years. The injury to the 1.62 acres in the White Creek Reach was calculated to be 1.37 DSAYs.

Lost use was based on a study of baseline estimates of visitor use at the Obed WSR prior to the oil spill and the number of days lost during the period when the river was closed to public use. It was determined that 509 fishing days and 400 paddling days were lost. A benefits transfer methodology was used to determine the economic value of each fishing and paddling day lost as a result of the spill, with the result of $29,654 for lost fishing days and $26,792 for lost paddling days, for a total lost use of $56,446.

Two restoration alternatives were evaluated to restore services to the injured resource: 1) Natural recovery (i.e., no action alternative) and the 2) Preferred alternative. The preferred alternative involves several actions chosen to restore the forest, stream and lost use injuries. The Trustees chose this alternative as the actions compensate for the interim loss of services. For forestry resources, the preferred restoration action was invasive vegetation removal in the area burned for 25 years and land acquisition along the Obed WSR corridor consistent with the Land Protection Plan for the park. HEA was used to calculate the amount of land to be acquired, with the result of 2.3 acres. The Trustees decided land acquisition was also preferred for the injury to lost use since the properties identified have significant recreational value and either provide access to the river and hiking areas or protect key parts of the Obed WSR corridor. The invasive vegetation removal costs were $11,722 and land acquisition costs were $17,050.

The preferred restoration action for the stream services resource consisted of several stream restoration projects in Centennial Park in Crossville, TN in the headwaters of the Little Obed River. The restoration projects include 0.19 acres of streambank restoration, invasive vegetation removal along 750 feet of stream, creation of 2.12 acres of bog gardens, and construction of 2.0 acres of rain gardens/water detention structures. Using HEA, these restoration projects would create 26.1 DSAYs (equal to the injury to stream services) at a cost of $691,600; however, other sources of funds will cover some of these costs, so the costs to be provided by the DARP would be $460,689. This is the preferred restoration action because it would restore resources within the Obed River watershed and it meets the evaluation criteria discussed in section 5.2.

Oversight of the restoration projects and administrative costs by the Trustee agencies are estimated to be $151,835.

Table ES-1 shows the injury and restoration scaling for each affected resource. The total costs are $697,742.

TABLE ES-1. Injury and restoration scaling for each affected resource.

Injured Resource	Injury Scaling	Restoration Action and Scaling	Restoration Action Costs
Forestry resources – 0.74 acres with recovery taking 172 years	24.3 DSAYs	Invasive vegetation removal for 25 years; Acquisition of 2.3 acres of land	$11,722 $17,050
Stream services – 6.29 acres of stream	26.1 DSAYs	Stream restoration in Centennial Park, headwaters of Little Obed River (26.1 DSAYs)	$460,689
Lost visitor use - 509 fishing days - 400 paddling days	$56,446	Acquisition of 16.1 acres of land	$56,446
Oversight and Administration			$151,835
Total			**$697,742**

1.0 INTRODUCTION

This Damage Assessment and Restoration Plan (DARP) was prepared by federal and state natural resource Trustees responsible for restoring natural resources and services of the Obed Wild and Scenic River (Obed WSR) injured by the 19 July 2002 oil well blowout (the “incident”) Howard/White Unit No. 1 oil well in Morgan County, Tennessee. The Obed WSR is a unit of the National Park Service (NPS) and was included into the Wild and Scenic Rivers System in 1976. Located on the Cumberland Plateau in eastern Tennessee, the Obed WSR corridor is managed cooperatively by the NPS and State of Tennessee. Through a Memorandum of Understanding, the Tennessee Wildlife Resource Agency (TWRA) manages the land it owns within the rims of the gorges of the Obed River, Daddys Creek, and Clear Creek within the authorized boundary of the Park, in accordance with the purpose and policies outlined in the Wild and Scenic Rivers Act, as amended, Public Law 90-542. The NPS exercises management responsibilities for the Obed River and its major tributaries, including Clear Creek.

The purpose of restoration, as outlined in this DARP, is to make the environment and the public whole for injuries resulting from the incident by implementing restoration actions that return injured natural resources and services to baseline conditions and compensate for interim losses. The Department of the Interior (DOI), represented by the NPS and the U.S. Fish and Wildlife Service (USFWS), and the State of Tennessee, represented by the Tennessee Department of Environment and Conservation (TDEC), are co-Trustees for the Natural Damage Assessment (NRDA) of this spill event. The agencies assisting the Trustees include the U.S. Geological Survey (USGS) and the TWRA. The Trustees have prepared this DARP to inform the public about injury assessment and restoration planning efforts.

1.1 Spill Incident

On 19 July 2002, a blowout occurred on the Howard/White Unit No. 1 oil well in Morgan County, Tennessee (Fig. 1) releasing an undetermined amount of crude oil. The well was being drilled to test for commercial oil production from the Nashville Group formation. 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 midnight on 19 July, the oil well caught fire. The spilled oil had flowed downhill from the wellhead into White Creek, at approximately 0.21 miles above its confluence with Clear Creek, and into Clear Creek, at approximately 0.37 miles 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 through 2007, with higher rates of release during periods of low river flow (NPS, 2007a; b).

Staff from the NPS responded with fire crews and technical staff. FWS staff also served in a response capability. Initial response actions to contain the oil were undertaken by the operator of the well and Responsible Party (RP), 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, with support from the U.S. Coast Guard (USCG). 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. 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 included the following locations (Fig. 2):

- Point of oil entry in Clear Creek
- Point of oil entry in White Creek
- Immediately upstream of Barnett Bridge
- Downstream (100 yards) of Barnett Bridge
- Downstream (0.5 miles) of Barnett Bridge
- Upstream of Jett Bridge, approximately 5 miles downstream of the spill event

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 were removed, except at the point of oil entry in Clear Creek. The RP has maintained sorbent and hard boom in Clear Creek continuously through June 2007 because oil has persistently seeped out of the bank. NPS staff has inspected the seep site regularly between June and November 2006 and again in June and July 2007. They observed oil sheen, oil globules, and oiled boom on each visit (NPS, 2006a; b; c; d; e; f; g; h; 2007a; b). Evidence of oil was consistently observed in Clear Creek at the seep site and downstream to the riffle just above the confluence with White Creek. The boom and sorbent materials were commonly observed to be poorly maintained.

NPS posted “Do Not Come in Contact with Water” signs at both Jett and Barnett Bridges shortly after the spill. On 23 July Clear Creek was officially closed to public use from Double Drop Falls to Jett Bridge (approximately 6 miles). 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. The NPS lifted the closure from Barnett Bridge to Jett Bridge on February 6, 2003, but maintained a one-half mile closure between Double Drop Falls and Barnett 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 oil from the creek. Oil-saturated soil was removed from the top of the slope above the cliff face on Clear Creek from 27 July to 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 slow 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.

Water, soil, and sediment samples were taken by EPA during the response activities. EPA, TDEC, and FWS personnel also collected additional samples on 25 July 2002 to assess the nature and extent of contamination in the impact areas during the response.

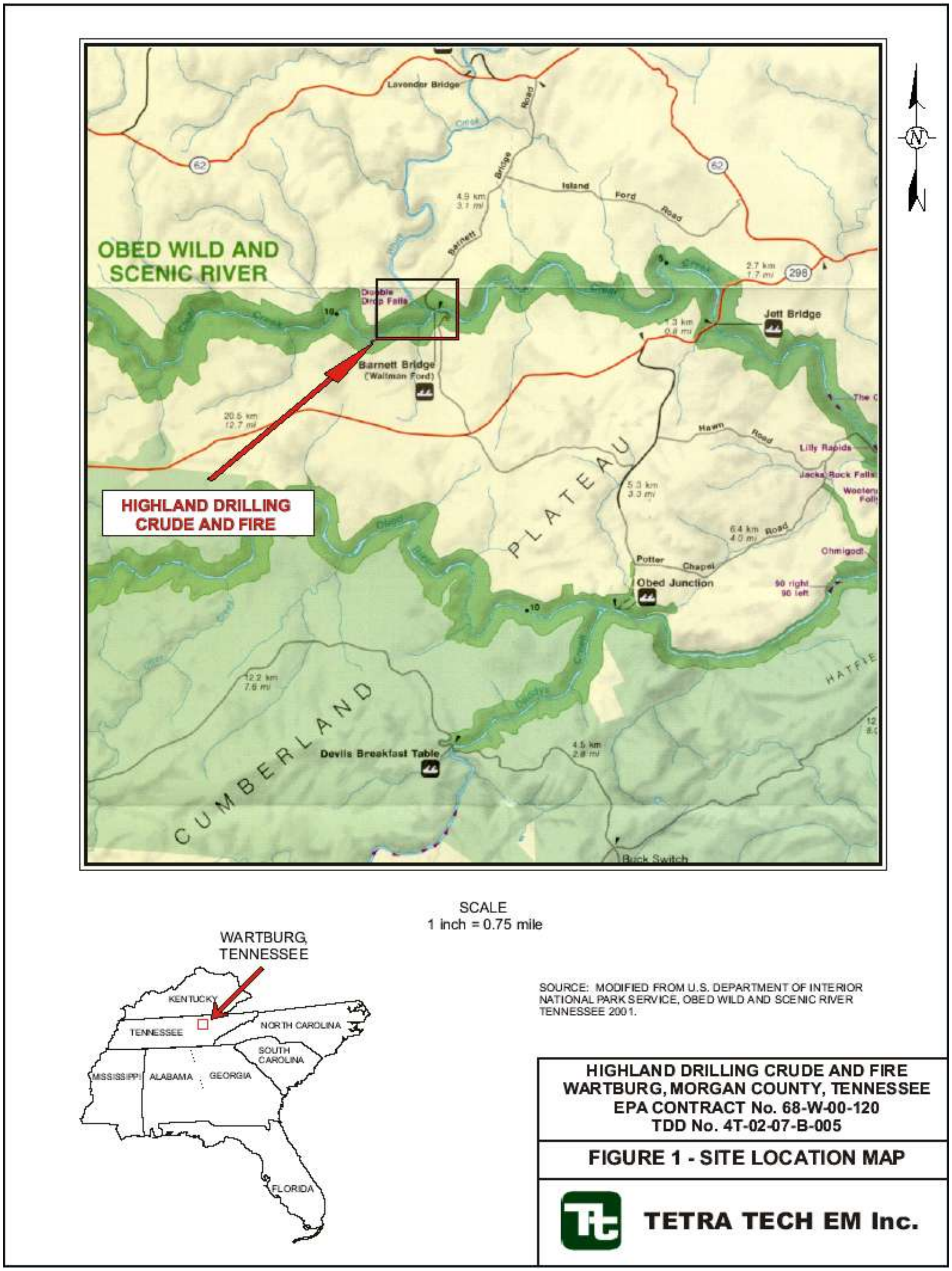

FIGURE 1. Location of the Howard/White Unit No. 1 oil spill and fire.

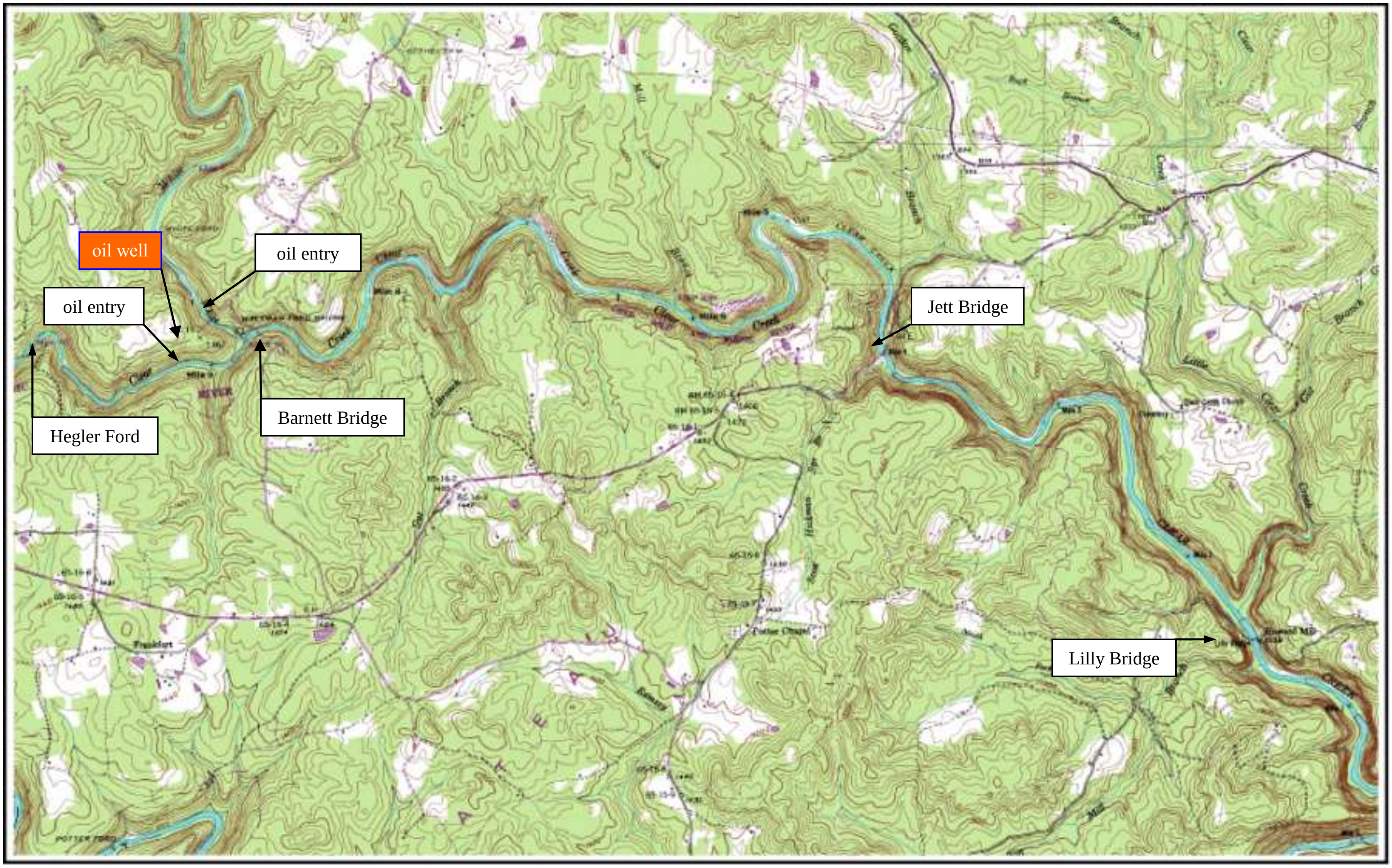

FIGURE 2. Topographic map showing the spill site, Clear and White Creek and the oil entry points for these creeks, Hegler Ford (upstream reference site), Barnett Bridge, Jett Bridge, and Lilly Bridge (derived from GIS data compiled by USFWS).

1.2 Summary of Natural Resource Injuries

The natural resource Trustees evaluated the information gathered during the response activities and from studies implemented during the Preassessment Phase and Injury Assessment Phase of the NRDA. Forest vegetation and soils, visitor use, and stream health (as indicated by benthic algae and invertebrates, fisheries, water quality, and sediment quality) were determined to have been affected as a result of the oil spill. There is some uncertainty in the duration of injury to stream health because it is unknown how long oil will continue to seep into Clear Creek. However, the Trustees used all of the available information, including focused studies, past literature, and expert scientific judgment, to estimate the injury as a result of the oil spill.

The natural resource injuries were determined using the Habitat Equivalency Analysis application discussed in further detail in the Injury Assessment section of this report and translated to discounted service acre years (DSAYs) or dollars. Using these methods, the Trustees estimated the injury to the 0.74 acres of oiled and burned forest to be 24.3 DSAYs. The Trustees estimated the injury to the 5.2 acres of stream services to be 26.1 DSAYs. The injury to visitor use was estimated to be $56,446.

1.3 Summary of the Preferred Restoration Alternative

The preferred restoration alternative involves five actions: 1) natural recovery – the primary restoration option for forest and stream injuries, 2) invasive vegetation control to compensate for the forest injury, 3) land acquisition/conservation to compensate for forest injury as well as lost visitor use in the Obed WSR, 4) restoration activities in the headwaters of the Little Obed River in Centennial Park, Crossville, TN to compensate for lost stream services, and in the event that the 4th action is unable to be implemented, 5) reclamation of an abandoned mine site in the Golliher Creek watershed that includes treatment of acid mine drainage (AMD) would also be appropriate to restore stream services. The Trustees prefer the Centennial Park project over the Golliher Creek project because it is located in the Obed River watershed where the injury occurred.

1.4 Organization of Document

This report presents information about the natural resource injury studies and proposed restoration actions for the Howard/White Unit No. 1 oil well blowout incident. Section 2 briefly summarizes the legal authority and regulatory requirements of the Trustees under the Oil Pollution Act of 1990 (OPA), and the role of the RP and the public in the damage assessment process. Section 3 describes the physical and ecological environments, the cultural and socioeconomic use of the impacted areas, and the current conditions of affected resources. Section 4 describes and quantifies the injuries caused by the spill, including an overview of preassessment activities, a description of assessment strategies employed by the Trustees, and a summary of assessment results. Section 5 provides a discussion of restoration options, including the economic and socio-economic impacts associated with each, and the appropriate scale of preferred options based on the nature and extent of injury presented in Section 4. Section 6 provides an analysis of environmental consequences from the two restoration alternatives. Section 7 is a summary of the preferred restoration alternative evaluated by the Trustees.

2.0 PURPOSE AND NEED FOR THE DARP

2.1 OPA Requirements

Under the OPA NRDA regulations in 15 C.F.R. Part 990, the NRDA process consists of three phases: 1) Preassessment; 2) Restoration Planning (includes Injury Assessment and Restoration Selection); and 3) Restoration Implementation. Preassessment Phase activities for a 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. Ultimately, the Preassessment Phase documents the collaborative decision made by the Trustees on whether or not to pursue the assessment and restoration planning phases of the NRDA. 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.

The Trustees conducted preassessment activities and prepared a Preassessment Phase report in April 2003. As a result, the Trustees determined that the above conditions had been met and had likely resulted in losses of natural resources and services from the date of the incident until the date of recovery. Thus, the Restoration Planning Phase was initiated. Under OPA, trustee agencies determine the damage claims to be filed against parties responsible for injuries to natural resources resulting from discharges of oil. Claims can be made for *primary* restoration (actions taken to directly restore the injured resources) and *compensatory* restoration (actions taken to replace the interim loss of resources from the time of injury until the resources recover to baseline conditions). The purpose of the Restoration Planning Phase is to quantify injuries to natural resources and services and determine the scale of the restoration actions. As the injury assessment is being completed, the Trustees develop a plan for restoring the injured natural resources and services. The Trustees are responsible for:

- Identifying a range of restoration alternatives,
- Reviewing and selecting the preferred alternative(s),
- Developing a Draft Restoration Plan presenting the alternative(s) to the public,
- Soliciting public comment on the Plan, and
- Considering these comments when developing a Final Restoration Plan.

Before initiating the Restoration Implementation Phase, the Final Restoration Plan is presented to the RP to implement or to fund the Trustees' costs of implementing the plan to avoid litigation. Should the RP decline to settle a claim, OPA authorizes Trustees to bring a civil action against the RP for damages and the Trustees' costs, or to seek disbursement from the USCG Oil Spill Liability Trust Fund (OSLTF) equal to the value of the damages plus the Trustees' costs. Costs include the cost of implementing the selected restoration action, the monitoring and necessary corrective actions, and the cost of the damage assessment itself (33 U.S.C. §§ 2701(5) and 2702(b), 15 CFR 990.62 and 990.63).

2.1.1 Coordination among the Trustees

The damage assessment and restoration planning process included the two co-Trustees (DOI as represented by NPS and USFWS, and the State of Tennessee represented by TDEC) of the river system and those agencies assisting the Trustees (USGS, TWRA). Together, these agencies became the Trustee Council and worked to meet their respective natural resource trustee responsibilities under OPA. The Trustee Council met on a regular basis to discuss the progress of the NRDA and the studies being completed to support the Injury Assessment and Restoration Planning efforts. As the federal co-Trustee, NPS assumed the role of the Federal Lead Administrative Trustee and the overall NRDA coordinator; however, all decisions were made by a consensus of the Trustee Council.

2.1.2 Coordination with the Responsible Party

The OPA regulations require the Trustees to invite the RP to participate in the damage assessment process. Accordingly, the Trustees delivered a letter to the RP, Pryor Oil Company, on 16 August 2002, alerting the RP that the Trustees were preparing to begin the Preassessment Phase of the NRDA, and that they were invited to participate in the preassessment as well as any further assessments or restoration planning. The RP chose not to participate with the Trustees and was not present at the Trustee Council meetings. A DOI Notice of Intent to Conduct Restoration Planning letter was sent to the RP on 29 April 2003, but the Trustees did not receive a written response from the RP. A third letter to the RP, dated 11 February 2005, was sent to notify the RP that the Trustee Council was preparing the DARP. The letter also offered an invitation to the RP to participate in DARP activities, with no response received from the RP. With the lack of participation from the RP, the Trustees collectively made determinations regarding injury and restoration.

2.1.3 Public Participation

The Trustees have provided the public with information regarding their NRDA activities via the Administrative Record (AR). The AR is available for public viewing at the Obed WSR Office. Through the AR, the public is able to obtain all documentation collected during the NRDA, provide restoration ideas and alternatives to the Trustees, and identify agency contacts to obtain more information.

The Trustees will also provide the draft Damage Assessment and Restoration Plan and Environmental Assessment for public review and hold public meetings to solicit comments. The Trustees will respond to the written and oral comments received on the draft plan during preparation of the final report.

2.1.4 Administrative Record

The AR was created during the Preassessment Phase and the files contain records from all of the injury assessment studies, meeting minutes, comments provided by the various agencies, reports, and all other documentation related to the NRDA. The AR is available for public viewing at the Obed WSR office, 208 N. Maiden Street, Wartburg, Tennessee.

2.2 NEPA Compliance

The National Environmental Policy Act (NEPA) (42 U.S.C §§ 4371 *et. seq.*) requires federal agencies to evaluate environmental values during a restoration project by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. This document serves as the Environmental Assessment (EA) required by NEPA in that it describes the affected environment, the need and purpose of the restoration, addresses alternative restoration options, the consequences of the proposed action, and the role for public participation within the decision-making process. The information summarized in this document also determines whether or not an Environmental Impact Statement (EIS) is required before a final restoration project(s) is chosen. An EIS is necessary when the proposed action is a major federal action that may significantly affect the quality of the human environment (40 CFR 1502.3).

The draft DARP/EA will be submitted for public review and comment. Based on the results of the public review, the Trustees will make the determination whether or not the preferred restoration actions will significantly affect the quality of the human environment and if the proposed restoration actions meet the threshold requiring an EIS. The results of these determinations will be included in the final DARP/EA.

3.0 AFFECTED ENVIRONMENT

This chapter presents a summary of the physical, biological, and cultural environment within the Obed WSR affected by the Howard/White Unit No. 1 oil spill. The affected environment includes the surface waters, sediment, shoreline, cliffs, and associated biological resources as well as the cultural resources and human uses of Clear Creek and White Creek. Also discussed is the Little Obed River headwater stream and Golliher Creek, neither of which were affected by the oil spill but are considered part of the preferred restoration alternative.

3.1 Physical Environment

3.1.1 The Obed WSR

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. Clear Creek and White Creek are part of the Obed River watershed that drains across the Cumberland Plateau, cutting 300 to 400 feet below the surface of the Plateau. Much of this vertical depth is accounted for by bluffs that are up to several hundred feet in height. The larger tributaries join the stream at grade, and the smaller ones often enter as waterfalls and seeps. Total precipitation varies from about 52 inches to 61 inches (Mayfield, 1984). Water resources and riparian environments are the principle resources of the Obed WSR. The waters of the Obed in this area, including Clear Creek, are relatively unpolluted (with the exception of the oil spill) and are considered to be among the highest quality in the state, supporting a rich array of plant and animal life. The waters in this area are currently listed on the 2006 303(d) list for the oil pollution.

The oil flowing from the well contaminated both White Creek, at approximately 0.21 miles above its confluence with Clear Creek, and Clear Creek, at approximately 0.37 miles above Barnett Bridge. The oil impacted at least 2 miles of Clear Creek (EPA, 2002). Clear Creek is a high-gradient, fourth-order stream located in Fentress and Morgan Counties, Tennessee. The physical resources affected from the contamination were the water and sediments within the creeks, the riparian wetlands and habitat alongside Clear Creek, and the highland areas and soils above the point of oil entry at Clear Creek.

The waters of Clear Creek showed evidence of oil contamination during sampling efforts (see *4.2.1 Water Quality*), and the Trustees assumed that the water quality remains affected since oil continues to seep into Clear Creek (observed June 2007). The affected waters in Clear Creek begin from the point of entry to just downstream of Barnett Bridge (2,560 ft long). White Creek also showed evidence of water contamination initially from the point of oil entry downstream to the confluence with Clear Creek (1,174 ft long), however, the amount currently observed in the creek is likely to be below levels that would cause significant impacts. Sediments were also affected as a result of the spill. There was initial evidence of contamination in the sediments in Clear Creek from the point of oil entry downstream to just below Barnett Bridge (2,560 ft). The Trustees assumed that this resource continues to be affected by the continual seepage of oil into

Clear Creek, however, the degradation of sediments was based on the effects observed in the injured biological resources (e.g., benthic invertebrates, fish), discussed under *3.2 Biological Environment*. Riparian wetlands and habitat, from the spill site to Barnett Bridge along Clear Creek were also affected in the initial period after the spill. Dead and stressed vegetation was observed, as well as a coating of oil on leaves of some of the surviving plants. However, the riparian areas observed after the spill had returned to baseline levels within a year, and the Trustees did not identify these resources as impaired after this time period.

The highland areas, from the oil well down to both White and Clear Creeks, were impacted by both oil and fire. The soils were soaked with oil and the fire burned the surface soil as well as the forest vegetation. An area 1.98 acres (0.8 hectares) in size was burned from the oil well to Clear Creek, of which 0.74 acres (0.3 hectares) are within the authorized boundary of the Obed WSR over which the Park owns a scenic easement property interest. The fire also burned an area estimated to be less than 1.24 acres on the slope from the oil well down to White Creek; however, this area was not part of the Obed WSR property. The forest vegetation and soil resources are currently injured as a result of the spill and fire.

3.1.2 Centennial Park, Crossville, TN

The Little Obed River is a headwater stream to the Obed River within the city limits of Crossville, TN. One of the smaller streams that empty into the Little Obed River also runs through Centennial Park, a Crossville City park with baseball fields and other recreational areas. The headwater stream was not affected by the oil spill, however, the site is the location of one of the preferred alternative actions discussed in subsequent sections.

The reaches of the small headwater stream to the Little Obed River in the preferred restoration area are heavily developed. The banks are incised 3-7 feet, and the stream has been channelized in the upper section of the city park. Entrenchment is consistent with upstream urban development/increased runoff coefficient. The banks are unstable, the substrate includes sandstone rubble and scoured residuum, and silt covers the bottom of the creek. In July 2007 (during drought conditions), the channel was dry in the uppermost sections, standing pools were present in the middle reaches, and the lowest reaches in the park had a trickle of flow, indicating viable perennial (or nearly so) habitat in the lowest third or so of the park (J. Burr, pers. comm., 2007). The riparian buffer is either non-existent or composed of non-native species. Water quality is degraded. Most of the drainage conveyances leading from the paved parking areas directly to the stream are unstable and managed poorly. Not only are they susceptible to flash runoff erosion and are washing away hillsides, the grounds crew crops the soils bare.

3.1.3 Golliher Creek, Morgan County, TN

Golliher Creek is a tributary and headwater creek to Crab Orchard Creek which empties into the Emory River. Golliher Creek is outside of the Obed WSR drainage and was not affected during the oil spill. However, like the Centennial Park site, it is the location of one of the preferred alternative actions discussed below.

Golliher Creek is currently listed in the TDEC 303(d) 2006 List of Impaired Waterbodies as a result of acid mine drainage (AMD). The upland banks of Golliher Creek were used for coal mining activities prior to the passage of the Surface Mining Control and Reclamation Act of 1977. The coal mining activities left open pits along the creek channel and acid-forming material that was exposed on the upland site during the operations oxidized and created pockets of standing and flowing surface water with depressed pH and elevated mineral content. Although coal mining operations no longer occur at this site, runoff events continue to contaminate Golliher Creek with acidic materials (TDEC, 2001). The water quality of Golliher Creek is poor with low pH levels (pH$\leq$ 3.0) and high levels of managanese and iron (TDEC, 2006). The total surface disturbance at this site is approximately 17 acres.

3.2 Biological Environment

3.2.1 The Obed WSR

Clear Creek and White Creek are important habitat for an array of species. Macroinvertebrates, such as the mussels *Villosa iris* and *Lampsilis fasciola*, are common to both creeks and rely on high water quality within the river system. Several species of fish inhabit both Clear and White Creek including smallmouth bass (*Micropterus dolomieu)*, largemouth bass (*Micropterus salmoides*), rock bass (*Ambloplites rupestris*), redbreast sunfish (*Lepomis auritus*), and Northern hogsucker (*Hypentelium nigricans*).

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 or along Clear Creek.

The forests bordering the Obed WSR are characterized as a dry oak-dominated forest with black and scarlet oak the most common and oldest species, with a mean age of 102 years and up to nearly 400 years (Walker et al., 2004; Webster and Jenkins, 2006). Other species include white pine, hickories, white oak, and chestnut oak. The rim and slopes of the river have thin soils, unique and striking rock outcrops, rugged terrain, and one of the richest floras in the southeastern United States including vascular plants, bryophytes, and lichens (Walker et al., 2004). Within the Obed River gorge, studies have reported 734 taxa within 393 genera and 122 families (Schmalzer et al., 1985). The cliff edge habitat was found to have unique community assemblages including state and federally listed species (Walker et al., 2004). Mammals and birds that have been observed in the Obed WSR include white-tailed deer, gray fox, red fox, gray squirrel, raccoon, cottontail rabbit, wood duck, mallard, and turkey. Songbirds and raptors are also seen frequently throughout the area.

Affected biological resources from the oil spill include benthic algae, macroinvertebrates, and fish. These resources are present in both Clear and White Creek occurring in the entire area of impact (Clear Creek: 2,560 ft long and 79.4 ft wide; White Creek: 1,174 ft long and 60 ft wide). There was a change in the benthic algae community that occurred immediately after the spill as a response to the change in water quality. A decrease in primary productivity was noted downstream of the spill site. Algal communities may be affected as long as oil continues to seep into Clear Creek. Benthic macrovinvertebrates were also affected and sampling between 2002 and 2006 showed lower index scores (e.g., taxa richness, EPT richness) indicating injury in the macroinvertebrate community during low water flows in Clear Creek. Fish, including redbreast sunfish and rock bass, were exposed to oil in the area of impact and showed evidence of sublethal stress (e.g., organ dysfunction and reduced condition indices). Impacts on reproduction were also observed but only immediately following the spill. The Trustees concluded that fish were affected in the impacted area from the spill site to Barnett Bridge.

Every canopy tree, most of which were oaks, in the burned area was killed. Few trees have resprouted because of the damaged root systems and the badly burned soil litter, duff, and surface horizons. Fireweed, a native weed that dominates disturbed sites, comprises the majority of the growth in vegetation since the spill.

3.2.2 Centennial Park, Crossville, TN

The riparian buffer in the headwater stream in Centennial Park ranges from spotty and composed mostly of non-natives to no canopy and mostly mown grass and weeds. The instream habitat is poor, consisting of silt and weedy aquatic vegetation in the upper sections and some viable natural substrate in the lower section (J. Burr, pers. comm., 2007).

