Lake Hartwell Restoration and Compensation Determination Plan

Final
March 2006

Prepared by:

Georgia Department of Natural Resources
South Carolina Department of Natural Resources
South Carolina Department of Health and Environmental Control
United States Army Corps of Engineers
United States Fish and Wildlife Service

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With assistance from:

Exponent
Industrial Economics, Incorporated
Schlumberger Technology Corporation

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for Lake Hartwell
February 2006

Prepared by the
State of Georgia Department of Natural Resources
State of South Carolina Department of Natural Resources
State of South Carolina Department of Health and Environmental Control
United States Army Corps of Engineers
United States Department of the Interior Fish and Wildlife Service

Regarding
Natural Resource Damage Assessment and Restoration

State of Georgia
Acting by and through

Department of Natural Resources:

By: _____ Date: 2-7-06
NOEL HOLCOMB
Commissioner

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Regarding
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State of South Carolina
Acting by and through

Department of Natural Resources:

By: _____ Date: 1-30-06
Name : JOHN E. FRAMPTON
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State of South Carolina
Acting by and through

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By: C. Earl Hunter Date: 2-3-06
C. Earl Hunter
Commissioner

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Regarding
Natural Resource Damage Assessment and Restoration

United States Army Corps of Engineers

By: _____ Date: 3/14/2006

Lester S. Dixon, PE
Director of Programs
South Atlantic Division
U.S. Army Corps of Engineers

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Regarding
Natural Resource Damage Assessment and Restoration

United States Department of the Interior
Acting by and through

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By: _____ Date: 2/23/06
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Acronyms and Abbreviations

Assessment Area	The Sangamo Weston/ Twelve Mile Creek/ Lake Hartwell PCB Contamination Superfund Site - as described in the June 1994 Record of Decision of the United States Environmental Protection Agency for Operable Unit 2.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cfs	cubic feet per second
CFR	Code of Federal Regulations
cm	centimeter
Corps	United States Army Corps of Engineers
CWA	Clean Water Act
DOI	United States Department of the Interior
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FCA	fish consumption advisory
GADNR	Georgia Department of Natural Resources
HAI	health assessment index
IBI	index of biotic integrity
mgd	million gallons per day
mg/kg	milligrams per kilogram
MOU	Memorandum of Understanding
MSL	mean sea level
NEPA	National Environmental Policy Act
NPL	National Priorities List
NRDA	natural resource damage assessment
OU1	Operable Unit 1
OU2	Operable Unit 2
PCB	polychlorinated biphenyl
RBP II	rapid bioassessment protocol
RCDP	Restoration and Compensation Determination Plan
RI/FS	remedial investigation and feasibility study
ROD	record of decision
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
Service	United States Fish and Wildlife Service

SQG	sediment quality guideline
STC	Schlumberger Technology Corporation
SVOC	semivolatile organic compound
Trustees	The entities authorized to assess injuries to natural resource damages: DOI through the Service, SCDNR, SCDHEC, GADNR, and the Corps
µg/L	microgram per liter
VOC	volatile organic compound
WMA	Wildlife Management Area

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Executive Summary

Under Federal law, Federal and state agencies are authorized to act as trustees of natural resources on behalf of the public. In the context of natural resource damage claims, Trustees may assess and recover damages for injuries and losses that have occurred to natural resources as a result of hazardous substances, and plan and implement actions to either restore, replace, or rehabilitate injured natural resources; or acquire equivalent resources or the services these resources provide (42 U.S.C. Section 9601 et seq., 43 CFR Part 11). A Trustee Council, consisting of the Georgia Department of Natural Resources (on behalf of the State of Georgia), the South Carolina Departments of Natural Resources and Health and Environmental Control (on behalf of the State of South Carolina), the United States Army Corps of Engineers (Corps), and the United States Fish and Wildlife Service (on behalf of the Department of the Interior) has been formed to evaluate natural resource injuries and losses due to releases of PCBs from the Sangamo Weston/Twelve Mile Creek/Lake Hartwell Superfund Site.

Twelvemile Creek flows southwest to Lake Hartwell through Pickens County, South Carolina. A narrow riverine channel, the creek has steep, heavily vegetated shorelines. Approximately seven miles upstream from Lake Hartwell, the lower portion of Twelvemile Creek contains three impoundments, each associated with a dam (Easley-Central, Woodside I, and Woodside II dams from upstream to downstream). The Easley-Central Water District uses the upper impoundment as a public water supply, and the two lower impoundments, Woodside I and II, are operated as hydroelectric facilities. Twelvemile Creek flows into Lake Hartwell, an artificial impoundment in the Savannah River constructed between 1955 and 1963. Lake Hartwell is bounded by Anderson, Oconee, and Pickens counties in South Carolina (to the east), and by Franklin, Hart, and Stephens counties in Georgia (to the west). Lake Hartwell has a surface area of approximately 56,000 acres with 962 miles of shoreline and is managed to provide flood control, reliable and consistent flows for hydropower generation and navigation, and wildlife and recreational amenities.

The presence of PCBs in Twelvemile Creek/Lake Hartwell was discovered when surface water, sediment, and fish from the area were sampled in the mid-1970s. The source of this contamination was determined to be the Sangamo-Weston, Inc. capacitor manufacturing plant in Pickens, South Carolina. Sangamo-Weston, Inc. operated the plant from 1955 to 1987. The liabilities associated with that operation were subsequently assumed by Schlumberger Technology Corporation (STC). Dielectric fluids, used in the manufacture of capacitors until 1977, contained PCBs, and materials containing these fluids were disposed via land burial. In addition, PCBs were present in discharges from the plant to Town Creek (a tributary of Twelvemile Creek). Surface water and sediment contaminated by the discharged PCBs eventually migrated downstream to Twelvemile Creek and Lake Hartwell.

In 1994, the United States Environmental Protection Agency (EPA) issued a Record of Decision (ROD) for the Twelvemile Creek/Lake Hartwell area that included natural recovery of PCB-contaminated sediments. This alternative was supported by studies showing that PCB-contaminated sediments are expected to be continually buried by sediment entering Twelvemile Creek and Lake Hartwell. In addition, the ROD called for ongoing monitoring of biota, adoption of risk-based guidelines for human consumption of Lake Hartwell fish, and a public education program designed to increase public awareness of the fish consumption advisory.

The Trustees have evaluated damages to natural resources in the Twelvemile Creek/Lake Hartwell Assessment Area resulting from the presence of PCBs. The Assessment Area formally includes: 1) Twelvemile Creek and selected tributaries, 2) the Seneca River Arm of Lake Hartwell, and 3) Lake Hartwell proper. As part of a cooperative effort between the Trustees and STC, this draft Restoration and Compensation Determination Plan (RCDP) has been developed to document injuries to natural resources within the Assessment Area that may be associated with the release of PCBs, and the damages and restoration actions that will compensate the public for losses resulting from these injuries.

Ecological Services

Various natural resources of concern within Twelvemile Creek and Lake Hartwell, including surface water, sediment, and biological resources, have been injured as defined in the Department of the Interior (DOI) regulations as a result of the release of PCBs. For example, PCBs were detected in surface waters of Twelvemile Creek and in the Seneca River Arm of Lake Hartwell at concentrations that exceed the Federal water quality criterion for ecological resources (0.014 μg/L; EPA 2002b). PCBs are present in sediment in Twelvemile Creek, the Seneca River Arm, and Lake Hartwell proper at varying concentrations, including at concentrations exceeding levels that have been associated with injury to biota. For example, PCB concentrations in fish tissue have been measured at concentrations that have been associated with the potential for adverse effects, including impairment of immunological and physiological functions, decreases in early life stage survival, decrease in reproductive performance and growth, impaired development, and mortality; and site-specific studies have documented adverse impacts on fish health in the Assessment Area. A site-specific risk assessment indicated risk of adverse effects to higher trophic level organisms such as birds and mammals as a result of dietary exposure to PCBs in the Twelvemile Creek Area.

The preferred restoration alternative to compensate for ecological losses in the Assessment Area from PCBs is removal of the Woodside I and Woodside II dams, followed by stream corridor restoration in Twelvemile Creek. This includes dredging sediments behind the two dams, dismantling each dam, and then implementing stream corridor improvement and restoration projects such as constructing in-stream habitat

structures, establishing erosion and run-off controls (emphasizing biological rather than mechanical controls), and planting native vegetation.

Dam removal and stream corridor restoration will provide multiple ecological benefits to the Assessment Area. Dam removal will speed the EPA remedy by enhancing transport of uncontaminated sediment through the Twelvemile Creek system and speeding the burial of contaminated sediment in Lake Hartwell. This process is expected to result in a more rapid decline of PCBs in fish and other biota, allowing for the potential for fishing advisories to be lifted sooner than they might be without the dam removal. This process will also result in lower PCB exposure to aquatic biota and the terrestrial fauna (e.g., birds and mammals) that feed on them. Dam removal is expected to restore the hydrology of lower Twelvemile Creek from the Easley-Central Dam to Lake Hartwell to a free-flowing riverine system, which in turn will enhance sedimentation processes, improve biodiversity and population density of native species, and provide more appropriate habitat for submerged and emergent vegetation. These improvements will be supplemented by stream corridor restoration, where appropriate, which is expected to provide better substrate for native vegetation, improve bottom habitat for native fish species, establish a more natural sedimentation regime, and improve streamside (riparian) habitat.

Recreational Services

Lake Hartwell is a regionally important recreational fishing resource. Because of the presence of PCBs, fish consumption advisories have been in place on the lake since 1976. These advisories constitute an injury as defined in the DOI regulations. Damages from these injuries are determined beginning in 1981 with the promulgation of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

By restricting people's ability to keep and consume the fish they catch, consumption advisories have been shown to reduce the value of a water body to recreational anglers. Using information from existing studies of this change in value at similar sites, the Trustees and STC estimated the present value of recreational fishing losses at Lake Hartwell to be between $7 and $18 million. This represents the value of lost and diminished recreational fishing trips (i.e., trips not taken and a lower value for each trip) to Lake Hartwell beginning in 1981, the year after CERCLA went into effect.

The preferred restoration alternatives to compensate for recreational fishing losses incurred in the Assessment Area include creation of new harvest opportunities for area anglers and improvement of public fishing access (e.g., jetties and boat ramps). The Trustees anticipate that harvest opportunities will be created through establishment of new public fishing areas, including development of existing lake sites and/or sub-impoundment areas. All new harvest sites would be located immediately adjacent to or in the vicinity of Lake Hartwell, in order to benefit those anglers who are directly

affected by the consumption advisories. Public fishing opportunities may also be enhanced through construction of jetties in the Lake Hartwell tailrace, and construction of boat ramps will provide increased access for anglers.

1 Introduction

Under the regulations guiding the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Federal and state natural resource agencies are designated to act as trustees for the public (43 CFR Part 11 1986). The trustees are responsible for recovering damages for injury to natural resources caused by a release of hazardous substances. Damages may include the cost of restoring the resource services to baseline conditions (i.e., conditions without a release) and the value of recreation and ecological service losses from the time of the injury until baseline is restored.

The presence of polychlorinated biphenyls (PCBs) in Twelvemile Creek and Lake Hartwell was discovered when the South Carolina Department of Health and Environmental Control (SCDHEC) sampled surface water, sediment, and fish from Twelvemile Creek and Lake Hartwell in the mid-1970s. Results from these analyses indicated PCB contamination, and it was concluded that the source of this contamination was the Sangamo-Weston, Inc. plant in Pickens, South Carolina. SCDHEC and the United States Environmental Protection Agency (EPA) issued an advisory against eating fish from Lake Hartwell in 1976; the advisory has been modified periodically on the basis of fish and sediment sampling conducted by SCDHEC. The State of Georgia has also issued lake-wide advisories during this period. As a result of this and subsequent sampling, the Sangamo-Weston, Inc./Twelvemile Creek/Lake Hartwell site was placed on the National Priorities List (NPL) in February 1990.

The United States Department of the Interior (DOI), through the Fish and Wildlife Service (Service), the United States Department of Defense through the United States Army Corps of Engineers (Corps), SCDHEC, South Carolina Department of Natural Resources (SCDNR), and Georgia Department of Natural Resources (GADNR) have conducted a natural resource damage assessment (NRDA) for the Twelvemile Creek and Lake Hartwell Assessment Area. The Service, the Corps, SCDHEC, SCDNR, and GADNR are referred to in this document as the natural resource trustees, or simply "Trustees." This Restoration and Compensation Determination Plan (RCDP) documents the injuries sustained by natural resources as a result of the release of PCBs from the Sangamo-Weston plant, and restoration actions that will compensate the public for losses resulting from these injuries.

1.1 Organization of this RCDP

This RCDP is organized into four sections:

- **Introduction—**This section describes the Sangamo-Weston Superfund site and the Twelvemile Creek/Lake Hartwell Assessment Area, identifies the responsible party and the authority for the Trustees to proceed with the NRDA, describes the public participation process,

and provides a summary of natural resource injuries and the proposed restoration actions.

- **Natural Resources and Contaminants of Concern—**This section describes the natural resources affected by the release, identifies the contaminants of concern, and describes the nature and extent of contamination.

- **Ecological Losses and Restoration Alternatives—**This section describes the injury determination process for ecological resources, provides documentation of injuries, describes the potential magnitude of these injuries, and provides an evaluation of restoration alternatives.

- **Recreational Fishing Losses and Restoration Alternatives—**This section describes the injury determination process for recreational fishing losses, provides documentation of injuries, describes the potential magnitude of these injuries, and provides an evaluation of restoration alternatives.

Appendix A provides a summary of investigations that were relied upon for the ecological injury determination. Appendix B provides a description of the fishing model for recreational fishing losses, and Appendix C contains the Environmental Assessment required for compliance with the National Environmental Policy Act (NEPA).

1.2 Overview of the Sangamo-Weston Site and the Twelvemile Creek/Lake Hartwell Assessment Area

1.2.1 Sangamo-Weston Superfund Site

Sangamo-Weston, Inc. owned and operated a capacitor manufacturing plant from 1955 to 1987 in Pickens, South Carolina (see Figures 1 and 2). The liabilities associated with that operation were subsequently assumed by STC. Dielectric fluids, used in the manufacture of capacitors until 1977, contained PCBs. Waste disposal practices at the Sangamo-Weston Plant included land-burial of off-specification capacitors and wastewater treatment sludges on the plant site and at six rural satellite disposal areas (Breazeale, Cross Roads, Dodgens, John Trotter, Nix, and Welborn sites; see Figure 2). Prior to the construction of a wastewater treatment plant in 1975 and subsequent upgrade of that plant in 1975 and 1976, PCBs were discharged from the Sangamo-Weston plant into Town Creek. The discharged PCBs eventually migrated downstream to Twelvemile Creek and Lake Hartwell. Sangamo-Weston discharges decreased until 1976, when only very limited quantities were released under a National Pollutant Discharge Elimination System permit. The Sangamo-Weston Plant and the six satellite disposal sites were managed together in the Superfund process as Operable Unit 1 (OU1). A Record of Decision (ROD) for OU1 was issued in 1990. Operable Unit 2 (OU2) consists of the

approximately 40 stream miles of Twelvemile Creek and its tributaries, the Twelvemile Creek Arm of Lake Hartwell, portions of the Keowee and Seneca River Arms of Lake Hartwell, and Lake Hartwell itself. This RCDP focuses on the Assessment Area as defined in Section 1.2.2 below.

EPA conducted a remedial investigation and feasibility study (RI/FS) for OU2 that included a sediment and aquatic biota study for more than 40 stream miles of the Twelvemile Creek watershed and portions of greater Lake Hartwell (Bechtel 1993). The final ROD for OU2 was issued in June 1994 (EPA 1997). The selected remedy includes monitored natural recovery of PCB-contaminated sediments by the continued deposition of clean sediment entering Lake Hartwell and subsequent burial and dilution of PCB-contaminated sediment. The remedy also included annual monitoring of fish tissue, *Corbicula* clams, and sediment; adoption of risk-based guidelines for human consumption of Lake Hartwell fish; and a public education program designed to increase public awareness of the fish consumption advisory (FCA). The ROD acknowledged the fact that the rate of natural recovery was affected by three dams on Twelvemile Creek that trap sediment, and thus the ROD included a component to manage releases of sediment accumulating behind the dams. A five-year review of the ROD has been initiated by EPA to evaluate the effectiveness of the selected remedy. This effort includes sediment deposition modeling and evaluation of sediment management plans for sediments trapped behind the dams on Twelvemile Creek (http://www.epa.gov/region4/waste/npl/nplsc/sangamsc.htm). Preliminary results of the modeling indicate that natural recovery is proceeding more slowly than was originally estimated.

1.2.2 Twelvemile Creek/Lake Hartwell Assessment Area

For the purposes of this RCDP, the Twelvemile Creek/Lake Hartwell Assessment Area (Assessment Area) is divided into three sub-areas: 1) Twelvemile Creek (Twelvemile Creek and selected tributaries), 2) the Seneca River Arm of Lake Hartwell (including the area referred to as the Twelvemile Creek Arm in Bechtel [1993]), and 3) Lake Hartwell proper (Lake Hartwell) (see Figures 1 and 2). The following tributaries are included in the Twelvemile Creek sub-area because they are associated with the satellite disposal sites: North Fork of Twelvemile Creek, Middle Fork of Twelvemile Creek, Town Creek, Wolf Creek, and Golden Creek.

The Assessment Area is situated in the southern mixed pine-oak forest region of South Carolina (e.g., longleaf pine, loblolly pine, shortleaf pine) (Kricher 1988). The Assessment Area supports as many as 250 species of birds, 40 species of mammals, and numerous aquatic, reptilian, and amphibian species (Bechtel 1994). Six state endangered species and three state threatened species are known to occur in Pickens County (SCDNR 2003), although their presence, if any, and distribution within the Assessment Area is not known.

1.2.2.1 Twelvemile Creek

Twelvemile Creek originates near Walnut Cove Mountain, approximately seven miles north-northeast of Pickens, South Carolina and is approximately 24 miles long. Twelvemile Creek drains a 106-square-mile watershed (encompassing more than 40 percent of Pickens County) and has a basin perimeter of approximately 55 miles. The elevation ranges from a high of 1,900 ft above mean sea level (MSL) at the headwaters to a low of 660 ft MSL at the confluence with Lake Hartwell. Major tributaries flowing into Twelvemile Creek include Town, Wolf, Rices, and Gold Creeks. Streamflow data recorded in Twelvemile Creek from 1954 through 1964 and from 1989 through 1993 indicate a maximum flow of 5,360 cubic feet per second (cfs) in 1961 and a minimum flow of 30 cfs in 1955. The average discharge during this period of record was 198 cfs.

Three impoundments are located along the lower portion of Twelvemile Creek, approximately 7 miles upstream from Lake Hartwell. These impoundments are associated with the Easley-Central, Woodside I, and Woodside II dams. The Easley-Central Water District uses the upper impoundment as a public water supply, and the two lower impoundments, Woodside I and II, are operated as hydroelectric facilities. In the early- to mid-1990s, the Easley-Central and Pickens water plants withdrew approximately 3.2 to 3.7 million gallons per day (mgd) of potable water from Twelvemile Creek to supply 5,500 residents (Bechtel 1993). The Easley Dam has an upper and lower pool elevation of 783 ft MSL and 763 ft MSL. The Woodside I impoundment has an upper and lower pool elevation of 760 and 736 ft MSL, respectively. Woodside II has an upper pool elevation of 722 ft MSL and a lower pool elevation of 684 ft MSL.

The upper portion of the Twelvemile Creek drainage basin is characterized by relatively steep terrain resulting from deeply incised stream valleys that have dissected the original plateau surface. Sections of upper Twelvemile Creek run through steep bluffs with dense thickets of mountain laurel and/or rhododendron, which are somewhat atypical of the Piedmont region. For example, in these areas, canopy species include white pine, a species typically found at higher elevations. The relief decreases south, in a downstream direction, until the creek widens to the Twelvemile Creek Arm of Lake Hartwell (Bechtel 1994). Both Twelvemile Creek and the Twelvemile Creek Arm of Lake Hartwell have narrow channels, with steep, heavily vegetated shorelines. The surrounding area is predominately rural and undisturbed forest (Bechtel 1994).

An annual average sediment load of 100,000 tons is transported by Twelvemile Creek downstream to Lake Hartwell. Sediments from Twelvemile Creek are composed of approximately 70 percent sand, 10 percent silts, and 20 percent clay (Bechtel 1993). A significant portion of the sediment transported by Twelvemile Creek is currently trapped behind the Woodside I and II dams. At the time of the writing of this RCDP it is estimated that approximately 100,000 cubic yards of sediment have accumulated behind the Woodside I dam and approximately 190,000 cubic yards have accumulated behind the Woodside II dam. A smaller amount (about 50,000 cubic yards) has accumulated behind Easley-Central dam (the Easley-Central dam has a high flow sluice gate for flushing sediment downstream). Historically, the sediment trapped behind Woodside I

and II was flushed downstream through sluice gates when the accumulation of sediment impaired power generation.

1.2.2.2 Lake Hartwell

Lake Hartwell is a man-made reservoir, constructed by the Savannah District of the Corps from 1955 to 1963 by damming the Savannah River. Lake Hartwell consists of a number of large arms, including the Keowee, Seneca River, and Twelvemile Creek Arms in the north portion of the lake and the Tugaloo, Six and Twenty Mile Creek, Coneross Creek, and Eighteen Mile Creek Arms in the main part of the lake. At normal pool elevations, Lake Hartwell has a surface area of approximately 56,000 acres and 962 miles of shoreline. Lake Hartwell is maintained by the Corps at a pool elevation of 660 ft MSL during the summer (considered to be the normal elevation), and 656 ft MSL from mid-October through mid-December. The average monthly flow of water into the lake (average from 1962–1992 data) ranged from 2,693 cfs to 6,222 cfs, and the lake has a holding capacity of 830 billion gallons of water (Bechtel 1993). Lake Hartwell is used for public recreation, flood control, and power generation. Recreation activities at the lake include swimming, boating, water-skiing, fishing, picnicking, and camping.

1.3 Authority

This RCDP has been prepared by the Trustees of the Twelvemile Creek/Lake Hartwell watershed. The Trustees are authorized to act on behalf of the public under Federal law to assess and recover natural resource damages, and to plan and implement actions to restore, replace, or rehabilitate natural resources injured or lost as a result of releases of a hazardous substance, or to acquire the equivalent resources or the services they provide (42 U.S.C. Section 9601 *et seq*. (CERCLA); 43 CFR Part 11). The Trustees for this site include the following:

- GADNR on behalf of the State of Georgia,
- SCDNR and SCDHEC on behalf of the State of South Carolina,
- The Corps, and
- The Service on behalf of DOI.

1.4 Coordination with Responsible Party

Under CERCLA, the party responsible for the release of a hazardous substance is liable for any resulting injuries to natural resources. Although the final authority regarding determinations of injury and restoration rests solely with the Trustees, the responsible party may be invited to participate in a cooperative natural resource damage

assessment (43 CFR Part 11). Cooperative assessments can be beneficial to the public by reducing duplication of effort, expediting the assessment, and implementing restoration earlier than might otherwise be the case.

The Trustees deem STC the responsible party for natural resource damages at the Twelvemile Creek/Lake Hartwell site. STC was invited by the Trustees to conduct a cooperative assessment for the site. STC's active involvement in the damage assessment and restoration planning includes the following:

- Providing funding and assistance for the RCDP during the settlement process
- Evaluating the feasibility and cost of dam removal and river restoration
- Providing comments on injury assessments for ecological and human-use services.

The Trustees believe that the cooperative process has worked well for this assessment and will continue through the implementation of ecological restoration. However, the determination of injury and necessary restoration or compensation is the sole responsibility of the Trustees.

1.5 Public Participation

A draft RCDP was released for public comment in February 2005. The public comment period ended in April 2005. The Trustees have reviewed all submitted comments. Responses to these comments, as well as the comments themselves, are provided in Appendix E. The Final RCDP is also available from the following sources:

- Online at:

  http://www.gofishgeorgia.com/content/displaycontent.asp?txtDocument=386

  or

  http://www.dnr.sc.gov/lakehartwell/plan.html;

- In electronic or hard-copy by request at: Paul League
  SCDNR
  P.O. Box 167
  Columbia, SC 29202
  Leaguep@dnr.sc.gov

1.6 Summary of Natural Resource Injury and Damages

The following sections summarize the major conclusions regarding injury and damages to ecological resources and recreational fishing in the Assessment Area. Detailed discussions are provided in Section 3.2 for ecological resources and Section 4.2 for recreational fishing.

1.6.1 Ecological

Surface water, sediment, and biological resources have been injured by releases of PCBs from the Sangamo-Weston plant. PCBs were detected in surface waters of Twelvemile Creek and in the Seneca River Arm of Lake Hartwell at concentrations that exceed the water quality criterion for ecological resources (0.014 μg/L; EPA 2002b). PCBs are widely distributed in sediment throughout the Assessment Area and have been measured in all areas at concentrations exceeding injury threshold levels. Concentrations of PCBs in sediment have declined with time in Twelvemile Creek; in addition, PCB levels decline with distance from Twelvemile Creek. PCB concentrations in Twelvemile Creek and the Seneca River Arm sediment are generally higher than in the remainder of Lake Hartwell. PCBs in sediment of all areas from 1995 to 2003 are present at lower concentrations than prior to 1995 (ERM 2003).

Data on PCB concentrations in Assessment Area fish show that higher levels of PCBs generally occur closer to the mouth of Twelvemile Creek. Fish sampled include largemouth bass (*Micropterus salmoides*), hybrid bass (*Morone chrysops x Morone saxatilis*), channel catfish *(Ictalurus punctatus*), bluegill sunfish (*Lepomis macrochirus*), threadfin shad (*Dorosoma petenense*), gizzard shad (*D. cepedianum*), redbreast sunfish (*Lepomis auritus*), and northern hog suckers (*Hypentelium nigricans*).

Site-specific studies have documented adverse impacts on fish health in the Assessment Area. Studies of largemouth bass in the Assessment Area have documented negative effects on survival and growth, primarily within the Twelvemile Creek Arm of Lake Hartwell; however, the degree to which these effects were the result of PCBs was not determined (Foltz and Mattison 1993; Greeley et al. 1994). Self (1993) recorded differences in nutritional indicators of redbreast sunfish populations in Twelvemile Creek relative to fish caught in a reference location, but could not conclude that there was an association between PCBs and these differences in health condition. Other fish studies in the Twelvemile Creek watershed observed changes in community composition and species abundance, but found that fish health within the watershed was similar to the health of fish in a reference watershed (Self 1993; Gibson and Alexander 1993).

Bechtel (1994) conducted an assessment of risks to higher trophic level organisms (birds and mammals) from exposure to PCBs. The assessment was conducted by estimating dietary exposure levels for belted kingfisher (*Ceryle alcyon*), eastern phoebe (*Sayornis phoebe*), green heron (*Butorides virescens*), osprey (*Pandion haliaetus)*, mink

(*Mustela vison*), and otter (*Lutra canadensis*) and comparing these values to literature-based toxicity reference values. Risk was characterized by dividing the exposure estimate by the toxicity reference value to develop a "hazard quotient."[1] This assessment used data collected prior to 1994 in the Seneca River Arm. Hazard quotients were greater than 1.0 for all receptors, suggesting possible adverse effects. The authors did not, however, define the magnitude of risk because of uncertainty in exposure estimates. Because of the decline in PCB concentrations in sediment and fish over time, current exposure of birds and mammals to PCBs, and exposures in areas other than the Seneca River Arm, are likely to be lower than that characterized in the 1994 risk assessment.

1.6.2 Recreational Fishing

Lake Hartwell is a regionally important recreational fishing resource, supporting over 700,000 angler-hours of effort each year (Bales 1993). Because of the presence of PCBs, FCAs have existed on the lake since 1976. These advisories constitute an injury to the Lake Hartwell recreational fishing resource. Damages from these injuries are determined beginning in 1981 with the promulgation of CERCLA.

FCAs have been shown to reduce the value of a water body to recreational anglers. Using information from existing studies, the Trustees estimate the present value of recreational fishing losses at this site to be no higher than $18 million. This represents the value of lost and diminished recreational fishing trips to the lake beginning in 1981.

1.7 Summary of Preferred Restoration Options

1.7.1 Ecological

The preferred restoration alternative to compensate for ecological losses incurred at the Assessment Area is removal of the Woodside I and Woodside II dams, followed by stream corridor restoration in Twelvemile Creek. This includes dredging sediments behind the two dams, demolishing each dam, and then implementing stream corridor improvement and restoration projects such as constructing instream habitat structures, establishing erosion and run-off controls (emphasizing biological rather than mechanical controls), and planting native vegetation.

[1] A hazard quotient is the ratio of the potential exposure to the substance, to the level at which no adverse effects are expected. If the hazard quotient is calculated to be less than 1.0, then no adverse health effects are expected as a result of exposure. If the hazard quotient is greater than 1.0, then adverse health effects are possible. The hazard quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. Note that a hazard quotient exceeding 1 does not necessarily mean that adverse effects will occur (EPA 2002a).

Dam removal and stream corridor restoration will provide multiple ecological benefits to the Assessment Area. Dam removal will speed the EPA remedy for OU2 by enhancing transport of uncontaminated sediment through the Twelvemile Creek system and speeding the burial of contaminated sediment in Lake Hartwell. In addition, dam removal is expected to restore the hydrology of lower Twelvemile Creek from the Easley-Central Dam to Lake Hartwell to a free-flowing riverine system, enhance sedimentation processes, improve biodiversity and population density of native species, and provide more appropriate habitat for submerged and emergent vegetation. These improvements will be augmented by stream corridor restoration, where appropriate, which is expected to provide better substrate for native vegetation, improve bottom habitat for native fish species, establish a more natural sedimentation regime, and improve streamside (riparian) habitat.

1.7.2 Recreational Fishing

The preferred restoration alternatives to compensate for recreational fishing losses incurred at the Assessment Area include creation of new harvest opportunities for area anglers and improvement of public fishing access (e.g., jetties and boat ramps). The Trustees anticipate that harvest opportunities will be created through establishment of new public fishing areas, including development of existing lake sites and/or sub-impoundment areas. All new harvest sites would be located immediately adjacent to or in the vicinity of Lake Hartwell, in order to benefit those anglers who are directly affected by the FCAs. Public fishing opportunities may also be enhanced through construction of jetties in the Lake Hartwell tailrace, and construction of boat ramps will provide increased access for anglers.

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2 Natural Resources of the Assessment Area and Contaminants of Concern

The following sections describe the natural resources within the Assessment Area, identify the contaminants of concern, and describe the nature and extent of contamination.

2.1 Natural Resources

The DOI regulation for NRDA [43 CFR Section 11.14(z)] defines natural resources as:

> *"land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: Surface water resources, ground water resources, air resources, geologic resources, and biological resources."*

The Trustees focused their NRDA on surface water resources (including sediment) and biological resources within the Assessment Area.

2.1.1 Surface Water Resources

The DOI regulation [43 CFR Section 11.14(pp)] defines surface water resources as:

> *"the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas."*

Surface waters that may have been exposed to PCBs from the Sangamo-Weston plant include the area encompassed by OU2: approximately 40 stream miles of Twelvemile Creek and its tributaries that are hydrologically connected to the six satellite disposal sites, the Seneca River Arm of Lake Hartwell, and Lake Hartwell (see Figure 2). Sediments that may have been exposed to PCBs include the bed and bank sediments of these waters.

2.1.2 Biological Resources

The DOI regulation [43 CFR Section 11.14(f)] defines biological resources as:

> *"those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition."*

The biological resources potentially exposed to releases from the Sangamo-Weston plant include benthic macroinvertebrates that live in and on sediments of the Twelvemile Creek and Lake Hartwell system, fish, birds, and mammals that forage in the creek or lake habitats.

The flowing reaches of Twelvemile Creek are habitat for numerous aquatic insects such as hellgrammites (*Corydalidae*), smaller alderflies (*Sialidae*), spongilla flies (*Neuroptera*), midges (*Chironomidae*), mosquitoes (e.g., *Anopheles* spp.), dragonflies (*Odonata*), mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*). Crayfish (*Cambarus* sp.) and water fleas (*Daphnia* sp.) are common in both the still waters of Lake Hartwell and the running waters of Twelvemile Creek. Other groups of invertebrates such as mussels, snails, and clams also can be found in Lake Hartwell (Bechtel 1994).

Twelvemile Creek supports a fairly varied fish community including, but not limited to golden shiner (*Notemigonus crysoleucas*), creek chub (*Semotilus atromaculatus*), grass pickerel (*Esox americanus*), darters, sculpins, catfish, shad, eels, and bullheads. Pool habitats of lower Twelvemile Creek support pumpkinseed (*Lepomis gibbosus*), bluegill, and largemouth bass (Bechtel 1994). In Lake Hartwell, fish species include crappie (*Pomoxis* spp.), bluegill, redbreast sunfish, redear sunfish (*Lepomis microlophus*), green sunfish (*Lepomis cyanellus*), pumpkinseed, largemouth bass, striped bass (*Morone saxatilis*), hybrid bass, and walleye (*Sander vitreus*) (Bechtel 1994).

The waterways of the Assessment Area provide habitat for a wide range of aquatic birds (e.g., ducks) and other birds that may depend on aquatic resources. For example, some of the most common ducks in the Assessment Area include mallard (*Anas platyrhynchos*), hooded merganser (*Lophodytes cucullatus*), and wood duck (*Aix sponsa*). Several species of wading birds such as the great blue heron (*Ardea herodias*) and green heron (*Butorides virescens*) are year-round residents and are attracted to the shorelines of both Twelvemile Creek and Lake Hartwell where they forage for fish, amphibians, and large invertebrates such as crayfish. Other wading birds such as the great egret (*Ardea alba*), cattle egret (*Bubulcus ibis*), and little blue heron (*Egretta caerulea*) are likely to occur only seasonally in the Assessment Area. Raptors such as bald eagle (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*) fish and nest in the Lake Hartwell

watershed. Belted kingfishers (*Ceryle alcyon*) are also resident, and likely use shoreline areas where vegetation provides suitable perch spots and water clarity is adequate to spot prey. Small birds such as the spotted sandpiper (*Actitis macularia*) and Louisiana waterthrush (*Seiurus motacilla*) are likely to be present throughout the Assessment Area, where they feed on invertebrates in the streams. Some terrestrial birds, such as the eastern phoebe and tree swallow (*Tachycineta bicolor*) may derive a portion of their diet from emerging aquatic insects in the Twelvemile Creek drainage (Bechtel 1994).

Twelvemile Creek, Lake Hartwell, and adjacent terrestrial areas provide habitat to 40 species of mammals. Mammals such as raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), gray fox (*Urocyon cinereoargenteus*), white-tailed deer (*Odocoileus virginianus*), and eastern cottontail (*Sylvilagus floridanus*) use the shores of Twelvemile Creek and Lake Hartwell as habitat. Small mammals present in terrestrial habitats within the watershed include eastern gray squirrel (*Sciurus carolinensis*), southern flying squirrel (*Glaucomys volans*), masked shrews (*Sorex cinereus*), southeastern shrew (*Sorex longirostris*), and Carolina short-tailed shrew (*Blarina carolinensis*). The eastern mole (*Scalopus aquaticus*), meadow vole (*Microtus pennsylvanicus*), long-tailed weasel (*Mustela frenata*), and several bat species can also be found in the area. Bobcats (*Lynx rufus*) are also common in the general Piedmont area. If present, mammals, including the muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), river otter (*Lutra canadensis*), and beaver (*Castor canadensis*), would use riparian habitats. Both mink and otter have been reported in Lake Hartwell, with otter being the more commonly reported of the two species. Twelvemile Creek offers suitable habitat for mink and otter, although these species have not been recorded in this area. With the exception of mink, river otter, and raccoon, which are piscivorous (i.e., fish-eating), most mammals in the Assessment Area are not likely to derive a substantial portion of their diet or other required resources from Twelvemile Creek and Lake Hartwell aquatic habitats (Bechtel 1994).

2.2 Contaminants of Concern

PCBs are the contaminant of concern in the Assessment Area. Full-screen analyses were conducted on a limited number of sediment and fish tissue (biological) samples during EPA's remedial investigation but those analyses did not detect appreciable quantities of other contaminants including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and/or inorganic analytes (metals) (Bechtel 1993).

PCBs are a mixture of synthetic organic chemicals consisting of 209 individual chlorinated biphenyls referred to as congeners. PCBs are an oily liquid or solid and are colorless or light yellow. PCBs have good insulating properties, are stable, and are non-flammable, and were therefore widely used in capacitors, transformers, and other electrical equipment. In the United States, PCB mixtures are known by their industrial trade name, Aroclor®. The different commercial mixtures were identified by a

numbering scheme; the most common mixture numbers were 1016, 1248, 1254, and 1260. The last two digits of the Aroclor® number correspond to the percentage of chlorine (by weight) in the mixture. Use of PCBs was generally banned in 1977 after it was discovered that they accumulate in the environment and can have harmful effects on organisms.

Once in the environment, PCBs do not readily degrade and tend to become closely associated with soil and sediment due to their low solubility. Although not highly volatile, once PCBs enter the atmosphere they can be distributed over long distances. PCBs that are present in sediment and water can be readily taken up by small organisms and fish because of the lipophilic ("fat-loving") quality of PCBs. Consumption of these contaminated organisms by predators transfers the PCBs to higher trophic levels in the food web where bioaccumulation can occur.

PCBs have been reported to elicit a broad range of toxic effects, including physiological, immunological, developmental, and reproductive effects. For example, reproductive success in fish, mammals, and birds can be adversely affected directly by toxic action on the reproductive tract, or indirectly on systems that regulate reproduction (e.g., endocrine and central nervous systems). In laboratory studies, PCBs have been reported to elicit a broad range of direct and indirect effects that could conceivably lead to decreased reproductive function. For example, the liver is reported to be one of the primary targets of PCB toxicity. Changes in the activity of liver enzymes can result in modulation of steroid hormone levels, suggesting a mechanism by which PCBs could alter reproductive function. PCBs have also been implicated in the modulation of other systems important for reproduction, such as the central nervous system and the adrenal and thyroid glands. Direct effects on the gonads and the female reproductive tract have also been reported (Fuller and Hobson 1986; Peakall 1986; Barron et al. 1995). Despite the extensive amount of information on the effects of PCBs on reproduction in mammals and birds, the precise mechanism by which PCBs cause these effects remains unclear.

2.3 Nature and Extent of PCB Contamination

Numerous evaluations of PCB concentrations in surface water, sediment, and biota of the Assessment Area have been conducted since 1976. Descriptions of all these studies are provided in Appendix A. Major findings of these investigations are briefly summarized here. Figures 3, 4, and 5 present locations of some of the sampling described in this section.

2.3.1 PCBs in Water

Surface water in the Assessment Area was analyzed for PCBs during the remedial investigation (50 stations during Phase I and nine stations during two storm events in Phase II) (Bechtel 1993). Sampling locations included Wolf Creek, the three impoundments on the lower reach of Twelvemile Creek, several arms of Lake Hartwell,

and reference stations upstream and outside of the drainage containing the Sangamo-Weston plant.

For the Phase I sampling effort, PCBs were undetected at detection limits ranging from 0.49 to 2.0 micrograms per liter (μg/L) and for the Phase II sampling, PCBs were undetected at detection limits of either 1.2 or 1.3 μg/L (Bechtel 1993). In addition to the remedial investigation sampling, Battelle (2002) collected nine high-volume water samples in Twelvemile Creek in 2001 to allow for lower detection limits. PCB concentrations in water from these samples ranged from a minimum of below the detection limit (detection limit not provided) at Station C-4, upstream from the confluence of Wolf Creek and Twelvemile Creek, to a maximum of 0.19 μg/L at Station C-0 on Town Creek, upstream of the Sangamo-Weston plant (see Figure 4).

2.3.2 PCBs in Sediment

Several investigations of PCBs in the Twelvemile Creek and Lake Hartwell Assessment Area were conducted between 1972 and 1993, prior to the RI/FS (e.g., studies included as Appendices in Bechtel 1993). An overview of all these studies is provided in Appendix A. Based on data from all these studies, the maximum PCB concentration measured in the Twelvemile Creek watershed was 22.1 milligrams per kilogram (mg/kg) in a sample collected from Town Creek in 1976 by SCDHEC as discussed in Bechtel (1993). In the Seneca River Arm of Lake Hartwell the maximum recorded PCB concentration was 73.2 mg/kg measured in a sediment core collected in 1988 by Germann (Bechtel 1994). The maximum PCB concentration measured in sediment of Lake Hartwell in the pre-RI/FS time period was 6.6 mg/kg in a sample collected by EPA in 1976 (Bechtel 1993).

The most comprehensive sediment investigation was conducted in two phases in 1991 and 1992 as part of the RI/FS for OU2 (Bechtel 1993). A total of 392 sediment samples were collected in Phase I from 50 sampling stations in Twelvemile Creek, the Twelvemile Creek Arm of Lake Hartwell, the Keowee River Arm of Lake Hartwell, the Seneca River Arm of Lake Hartwell, and Lake Hartwell. Phase II sediment sampling included a total of 735 samples collected at 374 locations in Twelvemile Creek and Lake Hartwell. In both phases, sampling included surface sediment grab sampling and sediment core sampling (see Bechtel [1993] for locations of all sampling stations).

As reported in the RI/FS, most upper Twelvemile Creek sediment samples had PCB concentrations below 0.35 mg/kg, with a maximum concentration of 6.5 mg/kg in a 5–10 centimeter (cm) core interval from Town Creek (Bechtel 1993). Surface sediment samples collected near the satellite disposal facilities had concentrations below 1.0 mg/kg, with most samples being less than 0.5 mg/kg. Many of the sediment samples collected from the lower Twelvemile Creek watershed had PCB concentrations less than 1.0 mg/kg, and observed concentrations ranged from 0.19 to a maximum of 1.5 mg/kg.

Bechtel (1993) also reported surface sediment grab samples collected from the Seneca River Arm area that ranged from a minimum of 0.02 mg/kg to a maximum of 9.48 mg/kg in the upper Twelvemile Creek Arm. Sediment core concentrations ranged from 0.03 mg/kg to a maximum of 21.52 mg/kg in a 30–35 cm interval of a core sample from Twelvemile Creek Arm. Sediment concentrations in grab samples and core samples from other locations in the Seneca River Arm area were lower (generally less than 3 mg/kg). Nine stations in Lake Hartwell had PCB concentrations ranging from 0.15 to 1.74 mg/kg in surface sediment samples, while sediment core concentrations in this area ranged from 0.07 mg/kg to 2.42 mg/kg (maximum at the 10–15 cm interval) (Bechtel 1993).

In summary, RI/FS sampling generally found that PCB concentrations were highest in sediment in the Twelvemile Creek and Seneca River Arms of Lake Hartwell, and decreased with distance downstream from the Twelvemile Creek Arm. Within the Twelvemile Creek watershed, concentrations were highest in Town Creek, as well as behind the three impoundments. Comparisons to historical sediment studies indicated that PCB concentrations were decreasing from the mid-1980s to the time of the RI/FS studies in the early 1990s (Bechtel 1993).

An annual monitoring program has been conducted since 1995 at 15 locations in Lake Hartwell and 5 locations in the Twelvemile Creek watershed as part of the post-ROD monitoring effort for OU2. The sediment PCB concentrations at these locations are consistent with the general pattern of decreasing concentration throughout the lake with increasing distance from the Twelvemile Creek Arm of Lake Hartwell, as seen in the RI/FS sampling (Bechtel 1993). PCB concentrations in surface sediment have also decreased over time. For example, in 1995, PCB concentrations in surface sediment of the Seneca River Arm area ranged from 0.5 to 23.3 mg/kg, with an average concentration of 6.5 mg/kg (ERM 1995). In 1999, PCB concentrations measured at the same monitoring locations ranged from 0.14 to 5.78 mg/kg, with an average concentration of 2.53 mg/kg and in 2003, corresponding measurements were 0.06 mg/kg (detection limit) to 5.51 mg/kg, and averaged 1.58 mg/kg (ERM 1999; ERM 2003).

2.3.3 PCBs in Biota

PCBs have been measured in transplanted *Corbicula* clams, suspended organic matter, mayflies, and fish residing in the Assessment Area. PCBs were sampled in transplanted *Corbicula* clams as part of the Biological Investigation in 1991 (Alexander 1994). After the 1994 ROD, *Corbicula* monitoring was continued on an annual basis, in conjunction with fish and sediment sampling. *Corbicula* tissue analysis was performed after 28 days of exposure to determine rates of PCB bioaccumulation. Analyses of the *Corbicula* samples in 1991 indicate that PCBs bioaccumulated in the clams placed in Town Creek (0.75 to 0.88 ppm) and Lake Hartwell (0.48 to 0.56 ppm) but not in the Tugaloo Arm of Lake Harwell (EPA and Mantech 1993). Concentrations in *Corbicula*

have been decreasing over time and show clear geographic trends, with concentrations decreasing with distance from the Sangamo-Weston plant.

As part of the 1991 biological investigation, allochthonous material (such as detritus, fine sediment, dead insect parts, etc.) was collected by placing drift nets in Town Creek below the Sangamo-Weston plant and in Town Creek below Lay Bridge. Samples had mean PCB concentrations of 0.066 mg/kg in Town Creek, 0.027 mg/kg in Twelvemile Creek, and 0.63 mg/kg in the Twelvemile Creek Arm of Lake Hartwell (EPA and Mantech 1993).

Concurrently with the seston and detritus collection, adult mayflies (*Hexagenia sp*.) were collected on two consecutive nights in July 1991 from the Twelvemile Creek and Tugaloo River Arms of Lake Hartwell (EPA and Mantech 1993). Mean PCB concentration of the mayfly sample collected from the Twelvemile Creek Arm of Lake Hartwell was 2.6 mg/kg (EPA and Mantech 1993).

Extensive measurements of PCB concentrations in fish from Lake Hartwell and the Seneca River Arm of Lake Hartwell have been performed beginning in 1976. Since 1990, much of the sampling has been conducted on an annual basis in accordance with monitoring requirements of the ROD for OU2, using the same species and survey stations, thereby generating detailed temporal and spatial profiles of PCB concentrations in some fish species.

The most extensive PCB data set is from annual monitoring of three sport fish species in Lake Hartwell and the Seneca River Arm. Largemouth bass, hybrid bass, and channel catfish have been analyzed annually since 1990 at two survey stations in Lake Hartwell, three stations in the Seneca River Arm and a reference station on the Tugaloo River Arm. The highest PCB concentrations have been measured in largemouth bass fillet samples at Station SV-107, which is closest to Twelvemile Creek (Figure 4). PCB concentrations in largemouth bass and channel catfish decrease with increasing distance from Twelvemile Creek, although a similar trend is not as apparent for hybrid bass. Temporal patterns are more variable for all species. PCBs in forage fish species have also been well characterized, primarily in the Seneca River Arm, where whole body composite samples of bluegill sunfish, threadfin shad, and gizzard shad have been collected periodically since 1991. Highest PCB concentrations in these species were also seen at the sampling station closest to the mouth of Twelvemile Creek.

Sampling in the Twelvemile Creek watershed has been limited to 1992, when fillet samples of redbreast sunfish and bluegill and whole body northern hog sucker were collected for PCB analysis at up to 12 stations (Gaymon 1992a). Highest PCB concentrations in hog suckers (12.5 mg/kg; 1992) were seen at a sampling location on Town Creek immediately downstream of the Sangamo-Weston plant site, whereas highest PCB concentrations in redbreast sunfish (4.59 mg/kg; 1992) were seen much farther downstream in the Lower Pool of Twelvemile Creek. Bluegill sunfish, which

were only collected at two locations, had the lowest PCB concentrations of any of the fish species (0.58–0.96 mg/kg) (Gaymon 1992b).

3 Ecological Losses and Restoration Alternatives

This section describes the ecological injuries resulting from the release of PCBs from the Sangamo-Weston plant, and presents an evaluation of proposed restoration projects that are intended to compensate the public for the ecological losses associated with these injuries. The first part of this section identifies injuries to ecological resources as defined by 43 CFR Part 11, including a description of the environmental pathways from the Sangamo-Weston plant to exposed resources and determination of specific injuries. The second part of this section presents a qualitative discussion of the potential magnitude of ecological injuries, including a discussion of uncertainties inherent in the analyses. The third part of this section presents a discussion of restoration activities proposed to compensate the public for the ecological losses resulting from the release. The restoration section includes discussions of restoration objectives, criteria used to evaluate restoration options, and a description of the restoration alternatives. The final part of this section presents an environmental assessment of the preferred restoration option including a discussion of the environmental consequences of the restoration and compliance with potentially applicable laws. Appendix C contains the more detailed Environmental Assessment required for compliance with NEPA.

3.1 Injury Determination

The DOI regulation [43 CFR Section 11.61 (a)(1)] requires the Trustees to determine:

> *"whether an injury to one or more of the natural resources has occurred; and that the injury resulted from the discharge of oil or release of a hazardous substance based upon the exposure pathway and the nature of the injury."*

Injury determination for the Assessment Area focused on aquatic-dependent resources. Aquatic-dependent resources are the non-living resources of Twelvemile Creek and Lake Hartwell (i.e., surface water resources, including sediment) and living ecological resources (i.e., biota) that are directly and indirectly dependent on Twelvemile Creek and Lake Hartwell. Examples of ecological resources that are directly dependent on Twelvemile Creek and Lake Hartwell are fish and benthic macroinvertebrates (e.g., aquatic insects). Examples of ecological resources that are indirectly dependent on Twelvemile Creek and Lake Hartwell include piscivorous birds and mammals.

3.1.1 Definition of Injury

During the injury determination phase of a damage assessment, the Trustees determine whether an injury has occurred to natural resources, based on definitions

provided at 43 CFR Section 11.62. The definitions as applied to ecological service losses in the Twelvemile Creek/Lake Hartwell NRDA are summarized below.

3.1.1.1 Surface Water Resources

The DOI regulation [43 CFR Section 11.62(b)] describes the circumstances that result in a determination of injury to a surface water resource from the release of a hazardous substance. The following circumstances are paraphrased from 43 CFR Section 11.62(b) (the reader should refer to the regulations for the complete definitions). Injury to surface water has occurred when:

- The release has resulted in concentrations and duration of substances in excess of standards for the protection of aquatic life as established by the Clean Water Act (CWA) if such concentrations were below the respective standards before the release [43 CFR Section 11.62(b)(iii)].
- The release has resulted in concentrations and duration of substances sufficient to have caused injury to biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments [43 CFR Section 11.62(b)(v)].

3.1.1.2 Sediment

Injury to sediment is defined as a component of injury to surface water resources and geological resources. In essence, injury to sediment as a surface water resource has occurred if concentrations and duration of substances:

> *"[in sediment are] sufficient to have caused injury … to ground water, air, geologic, or biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments" [43 CFR Section 11.62(b)(1)(v)].*

Injury to sediment as a geologic resource has occurred if:

> *"concentrations of substances [in sediment] have caused injury …to surface water, ground water, air, or biological resources when exposed to the substances" [43 CFR Section 11.62 (e)(11)].*

3.1.1.3 Biological Resources

An injury to a biological resource has resulted from the release of a hazardous substance if the concentration of the substance is sufficient to:

> "*Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations" [43 CFR Section 11.62(f)(1)(i)].*

The DOI regulation details numerous biological responses (e.g., death, disease, behavioral abnormalities, and reproduction malfunction) that can be evaluated in determining whether an injury to biological resources has occurred [43 CFR Section 11.62(f)(4)].

3.1.2 Determination of Injury

Determination of injury consists of documentation that there is 1) a viable pathway for the substance released from the point of release to a point at which natural resources are exposed to the released substance, and that 2) injury of site-related resources has occurred as defined in 43 CFR Section 11.62.

3.1.2.1 Pathways

The DOI regulation [43 CFR Section 11.14(dd)] defines pathway as:

> *"the route or medium through which… a hazardous substance is or was transported from the source of the discharge or release to the injured resource."*

The principal pathway of exposure of natural resources to PCBs released from the Sangamo-Weston plant was the plant's process water discharge to Town Creek.

The chemical properties of PCBs determine how they partition in the environment. PCBs have very low solubilities in water, but are fairly soluble in organic carriers. Thus, PCBs are said to be hydrophobic. For these reasons, once PCBs were discharged to the Town Creek/ Twelvemile Creek system, it is expected that the PCBs rapidly became more closely associated with particulate material than with water. Particulate matter may be suspended in the water column or on the creek bottom (bed sediment). Suspended particulate matter settles out of the water column as a function of particle size, mass, current velocity, and turbulence. Thus, as Twelvemile Creek enters the more quiescent waters of Lake Hartwell, heavier particles tend to settle out closest to the mouth of the creek, and finer, lighter particles tend to settle out farther from the mouth of the creek. The concentration of PCBs thus declines with distance from the mouth of Twelvemile Creek as a function of the mass and grain size composition of sediment originating from the Twelvemile Creek drainage and the decrease in current velocity as the creek enters Lake Hartwell.

In addition to being hydrophobic, PCBs are lipophilic and can be readily accumulated by organisms. PCBs enter the food web principally through the direct or incidental ingestion of contaminated organic matter, sediment, and water, and ingestion of contaminated prey.

In summary, existing information indicates that there is a pathway from the release to trust natural resources. Documentation of the presence of PCBs in surface water of Twelvemile Creek and sediment of Twelvemile Creek, the Seneca River Arm, and Lake Hartwell indicate that there is a pathway linking the release at the Sangamo-Weston plant to surface water resources of the Assessment Area. Documentation of the presence of PCBs in biota (fish, *Corbicula*, seston, and mayflies) indicates there is a pathway linking the release at the Sangamo-Weston plant to selected biological resources of the Assessment Area.

3.1.2.2 Injury

Table 1 presents a summary of the data relied upon for the injury determination in the Assessment Area, the regulatory basis for determining that injury has occurred, and a description of relevant thresholds for injury determination. Site-specific information is available and sufficient to document injury from releases of PCBs from the Sangamo-Weston plant to surface water, sediment, and selected biological resources in the Assessment Area as described below:

- **Surface Water Resources**—Surface water resources include the surface waters and sediment of Twelvemile Creek and Lake Hartwell. Although there has been extensive sampling of surface water in the Assessment Area, PCBs were detected in only a few high volume water samples from Twelvemile Creek (Battelle 2002). Analysis of these samples documented PCB concentrations at several locations to be greater than the ambient water quality criterion for the protection of aquatic life. Existing data for Lake Hartwell, however, are inconclusive for establishing injury to surface water based strictly on comparison of concentrations in water to the appropriate criteria, because detection limits are higher than the criteria. Data are sufficient to establish injury to sediment. PCBs have been documented in sediment in all segments of the Assessment Area at concentrations that are within the range of injury thresholds for biological resources.

- **Biological Resources—**Data are sufficient to establish injury to selected biological resources. In particular, PCBs in sediment have been documented at concentrations that are within the range of injury thresholds for benthic macroinvertebrates, and concentrations of PCBs in fish have exceeded levels that are associated with adverse effects in the scientific literature.

3.2 Potential Magnitude of Injury

Existing data were used to describe temporal and spatial distribution of PCBs in Assessment Area resources. Based on this distribution, qualitative depictions of the potential magnitude of injury were developed. This section of the RCDP discusses the available data in the context of thresholds for injury determination.

3.2.1 Surface Water

Injury has occurred to surface waters if concentrations of the hazardous substance exceed a water quality standard or a level at which injury to biological resources would be expected to occur. PCBs were detected in surface waters of Twelvemile Creek at concentrations up to 0.19 μg/L and in the Seneca River Arm at concentrations up to 0.088 μg/L by Battelle (2002). These concentrations exceed the water quality criterion for ecological resources of 0.014 μg/L (EPA 2002b; Table 1). Detection limits for all other sampling results are higher than the water quality criteria for PCBs and cannot be used for injury determination.

3.2.2 Sediment

Injury to sediment has occurred if concentrations of a hazardous substance are present at levels that are expected to result in injury to biological resources. There are no promulgated sediment quality criteria with which to compare concentrations of PCBs in sediment of the Assessment Area. However, several investigators have compiled sediment quality guidelines (SQGs) for PCBs (e.g., MacDonald 1994, Ingersoll et al. 1996, MacDonald et al. 2000). Most SQGs are derived using data from laboratory and field studies of effects associated with PCBs in sediment. The information base used to develop many of the SQGs include studies of both freshwater and marine sediment from across the United States. These studies include laboratory toxicity testing, field observation, and chemical fate and toxicity modeling. Measurement endpoints in the studies range from growth and survival to shifts in benthic community composition. SQGs for PCBs cover a wide range of concentrations and probability and severity of effect. In general, the probability of effects is lower at the low end of the range of SQGs and increases toward the high end of the range. For example, adverse effects to benthic communities are not expected to occur at concentrations of less than about 0.04 mg/kg PCBs (MacDonald et al. 2000) and are commonly observed at concentrations greater than about 5 mg/kg PCBs. Intermediate probability and severity of effects can be expected at concentrations of 1–5 mg/kg PCBs.

Concentrations of PCBs in Assessment Area sediment can be compared to these probable effects ranges to develop a qualitative indication of the potential magnitude of injury to sediment. Figures 6–8 present cumulative frequency distributions of PCBs in

surface sediment of Twelvemile Creek, the Seneca River Arm of Lake Hartwell, and the remainder of Lake Hartwell. For each area, these plots illustrate the proportion of all samples that have a concentration equal to or less than a given concentration of PCBs and illustrate the relationship between the frequency of an observed concentration and the potential for an adverse effect associated with that concentration. The existing surface sediment data is summarized below and in Table 1.

- **Twelvemile Creek**—There are results for 129 surface sediment samples in the Twelvemile Creek portion of the Assessment Area (excluding reference streams and samples upstream of the Sangamo-Weston plant and satellite disposal sites). The median concentration of PCBs in these samples is 0.16 mg/kg, and the maximum concentration reported was 22 mg/kg in 1976. PCBs are present at less than 0.04 mg/kg in 37 percent of samples, 0.04–1 mg/kg in 25 percent of samples, 1–5 mg/kg in 32 percent of the samples, and greater than 5 mg/kg in six percent of the samples (Bechtel 1993).

- **Seneca River Arm**—There are results for 287 surface sediment samples in the Seneca River Arm portion of the Assessment Area. The median concentration of PCBs in these samples is 1.2 mg/kg, and the maximum concentration reported was 73.2 mg/kg in 1988. PCBs are present at less than 0.04 mg/kg in 2.4 percent of samples, 0.04–1 mg/kg in 41 percent of samples, 1–5 mg/kg in 34 percent of samples, and greater than 5 mg/kg in approximately 22.9 percent of samples (Bechtel 1993).

- **Lake Hartwell**—There are results for 168 surface sediment samples in the Lake Hartwell portion of the Assessment Area. The median concentration of PCBs in these samples is 0.43 mg/kg, and the maximum reported concentration was 8.9 mg/kg in 1995. PCBs are present at less than 0.04 mg/kg in 16 percent of the samples, 0.04–1 mg/kg in 27 percent of samples, and 1–5 mg/kg in 25 percent of the samples. Approximately three percent of the samples had PCBs in excess of 5 mg/kg (Bechtel 1993). In addition, sediment samples collected in 2000 and 2001 indicate surface sediment PCB concentrations ranging from 0.55 mg/kg to 6.59 mg/kg (Brenner et al. 2004, Ickes et al. 2001).

3.2.3 Biological Resources

In this section, the potential for injury to biological resources is described for benthic macroinvertebrates, fish, birds, and mammals.

3.2.3.1 Benthic Macroinvertebrates

Self and Vezertzis (1993) conducted a Rapid Bioassessment Protocol (RBP II) in Twelvemile Creek. The authors reported that at one site in Lower Town Creek just below the Sangamo-Weston plant (Station 12), eight taxa were observed compared with 11 to 16 taxa at the four stations upstream of the plant. This result suggests that there are 27 to 50 percent fewer taxa at this specific station relative to upstream locations. This effect was not observed farther downstream and thus may be spatially limited to the area represented by Station 12. Based on overall RBP II scores, this study also suggests impairment to benthic macroinvertebrate communities within Town Creek, from downstream of the Sangamo-Weston plant to the creek's confluence with Wolf Creek. Thus, changes in benthic macroinvertebrate communities appear to be spatially limited to a segment of approximately 3.75 miles of Town Creek and Twelvemile Creek (Figure 9).

There are several sources of uncertainty in associating the benthic effects reported by Self and Vezertzis (1993) to releases of PCBs from the Sangamo-Weston plant, including the following:

- Although the single location downstream of the plant exhibited lower species richness, this location also had significantly elevated numbers of pollution-sensitive species.
- The RBP II method cannot differentiate between effects caused by the release of PCBs and potential effects caused by other factors such as habitat degradation and nutrient enrichment.
- The data reported by Self and Vezertzis (1993) cannot be used to predict effects for other years.

3.2.3.2 Corbicula

Corbicula have been deployed in Twelvemile Creek to measure uptake of PCBs. Greater bioaccumulation of PCBs in *Corbicula* in Twelvemile Creek than in a reference area is indicative of exposure. These conditions would indicate that C*orbicula* (and by extension, other filter-feeding organisms) would serve as pathways of exposure to higher trophic level biota [43 CFR Section 11.63(f)(2)]. Figure 10 presents the results of annual *Corbicula* monitoring for the period 1995–2003. These data indicate that *Corbicula* have accumulated PCBs at detectable levels at all locations that are downstream of the Sangamo-Weston plant (stations C-1, C-3, C-5, and C-6) in all years. Figure 10 also illustrates that concentrations have been declining at each of these locations during the monitoring. For example, the average concentration of PCBs in these stations was 3.31 mg/kg (range of 0.05–10 mg/kg) during the period 1995–1998 and 1.06 mg/kg (range of 0.051–6.4 mg/kg) during the period 1999–2003 (ERM 2003; Table 1).

3.2.3.3 Fish

Injury has occurred to fish if there is evidence of one or more of the conditions defined in the DOI damage assessment regulations [43 CFR Section 11.62(f)(1) and 43 CFR Section 11.62(f)(4)]. For the purposes of this RCDP, injury is evaluated based on comparisons of PCB levels in Assessment Area fish to thresholds associated with adverse effects as reported in the scientific literature (see Table 1). Several authors have developed effects thresholds for PCBs in fish that may be associated with injury (e.g., Hansen et al. 1973; Mayer et al. 1977; Bengtsson 1980; Niimi 1996; Monosson 1999/2000; Barron et al. 2000; Matta et al. 2001). The effects thresholds reported by these authors range from 1.6 mg/kg to 100 mg/kg, and vary based on factors such as endpoint and species. One source of uncertainty in applying these thresholds to estimate injury is the different measurement basis between the effects literature and the Twelvemile Creek/Lake Hartwell data.[2]

As is the case with sediment effects thresholds for benthic invertebrates, the probability and severity of adverse effects in fish is generally expected to increase with increased body burden of PCBs. For example, adverse effects are not expected to occur in fish at body burdens of less than about 1.6 mg/kg whole body (or approximately 0.8 mg/kg fillet) (Barron et al. 2000), but effects on physiology and immunocompetence may start to occur at concentrations above this threshold. Generally, cellular level responses, such as changes in physiology or immunological function, are more sensitive than responses such as growth, adult survival, and reproduction. For example, adult reproductive effects have been reported starting at concentrations of approximately 10 mg/kg whole body (~5 mg/kg fillet) and greater (Hansen et al. 1973; Monosson 1999/2000), and survival does not appear to be greatly affected until body burdens are greater than 50 mg/kg whole body (~25 mg/kg fillet) (Niimi 1996).

Table 2 provides a summary of the percentage of samples of each type (forage fish and sport fish) that falls within each potential effects interval for each sub-area of the Assessment Area. Table 2 illustrates that of a total of 362 forage fish sampled throughout the Assessment Area, 56 percent were below the lowest effect threshold of 1.6 mg/kg, 33 percent of the samples fell within the 1.6–10 mg/kg threshold interval, 10.5 percent of the forage fish exceeded 10 mg/kg, and no samples exceeded the highest threshold level of 50 mg/kg (all concentrations expressed as whole body). Of a total of 2,146 sport fish sampled throughout the Assessment Area, 33 percent were below the lowest effect threshold of 1.6 mg/kg, 52 percent of the samples fell within the 1.6–10 mg/kg threshold interval, 10 percent of the sport fish fell within the 10–50 mg/kg threshold interval, and approximately 0.5 percent exceeded the highest threshold level of 50 mg/kg (all concentrations expressed as whole body).

[2] Measurement basis in this case refers to tissue type. Most site-specific data regarding PCB concentrations in Assessment Area fish were measured in muscle tissue. Toxicological literature, however, reports effects thresholds for PCBs in fish whole body, muscle, and fillet tissue. Therefore, a conversion factor may need to be applied to the effects thresholds in order for threshold units to correspond with site-specific data measurement units.

The overall data set for PCBs in fish, and in particular, the data set for the annual monitoring, indicate clear spatial and temporal trends. Figure 11 shows plots of PCB concentrations in channel catfish, largemouth bass, and hybrid bass sampled from 1990 to 2003 at six locations in the Assessment Area. There is a clear trend of decreasing concentrations with distance from Twelvemile Creek for channel catfish and largemouth bass. In addition, data indicate that PCB concentrations in some fish species are also declining over time.

3.2.3.4 Fish Health Studies

The biological investigation portion of the remedial investigation reported results from health studies of redbreast sunfish and largemouth bass. Self (1993) reported redbreast sunfish results based on a health assessment index (HAI), which integrates measurements of various organs, tissues, and blood variables to identify fish health problems (high HAI scores indicate large deviations from "normal" and are suggestive of potential adverse effects). Self (1993) found HAI scores for sunfish were not significantly higher in Twelvemile Creek than at the reference station, and stations from Town Creek above and below the Sangamo plant had two of the lowest scores in the drainage (see Figure 9 for station locations). Self (1993) did not compare HAI scores for largemouth bass to reference conditions or report HAI scores for redbreast sunfish outside of Twelvemile Creek. Greeley et al. (1994) observed some differences in nutritional indicators (e.g., serum triglycerides, intestinal and stomach fullness, and gall bladder color indices) between sunfish from Twelvemile Creek and fish caught at a reference location on Milwee Creek. However, the researchers ascribed these differences to the fact that fish in Twelvemile Creek were nutritionally deprived (sunfish had not fed heavily in some time and responses of the indices indicated a lower nutritional status) compared to fish in Milwee Creek, and the researchers were not able to conclude that these differences were associated with PCB exposure. Greeley et al. (1994) also found that there was no difference in batch fecundity of sunfish between study area stations and reference stations.

Adams and Greeley (1991), Self (1993), and Greeley et al. (1994) investigated largemouth bass in the Assessment Area. Adams and Greeley (1991) noted a decrease in survival of about 20 percent in largemouth bass at Station SV-107 in the Seneca River Arm compared to fish at Stations SV-532 and SV-641 in Lake Hartwell (see Figures 3 and 4 for station locations). Decreased growth rates were observed in fish aged five to eight years at SV-107, but no effect was seen on growth rates of younger fish. A significant decrease in ovary weight was noted at station SV-107 but it did not appear to affect batch fecundity. Higher HAI scores were reported for largemouth bass at station SV-107 compared with the other two sampling stations in 1990 (Adams and Greeley 1991) and in 1992 (Self 1993). In 1992, Self (1993) found that HAI scores in largemouth bass at station SV-106 were not significantly higher than scores for fish at the reference station SV-641, nor were scores at any of the other three locations sampled in the Seneca River or Lake Hartwell. Self (1993) also examined largemouth bass health at three stations in the Twelvemile Creek watershed. The highest HAI score was seen in fish

from Hagood Reservoir, the reference location. HAI scores were lower, but not significantly different, at Twelvemile Creek upstream from Town Creek and at a location on Wolf Creek. Greeley et al. (1994) evaluated largemouth bass health, but results indicated no clear evidence of adverse effects for almost all indicators of organ dysfunction, histopathology, nutritional condition, gonadal-somatic indices, and circulating plasma estradiol levels at both SV-107 and SV-106 relative to the reference station (SV-641). These investigators also found that "fecundity of largemouth bass appeared to be relatively normal at all study sites." Results of these largemouth bass studies do not show any consistent effects on growth, survival, or reproduction across the Assessment Area, although there is some indication of adverse effects to fish collected from the upper part of the Seneca River Arm.