During informal consultation wtih the USFWS, it was determined that there were no threatened or endangered species in the headwater stream in Centennial Park, Crossville that might be affected by the proposed restoration project. The park is highly developed and maintained (mowed grass, ball fields, paved parking areas, etc.) and is surrounded for miles by suburban development. Representatives of the TWRA visited the site in July 2007 and did not note the presence of any species or habitats of concern.

3.2.3 Golliher Creek, Morgan County, TN

In its current condition, Golliher Creek does not support fish and other aquatic life because of the high acidity levels. Secondary production, an important ecological service of a headwater stream, is limited as a result of the degraded aquatic community. Benthic algae, fish, and macroinvertebrates will return to streams when the pH of the water returns to baseline conditions.

3.3 Cultural Environment and Human Use

3.3.1 Obed WSR

There is evidence that prehistoric Native American cultures used the gorges and bluffs along the Obed WSR as early as 12,000 B.C. as hunting grounds (NPS, 1994). Approximately 400 years ago, Native American groups of the Historic Period claimed the Obed WSR as tribal territory. The last prehistoric cultural period, known as the Mississippian period, saw an influx of different tribes in the region. From roughly 1300 to the mid-1800s, tribes such as the Creek, Chickasaw, Choctaw, Shawnee, Yuchi, and Cherokee all bore witness to the Obed River. These tribes could not farm the land surrounding the river however, due to its poor farming soil and steep bluffs. As a result, the tribes used the area for hunting and gathering, and on many occasions used the sandstone bluffs as shelter during inclement weather. During the 18th century, a group of European white males migrated through the Obed area. They were called "Longhunters," and they were in the area primarily to hunt and fish. Like the Native Americans before them, they did not make their homes at the Obed, but used the sandstone bluffs as shelters. Europeans settled on the Cumberland Plateau around 1800 and used the land for agriculture. Archaeological studies identified 13 culturally significant sites, ten of which were prehistoric rock shelters. The remaining three sites were associated with 19th and 20th century farmsteads and industries (NPS, 1994). It is unlikely federally controlled sites were affected by the oil spill, however, private and/or state archaeological/cultural sites were disturbed by the response efforts (DesJean, 2002).

With the excellent water quality, scenic canyons, deep swimming holes, and whitewater rapids, the park supports a variety of outdoor recreational activities, including whitewater paddling, rock climbing, hiking, swimming, fishing, and sightseeing. Many visitors are particularly attracted by the remote wilderness experience offered by the park, as there are no roads along the rivers and few signs of civilization (IEc, 2003b).

Five bridges span rivers and creeks within the park, allowing visitors access to the water and serving as focal points for recreation. A brief description provided by Industrial Economics, Inc. (2003b) of the four bridge access points potentially affected by the spill follows:

<u>Barnett Bridge</u>: The Barnett Bridge access to Clear Creek includes two to three primitive camping sites, pit toilets, a bulletin board, and a small, unpaved parking area with space for approximately ten to twelve cars. Recreational activities at Barnett Bridge include paddling, fishing, picnicking, camping, and swimming (a swimming hole with a tree swing is located approximately 500 yards downstream from the bridge).

<u>Jett Bridge</u>: The Jett Bridge access to Clear Creek includes a bulletin board, pit toilets, picnic tables, fire pits, and a paved parking area with space for approximately ten to fifteen vehicles. Recreational activities at Jett Bridge include paddling (Jett is a popular put-in and take-out area), fishing, picnicking, and swimming (a popular swim hole, known as "Slant Rock" is located just upstream of the bridge).

<u>Lilly Bridge</u>: The Lilly Bridge access to Clear Creek includes a bulletin board, pit toilets, and a partially paved parking area with space for approximately 25 vehicles. Recreational activities at Lilly Bridge include paddling, fishing, swimming, and sightseeing. A number of popular swim holes are located near the bridge, and the view of Clear Creek Canyon makes the Lilly Bridge area attractive to sightseers.

<u>Nemo Bridge</u>: The Nemo Bridge access on the north shore of the Emory River includes a bulletin board, changing rooms, pit toilets, 10-12 picnic tables and fire pits, and a large parking area with space for approximately 30-40 vehicles. In addition, Nemo Bridge access provides approximately twelve primitive camping sites on the south shore of the river and additional day use parking. Recreational activities at Nemo Bridge include paddling, fishing, swimming, picnicking, hiking, and camping. A number of popular swim holes are found just downstream of the bridge, outside of the park boundary.

The visitor use component of the Obed WSR was affected by the spill as many of the activities that occur frequently within the park's boundaries were prohibited as a result of the oil contamination. A section of Clear Creek was closed from July 2002 through February 2003, and an estimated 509 fishing days and 400 paddling days were lost. A survey revealed that 78% of visitors who had completed the survey indicated that they were negatively impacted by the spill. The ongoing release of oil into Clear Creek during low flows continues to impact visitors, whether their intended activity is fishing, swimming, or boating.

3.3.2 Centennial Park, Crossville, TN

Centennial Park, managed by the City of Crossville, TN, was built in 1992 and consists of 67 acres. The park facilities include four adult-sized softball fields with field house and concessions, five youth-sized softball fields, a regulation baseball field along with field house and concessions, two lighted picnic pavilions, 1.5 miles of paved walking and bicycle trails, combination basketball and tennis court area, regulation-sized double tennis court, 24 horseshoe pits, four sand volleyball courts, a large child play area with sand boxes, a playground designed specifically to accommodate children with special needs, and ample parking.

Consulations were initiated with the State Historic Preservation Office and Tribal governments on the potential for impacts to cultural resources in the park. Based on these consultations, there are no known cultural resources in the park.

3.3.3 Golliher Creek, Morgan County, TN

Crab Orchard Creek was once a heavily used site for whitewater fishing enthusiasts. However, the poor water quality due to the AMD contamination from several of its headwater creeks (e.g., Golliher Creek included) has limited recreational fishing. Many of the fish species have disappeared from the creek as result of the high acidicity levels. Golliher Creek is not a high public use site; however there have been some concerns with human safety on the uplands of the creek. The steep high wall of the mine against the hillside is hazardous and piles of unstable mine debris are unsafe for climbing.

4.0 INJURY ASSESSMENT

4.1 Introduction

The goal of injury assessment under OPA is to determine the nature and extent of injuries to the natural resources and services. This determination provides a technical basis for evaluating the need for, type of, and scale of restoration actions. Under the OPA regulations, “injury” is defined to include “an observable or measurable adverse change in a natural resource or an impairment of a natural resource service” (15 CFR § 990.30). Trustees are responsible for determining whether or not there is exposure or an adverse change to natural resources as a result of oil contamination or injury to a natural resource as a result of response actions. To proceed with restoration planning, trustees also quantify the degree and extent of injuries. Injuries are quantified by comparing the condition of the injured natural resources or services to baseline. “Baseline” is defined as “the condition of the natural resources and services that would have existed had the incident not occurred” (15 CFR § 990.30).

4.2 Overview of Preassessment Phase Activities and Findings

The data collected during the Preassessment Phase were necessary to determine the extent of injury to Clear and White Creeks and decide if restoration planning is appropriate. NPS, USFWS, TDEC, Oak Ridge National Laboratory (ORNL), 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. 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. A more detailed description of the following studies is presented in the Preassessment Phase Report (Research Planning, Inc., 2003) located in the Administrative Record.

4.2.1 Water Quality

Water quality monitoring of both Clear and White Creeks 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. Surface water grab samples were collected from Clear Creek and White Creek in July, August, and October 2002, as well as October 2003. Locations were chosen to represent water quality upstream of the spill site, at the site where the oil was discharged into the creeks, and downstream of the site to monitor the spatial extent of exposure. Water samples were analyzed for polynuclear aromatic hydrocarbons (PAH), metals, semivolatile organic compounds (SVOC), volatile organic compounds (VOC), EPA target analyte list of 23 metals, alkanes, and total petroleum hydrocarbons–diesel range organics (TPH-DRO).

Water samples collected in July, August, and October 2002 and analyzed by the Louisiana State University showed evidence of contamination by oil that was fingerprinted as matching the source oil from the oil well (Research Planning, Inc., 2003). Additional water samples collected in October 2003 also showed contamination with PAHs that were a match with the source oil. The sampling efforts and analyses indicated that 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.

NPS and USFWS personnel routinely surveyed Clear Creek and White Creek during the summer, fall, and winter of 2002 and early 2003 for evidence of oiled substrates and surface sheening. Survey efforts included snorkeling and videotaping the substrate and biota encountered. Stream substrates were disturbed to determine oil emergence areas and shorelines were also surveyed for residual free product and areas of paraffin accumulation.

4.2.2 Sediment Quality

In July and August 2002 sediment samples were collected from Clear Creek and White Creek representing unaffected upstream or background sites, points of oil entry into the creeks, and downstream sites. These samples were analyzed for SVOC, VOC, metals, and TPH-DRO. Sediment samples were also collected from three locations along Clear and White Creeks in August 2002 to be tested for alkanes and PAH. A third round of sediment sampling in October 2002 was completed and samples were analyzed for n-alkanes, PAH, metals, and VOC.

Based on sediment sampling conducted in 2002, sediments in Clear Creek showed evidence of contamination from the oil spill, with elevated TPH-DRO concentrations in sediments from the point of entry site to Barnett Bridge. Although there is potential for continued sediment contamination from ongoing oil seepage into Clear Creek, the Trustees proposed to assess sediment injury in terms of impacts to the benthic community, as reflected in contamination of mussels and crayfish and the health of the benthic macroinvertebrate community. Therefore, no additional injury assessment studies of sediments were completed.

4.2.3 Benthic Algae

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. Natural substrates were sampled and artificial substrates were deployed in Clear Creek upstream from the spill site, at Barnett Bridge, and at Jett Bridge (downstream of spill site) in October 2002 (Pennington and Associates, Inc. 2003). The artificial substrates were removed two months later and analyzed for chlorophyll and ash-free dry weight. The samples from the natural substrates were analyzed for species present, number of individuals per species, and calculation of metrics of biotic integrity.

The results indicated that the natural substrate sampled in October 2002 appeared to be similar among all three stations sampled. The December 2002 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 (Pennington and Associates, Inc. 2003). 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. Therefore, the Trustees used these data to assess the injury to benthic algae in terms of changes in primary production, which is the lowest trophic level in the stream ecosystem.

4.2.4 Macroinvertebrates

Impacts to benthic macroinvertebrates were assessed during the Preassessment Phase by three types of studies: 1) mussel sampling in August and October 2002 for chemical analysis of tissues to measure the bioavailability of the oil; 2) benthic monitoring conducted in October 2002 and 2003 to compare benthic species abundance and diversity between oiled and unoiled areas of Clear Creek; and 3) collection of crayfish samples in May 2003 (however, the samples were not analyzed until 2006).

All mussel tissues collected and analyzed in 2002 showed low or no detectable PAH. During August 2002 surveys, female mussels were observed ejecting from the sediments near the spill site 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.

The benthic macroinvertebrate community data collected in October 2002 showed impacts to the benthic macroinvertebrate communities in Clear Creek for the area above Barnett Bridge but not as far downstream as Jett Bridge (Research Planning, Inc., 2003). The degradation of benthic community health in Clear Creek dropped to "partially-supporting," whereas it previously was fully supporting and considered to be a reference stream.

The results of the October 2003 benthic macroinvertebrate sampling indicated that the benthic community in the area just above Barnett Bridge had returned to pre-spill levels by late 2003. A new site 0.4 miles downstream of Barnett Bridge was sampled in October 2003 to determine the downstream extent of impact, and this site was also normal in terms of its benthic community in late 2003. Sheens were released from both sites above and below Barnett Bridge during the October 2003 sampling efforts.

Based on the above data collected, the biological condition at the Jett Bridge site before and after the spill was considered to be non-impaired. Benthic index scores showed an impact immediately downstream of the spill site in 2002 but not in 2003. In summary, impacts to the benthic macroinvertebrate communities were detected in Clear Creek for the area above Barnett Bridge but not as far downstream as Jett Bridge.

4.2.5 Fish Community Health

Fish were collected, counted, and observed for anomalies in 2002, 2003, and 2004 to determine the Index of Biotic Integrity (IBI) metric for Clear Creek. Similar data were available from 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.

TDEC, TVA, and ORNL collected fish for analysis at two reference sites and two oiled sites (Barnett and Jett Bridges) in 2002 (Fig. 2). For a portion of the 2002 samples, preliminary analysis were conducted which indicated injury at various levels of biological organization to the health of both rock bass and redbreast sunfish (sentinel indicator species) collected from the oil spill site (Adams et al., 2003).

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. 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 collected from the fish collections in August 2002 indicated that rock bass may be the species most affected by oil exposure (Adams et al., 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 a weakened immune system. A depressed immune system in fish increases the chance of disease and parasites.

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

4.2.6 Forest Vegetation and Soils

A forestry study was conducted to document impacts to the forest structure by sampling vegetation within the burned site and a nearby reference site (Jenkins, 2003). Preassessment Phase field sampling was completed in January and February 2003. The diameter at breast height (dbh) and height of all woody stem species greater than or equal to 1.4 m in height were measured and their condition was assessed. 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. The age of the overstory trees were also determined.

Soil samples were collected in July and August 2002 and 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 SVOC, VOC, metals, and TPH-DRO (EPA, 2003). Another round of soil samples were collected throughout the burned forest community in February 2003 that documented the changes in fire severity and oil saturation.

The forestry study results showed high mortality of the vegetation in the footprint of the two slope areas (on both Clear Creek and White Creek) affected by the oil spill and fire. The soil was severely impacted by the oil spill and fire. The oil saturation and fire 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.

4.2.7 Riparian Wetlands and Habitat

During the Preassessment Phase, a botanist from TDEC's Division of Natural Heritage conducted surveys of the riparian habitat adjacent to and in Clear Creek, from the spill site to Barnett Bridge. Dead and stressed vegetation, consisting primarily of American water willow, *Justicia americana*, was observed along Clear Creek. Many occurrences of the royal fern, *Osmunda regalis*, which also occurs along the banks of Clear Creek, were observed to be damaged and dead. The botanist observed a coating of oil on the leaves on some surviving individual plants. Woody plants observed at the water's edge did not appear to be affected except for browning of the leaves where the plant came in contact with oily water.

4.2.8 Visitor Use

Visitor-use reports were compiled to document the potential impacts of the spill on park visitors during and after the spill event. Qualitative visitor-use surveys were completed between July and August 2002 and between August and September 2002 that documented response events that may have affected park visitor's experiences at the park. 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 (Industrial Economics, Inc., 2003a).

A total of 118 visitors completed an informal NPS visitor survey. The surveys revealed that 41% of the respondents could not participate in their intended activity; however, 85% of these respondents could participate in their activity at an alternate location. Seventy-eight percent of visitors who completed the survey were negatively impacted by the spill, with 33% being "slightly" affected, 29% "moderately" affected, and 38% "greatly" affected.

A quantitative study was completed that produced baseline estimates of visitor use at the Obed WSR prior to the oil spill. Visitor use at four bridge access areas in the park was calculated using visitation patterns observed by an experienced NPS Obed law enforcement ranger. It was estimated that the average number of fishing visitors per day at Barnett Bridge and Jett Bridge between 20 July 2002 and 31 October 2002 (the end of the fishing season) were 7 people on weekend days and 4 people on week days (Industrial Economics, Inc., 2003b). It was also estimated by NPS personnel that approximately 400 paddling days would have occurred on the closed section of Clear Creek between 20 July and 6 February 2003 (when the closure was lifted) in absence of the spill (Industrial Economics, Inc., 2003b).

4.2.9 Information Management

The USFWS provided Geographic Information System (GIS) data management support to the Trustee Council during the Injury and Restoration Assessment Phases of the NRDA project. The work consisted of gathering spatial data on all sampling and observation stations within the Clear Creek watershed. All analytical data were entered into a relational database and linked with the spatial database. The GIS database was used by the Trustee Council and researchers in the conduct of NRDA-related assessments.

4.3 Injury Assessment Strategy

Based on the data collected during the Preassessment Phase, the Trustee Council determined three categories of injury: 1) forestry resources; 2) stream resources; and 3) lost visitor use. To determine the restoration options appropriate to compensate for the injury, the Trustees were required to quantify the nature and extent of the injury. Each injury assessment study focused on determining both the magnitude of the injury (i.e., amount of biomass lost or reduction in stream health) and the time to full recovery. Two approaches were used for injury quantification: benefits transfer and habitat equivalency analysis (HEA). Benefits transfer involves using economic values that have been previously estimated and reported in existing studies to address similar issues in other contexts. That is, per-day monetary values from existing economic studies are combined with site-specific data on the number of days lost to estimate the total ecomomic value of the loss (NPS, 2003). HEA is a methodology used to determine compensation for injuries to resources such as forestry and stream resources. The principal concept underlying the HEA method is that lost habitat resources/services can be compensated through habitat replacement projects by providing additional resources/services of the same type (NOAA, 2000).

Under the HEA method, trustees determine the injury using metrics that can be used to scale appropriate compensatory restoration options. The size of a restoration action is scaled to ensure that the present discounted value of project gains equals the present discounted value of interim losses. That is, the proposed restoration action should provide services of the same type and quality, and of comparable value, as those lost due to injury (NOAA, 2000). The losses and gains are discounted at a standard rate to express future quantities in present terms based on the concept that present services are more valuable than future services. The selection of the metric(s) to quantify the injury and scale restoration options is key to the successful application of the HEA method.

Using the HEA method, the injuries are quantified in terms of the percent loss of ecological services (compared to pre-spill baseline levels) and the rate at which the lost services recover over time. Figure 3 shows a hypothetical curve of the reduction in services for a habitat after an incident and the expected rate of natural recovery. The inputs into such curves for each injured habitat are: 1) the percent loss in services immediately after the incident; and 2) the percent of baseline services at key points in time after the injury. For example, the ecological services of an injured forest as measured by lost biomass might be reduced to 25 percent of baseline during the period from the spill to when vegetation started to return. Recovery would be a function of the rate of oil degradation in the soils and the accumulation of biomass as the vegetation repopulated the area. By the end of the first growing season, the services might be predicted as 65 percent of baseline; by the end of the second year, services might be predicted to have returned to 90 percent of baseline; full recovery might be predicted to occur at the end of the growing season of the third year following the injury. The injury or lost interim services is then quantified using a term called a discounted-service-acre-year (i.e., the value or amount of services provided by one acre of habitat over one year). For the above example, if the injured area was 1 acre, the estimated injury would be 1.2 discounted service-acres-years (DSAYs). The calculations for this example are shown in Table 1.

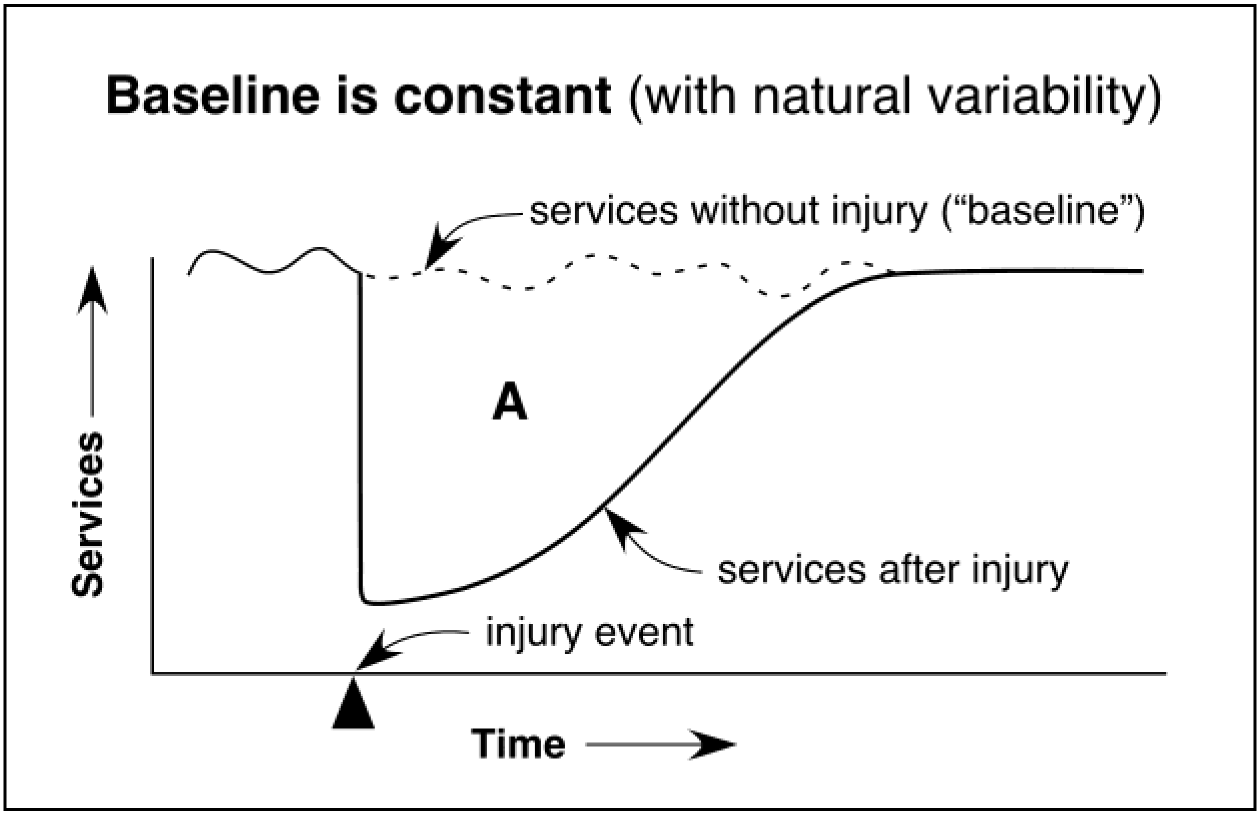

FIGURE 3. Hypothetical curve showing the lost services after an oil spill (area represented by the letter "A") and the expected rate of natural recovery, for habitats where the baseline is constant, though undergoing natural variability.

TABLE 1. Hypothetical injury calculated for 1.0 acre of injured forest habitat.

Years Post Spill	Year	Average Percent Service Loss	Discount Factor[1]	Discounted Ave. Percent Services Lost[2]	Discounted Service Acre Years Lost[3]
0	2003	75%	1.000	75%	0.750
1	2004	35%	0.971	34%	0.340
2	2005	10%	0.943	9%	0.094
3	2006	0%	0.915	0%	0.000
Total Discounted Service Acre Years Lost					**1.184**

[1] the standard discount rate, 3 percent; for year 2: disc. factor = (disc. factor from Year 1, 0.971) / (1 + 0.03)
[2] (discount factor) X (average percent service loss)
[3] (acres injured (1.0)) X (discounted average percent services lost)

This approach was used for stream and forestry resources by quantifying the injury as service acre-years, where a service acre-year is the flow of benefits that one acre of forest or one acre of stream habitat provides over the period of one year. For lost visitor use, losses were calculated as the reduction in visitors to the spill zone and the diminished value of recreational activities that occurred after the spill, expressed in dollars. Injury estimates in future years were discounted at three percent per year (NOAA, 1999), summed, and added to the injury in the year of the spill yielding an estimate of total injury. All of these methods produce an estimate of direct plus interim (from the time of injury until full recovery) loss of resources resulting from the oil.

Federal and state scientists, and local and regional experts, including those from Tennessee Tech University, Michigan Technological University, and ORNL, conducted the studies for each injury category. A full description of the injury assessment methods and results is presented in resource-specific injury reports prepared by the principal investigators. In each instance, the Trustees retained an outside expert to peer review key reports and, where appropriate, the principal investigators revised the report to address peer review comments prior to approval. Final injury reports and peer review comments were then placed into the Administrative Record, where they are available for public review (see *Section 2.1.4*). Section 4.4 of this final Restoration Plan presents a summary of each injury assessment, including methods and findings.

4.4 Injury Assessment Methods and Results

The following sections describe the results of the Trustees' injury assessments for resources as a result of the Obed oil spill. Descriptions of injuries are organized into the following three categories: forest vegetation and soils, stream health, and lost visitor use.

4.4.1 Forest Vegetation and Soils

The results from the forest vegetation sampling that occurred during the Preassessment Phase prompted a resampling of both the burned and reference site two years later. On 22-24 September 2004, within a 10 x 50 meter (m) plot, five subplots (10 x 10 m) were used to measure the diameter at breast height for all woody stems greater than or equal to 1 centimeter (cm), to identify the species (when possible), and to determine average age using tree cores. Using an age versus diameter relationship, the rate of accumulation of forest stand biomass at the Obed WSR burned and reference forest sites were estimated.

The current standing stock of biomass from the reference site was estimated to be 137 metric tons/hectare and the forest is accruing biomas at a rate of 0.92 metric tons/ hectare per year. The maximum tree age in the both the burned and reference forest was 149 years (Webster and Jenkins, 2006). Dry forest communities (pine, oak) have adapted to disturbances such as low-moderate intensity burns, which thins the understory and shrub layers but spares the overstory trees. However, the oil spill and burn that took place in 2002 was much more severe than the typical disturbance regime seen in forest communities. Analysis of the site revealed that overstory mortality at the burned sites was 100% (Webster and Jenkins, 2006). Few trees had resprouted (<15 %) within the two years following the spill/fire, and those that had were closer to the edge of the forest where the burn was not as severe. The soil litter, duff, and surface horizons were burned away and the soil seed bank was destroyed. Mychorrizae and root systems were killed so that trees could not resprout from their roots following the burn.

The soil sample analysis showed a decrease in alkane and PAH concentrations by 80% from February 2003 to September 2004 (Webster and Jenkins, 2006). Because of this rapid breakdown of hydrocarbons, it is unlikely that the compounds will inhibit future forest regeneration after the site experiences some initial re-vegetation by early successional species.

The recovery period for the burned forest was estimated using previous studies on the recovery times of both post disturbance succession of vegetation in post-agriculture fields (6-14 years) and strip mine areas (30-46 years). Webster and Jenkins (2006) estimated that the severity of the spill and fire on the Obed WSR forest community was likely to be more damaging than old agricultural fields but less damaging as compared to strip mine areas. It was estimated that there would be a 25-year time lag before woody species began to reestablish on the site and initiate normal stand development. However, the establishment of the herbaceous species, *Erechtites hieracifolia* (*E. hieracifolia*, fireweed), a native weed that dominates heavily disturbed sites, has covered over 10% of the burned forest ground (Fig. 4) since the spill occurred (Webster and Jenkins, 2006). As part of a primary restoration effort, the NPS will implement an invasive vegetation control plan at the beginning and end of at least two growing periods that would increase the rate of recovery of the natural forest vegetation. With the amount of *E. hieracifolia* growing within the burned site and the NPS primary restoration effort, it was estimated that 5% of biomass would accrue incrementally within the first 25 years following the spill.

Based on the rate of biomass accumulation and the age structure of the reference forest, it is estimated that it will take 172 years for the forest to return to pre-spill biomass standing stock. The recovery curve for the burned forest is shown in Figure 5. The curve was developed with a logarithmic equation that used the slope and intercept of the observed relationship between the rate of biomass accumulation and the age of the forest to determine the return of services. The inputs to the recovery curve can be found in Appendix A, Table 1. Using the HEA model and the injury curve, the injury for the 0.74 acres of burned forest was 24.3 DSAYs (Appendix A, Table 2).

FIGURE 4. The oiled and burned slope just above Clear Creek. Note growth of *E. hieracifolia*, a native weed that dominates sites after heavy disturbance. August 2004.

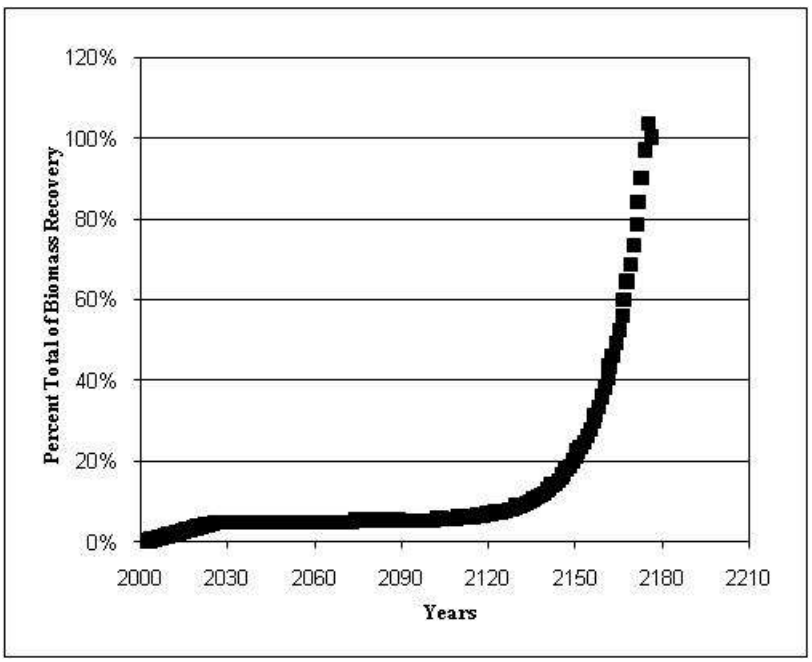

FIGURE 5. Recovery curve for the forest vegetation and soils. In the first 25 years, only 5% of services returned in the form of early successsional species. Normal stand development was estimated to occur 25 years after the spill and reach pre-spill conditions 172 years after the spill.

4.4.2 Stream Services

The injury to stream services was estimated using the data collected from several studies gathered during the Preassessment Phase (see section *4.2 Overview of Preassessment Phase Activities and Findings*) and the Injury Assessment Phase for the following resources: benthic algae, benthic macroinvertebrates, mussels, fish, ground water/geologic resources, riparian wetlands and habitat, sediment quality, and surface water quality. The injury assessment for each resource is discussed below.

The temporal and spatial component of the oil contamination was critical in determining the injury to the stream services. The data collected during the Preassessment Phase indicated that the spatial extent of the impacted stream area was from the spill site in both Clear Creek and White Creek to the pool located just below Barnett Bridge. Based on the GIS data compiled by the USFWS, the total length of injury for Clear Creek was 2,560 feet (ft), with 1,320 ft from the release site to the first riffle and 1,240 ft from the riffle to 500 ft below Barnett Bridge (since the site 2,000 ft below the bridge was not affected, based on the macroinvertebrate sampling). The total length of injury for White Creek was 1,174 ft.

The temporal component of the spill was more difficult to determine. The Trustees have documented observation of oil seeping from the bank at the spill site into Clear Creek through June 2007 (Table 2) and are unsure of how many years into the future the seep will continue. Based on the Preassessment and Damage Assessment data, the Trustees determined that the flow rate of the river may dictate how much oil is released into Clear Creek. In lower water flow years (i.e., 2002, 2005, 2006), oil was observed seeping from the well into Clear Creek and water samples showed contamination (see section *4.2.1 Water Quality*). In 2003 and 2004, years of higher flows, the observation of oil seeping into the Creek was not as apparent and the data showed little or no contamination. During the June 2007 site visit, “sheen was observed among the rocks as we stepped into the river near Barnett Bridge” (NPS, 2007a). The flow at the USGS gauge was 4.5 cubic feet per second, a historic low for this date.

TABLE 2. Observations of oil on Clear Creek between 2002 and 2007.

Date	Team	Observations
August 2002	J. Burr (TDEC-WPC) and Tetra Tech	Oil, paraffin, and sheen observed; water sample taken at point of entry had extremely high PAH concentrations (24,100 ppm) indicating that the sample included some floating oil; oil appeared to be fresh with a PAH pattern that matched the oil from the well, indicating that fresh oil continued to seep out of the creek bank in late August.
October 2002	J. Burr (TDEC-WPC)	Sheen observed upstream of Barnett Bridge during benthics collection.
May 2003	Williams, Bivens, Carter (TWRA); Bakaletz, Hudson, Williams (NPS)	Oily sheen rising from rocks in Clear Creek at Barnett Bridge as they were overturned during crayfish sampling.