3.2.3.5 Fish Community Studies

Gibson and Alexander (1993) conducted fish community studies in the Twelvemile Creek watershed using the index of biotic integrity (IBI; see Figure 9 for sampling locations). The IBI is determined from measurements of the following variables: species composition, trophic structure and abundance, and condition of individuals. IBI scores were used to assign impairment indexes that range from one (poor) to five (best). The authors reported a wide range of scores for reference stations including Big Generostee Creek and Six and Twenty Mile Creek. With the exception of one station in Twelvemile Creek downstream of Town Creek, other stations in Twelvemile Creek had IBI scores equal to or higher than the Six and Twenty Mile Creek station, which classifies fish community health at these locations from fair to good. Most of the adverse effects recorded were related to trophic composition, proportion of anomalies, the number of intolerant species present, and the abundance of tolerant species. The number of native species at stations in Twelvemile Creek ranged from 13 to 20, whereas the number of native species at the three reference stations was 6–18. The percent of tolerant individuals in Twelvemile Creek was seven to 78 percent, and 73 to 80 percent at the three reference stations. The authors were unable to conclusively attribute variations in fish community structure to the presence of PCBs in Twelvemile Creek, and suggested that habitat degradation in Twelvemile Creek was a major contributing factor.

3.2.3.6 Birds and Mammals

Bechtel (1994) conducted an assessment of risks to higher trophic level organisms (birds and mammals) from potential exposure to PCBs. The risk assessment relied on existing data for PCBs in fish and mayflies to develop estimates of dietary exposure to the following receptor species: belted kingfisher, eastern phoebe, green heron, osprey, mink, and otter. In the risk assessment, hazard quotients were developed by dividing the estimated dietary exposure for each species by appropriate toxicity reference values from the scientific literature. A hazard quotient greater than 1 indicates that the estimated exposure could result in unacceptable adverse effects (primarily reproductive effects).

Bechtel (1994) reported hazard quotients greater than 1 for all receptors evaluated. These results suggest that adverse effects on these species cannot be ruled out on the basis of the analysis conducted. There are several assumptions inherent in the Bechtel (1994) analysis that result in conservative estimates of risk (i.e., more likely to overstate than understate risk). Bechtel (1994) acknowledges the uncertainty associated in the analysis and concludes that: 1) exposure for green heron and belted kingfisher may be overestimated, 2) there is a low level of confidence regarding risk of reproductive effects to eastern phoebe, green heron, and osprey, and 3) population-level effects are unlikely for otter and the occurrence of mink in the Twelvemile Creek drainage is unknown. The risk assessment was based on data available in 1994 from the Seneca River Arm of Lake Hartwell, where concentrations of PCBs in fish have historically been the highest. Thus, current exposure of birds and mammals to PCBs, and exposure in areas other than the Seneca River Arm are likely to be lower than those characterized by Bechtel (1994).

3.3 Restoration and Scaling

This section reviews the Trustees' restoration objectives, outlines the criteria against which restoration options were evaluated, and discusses various proposed restoration alternatives. Following that, the restoration option preferred for compensation of ecological losses at the Assessment Area is described.

3.3.1 Restoration Objectives

The Trustees' overall restoration objective includes the restoration, rehabilitation, replacement, and/or the acquisition of the equivalent of the injured natural resources and the services those resources provide [43 CFR Section 11.82 (a)]. Specifically, the Trustees require restoration that will compensate the public for the injuries sustained by natural resources in the Assessment Area as the result of PCB contamination. EPA is currently implementing a remedy in Twelvemile Creek that involves the movement of uncontaminated sediment through Twelvemile Creek to Lake Hartwell, where it is expected to settle and reduce surface sediment concentrations of PCBs through burial and dilution. At the current rate of sediment transport, however, the remedy is expected to take years to complete, causing the public to experience ecological losses into the future. In addition, the public has experienced interim losses caused by the exposure of natural resources to PCBs. Therefore, the Trustees require compensation for both past and future losses in ecological services.

3.3.2 Evaluation Criteria

In order to assure the appropriateness and acceptability of restoration options for ecological losses incurred at the Assessment Area, the Trustees evaluated each option against site-specific restoration requirements. A project that satisfied these site-specific

criteria was then reviewed based on restoration factors listed in the DOI damage assessment regulations [43 CFR Section 11.82 (d)]. The criteria specific to compensatory restoration for the contamination at the Assessment Area include the following:

- Provision of restoration actions within the Twelvemile Creek/Lake Hartwell watershed.

- Provision of restoration actions specifically focused on protection and enhancement of the currently affected ecosystems as a whole. The Trustees maintain that in this case, ecosystem restoration is more appropriate and essential to the watershed than restoration of individual resources.

3.3.3 Restoration Alternatives

Several types of projects were considered as potential restoration alternatives for ecological damages sustained as a result of contamination in the Assessment Area. These alternatives included:

- **Dredging—**The objective of dredging is to remove Assessment Area sediments containing PCBs to reduce or eliminate future exposure of natural resources to PCBs in the dredged areas. Dredging could involve sediment removal in Lake Hartwell itself as well as in lower Twelvemile Creek where sediments continue to exceed the remedial goal of one mg/kg.

  While this primary restoration alternative would provide environmental benefits to Lake Hartwell and Twelvemile Creek, it would also constitute a significant disruption of the ecological community. Temporary, short-term physical habitat degradation for aquatic biota would occur as would the reintroduction of dissolved and particulate-phase PCBs into the water column. Another potentially significant impact of this alternative involves the disposal of a large volume of dredged sediments. Dredging was considered as a remedial alternative in 1994, but due to cost, technical feasibility uncertainty, and a lack of public support it was rejected. Because these same issues exist today, the Trustees did not further consider the dredging alternative.

- **Dam Removal—**Dam removal activities would include the removal of the Woodside I and Woodside II dams by STC with Trustee oversight (the Easley-Central Dam has a high flow sluice gate that allows sediment to pass downstream). The objective of dam removal is to establish a natural channel design and stream stability by balancing the processes of sediment aggradation (accumulation) and degradation

(erosion). The conceptual design for dam removal first requires that the sediment that has accumulated behind the dams be removed; appropriate disposal of dredged sediments would be determined following PCB testing. Next, the dams would be deconstructed (i.e., taken apart in pieces) in a way that will minimize the likelihood of excessive downstream transport of sediment. Bottom-most sections of each dam would remain, allowing construction of a riverbed with an appropriate slope. Then, loose pieces of the dams would be used to create instream habitat structures as part of stream corridor restoration in the dam-removal area. These instream structures would include riffle areas, weirs, and deflector wings. Finally, stream corridor restoration would be completed through the planting of native vegetation, establishment of erosion and runoff controls, and streambank stabilization.

- **Stream Corridor Restoration (outside the dam-removal area)—** Stream corridor restoration includes a broad range of measures designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level. Restoration actions may range from passive approaches that involve removal or attenuation of chronic disturbance activities to active restoration that involves intervention and installation of measures to repair damages to the stream corridor.

  A number of specific conservation/restoration needs have been identified for the Twelvemile Creek stream corridor (NRCS et al. 2002). These include riparian management practices (e.g., streambank stabilization, shoreline protection, bendway weirs, riparian buffer plantings, wetlands restoration, and riparian zone conservation easements), woodland management practices (e.g., reforestation, critical area seeding on access roads, waterbars/broad-based dips, and wildlife components), pastureland/hayland conservation management practices (e.g., cross-fencing, barrier fencing, alternative watering facilities, and heavy use areas), cropland management practices (e.g., permanent field borders/buffer strips, grass waterways, and conversion to permanent cover), and urban land management practices (e.g., drop structures for concentrated flows, stormwater detention, and vegetation components). The measures implemented would be consistent with the concept of natural channel design and would be designed to enhance stream stability and restore dynamic equilibrium of sediment transport. Selected projects would follow the guidance contained in the interagency document *Stream Corridor Restoration Principles, Processes, and Practices* which promotes the use of ecological processes (physical, chemical, and biological) and minimally intrusive solutions to restore self-sustaining stream corridor functions.

3.3.4 Overview of Preferred Restoration Alternative

Currently, the Woodside I and Woodside II dams span Twelvemile Creek a few miles downstream of Pickens, South Carolina. The preferred restoration alternative involves the removal of these two dams and implementation of various stream corridor restoration projects. Figure 12 illustrates the conceptual design for dam removal. First, the sediment that has accumulated behind the dams would be removed via dredging. The dredged material will be tested and reused and/or disposed as required by current Federal and state regulations and according to an approved plan. Next, the dams would be taken apart slowly, to minimize large sediment slugs from washing downstream and their corresponding impacts. Bottom-most sections of each dam would remain, allowing construction of a riverbed with an appropriate slope. Then, loose pieces of the dams would be used to create in-stream habitat structures as part of stream corridor restoration. These instream structures would include riffle areas, weirs, and deflector wings. Finally, where necessary, stream corridor restoration would be completed through the planting of native vegetation, establishment of erosion and runoff controls, and streambank stabilization.

Implementation of the preferred restoration alternative would provide several benefits to the Assessment Area . It is expected to speed the EPA remedy of flushing uncontaminated sediment through the creek to bury and dilute contaminated sediments in Lake Hartwell. Dam removal and stream corridor restoration is also expected to restore Twelvemile Creek from the Easley-Central Dam to Lake Hartwell to its pre-dam hydrology, biologic diversity, and overall riparian function. For example, restoration of natural flow in Twelvemile Creek will allow for unimpeded fish passage over the restored segment, enhance aquatic diversity by restoring natural riffle/pool systems, and reduce fragmentation of the riparian corridor. The restored reach of Twelvemile Creek is expected to provide better fish habitat. Finally, as part of the river restoration plan, the restored segment of Twelvemile Creek will provide new recreational opportunities for kayaking. The environmental consequences of dam removal and stream corridor restoration in Twelvemile Creek are presented in Section 3.4.1, and in the Environmental Assessment attached in Appendix C.

3.3.5 Evaluation Based on Criteria

In order to determine the appropriateness and sufficiency of the preferred restoration alternative, dam removal and stream corridor restoration activities were evaluated based on the criteria listed in Section 3.3.2. In addition to these site-specific criteria, the following criteria listed in the DOI regulation for damage assessment [43 CFR Section 11.82 (d)] were also considered:

- *Provision of restoration actions within the Twelvemile Creek/Lake Hartwell watershed (Site-specific).* Dam removal and stream corridor restoration in Twelvemile Creek is completely within the Lake Hartwell watershed.

- *Provision of restoration actions specifically focused on protection and enhancement of currently affected ecosystems as a whole (Site-specific).* Trustee review of the proposed dam removal and stream corridor restoration plan concludes that these activities will restore the lower Twelvemile Creek system from the Easley-Central Dam to Lake Hartwell, including hydrology, geology, and ecology.

- *Technical feasibility [43 CFR Section 11.82 (d)(1)]*. Dam removal and stream corridor restoration within Twelvemile Creek is technically feasible. An analysis by Restoration Systems, Inc. indicated that removal of sediment from behind the dams, dam dismantling (deconstruction), and stream corridor restoration (including instream habitat and revegetation of stream banks where necessary) were all possible for Woodside I and Woodside II.

- *The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources [43 CFR Section 11.82 (d)(2)]*. The Trustees believe the expense of purchasing Woodside I and Woodside II, dredging behind the dams, deconstructing the dams, and completing stream corridor restoration is reasonable based on the compensation required for ecological losses incurred in the Assessment Area. The criterion applied by the Trustees for determination of the appropriateness and sufficiency of a restoration option is whether the project provides habitat that supports the natural resources injured by PCB contamination. The combination of dam removal and stream corridor restoration is the only option that both speeds the remedy, thereby reducing future ecological losses, and provides a multitude of long-term benefits to the area's biota by restoring the creek system to its natural state.

- *Cost effectiveness [43 CFR Section 11.82 (d)(3)]*. Dam removal and stream corridor restoration is cost effective. The Trustees attempted but were unable to identify other, lower cost projects that adequately addressed restoration needs.

- *Results of any actual or planned response actions [43 CFR Section 11.82 (d)(4)]*. EPA is currently overseeing implementation of a remedy that involves movement of sediment through Twelvemile Creek to cap contaminated sediments in Lake Hartwell. This process is ongoing. Implementation of the preferred restoration will return Twelvemile Creek to a free flowing state over the project reach and is expected to increase the average rate of movement of uncontaminated sediment and thereby enhance the EPA remedy.

- *Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources [43 CFR Section 11.82 (d)(5)]*. Dredging and dam removal, as well as construction of instream habitat structures, may result in some short-term adverse effects to the Twelvemile Creek system, temporarily degrading creek habitat (e.g., increased suspended sediment load). The Trustees have reviewed these effects and have determined that the long-term benefits of a restored aquatic ecosystem (e.g., restoration of native fish communities) within the Assessment Area outweigh any initial negative impacts.

- *The natural recovery period and the ability of the resources to recover with or without alternative actions [43 CFR Section 11.82 (d)(6-7)]*. The potential for natural recovery of the resources in Twelvemile Creek and Lake Hartwell is currently determined by the rate of sediment movement through Twelvemile Creek into Lake Hartwell. This recovery would be speeded by implementation of the preferred restoration alternative because dam removal would restore natural transport of clean material to Lake Hartwell from the Easley-Central Dam to the lake.

- *Potential effects of action on human health and safety [43 CFR Section 11.82 (d)(8)]*. Dam removal and stream corridor restoration may result in potential exposures of humans to PCBs and risk of injury from heavy equipment (e.g., dredging and construction equipment). Therefore, these activities may affect human health and safety in the short term. The Trustees, however, expect that public exposure to these areas during restoration will be minimized, thereby limiting or possibly eliminating any risk.

- *Consistency and compliance with relevant Federal, state, and tribal laws and policies [43 CFR Section 11.82 (d)(9-10)]*. The Trustees' consideration of this criterion is discussed in detail in Section 3.4.2.

3.4 Environmental Assessment of Preferred Restoration Alternative

The Trustees reviewed multiple restoration alternatives as possible compensation for ecological losses sustained by natural resource damages at the Assessment Area . The Trustees selected the combination of dam removal (Woodside I and Woodside II) and stream corridor restoration within Twelvemile Creek based on the long-term benefits to the Assessment Area. The Trustees then reviewed this option in light of the evaluation criteria described above.

3.4.1 Environmental Benefits from Preferred Restoration Alternative

The Trustees selected removal of the Woodside I and II hydroelectric dams in Twelvemile Creek (with streambed/shoreline stabilization) and stream corridor restoration outside the dam-removal area as the preferred restoration alternative for injured natural resources and compensation of ecological losses within the Assessment Area. Although some initial adverse effects to the Twelvemile Creek system may occur, these effects are outweighed by the long-term benefits. These benefits will enhance EPA's selected remedy by accelerating deposition of clean sediment over PCB-contaminated sediment in Lake Hartwell, and restoring Twelvemile Creek between the Easley-Central Dam and Lake Hartwell from a dam-constricted system to a free-flowing riverine system with improved species diversity and richness.

Dam removal has recently emerged as an important tool for restoration of degraded riverine habitats in the United States, and a number of studies have evaluated the ecological benefits of dam removal (e.g., American Rivers 2002; Hart et al. 2002; Stanley and Doyle 2003). The specific benefits and disadvantages of dam removal are dependent on the hydrological, physical, chemical, and biological characteristics of the river system where removal is contemplated, and outcomes may differ even between systems with similar characteristics. The following review briefly presents some of the results of dam removal in other riverine systems. Note, however, that while these reported impacts indicate the potential results of dam removal in the Twelvemile Creek/Lake Hartwell system, alternate or additional benefits or disadvantages may occur.

Dam removal will help accelerate the selected remedy for OU2 by re-establishing a natural pattern of downstream flow of sediment in Twelvemile Creek from the Easley-Central Dam into Lake Hartwell and allowing natural recovery of PCB-contaminated sediment in the lake. The majority of ecological benefits that accrue from dam removal occur as a result of the restoration of a natural flow regime in a previously impounded system. The most immediate impact is an alteration of the hydrologic regime in the impounded areas upstream of dams from a slow-moving, lake-like system to a fast-flowing riverine system. As the flow changes, physical features of the areas both upstream and downstream of the former impoundments will change, restoring characteristics of non-impounded rivers. For example, dam removal will re-establish a more natural pattern of sediment movement and distribution in Twelvemile Creek from the Easley-Central Dam downstream to Lake Hartwell. Areas where cobble and gravel were previously buried by deep sediment trapped behind the impoundments will become re-exposed as a result of flushing, thereby providing new habitat for re-colonization by aquatic insects or spawning by fishes that prefer hard bottom substrates. Downstream of the impoundments, scouring and channel incision will be reduced and deposition of sediment will promote re-establishment of habitats for aquatic insects and rooted aquatic vegetation. In conjunction with mobilization of sediment, dam removal can have a beneficial effect on nutrient movement. Studies on other rivers have shown that, depending on the nature of sediments trapped behind impoundments, these impoundments can act as sinks for nutrients (e.g., phosphorus and nitrogen) and can limit

their migration downstream. Controlled dam removal allows for the transport of nutrient-rich sediments, increasing their availability to downstream ecological communities.

Downstream sediment transport and deposition associated with dam removal and flow restoration may also lead to restoration of submerged and emergent rooted vegetation that would provide spawning habitat for fish species. Flow restoration would allow periodic inundation of floodplains, which could promote the development of small ephemeral ponds that offer attractive spawning habitat for amphibians and expansion of riparian habitat attractive to a variety of bird and mammal species.

Effects on plant and animal communities can be dramatic when dams are removed from river systems, with many changes occurring as a result of changes in the physical properties of the river. For example, community composition can shift as slow-moving aquatic species adapted to lake-like conditions behind the impoundments are replaced by species adapted to faster-moving riverine habitats. Studies of dam removals in other locations have indicated that biodiversity and population densities of native aquatic organisms increase when natural flows are restored. Dam removal can also promote improvements in fish populations by removing obstructions that preclude passage of fish upstream. For example, removal of the Woodside I and II impoundments would open up a five-mile stretch of Twelvemile Creek to fish passage between the Easley-Central dam and Lake Hartwell.

In conjunction with dam removal, stream corridor restoration activities will be undertaken, including constructing in-stream habitat structures, establishing erosion and run-off controls, and planting native vegetation. These activities would produce benefits to both the physical and biological components of the watershed. For example, planting native vegetation along the shoreline would enhance bank stabilization and reduce soil runoff from surrounding lands, subsequently minimizing nonpoint source nutrient inputs and reducing turbidity. Shoreline vegetation also provides additional shading to the creek, helping to regulate fluctuations in water temperature resulting from exposure to direct sunlight, and increases structural diversity, thus providing additional foraging and breeding habitat for riparian wildlife. Other types of stream corridor restoration, such as conservation easements, would ensure the long-term sustainability of the riparian system Pieces of the demolished dams will be used to create features such as riffles or pools, and root wads and downed trees may be used to increase structural diversity and stabilize stream banks. These activities are expected to increase habitat diversity for benthic invertebrate and fish communities. Overhanging vegetation from streamside and in-stream plantings will provide both cover and structural components that would be attractive spawning habitat for some fish species.

Stream corridor restoration projects outside the dam-removal area, to be developed in cooperation with the Pickens County Soil and Water Conservation District and the Natural Resource Conservation Service, would in some cases use buffers and vegetation to remove stressors on the system. These would have very localized effects, including, but not limited to, restoring aspects of Twelvemile Creek's historic storm

hydrograph (with resultant changes in sediment dynamics), providing streambank stabilization, possibly returning the mixture of fine to coarse sediments to ecologically appropriate levels, shading the stream (and cooling the water column during summer), contributing organic detritus and structure to the aquatic ecosystem, filtering pollutants from runoff, and re-establishing or protecting ecological integrity and structure to riparian soils and plant communities.

Use of biological methods for streambank protection may include using fallen trees for root wads and log cribs to hold the bank in place; these methods provide instream habitat improvement by adding instream structure. Riparian zone conservation easements increase the quality of the land by providing increased fish and wildlife habitat, improving water quality by filtering and attenuating sediments and chemicals, reducing flooding, recharging groundwater, and protecting or restoring biological diversity and habitat continuity.

These stream corridor restoration measures are expected to have beneficial effects on water quality and restore conditions that are favorable to reestablishing native species and communities that are typical of free-flowing streams.

3.4.2 Potential Adverse Effects

Although most of the changes likely to occur to the Assessment Area as a result of dam removal would be positive, some short-term negative impacts also may occur. First, although dredging is intended to remove the bulk of sediment trapped behind the dams, there will be some initial sediment flushing, which is expected to result in short term increases in turbidity and overall decreases in water quality downstream of the removed dams. The released sediments may temporarily smother aquatic insects, riparian vegetation, and fish spawning habitats until dispersion and deposition of sediment becomes stabilized. The exact time span of such effects is dependent on the nature of the system in which dam removal is occurring, but is expected to be of relatively short duration at Twelvemile Creek because of the responsiveness of the system. Depending on precipitation, initial flushing could be completed over a single season or over several years. Engineering activities to be implemented during the removal of Woodside I and II should limit these temporary negative impacts through appropriate timing of dam removal relative to river stage, by sediment removal or channel-dredging prior to removal, and by gradually drawing down the impoundments to ensure that sediment is released in pulses as opposed to a single large flushing event. For example, it is anticipated that over 200,000 cubic yards of sediment may be removed from behind the dams prior to dam removal. Sediment removal would start early in the spring so that dams can be removed in early fall when low flow conditions occur in Twelvemile Creek. Water levels in the reservoirs behind the dams will drop as downstream flow increases, exposing sediments that may be colonized by invasive exotic species, which would lower habitat diversity and structure and thus suitability for native animal communities. Planned restoration of exposed river banks and re-planting of

native riparian vegetation will likely limit colonization by these species. Possible negative impacts from the release of impounded sediment containing PCBs will be managed by dredging sediment prior to dam deconstruction. The dredged material will be tested and reused and/or disposed as required by current Federal and state regulations and according to an approved plan.

Any stream corridor restoration project requiring the use of mechanical equipment and/or soil or sediment disturbance has the potential for local, short-term adverse impacts. These potential impacts may include increased turbidity and sedimentation, dust, noise, and the potential for releases of oil products. Use of best management practices during construction would avoid or minimize any adverse impacts and ensure no significant adverse impacts.

3.4.3 Compliance with the National Environmental Policy Act (NEPA) and Other Potentially Applicable Laws

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the preferred restoration plan is achieved, in part, through the coordination of this document with appropriate agencies and the public. The attached Environmental Assessment documents that all components of the dam removal and stream restoration projects are in compliance with all applicable Federal statutes, executive orders, and policies, including NEPA, 42 USC Section 4321 *et seq.*; the Endangered Species Act (ESA), 16 USC 1531, *et seq.*; the National Historic Preservation Act of 1966,16 USC Section 470 *et seq*.; the Fish and Wildlife Coordination Act, 16 USC Section 661 *et seq.;* the Rivers and Harbors Act of 1899,33 USC Section 403 *et seq.*; the Federal Water Pollution Control Act, 33 USC Section 1251 *et seq.*; Executive Order 11990, Protection of Wetlands; Executive Order 11988, Flood Plain Management; and Executive Order 12898, Environmental Justice.

4 Recreational Fishing Losses and Restoration Alternatives

Lake Hartwell is a regionally important recreational fishing resource. According to a 1992 creel survey (the most recent completed), Lake Hartwell supports over 700,000 angler-hours of effort each year (Bales 1993). The majority of this effort is attributed to boat anglers and occurs during the spring season, though significant fishing pressure exists in the winter, summer, and fall seasons as well. Largemouth bass is the most-often targeted species, followed by striped and hybrid bass, crappie, and channel catfish. Other species present include walleye, yellow perch, bluegill, white bass, and white catfish.

4.1 Injury Determination

Fish consumption advisories (FCAs) were first put in place on the Seneca River Arm of Lake Hartwell in 1976 by SCDHEC and EPA (Bales and Self 1993). This advisory warned the public not to eat fish taken from that area. The advisory was extended to the entire lake in 1985 for fish greater than 1.4 kg (3.1 lb). Lakewide advisories issued by the State of Georgia have also been in effect since at least that time.

The presence of FCAs constitutes an injury to the Assessment Area recreational fishing resource. Specifically, the DOI regulation states:

> *"An injury to a biological resource has resulted from the discharge of oil or release of a hazardous substance if concentration of the substance is sufficient to: …Exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism." [43 CFR Section 11.62 (f)(1)(iii)]*

The Trustees' approach to quantifying damages arising from this injury is discussed in the following sections.

4.2 Quantification of Damages

This section discusses the economic losses associated with changes in angler behavior attributable to the presence of FCAs in the Assessment Area. The DOI regulation refers to such losses as *compensable value.* Specifically:

> *"Compensable value is the amount of money required to compensate the public for the loss in services provided by the injured resources between the time of the discharge or release and the time the resources and the services those resources provided are fully returned to their baseline conditions." [43 CFR Section 11.83(c)(1)]*

Compensable value is typically measured in terms of changes in *consumer surplus.* Consumer surplus is the amount an individual would be willing to pay for a good or service above the market price. In the context of recreational activities such as fishing, this represents the additional amount a participant would be willing to pay to take part in an activity above and beyond any expenditures required to do so (e.g., the cost of traveling to the site).

FCAs are designed to modify anglers' behavior to reduce health risks. For example, FCAs may encourage anglers to alter where and how much they fish, what types of fish they target, and how they prepare and cook their catch. These types of angler responses have been documented in angler surveys and may lead to a loss of or reduction in consumer surplus (e.g., Fiore et al. 1989; Tilden et al. 1997; Connelly et al. 1992, 1996). For example, in the 1992 creel survey on Lake Hartwell, roughly 17 percent of anglers said they released their catch in response to FCAs (Bales 1993).

4.2.1 Approach to Estimating Damages

The DOI regulation identifies several methods to measure changes in social welfare associated with changes in fishing quality. Travel cost and random utility models in particular have been applied extensively in valuing recreational fishing opportunities. There exists a rich published literature containing values for sites in all regions of the country. Given the extent of existing research, as well as information regarding Lake Hartwell angler participation, the Trustees determined that the conduct of a primary study was not required to support damage estimation. That is, the Trustees believed that the likely reduction in uncertainty associated with the magnitude of damages afforded by a primary study was unlikely to justify its cost.

Drawing upon an existing random utility model, the Trustees chose to use the *benefits transfer* technique. Benefits transfer involves adapting research conducted to estimate economic values under one set of circumstances to an alternative situation. In this manner, existing valuation research is combined with site-specific data and information to develop a damage estimate. Benefits transfer, a unit value method, has been widely applied in environmental policy analysis and is approved for use in the DOI regulation [43 CFR Section 11.83(c)(2)(vi)].

Best practice in the conduct of benefits transfer generally involves five steps (EPA guidelines for preparing economic analyses describe these steps in more detail) (EPA 2000, Unsworth and Peterson 1986):

1. **Describe conditions to be valued**: Identify and describe in detail the valuation scenario, which in this case involves the nature and extent of fishing opportunities at Hartwell, the nature and extent of FCAs present, and the manner in which the advisories have affected angler behavior.

2. **Identify relevant research**: Conduct a detailed search for relevant research (in consideration of conditions described in Step 1) in published articles, databases, etc.

3. **Review research for quality and applicability**: Review relevant research carefully for quality and specific applicability.

4. **Transfer economic values**: Apply the valuation information identified in relevant, high-quality research to the conditions being valued; in this case, to estimated changes in welfare associated with FCAs on Lake Hartwell.

5. **Address uncertainty**: Evaluate assumptions made in the process of transferring economic values and the sensitivity of final damage estimates to such assumptions.

These steps are discussed below.

Step 1. Describe Conditions to be Valued—A significant aspect of the first step involved describing the nature of fishing resources at Lake Hartwell, as summarized in preceding sections. Next, the specific angler responses to FCAs were defined. Based on existing information and the experience of resource managers, the Trustees identified two primary categories of angler response:

- **Diminished fishing experience:** Anglers fishing on Lake Hartwell may suffer a diminished experience because they may not be able to eat all or some portion of their catch.

- **Decreased avidity:** Anglers may take fewer trips to Lake Hartwell and travel to sites farther away that do not have advisories.

Steps 2 and 3. Identify and Review Relevant Research for Quality and Applicability—The second step includes a rigorous review of available research to estimate losses associated with the two above categories. Online literature and database searches were conducted to identify relevant research. In addition, the Trustees contacted several members of the academic community and practitioners in the field of resource economics.

Considering the nature of the losses and physical characteristics of the resource (i.e., region, species present, nature of FCAs), the most relevant research is a model of angler site-choice for eastern Tennessee reservoirs developed by Dr. Paul Jakus (of Utah State University, formerly of University of Tennessee). This research draws upon a large dataset of anglers' site choices across several reservoirs and provides estimates of how they evaluate site quality attributes (e.g., water quality, FCAs, catch rates and access conditions) relative to travel costs. The research uses a standard site-choice model, the results of which have been peer-reviewed and published (Jakus et al. 1997). This

research is considered by the Trustees to be the best available source of information for estimating damages associated with the two categories of effects described above (Step 1).

Step 4. Transfer Economic Values—The fourth step entailed the actual transfer of valuation information. To ensure that the information transferred from the model is appropriate given the characteristics of the valuation scenario, the Trustees retained Dr. Jakus to assist in estimating damages. Dr. Jakus developed a model based on parameters most closely resembling conditions at Lake Hartwell. Details of this model are discussed in Appendix B. Valuation information from the model was combined with creel data from Lake Hartwell to calculate damages, as summarized below:

- **Transfer estimate of FCA impact:** Dr. Jakus' model provides estimates of the effect of FCAs on experience (value per trip) and avidity (number of trips) by simulating the removal of advisories on the reservoir site that most closely resembled Lake Hartwell in terms of advisories, size and species composition, and proximity to population centers. Overall, the model suggests a loss of $1.20 per trip, with a 95 percent confidence interval of $0.30–$1.95. This translates to roughly three percent of the baseline value of a fishing trip. These values are consistent with estimates for similar conditions at other sites (e.g., Feather et al. 1995; Montgomery and Needelman 1997; Chen and Cosslett 1998; Parsons and Hauber 1998).

- **Estimate number of trips to Lake Hartwell:** Creel survey data from the late 1970s, 1990, and 1992 were used to develop an estimate of the total number of annual fishing trips to Lake Hartwell over time. For years up to 1992, the average annual rate of growth in trips between actual counts from creel surveys was used. For years beyond 1992, an average annual rate of growth between zero and one percent was applied.

- **Calculate and sum losses:** Annual losses are calculated and summed over the relevant time period. The time period over which damages were calculated runs from 1981 (in accordance with CERCLA) until Lake Hartwell FCAs are estimated to be removed (between 20 years and indefinitely).

Step 5. Address Uncertainty—This damage analysis contained two primary sources of uncertainty noted above: 1) An assumption regarding whether, and to what extent, angling activity on Lake Hartwell has grown since 1992 and will continue to grow over time, and 2) an assumption regarding the future point in time when FCAs will be removed (and thus recreational fishing losses will cease to be incurred).

The Trustees considered a variety of information regarding likely trends in angling activity. For example, population in the Lake Hartwell area is growing (around one percent per year), however, broader recreational surveys do not show that fishing participation is increasing (FWS 1985, 1991, 1996; Cordell et al. 1999). Similarly, fishing license sales data in Georgia and South Carolina do not present a clear trend in angling activity.

There is also uncertainty regarding when Lake Hartwell FCAs are likely to be removed. Analysis of trends in fish tissue concentration data suggested that advisories on some species may remain in place indefinitely (e.g., striped and hybrid bass), while others (e.g., largemouth bass) could be removed in the relatively near future. In recognition of the considerable uncertainty associated with these parameters, the Trustees considered total damage estimates ranging from approximately $7 to $18 million. This range represents alternative assumptions regarding growth rate and advisory removal parameters.

4.3 Restoration and Scaling

This section reviews the Trustees' objectives in selecting restoration options for recreational fishing losses. It discusses the Trustees' evaluation criteria, proposed alternatives, and preferred restoration options.

4.3.1 Restoration Objectives

The Trustees' overall restoration objective includes the compensation of the public for the interim loss of recreational fishing opportunities incurred as a result of PCB contamination in the Assessment Area. In addition, EPA is currently implementing a remedy that involves the movement of uncontaminated sediment through Twelvemile Creek to Lake Hartwell, where it is expected to settle and cover and dilute PCB-contaminated sediment. Because the remedy is expected to take years to complete, the public will continue to experience reductions in recreational fishing services into the future. Therefore, the Trustees require compensation for both past and future losses in recreational fishing services.

4.3.2 Evaluation Criteria

In order to ensure the appropriateness and acceptability of restoration options for recreational fishing losses in the Assessment Area, the Trustees evaluated each option relative to site-specific restoration requirements. Projects that satisfied these requirements were then compared to restoration criteria listed in the DOI damage assessment regulations [43 CFR Section 11.82 (d)]. The criteria specific to compensatory restoration for recreational fishing losses at Lake Hartwell include:

- Restoration of *harvest* opportunities for anglers who have likely been affected by PCB contamination,
- Enhancement of catch/harvest opportunities in the vicinity of Lake Hartwell,
- Compatibility with state fisheries agencies' management objectives.

4.3.3 Restoration Alternatives

Several types of projects were considered as potential restoration alternatives. These alternatives included:

- **Creation of New Harvest Opportunities—**One of the main goals of South Carolina and Georgia state fisheries managers is to create new harvest opportunities for anglers. Projects to restore harvest opportunities for anglers in the vicinity of the Assessment Area could include development of new public fishing area lake sites and/or sub-impoundment sites (adjacent to the lake). These sites would be stocked with appropriate fish species, and would be managed for sustainability.
- **Improvement of Public Fishing Access—**State fisheries managers also focus on improving public fishing access to increase both catch and release and harvest opportunities for area anglers. In the case of the Lake Hartwell watershed, projects could include construction of fishing jetties, fishing piers, and boat ramps; or creating access on privately owned river properties (i.e., land acquisition).
- **Fish Stocking—**Fisheries managers could annually stock selected fish species into targeted, existing bodies of water (distinct from new or improved areas described above) in the Lake Hartwell watershed to improve catch opportunities for anglers.

4.3.4 Overview of Preferred Restoration Alternatives

The Trustees reviewed a broad array of restoration alternatives and determined that creation of harvest opportunities through the development or enhancement of public fishing areas in the vicinity of the Assessment Area, as well as improvement of public fishing access, are the preferred options. Such projects are consistent with identified objectives and are likely to generate long-term benefits to anglers in the watershed (Quintrell et al. 1981).

The Trustees are in the process of reviewing specific sites for implementation of each of the preferred restoration alternatives mentioned above. For example, the Trustees currently are reviewing more than 25 potential sites for creation of new harvest opportunities. Although the Trustees have not finalized which site(s) are most appropriate for implementing this type of restoration, descriptions of several potential sites are presented below as examples. As the Trustee and public review process continues, additional and/or more appropriate water bodies may be identified. In addition, the Trustees are considering improvement of public fishing access. Examples include: 1) construction of jetties in the Lake Hartwell tailwaters, which would provide much needed access for both Georgia and South Carolina anglers (because of a reciprocal license agreement in this area) and take advantage of existing infrastructure, and 2) installation of boat ramps, which would provide additional public fishing access.

4.3.4.1 New Harvest Opportunities: Georgia

Any new fishing sites in Georgia are expected to meet the criteria established by GADNR for a public fishing lake. These criteria (Hess and McCollum 1990) include the following:

- **Acreage—**Larger water bodies (i.e., between 100 and 500 acres) are preferred, though site-specific characteristics may make smaller water bodies equally acceptable.
- **Watershed to Pool Ratio—**The watershed:pool ratio should be between 10:1 and 25:1, to allow GADNR to fertilize for maximum fish production.
- **Percent Shallow Water—**The percent shallow water (i.e., water less than four feet deep) is not to exceed 20 percent, to prevent excessive aquatic vegetation.
- **Accessibility—**Sites should have no major obstacles (i.e., roads, bridges, homes, old dump sites) in the lake basin.

An example of a site that meets these criteria is Hart County Lake. Hart County Lake is a 62-acre site located approximately eight miles from Lake Hartwell. The Hart County site is expected to provide alternative catch and harvest opportunities to those anglers who fish or would fish in one of the most contaminated sections of Lake Hartwell. Restoration requires stream and wetlands mitigation, stocking, and long-term management for continued harvest opportunities.

4.3.4.2 New Harvest Opportunities: South Carolina

Any new fishing sites in South Carolina created for the purposes of Lake Hartwell restoration are expected to meet the following criteria developed by the state:

- **Proximity to Lake Hartwell—**Ponds in the Savannah River drainage are preferred.
- **Ownership—**Water bodies held by Federal, state, county, or municipal governments are preferred over privately held bodies.
- **Acreage—**Larger water bodies (i.e., greater than 10 acres) are preferred.
- **Accessibility—**Ponds that are readily accessible to the public are preferred.
- **Manageability—**Ponds that can be intensely managed are preferred (i.e., ponds with attributes conducive to flow, depth and wild fish control).

The Trustees are currently reviewing sites for purchase/lease to create new harvest opportunities for Lake Hartwell anglers. Examples of these sites include:

- Walhalla City Lake,
- Anderson Reservoir,
- City of Pickens,
- Three and Twenty Creek Watershed, and
- Lake Issaqueena.

Long-term leases or Memoranda of Understanding (MOUs) would be negotiated to bring these existing water bodies into South Carolina's public fishing lake program. SCDNR is also reviewing several potential sub-impoundment areas adjacent to Lake Hartwell.

Both the new lake sites and the sub-impoundments would be managed in the most effective manner based on the characteristics of the individual water body. Management activities would include, but not be limited to, liming and fertilization, angler access enhancement, and fish population manipulation and stocking. Where appropriate, ponds would be managed for bass, bream, and catfish. Ponds in which traditional bass/bream management would not be effective would be managed primarily for put-grow-take catfish.

4.3.4.3 Improvement of Public Fishing Access

The Trustees are evaluating restoration alternatives that would improve public fishing access, including construction of jetties in the Lake Hartwell tailrace and boat ramps at relevant locations.

The Hartwell tailwaters are currently stocked by both GADNR and SCDNR with a total of 24,000 catchable trout annually. In addition to trout fishing, the lower tailrace supports a popular striped bass fishery. For safety reasons, fishing access to the tailwaters is limited to low flow periods. Because of the bedrock-boulder substrate, it is hazardous to wade in the streambed. Therefore, improving access in the tailrace by constructing rock jetties would be a great benefit to anglers. Similar rock jetties were constructed in the Lake Russell tailrace. Based on creel survey data, the jetties are very popular with anglers, and support considerable angling pressure and fish harvest annually. In addition, the jetties will have very low maintenance requirements.

Boat ramps are also being considered to improve public fishing access. Boat ramps are a popular component of GADNR and SCDNR public fishing programs, and provide a cost-effective way to allow for additional and easier access to public fishing opportunities.

4.3.5 Evaluation Based on Criteria

In addition to the site-specific criteria listed in Section 4.3.2, general criteria listed in the DOI regulation for damage assessment [43 CFR Section 11.82 (d)] are also considered in evaluating these restoration options. Details regarding these criteria are provided below:

- *Restoration of harvest opportunities for anglers likely affected by PCB contamination at Lake Hartwell*. All preferred sites for creation of new harvest opportunities are either adjacent to or within close proximity of Lake Hartwell (i.e., within the Lake Hartwell watershed) and would provide similar harvest opportunities but without contamination concerns.

- *Enhancement of catch/harvest opportunities in the vicinity of Lake Hartwell*. Together with creation of additional public fishing areas, construction of jetties in the Hartwell tailrace and construction of additional boat ramps would increase fishing/harvest opportunities onsite.

- *Compatibility with the management objectives of the state fisheries agencies.* Creation/enhancement of harvest opportunities and public access to fisheries are goals of both GADNR and SCDNR.

- *Technical feasibility [43 CFR Section 11.82 (d)(1)]*. Creation and development of lake and sub-impoundment fishing areas are technically feasible, as indicated by preliminary feasibility investigations in other areas, such as Bacon and Laurens counties, Georgia. Jetty construction in Lake Hartwell is also feasible. Similar structures have been constructed on Lake Russell, and several suitable sites for jetties in the Hartwell tailwaters have been identified. Boat ramps are feasible as well; multiple boat ramps already exist in the area and GADNR and SCDNR are experienced in the design and construction of these access alternatives.

- *The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources [43 CFR Section 11.82 (d)(2)]*. The Trustees believe the expense of creating new lake sites and sub-impoundments, constructing tailrace jetties, and installing boat ramps is reasonable relative to the benefits these projects will generate, particularly with respect to existing, or potential Lake Hartwell anglers. These project types are the only appropriate and sufficient options for restoration of harvest, and to a lesser extent, catch opportunities compromised by PCB contamination.

- *Cost-effectiveness [43 CFR Section 11.82 (d)(3)]*. Creation of new lake sites and sub-impoundments, jetty construction, and boat ramp construction are cost effective. Land ownership and the potential for use of existing infrastructure were considered in identifying candidate sites. For example, Hart County Lake is within a state-owned Wildlife Management Area (WMA), thus eliminating land acquisition costs for this site. The Trustees attempted but were unable to identify other, lower-cost projects that met restoration criteria.

- *Results of any actual or planned response actions [43 CFR Section 11.82 (d)(4)]*. EPA is currently overseeing implementation of a remedy that involves movement of sediment through Twelvemile Creek to cap contaminated sediments in Lake Hartwell. This process is ongoing. Remedial actions are restricted to Twelvemile Creek, and therefore do not directly affect any of the preferred restoration sites (i.e., no response actions will occur at the restoration sites).

- *Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources [43 CFR Section 11.82 (d)(5)]*. Development of new fishing areas in existing lakes and sub-impoundment and jetty and boat ramp construction may result in some short-term adverse effects to the habitats at the preferred sites as a result of construction, etc. The Trustees have considered these effects and determined that the long-

term benefits to area anglers, which include ancillary ecological benefits associated with sustainable fisheries management, outweigh any initial negative impacts. Certain sites where infrastructure is already in place would experience negligible impacts.

- *The natural recovery period and the ability of the resources to recover with or without alternative actions [43 CFR Section 11.82 (d)(6-7)]*. The potential for natural recovery of the resources in Twelvemile Creek and Lake Hartwell is currently determined by the rate of sediment movement through Twelvemile Creek into Lake Hartwell. This recovery period was considered when evaluating recreational fishing losses in Lake Hartwell because of fishing advisories. The preferred ecological restoration alternative of dam removal will restore natural sedimentation patterns in the Twelvemile Creek watershed, which is expected to enhance natural recovery and result in shorter recovery times.

- *Potential effects of action on human health and safety [43 CFR Section 11.82 (d)(8)]*. Creation of new fishing areas and jetty and boat ramp construction may involve the use of heavy construction equipment. In addition, construction of public access facilities at these sites may also require use of machinery and vehicles. These actions may affect human health and safety. The Trustees, however, expect that public exposure to these areas during restoration will be minimized, thereby limiting or possibly eliminating any risk. As these restoration projects will occur in uncontaminated areas, no contaminant-related risks to human health and safety are expected.

- *Consistency and compliance with relevant Federal, state, and tribal laws and policies [43 CFR Section 11.82 (d)(9-10)]*. The Trustees' consideration of this criterion is discussed in detail in Section 4.4.2 and Appendix C.

4.4 Environmental Assessment of Preferred Restoration Alternative

4.4.1 Environmental Benefits from Preferred Restoration Alternatives

As discussed in the context of restoration criteria above, new fishing area development, jetty construction, and/or boat ramp installation are expected to generate significant long-term benefits to area anglers. Although related activities may cause some short-term adverse impacts, such impacts are not likely to be significant relative to the recreational benefits afforded by both types of projects.

New lake sites will provide new harvest opportunities for both boat and shore anglers in areas unaffected by contamination concerns. Associated sustainable fisheries management practices will also benefit the long-term viability of the areas' ecosystem. Minor adverse impacts associated with new fishing area development could include disruption of *in situ* biological communities during construction of public facilities or access (to the extent that these are not already in place).

Jetties will provide safe access to anglers in the tailwaters area of Lake Hartwell, and boat ramps will provide safe access to anglers in the Lake Hartwell area, creating additional fishing opportunities, with negligible future maintenance requirements. Short-term impacts arising from jetty and boat ramp construction could include disruption of sediments and benthic communities. For example, construction could increase short-term suspended sediment in adjacent waters potentially affecting area fish.

4.4.2 Compliance with NEPA and Other Potentially Applicable Laws

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the preferred restoration plan is achieved, in part, through the coordination of this document with appropriate agencies and the public. The attached Environmental Assessment documents that all recreational fishing projects, with the exception of new lake construction if any is undertaken as a restoration project (an outcome uncertain at this time), are in compliance with all applicable Federal statutes, executive orders, and policies, including NEPA, 42 USC Section 4321 *et seq.*; the Endangered Species Act (ESA), 16 USC 1531, *et seq.*; the National Historic Preservation Act of 1966, 16 USC Section 470 *et seq.*; the Fish and Wildlife Coordination Act, 16 USC Section 661 *et seq.*; the Rivers and Harbors Act of 1899, 33 USC Section 403 *et seq*.; the Federal Water Pollution Control Act, 33 USC Section 1251 *et seq.*; Executive Order 11990, Protection of Wetlands; and Executive Order 11988, Flood Plain Management. Additional compliance with the laws cited above, such as permitting, will be undertaken in the restoration project planning stages if necessary.

With respect to construction of new fishing lake(s), if these project(s) are undertaken as restoration, lack of information on specific location, site characteristics, size, and scope for the potential lake(s) makes predicting compliance with applicable laws more difficult. These projects have the greatest potential, out of any of the recreational fishing projects, for water quality, wetlands, fish and wildlife, and cultural resources impacts. Accordingly, prior to construction, if any, of new fishing lakes, the Trustees will undertake actions necessary to comply with NEPA, ESA, CWA and other applicable laws, regulations and Executive Orders.

With respect to all the recreational fishing projects, the federal Trustees are required under Executive Order Number 12898, 59 Fed. Reg. 7629, to identify and address any policy or planning impacts that disproportionately affect the health and environment in low income and minority populations. Since the restoration alternatives

will result in changes that benefit area communities and visiting anglers to Lake Hartwell, the federal Trustees have concluded that there would be no adverse impacts on low-income or minority communities due to implementation of the restoration alternatives.

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Table 1. Summary of injury determination for ecological resources in the Twelvemile Creek/Lake Hartwell assessment area.

Location	Number of Observations	Year(s)[a]	Total PCB			Injury Determination Basis as per 43 CFR 11	Injury Determination Threshold(s)	
			Min.[b]	Max.	Median		Total PCB	Description
Surface Water (µg/L)								
Twelvemile Creek	12	2001	0.0039	0.19	0.04	Concentrations exceed water quality criteria established by the Clean Water Act, or other Federal or State regulations that govern specific water use classifications [43 CFR 11.62(b)(i) - (iii)].	0.014 µg/L	Water quality standard for the protection of freshwater aquatic life (U.S. EPA 2002)
Seneca River Arm	6	2001	0.015	0.088	0.041			
Surface Sediment[c] (mg/kg)								
Twelvemile Creek	85	1976–1994	0.005	22.1	0.16	Concentrations of PCBs in sediment sufficient to cause injury to other natural resources (in this case biological resources) that are exposed to sediment (e.g., sediment-dwelling organisms) [43 CFR 11.62(b)(iv) - (v)].	>0.041.0 mg/kg	0.04 mg/kg represents a threshold concentration below which adverse effects are not expected to occur (MacDonald et al. 2000). A low incidence and severity of adverse effects are expected for sediment concentrations ranging from 0.04 to 1 mg/kg.
	44	1995–2003	0.06 *U*	3.9	0.39			
Seneca River Arm	187	1976–1994	0.01	73.2	1.2			
	100	1995–2003	0.06 *U*	23.3	2.01			
Lake Hartwell	122	1976–1994	0.001	6.6	0.43		>1.0–5.0 mg/kg >5 mg/kg	Increasing severity of effects (toxicity and changes in benthic community abundance and diversity) are expected at subsequently higher concentration intervals. Effects ranges are based in part on MacDonald et al. (2000); Ingersoll et al. (1996); MacDonald (1994); Persaud et al. (1993); EC and MENVIQ (1992); and Long et al. (1995).
	46	1995–2003	0.001	8.9	0.48			

Table 1. (cont.)

Location	Number of Observations	Year(s)[a]	Total PCB			Injury Determination Basis as per 43 CFR 11	Injury Determination Threshold(s)	
			Min.[b]	Max.	Median		Total PCB	Description
Macroinvertebrates (mg/kg)—*Corbicula*								
Twelvemile Creek	47	1995–2003	0.05	10.1	0.45	Data indicate a pathway for exposure of aquatic organisms to PCBs and potential exposure of higher trophic level organisms [43 CFR 11.63(f)].	NA	Evidence of bioaccumulation relative to reference conditions.
Seneca River Arm	7	1995–2003	1.27	6.81	2.10			
Macroinvertebrates (mg/kg)—Mayflies								
Twelvemile Creek	NA	1992			2.6[d]	Data indicate a pathway for exposure of aquatic organisms to PCBs and potential exposure of higher trophic level organisms [43 CFR 11.63(f)].	NA	Evidence of bioaccumulation relative to reference conditions. Potential for exposure to insectivorous birds (e.g., Bechtel 1994).
Macroinvertebrates—Assessment of Benthic Macroinvertebrate Community								
Twelvemile Creek		1993	Fewer taxa observed at one station downstream of Sangamo and lower RBP scores observed in Town Creek			None specific to benthic community composition; however the following categories of injury may apply: death [43 CFR 11.62(f)(i)] or avoidance [43 CFR 11.62 (f)(iii)(B)].	NA	Evidence of altered community composition suggests death, avoidance, or both in assessment area relative to reference area.

Table 1. (cont.)

Location	Number of Observations	Year(s)[a]	Total PCB			Injury Determination Basis as per 43 CFR 11	Injury Determination Threshold(s)	
			Min.[b]	Max.	Median		Total PCB	Description
Fish (mg/kg)								
Twelvemile Creek						Adverse changes in the viability of fish or their offspring that result in at least one of the following: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunction (e.g., reproduction or physical deformation) [43 CFR 11.62(f)(i)].	>1.6–10.0 mg/kg whole body >0.8–5 mg/kg fillet	Concentration range over which adverse effects on immunological and physiological functions, and early life stage survival of sensitive species would first be observed as suggested by studies by Barron et al. (2000) and Matta et al. (2001).
Forage Fish Fillet[e]	219[f]	1992	0.05	18	0.40			
Sport Fish Fillet[g]	19[f]	1992	6	14	0.10			
Seneca River Arm								
Forage Fish Fillet	1[h]	1985	3.8	3.8	3.8			
	65[f]	1995–2003	0.087	17.7	1.8		>10.0–50.0 mg/kg whole body >5–25 mg/kg fillet	Concentration range over which adverse effects on adult reproductive performance and growth would start to be observed based on studies by Hansen et al. (1973), Monosson (1999/2000), and Niimi (1996).
Forage Fish Whole body	29[i]	1986–1991	0.090	20.6	2.2			
Sport Fish Fillet	440[j]	1977–1994	0.1	97.0	3.2			
	638[f]	1995–2003	0.052	34	2.4		>50 mg/kg whole body >25 mg/kg fillet	Concentration range over which increased severity of reproductive and developmental toxicity observed in adult fish, and adult mortality first observed as indicated by Monosson (1999/2000) and Niimi (1996).
Sport Fish Whole body	13[k]	1986–1989	2.7	34.1	5.4			
Lake Hartwell								
Forage Fish Fillet	NA	Prior to 1995	NA	NA	NA			
	33[f]	1995–2003	0.0514 *U*	7.4	0.67			
Forage Fish Whole body	15[l]	1991	0.10 *U*	0.40	0.10			
Sport Fish FIllet	386[m]	1977–1994	0.05 *U*	12.7	0.70			
	639[f]	1995–2003	0.05 *U*	15.5	0.50			
Sport Fish Whole body	11[k]	1986–1989	0.20	6.7	1.8			
	NA	1995–2003	NA	NA	NA			

Table 1. (cont.)

Location	Number of Observations	Year(s)[a]	Total PCB			Injury Determination Basis as per 43 CFR 11	Injury Determination Threshold(s)	
			Min.[b]	Max.	Median		Total PCB	Description
Piscivorous and Insectivorous Birds								
All areas			No tissue PCBs data available. Injury Determination is based on exposure to PCBs via ingestion of contaminated prey (fish and emergent aquatic insects).			Adverse changes in the viability of birds or their offspring that result in at least one of the following: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunction (e.g., reproduction) or physical deformation [43 CFR 11.62(f)(i)].	NA	Potential for reproductive effects in insectivorous and piscivorous birds based on ecological risk assessment (Bechtel 1994).
Mammals (otter and mink)								
All areas			No tissue PCBs data available. Injury determination is based on exposure to PCBs via ingestion of contaminated prey (fish).			Adverse changes in the viability of mammals or their offspring that result in at least one of the following: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunction (e.g., reproduction) or physical deformation [43 CFR 11.62(f)(i)].	NA	Potential for reproductive effects in piscivorous mammals based on ecological risk assessment (Bechtel 1994).

Note: *U* - undetected at detection limit shown

[a] Available PCB concentration data are presented for each year interval. However, data may not exist for all years within a given interval.

[b] ND - not detected, detection limit not reported; < - not detected, value shown is reported detection limit.

[c] This analysis includes sediment samples in the surface sediment interval only, as this is the interval at which sediment-dwelling organisms would be expected to be exposed to concentrations observed at the time of the sampling. Surface sediment samples include all grab samples and the surface interval for all cores.

[d] Single sample from one station. Median could not be calculated with available information.

[e] Forage fish include bluegill, northern hog sucker, redbreast sunfish, black crappie, gizzard shad, threadfin shad, brown bullhead, and blueback herring.

[f] Muscle tissue samples.

[g] Sport fish include largemouth bass, channel catfish, white catfish, hybrid bass, flathead catfish, striped bass, walleye, and coosae bass.

[h] One skinless, no ribcage sample from Alexander (1994).

[i] Whole body samples except 5 deheaded and eviscerated samples from Alexander (1994).

[j] Muscle tissue samples except 61 skinless, no ribcage samples and 2 skin on, de-scaled with ribcage samples from Alexander (1994).

[k] Deheaded and eviscerated samples from Alexander (1994).

[l] Whole body sample.

[m] Muscle tissue except 16 skinless, no ribcage samples and 2 skin-on, descaled, with ribcage samples from Alexander (1994).

Table 2. Distribution of fish samples by injury threshold interval.

Fish Type	Number of Samples	Percentage of Samples Within Each Injury Threshold Interval			
		Interval A < 1.6 mg/kg PCBs whole body <0.8 mg/kg PCBs fillet	Interval B 1.6–10 mg/kg PCBs whole body 0.8–5 mg/kg PCBs fillet	Interval C 10.01–50 mg/kg PCBs whole body 5.01–25 mg/kg PCBs fillet	Interval D > 50 mg/kg PCBs whole body >25 mg/kg PCBs fillet
Twelvemile Creek					
Forage fish[a]	219	65	25	10	0
Sport fish[b]	19	58	26	16	0
Seneca River Arm					
Forage fish[a]	95	28	57	15	0
Sport fish[b]	1,091	9	67	23	1
Lake Hartwell					
Forage fish[a]	48	71	27	2	0
Sport fish[b]	1,036	58	37	5	0

[a] Forage fish include bluegill, northern hog sucker, redbreast sunfish, black crappie, gizzard shad, threadfin shad, brown bullhead, and blueback herring.

[b] Sport fish include largemouth bass, channel catfish, white catfish, hybrid bass, flathead catfish, striped bass, walleye, and coosae bass.

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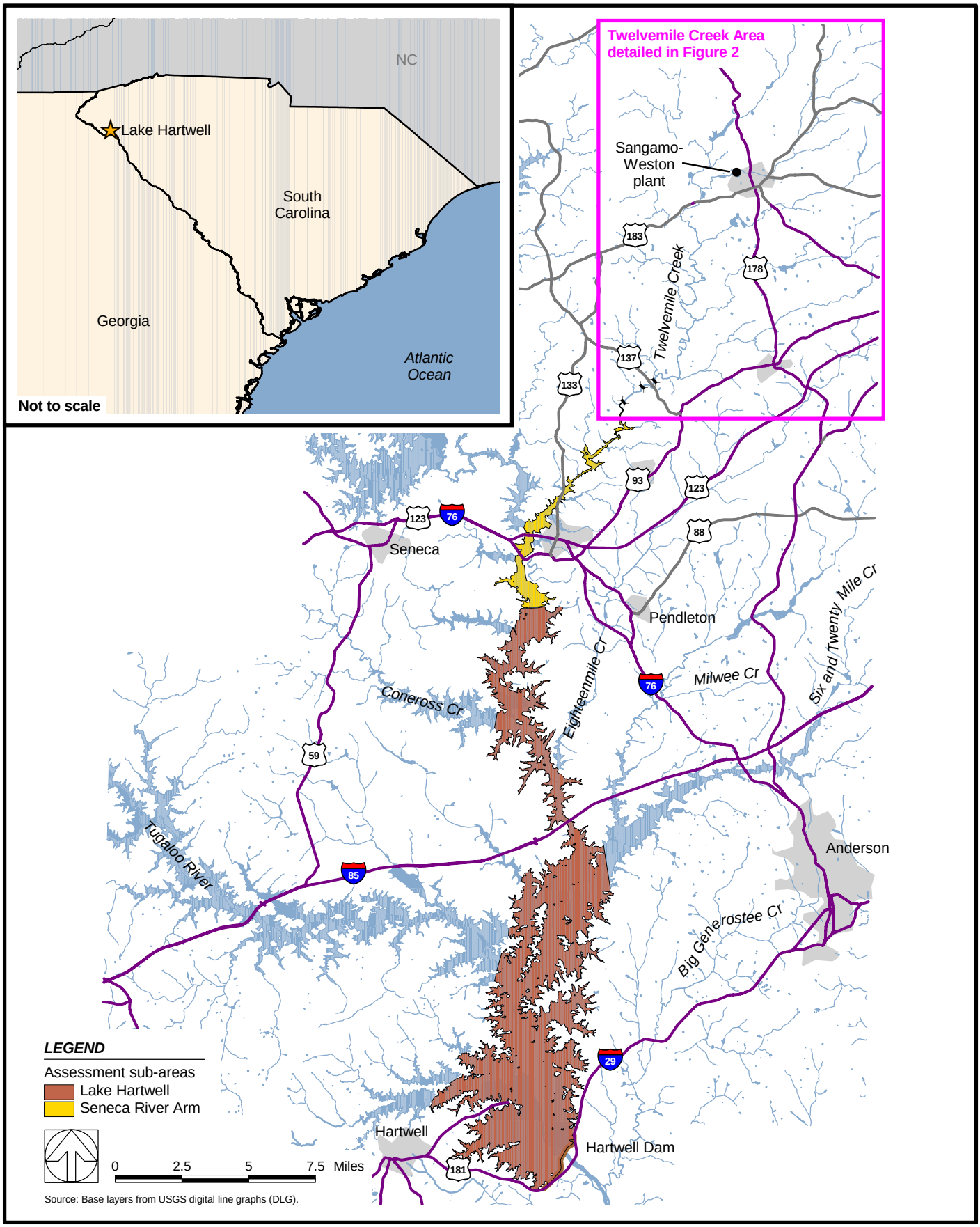


Figure 1. Twelvemile Creek/Lake Hartwell Assessment Area

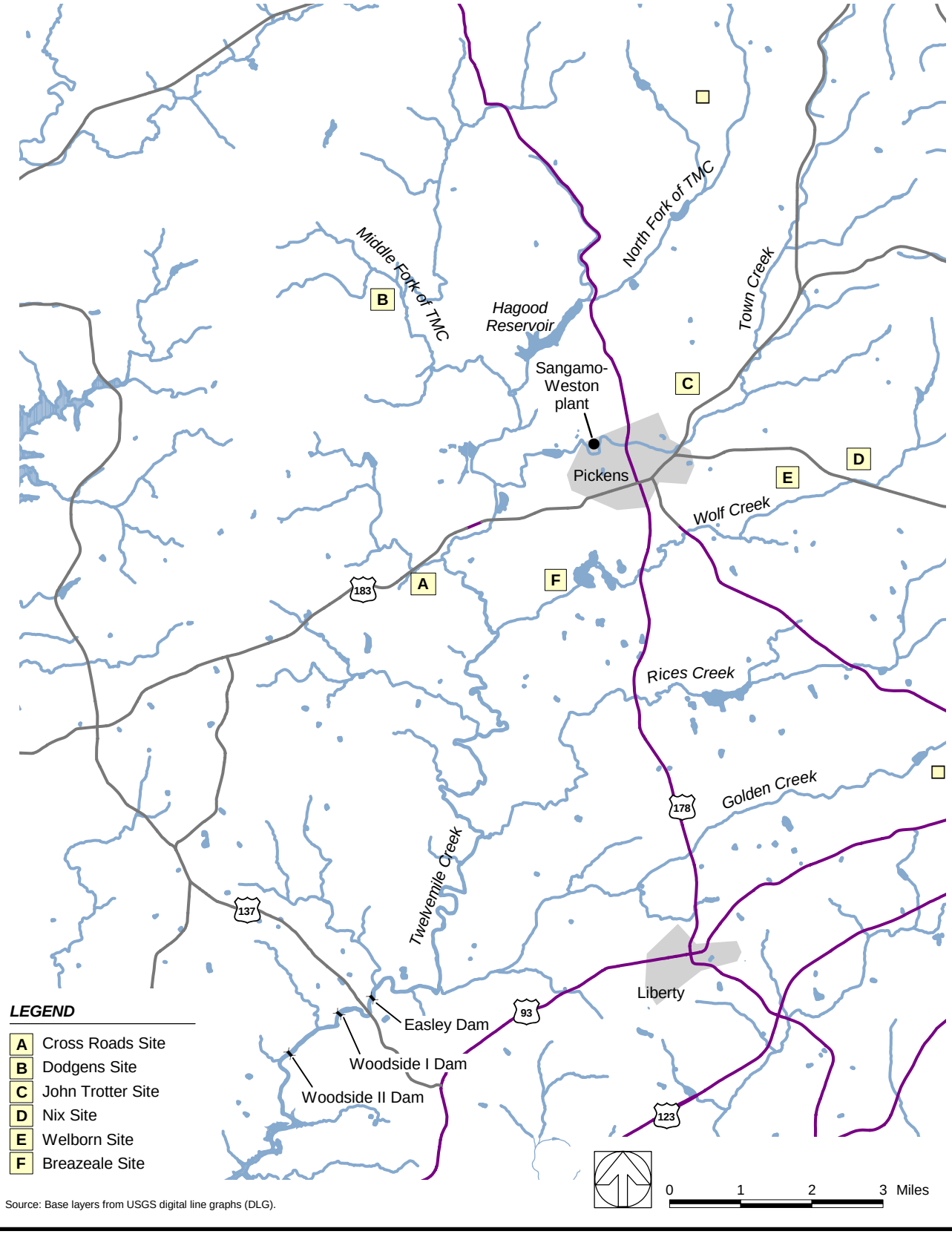


Figure 2. Detail of Twelvemile Creek Area

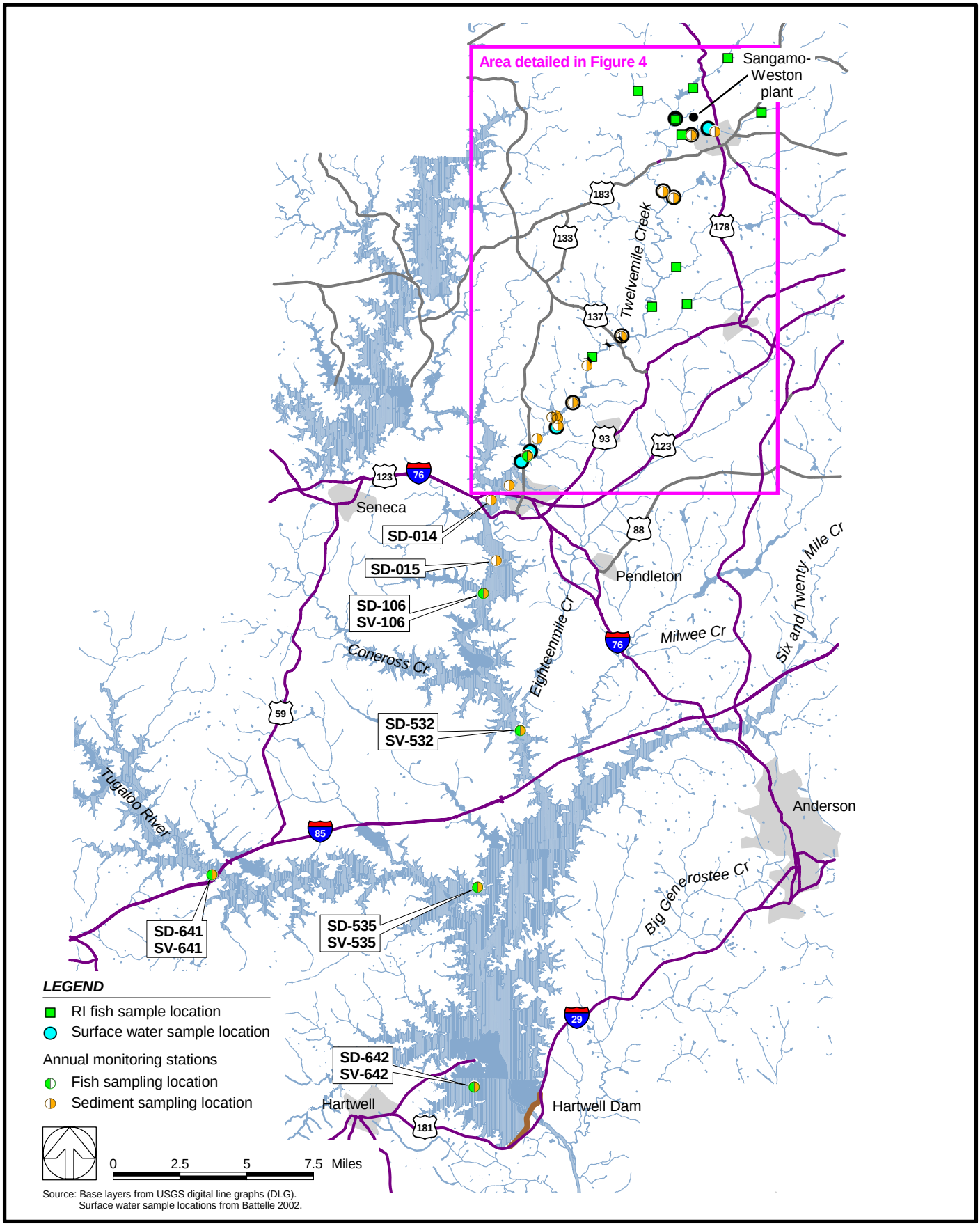
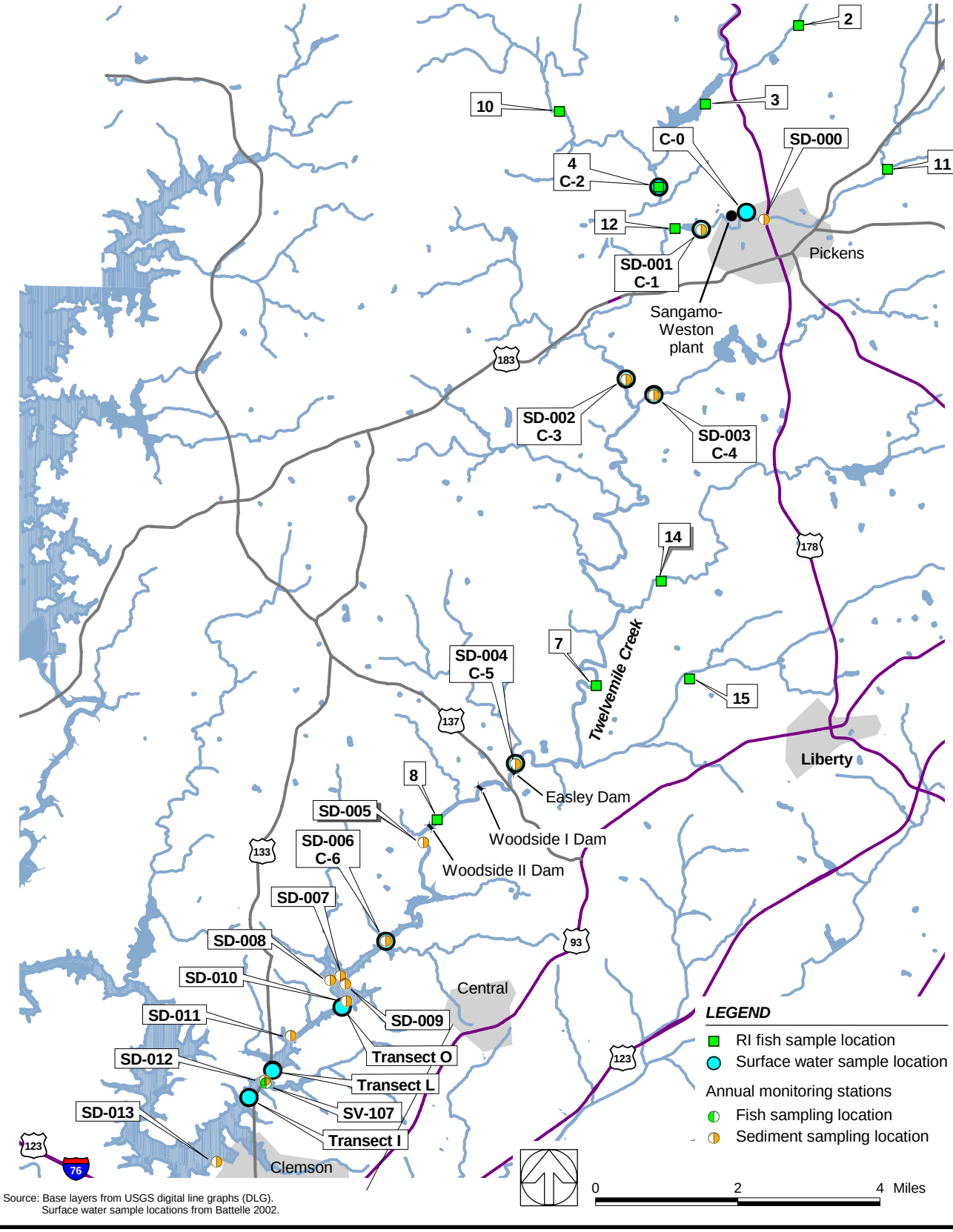


Figure 3. Surface water, sediment, and fish sampling station locations in Lake Hartwell



Source: Base layers from USGS digital line graphs (DLG).
Surface water sample locations from Battelle 2002.