TABLE 2. Cont.

Date	Team	Observations
October 2003	J. Burr (TDEC-WPC)	Oil seen on substrate during benthic collections, just upstream of Barnett Bridge.
August 2004	J. Burr (TDEC-WPC), J. Michel and H. Hinkeldey (RPI)	Water/sediment sampling; sheen observed at spill site and in pool downstream of spill site. Oil observed behind the boom.
June 2005	G. Harper (Emergency Response, Weston Solutions, Inc.), M. Hudson (NPS), N. Helton (NPS)	Oil observed seeping from the creek bank into the boom; more than a sheen had collected in the boom; sheen was also noted outside and adjacent to the boom on Clear Creek.
August 2005	S. Bakaletz and S. Ahlstedt (NPS)	A blob of paraffin that had the consistency of grease (approximately 6 inches in diameter) was observed washed onto rocks with leaves attached in White's Creek.
August 2005	A. Mathis and M. Hudson (NPS)	Sheen and paraffin observed just downstream from the last riffle before the spill site, in the rocks and detritus along the water's edge; rainbow sheen observed all over the pool at the site; sheen was solid and colorful throughout the pool; within the boom, the surface of water had a thick orange and yellow substance and occasionally, a solid surface of paraffin covered the water; downstream of site more sheen was observed in both the closest riffle to the site and the next riffle downstream.
October 2005	J. Burr (TDEC-WPC)	Sheen observed in pool at spill site, in riffle downstream of spill site, and at the next pool downstream of spill site; oil was observed behind booms while collecting benthics.
November 2005	B. Peacock (NPS) and D. Anderson (EPA)	Gas leaking at the well site.
June 2006	A. Mathis (NPS)	Observed oil seeping out from point of entry.
July 2006	A. Mathis (NPS)	Oil and sheen observed within booms, sheen observed outside of the booms; orange iron bacteria and yellow/orange paraffin also present; oil saturated absorbent pads observed.
August 2006	A. Mathis (NPS)	Oil observed standing on the water within the booms; orange iron bacteria and yellow/orange paraffin also present; oil saturated absorbent pads observed.
September 2006	A. Mathis (NPS)	Oil observed on absorbent pads, threads of yellow paraffin and orange iron bacteria within booms; sheen in pool outside of booms.
October 2006	J. Burr (TDEC-WPC)	Observed oil sheen on entire surface of pool at the spill site while collecting benthics, and in the riffle immediately downstream; booms were in place but poorly maintained.
November 2006	A. Mathis (NPS); S. Spurlin (EPA)	Obvious sheen and orange iron bacteria within booms; sheen on pool outside of booms (A. Mathis); waxy sheen coming from bank; minor film and yellow waxy accumulation (S. Spurlin).
June 2007	A. Mathis, R. Schapansky (NPS)	Slight sheens observed among rocks at Barnett Bridge, downstream of pool, and within 50 ft of the seep site; no visible solid paraffin.

4.4.2.1 Benthic Algae

The decrease in the number of species at the stations sampled downstream of the spill site (see section *4.2.3 Benthic Algae*) indicated a decrease in primary productivity in response to the oil contamination by December 2002 (5 months after the spill occurred). Algae are a food source for grazing fishes and invertebrates, and changes in the algal community may affect some higher trophic level species.

4.4.2.2 Benthic Macroinvertebrates

Table 3 shows a summary of the Tennessee Macroinvetebrate Index (TMI) scores for samples collected from Clear Creek over time since the spill. The TMI score is 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). A score of 10 or less is considered to be non-supporting or severely degraded; a score between 10 and 31 is considered to be partially supporting or slightly to moderately degraded; and a score greater than 32 indicates a fully supporting or non-degraded community. Table 3 also shows the flow conditions in the watershed for the period of July through September each year, since water levels for this period have a direct influence on the benthic macroinvertebrate community sampled in early October.

TABLE 3. TMI scores for benthic macroinvertebrate samples collected from Clear Creek since the spill in July 2002. A score >32 indicates a fully supporting community.

Sample Date	Helger Ford (upstream of spill)	Riffle Below Seep	Barnett Bridge (downstream of spill)	River Flow Conditions (July-Sept)
October 2002	38	-	20	Low
October 2003	40	-	40	High
2004	-	-	-	High
October 2005	34	18	24	Low-Moderate
October 2006	34	26	36	Low-Moderate

Table 3 shows that benthic macroinvertebrates were injured in October 2002 at Barnett Bridge but had returned to pre-spill levels in October 2003. Samples taken upstream and further downstream (Jett Access) were determined to have a healthy benthic community.

Benthic samples were collected outside of the NRDA in 2004 at Hegler Ford, Barnett Bridge, White Creek, and Jett Bridge as part of separate study (Goodfred and Cooke, unpublished data, cited in Cooke, 2006). The TMI scores from these samples showed that none of these sites were impaired. This was likely due to 2004 being a high-flow year. As part of the

NRDA studies, samples were collected in October 2005 and 2006 at the standard upstream location (Hegler Ford) and two downstream locations (at the first riffle below the seep and at the standard location at Barnett Bridge). The data through 2005 were analyzed by Cooke (2006) who concluded that the reference and Barnett Bridge impact sites had similar habitats, as well as good scores for sediment deposition and embeddedness, and thus could be used to detect impacts from the spill. The apparent recovery with the high-flow conditions of 2003 and 2004 was reversed during the lower flows in 2005 (Table 3). EPT richness, percent EPT, and percent clinger scores were also lower in the 2005 downstream samples than in the 2003 samples. EPT and clinger taxa are both sensitive to environmental disturbance. The downstream 2005 samples had higher percent OC values, which seems appropriate because Oligochaetes and Chironomidae larvae are considered to be more tolerant to stream disturbances than Ephemeroptera, Plecoptera, or Trichoptera. Cooke (2006) concluded that, during normal and high flow events, benthic communities at the Barnett Bridge sites appear non-impacted, but may be influenced by increased contact with oil during low flows.

In 2006, when flows were very low in July and moderate in August and September, the riffle below the seep site showed injury (Table 3). According to analysis of the data by Burr (2006), the total taxa numbers dropped from 32 at Hegler Ford (the control site) to 21 at the spill site (a loss of 1/3 of the taxa). The % OC (% of the sample made up of oligochaete worms and chironomids) rose sharply at the site immediately downstream of the spill zone. This is a negative metric, so a higher value means more impact. The sample at the site below the seep was dominated by worms of the Genus *Nais*, which have been noted to have an affinity for petroleum. There was one *Nais* in the Hegler Ford site sample, and five in the Barnett Bridge sample, but *Nais* was the dominant organism at the site immediately downstream of the seep (49 individuals out of 199 total organisms subsampled, or 25% of the community). The NCBI was significantly higher at the site below the seep (5.51) than at Hegler Ford (4.29) or Barnett Bridge (4.11). It is another negative metric; the higher the value, the more tolerant to pollution the biotic community. The % Clingers, which refers to the % of taxa that build fixed retreats or have adaptations to attach to surfaces in flowing water (as opposed to burrowers or sprawlers), declined by about 60% at the spill zone site compared to the control site at Hegler Ford. Clingers depend on stable, sediment-free or contaminant-free substrates.

Mussel tissue sampled in 2002 had no detectable PAH and a qualitative mussel survey in August 2005 did not provide any evidence that mussels were affected by the oil spill. Crayfish collected in May 2003 were also analyzed for PAH and no oil contamination was observed. The results of a mussel population and reproduction survey in 2005 were inconclusive since there was limited reproduction and recruitment in both the reference and impact study sites (Ahlstedt and Bakaletz, 2005). The Trustees conducted a second mussel tissue sampling study in June 2006. *Lampsilis fasciola*, wavyrayed lampmussels, and *Villosa iris*, rainbow mussels, were collected from Clear Creek above the spill site (reference site) and from Clear Creek at the junction with White Creek (impacted site) to determine if organ tissues showed lingering effects from the oil. The results of the study were inconclusive (Henley, 2007). There were no biologically meaningful differences between the tissues of mussels from the impacted site compared to the mussels from the reference site. However, because of a small sample size due to trematode infestation on mussels at the reference site, it was difficult to draw firm conclusions on the effects of lingering oil.

In summary, the benthic macroinvertebrates were impacted initially after the release of oil into the stream. In the years following the spill, benthic macroinvertebrates between the spill site to just below Barnett Bridge appear non-impacted during high-flow years, but may become impacted when the oil seepage rate increases during low-flow periods during the summer months (Cooke, 2006).

4.4.2.3 Ground Water/Geologic Sources

The oil well was observed by TDEC staff in November 2006, and it did not appear to be leaking. The well was observed to be leaking in the summer (2006) at about a half-pint per day. There is some hypothesizing that the leak may be temperature influenced (D. Mann, TDEC, per. comm., 2006).

4.4.2.4 Riparian Wetlands and Habitat

No further studies were conducted on riparian wetlands or habitat after the surveys were completed in the Preassessment Phase. The Trustees assume that injury to the riparian vegetation and habitat along Clear Creek was evident only within the first year following the spill and then returned to baseline services in the following year.

4.4.2.5 Sediment Quality

Evidence of oil contamination was found in sediment samples collected within Clear Creek downstream of the spill site in 2002 and 2004. This indicates an ongoing release of oil into the river system and accumulation in sediments. The Trustees assume injury to stream services and biota from sediment contamination will continue as long as oil continues to seep from the creek bank into Clear Creek.

4.4.2.6 Surface Water Quality

Water samples taken in 2002 and 2003 in Clear Creek showed evidence of oil contamination. Because oil continues to seep into Clear Creek, the Trustees assume that surface water quality will continue to be affected.

4.4.2.7 Fish Resources

Two sentinel fish species, redbreast sunfish and rock bass, were studied over a three-year period (2002-2004) to assess and evaluate the possible effects of the oil spill on the health and integrity of fish populations in Clear Creek (Adams et al., 2007). An integrative bioindicator approach, measuring a suite of selected biological responses at several levels of biological organization from the biochemical and physiological levels to the individual and population levels, was used to assess the potential effects of the oil spill on the health and integrity of these two sentinel fish populations in Clear Creek. The results indicated that both species from the Barnett Bridge site were exposed to oil and had sublethal stress (based on organ dysfunction and reduced condition indices) as a result of that exposure in 2002, compared to upstream control sites. Impacts on reproduction were observed in 2002 near the end of the breeding season for these species but not during the 2003 or 2004 breeding season. Levels of most sublethal stress responses that were observed in 2002 declined or were reduced dramatically in 2003 and 2004. Based on these studies, the Trustees concluded that there were no impacts to fish populations as a result of the spill; however, there was evidence of sublethal effects from the spill site to Barnett Bridge in 2002.

4.4.2.8 Summary of Injury to Stream Services

Using the Preassessment and Injury Assessment study results, the Trustees determined the percent of baseline services at key points in time to create the injury curve for stream services for both Clear and White Creeks. Table 4 shows the data that were used to determine the loss.

The Trustees divided Clear Creek into two reaches based on the level of impact from the contamination: the Seep Site (area from the seep to the first riffle just downstream of the seep) and the Downstream Site (area from the first riffle downstream to 500 ft below Barnett Bridge). The former would have higher oil exposures based on the proximity to the oil release site than the latter. As shown in Table 3, the Seep Site had a lower TMI score (18 and 26 in October 2004 and 2005, respectively) than the Downstream Site (24 and 36 in October 2004 and 2005, respectively). The injury to White Creek was calculated separately using a third recovery curve, since the amount of chronic seepage into White Creek is unknown but likely to be below levels to cause significant impacts to stream services.

In developing the injury curves for the period 2002 to 2003, the Trustees used the actual field data and observations of oil seepage patterns to estimate the percent reduction in stream services, as discussed in the following sentences and described in Table 4. All three stream reaches, the Clear Creek Seep Reach, the Clear Creek Downstream Reach, and White Creek, were estimated to have 0% services in July-August 2002. This was the month following the spill and a large amount of oil had entered the stream system from both release sites. Elevated TPH-DRO levels were found in water and sediment samples, and PAH contamination was apparent. Fish collected in August 2002 had lower visceral-somatic index, liver-somatic index, reduced feeding index, and weakened immune systems. Mussels were observed abnormally ejecting from the sediments. By October 2002, the percent of services provided by the Clear Creek Seep Reach were estimated to be at 25% of baseline, and White Creek and the Clear Creek Downstream Reach at 35% of baseline. The majority of the heavy oil had been removed but a constant sheen remained. The TMI was much lower in waters downstream of the spill (score = 20) compared to upstream sites (score = 38). EPT richness and % clingers (sensitive to disturbance) were both low. By December 2002, the percent services present increased by 5%-10%. The number of benthic algae species had decreased in December collections. By 2003, higher water flows occurred and the TMI showed no injury. However, the water samples still showed evidence of PAH contamination and oil sheens continued to be seen during benthic collections. An estimated 90% of the benthic macroinvertebrate species have one-year life cycles (Burr, 2007). Drift from upstream habitats would bring in nymphs and eggs, however it would take two years to fully recover to baseline conditions in the absence of oil. Thus, the services present were estimated at 75% of baseline for White Creek and the Clear Creek Downstream Reach (low amount of continuing oil exposure) and at 50% of baseline for the Clear Creek Seep Reach where there was chronic oil exposure.

In 2004, continued high water flows appeared to flush out the system, although some sheen was still observed during water and sediment sampling. No benthic invertebrate samples were collected, because it was assumed that the oil seepage would slow and benthic communities would continue to recover. Several important taxa have life cycles greater than one year, including odonates (dragonfly larvae) with a 2-4 year life cycle, perilidae stoneflies with a 2 year life cycle, megalopterans (hellgrammites) such as *Corydalus* and *Nigronia* have a 2-3 year life cycle, and gilled snails, mostly the females, live 4-5 years (Burr, 2007). Considering the time for these communities to recover, the Clear Creek Seep Reach was estimated to have services present at 75% compared to baseline (because of continued chronic oil exposures), and White Creek Reach and the Clear Creek Downstream Reach at 85% compared to baseline (low amounts of chronic oil exposure).

TABLE 4. Services present in both Clear and White Creeks as compared to baseline based on the Preassessment Phase and Injury Assessment Phase study results.

Period	**Clear Creek Seep Reach % Services Present**	**Clear Creek Downstream Reach % Services Present**	**White Creek Reach % Services Present**	**Evidence of Service Loss**
July-August 2002	0	0	0	Vegetation stressed and some mortality occurred; mussels ejecting from sediments (abnormal behavior); TPH-DRO in water samples was 4 times the background at Barnett Bridge; elevated TPH-DRO in sediment samples; PAH contamination above background levels in sediment samples downstream of spill; oil continued to seep out of creek bank into Clear Creek in late August.
October 2002	25	35	35	TMI showed moderate injury at Barnett Bridge with a score of 20 versus 38 at Hegler Ford (upstream site); EPT richness and % clingers lowest of all sites: clingers are very sensitive to environmental disturbance; low levels of BTEX in water samples; higher concentrations of metals (Al, Fe, Mn) in water samples; benthic algae showed no difference between upstream and downstream sites.
Dec 2002	30	45	45	For benthic algae; number of species decreased in areas downstream of spill. Upstream area had highest number of species.
2003	50	75	75	Higher water flow; TMI showed Clear Creek was not impaired at any sites, with score of 40 at Barnett Bridge and Hegler Ford; PAH contamination still observed in water samples; crayfish samples indicated no contamination; oil sheen rising from rocks at Barnett Bridge during crayfish sampling; oil seen on substrate during benthic collections, just upstream of Barnett Bridge.
2004	75	85	85	Higher water flows; sheen observed during water/sediment sampling.

TABLE 4. Cont.

Period	Clear Creek Seep Reach % Services Present	Clear Creek Downstream Reach % Services Present	White Creek Reach % Services Present	Evidence of Service Loss
2005	50	70	95	Low to moderate water flows: TMI indicated slight to moderate injury with score of 24 at Barnett Bridge and 18 at site immediately downstream of seep versus 34 at Hegler Ford; lack of younger age classes in mussels in Clear Creek; patch of paraffin observed on rocks during mussel survey.
2006	75	90	100	Low to moderate flows; observed product seeping out from point of entry, Barnett Bridge was not injured with a TMI score of 36; Seep Site was injured with score of 26 versus Hegler Ford score of 34.
2007-2022	75 (high flow) 50 (low flow)	90 (high flow) 75 (low flow)		Assume low flows occur 66% of time and Barnett Bridge site scores will not be injured during normal/high flows but some service losses due to oil seep; Barnett Bridge will be slightly injured during low flows with TMI score 25% below Hegler Ford reference site; assume Seep Site will be injured both during moderate/high flows with scores 25% below reference and during low flow with scores 50% below reference; assume seep will continue for 20 years, until 2022.

In 2005, stream flows were low to moderate. In Clear Creek, oil was observed seeping from the creek bank collecting within the boom and sheens were observed outside the boom during one of the site visits. The TMI at the upstream site scored at 34, whereas the Clear Creek Seep Site had a score of 18, and the Barnett Bridge site had a score of 24, indicating slight to moderate injury at both sites. At this time and forward, the Trustees decided to use the ratio of the TMI at each impacted site compared to the upstream site as the estimator for the percent of stream services lost in Clear Creek. Thus, the percent services for the Clear Creek Seep Reach in 2005 were estimated to have been about 50% (18/34 = 0.53 at the Seep Site) and about 70% (24/34 = 0.71 at the Downstream Site) as a result of lower flows and more oil releases from the seep.

Because of the low amount of chronic oil releases into White Creek, it is assumed that the benthic macroinvertebrates continued to recover from the oil spill, reaching 95% of baseline in 2005 (3 years after the spill, to account for the recovery of species with 2-3 year life cycles) and full recovery in 2006 (to account for recovery of species with a 4 year life cycle).

In 2006, flow conditions were low to moderate, and oil was observed seeping from the site of the oil spill. The TMI score at the Clear Creek Seep Site increased to 26 (slight injury) compared to 18 in 2005, the downstream Barnett Bridge site increased to a score of 36 compared to 24 in 2005, and the upstream site continued to score at 34. To account for life-history considerations, the percent services were estimated to increase in 2006 to 75% of baseline for the Clear Creek Seep Reach and 90% of baseline at the Clear Creek Downstream Reach.

The stream services present in Clear Creek from 2007 and into the future were harder to predict based on the changes of oil seepage and water flow rates in Clear Creek. There appears to be a correlation between flow conditions, oil seepage rates, and impacts to benthic macroinvertebrates, with higher seepage rates and impacts occurring during low-flow periods. The nearest USGS water gauge to the spill site is on the Obed River near Lancing, TN (location at 36°04’53.11” and 84°40’13.33”), about 12 miles downstream of the spill site. The monthly discharge statistics were obtained from the USGS web site: (http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw/). Data were available for the Lancing station for 35 years over the period 1957-2006 (shown in Appendix B). The 35-year mean flows are 387 cubic feet per second for July, 151 cubic feet per second for August, and 275 cubic feet per second for September. During the 1957-2006 period, there were 23 years (equal to about 66% of the time) when the average discharge in September was below 98 cubic feet per second. This value is the 70% duration flow exceedance. September data were used, as opposed to other months, because benthic sampling usually occurred in early October, and it was appropriate to use flow data that was collected near the time of the sampling. Using these data, it was assumed that stream services would be impacted by the oil seepage from the spill site approximately 66% of the time for a period of 20 years since the spill, i.e., unto 2022. The duration of seepage was estimated based on the fact that there has been no observable change in the rate of seepage over the five years since the spill. It is assumed that the seep will continue for many years, even if the source is identified and controlled, because of the oil remaining in the solutional features of the geological formation and vadose zone between the well and the streambank.

The Trustees estimated that, from 2007 through 2022, the Clear Creek Seep Reach would have services of 50% compared to baseline during low flows (based on the ratio of the TMI score for this site versus the upstream reference of 0.53 in the low-flow year of 2005) and 75% during high flows (based on the ratio of the TMI score for this site versus the upstream reference of 0.76 in the medium- to high-flow year of 2006). The Clear Creek Downstream Reach would have services of 75% compared to baseline during low flows, based on the ratio of the TMI score for this site versus the upstream reference of 0.71 in the low-flow year of 2005, and 90% services during high flows, based on the ratio of the TMI score for this site versus the upstream reference of >1.0 and accounting for a lag in full recovery because 10% of the species have 2-4 year life histories (Burr, 2007). In order to assign each year (beginning in 2007) a low or high flow event and the appropriate service level, a random number generator was used to assign low-flow years occurring 66% of the time. Figures 6 to 8 show the injury curves for stream services for the Clear Creek Seep Reach, the Clear Creek Downstream Reach, and the White Creek Reach, respectively. Appendix C, Tables C1-C3 shows the injury inputs and calculations.

Using the HEA application and discounting for the present loss of future services, the injury to stream services for the Clear Creek Seep Reach (2.41 acres: 1,320 ft long and 79.4 ft wide) was 16.01 discounted service acre-years (DSAYs). The injury to stream services for the Clear Creek Downstream Reach (2.26 acres: 1,240 ft long and 79.4 ft wide) was 8.76 DSAYs. The injury to stream services for White Creek (1.62 acres: 1,174 ft long and 60 ft wide) was 1.37 DSAYs. The total injury to the stream services as a result of the oil spill was 26.1 DSAYs.

4.4.3 Lost Visitor Use

The lost visitor use services were estimated using a "value-to-cost" scaling approach (15 CFR §990.53(d)(3)(ii)) that determines the scale of compensatory restoration that has an implementation cost equivalent to the economic value of lost services. The lost visitor use services were based on the lost fishing and paddling opportunities on the section of Clear Creek that was closed to the public. Lost fishing use days were estimated considering the number of fishing days that would have occurred in absence of the spill between 20 July 2002 and 31 October 2002 (the end of the fishing season). Using the number of visitors per week and weekend day found in the Preassessment Study (see *4.2.8 Visitor Use*), this analysis resulted in 509 lost fishing days (NPS, 2006i). A benefits transfer methodology was used to determine the economic value of each fishing day lost as a result of the spill. This methodology uses economic values previously estimated in similar studies for similar resources to determine the injury. Past studies with similar conditions as the Obed WSR indicated that the 509 lost fishing days was valued at $29,654 (NPS, 2006i).

Lost paddling days were estimated in the Preassessment Study (see *4.2.8 Visitor Use*) as the number of baseline paddling days that occurred between 20 July 2002 and 6 February 2003 (when the closure was lifted on Clear Creek) in the absence of the spill. The benefits transfer methodology was again used to determine the economic value of each paddling day lost through the estimates made in past literature at similar sites with non-motorized activities. NPS (2003) estimated that 400 lost paddling days were valued at $26,792. Summing both fishing and paddling losses, the total value of lost visitor use was estimated to be $56,446.

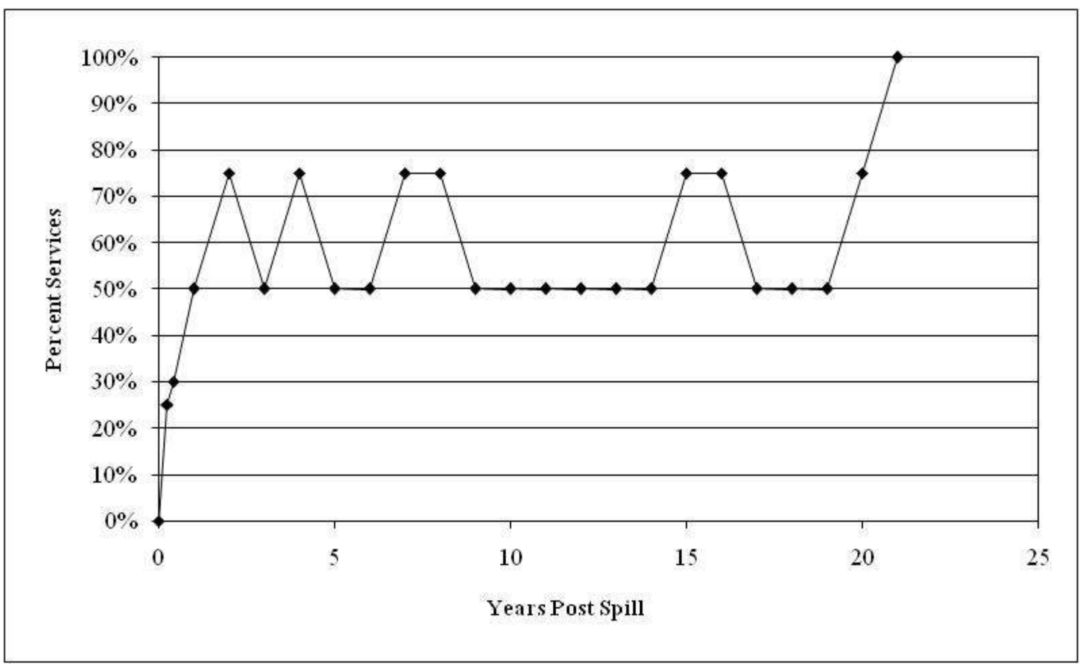

FIGURE 6. Injury curve for stream services for the Clear Creek Seep Reach. It was assumed that increased oil seepage during low-flow conditions 66% of the time (assigned randomly, beginning in 2007) would affect benthic communities. The oil seepage is estimated to continue for 20 years after the spill.

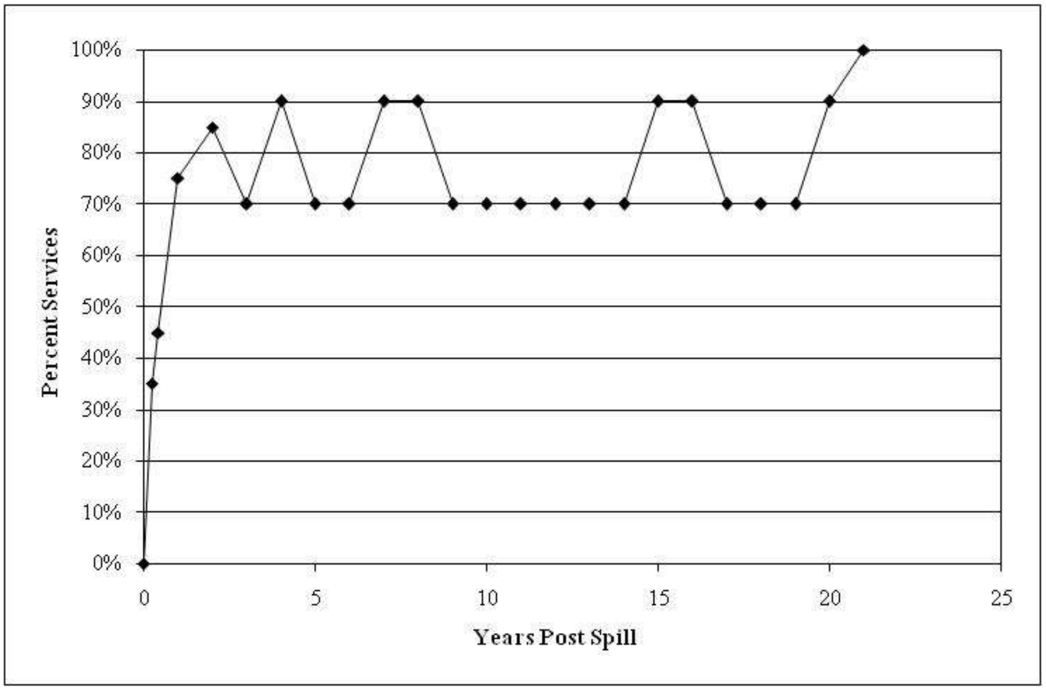

FIGURE 7. Injury curve for stream services for the Clear Creek Downstream Reach. Chronic oil seepage would also affect this stream reach, but at lower levels.

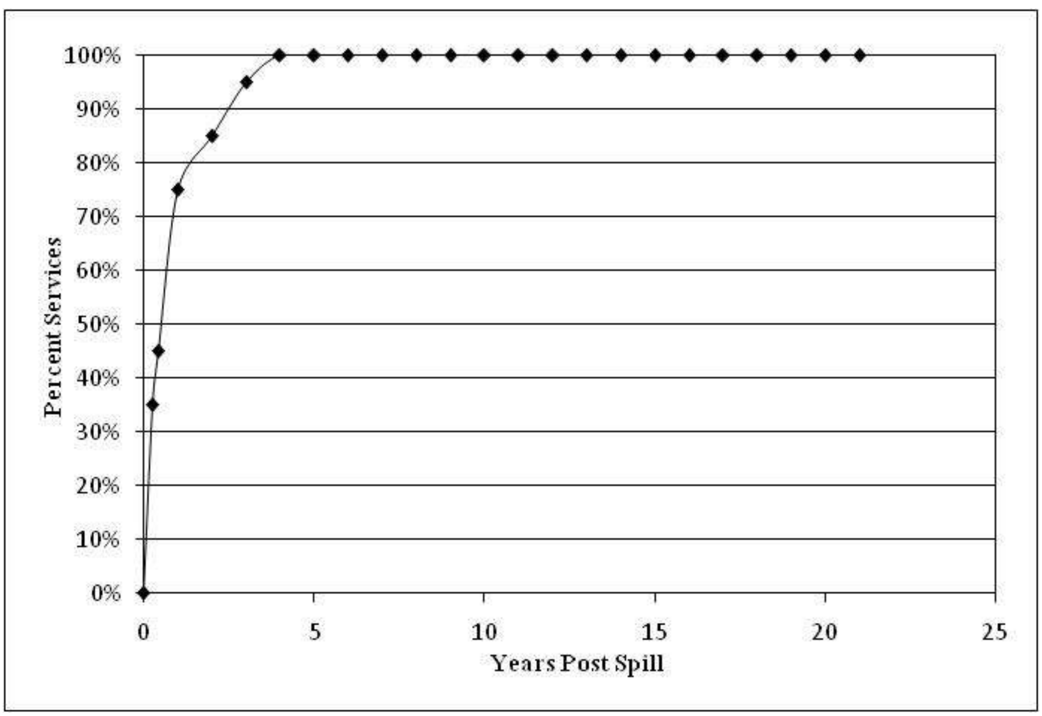

FIGURE 8. Injury curve for stream services for the White Creek Reach. Oil exposure ended in 2002, thus the recovery curve reflects the 2-4 year life histories of an estimated 10% of the benthic macroinvertebrates in the benthic community present.

5.0 RESTORATION ALTERNATIVES

The goal of restoration under OPA is to restore natural resources injured by incidents to the condition that they would have been if the incident had not occurred. OPA requires that this goal be achieved by restoring natural resources and compensating for interim losses of those resources and their services that occur during the period of recovery. The following sections describe the methods used by the Trustees to identify and evaluate appropriate restoration projects using the guidelines provided by OPA, as well as NEPA.

The restoration alternatives identified by the Trustees for each injured resource are as follows: 1) Natural recovery alternative (synonymous with the NEPA no action alternative) and 2) Preferred alternative. The preferred alternative consists of five restoration actions including, a) Natural recovery as a primary restoration for forest and stream services; b) Primary restoration to restore forest vegetation and soil services in the form of invasive vegetation control in the footprint of the burn area; c) compensatory restoration through an acquisition of land or a conservation easement in the Obed WSR corridor to restore forest vegetation and soil services as well as lost visitor use; d) Improvement of water quality to the Little Obed River, a headwater stream of the Obed River, to restore stream services (i.e., Centennial Park watershed project); and e) Acid mine drainage reclamation project at Golliher Creek to restore stream services if the Little Obed River project cannot be implemented.