Figure 4. Surface water, sediment, and fish sampling station locations in Upper Lake Hartwell and Twelvemile Creek

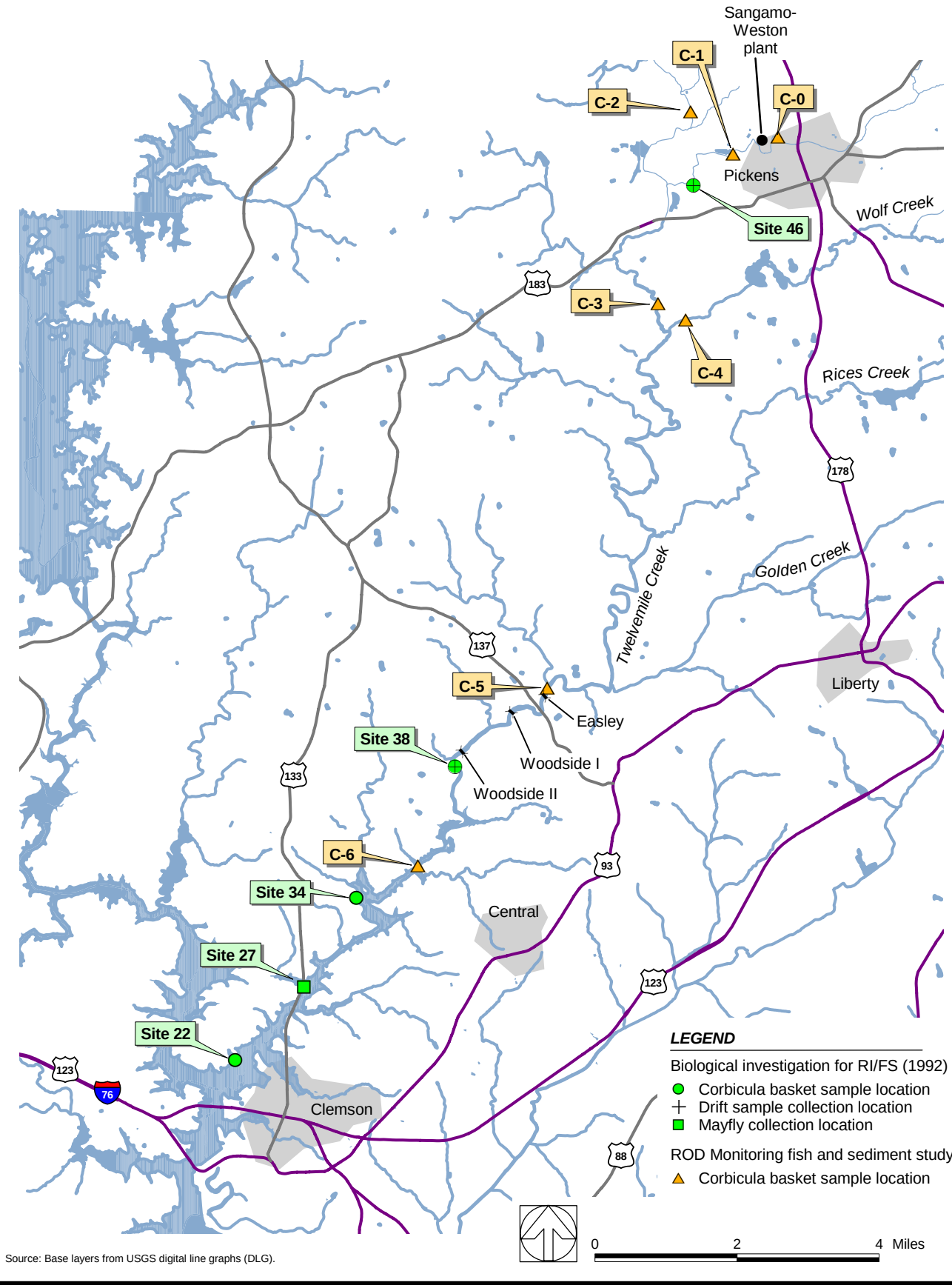


Figure 5. *Corbicula,* drift sample, and mayfly sample stations in Twelvemile Creek

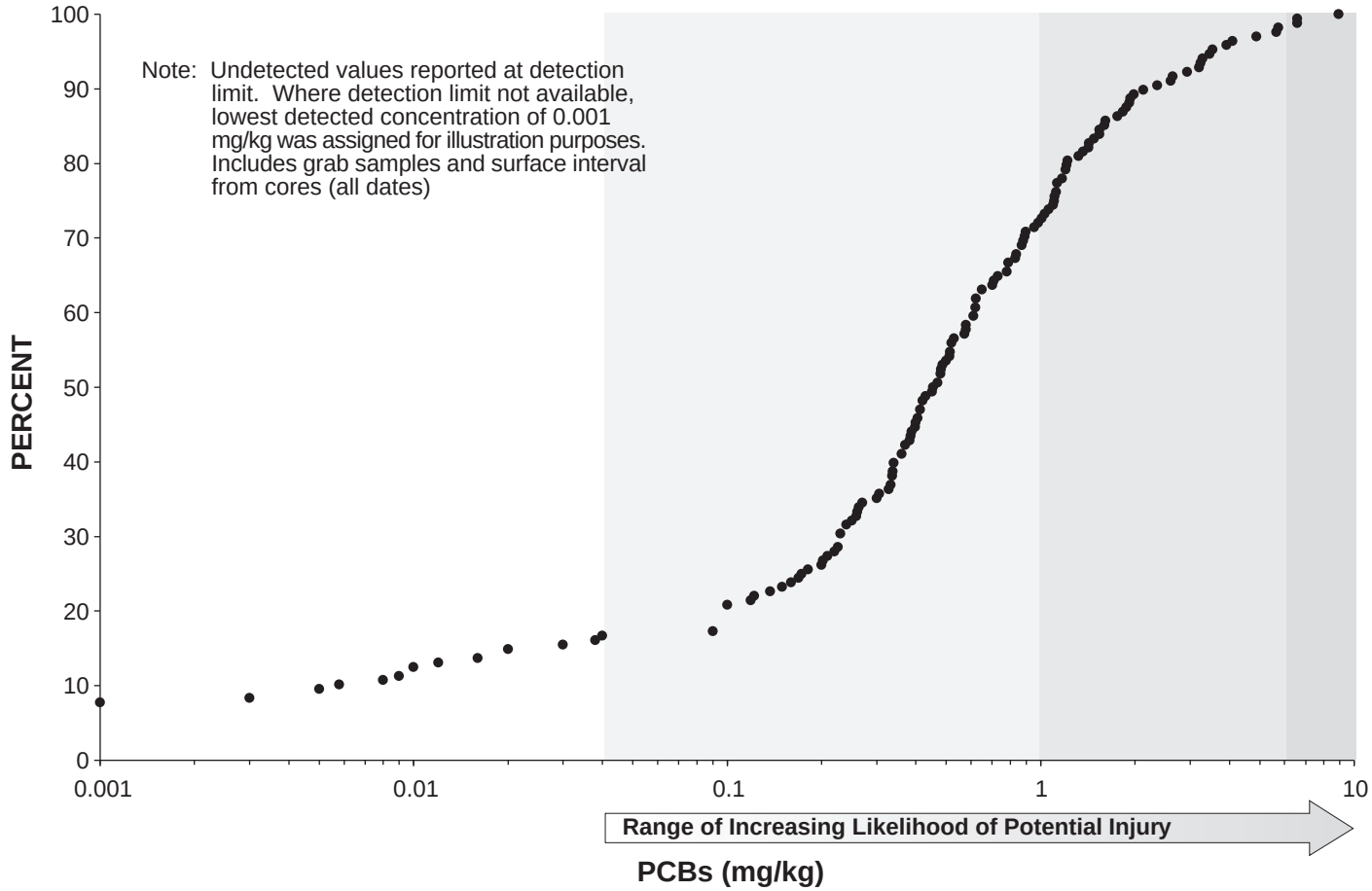


Figure 6. Cumulative frequency of PCBs in surface sediment from Lake Hartwell

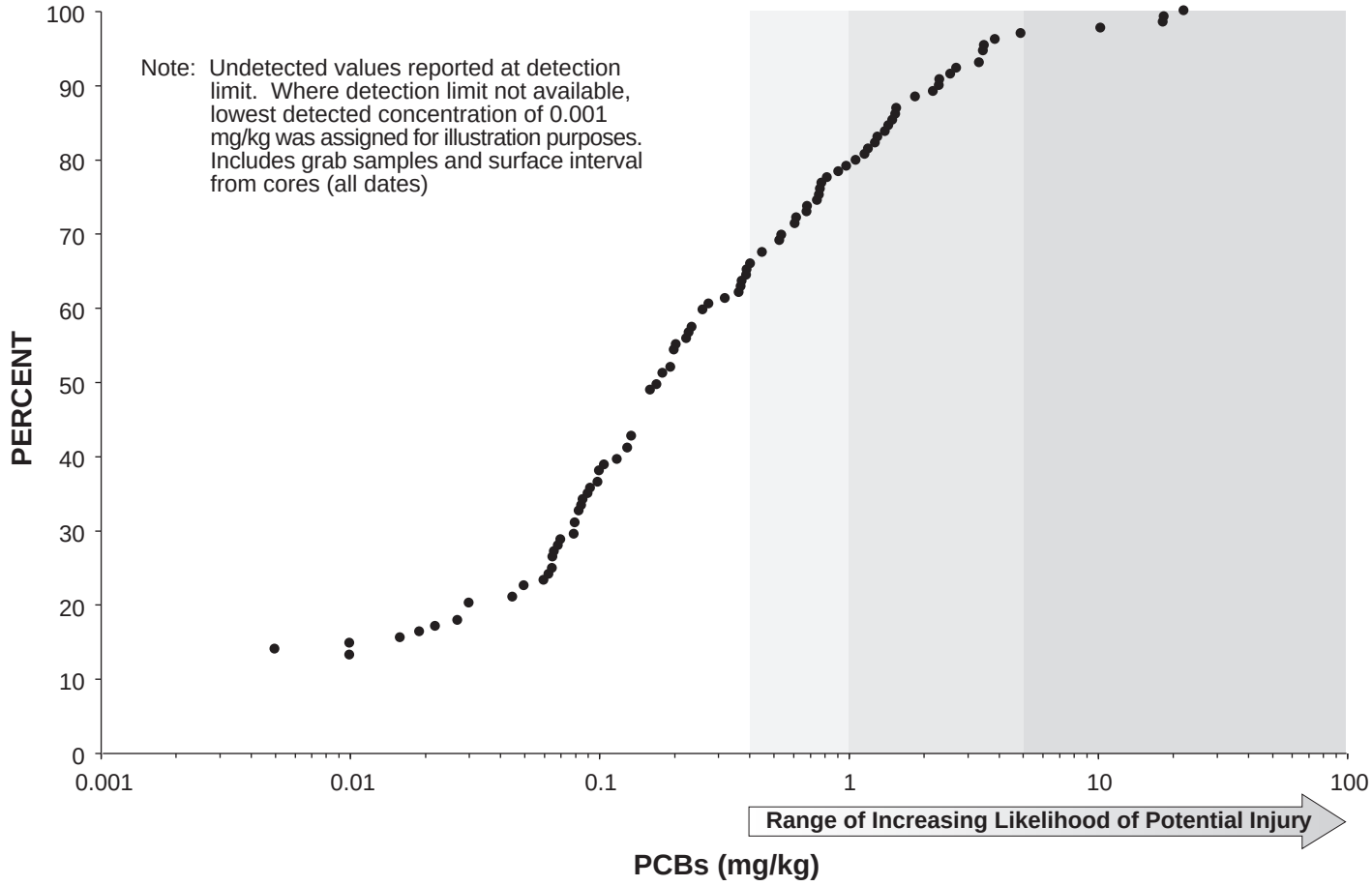


Figure 7. Cumulative frequency of PCBs in surface sediment from Twelvemile Creek and Twelvemile Creek Watershed

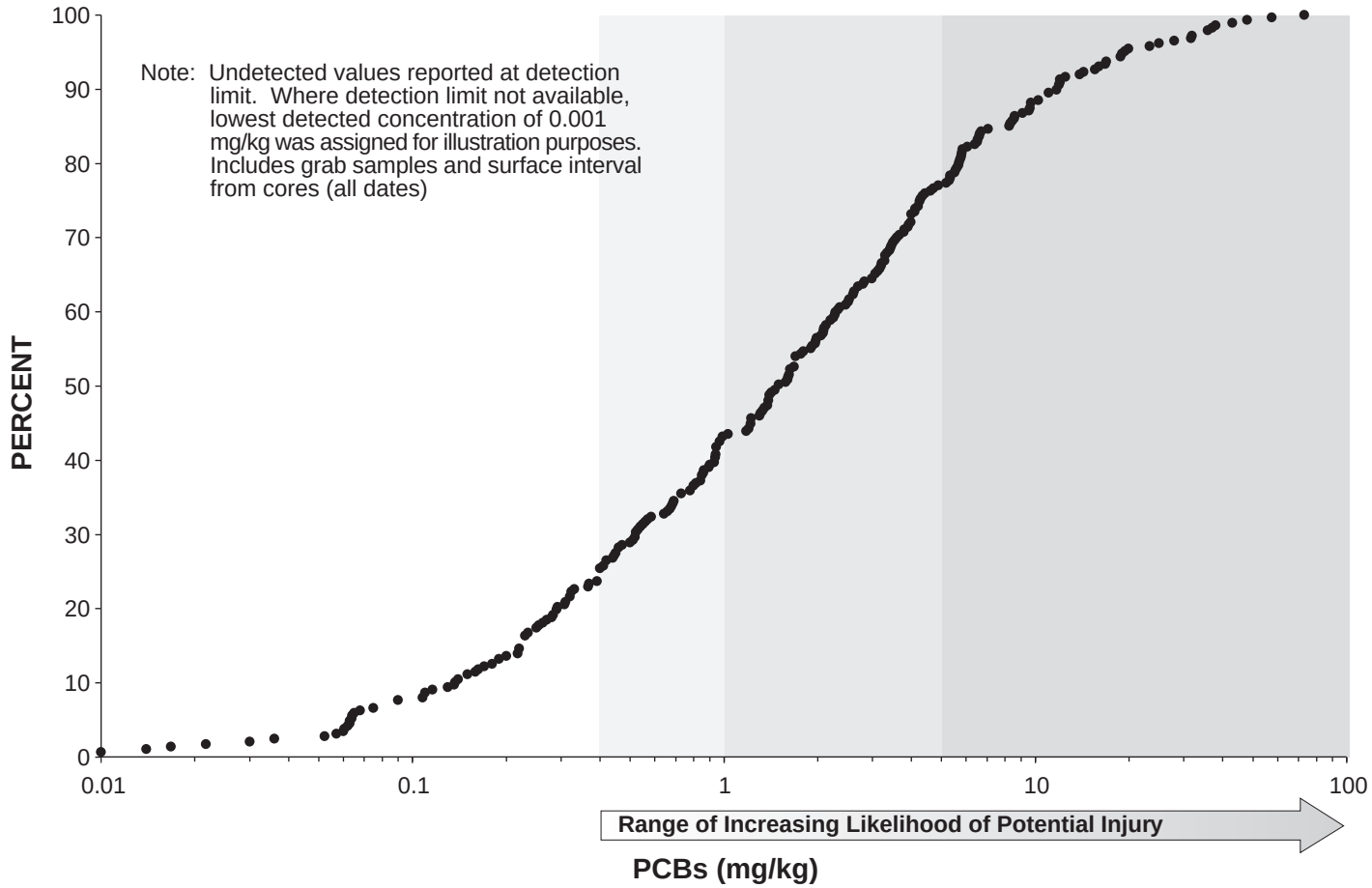


Figure 8. Cumulative frequency of PCBs in Seneca River Arm surface sediment

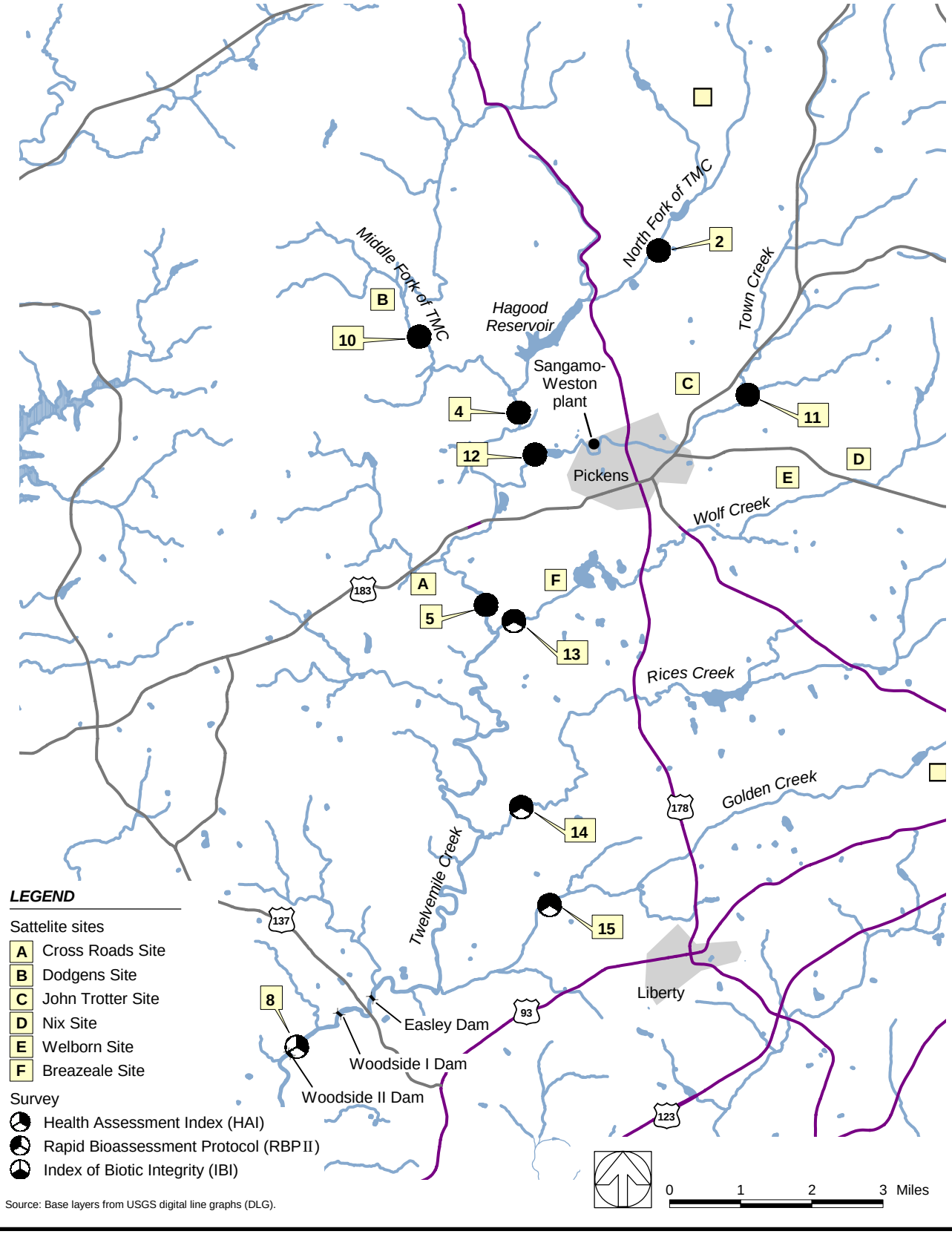


Figure 9. Locations of sampling for studies in the RI biological investigation

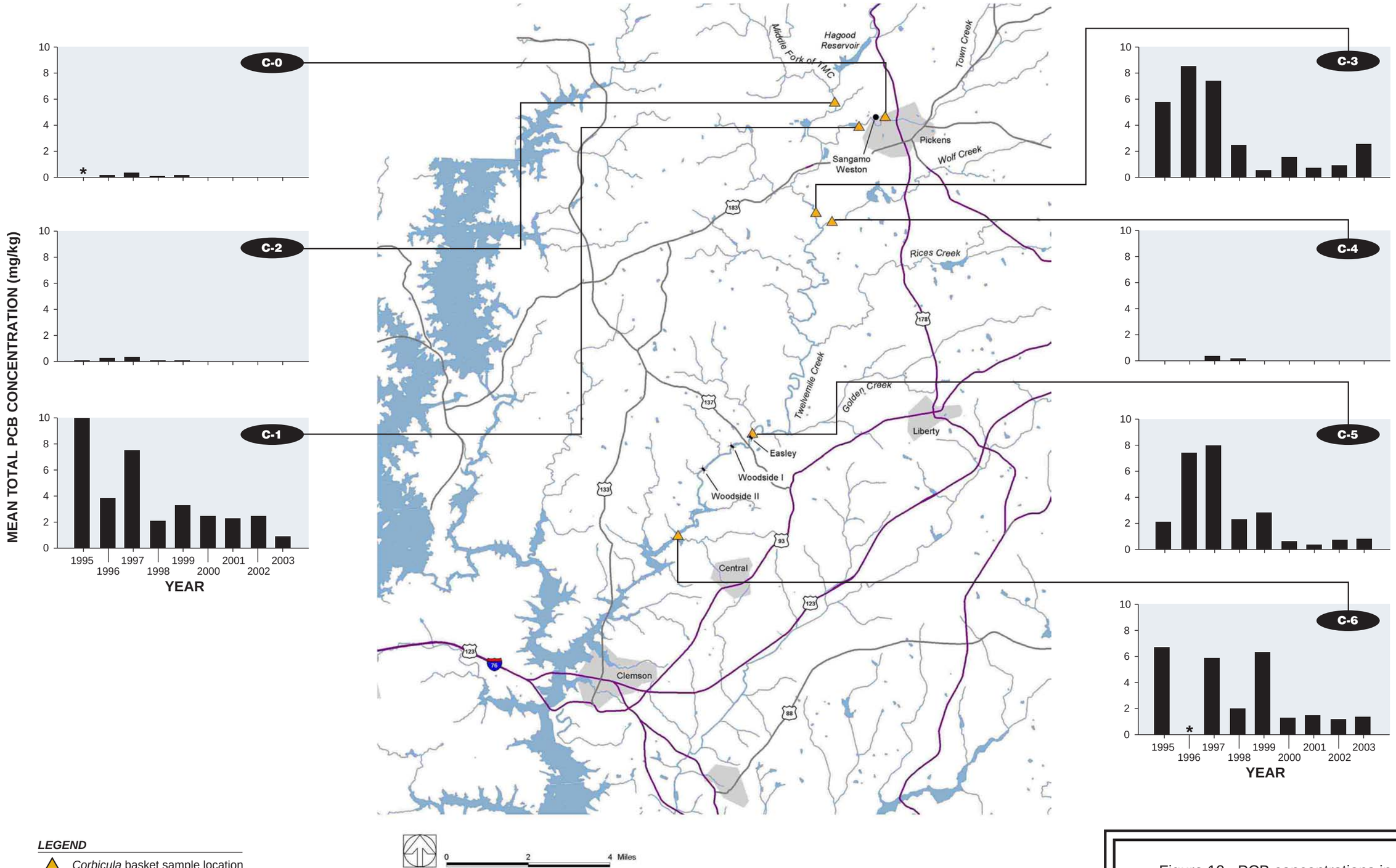
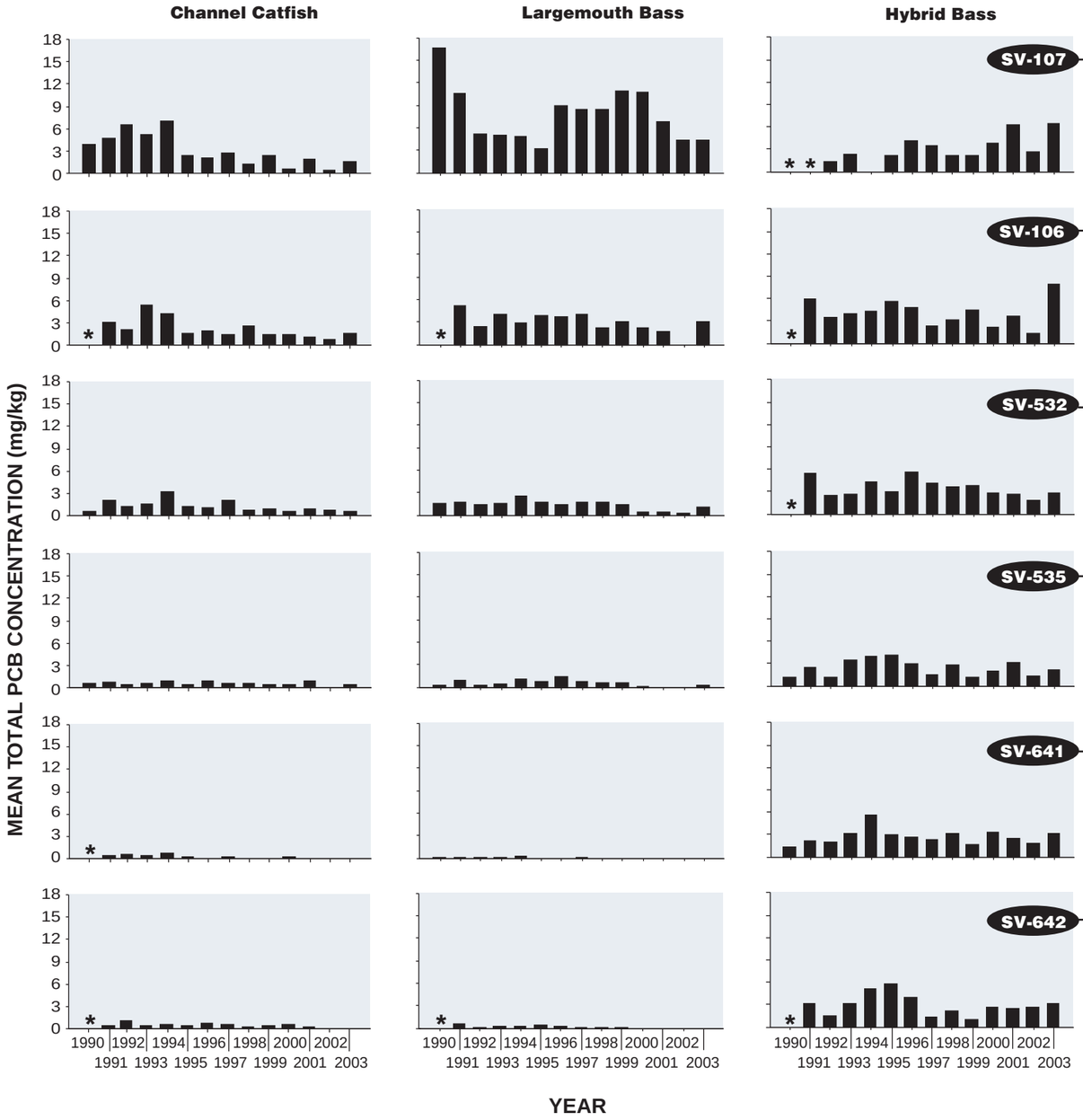
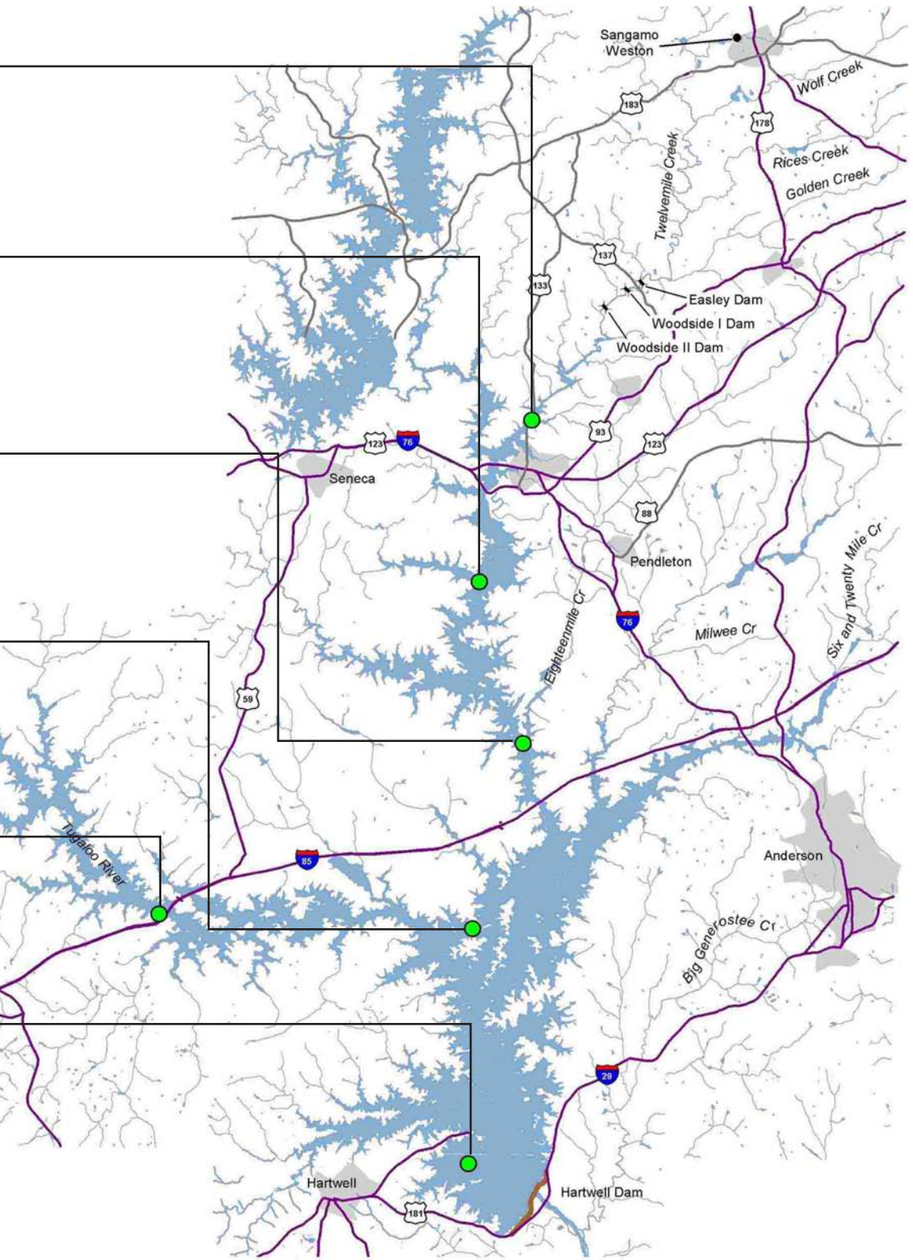


Figure 10. PCB concentrations in *Corbicula* 1995–2003





LEGEND

- Fish sampling location
- * No data

Note: Mean calculated from fillet data, N = ~10 (hybrid and largemouth bass) N = ~4 (channel catfish). Calculations included with undetected values samples at the detection limit.

Figure 11. Annual fish tissue sampling results 1990–2003

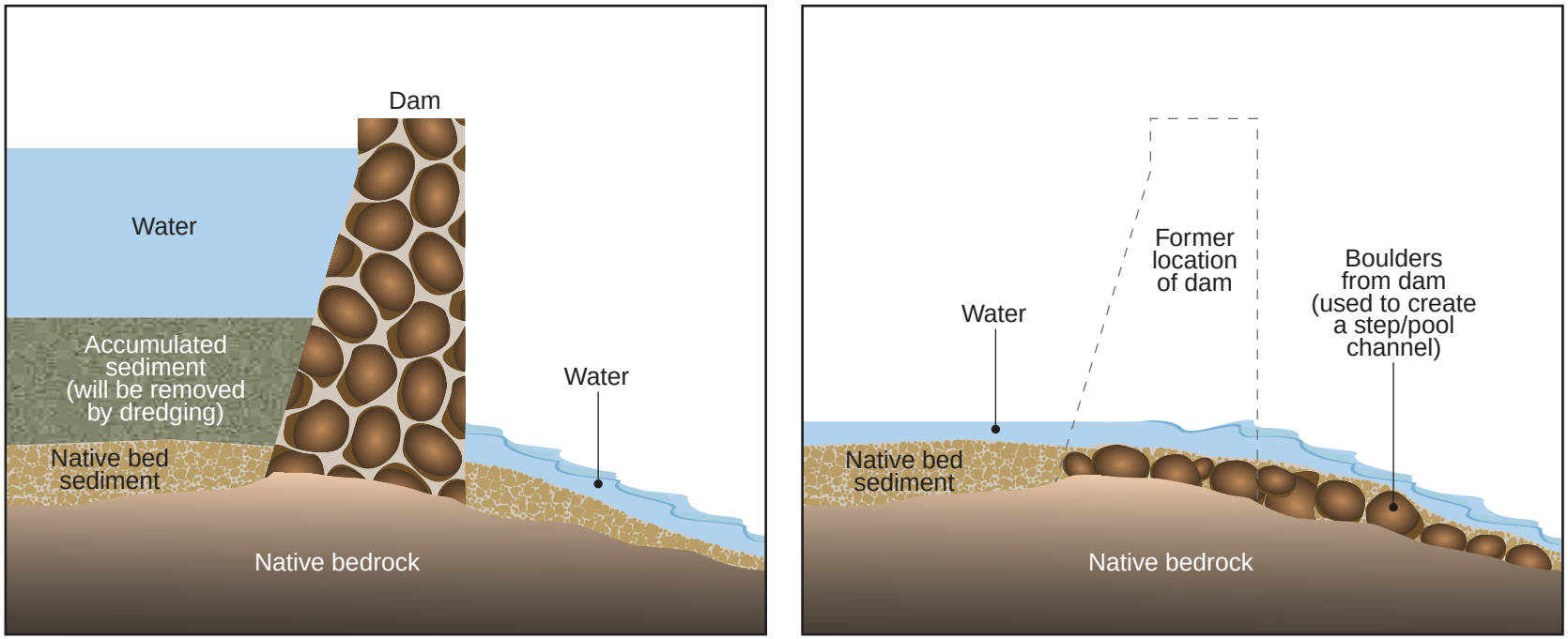


Figure 12. Conceptual design for dam removal

Appendix A

Summary of Relevant Environmental Studies

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Summary of Relevant Environmental Studies

Several environmental studies have been conducted in association with the Superfund process at both Operable Unit 1 (OU1) and Operable Unit 2 (OU2) of the Sangamo-Weston plant. The only sampling conducted in OU1 that is directly relevant to this Restoration and Compensation Determination Plan (RCDP) is sediment sampling in tributaries to Twelvemile Creek. Studies conducted in OU2 have included investigations of surface water chemistry, sediment chemistry, bioaccumulation of polychlorinated biphenyls (PCBs) in fish, *Corbicula* clams, and other biota, and various biological effects investigations.

Surface Water Chemistry

Surface water was collected at 50 stations in OU2 during Phase I of the remedial investigation (July and August 1991) (Bechtel 1993). Water was collected at the surface (50 samples) and from the near bottom when the water depth exceeded 4 to 6 ft (38 samples). All samples were analyzed for PCBs and total organic carbon (TOC). Seven samples (4 surface and 3 near bottom) were also analyzed for volatile organic compounds (VOCs), base/neutral/acid extractable organics, metals, cyanide, total dissolved solids (TDS)/total suspended solids (TSS), chloride, fluoride, sulfate, nitrite/nitrate, and dissolved organic carbon (DOC). Two stations were on the North Fork of Twelvemile Creek, upstream of the confluence with Town Creek. One station was in Hagood Reservoir also on the North Fork of Twelvemile Creek. An additional station was upstream of the Sangamo-Weston plant discharge on Town Creek. Other stations were located in the Middle Fork of Twelvemile Creek, Wolf Creek, three impoundments on the lower reach of Twelvemile Creek, and several arms of Lake Hartwell (see Bechtel [1993] for sampling locations). All results from the Phase I sampling (for Aroclors® 1016, 1221, 1232, 1242, 1248, 1254 and 1260) were undetected at detection limits ranging from 0.49 to 2.0 μg/L.

During Phase II of the remedial investigation (April and May 1992), surface water was collected during two storm events for use in the sediment contaminant transport modeling (Bechtel 1993). The four samples collected during the first storm event were analyzed for pesticides/PCBs, base/neutral/ acid extractable organics, metals, cyanide, TDS/TSS, TOC, and DOC. The five samples collected during the second storm event were analyzed for pesticides/PCBs, TDS/TSS, TOC, and DOC. All results for Aroclor® analyses in the Phase II sampling were undetected at either 1.2 or 1.3 μg/L.

Battelle (2002) collected nine high-volume water samples in 2001 (see Figures A-1 and A-2). Approximately 20 L of water were collected from each of the sampling stations, co-located with the *Corbicula* basket sampling locations (C-0 to C-6) in Twelvemile Creek. Additionally, a water sample was taken from Transect T-O and a 60 L sample from transect T-L (additional volume for quality assurance samples). Water samples were obtained from approximately 1 m above the sediment surface. The water

samples were filtered on two filters (GFC and Empore™). Both the water and particulates on the filters were analyzed for PCBs. PCB concentrations in particulates ranged from below the detection limit (detection limit not reported) at Station C-4 to 0.181 μg/L at Station C-0. PCB concentrations in water ranged from a minimum of below the detection limit (limit not provided) at Station C-4 to a maximum of 0.19 μg/L at Station C-0 on Town Creek, upstream of the Sangamo-Weston plant (Battelle 2002).

Water in the assessment area was also reportedly sampled by the United States Army Corps of Engineers (the Corps) in 1985 and the South Carolina Department of Health and Environmental Control (SCDHEC) from 1976 to 1993, but the results of these samplings were not reported in the remedial investigation and were not available at the time of this writing.

Sediment Chemistry

Pre RI/FS Sampling

Several investigations of PCBs in the Twelvemile Creek and Lake Hartwell assessment area were conducted prior to the remedial investigation and feasibility study (RI/FS) (Bechtel 1993). The RI/FS provides a summary of the studies and some, but not all, of the data. The following is an overview of these studies and the available results.

- **SCDHEC (1972–1976)—**SCDHEC (1976b) sampled the Twelvemile Creek watershed and Lake Hartwell on various occasions between 1972 and 1976. The sampling locations included Twelvemile Creek, Lake Hartwell, Wolf Creek, and Town Creek. Thirty-five surface sediment grab samples were collected to provide initial information documenting PCB concentrations throughout the study area. PCB concentrations in 1976 ranged from below the detection limit to 22.08 mg/kg (in Town Creek).

- **Billings (1976)—**This Masters thesis from a student of the University of South Carolina focused on two sediment cores collected from behind the uppermost impoundment on Twelvemile Creek. The core was sectioned into 2 cm intervals and PCB concentrations ranged from 2.2 to 11.1 mg/kg (in the 0–2 cm interval). Concentrations were detectable at a depth of 22 cm.

- **EPA (1976, 1985)—**EPA collected various fish species (e.g., hybrid and largemouth bass, black crappie, and channel catfish) from sampling locations similar to the SCDHEC studies and an additional location on Twelvemile Creek above the impoundments. Concentrations of PCBs in fish in 1976 ranged from 1.21 mg/kg at Tyger River at Highway 56 to 135 mg/kg at Twelvemile Creek at the

bridge on Secondary Road #273. No additional information on this study is presented by Bechtel (1993).

- **SCDHEC (1976–1993)—**Bechtel (1993) reported that SCDHEC (1976a) collected sediment and surface water samples from Lake Hartwell on an annual basis during this time period. The number of samples apparently varied throughout the years, but an average of 5 samples per year were collected. No information on sample locations or results is presented by Bechtel (1993).

- **Corps (1981)—**The Corps collected 10 surface water and 12 sediment samples in March and September 1981 from Twelvemile Creek, Lake Hartwell proper, and Twelvemile Creek and Tugaloo River arms of Lake Hartwell. Surface water data were not reported by Bechtel (1993). PCBs were detected in most samples, including the Tugaloo River and Twenty-six Mile Creek arms of Lake Hartwell, and the Savannah River downstream from the lake. Concentrations ranged from 0.003 mg/kg to 1.32 mg/kg in samples from the Tugaloo River Arm, and 0.238 mg/kg to 1.12 mg/kg in Twelvemile Creek. Concentrations ranged from 0.008 mg/kg to 1.54 mg/kg in samples from Lake Hartwell proper.

- **Polansky (1984)—**This Masters thesis from a student at Clemson University described PCB sampling results from 6 cores obtained from six sites at a depth of 25 to 50 cm. Four cores were obtained from Twelvemile Creek Arm of Lake Hartwell, one core from the Keowee Arm and one core opposite Clemson in the Seneca River Arm. The cores were segmented into 4 to 6 cm intervals for analysis. The maximum PCB concentration was 46 mg/kg at the 25–30 cm interval of the core from Twelvemile Creek collected downstream from Highway 137.

- **Dunnivant (1985)—**This Masters thesis reported results from seven sediment cores collected at discrete locations between Madden Bridge and Lake Hartwell dam. The cores were sectioned into 4 cm intervals for analysis, along with a re-analysis of the 6 cores from Polansky (1984). Concentrations were reported to a maximum of 56 mg/kg at the 8–12 cm interval in the core from Town Creek. Concentrations from below the detection limit to 15.43 mg/kg were reported in samples from Lake Hartwell proper and concentrations also increased with depth in most samples with subsurface maxima typically at 12 to 24 cm.

- **EPA (1985) Region IV—**EPA collected 18 surface sediment samples from the Twelvemile Creek Arm of Lake Hartwell and from watershed creeks downstream from the offsite disposal areas. This study found the highest PCB concentrations in Twelvemile Creek near the vicinity

of Madden Bridge (48 mg/kg), with decreasing concentrations with distance from the Sangamo-Weston plant. Concentrations of PCBs in sediment downstream of the Madden Bridge ranged from 1.38 mg/kg to 48 mg/kg.

- **RMT (1987)—**Twenty-six cores with a maximum depth of 50 cm were collected from 22 tributaries of Twelvemile Creek, between the confluence of Middle and North forks of Twelvemile Creek to the north and Golden Creek in the south. Each core was homogenized to create one composite sample. No additional information was presented on this study by Bechtel (1993).

- **Germann (1988)—**This Masters thesis from a student at Clemson University reported results of PCB analyses of 80 cores that were sectioned into 5 cm intervals. Cores were collected from Town Creek, Twelvemile Creek, Lake Hartwell, and the Keowee River, Tugaloo River and Twelvemile Creek arms of Lake Hartwell. Analyses of the cores showed that the highest PCB concentrations were found in the Twelvemile Creek Arm of Lake Hartwell, and that concentrations increased with depth, to a maximum at 10–30 cm, and then a decrease in concentration with depth (maximum depth of 67 cm).

- **Versar (1988)—**One surface sediment sample was collected from each of 85 tributaries to Twelvemile Creek. Only 2 samples contained PCB concentrations greater than the detection limit (1.6 mg/kg). One sample was from Town Creek below the Sangamo-Weston plant, and the other from an unnamed creek near Maw Bridge. Other results were not reported by Bechtel (1993).

- **RMT (1989)—**Six surface sediment samples were collected from ponds, drainage ditches and creeks near the Breazeale, Dodgens, Cross Roads and John Trotter offsite disposal areas. Concentrations of PCBs at these locations ranged from 0.07 to 1.8 mg/kg.

RI/FS Investigation Sampling (Bechtel 1993)

The most comprehensive sediment investigation was conducted as part of the RI/FS for OU2. The study was completed in two sampling events. Phase I sampling in July and August 1991 verified previous sediment results and characterized PCB concentrations and spatial distribution in the study area. Phase II sampling in April and May 1992 provided additional information about PCB concentrations in areas of upper Lake Hartwell and the Twelvemile Creek watershed. Sediment grab samples and sediment core samples were collected during both sampling events. Sediment grab samples were collected to a depth of 10–15 cm, and sediment core samples were sectioned into 5 cm increments for PCB analyses.

Two methods were used to analyze PCB concentrations in sediment for the remedial investigation (Bechtel 1993). Samples were analyzed with EPA methods at Contract Laboratory Program (CLP) laboratories and with a field screening method. The field screening method was performed with a modified Spittler method (described in detail in Bechtel 1993). The results of the field method were quantified by calculating the total peak areas of Aroclor® indicator peaks. For atypical peak patterns that were accompanied with distinct Aroclor® patterns, all the peaks in the total peak area were included in the calculation. PCB concentrations quantified by the field method were not corrected for moisture content, but CLP data were moisture-corrected. Field screening results were quantified as total PCBs; the CLP results were Aroclor®-specific. The field method required only a 2-gram sample aliquot, while the CLP method required a 30-gram aliquot. The field method quantified to 1 mg/kg, while the CLP method had a method detection limit of 0.01 mg/kg. Samples below 1 mg/kg were estimated and flagged with a qualifier. A comparison of the two methods was performed by analyzing 122 samples with both methods. In general, PCB results from the field method were more conservative; 92 percent of the field method results were higher than those quantified with the CLP method. One false negative was reported by the field method.

A total of 392 sediment samples, including 341 sediment core samples and 51 sediment grab samples, were collected during Phase I from an area extending approximately 50 miles, from the Sangamo-Weston plant to the offsite disposal areas to Hartwell Dam. A total of 50 sampling stations in Twelvemile Creek, the Twelvemile Creek Arm of Lake Hartwell, the Keowee River Arm of Lake Hartwell, the Seneca River Arm of Lake Hartwell, and Lake Hartwell proper were sampled. The sediment grab samples were co-located with the surface water sampling. Sediment core samples were taken at the same surface water and surface sediment station locations.

Phase II sediment sampling included a total of 735 samples consisting of 185 surface sediment samples and 550 sediment core samples collected at 374 locations. A subset of the stations in Phase II was co-located with stations sampled for the biological investigation. Twenty transects, with up to five core stations, were established across Lake Hartwell and Twelvemile Creek. As many as 11 grab samples were taken between sediment core locations on each transect.

In addition to sediment sampling in OU2, RMT (1989) collected sediment samples in Twelvemile Creek and its tributaries, in the vicinity of the offsite disposal areas. A total of 18 samples were collected as part of this effort.

Most upper Twelvemile Creek sediment samples had PCB concentrations below 0.35 mg/kg. A maximum concentration of 6.5 mg/kg in a 5–10 cm core interval was detected in Town Creek. Surface sediment samples collected near the disposal facilities had concentrations below 1 mg/kg, with most samples being less than 0.5 mg/kg. Many of the sediment samples collected from the lower Twelvemile Creek watershed had PCB concentrations less than 1 mg/kg, and ranged from 0.19 to a maximum of 1.5 mg/kg. Results of the sediment cores in the pool area behind Woodside I and II dams reveal that PCB concentrations were higher at depth than at the surface.

PCB concentrations were below the detection limit (detection limit not available) in 9 of the 18 sediment samples collected in tributaries of Twelvemile Creek in the vicinity of the offsite disposal sites (OU1 sampling described above). A maximum concentration of 0.14 mg/kg was found in an unnamed tributary to Wolf Creek near the Welborn disposal area.

PCB concentrations in sediment grab samples collected in the upper Twelvemile Creek Arm of Lake Hartwell ranged from 0.02 to 9.48 mg/kg. The maximum concentration of 61.1 mg/kg was analyzed by the field method in a core interval of >45 cm. Grab samples collected from the middle section of the Twelvemile Creek Arm of Lake Hartwell had PCB concentrations of 0.06 to 8.3 mg/kg. Sediment core concentrations from the middle section of Twelvemile Creek Arm ranged from 0.04 to a maximum of 18.23 mg/kg (found in the 30 to 35 cm interval of a core sample). Grab samples from the lower Twelvemile Creek Arm of Lake Hartwell had PCB concentrations ranging from 0.16 to 7.01 mg/kg. Sediment core sample concentrations ranged from a minimum of 0.04 to a maximum of 21.52 mg/kg in the 25–30 cm interval.

Concentrations of PCBs in 18 sediment grab samples from the Keowee River Arm of Lake Hartwell ranged from 0.05 to 1.42 mg/kg. PCBs in sediment cores at these locations ranged from 0.03 to 4.12 mg/kg (measured in the 15–20 cm interval of a sediment core collected from Station 144).

In the Seneca River Arm of Lake Hartwell, PCB concentrations in grab samples ranged from 0.04 to 2.8 mg/kg and in sediment core samples ranged from 0.03 to 11.21 mg/kg (maximum in the 30–35 cm interval of a core collected from Station 102).

Nine stations in Lake Hartwell proper were sampled and PCB concentrations ranged from 0.15 to 1.74 mg/kg in sediment grab samples. Sediment core concentrations in this area ranged from 0.07 to 2.42 mg/kg (maximum at the 10–15 cm interval). No more specific information was available regarding this sampling.

In general, PCB concentrations were highest in sediment in the Twelvemile Creek and Seneca River Arms of Lake Hartwell, and generally decreased with distance downstream from the Twelvemile Creek Arm. Similarly, concentrations were highest in Town Creek, as well as the three impoundments. Comparisons to historical sediment studies indicated that PCB concentrations have been decreasing between the mid-1980s to the mid-1990s (Bechtel 1993).

ROD Sediment Monitoring

An annual monitoring program of the Sangamo-Weston site has been conducted since 1995 as part of the post-Record of Decision (ROD) monitoring effort. The ROD required sediment samples to be collected from 15 locations in Lake Hartwell and 5 locations in the Twelvemile Creek watershed (Figures A-1 and A-2). At each of the Lake Hartwell locations, a transect was placed, in which five grab samples were collected and

composited into a single sample for analysis. The most current data available is from the 2003 monitoring event. Six stations in the Twelvemile Creek watershed, ten stations in Twelvemile Creek and Seneca River Arm, and five stations in Lake Hartwell were sampled in April and May 2003.

The sediment concentrations of PCBs are consistent with the general pattern of decreasing concentration throughout the lake with increasing distance from Twelvemile Creek Arm of Lake Hartwell. Total PCB concentrations in grab samples ranged from less than 0.06 ppm (the detection limit) in Wolf Creek and Town Creek tributaries to 5.51 ppm in the Twelvemile Creek Arm. PCB concentrations in 2003 were lower than previous years, with the maximum concentration being approximately 4.0 ppm lower than the 2002 maximum.

Other Sampling

Sediment sampling outside of the remedial process has been conducted. For example, Ickes et al. (2001) and Brenner et al. (2004) collected sediment cores from Twelvemile Creek and the upper arm of Lake Hartwell. PCB concentrations in surface sediment samples ranged from 0.39 mg/kg to 8.79 mg/kg in the top 10 cm.

PCBs in Fish

SCDHEC Sampling

In 1990, SCDHEC began a yearly fish study in Lake Hartwell. In the last sampling survey completed by SCDHEC in 1992, a total of 144 fish were sampled at the same six locations identified in the Biological Investigation (SV-107, SV-106, SV-532, SV-535, SV-642, and SV-641) (Figures A-1 and A-2). Fillets from largemouth bass, hybrid bass, and channel catfish were analyzed for PCBs (Gaymon 1992a).

SCDHEC also collected forage fish and walleye, as well as the three game fish (largemouth bass, hybrid bass and channel catfish) in Lake Hartwell in 1991. Eighteen walleye samples were collected from SV-642 and SV-288. Five fish composites of bluegill sunfish, threadfin shad, gizzard shad, and blueback herring were collected from SV-107, SV-532, and SV-641 (Gaymon 1992b).

The highest mean total PCB concentrations reported in largemouth bass and channel catfish were 5.14 and 7.10 ppm at SV-107. The maximum PCB concentration in hybrid bass was 3.48 ppm at SV-106. Walleye had mean total PCB concentrations of 4.14 and 3.48 ppm at SV-288 and SV-642, respectively. Forage fish concentrations were highest at Station SV-107, and were 12.43, 3.00, and 3.37 ppm in gizzard shad, threadfin shad, and bluegill, respectively.

Biological Investigation

A biological investigation was conducted by state and federal agencies as part of the RI/FS at Twelvemile Creek and Lake Hartwell (Corps 1994). Sample collection of fish began in the spring of 1992 in Twelvemile Creek, and spring of 1991 in Lake Hartwell. Twelve stations were sampled in Twelvemile Creek and three tributaries (Figure A-3). Each station was 0.3 to 0.5 miles in length. Six stations that were historically sampled in Lake Hartwell (SV-107, SV-106, SV-532, SV-535, SV-642, and SV-641) were chosen for fish collection. In the spring of 1991, 1992, and 1993, a total of 134, 144, and 144 fish, respectively, were collected in Lake Hartwell. Largemouth bass (*Micropterus salmoides*), hybrid bass (*Morone* sp.), and channel catfish (*Ictalurus punctatus*) were selected to represent sport fish and/or commercial fish, as well as fishes that occupy different habitats or have different seasonal migration behavior. Threadfin shad (*Dorosoma petenense*), gizzard shad (*Dorosoma cepedianum*), blueback herring (*Alosa aestivalis*), and bluegill (*Lepomis macrochirus*) were also collected at stations SV-107, SV-532, and SV-641 in 1991–1993 to represent forage fish (Corps 1994).

Ten redbreast sunfish (*Lepomis auritus*) and ten northern hog suckers (*Hpentelium nigricans*) were targeted for collection at each Twelvemile Creek station and at two reference sites (Reference Station 1 at Six and Twenty Mile Creek; Reference Station 2 at Milwee Creek; Figure A-3) in 1992. Redbreast sunfish were specifically targeted for collection because they are abundant in the assessment area and they are likely to be caught by anglers. Northern hog suckers were targeted because they are representative of bottom feeding species which would be expected to be maximally exposed to PCBs. At three stations, largemouth bass and bluegill were substituted for redbreast sunfish (Corps 1994).

Fish collected from Town Creek and Twelvemile Creek had the highest PCB concentrations. Mean total PCB concentrations in redbreast sunfish (<0.10 to 4.59 ppm), northern hog sucker (<0.10 to 12.50), bluegill sunfish (0.58 to 0.96 ppm) and largemouth bass (0.09 to 4.02 ppm) were highest at Stations 4, 5, 8, and 12. Mean total PCB concentrations in fish from Station SV-107 in 1990, 1991, and 1992 are as follows: largemouth bass (14.57, 10.75, 5.14 ppm), channel catfish (3.79, 5.27, 7.10 ppm); gizzard shad (NA, 12.43, 1.36 ppm), hybrid bass (NA, 5.94, NA ppm), and bluegill sunfish (NA, 3.37, NA ppm) (Corps 1994). PCB concentrations generally decreased downstream from station SV-107 (Corps 1994).

ROD Monitoring (ERM 2003)

In the 1994 ROD for the study site, it was determined that aquatic biota and sediment should be monitored on an annual basis at Stations SV-107, SV-106, SV-532, SV-535, SV-641, and SV-642. The ROD requires that a minimum of 10 largemouth bass, 10 hybrid bass and 4 channel catfish (representing game fish species) be collected every spring. At three stations (SV-107, SV-532, and SV-641) gizzard shad, blueback herring, threadfin shad, and bluegill (representing forage fish species) were collected. The most current data available is from the 2003 monitoring event. A total of 152 fish

samples (including largemouth bass, hybrid bass, channel catfish, bluegill, threadfin shad, and gizzard shad) were collected from 6 locations in Lake Hartwell. In general, sampling results for forage fish (bluegill, gizzard shad, and threadfin shad) showed decreasing PCB concentrations with increasing distance from the Twelvemile Creek Arm. The highest concentration of PCBs (3.97 mg/kg) in forage fish was found in gizzard shad in Twelvemile Creek. The maximum and minimum concentrations in bluegill were 1.29 and 0.0528 ppm (the detection limit). Concentrations ranged from 0.642 to 1.63 ppm in threadfin shad. Concentrations in hybrid bass (a predatory and mobile fish) did not show a consistent pattern, although all six stations exceeded the 2.0 ppm United States Food and Drug Administration tolerance value. The highest mean value of 7.90 ppm was detected in Twelvemile Creek and the lowest mean value of 2.21 ppm was detected at Station SV-535. In less mobile gamefish (largemouth bass and channel catfish), PCB concentrations also decreased with distance from the Twelvemile Creek Arm. Of the 24 catfish collected, none exceeded 2.00 ppm (from Twelvemile Creek); (ERM 2003).

Study of Natural Attenuation

Battelle conducted a study in 2002 to determine the natural mechanisms that contribute to the recovery of PCBs in sediment (Battelle 2002). The study focused on the burial of contaminated sediment with clean sediment, and the weathering of contaminants. For this study, eight cores were collected from three transects in Lake Hartwell that were historically established in the EPA Region 4 and Corps ongoing annual monitoring program. The cores were divided into 5 cm increments. In addition to the cores, twenty-one surface sediment samples were collected from Lake Hartwell including two surface sediment grab samples from each of the stations identified for *Corbicula* monitoring. Nine high-volume surface water samples were also collected close to the Sangamo-Weston plant (these results are described in the "Surface Water Chemistry" section above).

Total PCBs in the surface interval (0–10 cm) of cores ranged from 0.94 to 11.8 mg/kg. Total PCBs in surface grab samples ranged from below the detection limit, to 3.813 mg/kg. Surface sediment recovery rates were determined as a function of natural sedimentation rates. To determine how quickly sediment concentrations were approaching the 1.0 mg/kg cleanup goal, the concentrations were plotted against sediment depth for all eight cores. A logarithmic model was fit to the data, and a regression equation was calculated. The equation was used to determine the amount of natural sedimentation that would be required to achieve a net concentration of 1.0 mg/kg in surface sediment, taking into account natural mixing. Within the study area, Battelle (2002) found that a maximum of 5.8 cm of sediment accumulation would be required to achieve 1 mg/kg PCBs at the T-I-B transect location (farthest downstream from the facility). At transect T-L-A, which is located farther upstream from T-I-B, Battelle (2002) found that natural attenuation (burial with clean sediment) had already achieved the cleanup level goal of 1 mg/kg. Sedimentation rates were calculated to determine the mass of sediment deposited per year. Sedimentation rates for surface samples ranged from 0.595 g/cm^2-year at T-I-A to 3.36 g/cm^2-year at T-O-C (transect located farthest

upstream of the three transects). To achieve a total PCB concentration of 1 mg/kg at location T-I-B, sedimentation over 3 to 6 years was estimated to be needed. The time required for the sampled locations to reach a 0.4 mg/kg goal (sediment quality based on EPA's equilibrium partitioning approach) ranged from 3–5 years at T-O-A and T-L-B to 10–15 years at T-I-B. The time required to meet a 0.05 mg/kg ranged from a minimum of 2–5 years at transect T-O-C to a maximum of 21–25 years at T-I-B.

Corbicula

As part of the biological investigation in 1991, two clam baskets or cages, each containing approximately 40 "clean" *Corbicula fluminea* were placed in Town Creek downstream of the Sangamo-Weston plant, and in Twelvemile Creek at Lay Bridge, two sites at station SV-107 and one site at SV-641 in the Tugaloo River Arm for 28 days (Figure A-4). *Corbicula* tissue analysis was performed after 28 days of exposure to determine rates of PCB bioaccumulation and to determine whether the results indicated possible ongoing PCB sources (Corps 1994). After the 1994 ROD, *Corbicula* monitoring was continued on an annual basis, in conjunction with fish and sediment sampling.

Analyses of the *Corbicula* samples in 1991 indicated that PCBs bioaccumulated in the clams placed in Town Creek and Lake Hartwell. Total PCB concentrations ranged from 0.75 to 0.88 ppm in Town Creek and 0.45 to 0.57 ppm in Twelvemile Creek. Samples placed in the Twelvemile Creek Arm of Lake Hartwell had total PCB concentrations ranging from 0.48 to 0.56 ppm. However, *Corbicula* placed in the Tugaloo arm of Lake Harwell and the Hudson River (the source of the *Corbicula*) contained PCB concentrations below the detection limit (Corps 1994). The most recent *Corbicula* results are from the 2003 ROD monitoring sampling event. The maximum PCB concentration (12.6 ppm) in tissue was collected in Twelvemile Creek at Station C-3. Concentrations decreased to a minimum of 0.94 ppm at downstream location C-5. *Corbicula* collected from C-0, C-2 and C-4 were below the detection limit (0.05 ppm). Time series analysis of *Corbicula* data between 1995 to 2003 indicate that concentrations in recent years are lower than the 1995–1997 time period. Concentrations were mostly undetected in the background stations (upstream locations on Town, Wolf, and Twelvemile creeks) (ERM 2003).

Seston and Detritus

As part of the 1991 biological investigation, allochthonous material (such as detritus, fine sediment, dead insect parts, etc.) was collected by placing drift nets in Town Creek below the Sangamo-Weston plant and in Town Creek below Lay Bridge. The material was collected overnight and the samples were divided into fine and coarse particulate matter before PCB analysis. Seston (suspended organic matter) was collected in Lake Hartwell with a plankton net at a single station near Clemson, South Carolina.

Fine particulate detritus samples had total mean PCB concentrations ranging from 0.027 mg/kg (as Aroclor® 1254) in Twelvemile Creek to 0.066 mg/kg (as Aroclor® 1248)

in Town Creek. Mean total PCB concentration in coarse particulate matter collected from Town Creek was 0.51 mg/kg (as Aroclor® 1248). PCB analysis was not done on coarse samples from Twelvemile Creek. The mean total PCB concentration in seston from the Twelvemile Creek Arm of Lake Hartwell was 0.63 mg/kg as Aroclor® 1254.

Mayflies

Concurrently with the seston and detritus collection, adult mayflies (*Hexagenia sp*.) were collected on two consecutive nights in July 1991 (see Figure A-4 for sampling location). The mayflies were collected from the Twelve Mile Creek and Tugaloo Arms of Lake Hartwell using a white sheet hung approximately 4–5 ft above the ground and illuminated by a 15-watt lamp. The total mean PCB concentration of the mayfly sample collected from the Twelvemile Creek Arm of Lake Hartwell was 2.6 mg/kg.

Biological Effects Investigations

During the course of the natural resource damage assessment, the Trustees relied on existing information to determine the potential magnitude of injuries. For biological injuries, the Trustees relied primarily on a series of technical investigations conducted as part of the remedial investigation report (Corps 1994). This section describes the studies and provides summaries of results for studies of benthic macroinvertebrate communities, adverse effects on fish and fish communities, and potential injuries to piscivorous birds and mammals. Figure A-3 is a map of Lake Hartwell and the Twelvemile Creek drainage showing the locations of sampling stations for the various biological investigations.

Benthic Macroinvertebrates

Self and Vezertzis (1993) conducted a rapid bioassessment protocol (RBP) study at nine sites in the Twelvemile Creek watershed and one reference site in Six and Twenty Mile Creek. The RBP is an assessment of benthic communities at the family level and was conducted according to the protocol described by Plafkin et al. (1989), whereby each sampling location is scored according to eight metrics.

Eight of the nine sites in the Twelvemile Creek drainage were classified as moderately impaired. A single site immediately downstream of the Sangamo-Weston plant exhibited evidence of impairment as compared to the upstream reference area. However, other downstream sites and tributary sites showed a lower level of impairment.

Fish Health Assessment Index

Self (1993) conducted a fish health assessment index (HAI) study to assess potential impacts of PCBs on redbreast sunfish (*Lepomis auritus*) in Twelvemile Creek and largemouth bass (*Micropterus salmoides*) in Twelvemile Creek and Lake Hartwell.

HAI is based on measurements of various organs, tissues, and blood variables to identify fish health problems. Redbreast sunfish were collected from nine stations in Twelvemile Creek and largemouth bass were collected from three stations in the Twelvemile Creek drainage and six stations in Lake Hartwell (see Figure A-3). A high HAI score is indicative of potential impairments to fish health, whereas a low score suggests little or no adverse effect.