5.1 Restoration Strategy

There are two kinds of restoration options available under the OPA guidelines, primary and compensatory restoration. Primary restoration is an action that expedites the return of injured resources to their baseline condition by directly restoring the injured resources. Compensatory restoration addresses interim losses of natural resource services from the time of initial injury until full recovery of natural resources to their baseline condition. The scale of the compensatory restoration projects depends on the nature, extent, severity, and duration of the resource injury. Primary restoration can reduce the amount of compensatory restoration that may be needed.

The Trustees considered several alternatives for each injury (forest, stream, and lost visitor use) before identifying the most appropriate restoration option. All projects were reviewed using the evaluation criteria found in *Section 5.2* (see below) to determine the most appropriate restoration project for the lost services. The preferred projects were then scaled appropriately to compensate for the injury. The following sections describe the restoration options for each resource in more detail.

5.2 Evaluation Criteria

The OPA regulations (15 C.F.R. §990.54) require the Trustees to identify restoration alternatives based on specific criteria. The following criteria, presented in the order listed in the regulations, were considered:

- Cost to carry out the alternative;

- Extent to which each alternative is expected to meet the Trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensating for interim losses;
- Likelihood of success of each alternative;
- Extent to which each alternative will prevent future injury as a result of the incident and avoid collateral injury as a result of implementing the alternative;
- Extent to which each alternative benefits more than one natural resource and/or service; and
- Effect of each alternative on public health and safety.

5.3 Environmental Consequences

The Trustees examined a variety of proposed projects to restore resources and/or services lost as a result of the spill. Cumulative, indirect, and direct impacts as well as project-specific environmental consequences to be considered in both OPA and NEPA regulations for each restoration alternative are provided for each resource under *6.0 Environmental Consequences*.

5.4 Natural Recovery Alternative

OPA requires the Trustees to consider a natural recovery alternative. The natural recovery alternative is synonymous with the NEPA no action alternative. Under this alternative, the Trustees would take no direct action to restore injured natural resources or compensate for lost services pending environmental recovery. Instead, the Trustees would rely on natural processes for recovery of the injured natural resources. To document the natural recovery of injured resources, site visits are warranted. Currently, NPS visits the spill site once every two weeks in the summer months to inspect and monitor the site. NPS documents observations from every site visit. This will continue through the summer of 2008. The RP was periodically visiting the site to cleanup any additional oil that seeped into Clear Creek. It is unclear if the RP is continuing to visit the site.

While natural recovery is the primary restoration option for the injured forest and stream services, the interim losses suffered would not be compensated under the natural recovery alternative. Therefore, the Trustees have not identified this alternative as the preferred alternative for the interim losses for forest and stream services and the lost visitor use.

5.5 Preferred Alternative

The Trustees have identified five restoration actions under the preferred alternative to restore forest vegetation and soil, stream, and lost use services injured or lost as a result of the oil spill. The first action is natural recovery, a primary restoration action to be used for forest and stream services in the location of the injury. The following sections describe the remaining four restoration actions in greater detail.

5.5.1 Invasive Vegetation Control

5.5.1.1 Project Descriptions and Restoration Objectives

The Trustees identified primary restoration in the form of invasive vegetation control in the footprint of the burn area to restore forest vegetation and soils services. The restoration action would be a semi-annual removal of invasive plant species from the footprint of the burn area for at least 25 years. The possible treatment methods that may be used by NPS personnel include foliar application (herbicides sprayed on foliage), cut-stump application (herbicide sprayed on the cut stump), or manual removal. Manual removal is the preferred method, however treatment is dependent on both species and location. If there are trust resources nearby, NPS employs either manual methods only, or cut-stump application of herbicides. Herbicides that include surfactants or oil bases are not used near bodies of water. The restoration objective is to speed the rate of natural recovery by removal of invasive vegetation that, in turn, would aid the forest in re-vegetating the burned slope more quickly with native plants and trees.

5.5.1.2 Probability of Success, Performance Measures, and Monitoring

NPS will monitor the burned forest for the expected 25-year duration of the invasive vegetation removal restoration activities to determine how the natural vegetation is recovering. Thus, they will determine if the invasive vegetation control plan needs to be revised and/or if the plan needs to continue past the time allotted.

5.5.1.3 Approximate Project Costs

To control invasive vegetation, NPS estimated that the area would need to be treated once in the spring and once at the end of the summer, and that each treatment would take approximately one 8-hour day. The cost of a GS 5/1 to work 16 hours per growing season is currently $233.90 including benefits. With a 5% annual increase and 25 years, the total cost is $11,722.

5.5.1.4 Environmental and Socio-Economic Impacts

There are no adverse socio-economic impacts associated with the removal of invasive species. There may be some environmental impacts with the disturbance of soils when removing the vegetation or from the use of herbicides. The manual removal method is preferred, however when manual removal of a species is not possible due to extensive root systems or if removal would cause significant soil loss, herbicides may be used. The Trustees determined that any impacts would be minor as the application of the herbicide to individual plants would be fairly localized. Glyphosate, the main herbicide used in the Park, has an average half-life in soils of 47 days and less than eight days in water, however the amount applied is directly related to the duration of the half-life (WA DOT, 2007). NPS' invasives biotechnician estimated that the amount likely used in the Park would break down in soils within 72 hours (N. Helton, NPS, pers. comm., 2007). Glyphosate is not mobile and has a very low potential to contaminate groundwater. Glyphosate is of relatively low toxicity to fish. In addition, glyphosate has an extremely high ability to bind to soil particles. Accordingly it is not easily leached into either groundwater or surface water (D. Gregg, OCWA, pers. comm. 2007a). Garlon 3A, another herbicide that may be used, has a half-life of 46 days and is also not mobile (VA Dept of Forestry, 1997). The impacts of ground disturbance or herbicides in specific cases are expected to be outweighed by the benefit of the quicker return of native species to the impacted forest site.

5.5.1.5 Evaluation

This project meets the evaluation criteria discussed in *Section 5.2*. It is cost effective, has a high likelihood of success, and has minimal potential for adverse environmental effects. As primary restoration, it will directly restore the injured resources.

5.5.1.6 Alternatives Considered But Dismissed

The Trustees considered several other restoration projects to compensate for the forest injury. Projects that were considered, but then dimissed, included:

- Hemlock Woolly Adelgid Removal: *Adelges tsugae* (hemlock wooly adelgid), an aphid that feeds on and eventually kills eastern and Carolina hemlocks, has been identified in Frozen Head State Park (10 to 12 miles from the Obed WSR). Two predatory beetles, *Sasajiscymnus tsugae* and *Laricobius nigrinus*, feed on aphids and have been identified as an appropriate management tool to control the outbreak of this invasive insect. The NPS states that the aphids will soon be present in the Obed WSR if they are not already present. Many hemlocks are part of the canopy along the streams and are considered extremely beneficial to wildlife and water quality. One project considered was to design a plan using the beetles to protect the hemlocks within the Obed WSR. This proposal was not chosen because NPS expects to eventually receive funding internally to mitigate the possible future aphid infestation.

- Slope Fertilization: The Trustees considered the addition of fertilizer to the contaminated and burned slope to aid in the recovery of the soils and vegetation. This project was not considered further because the Trustees did not want excess nutrients to enter Clear Creek. Clear Creek has an adequate amount of nutrients in the system, and fertilizer runoff from the slope to the stream may cause additional problems.

5.5.2 Land Acquisition

5.5.2.1 Project Descriptions and Restoration Objectives

The Trustees identified compensatory restoration through an acquisition of land or a conservation easement in the Obed WSR corridor to restore forest vegetation and soils services and lost use services. The compensatory restoration action to restore forest vegetation and soil services would be the acquisition of a conservation easement or outright purchase from a willing landowner of a property that borders the Obed WSR. NPS is considering two parcels of land, Tract 101-10 (conservation easement) and Tract 102-14 (land purchase). Figure 9 shows the land ownership along the Obed WSR corridor, with green indicating land under NPS or TWRA management. The two tracts of interest are shown in red. These two tracts clearly represent

FIGURE 9. Map of the Obed WSR showing Tract 101-10 and 102-14 (source: Ron Cornelius, Big South Fork NPS, 2007). The Tracts in green are owned by the Park, The State's Wildlife Management Area, and The Nature Conservancy.

significant gaps in NPS management of the Obed WSR corridor. Tract 101-10 is approximately 169 acres and proposed for acquisition of a conservation easement. This tract lies between river mile 3 and river mile 1 of the Obed WSR (ending about 1 mile upstream of the Obed/Emory confluence). Tract 101-10 is on river left, with the majority of the property facing the Catoosa Wildlife Management Area property that is jointly managed by the WMA and the NPS. Tract 102-14 is approximately 29 acres and located at the junction of Daddy's Creek and the Obed River. Of the two tracts, purchasing Tract 102-14 is the highest priority for the Park because it has river access, scenic value, endangered species habitat, developmental potential, and harvestable timber (NPS, 1992).

Acquiring an easement or an outright purchase of one of the above tracts of land also would compensate for the lost use services. Part of the management objectives outlined in the General Management Plan for the Obed WSR was to provide visitor experience through "the primitive nature of the resource between existing public bridge crossings" and for visitors to "enjoy the special values of the Obed WSR (essentially primitive, unpolluted, and generally inaccessible) while assuring the protection of those values" (NPS, 1994). The assurance that a continuous corridor of land along the Obed WSR will not be developed in the future is following the Parks' management objectives while also compensating for lost visitor use as a result of the spill.

NPS has an approved Land Protection Plan (LPP) that was used to identify potential properties using the following objectives (NPS, 1992):

- Identify those lands or interests in land that need to be in Federal ownership to achieve management unit purposes consistent with public objectives of the unit.
- To the maximum extent practical, use cost-effective alternatives rather than direct Federal purchase of private land: when acquisition is necessary, acquire or retain only the minimum interest necessary to meet management objectives.
- Cooperate with landowners, other Federal agencies, State, and local governments, and the private sector to manage land for public use or protect it for resource conservation.
- Formulate or revise, as necessary, plans for land acquisition and resource use or protection to assure the sociocultural impacts are considered and that the most outstanding areas are adequately managed.

All of the above objectives were considered in the selection of the two priority tracts of land for compensation. The LPP states than an easement is appropriate whenever the protection of scenic values is the major concern, there is no Federal development, and public use is limited to the river and floodplain.

5.5.2.2 Scaling Approach

The Trustees used a restoration curve, similar to the injury curve, to determine the amount of land that could be purchased to compensate for the 24.3 DSAYs of forestry resources lost as a result of the spill and fire. With the acquisition of a conservation easement or the outright purchase of a tract of land with similar characteristics to the injured forest, forest resources would be protected from future development compensating for the lost forest services.

The recovery curve was developed with a maximum service benefit of 50% because only half of the tracts are capable of being developed in the future due to the slope of the properties as well as the floodplain (P. Campbell, NPS, pers. comm., 2007a; M. Hudson, NPS, pers. comm., 2007a). The Trustees also assumed that with the increase in development in Morgan County in recent years, and the development of several new housing subdivisions near the Obed WSR, the likelihood of future development on the land is fairly high. It was estimated that full development of half of either tracts of land could occur within 20 years. The Trustees assumed that the acquisition or purchase would occur in the year 2010. In the absence of the easement or purchase, the Trustees estimated an exponential increase in development from 2010 to 2029 (Appendix A, Table A3). The percentages were provided for each year after the start of the project (2010) to estimate the credit that the easement (or purchase) is providing through the prevention of increasing development on the land. Using the restoration curve inputs shown in Table A3 of Appendix A, the Trustees estimated that 2.3 acres of land could be acquired for a conservation easement in order to restore the 24.3 lost DSAYS.

The Trustees decided to add the lost visitor use restoration resources to the forest injury resources to acquire more land than would have been possible using only forest injury resources. Restoration projects for lost visitor use services were scaled to a dollar amount, where the loss of visitor use days was given a dollar value based on the public being unable to use the resource. The dollar amount of $56,446 will be used to acquire additional acres of the land through a purchase or conservation easement.

5.5.2.3 Probability of Success, Performance Measures, and Monitoring

There is a high probability of success since there are no changes occurring to the natural resources in the acquisition of a land easement or land purchase. The prevention of future development on the property along the Obed River is "protecting the natural systems, cultural resources, landscape character, and biodiversity of the Wild and Scenic River area," one of the management objectives for the resources of the Obed WSR (NPS 1994).

Communication with landowners on a semi-annual basis will be included as part of the monitoring plan in order to prevent easements from being ignored or illegal activities occurring on the land. Overflights and visits to the tract of land may be necessary periodically and are part of the NPS regular monitoring of the Obed WSR corridor (NPS, 1992).

5.5.2.4 Approximate Project Costs

The average cost of an acre of land within the authorized boundary of the Obed WSR is $3,500 (P. Campbell, NPS, pers. comm., 2007b). The forestry services restoration was scaled at 2.3 acres, thus the cost for this component would be $8,050. The compensation from the lost visitor use, at $56,446, would allow for purchase of 16.1 acres. Other costs associated with the application of a conservation easement or land acquisition of a tract include an environmental assessment ($2,500), appraisal ($5,000), and closing costs ($1,500). Thus the total cost for the preferred restoration option of land acquisition to restore forestry resources is $17,050. Additional funding sources identified by NPS would allow additional acres to be acquired, to complete acquisition of a specific tract that exceeded the amount available from the restoration.

The NPS will cover all other costs associated with the land acquisition, including negotiation with the land owner, contract management, and long-term monitoring.

5.5.2.5 Environmental and Socio-Economic Impacts

The placement of a conservation easement on a private tract of land or purchase of a tract of land for NPS use will have some socio-economic impacts as outlined in the LPP (NPS, 1992): 1) Land acquisition will prohibit timber harvesting and future residential development; and 2) lands where easements are purchased may be assessed at a lower tax rate. However, these are minor impacts considering the former is an objective that the NPS is trying to meet (e.g., no invasive activity on the land to compensate for lost forest services). The latter may be compensated through visitors coming to the NPS and spending money on local accommodations and food that would benefit the community.

No adverse environmental impacts are expected with the acquisition of a conservation easement or tract of land. A land easement or purchase will have several positive environmental benefits. The easement or purchase of land along the Obed WSR will benefit the affected resources by providing similar forest vegetation and soils that were lost in the spill and fire, as well as providing natural riparian habitat along the Obed WSR. Land that is prevented from future development is beneficial for wildlife, native plant and tree species, as well as NPS visitors, as the undeveloped primitive character of the forest along the Obed provides a unique natural setting. A land easement or purchase will help to reduce the trend of development along the creek edge, therefore reducing sedimentation of the river. This in turn will also benefit the threatened and endangered species that inhabit Clear Creek. In addition, no impacts to public health and safety or historical or archaeological resources are anticipated. In fact, several of the archaeological sites on Tract 101-10 have already been looted, and increased patrolling and legal consequences could help thwart illegal activities. A conservation easement, as would occur on Tract 101-10, will prompt an archaeological inventory of the area that would help gather more information about what is present on the land and how to best preserve those resources.

5.5.2.6 Evaluation

This project meets the evaluation criteria discussed in *Section 5.2*. The acquisition of land will compensate for interim losses of forest and lost use services (in-kind restoration) and will occur in the same geographic vicinity of the spill (in-place). This has a number of benefits including: (1) the protection of the unique characteristics of the geographic area; (2) no risks to human health or safety; and (3) additional ecological benefits in the form of habitat availability for wildlife and native vegetation. In addition, the opportunity to combine forest restoration with the lost visitor use injury (*Section 5.4.4 Lost Visitor Use*) makes this option cost-effective for both injuries.

The Trustees preferred acquiring land or conservation easement over the restoration alternatives that were dismissed because the former provides important benefits with no adverse impacts to other natural resources. As a Wild and Scenic River, the park's first, most overarching purpose is to provide an environment "protect[ed] for the benefit and enjoyment of present and future generations" (NPS, 1994). Therefore, protecting previously vulnerable land within the

NPS's legislative boundaries should take precedence over new programs for educating and informing the public when such an option is available. This alternative is part of the NPS LPP that has gone through extensive public review and approval, and there are willing landowners who want to preserve the Obed WSR corridor. Other reasons for choosing these tracts of land include:

- Both tracts of land have timber on the property that is mature and harvestable.
- Acquiring either tract would provide continual protection along the river since NPS lands occur on either side of these properties.
- Tract 101-10 is highly desirable for development because the cliffs are sheer and the land leading to them is fairly flat, so homes built on the tract can be built virtually on top of the river, with sweeping views.
- The USGS river gauge at Alley Ford is accessed by crossing Tract 101-10. Preserving that access is important both from a visitor use and scientific perspective.
- Tract 101-10 tract currently offers outstanding recreational values, including scenic views, wilderness character, and solitude.
- Tract 102-14 has river access and is an important put-in, the only one for the section of the Obed River within the park except Potter's Ford, which is 12 miles upstream and much more difficult to access. Also, since that put-in is not owned or controlled by the park, its use as a put-in is at the discretion of the landowner, and ownership may change in the future.
- The portion of Tract 102-14 that adjoins the Obed River contains one of the most significant populations of Cumberland rosemary, a federally threatened plant, within the authorized park boundary.

From the perspective of compensatory restoration for lost visitor use, protecting the land alongside the river from development is extremely important to the overall quality of the recreational experience. Most of Tract 101-10 is in the viewshed of hikers on the segment of the Cumberland Trail that goes through the Obed WSR and Catoosa Wildlife Management Area. A popular stopping place on the Cumberland Trail, Alley Ford, is often used for picnicking and fishing. Preserving the view from Alley Ford would be a positive outcome of the easement that would benefit hikers and fishers, as well as boaters. Development of Tract 101-10 poses a great threat to the viewshed of all park users, but especially boaters, who are most likely to venture into the canyon areas. The upper mile of the tract, which is mostly steep cliffs with flat rims, adjoins a segment of river that is very straight. Any development on the canyon rim would be visible to boaters for a longer period than if that length of the river had more meanders (A. Mathis, NPS, pers. comm., 2007).

Tract 102-14 is an important access point for whitewater paddlers. Catoosa Wildlife Management Area is closed to visitors for much of the paddling season and, during these closures, Obed Junction is the only available put-in for the Obed River canyon run and the only available take-out for the Daddy's Creek canyon run. Obed Junction is also very popular with campers and fishermen. Tract 102-14 is rugged and extremely beautiful. It is bordered on one side by Ramsey Creek, a significant tributary of the Obed River. This cascading, boulder-filled stream is deeply shaded by hemlock forests and lined with dense rhododendron thickets. A high rock outcropping on Tract 102-14 provides a commanding view of the junction of the Obed and

Daddy's Creek. The Obed River itself at this point features a long, very scenic series of rapids and shoals (M. Hudson, NPS, pers. comm., 2007b). The recreational experience by visitors to the Park would be enhanced by the purchase of this tract of land.

5.5.2.7 Alternatives Considered But Dismissed

The Trustees considered one other restoration project to compensate for the forest injury. The project that was considered, but then dimissed, included:

- Acquisition to an Identified Recreational Climbing Site: One tract of land exists adjacent to the park boundary with approximately 3.0 acres of privately owned land used by climbers. This piece of land is similar in vegetation, slope, distance to the creek, and available habitat as the land that was injured in the spill and fire. This option was not considered further as there was no willing seller.

The Trustees considered several restoration projects to compensate for the lost visitor use. Projects that were considered, but then dismissed, included:

- Wayside exhibits for the Nemo Bridge access site, including:
  - Two custom rail-mounted low profile bases that allow for interpretation of the river ecosystem and the history of the area,
  - A three-sided upright base with one bulletin case at the Trailhead for general visitor information, warnings, and other notifications,
  - A parking lot entrance sign, and
  - One trail distance sign (to describe trails and trail distances).

The potential cost for these exhibits is estimated at $30,900. This option was not selected as potential funding sources may already exist through NPS Project Management Information Systems.

- Public education cases/signs for Lilly Bluff/Nemo bridge access areas that would include:
  - Trail signage (trailhead signs, milemarkers, etc) in the Lilly Bridge access area
  - Extra wayside panels in case of vandalism
  - Two more three-sided upright bases with bulletin cases (one for both Lilly and Nemo Bridges)

The potential cost for these case/signs is estimated at $10,000-$20,000. This option was not selected as there are already funding sources identified through the NPS Project Management Information Systems program to support this project.

- Addition of an audio/visual kiosk in the visitor center for slideshows or park video (to be produced at a later date) that would include:
  - Kiosk shell
  - LCD monitor
  - DVD player or computer to play the A/V production

The potential cost for the audio/visual kiosk is estimated at $3,000 - $4,000. This option was not selected as potential funding sources may exist through the NPS Project Management Information Systems program.

5.5.3 Stream Restoration

No primary restoration was available to expedite recovery of stream services other than natural recovery. The Trustees considered efforts to stop the seepage of oil into Clear Creek; however, there are many difficulties with this alternative because it is not technically feasible to control the movement of oil in the geological formation. Capturing the oil would be a possibility, but would also be unlikely because the terrain would not allow for installation of a recovery trench, etc. The Trustees have referred all regulatory issues regarding the well to the appropriate regulatory authorities.

The Trustees identified the improvement of water quality to the Little Obed River (Centennial Park watershed project), a headwater stream of the Obed River, as an option to restore stream services. A second project was identified in the event that the Little Obed River option could not be completed and also to evaluate the cost effectiveness of the option. The second alternative selected was the restoration of an abandoned coal mine site on Golliher Creek where acid mine drainage (AMD) occurs, draining into Crab Orchard Creek. Crab Orchard Creek flows into the Emory River.

These projects were identified to aid in improving the water quality that will, in turn, restore the stream services that were lost as a result of the oil releases.

5.5.3.1 Project Descriptions and Restoration Objectives

5.5.3.1.1 Centennial Park Watershed Project

The Little Obed River is a headwater stream to the Obed River that drains approximately 5 square miles within the city limits of Crossville, TN. The health of the Obed River depends on the quality of the inflows from all the tributaries that contribute to the river (D. Gregg, OCWA, pers. comm., 2007b). The water quality of the Obed River is affected by the activities within the river corridor itself, but also by any activities that occur alongside the smaller creeks and streams that empty into the Obed River. Dilution and regeneration allow rivers to accommodate some amount of disturbance along their corridor or headwater streams; however, if the volume or toxicity of a pollutant becomes significant, waters downstream can be impacted (D. Gregg, OCWA, pers. comm., 2007b). One of the smaller streams that empty into the Little Obed River also runs through Centennial Park, a Crossville City park with baseball fields and other recreational areas with manicured lawns and trails. The upper reaches of this small stream are heavily developed, and there are large commercial buildings and parking lots that drain into the city park. The stream has been channelized in the upper section of the city park, and currently the banks are unstable. Silt covers the bottom of the creek. Restoring this small stream that flows into the Little Obed River would alleviate some of the pollutants entering the Obed River.

The Trustees chose restoration of the Centennial Park stream as part of the preferred restoration alternative to compensate for stream injuries in the Obed River. The restoration activities include streambank restoration and vegetation, removal of invasive vegetation, and creation of a bog garden and rain gardens. Streambank restoration would require site preparation on 1.82 acres (creating more normal bank slopes), and landscaping for erosion control. Removal of invasive plant species from existing riparian buffer would be needed on 3.56 acres, affecting 750 ft of the stream. The bog garden and rain gardens would act as a filter strip to catch nonpoint source runoff. The bog garden would require site preparation, a sign and boardwalk, and planting of native vegetation. The rain gardens would require site preparation, plant materials, and labor. The restoration objectives would be to return the headwater stream banks in Centennial Park to their original contour and vegetation, thereby reducing the effects of erosion and nonpoint source pollution and improving the overall water quality of the stream through stormwater detention and filtering. An increase in the water quality for this project would be based on an increase in the health of benthic macroinvertebrate community in the stream over time.

5.5.3.1.2 Golliher Creek

Golliher Creek is a tributary to Crab Orchard Creek which empties into the Emory River (Fig. 10). The Obed River is a tributary of the Emory River above the junction with Crab Orchard Creek, thus Golliher Creek is not part of the Obed WSR drainage. Prior to the passage of the Surface Mining Control and Reclamation Act of 1977, coal mining occurred in the upland areas of Golliher Creek. The coal mining activities left open pits along the creek channel, and acid-forming material that was exposed during the operations oxidized and created pockets of standing and flowing surface water with depressed pH and elevated mineral content. Golliher Creek was then exposed to the acidic materials during runoff events. Although coal mining operations have been abandoned, the runoff events continue to carry the acidic materials into the creek (TDEC, 2001). The total surface disturbance at this site is approximately 17 acres.

Golliher Creek is currently listed in the TDEC 303(d) 2006 List of Impaired Waterbodies as a result of AMD. Active soil loss and release of AMD in Golliher Creek has caused low pH ($pH \leq 3.0$) and elevated levels of manganese and iron in the water (TDEC, 2006). Fish and other aquatic life cannot tolerate the high acidity levels ($pH \leq 6.5$) (Fairchild et al., 1999). Improved water quality and, in turn, a fully supporting aquatic community would require the remediation of the AMD sites along Golliher Creek. There are two abandoned mine sites on either side of Golliher Creek located 1.5 miles upstream of the junction with Crab Orchard Creek. TVA has already begun a remediation project at the abandoned mine on the northeast side of the creek; they are projected to complete the project in the summer of 2008. However, there are no plans or funds to remediate the other abandoned mine on the southwest side of Golliher Creek. The Trustees decided that this would be an appropriate restoration project to compensate for injured stream services because, with restoration of the second site, all AMD into Golliher Creek would be controlled and the stream would be able to fully recover. Other AMD sites were visited and evaluated, but none provided the opportunity for cost-effective and complete control of AMD into a stream reach.

The restoration project on the southwest side of Golliher Creek would be accomplished in two phases. The first phase would include the regrading and revegetation of the 17 acres of land

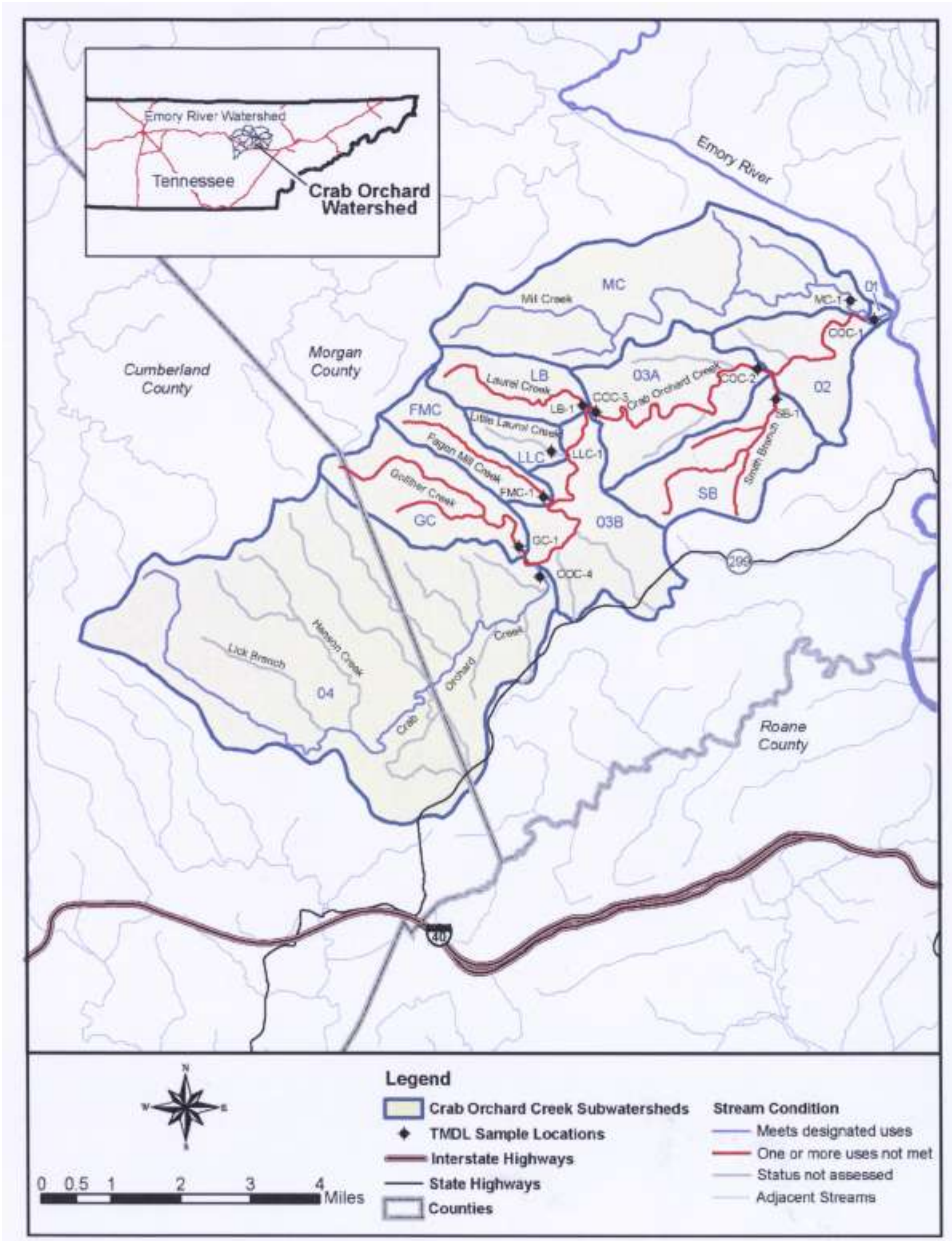

FIGURE 10. Map of Golliher Creek (source: TVA, 2004).

followed by the establishment of positive surface drainage. Revegetation is completed by seeding the soil using seed, commercial fertilizer, agricultural limestone, and mulch material on newly graded areas. The soil is pulverized with lime and fertilizer and then seed is applied to the soil with a hydroseeder, cultipacker seeder, or tractor-mounted cyclone seeder. Three tons of straw or hay mulch per acre will be anchored to the soil using a mulching machine immediately following seeding. Positive surface drainage and stabilization of the site would require grading to eliminate pits or any depressions that would hold water.

After grading is complete, surface drainage would be provided by construction of grass-lined waterways. Terraces may be constructed to carry runoff to grassed waterways. The second phase of the project would occur after the hydrology of the site was stabilized. The seeps would be located and the AMD treatment systems would be constructed. AMD Passive Treatment Sizing is determined using a web-based cost-modeling tool provided by the U.S. DOI Office of Surface Mining (http://amd.osmre.gov/). However, the Crab Orchard Creek Watershed Restoration Plan (TVA, 2004), developed by TVA, TDEC/Division of Water Pollution Control and the Emory River Watershed Association, suggested using two limestone treatment ponds and the creation of one wetland to reduce acidity on the northeastern AMD site on Golliher Creek. For cost estimates, the Trustees assumed that a similar number of treatment ponds/wetlands would be needed on the southeastern AMD site as well. Further ground surveys will be needed to determine the actual number of ponds and wetlands required to reduce AMD.

Restoration objectives include controlling the active soil loss from the upland banks of Golliher Creek, reducing the acidity in Golliher Creek, and measuring an increase in the TMI score indicating a return of aquatic life to the waterbody.

5.5.3.2 Scaling Approach

5.5.3.2.1 Centennial Park Watershed Project

To scale the injury of the stream services from Clear Creek and White Creek to the Centennial Park Watershed Project, the Trustees compared the ecological importance of each stream. The Little Obed River headwater stream was assumed to be equivalent to Clear Creek and White Creek in ecological services because of the high secondary production in headwater streams. Larger creeks and streams, such as Clear Creek and White Creek, have higher numbers of mussels and fish but are a smaller source of macroinvertebrate or secondary production. Even though primary headwater streams are much smaller in size, they provide downstream creeks and rivers with an essential water supply and food source (macroinvertebrates and decaying organic matter) (Ohio EPA, 2003).