HAI scores for redbreast sunfish in Twelvemile Creek ranged from a low (39.3) at Station 12 in Town Creek and Station 2 in North Fork to highs of 62.7 in Wolf Creek (station 13) and 62.9 at the lower pool (Station 8). Scores from Town Creek both upstream (Station 11) and downstream (Station 12) of the Sangamo-Weston plant site were two of the lowest scores in the study area.

HAI scores for largemouth bass in the Twelvemile Creek drainage were relatively high, with the highest score (91.3) at Hagood Reservoir, a reference site. In Lake Hartwell, HAI scores for largemouth bass generally declined with distance from Twelvemile Creek. The HAI score for largemouth bass in Twelvemile Creek (SV-107) was significantly higher than scores for Eighteenmile Creek (SV-532), Andersonville Island (SV-535), Big Oaks (Hartwell Dam SV-642), and Tugaloo State Park (SV-641). Largemouth bass from Twelvemile Creek (SV-107) and Martin Creek (SV-106) had the highest occurrence of fatty liver condition, which can be associated with exposure to PCBs and other organic contaminants.

Index of Biotic Integrity

Gibson and Alexander (1993) reported the results of a fish community study (the index of biotic integrity, or IBI) in Twelvemile Creek. The IBI is determined from measurements of the following variables: species composition, trophic structure and abundance, and condition of individuals. IBI scores were used to assign impairment indexes that range from 1 (poor) to 5 (best).

Nine stations were sampled in the Twelvemile Creek drainage: two stations in Town Creek downstream of the Sangamo-Weston plant (Stations 12 and 5), one station upstream of the plant (Station 11), and the remaining stations on tributaries to Twelvemile Creek that are downstream of the offsite disposal areas. In addition, three reference locations were sampled (Six and Twenty Mile Creek, Milwee Creek, and Big Generostee Creek).

Both stations (11 and 12) in Town Creek, were assigned an IBI classification of "fair." Station 5, in Twelvemile Creek downstream of Town Creek was the only location to receive a score of "poor." Station 2 (North Fork) and Station 13 (Wolf Creek) both received scores of "good" and Stations 10 (Middle Fork), 4 (Twelvemile Creek), and 15 (Golden Creek) received scores of "fair." Station 14 (Rices Creek) received a score of "good." Reference stations 1 through 3 received scores of "fair," "poor," and "very poor," respectively. Stations classified as "fair" or "good" were most affected by metrics related to trophic composition. Stations classified as "poor" or "very poor" were affected

by trophic composition metrics as well as having fewer native species and lower catch rates.

Bioindicator Assessment

Greeley et al. (1994) reported the results of a bioindicator assessment of fish health and reproductive success in Lake Hartwell and Twelvemile Creek. The bioindicator assessment consisted of a wide range of analyses of physiological variables that may be associated with exposure to PCBs. The variables measured and tested included such things as blood and plasma chemical analysis, histopathological analysis on liver and spleen, and analyses to determine the presence of detoxification enzymes, hormone levels, and estrogenic activity.

Approximately 15 largemouth bass of each sex were collected from three study sites in Lake Hartwell: Twelvemile Creek (SV-107), Martin's Creek (SV-106), and Tugaloo Arm (SV-641). Approximately 15 redbreast sunfish of each sex were collected from Twelvemile Creek (fish from various locations were combined) and Milwee Creek.

The results of this study for largemouth bass indicated no clear evidence of adverse effects for almost all indicators of organ dysfunction, histopathology, nutritional condition, condition indices, gonadal-somatic indices, and circulating plasma estradiol levels at both SV-107 and SV-106 relative to the reference station (SV-641). In addition, fecundity of largemouth bass appeared to be relatively normal at all study sites. The results of this study for redbreast sunfish revealed moderate induction of detoxification enzymes in both Twelvemile Creek and Milwee Creek. Indicators of organ dysfunction in redbreast sunfish suggested that fish from the Milwee Creek reference site were showing more signs of environmental stress than fish from Twelvemile Creek. There was no clear evidence of adverse effects in Twelvemile Creek relative to the reference site for condition indices, histopathological indicators, or batch fecundity; however, fish from Twelvemile Creek had a lower nutritional status than those from Milwee Creek.

Growth and Survival of Largemouth Bass

Foltz and Mattison (1993) conducted a study of growth and survival of largemouth bass in Lake Hartwell. Largemouth bass were collected at six sites in Lake Hartwell (SV-107, SV-106, SV-532, SV-535, SV-641, and SV-642). Length/weight and length/age relationships were developed for each site and compared between sites, and annual mortality was estimated for each site. The authors reported that fish from SV-107 were less plump (i.e., lower weight per unit length) than at other stations and that annual mortality ranged from 45 percent to 59 percent, but there was no significant difference between stations.

Birds and Mammals

There are no site-specific data on PCB levels in birds or mammals from the Lake Hartwell/ Twelvemile Creek assessment area, or any site-specific studies of adverse effects to these resources. However, Bechtel (1994) conducted an ecological risk assessment wherein the authors estimated potential risk to birds and mammals from eating aquatic insects and fish containing PCBs. The approach largely involves use of food-web exposure modeling to compare PCB concentrations in fish consumed by piscivorous wildlife to literature-based effects levels. Bechtel (1994) used several conservative assumptions regarding exposure and toxicity and calculated hazard quotients for eastern phoebe (3.7), green heron (2), belted kingfisher (8.8), osprey (3.1), and otter/mink (87). Exposure calculations for the eastern phoebe, an insectivorous bird, were based on the single result for mayfly described above.

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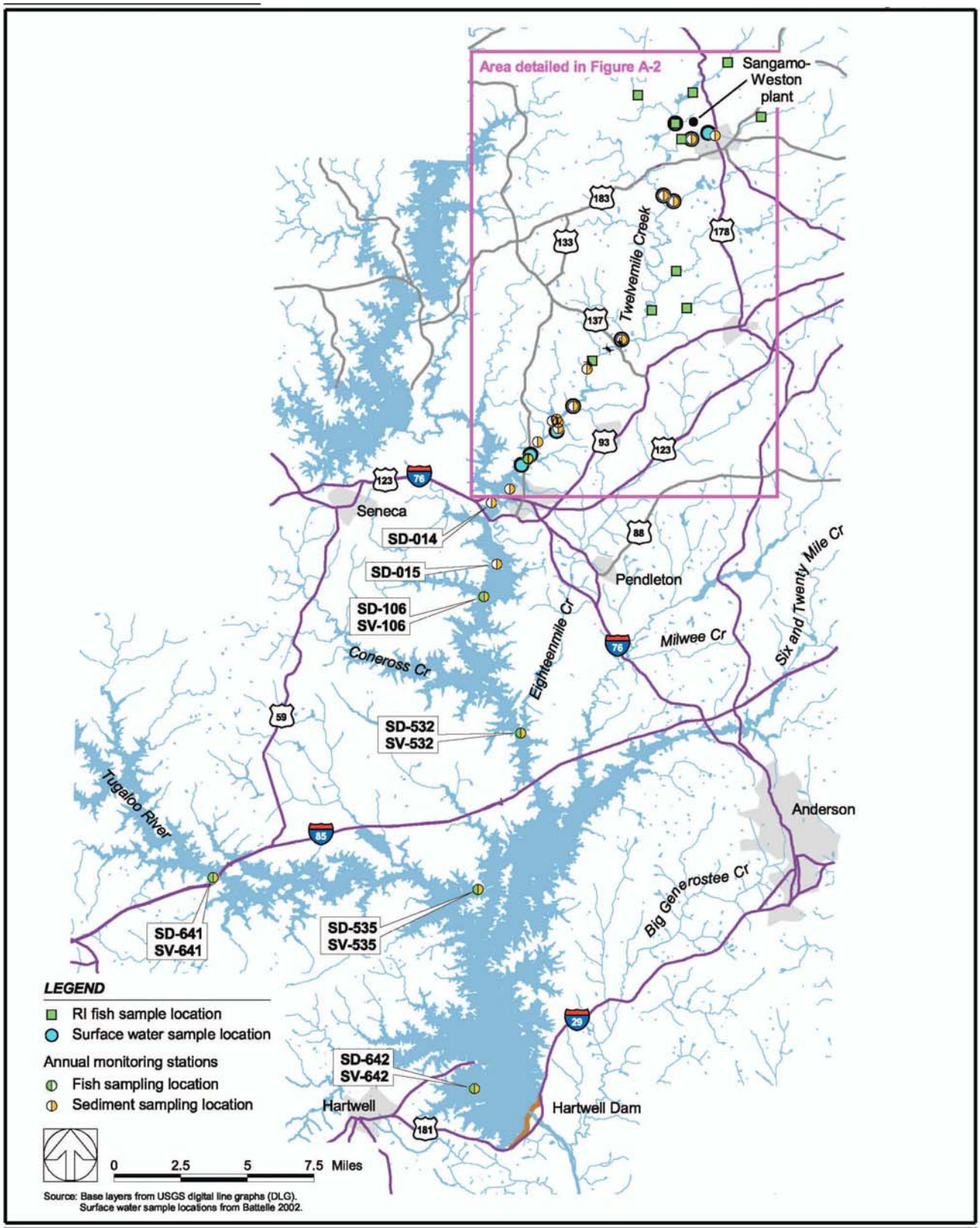

Figure A-1. Sampling station locations in Lake Hartwell

8600A8V.002 0301 | Jan 08, 2004 | complete view | Fig A1 Lake Hartwell layout | m:/lake_hartwell_sc/projects/post_remediation_0104.apr

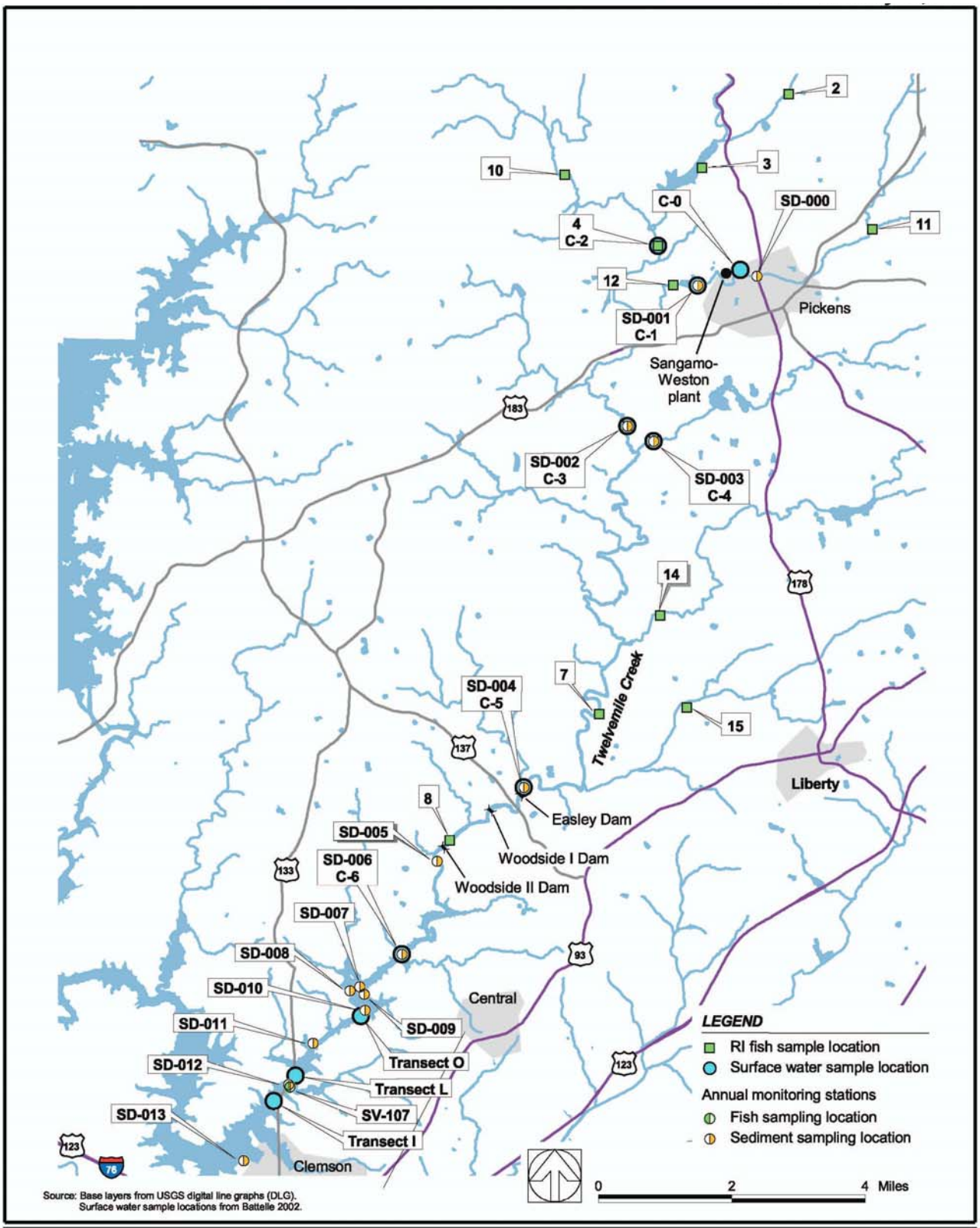

Figure A-2. Sampling station locations in Upper Lake Hartwell and Twelvemile Creek

8600A8V.002 0301 | Jan 08, 2004 | north view | Fig A2 Lake Hartwell - north layout | m:/lake_hartwell_sc/projects/post_remediation_0104.apr

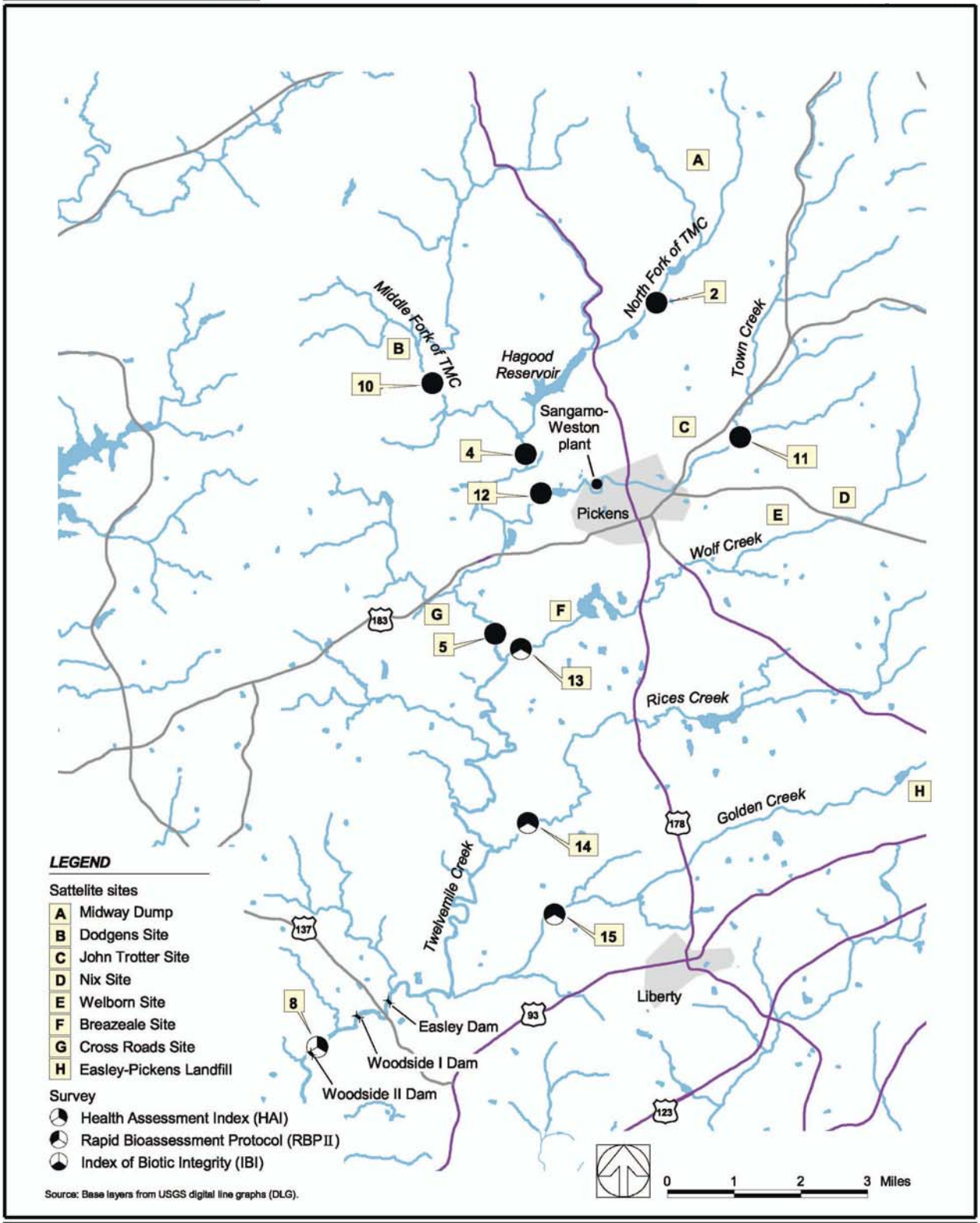

Figure A-3. Locations of sampling for studies in the RI biological investigation

8600A8V.002 0301 | Jan 08, 2004 | stations by study view | Fig A3 stations by study layout | m:/lake_hartwell_sc/projects/post_remediation_0104.apr

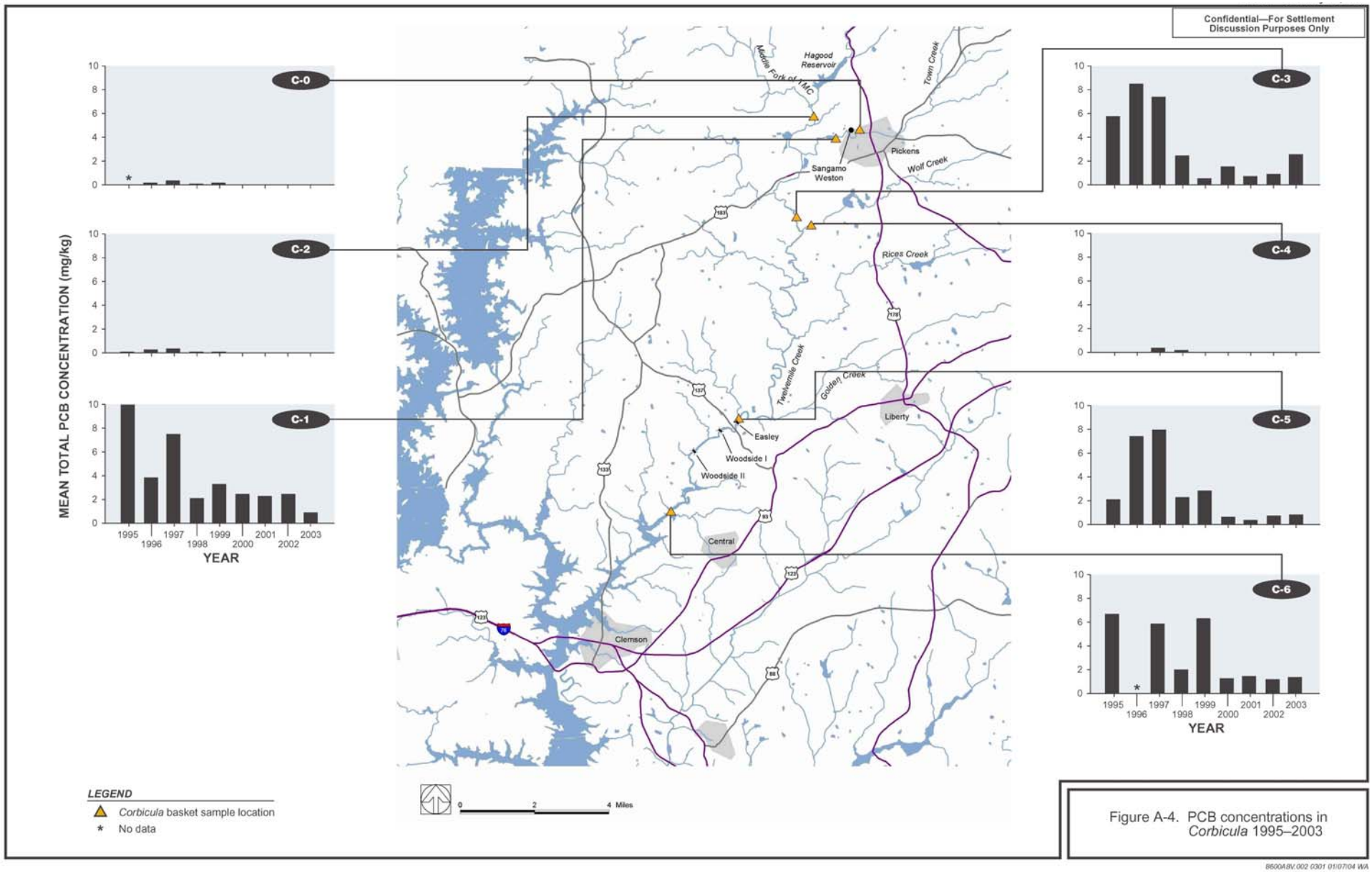

Figure A-4. PCB concentrations in *Corbicula* 1995–2003

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Appendix B

The Fishing Model for the Recreational Fishing Assessment

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The Fishing Model for the Recreational Fishing Assessment

In developing this restoration compensation determination plan, the Trustees relied, in part, on the results of a model designed to uncover the role health advisories and other fishing site attributes have on recreational angler behavior. The model used by the Trustees is based on a subset of data used in a recreational fishing model published by Jakus et al. (2000).

This section begins with a brief description of the site-choice random utility model, followed by a description of the data collection methods. The empirical results are then presented.

Standard Random Utility Site Choice Model

Random utility models (RUM) are recognized as an appropriate methodology for analyzing angler behavior and measuring recreational fishing damages [43 CFR 11.83 (c)(2)(iv)]. RUMs utilize data on angler site choices to determine how they trade off site quality attributes (e.g., catch rates, access conditions, presence of fish consumption advisories) with travel costs. The model can be used to calculate the change in utility (expressed in dollars) that an angler would experience given a change in the characteristics of a fishing site. In this case, the model is used to estimate the benefits of removing a consumption advisory from a reservoir similar in character to Lake Hartwell.

Data

Data were collected in the fall of 1994, 1995, 1996, and 1997 using a random digit dial telephone survey method. Ten thousand randomly drawn phone numbers were initially selected, with businesses, fax machines, disconnects, and those respondents with hearing/language problems considered ineligible. The effective response rates (completions divided by eligible numbers less "no contacts") were 46.7, 54.8, 43.4, and 37.2 percent for 1994, 1995, 1996, and 1997, respectively. Those who had indicated that they had been fishing in Tennessee between March 1 and August 31 of that year were then asked if they had fished in reservoirs. If so, reservoir anglers were asked which reservoirs were visited, how often, and the average daily catch rate at each.

Data were composed of anglers originating in the 35-county "East Tennessee" region established by Jakus et al. (1997, 1998a, 2000). After adjustments for trips that were clearly multipurpose (roughly, any travel distance greater than 150 miles), a pool of 540 reservoir anglers remained. These anglers averaged between 13 and 16 reservoir fishing trips during the six-month season, with the greatest number observed in 1994 (16.2 trips) and the lowest in 1997 (12.6 trips) (Jakus et al. 1998b, 1999). Four of the thirteen sites (Cherokee, Chickamauga, Norris, and Watts Bar) accounted for

approximately 57 percent of all angler trips. Distances to each reservoir were calculated from the zip code centroid to the dam site using ZIPFIP (a computer program designed by the United States Department of Agriculture's Economic Research Service).

For this model, travel cost is calculated using the individual's hourly wage rate (income divided by 2000 hours) as an estimate of the opportunity cost of time, and an average driving speed of 50 mph. In addition, operating costs are assumed to be $0.30 per mile. Catch rate was measured as actual catch rate reported by the angler if he or she visited the site, and the sample mean catch rate if the reservoir was not visited. The number of ramps, a measure of "site access," was determined from maps contained in the Tennessee and North Carolina gazetteers (DeLorme Publishing). Water level data were provided by the Tennessee Valley Authority. Water levels are measured as deviations from the water level experienced in 1996. Positive values for the variable indicate water elevations greater than those experienced in 1996; negative values indicate water elevations less than those experienced in 1996 (see Jakus et al. 2000).

Consumption advisory is an "indicator variable" taking a value of 1 if the reservoir has an advisory in place and zero if not. This approach to capturing advisory effects does not distinguish between advisories of different "extents" (i.e., different species, recommended consumption levels). Instead, *Consumption advisory* treats the presence of an advisory as indicative of the health of the fishery for consumption purposes.

Empirical Results

The site choice model is estimated using travel cost and other site-specific quality measures, including the presence of fish consumption advisories on a reservoir, as explanatory variables. This model is estimated to establish whether or not anglers adjust site selection in response to fish consumption advisories.

Table B-1 shows the multinomial logit (MNL) site-choice model. Of the thirteen reservoir choices in the East Tennessee region, six have fish consumption advisories. One of the reservoirs with an advisory is Watts Bar, a site with advisories covering eight different species. The estimated coefficients from the MNL site choice model all have the expected sign and are statistically significant. For example, the model indicates that anglers are less likely to choose a more distant site, more likely to choose a site with a boat ramp, and more likely to choose sites with higher catch rates. *Consumption advisory* is negative and significant, suggesting that, all else being equal, anglers are less likely to choose a site with an advisory than a site without an advisory.

Table B-1. Multinomial logit site choice model.

Variable	Beta	Asymptotic t-Ratio[a]
Travel cost	–0.041	–9.100
Number of boat ramps	0.028	6.738
Catch rate (fish per trip)	0.116	4.634
Consumption advisory	–0.343	–2.748
Deviation from 1996 average daily water level, August 1–August 31	0.069	1.959
Deviation from 1996 average daily water level, April 15–May 15	–0.056	–1.549

[a] Calculated using White's generalized covariance matrix.

Consumer Surplus Estimates

Given the negative relationship between fish consumption advisories and site choice decisions, economic benefits associated with a reservoir "clean up" can be estimated by simulating removal of the advisories from a reservoir within the site choice set. The MNL model yields a mean per trip consumer surplus measure. In "cleaning up" Watts Bar Lake such that the advisory could be removed, the mean per trip benefit across all anglers is $1.20, with a 95 percent confidence interval of $0.30–$1.95.

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Appendix C

Environmental Assessment for Implementing the Restoration and Compensation Determination Plan for the Sangamo/Weston Twelvemile Creek/Lake Hartwell Polychlorinated Biphenyls (PCB) Contamination Superfund Site in South Carolina and Georgia

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Environmental Assessment for Implementing the Draft Restoration and Compensation Determination Plan

for the

Sangamo Weston/Twelvemile Creek/Lake Hartwell Polychlorinated Biphenyls (PCB) Contamination Superfund Site in South Carolina and Georgia

Department of the Interior, U. S. Fish and Wildlife Service
Department of Defense, Army Corps of Engineers

December 2005

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LIST OF ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
Corps	Department of Defense, Army Corps of Engineers
Plan	Draft Restoration and Compensation Determination Plan
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
GADNR	Georgia Department of Natural Resources
NRCS	Natural Resources Conservation Service
NRDA	Natural Resources Damage Assessment
PCBs	Polychlorinated biphenyls
Pickens County S&WCD	Pickens County Soil and Water Conservation District
PRP	Potentially Responsible Party
STC	Schlumberger Technology Corporation
Service	U.S. Department of the Interior, Fish and Wildlife Service
SCDNR	South Carolina Department of Natural Resources
SCDEHC	South Carolina Department of Health and Environmental Control
USDA	United States Department of Agriculture
Federal Trustees	Corps and Service
State Trustees	GADNR, SCDEHC, and SCDNR
U.S.C.	United States Code

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1.0 INTRODUCTION

This National Environmental Policy Act (NEPA) document has been prepared jointly by the Department of the Interior, U. S. Fish and Wildlife Service (Service), and the Department of Defense, Army Corps of Engineers (Corps), to inform the interested public of the proposed implementation of a Restoration and Compensation Determination Plan (Plan) pursuant to 43 CFR § 1190. The proposed restoration actions in the plan are: (1) removal of the Woodside I and II dams, (2) stream corridor restoration in Twelvemile Creek and (3) enhancement of recreational fishing opportunities at and in the vicinity of Lake Hartwell. Our partners are the State of South Carolina, South Carolina Department of Natural Resources (SCDNR) and South Carolina Department of Health and Environmental Control (SCDHEC); the Georgia Department of Natural Resources (GADNR); and Schlumberger Technology Corporation (STC).

The Federal and State agencies (Federal and State Trustees, respectively, or, collectively, the Trustees) have collaborated with STC (Potentially Responsible Party, PRP) to identify and develop restoration strategies to compensate for natural resource injuries and losses arising from the release of PCBs in Twelvemile Creek and Lake Hartwell. The release was at and from the site known as the Sangamo Weston/Twelvemile Creek/Lake Hartwell PCB Contamination Superfund Site (Site) in the upper Savannah River drainage in South Carolina and Georgia. The PCBs entered the water column, bound to sediments, and concentrated in biota in Twelvemile Creek and downstream in Lake Hartwell, resulting in ecological injuries and recreational fishing losses. The collaboratively developed restoration measures are set forth in the Plan and will be institutionalized in a Consent Decree.

While the Plan has been developed in cooperation with the PRP, it is the Trustees' sole responsibility to ensure that implementation of the Plan adequately compensates for and restores natural resource injuries and losses. The injury determinations and selection of restoration projects are therefore those of the Trustees.

The Plan establishes that Sangamo-Weston, Inc. operated a capacitor plant from 1955 to 1987. The liabilities associated with that operation were subsequently assumed by STC. Dielectric fluids used in the manufacture of capacitors until 1977 contained PCBs, and materials containing these fluids were disposed via land burial. In addition, PCBs were present in discharges from the plant to Town Creek (a tributary of Twelvemile Creek). PCBs eventually migrated to and caused natural resource injuries and losses in Twelvemile Creek and Lake Hartwell. PCBs can cause adverse health impacts and changes in community composition and species abundance to herbivorous and piscivorous fish. There is some evidence suggesting that there may be risks to piscivorous and insectivorous birds from consumption of PCBs in their diet. PCB burdens in gamefish have caused the States to issue fish consumption advisories beginning in 1976; this has reduced the realized value of Lake Hartwell recreational fisheries. The State and Federal Trustees have determined that compensation for natural resource injuries and damages can most effectively be achieved by (1) removal of two dams, the Woodside I and Woodside II hydroelectric power dams, in Twelvemile Creek,

(2) stream corridor restoration in Twelvemile Creek, and (3) creation of new recreational fishing harvest opportunities.

Our development, support for, and implementation of the Plan encompasses three Federal actions that will compensate for and restore recreational fishing and ecological injuries and losses:

1. Implementation of $7 to $18 million in projects that create opportunities for public harvest of fish not subject to the current PCB-related fish consumption advisories or enhancement of fishing facilities within Lake Hartwell or the Lake Hartwell area (recreational fish enhancement),

2. Implementation of projects that improve the habitats within the Twelvemile Creek stream corridor (stream corridor restoration), and

3. Oversight, including review and approval of removal of the Woodside I and Woodside II hydroelectric power generating dams from Twelvemile Creek, and stream corridor restoration of the affected stream reach by STC.

2.0 DESCRIPTION, PURPOSE AND NEED FOR ACTION

This NEPA document, which is an appendix to the Plan, has been prepared to inform the public and interested organizations of the intent of the Trustees to implement the Plan, consider the possible consequences of implementing the Plan, and to provide the interested public and organizations an opportunity to provide comments on the Plan. Restoration strategies were identified and developed to compensate the public for the PCB-related natural resource injuries and losses at and in Twelvemile Creek and Lake Hartwell, in accordance with statutory and regulatory provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §§ 9601, *et seq*.). The Federal Trustees have decided that implementation of the Plan, as proposed, is appropriate.

Selection of the preferred restoration alternative was based on projects that (1) have negligible adverse direct, indirect, and cumulative impacts, (2) can be implemented in a reasonable time frame, (3) are generally acceptable to the Trustees, the PRP, stakeholders, and the public, (4) are protective of living trust and cultural resources, (5) are within reasonable proximity of the impacted area and ideally within the Savannah River watershed, (6) are scientifically sound and, if warranted, consistent with the principles of scientific integrity and adaptive management, (7) are consistent with all applicable state and federal laws, regulations, policies, and Executive Orders, and (8) have the lowest long-term operation and maintenance cost obligations for the Trustees.

3.0 AFFECTED ENVIRONMENT

3.1 Lake Hartwell

Lake Hartwell is an artificial impoundment in the Savannah River; it was constructed between 1955 and 1963. The distance from the dam to the upper limit of the Seneca River Arm (the eastern arm) is 45 miles; to the Tugaloo River Arm (the western arm) is 49 miles. Hartwell dam is located seven miles below the confluence of the Seneca and Tugaloo Rivers, which form the Savannah River. Lake Hartwell is bounded by Anderson, Oconee, and Pickens counties in South Carolina (to the east), and by Franklin, Hart, and Stephens counties in Georgia (to the west). Lake Hartwell is in the Piedmont Geographic Province, at the transition to the foothills. Lake Hartwell has a surface area of approximately 56,000 acres with 962 miles of shoreline and is managed to provide flood control, reliable and consistent flows for hydropower generation and navigation, and wildlife and recreational amenities.

3.2 Twelvemile Creek

Twelvemile Creek begins to be discernable some 40 miles upstream of the Lake Hartwell dam, in the Seneca River drainage, north by northeast of Clemson, South Carolina. It is located entirely in Pickens County, is about 24 miles long, drains a 106-square-mile watershed, and has about 1,240 feet of elevation change between the headwaters and Lake Hartwell.