The Trustees estimated the number of DSAYs generated for each restoration activity. The first activity, streambank restoration, will increase stream services in 0.19 acres of stream habitat (1,660 ft long and 5 ft wide). It would begin in 2009 and generate a 20% increase in stream services (i.e., macroinvertebrate biomass) each year after completion until reaching 80% (at year four). Other injuries in the watershed will constrain full ecological functioning in the stream. The streambank restoration is assumed to have a lifespan of 75 years. Streambank stabilization, coupled with fencing, led to revegetated eroding banks and a significant increase in macroinvertebrate densities in an intensely grazed riparian area of a small Pennsylvania creek (Carline et al., 2004). Discounting the percent services each year into the future generates 3.68 DSAYs from streambank restoration (Appendix C, Table C5).

The second restoration activity in Centennial Park, invasive vegetation removal along 750 ft of stream, would generate a small increase in stream services. The Trustees assumed that invasive vegetation along the stream banks already provided some services, therefore, the project started in 2009 with 50% of services already present. Services would increase by 10% every year until reaching 80% where services would remain for the life of the project. The experience is that invasive species are never completely removed from the system, therefore, an increase in benthic macroinvertebrates as a result of an increase in the natural vegetation would never reach 100%. Furthermore, other injuries in the watershed will constrain full ecological functioning in the stream. As was done for streambank restoration, discounting the percent services each year into the future and giving the project a lifespan of 75 years generates 0.18 DSAYs from invasive vegetation removal (Appendix C, Table C6).

The third restoration activity in Centennial Park is construction of 2.12 acres of bog garden. Bog gardens act as water detention structures to slow stormwater discharge into streams and as filter strips to control nonpoint sources; they provide only limited benefits for secondary production (Burr, 2007). The filtering of pollutants through the garden will improve water quality and that, in turn, will provide a better habitat for macroinvertebrates in downstream sections of the stream in Centennial Park. Vegetated filter strips used in agricultural practices have been highly successful at protecting waterbodies in various ways that include (Dillaha et al., 1989):

- Intercept surface runoff trapping as much as 75 to 100 percent of sediment,
- Capture nutrients in runoff through plant uptake and adsorption to soil particles,
- Promote the change of pollutants into less toxic forms, and
- Remove over 60% of some pathogens from the runoff.

The primary benefit of the bog garden will be improvement of macroinvertebrate production downstream, but it will also provide aquatic habitat for macroinvertebrates within the footprint of the bog garden. To include this benefit, the Trustees assumed that the bog garden habitat would provide up to 25% of the stream services of the open stream habitat (Burr, 2007). The Trustees assumed a 5% increase in production after each year following the completion of the bog garden with a maximum service benefit of 25% over the lifetime of the project (75 years) (Appendix C, Table C7). Creation of the 2.12-acre bog garden generates 12.60 DSAYs.

The fourth restoration activity proposed by the Trustees is the creation of 2.0 acres of rain gardens and water detention structures. A rain garden is constructed by excavating an area, placing gravel within the area and then covering the gravel with landscape filter fabric and soil/compost mix. The perimeter of the site is then planted with non-grassy vegetation (e.g., trees and water tolerant shrubs) while the interior is planted with water tolerant herbaceous perennials. A low berm is constructed on the downslope side of the garden to allow for standing water during storm events. The rain garden increases the rate of water infiltration into the ground and acts as a storage facility so that runoff is captured instead of flowing directly into the stream. The primary benefit of the rain gardens will be improvement of macroinvertebrate production downstream through retention and filtering of stormwater runoff, but they will also provide aquatic habitat for macroinvertebrates within the footprint of the rain gardens. To include this benefit, the Trustees assumed that the rain garden habitat would provide up to 20% of the stream services of the open stream habitat (Burr, 2007). The Trustees assumed a 5% increase in production after each year following the completion of the bog garden reaching 20% stream services over the lifetime of the project (75 years) (Appendix C, Table C8). Creation of 2.0 acres of rain gardens generates 9.65 DSAYs. These four restoration activities in Centennial Park, Crossville, TN would generate 26.1 DSAYs of restoration, which is equal to the DSAYs calculated for injury to stream services.

5.5.3.2.2 Golliher Creek

For restoration scaling purposes, the Trustees assumed that the abandoned mines occurring on the northeast and southwest sides of Golliher Creek were supplying equal amounts of acidity load into the creek (the disturbed number of acres are similar). The northeast side of the creek is currently being restored with completion estimated by 2008. The Trustees assumed that the restoration on the mine site northeast of the creek would decrease sediment and acidity loads into Golliher Creek by 50%, and the restoration of the mine site on the southwest side of Golliher Creek would reduce all remaining sediment and acidity loads, thereby accomplishing 100% removal of the sources of injury to Golliher Creek. Based on the Crab Orchard Creek Watershed Plan (TVA, 2004) and site visits by the Trustees, there are no other sources of AMD in Golliher Creek.

Remediating Golliher Creek AMD sites to remove the entire acidity load introduced by the mines will have some effect in downstream reaches beyond Golliher Creek. However, the effect will quickly decrease once the stream enters the mainstem of Crab Orchard Creek because of dilution with the highly acidic waters of Crab Orchard Creek. The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) was used to determine the downstream benefits in Crab Orchard Creek of 100% reduction in anthropogenic acidity in Golliher Creek. The calculations used in this analysis were based on data for stream flows and acidity in the Crab Orchard Creek Watershed Restoration Plan (TVA, 2004) for specific stations along the main stem of the creek. The Crab Orchard Creek station closest to Golliher Creek is located about 4 miles downstream from the mouth of Golliher Creek. The percent and absolute change in acidity load is related to stream flow, thus different stream flow conditions were used in the STEPL calculations. Even with 100% reduction in the acidity from Golliher Creek, the acidity reduction in Crab Orchard Creek under low-flow conditions was only 15% and under median-flow conditions was 59%. Under these conditions, aquatic life would still be significantly injured because of their frequent exposure to highly acidic water (pH< 3) during regular low-flow conditions. Based on this analysis, no benefits to stream services were considered downstream of Golliher Creek.

To scale the Golliher Creek restoration project to the amount of injury to the stream, the Trustees assumed that the remediation of the abandoned mine on the southwest side of the creek would be complete in 2009. Based on previous AMD reclamation projects, it was assumed that once complete, the water quality would improve almost immediately. This was shown in Goodrich-Mahoney and Ziemkiewicz (2006) when a partially reclaimed surface mine near

Valley Point, Preston County, West Virginia was restored in 2004 using a passive AMD treatment system. Water quality sampling one month later revealed a 95% removal efficiency for acidity, iron, and aluminum. With the pH restored, Trustees estimated that, within the first year of project completion, 50% of benthic macroinvertebrates would return to Golliher Creek and after two years, 100% of macroinvertebrates would return. These percentages were based on the life history of species known to inhabit streams systems in Tennessee Bioregion 68a. Most benthic macroinvertebrate species (i.e., mayflies, caddisflies) have short life histories (less than one year) and, therefore are able to repopulate a waterbody in a relatively short time period once the invertebrates drift into an area. The passive AMD treatment systems are constructed to have a life span of approximately 30 years providing services until 2039. Using these estimates, the remediation of the AMD site would restore 1.82 acres of Golliher Creek (7,920 ft long and 10 ft wide) and produce 30.2 DSAYs (Appendix C, Table C4) to compensate for the injured stream services that were calculated to be 26.14 DSAYs.

5.5.3.3 Probability of Success, Performance Measures, and Monitoring

5.5.3.3.1 Centennial Park Watershed Project

The Centennial Park Watershed Project is a strong candidate for restoration because of the commitment of the Obed Watershed Community Association (OWCA), a 501(c)(3) membership organization that was formed in 2005. Their goal is to increase public appreciation for the cultural, historical, and environmental resources of the Obed River watershed within Cumberland County through encouraging programs and activities that will protect these resources. In February 2007, OWCA received a grant from TDEC to set up a volunteer monitoring project for three injured stream segments in the Obed River watershed and develop Watershed Restoration and Management Plans for these streams (the streams did not include the Little Obed River). OWCA has a Technical Advisory Committee made up of representatives of TDEC, Tennessee Tech University Center for Water Management, Natural Resource Conservation Service, TWRA, TVA, Tennessee Department of Transportation, NPS, Veolia International (the company that has the contract to manage Crossville’s Wastewater Treatment plant), and DEPA (a private environmental consulting firm). In addition, OWCA is involved with the Habitat Conservation Plan process that has begun recently and includes all of Cumberland County. Its staff, Louise Gorenflo and Dennis Gregg, have almost 30 years of experience working in Cumberland County on a range of issues of concern to the community, and they both hold Master’s degrees in Ecology from the University of Tennessee. Thus, OWCA has the technical experience, financial support, and community outreach to be successful in implementing the restoration project.

In addition, the City of Crossville will be an active partner in the Centennial Park Watershed Project. They have committed to provide personnel and equipment to help construct components of the projects and to maintain these new aspects of the park once completed.

Monitoring will be a key component of the Centennial Park Watershed Project. OWCA has developed a volunteer-based monitoring program that it is using for studies under contract with TDEC on three stream segments. Because benthic macroinvertebrate monitoring is not part of the planned monitoring program in Centennial Park, it has been included at additional costs.

5.5.3.3.2 Golliher Creek

The Golliher Creek site is a strong candidate for restoration because there are baseline data already available for this creek, a watershed plan has been developed for this site (TVA, 2004), and the TDEC Tennessee Land Reclamation Office has already begun the restoration of the opposite (northeast) side of the creek that is scheduled to be complete in 2008. The Crab Orchard Creek Restoration Partnership is a consortium of agencies and groups that are interested in restoring Crab Orchard Creek and its tributaries and removing them from the 303(d) list. Partners include TDEC, TVA, Emory River Watershed Association, Morgan County, Oakdale School, Natural Resource Conservation Service, TWRA, University of Tennessee, Tennessee Scenic Rivers Association, and Chota Canoe Club. The goals of the Crab Orchard Creek Restoration Partnership are to restore Crab Orchard Creek and its tributaries to fully supporting their designated uses, and protect public health and well being by reclaiming hazardous abandoned mine land. Thus, there is a well-established organization to oversee and manage the restoration project. Restoring the abandoned mine site on the southwest side of Golliher Creek would complete the restoration in this tributary.

Ziemkiewicz et al. (2003) summarized performance data for 18 limestone leach bed sites located in Tennessee, Alabama, West Virginia, and Indiana. Limestone leach beds are similar in functionality to limestone ponds (TVA, 2004) but little data exist on the performance of limestone ponds. The acidity reduction factors were calculated for each limestone leach bed site and, excluding minimum and maximum calculated values, the acidity reduction factor was 93% (Ziemkiewicz et al., 2003). Fairchild et al. (1999) observed a significant recovery of water quality, fish, and invertebrate communities following the reclamation of an abandoned surface mine site in western Missouri.

There would be no monitoring costs associated with this project because the northeast side restoration (completed by TDEC) is already being monitored. That monitoring will continue, serving to monitor the southwest side as well. TVA (2004) recommends the following monitoring plan for the AMD reclamation sites in Crab Orchard Creek:

Mine Site Monitoring:

- Pre-reclamation sampling of seeps will be conducted to establish a baseline, including 3-4 sample collections under variable conditions (low and high flows). Parameters to sample include: pH, conductivity, acidity, alkalinity, iron, manganese, and aluminum.
- Post-reclamation sampling: mine reclamation treatments will be monitored to assess effectiveness and to ensure that the reclamation installations remain intact and function properly. Monitoring schedule will be quarterly for one year.

In-stream Water Quality Monitoring:

- Post-reclamation monitoring: stream segments will be monitored quarterly for one year following reclamation. Parameters sampled to include pH and conductivity.
- Post project, there will be a year of monitoring for pH, conductivity, acidity, alkalinity, iron, and manganese to support delisting restored stream segments.

Biologic Community Monitoring:

- Identify and assess 3rd and 4th order creeks to use as reference sites. Post-reclamation conditions in Golliher Creek (3rd order stream) and Crab Orchard Creek (4th order) will be compared with reference creeks of comparable size. Possible least degraded streams could include Laurel Creek, above the small tributary, or the upper headwaters of Crab Orchard Creek above the TDEC COC-4 sample site.
- Pre-reclamation monitoring of stream segments to establish baseline with one sample collection using a semi-quantitative single habitat (SQKICK) survey method.
- Post-reclamation monitoring of all restored stream segments, one sample collection using SQKICK methodology (this collection coordinated with the year of sampling to support delisting of stream segment). Timing to allow at least two years of recovery time for macroinvertebrates.

Long Term/Periodic Assessment:

- TDEC Watershed Monitoring**:** TDEC will conduct monitoring of Crab Orchard Creek as part of their regular watershed planning cycle at one sample location. TDEC's watershed planning process includes sampling of this location on a five-year interval.

5.5.3.4 Approximate Project Costs

5.5.3.4.1 Centennial Park Watershed Project

The costs for the restoration projects in Centennial Park were developed by the OWCA. Some of the restoration projects will be cost-shared through in-kind contributions by the City of Crossville Department of Public Works and volunteer efforts by local citizens, as described below and shown in Table 5.

TABLE 5. Costs for restoration activities in Centennial Park, Little Obed River watershed.

Activity	Estimated Cost	Contributed Cost by Others	DARP Contribution
Invasive Vegetation Removal	$7,120	$7,120	$0
Streambank Restoration	$91,000	$66,000	$25,000
Streambank Landscaping	$64,980	$0	$64,980
Bog Garden	$42,900	$11,040	$31,860
Rain Garden	$435,600	$217,800	$217,800
Monitoring	$50,000	$0	$50,000
Oversight and Administration	$71,049	$0	$71,049
Totals	**$762,649**	**$301,960**	**$460,689**

Invasive vegetation removal is estimated to cost \$2,000 per acre for 3.56 acres, or \$7,120. This project will be implemented using in-kind volunteer labor overseen by certified personnel in invasive vegetation removal and herbicide application.

Streambank restoration consists of site preparation work to create a more normal bank slope, which will cost \$91,000 for 1.82 acres at \$50,000 per acre. However, the City of Crossville Department of Public Works will remove the existing sewer line adjacent to the stream as part of their planned sewer system upgrade program in 2008, thus the additional costs to restore the stream banks to a more natural slope and planting woody vegetation is estimated to cost \$25,000 beyond what would normally be expected for the planned work by the City. In addition, buffer areas around the stream will be graded and planted for erosion control. The costs for this work on 7,220 ft^2 are \$9/ft^2, for a total of \$64,980.

The bog garden costs include a design fee (\$4,000), site preparation (\$2,000), boardwalk construction (\$22,500), plants and labor (\$12,000), and signage (\$2,400), for a total of \$42,900. The City of Crossville Department of Public Works and volunteers will contribute much of the labor and equipment for this project. Actual out-of-pocket expenses are estimated to be \$31,860.

The OCWA has identified six sites for construction of rain gardens and runoff detention structures, covering an estimated 188,500 ft^2. They estimate the costs for construction, planting, and maintenance of the rain gardens at \$5/ft^2. Through the restoration scaling calculations, it was determined that 87,120 ft^2 of rain gardens would offset the remaining stream services injuries, at a cost of \$435,600. However, the City of Crossville and volunteers will contribute some labor and equipment, offsetting the costs by an estimated 50%, thus the costs to be covered by the restoration project are estimated to be \$217,800.

It will be important to monitor the effectiveness of these restoration projects in Centennial Park. The OWCA and its volunteers will be conducting monitoring studies of the projects that include visual assessments (using the Maryland protocols, which are an assessment of the stream morphology and sediments) and water quality measurements. Additional costs are estimated to be \$10,000 per year for collection and analysis of benthic invertebrate samples.

The OWCA costs include a half-time staff member to oversee the project, report to the Trustees on project status, and prepare required reports. The annual costs include \$20,000 (half-time salary), \$2,000 in benefits, and \$1,683 in overhead costs, for a total annual cost of \$23,683. For the three years of the project period, oversight and administrative costs will be \$71,040.

5.5.3.4.2 Golliher Creek

The first phase of the abandoned mine restoration project on Golliher Creek, which includes regrading, revegetation, and establishing positive surface drainage, is estimated to cost \$10,400 per acre of land. This cost estimate is based on the first phase of work that was completed by TDEC-WPC Land Reclamation Section in 2006 on the northeast side of Golliher Creek (T. Eagle, TDEC, pers. comm., 2007) and accounting for a 10% increase in costs per year until implementation in 2009. Thus, the Trustees will need approxmately \$176,800 to complete the first phase of work on the 17-acre site on the southwest side. The second phase of the project, constructing the two limestone treatment ponds in 2009, is estimated to cost $48,315 per pond for two ponds plus one wetland/settling pond at $43,500, based on cost estimates in the Crab Orchard Creek Watershed Plan prepared by TVA (2004) and accounting for a 10% increase in costs per year since 2004. Monitoring costs are estimated to be $10,000 per year for 5 years. Table 6 provides the list of expenditures and total costs.

TABLE 6. Estimated costs for Golliher Creek Restoration.

Activity	Cost
Phase 1	$176,800
Phase 2	$140,130
Monitoring (5 years)	$50,000
Total Cost	**$366,930**

5.5.3.5 Environmental and Socio-Economic Impacts

5.5.3.5.1 Centennial Park Watershed Project

Restoration activities in Centennial Park will have positive environmental impacts on the affected resources described above in Section *3.0 Affected Environment* (water, sediment, and biological community). Currently, the stream has been channelized in the upper section of the park, banks are unstable, and there is little streamside vegetation to provide shade or habitat in many areas. The stream bottom is silt and provides little benthic invertebrate habitat. All of the proposed activities will improve stream habitat directly through bank stabilization and vegetation and indirectly through stormwater detention and filtering. The improvement of water quality and sediment on the stream bottom, as well as riparian vegetation will provide important habitat and initiate the return of benthic algae, fish, and macroinvertebrates. There may be some environmental impacts associated with application of herbicides in some locations, however they will be used only when manual removal will cause significant soil loss. The removal of invasive vegetation will be done primarily through manual hand control and cutting. Plants will be removed where the soil disturbance will not cause an erosion or siltation problem. Herbicides will only be used on the cut stems of the largest, most woody plants, where the removal of the plant would cause significant soil loss into the stream bed, or where the size of the root system makes removal impractical. The herbicide used, glyphosate, is readily metabolized by soil bacteria and is non-toxic to soil invertebrates. As discussed above, glyphosate is of relatively low toxicity to fish, birds, mammals, invertebrates, and fish. It has an extremely high ability to bind to soil particles and therefore is not easily leached into either groundwater or surface water (D. Gregg, pers. comm., 2007a).

Some of the key components of the Centennial Park project will be its outreach and public benefits. The park is heavily used, and the public will be exposed to the attractive aspects of all of the restoration features. Rather than thinking of how to shed water off of their property, people in the community can begin to see the value of retention as allowing a different kind of self-maintaining landscaping that does not need to be mowed or watered, that attracts birds and other wildlife. The city of Crossville will have a stormwater ordinance (including a stream buffer section) in place by July 2008. However, these regulations will not apply outside of city limits, and their effectiveness ultimately depends on the interest and willingness of the community to protect its waters. The city will be required to train their own public works employees and to sponsor trainings for builders and developers. The projects at Centennial Park will demonstrate techniques and designs that can be used in other projects throughout the watershed. Education of builders, developers, and property owners is key to the adoption of these new practices. Thus, the restoration projects at Centennial Park will have very high educational and socio-economic values.

5.5.3.5.2 Golliher Creek

Restoration of the remaining abandoned mine site on Golliher Creek will have considerable positive environmental impacts on the affected resources described in Section *3.0 Affected Resources* (water, sediment, biological community) located outside of the Obed watershed. Grading, stabilization, and revegetation of the land surface of the abandoned mine will control sediment runoff into the stream and provide better upland habitat. Treatment of AMD discharges will allow return of a fully supporting benthic community. Headwater streams are extremely productive in terms of secondary production, thus the return of Golliher Creek to a fully supporting community will contribute to the improvement of the Crab Orchard watershed. Benthic algae, fish, and macroinvertebrates will return to streams when the pH of the water returns to baseline conditions.

One of the key concerns with abandoned mines in Tennessee is human safety. The steep high wall of the mine against the hillside poses significant hazards from falling off the edge. Piles of unstable mine debris are unsafe for climbing. Restoration of these sites will reduce the risks of injury or death from recreational use. Landowners in the watershed recognize the value of restoration of abandoned mine lands both in terms of environmental quality and public safety.

Crab Orchard Creek once supported muskellunge (*Esox masquinongy)* populations and is a favorite of whitewater enthusiasts. Crab Orchard Creek's designated uses include support of fish and aquatic life, recreation, livestock watering/wildlife, and irrigation. It is listed on the Nationwide Rivers Inventory for exceptional scenic, recreational, geologic, and fish/wildlife values. These uses have been degraded by the poor water quality resulting from AMD. TVA and TDEC are working to mitigate four of the largest sources of AMD in the Crab Orchard Creek watershed, including the site on the northeast side of Golliher Creek. Thus, major efforts are being made to improve water and land quality in the watershed. The full restoration of Golliher Creek will be an important contribution to the overall recovery of the watershed to its full historical use.

5.5.3.6 Evaluation

Both the abandoned mine reclamation and AMD treatment at Golliher Creek and the restoration of the headwater creek of the Little Obed River in Centennial Park aim at improving water quality to two creeks that are currently on the 2006 303(d) list of impaired waterbodies (TDEC, 2006). The costs of both projects are similar, and both provide substantial environmental and socio-economic benefits. The Trustees prefer the Centennial Park watershed project over the Golliher Creek project because the Centennial Park project will restore stream services within the Obed River watershed. The Golliher Creek project is located within the Emory River watershed, below where the Obed River enters the Emory River.

5.5.3.6 Alternatives Considered But Dismissed

The Trustees evaluated several alternatives for compensatory restoration for stream services. These alternatives are briefly described and the reasons for their rejection are summarized below:

- Implementation of best management practices to control sedimentation in streams from non-point sources, similar to the kinds of projects funded under Section 319 of the Clean Water Act. Potential partners including the Natural Resources Conservation Service, TDEC, and the FWS Partners Program were contacted. Several potential sites were visited, but no promising projects were identified within the Obed River watershed. Also, there were few data on which to estimate the benefit of reductions in sedimentation on stream services, particularly in estimating the distance downstream of the benefit.
- Plugging of leaking wells, particularly the one at Potter's Ford. It was felt that there were existing regulations for control of oil discharges.
- Implementation of some elements of the Spotfin Chub recovery plan. The oil spill was not known to have impacted spotfin chub specifically. Also, the Spotfin Chub recovery plan was outdated, and some items on the summary were already being/have been done.
- Acid mine drainage treatment by dosing of Rock Creek with limestone sand. Rock Creek is within the Obed WSR and has very poor water quality. The abandoned mine site was visited by the Trustees and experts in abandoned mine restoration. It was decided that regrading and contouring work on Rock Creek would cause significant damage to the stream and should not be attempted at this time.

5.6 Agency Consultation

NPS has conducted an informal consultation with the USFWS, Tribal Councils, and the Tennessee State Historic Preservation Office (SHPO) for the preferred alternative restoration actions. The USFWS was a participating member of the Trustee Council and assisted in the identification of the restoration actions listed above. The USFWS concurred with the NPS finding that the preferred alternatives occurring within Park boundaries and in the Little Obed River watershed are "not likely to adversely affect" any federally threatened or endangered species listed within the state of Tennessee. The USFWS stated that NPS has fulfilled the requirements of Section 7 of the Endangered Species Act through the informal consultation letter (Appendix E).

Seven Tribal Councils were consulted and asked to contact NPS if they planned to respond. Only one tribe confirmed, the United Keetoowah Band of Cherokee Indians in Oklahoma, and they had no comments on the proposed actions (Appendix F).

SHPO reviewed the area where the preferred alternative actions are to be implemented and concurred that there are no archaeological resources eligible for listing in the National Register of Historic Places (Appendix G).

5.7 Restoration Oversight and Administration

NPS will serve as the Contract Office Representative (COR) and will oversee the implementation of the restoration projects listed above. This includes two meetings and one site visit per year (for a total of two years), periodic conference calls, status reports, and administrative support for each of the projects. Table 7 shows the costs estimated to cover oversight and administrative costs.

USFWS and TDEC will also participate in the support and oversight of the restoration projects. Each agency will also attend two meetings per year and participate in conference calls or provide support to the implementation of the restoration project when needed. The costs for USFWS and TDEC are shown in Tables 8 and 9, respectively. The total costs for oversight and administration by the Trustee agencies are estimated to be $151,835.

TABLE 7. Restoration phase oversight and administration costs for NPS.

Staff	Meeting /Travel Time	Oversight/ Support (Hours	Total Hours	2008 Hourly Rate	2009 Hourly Rate	Cost	Overhead Costs	Travel Costs	Total Cost
P. Campbell	48	80	128	$ 48.32	$ 49.77	$ 6,277.34	$ 1,057.10	N/A	$ 7,334.45
R. Schapansky	48	150	198	$ 36.40	$ 37.49	$ 7,315.31	$ 1,231.90	N/A	$ 8,547.21
J. Carriero	80	80	160	$ 66.26	$ 68.25	$ 10,760.61	$ 1,812.09	$4,610	$ 17,182.69
R. Dawson	80	20	100	$ 66.95	$ 68.96	$ 6,795.43	$ 1,144.35	$2,662	$ 10,601.77
A. Mathis	136	1934	2070	$ 23.23	$ 23.93	$ 48,807.39	$ 8,219.16	N/A	$ 57,026.56
Total Cost									**$ 100,693**

TABLE 8. Restoration phase oversight and administration costs for USFWS.

Staff	Meetings/ Travel Time	Oversight/ Support (Hours	Total Hours	2008 Hourly Rate	2009 Hourly Rate	Cost	DOI Overhead Cost	Travel Costs	USFWS Overhead Costs	Total Cost
S. Alexander	48	345.6	393.6	$ 44.05	$ 45.59	$ 17,641.34	$ 2,970.80	$550	$ 3,274.44	**$ 24,437**

TABLE 9. Restoration phase oversight and administration costs for TDEC.

Staff	Meetings/ Travel Time (Hours)	Oversight/ Support (Hours)	Total Hours	2008 Hourly Rate	2009 Hourly Rate	Cost	Overhead Costs	Travel Costs	Total Cost
D. Mann	52	80	132	$ 43.46	$ 44.76	$ 5,822.77	$ 1,316.53	$ 1,100.79	$ 8,240.09
J. Burr	48	345.6	393.6	$ 36.56	$ 37.66	$ 14,605.87	$ 3,302.39	$ 556.68	$ 18,464.93
Total Cost									**$ 26,705**

6.0 ENVIRONMENTAL CONSEQUENCES

6.1 Environmental Analysis

The following sections describe the potential environmental consequences of the restoration alternatives presented above as required in the CEQ regulations to implement NEPA. Affected resources of the physical (e.g., soil, sediment, and water quality), biological (e.g., aquatic biota and forest vegetation), and cultural environment and human use (e.g., lost visitor use) are explored for positive and negative impacts from two alternatives: 1) Natural recovery and 2) Preferred alternative. The preferred alternative consists of five actions: a) Natural recovery as a primary restoration action to restore forest and stream services; b) Primary restoration to restore forest vegetation and soil services in the form of invasive vegetation control in the footprint of the burn area; c) Compensatory restoration through an acquisition of land or a conservation easement in the Obed WSR corridor to restore forest vegetation and soil services as well as lost visitor use; d) Improvement of water quality to the Little Obed River, a headwater stream of the Obed River, to restore stream services (i.e., Centennial Park watershed project); and e) Compensatory restoration through AMD reclamation on Golliher Creek. Impacts are organized into three categories: direct, indirect, and cumulative.

Direct – Direct impacts are those caused by the implementation of the alternative that occurs at the same time and in the same place as the restoration action.

Indirect – Indirect impacts are those caused by implementing the alternative but that occur later or in a different location from the restoration action.

Cumulative – Cumulative impacts are defined as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions” (40 CFR 1508.7).

The following terms are defined and used in the analysis of impacts, both negative and positive.

Negligible – Resources (e.g., biota, soil, water quality) would not be affected or the effects would be below levels of detection. Visitor use in areas of restoration would not be affected.

Minor – Slight impacts to resources may be detected but are localized and short-term. Alterations in aquatic or terrestrial communities (e.g., density and richness) would occur but would be within the natural range of variability. Visitor use may be altered slightly as a result of restoration alternatives but would be short-term.

Moderate – Impacts on resources are readily apparent. Changes in water, soil, or sediment quality and alterations in aquatic or terrestrial communities may 1) occur over a large area but are short in duration, or 2) be localized but persistent. Visitor use or public recreation may be affected temporarily.

Major – Substantial changes in soil, sediment, or water quality, and native aquatic or terrestrial communities occur and are persistent. Density and richness of native biota are altered permanently. Visitor use and public recreation in an area is affected permanently.

The analysis for both alternatives have been assessed according to the severity of the impact (e.g., negligible, minor, and major), and if the impact was considered positive or negative. Impacts to the physical environment are analyzed in Table 10. Impacts to the biological environment are analyzed in Table 11. Impacts to the cultural environment and human use are analyzed in Table 12.

The direct impacts from the two restoration alternatives ranged from negligible to moderate for negative impacts, and minor to major for positive impacts. The most severe direct impact from the natural recovery alternative was the slow return of the native vegetation in the burned and oiled forest site, affecting soils, vegetation, and visitor use. Temporary disturbance of soils and possible contamination of soils from herbicides and their affects on water quality were among the minor, negative impacts of the preferred alternative during invasive vegetation removal as well as the construction of the Centennial Park watershed project. Some disturbance of vegetation and biota may occur during the Centennial Park project and the Golliher Creek AMD reclamation project, although this was also seen to be minor. Some noise generated from machinery or equipment during the construction process may disturb wildlife or humans. However, impacts from noise are expected to be minor and short term, as they would only occur during the actual excavation activities of the watershed project. The positive impacts outweighed the negative and included a more rapid recovery of native vegetation through removal of invasive species, the prevention of future soil and sediment disturbance through a land purchase or easement, and reduced soil and sediment erosion within the Little Obed River and Golliher Creek. The protection of forest vegetation through a land purchase or easement was considered a major positive impact as it benefits the vegetation, the soil and water quality, as well as visitors to the Park. The Centennial Park watershed project also benefits the public by providing a more scenic area surrounding the headwater stream and provides an opportunity of learning about stream restoration. Overall, the preferred restoration alternative identified by the Trustees will enhance the physical, biological, and cultural/human-use resources of Obed WSR and the watershed.

The indirect impacts from the two alternatives ranged from negligible to moderate for negative impacts, and negligible to major for positive impacts. A decrease in water quality from the runoff during the slow, natural recovery of soil and vegetation was a moderate, negative impact. Minor negative impacts for the natural recovery alternative include the spread of invasive species to other NPS lands. Minor negative impacts for the preferred alternative include: 1) affected water quality and biota from soil disturbance and addition of herbicides during invasive vegetation removal and construction during the Centennial Park watershed project, and 2) affected water quality from turbidity during the Golliher Creek AMD reclamation project. A major positive indirect impact from the preferred alternative was the land purchase or easement action that will provide continuous riparian habitat on the Obed WSR. This will, in turn, support healthy aquatic and terrestrial communities. Acquiring land would help to protect threatened or endangered species by prohibiting development or timber harvesting. Other positive impacts include reducing sediment loads into Clear Creek by increasing the rate of vegetative recovery

TABLE 10. Restoration alternatives impact analysis on the physical environment (soils, water, and sediments).

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
1. Natural Recovery Alternative	**Moderate, Negative:** Oiled soils will continue to recover at natural rates within the spill/burn footprint. Slow vegetation recovery will result in increased soil loss from erosion. Although the impacted area is small, the estimated long term recovery for soil (25+ years) is locally significant. Clear Creek will continue to exist in its present condition, experiencing intermittent pulses of increased oil releases during low flows that will affect water quality.	**Moderate, Negative:** Slow soil and vegetation recovery will result in increased soil runoff from the steep slope into Clear Creek, decreasing water quality for many years.	**Minor, Negative:** With growing water quality concerns in Clear Creek from development in the watershed above the site, increased sedimentation from the burned slope could incrementally affect water quality immediately downstream from the site until the site naturally recovers.
2. Preferred Alternative			
a. Natural recovery	**Moderate, Negative:** Oiled soils will continue to recover at natural rates within the spill/burn footprint. Slow vegetation recovery will result in increased soil loss from erosion. Although the impacted area is small, the estimated long term recovery for soil (25+ years) is locally significant. Clear Creek will continue to exist in its present condition, experiencing intermittent pulses of increased oil releases during low flows that will affect water quality.	**Moderate, Negative:** Slow soil and vegetation recovery will result in increased soil runoff from the steep slope into Clear Creek, decreasing water quality for many years.	**Minor, Negative:** With growing water quality concerns in Clear Creek from development in the watershed above the site, increased sedimentation from the burned slope could incrementally affect water quality immediately downstream from the site until the site naturally recovers.
b. Invasive Vegetation Removal	**Minor, Negative:** Removal of invasive vegetation may temporarily disturb soil in the treatment area; addition of herbicides to remove species may affect soils. However, soil disturbance and herbicide application is localized and contamination of soil would be temporary**. Moderate, Positive:** Removal of invasive species will allow more rapid growth of native vegetation within the burned slope.	**Minor, Negative:** Soil disturbance may temporarily increase soil runoff into water increasing turbidity; addition of herbicides to remove species may affect nearby water quality. **Minor, Positive:** Increasing the rate of vegetation recovery will eventually reduce sediment loads into Clear Creek.	**Minor, Positive:** Although the site is small, an increase in the establishment of a mature vegetation community on the site will reduce sediment loads into a stressed watershed.

TABLE 10. Cont.

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
c. Land Purchase/Conservation Easement	**Major, Positive:** Will prevent development of protected lands and in turn, will prevent future soil and sediment disturbances. Such development is very likely and would include timber removal, soil disruptions, and construction of homes and other structures.	**Moderate, Positive:** Will prevent future soil and water quality degradation associated with runoff from development along the riparian zone in the Obed WSR corridor.	**Moderate, Positive:** Will prevent future soil and water quality degradation associated with runoff from development along the riparian zone in the Obed WSR corridor.
d. Centennial Park Watershed Project	**Minor, Negative:** Temporary impacts to water quality in the Little Obed River within the project site from the application of herbicides, however, they will be used only when manual removal will cause significant soil loss. Removing invasive vegetation and stabilizing banks of the river may cause soil disturbance and some temporary erosion, even when implementing control practices. **Moderate, Positive:** Stabilized stream banks, water gardens, and riparian vegetation will significantly reduce sediment and soil erosion in the project area.	**Minor, Negative:** Temporary impacts to water quality in the Little Obed River downstream from the application of herbicides; however, the amounts used will be very small and have minor, local affects. Temporary increases in turbidity will affect water quality downstream; however impacts are likely to be minor because of the small amount of area to be disturbed at any one time. **Moderate, Positive:** Stabilized stream banks, water gardens, and riparian vegetation will significantly reduce sediment and soil erosion in the downstream sections of the Little Obed River.	**Moderate, Positive:** Stabilized stream banks, water gardens, and riparian vegetation will significantly reduce sediment and soil erosion both in the project area and downstream in the Little Obed River. Public outreach and education during project implementation and as a demonstration site in a highly public area will greatly expand on the cumulative benefits as the public learns about the value of stream restoration.
e. Golliher Creek AMD Reclamation Project	**Minor, Negative:** Temporary impacts to water quality in Golliher Creek during bank stabilization; soil disturbance and temporary erosion may affect Creek waters, although impacts would be short-term. **Moderate, Positive:** Grading, stabilization, and revegetation of the land surface will reduce sediment runoff into the creek and provide better upland habitat.	**Minor, Negative:** Temporary increase in turbidity will affect water quality downstream; however impacts are likely to be minor because of the small area to be disturbed during implementation. **Major, Positive:** Removal of acidic materials will return pH in waters to natural, pre-AMD levels.	**Major, Positive:** The AMD project on the northeast side of Golliher Creek will be completed by 2008, restoring the pH to half of pre-AMD levels. Completing the southwest side of Golliher Creek will complete the restoration.

TABLE 11. Restoration alternatives impact analysis on the biological environment.

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
1. Natural Recovery Alternative	**Moderate, Negative:** Native vegetation will be slow to recover and will have to compete with invasive vegetation for space and nutrients.	**Minor, Negative:** Allowing the growth of invasive species in the burned area may permit the possible spread of invasive species into other areas within the Park.	**Negligible:** No cumulative impacts will be observed on biota or forest vegetation because the burned area represents such a small area within the Obed WSR corridor.
2. Preferred Alternative			
a. Natural recovery	**Moderate, Negative:** Native vegetation will be slow to recover and will have to compete with invasive vegetation for space and nutrients.	**Minor, Negative:** Allowing the growth of invasive species in the burned area may permit the possible spread of invasive species into other areas within the Park.	**Negligible:** No cumulative impacts will be observed on biota or forest vegetation because the burned area represents such a small area within the Obed WSR corridor.
b. Invasive Vegetation Removal	**Moderate, Positive:** Quicker return of native species to the burned slope will benefit all species using this habitat.	**Minor, Negative:** Disturbance of soils during invasive species removal may cause increased turbidity of Clear Creek during runoff events; this may indirectly affect biota by smothering habitats used by biota. Herbicide used on invasive vegetation may cause adverse impacts on aquatic biota if it enters Clear Creek; however the herbicide used is of low toxicity to fish and has a short half-life. **Minor, Positive:** Increasing the rate of vegetation recovery will eventually reduce sediment loads and potential impacts to aquatic biota in Clear Creek.	**Moderate, Positive:** Although the impacted site is small, it presents a gap in the continuity of the riparian buffer in this area. Quicker re-establishment of the vegetation will close this gap sooner.
c. Land Purchase/Conservation Easement	**Major, Positive:** Acquiring land protects the forest vegetation from timber harvesting or development.	**Major, Positive:** Continuous riparian habitat on the Obed WSR will support healthy aquatic communities; continuous forested habitat will support terrestrial biota (e.g., threatened and endangered species and native tree species).	**Moderate, Positive:** Prevention of development will prevent fragmentation of the riparian corridor along the Obed WSR.

TABLE 11. Cont.

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
d. Centennial Park watershed Project	**Minor, Negative:** Some vegetation and biota may be disturbed during the streambank stabilization and construction of the rain and bog gardens. However, the vegetation and biota are already of low quality in this highly disturbed site.	**Minor, Negative:** Stabilizing streambanks and constructing rain/bog gardens may cause soil disturbance and some initial erosion which may indirectly affect downstream aquatic biota via smothering of habitats; however the construction phase should be short-term (3-4 months). **Moderate, Positive:** Sediments on the substrate of the Little Obed River are silt and do not support a healthy population of native biota. Restoring the river will return the substrate to the more natural habitat of sediments that will support the aquatic community. Stabilizing the stream banks and removal of invasive species will also support native plants and associated biota.	**Moderate, Positive:** Stabilized stream banks, water gardens, and riparian vegetation will significantly improve water quality and associated biota in the project area and downstream in the Little Obed River. Public outreach and education during project implementation and as a demonstration site in a highly public area will greatly expand on the cumulative benefits as the public learns about the value of stream restoration.
e. Golliher Creek AMD Reclamation Project	**Minor, Negative:** Some vegetation and biota may be disturbed during stabilization and grading of uplands. However, these activities will provide a more natural upland habitat for vegetation and biota to inhabit.	**Major, Positive:** Treatment of AMD discharges will allow the return of a fully supporting benthic community in Golliher Creek. Return of native fish species to the creek will also occur.	**Major, Positive:** Completing the southwest side of Golliher Creek will complete the stream restoration, with the northeast side having been completed in 2008. The cumulative impact of the restoration of both riverbanks is the return of the benthic community and native fish species.

TABLE 12. Restoration alternatives impact analysis on the cultural environment and human use.

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
1. Natural Recovery Alternative	**Minor, Negative:** The slow rate of natural re-vegetation in the burned area and oil sheens on the water surface during low flow periods will be observable by the public who boat along this part of the Obed WSR. There are no cultural resources in this area.	**Negligible:** No indirect impacts are expected on visitor use.	**Negligible:** No cumulative impacts are expected on visitor use.
2. Preferred Alternative			
a. Natural Recovery	**Minor, Negative:** The slow rate of natural re-vegetation in the burned area and oil sheens on the water surface during low flow periods will be observable by the public who boat along this part of the Obed WSR. There are no cultural resources in this area.	**Negligible:** No indirect impacts are expected on visitor use.	**Negligible:** No cumulative impacts are expected on visitor use.
b. Invasive Vegetation Removal	**Moderate, Positive:** Allowing for the more rapid growth of native vegetation by removing invasive vegetation will provide natural scenic views along Clear Creek for visitors who recreate along the creek. There are no cultural resources in this area.	**Negligible:** No indirect impacts are expected on visitor use.	**Negligible:** No cumulative impacts are expected on visitor use.
c. Land Purchase/Conservation Easement	**Major, Positive:** Land that is prevented from future development is beneficial for visitors of the Park as the wildlife, native plant and tree species, and the undeveloped primitive character of the forest along the Obed WSR provides a unique natural setting for visitors to enjoy; one of the tracts of land being considered is a put-in access point along the river, an important site for recreational boaters. Any cultural resources would also be protected.	**Negligible:** No indirect impacts are expected on visitor use or cultural resources	**Negligible:** No cumulative impacts are expected on visitor use or cultural resources.

TABLE 12. Cont.

Alternative	Direct Impact	Indirect Impact	Cumulative Impact
d. Centennial Park Watershed Project	**Minor, Negative:** Public use of the area being restored may be prohibited during the implementation and construction of the project. Some noise generated from machinery or equipment during the construction process may disturb visitors to Centennial Park. However, impacts from noise are expected to be minor and short term, as they would only occur during the actual excavation activities of the watershed project. **Moderate, Positive:** Centennial Park is heavily used and the restoration project will provide informative and educational opportunities for the public to enjoy.	**Minor, Positive:** The projects at Centennial Park will demonstrate techniques and designs that can be used in other projects throughout the watershed.	**Minor, Positive:** The projects at Centennial Park will demonstrate techniques and designs that can be used in other projects throughout the watershed.
e. Golliher Creek AMD Reclamation Project	**Negligible:** No direct impacts are expected on visitor use. There are no cultural resources in this area.	**Minor, Positive:** Public use of the river may increase with the return of some recreational fish species (i.e., muskellunge).	**Minor, Positive:** The return of rivers to their historical environments has small but cumulative impacts on the larger watershed. The restoration of Golliher Creek provides a small step to improving the quality of the Crab Orchard Creek watershed that was once used for fishing and recreating.

after invasive vegetation removal, prevention of future soil and water quality degradation along the Obed WSR through a land purchase or easement, and the reduction of sediment and soil erosion into the Little Obed River and Golliher Creek. Restoring the Little Obed River will have an indirect positive impact on the aquatic communities of the river by changing the substrate of the river from the current unhealthy silt to a more healthy sediment substrate. Reclamation of the AMD site along Golliher Creek will have an indirect positive impact on the benthic and fish communities by decreasing the acidity levels in the creek waters, promoting the return of native species.

Cumulative impacts ranged from negligible to minor for negative impacts and negligible to major for positive impacts. The only negative cumulative impact was on water quality when choosing the natural recovery alternative. The incremental affect of sedimentation from the burned slope into Clear Creek that is already affected by development upstream of the site was a concern. The incremental affect on water quality would last until the site recovered. Positive impacts from the preferred alternative include: 1) reduction of sediment loads and prevention of future water quality issues through more rapid establishment of a native mature community, 2) continuity of the riparian corridor with the land purchase or easement along the Obed WSR, 3) healthy water quality and biota downstream of the Centennial Park watershed site from re-stabilized banks and bog and rain gardens, and 4) full restoration of Golliher Creek with the reclamation of the southwest riverbanks in addition to the northeast riverbanks.

For actions within the Park boundaries, impairment determinations on NPS resources must be made. An impairment, defined in the Organic Act and the General Authorities Act, is "…an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values" (NPS Management Policies, Section 1.4). The Trustees determined that no impairment of NPS resources would occur from the removal of invasive species or through land acquisition, the only two actions of the preferred alternative occurring within Park lands. NPS regularly removes invasive species in other areas within the park boundary and these actions do not harm the integrity of park resources or values. The Trustees agreed that acquiring land would help to protect threatened or endangered species by prohibiting development or timber harvesting to occur.

As was stated above (*5.6 Agency Consultation*), the preferred alternatives are "not likely to adversely affect" any federally threatened or endangered species listed within the state of Tennessee. The Centennial Park watershed project site does not provide suitable habitat to the listed species that occur in Cumberland County, Tennessee. There is a possibility of three listed species occurring within Park boundaries (i.e. purple bean, spotfin chub, and Indiana bat) however, the preferred alternative actions listed for Park lands are not likely to negatively impact these species.

6.2 Environmentally Preferred Alternatives

The environmentally preferred alternative is the alternative that will promote the national environmental policy expressed in NEPA (Sec. 101 (b)). This includes alternatives that:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Ensure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

The environmentally preferred alternative, based on the above criteria, are natural recovery, invasive species removal, land acquisition, the Centennial Park watershed project, and the Golliher Creek AMD reclamation project. Invasive species removal on the burned slope on Clear Creek ensures that a more natural setting with native vegetation will occur more quickly than if the natural recovery alternative (or no action alternative) was chosen. A more natural setting along Clear Creek is aesthetically pleasing to Park visitors and preserves the important natural aspects along the Obed WSR corridor.

Land acquisition by purchase or easement along the Obed WSR will provide for a continuous corridor along the Obed WSR of which the Park can protect for future generations to enjoy. The sites chosen for acquisition have a wide range of benefits (e.g., river access, scenic value, and endangered species habitat), and there is no risk of degradation or other undesirable consequences to the site that is acquired.

The Centennial Park watershed project will control and filter non-point source runoff, stablize the streambanks, and improve the riparian habitat, which will improve water quality within the Obed River watershed. This project has broader benefits because of the community participation and public outreach components. The Golliher Creek project, only to be implemented if the Centennial Park watershed project cannot be accomplished, would restore the creek to more natural conditions with the removal of AMD. The project will improve water quality and support native habitat and species, returning the waters downstream of the AMD site to their historic uses.

7.0 SUMMARY

7.1 Injury Summary

Three main categories of injury were determined during the Preassessment and Restoration Planning Phases of the Obed WSR NRDA: forestry resources including vegetation and soils, stream services, and lost visitor use. Studies have been completed since the time of the spill (2002) to determine the degree and extent of the injury for the three injury categories.

Using the HEA approach, the injury to forestry resources was determined to be 24.3 DSAYs for the 0.74 acres of injured forest vegetation and soils. The forest was estimated to return to pre-spill biomass standing stock in approximately 172 years.

The stream injury was based on several resource including benthic algae, fish, benthic macroinvertebrates, mussels, sediment quality, surface water quality, riparian vegetation, and groundwater/geologic sources. Three recovery curves were used to quantify the injury to the three stream reaches based on their degree and duration of exposure to oil. The continued chronic release of oil from the site through 2007 was an important factor affecting the recovery rates. The health of benthic macroinvertebrates was an important consideration in quantifying the lost stream services. The injury for the 6.29 acres of injured stream services in Clear and White Creeks was estimated to be 26.1 DSAYs.

The injury to visitor use was estimated using a “value-to-cost” scaling approach based on the lost fishing and paddling opportunities on the section of Clear Creek that was closed to the public. The dollar amount of this loss was estimated to be $56,446.

7.2 Restoration Summary and Timeline

Table 13 summarizes scaling and cost of the preferred restoration alternative actions (excluding natural recovery) for the Obed WSR oil spill incident. The Trustees selected land acquisition/conservation and invasive vegetation control as the preferred restoration action to compensate for the forest injury. The invasive vegetation control will start immediately upon receipt of funds and continue for 25 years. The land acquisition project will be implemented by the NPS within 12 months after receipt of funds. Two tracts with willing sellers have already been identified as part of the Land Protection Plan for the Obed WSR. It normally takes 12-15 months for contract closure once the funds are available.

Land acquisition was also chosen to compensate for lost visitor use in the Obed WSR. It will follow the same schedule as discussed above.

Restoration activities in the headwaters of the Little Obed River in Centennial Park, Crossville, TN will restore lost stream services within the affected watershed. The removal of the invasive species (two week effort) and the restoration of the streambank would occur in conjunction with the relocation and upgrade of the city of Crossville’s sewer lines and therefore would not be implemented before July 1, 2008 (when the city’s FY2009 budget is approved). The construction of the rain gardens (approximately a 3 month effort) could begin any time after receipt of restoration funds, during which a contract would be negotiated with the OWCA for implementation. The overall project is estimated to take 2-3 years for design and construction. Monitoring will continue for five years. The Golliher Creek AMD restoration project was not included in Table 13 as it will only be implemented if the Centennial Park watershed project is unable to occur.

TABLE 13. Summary of injuries, preferred restoration actions, and restoration costs for the Obed WSR oil spill.

Injured Resource	Preferred Restoration Actions	Scale of Restoration	Restoration Costs
Forest Vegetation and Soils	Primary Restoration: Invasive Vegetation Control Compensatory Restoration: Land Acquistion/ Conservation	Removal of invasive species on the burned tract for 25 years. Acquistion of 2.3 acres.	$28,772
Stream Services	Centennial Park, streambank restoration, invasive vegetation removal, creation of a bog garden and rain gardens	Restoration of 1,660 ft of streambank. Removal of invasive species along 750 ft of stream channel. Construction of 2.12 acre bog garden Construction of 1.4 acres of rain gardens	$460,689
Lost Visitor Use	Land Acquistion/ Conservation	Acquistion of 16.1 acres.	$56,446
Oversight and Administration			$151,835
Total			**$697,742**

8.0 REFERENCES CITED

Adams, S.M., M.S. Greely, and M.J. Peterson. 2003. Assessment of exposure and injury to fish from oil discharges into Clear Creek. Proposal prepared by Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN. Prepared for the Clear Creek Oil Spill NRDA Trustee Council. 21 pp.

Adams, S.M., M.S. Greeley, and M.J. Peterson. 2006. Assessment of exposure and injury to fish from oil discharges into Clear Creek. Prepared by Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN. Prepared under contract to the National Park Service, 46 pp.

Ahlstedt, S.A. and S. Bakaletz, 2005. Assessment of freshwater mussel populations in Clear Creek, Tennessee (Emory-Obed River System) following an oil well fire and resulting spill (2005). Prepared for the Obed Wild and Scenic River, National Park Service, Wartburg, TN, 13 pp.

Arnwine, D. 2002. Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys. Division of Water Pollution Control, Department of Environment and Conservation, State of Tennessee.

Burr, J. 2006. Benthic Results – October 13, 2006. Email to the Trustee Council on 7 December 2006. Tennessee Department of Environment and Conservation.

Burr, J. 2007. Memo to the Trustee Council. Tennessee Department of Environment and Conservation.

Burr, J., pers. comm., 2007. Tennessee Department of Environment and Conservation – Water Pollution Control, Knoxville, Tennessee. Email: June 13, 2007.

Campbell, P., pers. comm.., 2007a. National Park Service, Wartburg, Tennessee. Email: January 16, 2008.

Campbell, P., pers. comm.., 2007b. National Park Service, Wartburg, Tennessee. Within email from A. Mathis: June 13, 2007.

Carline, R.F., M.C. Walsh, and A.M. Smith. 2004. Responses of streams to restoration of intensively grazed riparian areas: Spring Creek, West Branch Susquehanna River Watershed. Chesapeake Bay Program, U.S. EPA. 100 pp.

Cooke, S.B. 2006. Quantification of injury to aquatic resources resulting from the Pryor Oil Spill and Fire, Obed Wild and Scenic River. Prepared for the Obed Wild and Scenic River, National Park Service, Wartberg, TN, 34 pp + appendix.

DesJean, Tom. 2002. Report of section 106 cultural resources evaluations for emergency oil spill containment on White Creek. National Park Service. 11 pp.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of ASAE, 32 (2): 513-519.

Eagle, T. pers. comm., 2007. Tennessee Department of Environment and Conservation – Water Pollution Control, Knoxville, Tennessee. Email: May 22, 2007.

Fairchild, J.F., B.C. Poulton, T.W. May, and S.M. Miller. 1999. Evaluation of the recovery of fish and invertebrate communities following reclamation of a watershed impacted by an abandoned coal surface mine. U.S. Geological Survey Toxic Substances Hydrology Program--Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999. Vol 1, Section D: 261-268.

Goodrich-Mahoney, J.W. and P. Ziemkiewicz. 2006. Demonstrating a market-based approach to the reclamation of mined lands in West Virginia. Quarterly Report: Oct 1, 2004 – Dec 30, 2004. National Mine Land Reclamation Center, Morgantown, Virginia. 14 pp.

Gregg, D. pers. comm., 2007a. Obed Watershed Community Association, Crossville, Tennessee. Email: September 6, 2007.

Gregg, D. pers. comm., 2007b. Obed Watershed Community Association, Crossville, Tennessee. Email: April 29, 2007.

Helton, N. pers. comm., 2007. National Park Service, Wartburg, Tennessee. Email: September 10, 2007.

Henley, W.F. 2007. Tissue Evaluations for Determination of Sublethal Effects of Oil Contamination in Freshwater Mussels from Clear Creek, Tennessee. Report prepared by Freshwater Mollusk Conservation Center, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA. Submitted to the National Park Service. 34 pp.

Hudson, M., pers. comm., 2007a. National Park Service, Wartburg, Tennessee. Within email from A. Mathis: January 8, 2007.

Hudson, M., pers. comm., 2007b. National Park Service, Wartburg, Tennessee. Email: June 15, 2007.

Industrial Economics, Inc. 2003a. Documentation of Visitor Impacts from the Howard/White Unit No. 1 Oil Spill. Contract No. 1443CX2605-98-004, Task Order T2310025013 – Ephemeral Data Collection for Oil Spill NRDA at Obed WSR, TN. Prepared under contract to Foster Wheeler Environmental Corporation; MOA014469 – Task 19. 8 pp.

Industrial Economics, Inc. 2003b. Documentation of Visitor Use of Obed Wild and Scenic River. Contract No. 1443CX2605-98-004, Task Order T2310025013 – Ephemeral Data Collection for Oil Spill NRDA at Obed WSR, TN. Prepared under contract to Foster Wheeler Environmental Corporation; MOA014469 – Task 19. 11 pp. + appendices.

Mann, D., pers. comm., 2006. Tennessee Department of Environment and Conservation – Water Pollution Control, Knoxville, Tennessee. Email: December 14, 2006.

Mathis, A., pers. comm., 2007. National Park Service, Wartburg, Tennessee. Email: January 8, 2007.

Mayfield, M.W. 1984. Variations in streamflow among watersheds of the Cumberland Plateau, Tennessee. Ph.D. Dissertation, UT Knoxville, Knoxville, Tennessee.

NPS (National Park Service). 1992. Obed Wild and Scenic River- Land Protection Plan. Department of the Interior. 62 pp.

NPS. 1994. Obed Wild and Scenic River - General Management Plan. Department of the Interior. 161 pp.

NPS. 2003. Damage Assessment and Restoration Handbook. Environmental Quality Division, Environmental Response, Damage Assessment, and Restoration Branch, National Park Service, Department of the Interior, Washington, DC. 61 pp. + appendices.

NPS. 2006a. Howard/White #1 Site Visit, 6/16/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006b. Howard/White #1 Site Visit, 7/3/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006c. Howard/White #1 Site Visit, 7/17/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006d. Howard/White #1 Site Visit, 7/31/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006e. Howard/White #1 Site Visit, 8/16/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006f. Howard/White #1 Site Visit, 9/8/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006g. Howard/White #1 Site Visit, 10/6/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006h. Howard/White #1 Site Visit, 11/29/06. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2006i. Lost Visitor Use Services Howard/White No. 1 Oil Spill at the Obed Wild and Scenic River. Prepared by Bruce Peacock, NPS. 8 pp + attachments.

NPS. 2007a. Howard/White #1 Site Visit, 6/15/07. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

NPS. 2007b. Howard/White #1 Site Visit, 7/16/07. Memo from Amy Mathis, NPS to Steve Spurlin, USEPA.

Ohio EPA. 2003. Fact Sheet: The importance and benefits of primary headwater streams. Division of Surface Water, Ohio EPA, Columbus, OH. 1 pp.

Pennington and Associates, Inc. 2003. A survey of the periphyton community, Clear Creek, Tennessee. Report submitted to Obed Wild and Scenic River, National Park Service, 23 pp.

Research Planning, Inc. 2003. Preassessment Phase Report for the Howard/White Unit No. 1 Oil Spill, Natural Resource Damage Assessment. Prepared for the National Park Service, Denver, CO. 47 pp + appendices.

Schmalzer, P.A., T.S. Patrick, and H.R. DeSelm. 1985. Vascular flora of the Obed Wild and Scenic River, Tennessee. Castanea 50:71-88.

TDEC. 2001. Total Maximum Daily Load (TMDL) For pH in Crab Orchard Creek Located in The Emory River Watershed (HUC 06010208) Cumberland and Morgan County, Tennessee, September 21, 2000. State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2006. Proposed Final Version Year 2006 303(d) List, August, 2006. State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TVA. 2004. Crab Orchard Creek Watershed Restoration Plan. Tennessee Valley Authority, Tennessee Department of Environment and Conservation, Emory River Watershed Association. 34 pp.

Virginia Department of Forestry (VA Dept of Forestry). 1997. Herbicide Fact Sheet. Charlottesville, VA.

Washington State Department of Transportation (WA DOT). 2007. Glyphosate, Roadside Vegetation Management Herbicide Fact Sheet. Oregon State University and Intertox, Inc. 4 pp.

Walker, G., E. Parisher, P. Smith, D. Whitlock, D.Kramer, U. Matthes, and L. Morefield. 2004. Characterization of Plant Community Structure and Abiotic Conditions on Climbed and Unclimbed Cliff Faces in the Obed River Gorge. Report to the NPS, Obed Wild and Scenic River prepared by the Department of Biology, Appalachian State University. Available at: http://www.nps.gov/obed/parkmgmt/index.htm. Accessed on 4 July 2007.

Webster, C.R. and M.A. Jenkins. 2006. The impact of an oil spill and subsequent burning on the vegetation of Obed Wild and Scenic River, Tennessee: Estimating the time interval required for recovery of stand biomass. Prepared for the Obed Wild and Scenic River, National Park Service, Wartberg, TN, 13 pp.

Ziemkiewicz, P.F., J.G. Skousen, and J. Simmons. 2003. Long-term Performance of Passive Acid Mine Drainage Systems. Mine Water and the Environment. Volume 22: pp. 188-129.

APPENDIX A
Forest Injury Curve Inputs and DSAYs

TABLE A1. Inputs to the forest injury curve. PS = post spill. The forest would return to pre-spill biomass levels just over 172 years after the spill.

Year	Percent Services Present
2001	100%
Spill: 2002	0.00%
2003	0.20%
2004	0.40%
2005	0.60%
2006	0.80%
2007	1.00%
2008	1.20%
2009	1.40%
2010	1.60%
2011	1.80%
2012	2.00%
2013	2.20%
2014	2.40%
2015	2.60%
2016	2.80%
2017	3.00%
2018	3.20%
2019	3.40%
2020	3.60%
2021	3.80%
2022	4.00%
2023	4.20%
2024	4.40%
2025	4.60%
2026	4.80%
25 yrs PS: 2027	5.00%
2036	5.00%
2046	5.01%
2056	5.02%
2066	5.03%
2076	5.07%
2086	5.15%
2096	5.31%
2106	5.64%
2116	6.34%
2126	7.77%
2136	10.75%
2146	16.91%
2156	29.69%
2166	56.18%
2174	96.70%
173 yrs PS: 2175	103.64%

TABLE A2. Injury (DSAYs) calculated for 0.74 acres of impacted forest services.

Years Post Spill	Year	Percent Biomass Level (start of year)	Percent Biomass Loss (start of year)	Average Percent Biomass Loss	Discount Factor	Discounted Average Biomass Lost	Discounted Acre Years Lost
0	2002	0.00%	100.00%	99.90%	1.000	99.90%	0.740
1	2003	0.20%	99.80%	99.70%	0.971	96.80%	0.717
2	2004	0.40%	99.60%	99.50%	0.943	93.79%	0.695
3	2005	0.60%	99.40%	99.30%	0.915	90.87%	0.673
4	2006	0.80%	99.20%	99.10%	0.888	88.05%	0.652
5	2007	1.00%	99.00%	98.90%	0.863	85.31%	0.632
6	2008	1.20%	98.80%	98.70%	0.837	82.66%	0.613
7	2009	1.40%	98.60%	98.50%	0.813	80.09%	0.593
8	2010	1.60%	98.40%	98.30%	0.789	77.60%	0.575
9	2011	1.80%	98.20%	98.10%	0.766	75.19%	0.557
10	2012	2.00%	98.00%	97.90%	0.744	72.85%	0.540
11	2013	2.20%	97.80%	97.70%	0.722	70.58%	0.523
12	2014	2.40%	97.60%	97.50%	0.701	68.38%	0.507
13	2015	2.60%	97.40%	97.30%	0.681	66.26%	0.491
14	2016	2.80%	97.20%	97.10%	0.661	64.19%	0.476
15	2017	3.00%	97.00%	96.90%	0.642	62.20%	0.461
16	2018	3.20%	96.80%	96.70%	0.623	60.26%	0.447
17	2019	3.40%	96.60%	96.50%	0.605	58.38%	0.433
18	2020	3.60%	96.40%	96.30%	0.587	56.57%	0.419
19	2021	3.80%	96.20%	96.10%	0.570	54.80%	0.406
20	2022	4.00%	96.00%	95.90%	0.554	53.10%	0.393
21	2023	4.20%	95.80%	95.70%	0.538	51.44%	0.381
22	2024	4.40%	95.60%	95.50%	0.522	49.84%	0.369
23	2025	4.60%	95.40%	95.30%	0.507	48.29%	0.358
24	2026	4.80%	95.20%	95.10%	0.492	46.78%	0.347
25	2027	5.00%	95.00%	95.00%	0.478	45.37%	0.336
26	2028	5.00%	95.00%	95.00%	0.464	44.05%	0.326
27	2029	5.00%	95.00%	95.00%	0.450	42.77%	0.317
28	2030	5.00%	95.00%	95.00%	0.437	41.52%	0.308
29	2031	5.00%	95.00%	95.00%	0.424	40.31%	0.299
30	2032	5.00%	95.00%	95.00%	0.412	39.14%	0.290
31	2033	5.00%	95.00%	95.00%	0.400	38.00%	0.282
32	2034	5.00%	95.00%	95.00%	0.388	36.89%	0.273
33	2035	5.00%	95.00%	95.00%	0.377	35.82%	0.265
34	2036	5.00%	95.00%	95.00%	0.366	34.77%	0.258
35	2037	5.00%	95.00%	95.00%	0.355	33.76%	0.250
36	2038	5.00%	95.00%	95.00%	0.345	32.78%	0.243
37	2039	5.00%	95.00%	94.99%	0.335	31.82%	0.236
38	2040	5.01%	94.99%	94.99%	0.325	30.89%	0.229
39	2041	5.01%	94.99%	94.99%	0.316	29.99%	0.222
40	2042	5.01%	94.99%	94.99%	0.307	29.12%	0.216
41	2043	5.01%	94.99%	94.99%	0.298	28.27%	0.210

TABLE A2. Cont.

Years Post Spill	Year	Percent Biomass Level (start of year)	Percent Biomass Loss (start of year)	Average Percent Biomass Loss	Discount Factor	Discounted Average Biomass Lost	Discounted Acre Years Lost
42	2044	5.01%	94.99%	94.99%	0.289	27.45%	0.203
43	2045	5.01%	94.99%	94.99%	0.281	26.65%	0.197
44	2046	5.01%	94.99%	94.99%	0.272	25.87%	0.192
45	2047	5.01%	94.99%	94.99%	0.264	25.12%	0.186
46	2048	5.01%	94.99%	94.99%	0.257	24.39%	0.181
47	2049	5.01%	94.99%	94.99%	0.249	23.68%	0.175
48	2050	5.01%	94.99%	94.99%	0.242	22.99%	0.170
49	2051	5.01%	94.99%	94.99%	0.235	22.32%	0.165
50	2052	5.01%	94.99%	94.99%	0.228	21.67%	0.161
51	2053	5.01%	94.99%	94.99%	0.221	21.04%	0.156
52	2054	5.01%	94.99%	94.98%	0.215	20.42%	0.151
53	2055	5.02%	94.98%	94.98%	0.209	19.83%	0.147
54	2056	5.02%	94.98%	94.98%	0.203	19.25%	0.143
55	2057	5.02%	94.98%	94.98%	0.197	18.69%	0.138
56	2058	5.02%	94.98%	94.98%	0.191	18.14%	0.134
57	2059	5.02%	94.98%	94.98%	0.185	17.62%	0.131
58	2060	5.02%	94.98%	94.98%	0.180	17.10%	0.127
59	2061	5.02%	94.98%	94.97%	0.175	16.60%	0.123
60	2062	5.03%	94.97%	94.97%	0.170	16.12%	0.119
61	2063	5.03%	94.97%	94.97%	0.165	15.65%	0.116
62	2064	5.03%	94.97%	94.97%	0.160	15.19%	0.113
63	2065	5.03%	94.97%	94.97%	0.155	14.75%	0.109
64	2066	5.03%	94.97%	94.96%	0.151	14.32%	0.106
65	2067	5.04%	94.96%	94.96%	0.146	13.90%	0.103
66	2068	5.04%	94.96%	94.96%	0.142	13.50%	0.100
67	2069	5.04%	94.96%	94.95%	0.138	13.10%	0.097
68	2070	5.05%	94.95%	94.95%	0.134	12.72%	0.094
69	2071	5.05%	94.95%	94.95%	0.130	12.35%	0.092
70	2072	5.05%	94.95%	94.94%	0.126	11.99%	0.089
71	2073	5.06%	94.94%	94.94%	0.123	11.64%	0.086
72	2074	5.06%	94.94%	94.94%	0.119	11.30%	0.084
73	2075	5.07%	94.93%	94.93%	0.116	10.97%	0.081
74	2076	5.07%	94.93%	94.92%	0.112	10.65%	0.079
75	2077	5.08%	94.92%	94.92%	0.109	10.34%	0.077
76	2078	5.08%	94.92%	94.91%	0.106	10.04%	0.074
77	2079	5.09%	94.91%	94.91%	0.103	9.75%	0.072
78	2080	5.10%	94.90%	94.90%	0.100	9.46%	0.070
79	2081	5.10%	94.90%	94.89%	0.097	9.19%	0.068
80	2082	5.11%	94.89%	94.88%	0.094	8.92%	0.066
81	2083	5.12%	94.88%	94.87%	0.091	8.66%	0.064
82	2084	5.13%	94.87%	94.87%	0.089	8.40%	0.062
83	2085	5.14%	94.86%	94.86%	0.086	8.16%	0.060

TABLE A2. Cont.

Years Post Spill	Year	Percent Biomass Level (start of year)	Percent Biomass Loss (start of year)	Average Percent Biomass Loss	Discount Factor	Discounted Average Biomass Lost	Discounted Acre Years Lost
84	2086	5.15%	94.85%	94.84%	0.083	7.92%	0.059
85	2087	5.16%	94.84%	94.83%	0.081	7.69%	0.057
86	2088	5.17%	94.83%	94.82%	0.079	7.46%	0.055
87	2089	5.19%	94.81%	94.81%	0.076	7.24%	0.054
88	2090	5.20%	94.80%	94.79%	0.074	7.03%	0.052
89	2091	5.22%	94.78%	94.78%	0.072	6.83%	0.051
90	2092	5.23%	94.77%	94.76%	0.070	6.63%	0.049
91	2093	5.25%	94.75%	94.74%	0.068	6.43%	0.048
92	2094	5.27%	94.73%	94.72%	0.066	6.24%	0.046
93	2095	5.29%	94.71%	94.70%	0.064	6.06%	0.045
94	2096	5.31%	94.69%	94.68%	0.062	5.88%	0.044
95	2097	5.33%	94.67%	94.65%	0.060	5.71%	0.042
96	2098	5.36%	94.64%	94.63%	0.059	5.54%	0.041
97	2099	5.39%	94.61%	94.60%	0.057	5.38%	0.040
98	2100	5.42%	94.58%	94.57%	0.055	5.22%	0.039
99	2101	5.45%	94.55%	94.54%	0.054	5.07%	0.038
100	2102	5.48%	94.52%	94.50%	0.052	4.92%	0.036
101	2103	5.52%	94.48%	94.46%	0.051	4.77%	0.035
102	2104	5.56%	94.44%	94.42%	0.049	4.63%	0.034
103	2105	5.60%	94.40%	94.38%	0.048	4.49%	0.033
104	2106	5.64%	94.36%	94.33%	0.046	4.36%	0.032
105	2107	5.69%	94.31%	94.28%	0.045	4.23%	0.031
106	2108	5.75%	94.25%	94.23%	0.044	4.11%	0.030
107	2109	5.80%	94.20%	94.17%	0.042	3.98%	0.030
108	2110	5.86%	94.14%	94.10%	0.041	3.87%	0.029
109	2111	5.93%	94.07%	94.04%	0.040	3.75%	0.028
110	2112	6.00%	94.00%	93.96%	0.039	3.64%	0.027
111	2113	6.07%	93.93%	93.89%	0.038	3.53%	0.026
112	2114	6.16%	93.84%	93.80%	0.036	3.42%	0.025
113	2115	6.24%	93.76%	93.71%	0.035	3.32%	0.025
114	2116	6.34%	93.66%	93.61%	0.034	3.22%	0.024
115	2117	6.44%	93.56%	93.51%	0.033	3.12%	0.023
116	2118	6.55%	93.45%	93.39%	0.032	3.03%	0.022
117	2119	6.66%	93.34%	93.27%	0.031	2.94%	0.022
118	2120	6.79%	93.21%	93.14%	0.031	2.85%	0.021
119	2121	6.92%	93.08%	93.00%	0.030	2.76%	0.020
120	2122	7.07%	92.93%	92.85%	0.029	2.67%	0.020
121	2123	7.23%	92.77%	92.69%	0.028	2.59%	0.019
122	2124	7.40%	92.60%	92.51%	0.027	2.51%	0.019
123	2125	7.58%	92.42%	92.33%	0.026	2.43%	0.018
124	2126	7.77%	92.23%	92.12%	0.026	2.36%	0.017
125	2127	7.98%	92.02%	91.91%	0.025	2.28%	0.017

TABLE A2. Cont.

Years Post Spill	Year	Percent Biomass Level (start of year)	Percent Biomass Loss (start of year)	Average Percent Biomass Loss	Discount Factor	Discounted Average Biomass Lost	Discounted Acre Years Lost
126	2128	8.21%	91.79%	91.67%	0.024	2.21%	0.016
127	2129	8.45%	91.55%	91.42%	0.023	2.14%	0.016
128	2130	8.71%	91.29%	91.15%	0.023	2.07%	0.015
129	2131	8.99%	91.01%	90.86%	0.022	2.01%	0.015
130	2132	9.29%	90.71%	90.55%	0.021	1.94%	0.014
131	2133	9.62%	90.38%	90.21%	0.021	1.88%	0.014
132	2134	9.97%	90.03%	89.85%	0.020	1.82%	0.013
133	2135	10.34%	89.66%	89.46%	0.020	1.75%	0.013
134	2136	10.75%	89.25%	89.04%	0.019	1.70%	0.013
135	2137	11.18%	88.82%	88.59%	0.018	1.64%	0.012
136	2138	11.65%	88.35%	88.10%	0.018	1.58%	0.012
137	2139	12.15%	87.85%	87.58%	0.017	1.53%	0.011
138	2140	12.69%	87.31%	87.02%	0.017	1.47%	0.011
139	2141	13.27%	86.73%	86.42%	0.016	1.42%	0.011
140	2142	13.90%	86.10%	85.77%	0.016	1.37%	0.010
141	2143	14.57%	85.43%	85.07%	0.015	1.32%	0.010
142	2144	15.29%	84.71%	84.32%	0.015	1.27%	0.009
143	2145	16.07%	83.93%	83.51%	0.015	1.22%	0.009
144	2146	16.91%	83.09%	82.64%	0.014	1.17%	0.009
145	2147	17.81%	82.19%	81.71%	0.014	1.12%	0.008
146	2148	18.78%	81.22%	80.70%	0.013	1.08%	0.008
147	2149	19.82%	80.18%	79.62%	0.013	1.03%	0.008
148	2150	20.94%	79.06%	78.46%	0.013	0.99%	0.007
149	2151	22.15%	77.85%	77.20%	0.012	0.94%	0.007
150	2152	23.44%	76.56%	75.86%	0.012	0.90%	0.007
151	2153	24.84%	75.16%	74.41%	0.012	0.86%	0.006
152	2154	26.34%	73.66%	72.85%	0.011	0.82%	0.006
153	2155	27.95%	72.05%	71.18%	0.011	0.77%	0.006
154	2156	29.69%	70.31%	69.38%	0.011	0.73%	0.005
155	2157	31.56%	68.44%	67.44%	0.010	0.69%	0.005
156	2158	33.56%	66.44%	65.36%	0.010	0.65%	0.005
157	2159	35.72%	64.28%	63.11%	0.010	0.61%	0.005
158	2160	38.05%	61.95%	60.70%	0.009	0.57%	0.004
159	2161	40.55%	59.45%	58.11%	0.009	0.53%	0.004
160	2162	43.23%	56.77%	55.32%	0.009	0.49%	0.004
161	2163	46.13%	53.87%	52.32%	0.009	0.45%	0.003
162	2164	49.24%	50.76%	49.09%	0.008	0.41%	0.003
163	2165	52.58%	47.42%	45.62%	0.008	0.37%	0.003
164	2166	56.18%	43.82%	41.89%	0.008	0.33%	0.002
165	2167	60.05%	39.95%	37.87%	0.008	0.29%	0.002
166	2168	64.21%	35.79%	33.55%	0.007	0.25%	0.002

TABLE A2. Cont.

Years Post Spill	Year	Percent Biomass Level (start of year)	Percent Biomass Loss (start of year)	Average Percent Biomass Loss	Discount Factor	Discounted Average Biomass Lost	Discounted Acre Years Lost
167	2169	68.69%	31.31%	28.90%	0.007	0.21%	0.002
168	2170	73.51%	26.49%	23.90%	0.007	0.17%	0.001
169	2171	78.69%	21.31%	18.53%	0.007	0.13%	0.001
170	2172	84.26%	15.74%	12.74%	0.007	0.08%	0.001
171	2173	90.25%	9.75%	6.52%	0.006	0.04%	0.000
172	2174	96.70%	3.30%	-0.17%	0.006	0.00%	0.000
173	2175	103.64%	-3.64%	-1.82%	0.006	-0.01%	0.000
Total Discounted Service-Acre Years (DSAYs)							**24.3**

TABLE A3. Forest Restoration Inputs. The acquisition of a land easement of 2.3 acres would need to be purchased to compensate for 24.3 DSAYs. Only 50% of the land can be developed and it is assumed that the land would likely be developed within 20 years. The percent of services would be discounted each year into the future until reaching 175 years, where the discounted effective-acreage reaches zero**.**

Year	% Service Level (start of year)	Ave. Annual % Service	Discount Factor	Disc. Ave. % services	Discounted effective-Acreage
2002	0	0	1.000		
2003	0.0%	0.0%	0.971	0%	0.000
2004	0.0%	0.0%	0.943	0%	0.000
2005	0.0%	0.0%	0.915	0%	0.000
2006	0.0%	0.0%	0.888	0%	0.000
2007	0.0%	0.0%	0.863	0%	0.000
2008	0.0%	0.0%	0.837	0%	0.000
2009	0.0%	1.3%	0.813	1%	0.024
Start of Project: 2010	2.5%	3.8%	0.789	3%	0.069
2011	5.0%	6.3%	0.766	5%	0.112
2012	7.5%	8.8%	0.744	7%	0.152
2013	10.0%	11.3%	0.722	8%	0.189
2014	12.5%	13.8%	0.701	10%	0.225
2015	15.0%	16.3%	0.681	11%	0.258
2016	17.5%	18.8%	0.661	12%	0.289
2017	20.0%	21.3%	0.642	14%	0.318
2018	22.5%	23.8%	0.623	15%	0.345
2019	25.0%	26.3%	0.605	16%	0.370
2020	27.5%	28.8%	0.587	17%	0.393
2021	30.0%	31.3%	0.570	18%	0.415
2022	32.5%	33.8%	0.554	19%	0.435
2023	35.0%	36.3%	0.538	19%	0.454
2024	37.5%	38.8%	0.522	20%	0.471
2025	40.0%	41.3%	0.507	21%	0.487
2026	42.5%	43.8%	0.492	22%	0.501
2027	45.0%	46.3%	0.478	22%	0.515
2028	47.5%	48.8%	0.464	23%	0.527
2029	50.0%	50.0%	0.450	23%	0.524
2030	50.0%	50.0%	0.437	22%	0.509
2031	50.0%	50.0%	0.424	21%	0.494
2032	50.0%	50.0%	0.412	21%	0.480
2033	50.0%	50.0%	0.400	20%	0.466
2034	50.0%	50.0%	0.388	19%	0.452
2035	50.0%	50.0%	0.377	19%	0.439
2036	50.0%	50.0%	0.366	18%	0.426
2037	50.0%	50.0%	0.355	18%	0.414
2038	50.0%	50.0%	0.345	17%	0.402
2039	50.0%	50.0%	0.335	17%	0.390
2040	50.0%	50.0%	0.325	16%	0.379

TABLE A3. Cont.

Year	% Service Level (start of year)	Ave. Annual % Service	Discount Factor	Disc. Ave. % services	Discounted effective-Acreage
2041	50.0%	50.0%	0.316	16%	0.368
2042	50.0%	50.0%	0.307	15%	0.357
2043	50.0%	50.0%	0.298	15%	0.347
2044	50.0%	50.0%	0.289	14%	0.337
2045	50.0%	50.0%	0.281	14%	0.327
2046	50.0%	50.0%	0.272	14%	0.317
2047	50.0%	50.0%	0.264	13%	0.308
2048	50.0%	50.0%	0.257	13%	0.299
2049	50.0%	50.0%	0.249	12%	0.290
2050	50.0%	50.0%	0.242	12%	0.282
2051	50.0%	50.0%	0.235	12%	0.274
2052	50.0%	50.0%	0.228	11%	0.266
2053	50.0%	50.0%	0.221	11%	0.258
2054	50.0%	50.0%	0.215	11%	0.250
2055	50.0%	50.0%	0.209	10%	0.243
2056	50.0%	50.0%	0.203	10%	0.236
2057	50.0%	50.0%	0.197	10%	0.229
2058	50.0%	50.0%	0.191	10%	0.223
2059	50.0%	50.0%	0.185	9%	0.216
2060	50.0%	50.0%	0.180	9%	0.210
2061	50.0%	50.0%	0.175	9%	0.204
2062	50.0%	50.0%	0.170	8%	0.198
2063	50.0%	50.0%	0.165	8%	0.192
2064	50.0%	50.0%	0.160	8%	0.186
2065	50.0%	50.0%	0.155	8%	0.181
2066	50.0%	50.0%	0.151	8%	0.176
2067	50.0%	50.0%	0.146	7%	0.171
2068	50.0%	50.0%	0.142	7%	0.166
2069	50.0%	50.0%	0.138	7%	0.161
2070	50.0%	50.0%	0.134	7%	0.156
2071	50.0%	50.0%	0.130	7%	0.152
2072	50.0%	50.0%	0.126	6%	0.147
2073	50.0%	50.0%	0.123	6%	0.143
2074	50.0%	50.0%	0.119	6%	0.139
2075	50.0%	50.0%	0.116	6%	0.135
2076	50.0%	50.0%	0.112	6%	0.131
2077	50.0%	50.0%	0.109	5%	0.127
2078	50.0%	50.0%	0.106	5%	0.123
2079	50.0%	50.0%	0.103	5%	0.120
2080	50.0%	50.0%	0.100	5%	0.116
2081	50.0%	50.0%	0.097	5%	0.113
2082	50.0%	50.0%	0.094	5%	0.109
2083	50.0%	50.0%	0.091	5%	0.106
2084	50.0%	50.0%	0.089	4%	0.103

TABLE A3. Cont.

Year	% Service Level (start of year)	Ave. Annual % Service	Discount Factor	Disc. Ave. % services	Discounted effective-Acreage
2085	50.0%	50.0%	0.086	4%	0.100
2086	50.0%	50.0%	0.083	4%	0.097
2087	50.0%	50.0%	0.081	4%	0.094
2088	50.0%	50.0%	0.079	4%	0.092
2089	50.0%	50.0%	0.076	4%	0.089
2090	50.0%	50.0%	0.074	4%	0.086
2091	50.0%	50.0%	0.072	4%	0.084
2092	50.0%	50.0%	0.070	3%	0.081
2093	50.0%	50.0%	0.068	3%	0.079
2094	50.0%	50.0%	0.066	3%	0.077
2095	50.0%	50.0%	0.064	3%	0.075
2096	50.0%	50.0%	0.062	3%	0.072
2097	50.0%	50.0%	0.060	3%	0.070
2098	50.0%	50.0%	0.059	3%	0.068
2099	50.0%	50.0%	0.057	3%	0.066
2100	50.0%	50.0%	0.055	3%	0.064
2101	50.0%	50.0%	0.054	3%	0.062
2102	50.0%	50.0%	0.052	3%	0.061
2103	50.0%	50.0%	0.051	3%	0.059
2104	50.0%	50.0%	0.049	2%	0.057
2105	50.0%	50.0%	0.048	2%	0.055
2106	50.0%	50.0%	0.046	2%	0.054
2107	50.0%	50.0%	0.045	2%	0.052
2108	50.0%	50.0%	0.044	2%	0.051
2109	50.0%	50.0%	0.042	2%	0.049
2110	50.0%	50.0%	0.041	2%	0.048
2111	50.0%	50.0%	0.040	2%	0.046
2112	50.0%	50.0%	0.039	2%	0.045
2113	50.0%	50.0%	0.038	2%	0.044
2114	50.0%	50.0%	0.036	2%	0.043
2115	50.0%	50.0%	0.035	2%	0.041
2116	50.0%	50.0%	0.034	2%	0.040
2117	50.0%	50.0%	0.033	2%	0.039
2118	50.0%	50.0%	0.032	2%	0.038
2119	50.0%	50.0%	0.031	2%	0.037
2120	50.0%	50.0%	0.031	2%	0.036
2121	50.0%	50.0%	0.030	1%	0.035
2122	50.0%	50.0%	0.029	1%	0.034
2123	50.0%	50.0%	0.028	1%	0.033
2124	50.0%	50.0%	0.027	1%	0.032
2125	50.0%	50.0%	0.026	1%	0.031
2126	50.0%	50.0%	0.026	1%	0.030
2127	50.0%	50.0%	0.025	1%	0.029
2128	50.0%	50.0%	0.024	1%	0.028

TABLE A3. Cont.

Year	% Service Level (start of year)	Ave. Annual % Service	Discount Factor	Disc. Ave. % services	Discounted effective-Acreage
2129	50.0%	50.0%	0.023	1%	0.027
2130	50.0%	50.0%	0.023	1%	0.026
2131	50.0%	50.0%	0.022	1%	0.026
2132	50.0%	50.0%	0.021	1%	0.025
2133	50.0%	50.0%	0.021	1%	0.024
2134	50.0%	50.0%	0.020	1%	0.024
2135	50.0%	50.0%	0.020	1%	0.023
2136	50.0%	50.0%	0.019	1%	0.022
2137	50.0%	50.0%	0.018	1%	0.022
2138	50.0%	50.0%	0.018	1%	0.021
2139	50.0%	50.0%	0.017	1%	0.020
2140	50.0%	50.0%	0.017	1%	0.020
2141	50.0%	50.0%	0.016	1%	0.019
2142	50.0%	50.0%	0.016	1%	0.019
2143	50.0%	50.0%	0.015	1%	0.018
2144	50.0%	50.0%	0.015	1%	0.018
2145	50.0%	50.0%	0.015	1%	0.017
2146	50.0%	50.0%	0.014	1%	0.017
2147	50.0%	50.0%	0.014	1%	0.016
2148	50.0%	50.0%	0.013	1%	0.016
2149	50.0%	50.0%	0.013	1%	0.015
2150	50.0%	50.0%	0.013	1%	0.015
2151	50.0%	50.0%	0.012	1%	0.014
2152	50.0%	50.0%	0.012	1%	0.014
2153	50.0%	50.0%	0.012	1%	0.013
2154	50.0%	50.0%	0.011	1%	0.013
2155	50.0%	50.0%	0.011	1%	0.013
2156	50.0%	50.0%	0.011	1%	0.012
2157	50.0%	50.0%	0.010	1%	0.012
2158	50.0%	50.0%	0.010	0%	0.012
2159	50.0%	50.0%	0.010	0%	0.011
2160	50.0%	50.0%	0.009	0%	0.011
2161	50.0%	50.0%	0.009	0%	0.011
2162	50.0%	50.0%	0.009	0%	0.010
2163	50.0%	50.0%	0.009	0%	0.010
2164	50.0%	50.0%	0.008	0%	0.010
2165	50.0%	50.0%	0.008	0%	0.009
2166	50.0%	50.0%	0.008	0%	0.009
2167	50.0%	50.0%	0.008	0%	0.009
2168	50.0%	50.0%	0.007	0%	0.009
2169	50.0%	50.0%	0.007	0%	0.008
2170	50.0%	50.0%	0.007	0%	0.008
2171	50.0%	50.0%	0.007	0%	0.008

TABLE A3. Cont.

Year	% Service Level (start of year)	Ave. Annual % Service	Discount Factor	Disc. Ave. % services	Discounted effective-Acreage
2172	50.0%	50.0%	0.007	0%	0.008
2173	50.0%	50.0%	0.006	0%	0.007
2174	50.0%	50.0%	0.006	0%	0.007
2175	50.0%	50.0%	0.006	0%	0.007
2176	50.0%	25.0%	0.006	0%	0.003
Total Discounted Service Acre Years Restored					24.3

APPENDIX B
USGS Monthly Statistics for Discharges in the Obed River

USGS 03539800 OBED RIVER NEAR LANCING, TN

Morgan County, Tennessee
Hydrologic Unit Code 06010208
Latitude = 36°04'53.11", Longitude = 84°40'13.33" NAD27
Drainage area 518 square miles
Gage datum 891.91 feet above sea level NGVD29

00060, Discharge, cubic feet per second,												
YEAR	**Monthly mean in cfs (Calculation Period: 1957-05-01 -> 2005-09-30)**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1957					735.5	664.6	57.0	10.9	100.6	586.7	3,829	2,655
1958	991.3	872.9	1,514	2,399	1,948	70.7	39.3	104.3	20.9	10.5	65.8	187.3
1959	1,442	1,686	1,551.	1,454	386.7	404.1	152.2	294.8	147.4	113.4	742.2	2,848
1960	1,594	1,913	2,503	885.2	911.6	127.9	240.7	66.4	812.6	690.2	754.8	1,034
1961	1,222	2,948	3,313	2,005	838.8	1,475	328.5	235.9	24.0	11.8	158.9	2,269
1962	3,551	3,611.	2,597	3,327	115.4	183.7	73.4	15.0	114.5	294.7	1,355	956.8
1963	792.1	1,330.	4,183	337.9	588.0	162.4	341.8	115.1	33.2	1.87	4.98	43.5
1964	1,499	2,031	3,473	3,031	641.0	215.2	94.5	224.3	71.6	165.2	337.3	1,622
1965	1,692	1,056	3,479	1,605	548.5	301.0	464.0	172.2	69.9	87.4	112.9	139.7
1966	505.7	2,401	1,066	1,453	1,741	86.1	62.9	108.2	79.3	188.1	875.8	1,567
1967	979.6	1,318	2,368	593.1	1,342	410.1	2,323	359.9	82.6	317.3	1,134	3,149
1968	2,526	353.9	2,149	1,679	807.3	144.9	28.6	12.0	1.43			
1973			3,982	1,635	3,918	1,390.	1,060.	251.3	79.9	32.9	2,071	2,642
1974	4,780.	2,688	2,212	1,164	1,135	193.6	28.4	40.6	268.3	280.2	1,026	2,327
1975	2,838	2,884	6,220.	1,054	886.2	204.9	45.9	70.7	822.4	1,552	1,667	1,382
1976	2,228	1,159	1,724	769.5	715.8	751.5	633.6	41.1	18.4	337.6	328.0	974.8
1977	1,123	793.1	1,839	3,522	420.6	152.4	45.6	75.5	345.5	656.0	2,994	2,101
1978	2,091	657.9	1,859	453.2	1,437	955.3	261.5	479.9	33.9	13.8	87.3	1,636
1979	4,239	2,099	2,005	2,013	1,499	465.5	2,572	156.1	426.3	588.8	2,152	1,056
1980	2,170.	831.0	3,923	1,187	833.4	87.7	11.3	7.13	8.02	1.58	40.0	127.7
1981	69.5	1,248	1,005	1,939	393.0	916.8	29.9	47.9	97.2	445.8	716.2	1,420
1982	3,288	1,974	1,964	793.8	545.1	222.6	146.6	405.6	856.4	116.3	926.2	3,074
1983	881.3	1,773	896.9	3,056	2,517	409.5	37.2	15.6	5.01	13.2	918.3	2,429
1984	1,227	1,435	2,353	1,524	4,066	152.4	724.5	303.7	26.9	515.1	1,659	1,247
1985	1,184	2,193	682.3	802.0	303.2	103.6	64.9	587.4	87.3	594.0	1,064	833.6
1986	302.8	1,991	791.8	260.8	599.9	288.9	33.5	10.1	82.3	276.5	2,225	1,872
1987	1,299	1,746	1,127	1,531	370.1	195.5	290.7	20.0	23.8	26.5	118.8	404.7
1999			1,866	852.3	1,529	544.8	1,843	47.3	5.28	9.40	29.7	132.3
2000	568.4	1,216	1,525	2,283	384.4	287.9	76.8	62.9	13.3	4.05	36.0	519.6
2001	1,098	2,887	965.6	826.4	255.5	82.7	96.6	260.1	29.6	21.3	146.1	833.5

2002	3,465	895.3	2,730.	1,549	1,552	91.0	110.3	16.4	72.2	177.3	1,281	2,447
2003	515.2	4,696	689.0	2,505	3,649	746.9	163.5	122.6	812.3	148.6	1,073	1,453
2004	1,274	2,638	2,341	1,168	514.2	651.4	636.0	150.6	2,220.	570.0	1,668	3,879
2005	2,028	2,256	954.3	1,606	1,132	97.1	378.6	249.5	44.4	21.2	250.4	713.9
2006	2,091	1,262	935.5	2,412	374.3	153.5	49.9	134.6	275.4			
Mean of monthly Discharge	1,740	1,840	2,140	1,580	1,130	383	387	151	235	269	965	1,510
** No Incomplete Data is used for Statistical Calculation												

APPENDIX C
Stream Injury and Restoration Calculations

TABLE C1. Injury (DSAYs) calculated for 2.41 acres of impacted stream services for the Clear Creek Seep Reach.

Year Post Spill		% Service Level (start of year)	% Service Loss (start of year)	Ave. % Service Loss	Discount Factor	Disc. Ave. % Services Lost	Discounted Service Acre-Years Lost
0	Jul-02	0%	100%	88%	1.000	88%	0.526
0.25	Oct-02	25%	75%	73%	0.993	72%	0.294
0.42	Dec-02	30%	70%	60%	0.988	59%	0.829
1	2003	50%	50%	38%	0.971	36%	0.876
2	2004	75%	25%	38%	0.943	35%	0.850
3	2005	50%	50%	38%	0.915	34%	0.826
4	2006	75%	25%	38%	0.888	33%	0.802
5	2007	50%	50%	50%	0.863	43%	1.038
6	2008	50%	50%	38%	0.837	31%	0.756
7	2009	75%	25%	25%	0.813	20%	0.489
8	2010	75%	25%	38%	0.789	30%	0.712
9	2011	50%	50%	50%	0.766	38%	0.922
10	2012	50%	50%	50%	0.744	37%	0.895
11	2013	50%	50%	50%	0.722	36%	0.869
12	2014	50%	50%	50%	0.701	35%	0.844
13	2015	50%	50%	50%	0.681	34%	0.819
14	2016	50%	50%	38%	0.661	25%	0.597
15	2017	75%	25%	25%	0.642	16%	0.386
16	2018	75%	25%	38%	0.623	23%	0.562
17	2019	50%	50%	50%	0.605	30%	0.728
18	2020	50%	50%	50%	0.587	29%	0.707
19	2021	50%	50%	38%	0.570	21%	0.515
20	2022	75%	25%	13%	0.554	7%	0.167
21	2023	100%	0%	0%	0.587	0%	0.000
		Total Discounted Service Acre Years Lost					**16.01**

TABLE C2. Injury (DSAYs) calculated for 2.26 acres of impacted stream services for the Clear Creek Downstream Reach.

Year Post Spill	Year	% Service Level (start of year)	% Service Loss (start of year)	Ave. % Service Loss	Discount Factor	Disc. Ave. % Services Lost	Discounted Service Acre-Years Lost
0	Jul-02	0%	100%	83%	1.000	83%	0.466
0.25	Oct-02	35%	65%	60%	0.993	60%	0.229
0.42	Dec-02	45%	55%	40%	0.988	40%	0.519
1	2003	75%	25%	20%	0.971	19%	0.439
2	2004	85%	15%	23%	0.943	21%	0.479
3	2005	70%	30%	20%	0.915	18%	0.414
4	2006	90%	10%	20%	0.888	18%	0.402
5	2007	70%	30%	30%	0.863	26%	0.585
6	2008	70%	30%	20%	0.837	17%	0.379
7	2009	90%	10%	10%	0.813	8%	0.184
8	2010	90%	10%	20%	0.789	16%	0.357
9	2011	70%	30%	30%	0.766	23%	0.520
10	2012	70%	30%	30%	0.744	22%	0.505
11	2013	70%	30%	30%	0.722	22%	0.490
12	2014	70%	30%	30%	0.701	21%	0.476
13	2015	70%	30%	30%	0.681	20%	0.462
14	2016	70%	30%	20%	0.661	13%	0.299
15	2017	90%	10%	10%	0.642	6%	0.145
16	2018	90%	10%	20%	0.623	12%	0.282
17	2019	70%	30%	30%	0.605	18%	0.410
18	2020	70%	30%	30%	0.587	18%	0.398
19	2021	70%	30%	20%	0.570	11%	0.258
20	2022	90%	10%	5%	0.554	3%	0.063
21	2023	100%	0%	0%	0.538	0%	0.000
		Total Discounted Service Acre Years Lost					**8.76**

TABLE C3. Injury (DSAYs) calculated for 1.62 acres of impacted stream services for the White Creek Reach.

Year Post Spill	Year	% Service Level (start of year)	% Service Loss (start of year)	Ave. % Service Loss	Discount Factor	Disc. Ave. % Services Lost	Discounted Service Acre-Years Lost
0	Jul-02	0%	100%	83%	1.000	83%	0.334
0.25	Oct-02	35%	65%	60%	0.993	60%	0.164
0.42	Dec-02	45%	55%	40%	0.988	40%	0.371
1	2003	75%	25%	20%	0.971	19%	0.314
2	2004	85%	15%	10%	0.943	9%	0.152
3	2005	95%	5%	3%	0.915	2%	0.037
4	2006	100%	0%	0%	0.888	0%	0.000
5	2007	100%	0%	0%	0.863	0%	0.000
6	2008	100%	0%	0%	0.837	0%	0.000
7	2009	100%	0%	0%	0.813	0%	0.000
8	2010	100%	0%	0%	0.789	0%	0.000
9	2011	100%	0%	0%	0.766	0%	0.000
10	2012	100%	0%	0%	0.744	0%	0.000
11	2013	100%	0%	0%	0.722	0%	0.000
12	2014	100%	0%	0%	0.701	0%	0.000
13	2015	100%	0%	0%	0.681	0%	0.000
14	2016	100%	0%	0%	0.661	0%	0.000
15	2017	100%	0%	0%	0.642	0%	0.000
16	2018	100%	0%	0%	0.623	0%	0.000
17	2019	100%	0%	0%	0.605	0%	0.000
18	2020	100%	0%	0%	0.587	0%	0.000
19	2021	100%	0%	0%	0.570	0%	0.000
20	2022	100%	0%	0%	0.554	0%	0.000
21	2023	100%	0%	0%	0.538	0%	0.000
		Total Discounted Service Acre Years Lost					**1.37**

TABLE C4. Golliher Creek Restoration Inputs. 50% of the benthic macroinvertebrates would return to the creek system one year after the remediation was complete. Complete recovery of macroinvertebrates is expected two years after remediation. The lifespan of the limestone treatment ponds are expected to be 30 years. A 3% discount factor was used.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
0	2002	0%	0%	1.000	0%	0.000
1	2003	0%	0%	0.971	0%	0.000
2	2004	0%	0%	0.943	0%	0.000
3	2005	0%	0%	0.915	0%	0.000
4	2006	0%	0%	0.888	0%	0.000
5	2007	0%	0%	0.863	0%	0.000
6	2008	0%	25%	0.837	21%	0.381
7	2009	50%	75%	0.813	61%	1.109
8	2010	100%	100%	0.789	79%	1.435
9	2011	100%	100%	0.766	77%	1.393
10	2012	100%	100%	0.744	74%	1.353
11	2013	100%	100%	0.722	72%	1.313
12	2014	100%	100%	0.701	70%	1.275
13	2015	100%	100%	0.681	68%	1.238
14	2016	100%	100%	0.661	66%	1.202
15	2017	100%	100%	0.642	64%	1.167
16	2018	100%	100%	0.623	62%	1.133
17	2019	100%	100%	0.605	61%	1.100
18	2020	100%	100%	0.587	59%	1.068
19	2021	100%	100%	0.570	57%	1.037
20	2022	100%	100%	0.554	55%	1.007
21	2023	100%	100%	0.538	54%	0.977
22	2024	100%	100%	0.522	52%	0.949
23	2025	100%	100%	0.507	51%	0.921
24	2026	100%	100%	0.492	49%	0.894
25	2027	100%	100%	0.478	48%	0.868
26	2028	100%	100%	0.464	46%	0.843
27	2029	100%	100%	0.450	45%	0.819
28	2030	100%	100%	0.437	44%	0.795
29	2031	100%	100%	0.424	42%	0.772
30	2032	100%	100%	0.412	41%	0.749
31	2033	100%	100%	0.400	40%	0.727
32	2034	100%	100%	0.388	39%	0.706
33	2035	100%	100%	0.377	38%	0.686
34	2036	100%	100%	0.366	37%	0.666
35	2037	100%	100%	0.355	36%	0.646
36	2038	100%	100%	0.345	35%	0.627
37	2039	100%	50%	0.335	17%	0.305
		Total Discounted Service Acre Years Gained:				**30.161**

TABLE C5. Stream Restoration Inputs: Little Obed River Streambank Restoration. Benthic macroinvertebrates would increase by 20% each year over a 5-year period after completion. The lifespan of the restoration project was estimated to be 75 years. A 3% discount factor was used.

Year Post Spill	Years	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
0	2002	0%	0%	1.000	0%	0.000
1	2003	0%	0%	0.971	0%	0.000
2	2004	0%	0%	0.943	0%	0.000
3	2005	0%	0%	0.915	0%	0.000
4	2006	0%	0%	0.888	0%	0.000
5	2007	0%	0%	0.863	0%	0.000
6	2008	0%	10%	0.837	8%	0.016
7	2009	20%	30%	0.813	24%	0.046
8	2010	40%	50%	0.789	39%	0.075
9	2011	60%	70%	0.766	54%	0.102
10	2012	80%	80%	0.744	60%	0.113
11	2013	80%	80%	0.722	58%	0.110
12	2014	80%	80%	0.701	56%	0.107
13	2015	80%	80%	0.681	54%	0.104
14	2016	80%	80%	0.661	53%	0.101
15	2017	80%	80%	0.642	51%	0.098
16	2018	80%	80%	0.623	50%	0.095
17	2019	80%	80%	0.605	48%	0.092
18	2020	80%	80%	0.587	47%	0.090
19	2021	80%	80%	0.570	46%	0.087
20	2022	80%	80%	0.554	44%	0.084
21	2023	80%	80%	0.538	43%	0.082
22	2024	80%	80%	0.522	42%	0.080
23	2025	80%	80%	0.507	41%	0.077
24	2026	80%	80%	0.492	39%	0.075
25	2027	80%	80%	0.478	38%	0.073
26	2028	80%	80%	0.464	37%	0.071
27	2029	80%	80%	0.450	36%	0.069
28	2030	80%	80%	0.437	35%	0.067
29	2031	80%	80%	0.424	34%	0.065
30	2032	80%	80%	0.412	33%	0.063
31	2033	80%	80%	0.400	32%	0.061
32	2034	80%	80%	0.388	31%	0.059
33	2035	80%	80%	0.377	30%	0.057
34	2036	80%	80%	0.366	29%	0.056
35	2037	80%	80%	0.355	28%	0.054
36	2038	80%	80%	0.345	28%	0.053
37	2039	80%	80%	0.335	27%	0.051
38	2040	80%	80%	0.325	26%	0.050
39	2041	80%	80%	0.316	25%	0.048

TABLE C5. Cont.

Year Post Spill	Years	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
40	2042	80%	80%	0.307	25%	0.047
41	2043	80%	80%	0.298	24%	0.045
42	2044	80%	80%	0.289	23%	0.044
43	2045	80%	80%	0.281	22%	0.043
44	2046	80%	80%	0.272	22%	0.042
45	2047	80%	80%	0.264	21%	0.040
46	2048	80%	80%	0.257	21%	0.039
47	2049	80%	80%	0.249	20%	0.038
48	2050	80%	80%	0.242	19%	0.037
49	2051	80%	80%	0.235	19%	0.036
50	2052	80%	80%	0.228	18%	0.035
51	2053	80%	80%	0.221	18%	0.034
52	2054	80%	80%	0.215	17%	0.033
53	2055	80%	80%	0.209	17%	0.032
54	2056	80%	80%	0.203	16%	0.031
55	2057	80%	80%	0.197	16%	0.030
56	2058	80%	80%	0.191	15%	0.029
57	2059	80%	80%	0.185	15%	0.028
58	2060	80%	80%	0.180	14%	0.027
59	2061	80%	80%	0.175	14%	0.027
60	2062	80%	80%	0.170	14%	0.026
61	2063	80%	80%	0.165	13%	0.025
62	2064	80%	80%	0.160	13%	0.024
63	2065	80%	80%	0.155	12%	0.024
64	2066	80%	80%	0.151	12%	0.023
65	2067	80%	80%	0.146	12%	0.022
66	2068	80%	80%	0.142	11%	0.022
67	2069	80%	80%	0.138	11%	0.021
68	2070	80%	80%	0.134	11%	0.020
69	2071	80%	80%	0.130	10%	0.020
70	2072	80%	80%	0.126	10%	0.019
71	2073	80%	80%	0.123	10%	0.019
72	2074	80%	80%	0.119	10%	0.018
73	2075	80%	80%	0.116	9%	0.018
74	2076	80%	80%	0.112	9%	0.017
75	2077	80%	80%	0.109	9%	0.017
76	2078	80%	80%	0.106	8%	0.016
77	2079	80%	80%	0.103	8%	0.016
78	2080	80%	80%	0.100	8%	0.015
79	2081	80%	80%	0.097	8%	0.015
80	2082	80%	80%	0.094	8%	0.014
81	2083	80%	80%	0.091	7%	0.014
82	2084	80%	80%	0.089	7%	0.014
		Total Discounted Service Acre Years Gained:				**3.684**

TABLE C6. Stream Restoration Inputs: Little Obed River, Invasive Vegetation Removal. Stream length = 750 ft; stream width = 5 ft. Vegetation (invasive and natural) provided 50% of services before removal. After removal of invasive vegetation, the services increased by 10% each year, reaching 90%. The lifespan of the restoration project was estimated to be 75 years. A 3% discount factor was used.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
0	2002	0%	0%	1.000	0%	0.000
1	2003	0%	0%	0.971	0%	0.000
2	2004	0%	0%	0.943	0%	0.000
3	2005	0%	0%	0.915	0%	0.000
4	2006	0%	0%	0.888	0%	0.000
5	2007	0%	0%	0.863	0%	0.000
6	2008	0%	0%	0.837	0%	0.000
7	2009	50%	5%	0.813	4%	0.003
8	2010	60%	15%	0.789	12%	0.010
9	2011	70%	25%	0.766	19%	0.016
10	2012	80%	30%	0.744	22%	0.005
11	2013	80%	30%	0.722	22%	0.005
12	2014	80%	30%	0.701	21%	0.005
13	2015	80%	30%	0.681	20%	0.004
14	2016	80%	30%	0.661	20%	0.004
15	2017	80%	30%	0.642	19%	0.004
16	2018	80%	30%	0.623	19%	0.004
17	2019	80%	30%	0.605	18%	0.004
18	2020	80%	30%	0.587	18%	0.004
19	2021	80%	30%	0.570	17%	0.004
20	2022	80%	30%	0.554	17%	0.004
21	2023	80%	30%	0.538	16%	0.003
22	2024	80%	30%	0.522	16%	0.003
23	2025	80%	30%	0.507	15%	0.003
24	2026	80%	30%	0.492	15%	0.003
25	2027	80%	30%	0.478	14%	0.003
26	2028	80%	30%	0.464	14%	0.003
27	2029	80%	30%	0.450	14%	0.003
28	2030	80%	30%	0.437	13%	0.003
29	2031	80%	30%	0.424	13%	0.003
30	2032	80%	30%	0.412	12%	0.003
31	2033	80%	30%	0.400	12%	0.003
32	2034	80%	30%	0.388	12%	0.003
33	2035	80%	30%	0.377	11%	0.002
34	2036	80%	30%	0.366	11%	0.002
35	2037	80%	30%	0.355	11%	0.002
36	2038	80%	30%	0.345	10%	0.002
37	2039	80%	30%	0.335	10%	0.002
38	2040	80%	30%	0.325	10%	0.002
39	2041	80%	30%	0.316	9%	0.002

TABLE C6. Cont.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
40	2042	80%	30%	0.307	9%	0.002
41	2043	80%	30%	0.298	9%	0.002
42	2044	80%	30%	0.289	9%	0.002
43	2045	80%	30%	0.281	8%	0.002
44	2046	80%	30%	0.272	8%	0.002
45	2047	80%	30%	0.264	8%	0.002
46	2048	80%	30%	0.257	8%	0.002
47	2049	80%	30%	0.249	7%	0.002
48	2050	80%	30%	0.242	7%	0.002
49	2051	80%	30%	0.235	7%	0.002
50	2052	80%	30%	0.228	7%	0.001
51	2053	80%	30%	0.221	7%	0.001
52	2054	80%	30%	0.215	6%	0.001
53	2055	80%	30%	0.209	6%	0.001
54	2056	80%	30%	0.203	6%	0.001
55	2057	80%	30%	0.197	6%	0.001
56	2058	80%	30%	0.191	6%	0.001
57	2059	80%	30%	0.185	6%	0.001
58	2060	80%	30%	0.180	5%	0.001
59	2061	80%	30%	0.175	5%	0.001
60	2062	80%	30%	0.170	5%	0.001
61	2063	80%	30%	0.165	5%	0.001
62	2064	80%	30%	0.160	5%	0.001
63	2065	80%	30%	0.155	5%	0.001
64	2066	80%	30%	0.151	5%	0.001
65	2067	80%	30%	0.146	4%	0.001
66	2068	80%	30%	0.142	4%	0.001
67	2069	80%	30%	0.138	4%	0.001
68	2070	80%	30%	0.134	4%	0.001
69	2071	80%	30%	0.130	4%	0.001
70	2072	80%	30%	0.126	4%	0.001
71	2073	80%	30%	0.123	4%	0.001
72	2074	80%	30%	0.119	4%	0.001
73	2075	80%	30%	0.116	3%	0.001
74	2076	80%	30%	0.112	3%	0.001
75	2077	80%	30%	0.109	3%	0.001
76	2078	80%	30%	0.106	3%	0.001
77	2079	80%	30%	0.103	3%	0.001
78	2080	80%	30%	0.100	3%	0.001
79	2081	80%	30%	0.097	3%	0.001
80	2082	80%	30%	0.094	3%	0.001
81	2083	80%	30%	0.091	3%	0.001
82	2084	80%	30%	0.089	3%	0.001
		Total Discounted Service Acre Years Gained:				**0.176**

TABLE C7. Stream Restoration Inputs: Little Obed River, Bog Garden Construction, 2.12 acres. Increase in services was 5% each year for the first five years after completion, to a maximum of services 25% which continued for 75 years. A 3% discount factor was used.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
0	2002	0%	0%	1.000	0%	0.000
1	2003	0%	0%	0.971	0%	0.000
2	2004	0%	0%	0.943	0%	0.000
3	2005	0%	0%	0.915	0%	0.000
4	2006	0%	0%	0.888	0%	0.000
5	2007	0%	0%	0.863	0%	0.000
6	2008	0%	3%	0.837	2%	0.044
7	2009	5%	8%	0.813	6%	0.129
8	2010	10%	13%	0.789	10%	0.210
9	2011	15%	18%	0.766	13%	0.285
10	2012	20%	23%	0.744	17%	0.356
11	2013	25%	25%	0.722	18%	0.384
12	2014	25%	25%	0.701	18%	0.372
13	2015	25%	25%	0.681	17%	0.362
14	2016	25%	25%	0.661	17%	0.351
15	2017	25%	25%	0.642	16%	0.341
16	2018	25%	25%	0.623	16%	0.331
17	2019	25%	25%	0.605	15%	0.321
18	2020	25%	25%	0.587	15%	0.312
19	2021	25%	25%	0.570	14%	0.303
20	2022	25%	25%	0.554	14%	0.294
21	2023	25%	25%	0.538	13%	0.285
22	2024	25%	25%	0.522	13%	0.277
23	2025	25%	25%	0.507	13%	0.269
24	2026	25%	25%	0.492	12%	0.261
25	2027	25%	25%	0.478	12%	0.254
26	2028	25%	25%	0.464	12%	0.246
27	2029	25%	25%	0.450	11%	0.239
28	2030	25%	25%	0.437	11%	0.232
29	2031	25%	25%	0.424	11%	0.225
30	2032	25%	25%	0.412	10%	0.219
31	2033	25%	25%	0.400	10%	0.212
32	2034	25%	25%	0.388	10%	0.206
33	2035	25%	25%	0.377	9%	0.200
34	2036	25%	25%	0.366	9%	0.194
35	2037	25%	25%	0.355	9%	0.189
36	2038	25%	25%	0.345	9%	0.183
37	2039	25%	25%	0.335	8%	0.178
38	2040	25%	25%	0.325	8%	0.173
39	2041	25%	25%	0.316	8%	0.168
40	2042	25%	25%	0.307	8%	0.163

TABLE C7. Cont.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
41	2043	25%	25%	0.298	7%	0.158
42	2044	25%	25%	0.289	7%	0.153
43	2045	25%	25%	0.281	7%	0.149
44	2046	25%	25%	0.272	7%	0.145
45	2047	25%	25%	0.264	7%	0.140
46	2048	25%	25%	0.257	6%	0.136
47	2049	25%	25%	0.249	6%	0.132
48	2050	25%	25%	0.242	6%	0.128
49	2051	25%	25%	0.235	6%	0.125
50	2052	25%	25%	0.228	6%	0.121
51	2053	25%	25%	0.221	6%	0.118
52	2054	25%	25%	0.215	5%	0.114
53	2055	25%	25%	0.209	5%	0.111
54	2056	25%	25%	0.203	5%	0.108
55	2057	25%	25%	0.197	5%	0.104
56	2058	25%	25%	0.191	5%	0.101
57	2059	25%	25%	0.185	5%	0.098
58	2060	25%	25%	0.180	5%	0.096
59	2061	25%	25%	0.175	4%	0.093
60	2062	25%	25%	0.170	4%	0.090
61	2063	25%	25%	0.165	4%	0.087
62	2064	25%	25%	0.160	4%	0.085
63	2065	25%	25%	0.155	4%	0.082
64	2066	25%	25%	0.151	4%	0.080
65	2067	25%	25%	0.146	4%	0.078
66	2068	25%	25%	0.142	4%	0.075
67	2069	25%	25%	0.138	3%	0.073
68	2070	25%	25%	0.134	3%	0.071
69	2071	25%	25%	0.130	3%	0.069
70	2072	25%	25%	0.126	3%	0.067
71	2073	25%	25%	0.123	3%	0.065
72	2074	25%	25%	0.119	3%	0.063
73	2075	25%	25%	0.116	3%	0.061
74	2076	25%	25%	0.112	3%	0.060
75	2077	25%	25%	0.109	3%	0.058
76	2078	25%	25%	0.106	3%	0.056
77	2079	25%	25%	0.103	3%	0.055
78	2080	25%	25%	0.100	2%	0.053
79	2081	25%	25%	0.097	2%	0.051
80	2082	25%	25%	0.094	2%	0.050
81	2083	25%	25%	0.091	2%	0.048
82	2084	25%	13%	0.089	1%	0.024
		Total Discounted Service Acre Years Gained:				**12.60**

TABLE C8. Stream Restoration Inputs: Little Obed River, Rain Gardens Construction, 2.0 acres. Increase in services was 5% each year for the first five years after completion, to a maximum of services 20% which continued for 75 years. A 3% discount factor was used.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
0	2002	0%	0%	1.000	0%	0.000
1	2003	0%	0%	0.971	0%	0.000
2	2004	0%	0%	0.943	0%	0.000
3	2005	0%	0%	0.915	0%	0.000
4	2006	0%	0%	0.888	0%	0.000
5	2007	0%	0%	0.863	0%	0.000
6	2008	0%	3%	0.837	2%	0.042
7	2009	5%	8%	0.813	6%	0.122
8	2010	10%	13%	0.789	10%	0.197
9	2011	15%	18%	0.766	13%	0.268
10	2012	20%	20%	0.744	15%	0.298
11	2013	20%	20%	0.722	14%	0.289
12	2014	20%	20%	0.701	14%	0.281
13	2015	20%	20%	0.681	14%	0.272
14	2016	20%	20%	0.661	13%	0.264
15	2017	20%	20%	0.642	13%	0.257
16	2018	20%	20%	0.623	12%	0.249
17	2019	20%	20%	0.605	12%	0.242
18	2020	20%	20%	0.587	12%	0.235
19	2021	20%	20%	0.570	11%	0.228
20	2022	20%	20%	0.554	11%	0.221
21	2023	20%	20%	0.538	11%	0.215
22	2024	20%	20%	0.522	10%	0.209
23	2025	20%	20%	0.507	10%	0.203
24	2026	20%	20%	0.492	10%	0.197
25	2027	20%	20%	0.478	10%	0.191
26	2028	20%	20%	0.464	9%	0.185
27	2029	20%	20%	0.450	9%	0.180
28	2030	20%	20%	0.437	9%	0.175
29	2031	20%	20%	0.424	8%	0.170
30	2032	20%	20%	0.412	8%	0.165
31	2033	20%	20%	0.400	8%	0.160
32	2034	20%	20%	0.388	8%	0.155
33	2035	20%	20%	0.377	8%	0.151
34	2036	20%	20%	0.366	7%	0.146
35	2037	20%	20%	0.355	7%	0.142
36	2038	20%	20%	0.345	7%	0.138
37	2039	20%	20%	0.335	7%	0.134
38	2040	20%	20%	0.325	7%	0.130
39	2041	20%	20%	0.316	6%	0.126
40	2042	20%	20%	0.307	6%	0.123

TABLE C8. Cont.

Year Post Spill	Year	% Service Level (start of year)	Ave. % Service Level	Discount Factor	Disc. Ave. % Services Gained	Discounted Service Acre-Years Gained
41	2043	20%	20%	0.298	6%	0.119
42	2044	20%	20%	0.289	6%	0.116
43	2045	20%	20%	0.281	6%	0.112
44	2046	20%	20%	0.272	5%	0.109
45	2047	20%	20%	0.264	5%	0.106
46	2048	20%	20%	0.257	5%	0.103
47	2049	20%	20%	0.249	5%	0.100
48	2050	20%	20%	0.242	5%	0.097
49	2051	20%	20%	0.235	5%	0.094
50	2052	20%	20%	0.228	5%	0.091
51	2053	20%	20%	0.221	4%	0.089
52	2054	20%	20%	0.215	4%	0.086
53	2055	20%	20%	0.209	4%	0.084
54	2056	20%	20%	0.203	4%	0.081
55	2057	20%	20%	0.197	4%	0.079
56	2058	20%	20%	0.191	4%	0.076
57	2059	20%	20%	0.185	4%	0.074
58	2060	20%	20%	0.180	4%	0.072
59	2061	20%	20%	0.175	3%	0.070
60	2062	20%	20%	0.170	3%	0.068
61	2063	20%	20%	0.165	3%	0.066
62	2064	20%	20%	0.160	3%	0.064
63	2065	20%	20%	0.155	3%	0.062
64	2066	20%	20%	0.151	3%	0.060
65	2067	20%	20%	0.146	3%	0.059
66	2068	20%	20%	0.142	3%	0.057
67	2069	20%	20%	0.138	3%	0.055
68	2070	20%	20%	0.134	3%	0.054
69	2071	20%	20%	0.130	3%	0.052
70	2072	20%	20%	0.126	3%	0.051
71	2073	20%	20%	0.123	2%	0.049
72	2074	20%	20%	0.119	2%	0.048
73	2075	20%	20%	0.116	2%	0.046
74	2076	20%	20%	0.112	2%	0.045
75	2077	20%	20%	0.109	2%	0.044
76	2078	20%	20%	0.106	2%	0.042
77	2079	20%	20%	0.103	2%	0.041
78	2080	20%	20%	0.100	2%	0.040
79	2081	20%	20%	0.097	2%	0.039
80	2082	20%	20%	0.094	2%	0.038
81	2083	20%	20%	0.091	2%	0.036
82	2084	20%	10%	0.089	1%	0.018
		Total Discounted Service Acre Years Gained:				**9.650**

APPENDIX D
List of Preparers, Agencies and Contacts Consulted

List of Preparers

U.S. Department of the Interior
National Park Service
Philip Campbell, Obed Wild and Scenic River
Amy Mathis, Obed Wild and Scenic River
Steve Bakalez, Big South Fork National River and Recreation Area
Rick Dawson, FLAT Representative
Bruce Peacock, Economist

Tennessee Department of Environment and Conservation
Jonathan Burr
Debbie Mann
Patrick Parker

U.S. Fish and Wildlife Service
Steven R. Alexander

U.S. Department of the Interior
Jerry Thornton, Counsel

Research Planning, Inc.
Heidi Dunagan
Jacqueline Michel

List of Agencies and Contacts Consulted

To be completed after public review.

APPENDIX E
USFWS Consultation

United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, TN 38501

November 30, 2007

Mr. Philip Campbell
National Park Service
Obed Wild and Scenic River
P.O. Box 429
Wartburg, Tennessee 37887

Attention: Ms. Amy Mathis

Re: FWS #08-FA-0095

Dear Mr. Campbell:

U.S. Fish and Wildlife Service (Service) personnel have reviewed your proposal to control exotic vegetation in the restoration area of the Pryor oilwell blowout adjacent to Clear Creek and potential land acquisition areas within the Obed Wild and Scenic River (WSR) boundaries in Morgan County, Tennessee. These activities are associated with the Natural Resource Damage Assessment and Restoration (NRDAR) project that we have collaborated on for several years. The National Park Service (NPS) and the other natural resource trustees propose a variety of integrated pest management (IPM) techniques to achieve the goals outlined in the Damage Assessment and Restoration Plan (DARP) for the Obed WSR. The DARP will also serve as the appropriate National Environmental Policy Act documentation for this NRDAR.

The NPS has made a finding of "not likely to adversely affect" for the following federally threatened (T) and endangered (E) species: spotfin chub (*Erimonax monachus*) (T); Virginia spiraea (*Spiraea virginiana*) (T); Cumberland rosemary (*Conradina verticillata*); Indiana bat (*Myotis sodalis*) (E); and purple bean (*Villosa perpurpurea*) (E). Based on the information provided, we concur with your determination. This finding will be incorporated into the final DARP. In view of this, we believe that you have fulfilled the requirements of section 7 of the Endangered Species Act. Obligations under section 7 must be reconsidered, however, if: (1) new information reveals that the proposed action may affect listed species in a manner or to an extent not previously considered, (2) the proposed action is subsequently modified to include activities which were not considered during this consultation, or (3) new species are listed or critical habitat designated that might be affected by the proposed action.

These constitute the comments of the U.S. Fish and Wildlife Service, provided in accordance with provisions of the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.) and the National Environmental Policy Act (42 U.S.C. 4321-4347; 83 Stat. 852). Your interest and initiative to protect endangered and threatened species are greatly appreciated. If you have questions or if we can be of further assistance, please contact Mary Jennings of my staff at 931/528-6481, ext. 203, or via e-mail at *mary_e_jennings@fws.gov*.

Sincerely,

Lee A. Barclay

Lee A. Barclay, Ph.D.
Field Supervisor

xc: Debbie Mann, TDEC, Nashville, TN
Jerry Thornton, DOI-SOL, Knoxville, TN

United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, TN 38501

November 30, 2007

Mr. Philip Campbell, Unit Leader
National Park Service
Obed Wild and Scenic River
P.O. Box 429
Wartburg, Tennessee 37887

Attention: Ms. Amy Mathis

Re: FWS #08-FA-0212

Dear Mr. Campbell:

U.S. Fish and Wildlife Service (Service) personnel have reviewed your proposal for restoration activities in the Little Obed River watershed in Crossville, Cumberland County, Tennessee. These activities are associated with the Natural Resource Damage Assessment and Restoration (NRDAR) project that we have collaborated on for several years. The National Park Service (NPS) and the other natural resource trustees propose a variety of stormwater management and stream restoration activities to achieve the goals outlined in the Damage Assessment and Restoration Plan (DARP) for the Obed WSR. The DARP will also serve as the appropriate National Environmental Policy Act documentation for this NRDAR.

The NPS has made a finding of "not likely to adversely affect" for the following federally threatened (T) and endangered (E) species: spotfin chub (*Erimonax monachus*) (T); Virginia spiraea (*Spiraea virginiana*) (T); Cumberland bean (*Villosa trabilis*) (E); and purple bean (*Villosa perpurpurea*) (E). Based on the information provided, we concur with your determination. This finding will be incorporated into the final DARP. In view of this, we believe that you have fulfilled the requirements of section 7 of the Endangered Species Act. Obligations under section 7 must be reconsidered, however, if: (1) new information reveals that the proposed action may affect listed species in a manner or to an extent not previously considered, (2) the proposed action is subsequently modified to include activities which were not considered during this consultation, or (3) new species are listed or critical habitat designated that might be affected by the proposed action.

These constitute the comments of the U.S. Fish and Wildlife Service, provided in accordance with provisions of the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.) and the National Environmental Policy Act (42 U.S.C. 4321-4347; 83 Stat. 852). Your interest and initiative to protect endangered and threatened species are greatly appreciated. If you have questions or if we can be of further assistance, please contact Mary Jennings of my staff at 931/528-6481, ext. 203, or via e-mail at *mary_e_jennings@fws.gov*.

Sincerely,

Lee A. Barclay

Lee A. Barclay, Ph.D.
Field Supervisor

xc: Debbie Mann, TDEC, Nashville, TN
Jerry Thornton, DOI-SOL, Knoxville, TN

APPENDIX F
Tribal Council Consultation

United Keetoowah Band
Of Cherokee Indians in Oklahoma
P.O. Box 746 • Tahlequah, OK 74465
2450 S. Muskogee • Tahlequah, OK 74464
Phone: (918) 431-1818 • Fax: (918) 431-1873
www.ukb-nsn.gov

Historic Preservation Program

October 18, 2007

Phillip Campbell
Unit Manager
National Park Service
Obed Wild and Scenic River
PO Box 429
Wartburg, TN 37887

Dear Mr. Campbell:

We are in receipt of your letter dated October 1, 2007 regarding the proposed plan.

We have no comments. However, if at any time, an inadvertent discovery of human remains or funerary items is made, please contact me at 918-822-1952.

Best Regards,

Lisa C. Stopp
Interim Director, Language, History and Culture
Acting Tribal Historic Preservation Officer

APPENDIX G
State Historic Preserveration Office Consultation

TENNESSEE HISTORICAL COMMISSION
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
2941 LEBANON ROAD
NASHVILLE, TN 37243-0442
(615) 532-1550

October 16, 2007

Ms. Amy Mathis
Trustee Council Administrative Coordinator
Obed Wild and Scenic River
Post Office Box 429
Wartburg, Tennessee 37887

RE: NPS, ARCHAEOLOGICAL ASSESSMENT, WHITE CREEK OIL SPILL/MILL SITE, UNINCORPORATED, MORGAN COUNTY, TN

Dear Ms. Mathis:

At your request, our office has reviewed the above-referenced archaeological survey report in accordance with regulations codified at 36 CFR 800 (Federal Register, December 12, 2000, 77698-77739). Based on the information provided, we concur that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places.

We appreciate the National Park Service's response to the potential damage to historic properties posed by the oil spill on White Creek. Given the expansion of oil and gas operations in Big South Fork National River and Recreation Area (BSFNRRA) and the Obed Wild and Scenic River area, we urge the National Park Service to continue to monitor the potential direct and cumulative effects of these industries on cultural resources.

Your cooperation is appreciated.

Sincerely,

E. Patrick McIntyre, Jr.

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jmb

cc: Tom DesJean, NPS, BSFNRRA