The lower portion of the Twelvemile Creek drainage basin is characterized by relatively steep terrain resulting from deeply incised stream valleys that have dissected the original plateau surface (the Gorge). This gorge runs through steep bluffs with dense thickets of mountain laurel and rhododendron, which are somewhat atypical of the Piedmont region. For example, in these areas canopy species include white pine, a species typically found at higher elevations. The relief decreases south, in a downstream direction, until the creek widens to the Twelvemile Creek Arm of Lake Hartwell (Bechtel Environmental, Inc. 1994). Both Twelvemile Creek and the Twelvemile Creek Arm of Lake Hartwell have narrow channels, with steep, heavily vegetated shorelines. The surrounding area is predominately rural and undisturbed forest (Bechtel Environmental, Inc. 1994).

Three low head dams, located in the first 7.0 miles upstream of Lake Hartwell, impound short reaches of the creek near Cateechee, South Carolina. Descending downstream, these are the Easley-Central at a height of 15 feet (water supply), Woodside I at a height of 30 feet (hydropower), and Woodside II at a height of 40 feet (hydropower) dams. They are located about 4.0, 4.7, and 5.7 miles downstream of the Liberty Bridge highway crossing, respectively. The Lake Hartwell backwater is generally set at 1.5 miles downstream of the Woodside II dam, or 7.2 miles downstream of the Liberty Bridge highway crossing. The dams are situated 1.5 (Woodside II), 2.5 (Woodside I), and 3.2 (Easley-Central) miles upstream of the Lake Hartwell backwater. There are four bridges of interest downstream of the Woodside II dam: Lay (in

Twelvemile Creek), and Maw, Madden, and the Highway 133 crossing in the Lake Hartwell backwater.

The average annual sediment load of Twelvemile Creek is about 100,000 tons; composition is 70 percent sand, 10 percent silts, and 20 percent clays. The composition of the bed sediments at Liberty Bridge is about 92 percent sand and gravel, 5 percent silt, and 3% clay. While clays and silts may pass over the three dams in suspension, the larger particles are more likely to be held behind the dams. These three impoundments and the backwater portion of the creek are nearly filled with sediments. The accumulated sediments behind the two Woodside dams exceed 12 feet in depth; behind the Easley-Central Dam, accumulated sediments run about 7 feet deep. Estimated total volume of accumulated sediment behind the dams is 250,000 to 300,000 cubic yards. In parts of Twelvemile Creek that are less influenced by the dams, the depth of sediment to bedrock is generally two to three feet.

Historically, sediment behind the dams has been periodically flushed downstream via sluice gates. Flushing during high flows is preferable, to minimize negative impacts to downstream water quality and aquatic biota. The existing sluice gates at the Woodside I and II dams are older mechanisms that do not permit flushing during higher flows. Because of difficulty in controlling, monitoring, and opening and closing the gates at Woodside I and II, sediments must be released in a massive slug; the last flushing of Woodside II in 1993 resulted in a fish kill and downstream habitat degradation. Since 1998, sediments have been removed from Woodside I and II via dredging and pumping over the dams. Sediment accumulation below the dams, particularly Woodside II, has remained a problem. The gating mechanism at the Easley-Central Dam allows the gates to be opened and closed during high flows.

4.0 ALTERNATIVES

Several types of projects were considered as potential restoration alternatives for ecological injuries sustained as a result of contamination in Twelvemile Creek and Lake Hartwell. These alternatives included the following:

4.1 No Action Alternative

Under the No Action Alternative, the Trustees would take no direct action to restore injured natural resources or to compensate the public for lost services pending environmental recovery.

4.2 Dredging Alternative

Dredging activities would remove PCB-contaminated sediment in the assessment area and would reduce future exposure of natural resources to contamination. Dredging could involve sediment removal in Lake Hartwell itself as well as in lower Twelvemile Creek between the Easley Central Dam and Lake Hartwell, where sediments continue to

exceed the remedial goal of one mg/kg PCBs (Environmental Resources Management 2003).

While this primary restoration alternative would provide environmental benefits to Lake Hartwell and Twelvemile Creek, it would also constitute a significant disruption of the ecological community. Temporary, short-term physical habitat degradation for aquatic biota would occur as would the reintroduction of dissolved and particulate-phase PCBs into the water column. Another potentially significant impact of this alternative involves the disposal of a large volume of dredged sediments. Dredging was considered as a remedial alternative in 1994, but because of cost, technical feasibility uncertainty, and a lack of public support, it was rejected. Because these same issues exist today, the Trustees did not further consider the dredging alternative.

4.3 Preferred Restoration Alternative

The Preferred Restoration Alternative consists of three main elements; dam removal, stream corridor restoration (outside the Twelvemile Creek dam-removal-area), and compensatory restoration for recreational fishing.

4.3.1 Dam Removal Component

Dam removal activities would include the removal of the Woodside I and Woodside II dams by STC with Trustee oversight. The objective of dam removal is to establish a natural channel design and stream stability by balancing the processes of sediment aggradation (accumulation) and degradation (erosion). The conceptual design for dam removal first requires that the sediment that has accumulated behind the dams be removed; appropriate disposal of dredged sediments would be determined following PCB testing. Next, the dams would be deconstructed (i.e., taken apart in pieces) in a way that will minimize the likelihood of excessive downstream transport of sediment. Bottom-most sections of each dam would remain, allowing construction of a riverbed with an appropriate slope. Then, loose pieces of the dams would be used to create instream habitat structures as part of stream corridor restoration in the dam-removal area. These instream structures would include riffle areas, weirs, and deflector wings. Finally, stream corridor restoration would be completed through the planting of native vegetation, establishment of erosion and runoff controls, and streambank stabilization.

4.3.2 Stream Corridor Restoration Component (outside the Twelvemile Creek dam-removal area

Stream corridor restoration includes a broad range of actions and measures designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level. Restoration actions may range from passive approaches that involve removal or attenuation of chronic disturbance activities to active restoration that involves intervention and installation of measures to repair damages to the stream corridor.

A number of specific conservation/restoration needs have been identified for the Twelvemile Creek stream corridor (NRCS et al. 2002). These include riparian management practices (streambank stabilization, shoreline protection, bendway weirs, riparian buffer plantings, wetlands restoration, and riparian zone conservation easements), woodland management practices (reforestation, critical area seeding on access roads, waterbars/broad-based dips, and wildlife components), pastureland/hayland conservation management practices (cross-fencing, barrier fencing, alternative watering facilities, and heavy use areas); cropland management practices (permanent field borders/buffer strips, grass waterways, and conversion to permanent cover); and urban land management practices (drop structures for concentrated flows, stormwater detention, and vegetation components).

Specific stream corridor restoration projects to be funded with recovered STC natural resource damage monies would be developed by the Trustees in concert with the Pickens County Soil and Water Conservation District (Pickens County S&WCD) and the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) and would be consistent with the locally-developed *Twelvemile Creek Stream Corridor Restoration Plan* (NRCS et al. 2002). The measures implemented would be consistent with the concept of natural channel design and would be designed to enhance stream stability and restore dynamic equilibrium of sediment transport. Selected projects would follow the guidance contained in the interagency document *Stream Corridor Restoration Principles, Processes, and Practices* (USDA NRCS, 1998), which promotes the use of ecological processes (physical, chemical, and biological) and minimally intrusive solutions to restore self-sustaining stream corridor functions.

4.3.3 Recreational Fishing Restoration Component

This section describes the recreational fishing restoration component of the preferred restoration alternative. These components would provide offsite recreational fishing services, including fish harvest and fishing effort, to replace lost services on Lake Hartwell, or the enhancement or creation of public fishing facilities within Lake Hartwell. When funds are available for implementing these components, the State and Federal Trustees will consider approval of each specific project. If required, further NEPA compliance would be implemented at this time.

A wide variety of alternatives were explored to replace lost recreational fishing services; these alternatives can be grouped into three categories. The first category is Public Fishing Lakes, which includes new lake construction, purchase or lease of existing lakes, and construction of subimpoundments within the Lake Hartwell basin. The second category is the enhancement of Public Fishing Access, which includes constructing fishing jetties, fishing piers, and boat ramps, or creating access on privately owned river properties. The third category of potential projects is fish stocking, which refers to annually stocking selected fish species into targeted bodies of waters in the Lake Hartwell watershed.

4.3.3.1 Public Fishing Lakes---The scope of this alternative includes new lake construction, purchase or lease of existing lakes, and construction of subimpoundments within the Lake Hartwell basin. The GADNR and the SCDNR would identify suitable sites (generally less than 200 acres) for the construction of a new impoundment or existing impoundments that could potentially be leased or purchased for public fishing. Additionally, subimpoundments of Lake Hartwell are being considered for intensive management to increase harvest opportunities. Water control structures and exclusion devices may be used in the management of Lake Hartwell subimpoundments to prevent fish with elevated concentrations of PCBs from entering the managed subimpoundments from Lake Hartwell. Following lease, purchase, or construction, these impoundments would be part of the GADNR or SCDNR public fishing lakes programs.

All of these water bodies would be actively managed, which may include liming and fertilization, angler access enhancement (ramps, piers, trails, etc), population manipulation, and stocking. A bass/bream management scheme would be employed where possible. Channel catfish may also be stocked to supplement bass/bream harvest.

The criteria that would be used to evaluate potential sites for the lease, purchase, or construction of public fishing lakes include the following:

- Proximity to Lake Hartwell: sites in the Savannah River drainage are preferred;
- Ownership: sites held by Federal, State, county, or municipal governments are preferred over privately held sites;
- Acreage: larger water bodies are preferred in order to replace services with as few projects as possible;
- Accessibility: ponds that are readily accessible to the public are preferred; and
- Manageability: ponds that can be intensely managed are preferred.

4.3.3.2 Public Fishing Access---This alternative includes potential construction or enhancement of fishing jetties, fishing piers, and boat ramps within Lake Hartwell or creating access on privately owned river properties. Rock fishing jetties in the Lake Hartwell Tailrace may be constructed to provide improved access to a put-and-take trout fishery. In addition, instream habitat work would be completed to provide improved trout habitat and angling locations within casting distance of the jetties. The location of the rock jetties would be adjacent to existing recreation areas located downstream from the Hartwell Dam. The jetties would provide angling access to the Lake Hartwell Tailrace during both generation and non-generation periods. Access to this area is currently limited to non-generation periods only.

An additional consideration within this alternative is the creation of public fishing access along rivers. Locations in the Savannah Basin and other rivers throughout Georgia or South Carolina would be considered. Though additional public access of this type is needed throughout both States, the lack of similarity with the Lake Hartwell fishing experience and the distance away from the impact area makes this a low priority feature at this time. Thus, rock fishing jetties in the Lake Hartwell tailrace are most likely to be selected for implementation.

4.3.3.3 Fish Stocking---The fish stocking alternative would involve the annual stocking of selected fish species into targeted bodies of waters in the Lake Hartwell watershed. This alternative would provide increased harvest opportunities for Lake Hartwell area anglers who have been affected by the consumption advisories. The species most often stocked would be channel catfish, bream, bass, and trout. The fish would be stocked in small impoundments acquired or constructed as part of this compensatory restoration plan as well as existing small public impoundments in the Lake Hartwell area.

5.0 ENVIRONMENTAL CONSEQUENCES

Standard best management practices, including steam cleaning equipment before it comes in contact with the water column, briefing workers, silt fencing, coffer dams, complete removal of temporary fill, use of portable toilets, and other routine best management practices associated with project construction are common to all alternatives and will not be identified.

5.1 Environmental Consequences of the No Action Alternative

NEPA requires that the Trustees evaluate the No Action alternative, which is also an option that can be selected under CERCLA. Under this alternative, the Trustees would take no direct action to restore injured natural resources or to compensate the public for lost services pending environmental recovery.

Under this alternative, biota would continue to be exposed to PCBs in surficial sediments in the assessment area. Concentrations of PCBs (and any associated effects) in biota, including game fish, would continue to decline, but at a slower rate than under the preferred alternative. This in turn may prolong the period during which fish consumption advisories remain in effect, relative to the preferred alternative, and correspondingly limit the value of Lake Hartwell to recreational anglers. This in turn would limit the value of Lake Hartwell to recreational anglers and would maintain harmful economic effects associated with lost use.

Geophysical conditions associated with Twelvemile Creek and the two Woodside dams would continue unabated. The impoundments and backwaters would continue to fill, adding to the degradation of free-flowing stream habitat in Twelvemile Creek. The sediment transport and flow instabilities in the affected reaches would not be corrected,

and ongoing erosion, water quality degradations, and habitat degradation would continue unabated. The filling of the reservoirs with sediments would eventually eliminate the value of the dams for hydropower. Dam owners would be faced with the decision to either abandon the structures or dredge the impoundments. Dredging might extend the life of the hydropower facilities for another few decades, but would also require equipment and haul truck access, and the dredge spoil would require a permanent disposal site. In addition, routine dredging and removal of accumulated sediments from the watershed, in order to support hydroelectric power production, would interfere with the EPA-selected remedy. According to the Record of Decision for the site, "EPA's selected remedy shall include the development of a routine schedule for sluicing of all three impoundments" (EPA 1994).

The No Action alternative would not meet the Trustees' goals and objectives to restore natural resource injuries caused by the release of PCBs to Twelvemile Creek and Lake Hartwell, and to compensate the public for recreational fishing losses. The Trustees' responsibility to seek restoration for injured natural resources is clearly set forth in CERCLA. If we select the No Action alternative, we would not be receiving adequate compensation for the injured natural resources. Furthermore, the selected remedy is limited by the two Woodside and the Easley-Central dams that trap sediment and prevent it from moving downstream where it can bury contaminated sediment. Therefore, the No Action alternative was rejected because natural resource injuries would be sustained, natural recovery would continue at the current pace, and technically feasible and cost-effective alternatives exist to expedite recovery and to compensate for losses.

5.2 Environmental Consequences of the Preferred Restoration Alternative

The following sections describe the anticipated impacts of the various components of the Preferred Restoration Alternative, including dam removal, stream corridor restoration outside the dam removal area, and the recreational fishing restoration components.

5.2.1 Environmental Consequences of the Dam Removal Component

The dam removal component consists of removing excess sediment that has accumulated upstream of Woodside I and Woodside II dams; deconstructing the dams, and establishing a stable profile through the dam removal section that will maintain channel geometry while transporting water and sediment without aggrading or degrading (natural channel design); and placing bank and stream stabilization structures such as riparian plantings, bank grading, riffles, weirs, and deflector vanes in the stream reach from the base of the Easley-Central Dam to below the Woodside II Dam. Implementation of the dam removal alternative would result in balanced sediment dynamics through the target reach and enhanced transport of clean sediment downstream, where it will be deposited over sediment with elevated PCBs. The destabilizing influences of the dams and the sediments stored behind the dams and in unstable banks would be mitigated by the restored natural channel.

Some initial adverse effects to the Twelvemile Creek ecosystem may occur as a result of equipment and material access and construction pads with associated noise and dust; transport and storage of dam debris and spoil material in a landfill or other repository; and discharges of pollutants, including temporary fill, soils, oil, and concrete dust, into the water column. These effects will be of short duration and are outweighed by the long-term benefits.

Dam removal would help to speed up attainment of EPA's selected remedy for the site by re-establishing a natural pattern of downstream flow of "clean" sediment in Twelvemile Creek and into Lake Hartwell and allowing natural recovery of PCB-contaminated sediment in the Lake. The majority of ecological benefits that would accrue from dam removal would occur as a result of the restoration of a natural flow regime in a previously impounded system. The most immediate impact would be an alteration of the hydrologic regime in the impounded areas upstream of the dams from a slow-moving, lake-like system to a fast-flowing riverine system. As the flow changes, physical features of the areas both upstream and downstream of the former impoundments would change, restoring characteristics of non-impounded rivers. For example, dam removal would re-establish a more natural pattern of sediment movement and distribution in Twelvemile Creek . Areas where cobble and gravel were previously buried by deep sediment trapped behind the impoundments would become re-exposed as a result of dredging and ongoing flushing by moving water, thereby providing new habitat for re-colonization by aquatic insects or spawning by fishes that prefer hard bottom substrates. Downstream of the impoundments, scouring and channel incision would be reduced and deposition of sediment would promote re-establishment of habitats for aquatic insects and rooted aquatic vegetation. In conjunction with mobilization of sediment, dam removal can have a beneficial effect on nutrient movement. Studies on other rivers have shown that, depending on the nature of sediments trapped behind impoundments, these impoundments can act as sinks for nutrients (e.g., phosphorus and nitrogen) and can limit their migration downstream. Dam removal liberates these nutrient-rich sediments, increasing their availability to downstream ecological communities (American Rivers 2002).

Downstream sediment transport and deposition associated with dam removal and flow restoration may also lead to restoration of submerged and emergent rooted vegetation that would provide spawning habitat for fishes. Flow restoration would allow periodic inundation of floodplains, which could promote the development of small ephemeral ponds that offer attractive spawning habitat for amphibians and expansion of riparian habitat attractive to a variety of bird and mammal species (American Rivers 2002).

Effects on plant and animal communities can be dramatic when dams are removed from river systems, with many changes occurring as a result of changes in the physical properties of the river. For example, community composition can shift as slow-moving aquatic species adapted to lake-like conditions behind the impoundments are replaced by species adapted to faster-moving riverine habitats. Studies of dam removals in other locations have indicated that biodiversity and population densities of native aquatic

organisms increase when natural flows are restored (American Rivers 2002). Dam removal can also promote improvements in fish populations by removing obstructions that preclude passage of fish upstream.

In conjunction with dam removal, stream corridor restoration activities would be undertaken to create a stable, natural-looking channel in the dam removal reach. These activities may include constructing instream habitat structures, establishing erosion and run-off controls, and planting native vegetation. These activities would produce benefits to both the physical and biological components of the watershed. For example, planting native vegetation along the shoreline would enhance bank stabilization and reduce soil runoff from surrounding lands, subsequently minimizing nonpoint source nutrient inputs and reducing turbidity. Shoreline vegetation also provides additional shading to the creek, helping to regulate fluctuations in water temperature resulting from exposure to direct sunlight, and increases structural diversity, thus providing additional foraging and breeding habitat for riparian wildlife (USDA-NRCS 1998).

Components of stream corridor restoration are also likely to enhance abundance and diversity of aquatic communities. Pieces of the deconstructed dams would be used to create features such as riffles and pools, and root wads and downed trees may be used to increase structural diversity and stabilize stream banks. These activities would increase habitat diversity for benthic invertebrate and fish communities (USDA-NRCS 1998). Vegetation from streamside and instream plantings would provide both cover and structural components that would be attractive spawning habitat for some fish species.

Although most of the changes likely to occur to the Twelvemile Creek/Lake Hartwell system as a result of dam removal would be positive, some short-term negative impacts also may occur. First, although dredging is intended to remove the bulk of sediment trapped behind the dams, there would be some initial sediment flushing, which is expected to initially result in short-term increases in turbidity and overall decreases in water quality downstream of the removed dams. The released sediments may temporarily smother aquatic insects, riparian vegetation, and fish spawning habitats until dispersion and deposition of sediment becomes stabilized. The exact time span of such effects is dependent on the nature of the system in which dam removal is occurring but is expected to be of relatively short duration in Twelvemile Creek because of the responsiveness of the system. Depending on precipitation, initial flushing could be completed over a single wet season or several years. Engineering activities to be implemented during dam removal should limit these temporary negative impacts through appropriate timing of dam removal relative to river stage, by sediment removal prior to dam removal, and by gradually drawing down the impoundments to ensure that sediment is released in pulses as opposed to a single large flushing event. For example, it is anticipated that approximately 290,000 cubic yards of sediment may be removed from behind the dams prior to dam removal. Sediment removal would start early in the spring so that the dams could be removed in early fall when low flow conditions occur in Twelvemile Creek. Water levels in the reservoirs behind the dams would drop as downstream flow increases, exposing sediments that may be colonized by invasive exotic species, which would lower habitat diversity and structure and thus suitability for native

animal communities. Planned restoration of exposed river banks and replanting of native riparian vegetation would likely limit colonization by these species. A potential negative impact could be the downstream release of PCB-bearing sediment trapped behind the two dams. Pre-removal assessment of trapped sediment would be undertaken to ensure that dam removal does not result in a negative impact from additional loading of PCBs into Lake Hartwell.

5.2.2 Environmental Consequences of the Stream Corridor Restoration Component (Outside the Dam-Removal Area)

Stream corridor restoration projects, to be developed in cooperation with the Pickens County S&WCD and NRCS, would in some cases use buffers and vegetation to mitigate stressors on the system. These would have very localized effects, restoring aspects of Twelvemile Creek's historic storm hydrograph (with resultant changes in sediment dynamics), providing streambank stabilization, possibly returning the mixture of fine to coarse sediments to ecologically healthy levels, shading the stream (and cooling the water column during summer), contributing organic detritus and structure to the aquatic ecosystem, filtering pollutants from runoff, and re-establishing or protecting ecological integrity and structure of riparian soils and plant communities.

Use of biological methods for streambank protection may include using fallen trees for root wads and log cribs to hold the bank in place; these methods provide instream habitat improvement by adding instream structures. Limiting land use that degrades habitat through riparian zone conservation easements increases the quality of the land by providing increased fish and wildlife habitat, improving water quality by filtering and attenuating sediments and chemicals, reducing flooding, recharging groundwater, and protecting or restoring biological diversity and habitat continuity (USDA-NRCS 1998).

Stream corridor restoration measures would have synergistic effects on water quality and stream ecology. They would restore conditions favorable to native species and communities. These effects would be beneficial because the restored system would enhance the competitive advantage of specialist species relative to generalist species (Bednarek 2001).

Any stream corridor restoration project requiring the use of mechanical equipment and/or soil or sediment disturbance has the potential for local, short-term adverse impacts. These would include increased turbidity and sedimentation, dust, noise, and the potential for releases of oil products. Use of best management practices during construction would avoid or minimize any adverse impacts and ensure no significant adverse impacts.

5.2.3 Environmental Consequences of the Public Fishing Lakes Component

Only minor and temporary water quality impacts are expected to occur as a result of the implementation of most of the public fishing lakes component of the recreational fishing compensatory restoration plan. The lease or purchase of existing impoundments or the enhancement of Lake Hartwell subimpoundments for the public fishing lakes programs may result in temporary water quality impacts while new water control structures, walking trails, small boat ramps, or other bank fishing amenities are constructed. These impacts would include a temporary increase in turbidity until construction is completed.

The specific location, site characteristics, size, and scope for the potential construction of a new fishing lake have not yet been determined. This portion of the restoration plan has the greatest potential for water quality and other environmental impacts, Construction of a new lake, if undertaken, would require additional NEPA compliance to address specific environmental impacts. Further, construction might require permits under the Clean Water Act or the Rivers and Harbors Act, depending on specifics of the project.

All of the proposed public fishing lakes projects would enhance public recreation in the Lake Hartwell area. All of these proposed projects, with the exception of construction of a new fishing lake, would involve areas that have been previously disturbed (existing lakes and ponds and subimpoundments of Lake Hartwell). A cultural resource survey would be required prior to construction of a new fishing lake if ultimately undertaken by the Trustees.

Only minor impacts are expected to occur to any wildlife species as a result of the proposed projects. Construction activities would temporarily displace local wildlife, but the impacts would be minor and short-term. Fishery resources at the selected project sites would be enhanced through management activities and increased stocking. Additional Endangered Species Act coordination would be required if the Trustees propose to construct a new fishing lake.

There are no impacts expected to air quality during or following construction of these proposed projects. The proposed construction sites are not located in a nonattainment zone. With the potential exception of the construction of a new fishing lake, the recreational fishing project alternatives would have minimal or no wetland impacts. However, if Lake Hartwell subimpoundments are enhanced installation of new water control structures may require permits under the Clean Water Act or the Rivers and Harbors Act. Purchase, lease and management of existing lakes and ponds would not result in wetland impacts.

5.2.4 Environmental Consequences of the Public Fishing Access Component

The construction of fishing jetties, fishing piers, and boat ramps may result in temporary water quality impacts. These impacts would include a temporary increase in turbidity until construction is completed. Likewise, the construction of fishing jetties in the Lake Hartwell Tailrace would result in a temporary increase in turbidity during construction. Large rock, with very little loose sediment, would be used to construct the jetties and instream habitat structures and no long-term increase in turbidity should result.

Implementation of the various components within this alternative should have no impacts on air quality or cultural resources, little or no effect on wetlands, and all would enhance public recreation in the Lake Hartwell area. The Hartwell Tailrace jetties would provide new substrate for the colonization of macrophytes (Muotka et al. 2002). This would attract forage fish and, in turn, provide an attraction point for predator species. Also, the jetties and habitat structures are known to provide good ambush points for predator fish species to feed on forage fish. The slack water eddies behind such structures would provide a refuge and resting point for trout in a high velocity area such as the Hartwell Tailrace.

5.2.5 Environmental Consequences of the Fish Stocking Component

The enhancement of native species through increased stocking would not have any anticipated adverse impacts. Stocking would result in increased recreational fish harvest opportunities in the Lake Hartwell area.

5.3 Endangered Species

The Service has conducted an intra-Service Section 7(a) (2) consultation concurrent with the review of this EA. The proposed actions comply with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 - 1543). With the exception of the construction of new fishing lakes at as yet undecided locations, the projects as proposed are not likely to adversely affect federally listed, proposed, or candidate endangered and threatened species, or proposed or designated critical habitat.

However, obligations under Section 7 of the Act must be reconsidered if (1) new information reveals impacts of this identified action that may affect listed species or critical habitat in a manner not previously considered, (2) this action is subsequently modified in a manner which was not considered in this assessment, or (3) a new species is listed or critical habitat is determined that may be affected by the identified action.

5.4 Cultural Resources

Coordination of this NEPA document pursuant to Section 106 of the National Historic Preservation Act was conducted with both the Georgia State Historic Preservation Officer (GA SHPO) and the South Carolina State Historic Preservation Officer (SC SHPO) for their review. This coordination has resulted in the preparation of a draft Memorandum of

Agreement (MOA) for the mitigation of adverse effects related to the removal of Woodside I and II dams. This MOA, between the Corps, the Service, the SC SHPO, and STC, details the proposed mitigation activities that will be completed. The mitigation activities will include photographic recording and historic documentation of both dams prior to removal. The draft MOA has been coordinated with all parties with only minor comments and a Final MOA is currently being completed. The Advisory Council on Historic Preservation, Catawba Indian Nation and the Eastern Band of the Cherokee Indians have been offered the opportunity to provide comments on these proposed actions. The Advisory Council and the Catawba Nation had no objections or comments for the MOA, while the Eastern Band of the Cherokee did not respond to the consultation request.

5.5 Wetlands / Waters of the U.S

Many of the activities that are proposed for natural resource compensation would potentially require permitting pursuant to Sections 404 and 401 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. These activities include new fishing lake construction, fishing access construction, dredging, stream corridor restoration, etc. Appropriate permits would be obtained before any of these activities would be completed. In many cases, these permits would also include additional NEPA documentation and the opportunity for further public comment.

6.0 REGULATORY COMPLIANCE

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the various alternatives is achieved, in part, through the coordination of this document with appropriate agencies and the public. This section documents compliance with all applicable Federal statutes, executive orders, and policies.

1. National Environmental Policy Act of 1969
The proposed action complies with the NEPA of 1969, as amended (42 U.S.C. 4321, et seq. P.L. 91-190). The Service and Corps have prepared this draft EA to analyze Plan implementation and decision-making consistent with the requirements of NEPA.

2. Endangered Species Act of 1973
The proposed action complies with the ESA of 1973, as amended (16 U.S.C. 1531, et seq. P.L. 93-205). The Service has conducted an intra-Service section 7(a) (2) consultation concurrent with the review of this draft EA.

3. Clean Water Act of 1972
Some of the restoration and compensation plan components may require separate authorizations under sections 401, 402, and/or 404 of the CWA, as amended, Federal Water Pollution Control Act (33 U.S.C. 1251, et seq. P.L. 92-500). The requisite permits will be applied for and received prior to project implementation.

4. Clean Air Act of 1972
The proposed action complies with Section 309 of the Clean Air Act of 1972, as amended (42 U.S. C. 1857h-7, et seq. P. L. 91-604).

5. National Historic Preservation Act of 1966
The proposed action requires coordination with two State Historic Preservation Offices and approval from cultural resources officials representing both of the Federal Trustees under the National Historic Preservation Act, as amended (16 U.S.C. 470a, et seq. P.L. 89-655); the Archeological and Historic Preservation Act, as amended, and Executive Order 11593. The plan has been coordinated with both the Georgia State Historic Preservation Officer (GA SHPO) and the South Carolina State Historic Preservation Officer (SC SHPO). This coordination has resulted in the preparation of a draft Memorandum of Agreement (MOA) for the mitigation of adverse effects related to the removal of Woodside I and II dams. This MOA, between the Corps, the Service, the SC SHPO, and STC, details the proposed mitigation activities that will be completed.

6. Lands Act of 1953
The proposed action is in compliance with the State Sovereignty and Submerged Lands program and the Submerged Lands Act of 1953 (43 U.S.C. 1301, et seq.)

7. Rivers and Harbors Act of 1899
Specific implementation measures may require Section 10 permits under the Rivers and Harbors Act of 1899, as amended (33 U.S.C. 401, et seq.). If permits are required, they will be obtained at the specific project design and implementation phase

8. Information Quality Act
The Information Quality Act (P.L. 106-554, H. R. 5658, Section 515) requires Federal agencies to develop and implement guidelines “for ensuring and maximizing the quality, objectivity, utility and integrity of information (including statistical information) disseminated [or used] by Federal agencies" in decision making. The information in the draft EA, RCDP, and supporting documents comprise the best available scientific information. This draft EA complies with the Information Quality Act and the Fish and Wildlife Services’ Information Quality Act Guidelines.

9. Regulatory Flexibility Act, as amended
The Regulatory Flexibility Act of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (5 U.S.C. 601-612), requires Federal agencies to determine whether proposed actions may have a significant impact on substantial numbers of small businesses through an Initial Regulatory Flexibility Analysis. The power provided by the two dams is minimal and is sold to the power company grid. No small businesses will be affected.

10. Rivers and Harbors Improvement Act
The proposed action addresses the restoration of healthy rivers and fisheries; as such, it serves as indirect guidance to the Secretary of the Department of the Army for the planning and implementation of improvements to rivers, harbors, and waterways regarding prioritization and incorporation of "due regard for wildlife conservation" which he may prosecute (33 U.S.C. 540).

11. Ports and Waterways Safety Act
The proposed action addresses river restorations; as such, it serves as indirect guidance to the Secretary of the Department of the Army for prioritizing environmental, economic, and other factors during the planning and management of vessel operating requirements and aids to navigation, including waterways and channel maintenance, in navigable waters of the United States (33 U.S.C. 1223 and 1224).

12. Farmland Protection Policy Act
The proposed action will have no effect on prime agricultural land (16 U.S.C. 590)

13. E.O. *11990,* Protection of Wetlands
The proposed action is being developed in compliance with E.O. 11990.

14. E.O. *11988,* Flood Plain Management
The proposed action is being developed in compliance with E.O. 11988.

15. E.O. *12898,* Environmental Justice
There will be no effect to minority or low-income populations because the area is undeveloped.

16. E.O. 13045, Protection of Children
There will be no effect to children because the area is undeveloped.

17. E.O. 13186, Protection of Migratory Birds
The proposed action is being developed consistent with the Executive Order.

18. E.O. 13112, Invasive Species
The proposed action is being developed consistent with the Executive Order.

19. E.O. 12866, Regulatory Planning and Review
The proposed action is being developed to be consistent with this Executive Order.

7.0 LIST OF PREPARERS

Catherine D. Duncan, Environmental Contaminants Specialist, U. S. Fish and Wildlife Service, Charleston, SC

James A. Sykes, District Fisheries Biologist, U. S. Army Corps of Engineers, Elberton, GA

Kevin Moody, NEPA Coordinator, U. S. Fish and Wildlife Service, Atlanta, GA

8.0 REFERENCES

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Personal Communication, Joe Carroll, Restoration Systems, LLC, Greensboro, NC, and Will Harmon, Buck Engineering, Cary, NC, December 2, 2003.

USDA-NRCS. 1998. Stream Corridor Restoration: Principles, Processes and Practice. The Federal Interagency Stream Restoration Working Group. Various pagination.

Finding of No Significant Impact

Project Description. The Department of the Interior, U. S. Fish and Wildlife Service (Service), and the Department of Defense, Army Corps of Engineers (Corps) propose to restore and compensate for injuries to natural resources caused by the release of polychlorinated biphenyls (PCBs) into Twelvemile Creek and Lake Hartwell in the upper Savannah River drainage in South Carolina and Georgia. The proposed restoration actions are: (1) removal of the Woodside I and II dams, (2) stream corridor restoration in Twelvemile Creek and (3) enhancement of recreational fishing opportunities at and in the vicinity of Lake Hartwell. Our partners are the State of South Carolina, South Carolina Department of Natural Resources (SCDNR) and South Carolina Department of Health and Environmental Control (SCDHEC); the Georgia Department of Natural Resources (GADNR); and Schlumberger Industries, Inc. (Schlumberger).

The proposed restoration actions are more thoroughly described in the Lake Hartwell Restoration and Compensation Determination Plan to which this Environmental Assessment is an Appendix.

Coordination. The Department of the Interior, U. S. Fish and Wildlife Service and the Department of Defense, Army Corps of Engineers have coordinated this project with other Federal and State Resource Agencies and the interested public.

Environmental Impacts. The approval of this project is in compliance with all environmental laws.

Determination. I have determined that this action does not constitute a major Federal action significantly affecting the quality of the human environment. Therefore, the action does not require the preparation of a detailed statement under Section 102 (2) (c) of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.). My determination was made considering the following factors discussed in the Environmental Assessment to which this document is an Appendix.

a. The project would not adversely impact any threatened or endangered species potentially occurring in the project area.

b. No apparent unacceptable adverse cumulative or secondary impacts would result from project implementation.

c. All cultural resource issues would be addressed prior to implementing any of the proposed actions.

d. All potentially impacted wetlands and waters of the U.S. issues would be addressed prior to project construction.

e. The proposed project raised no Environmental Justice concerns.

Findings. Approval of the restoration and compensation alternatives as proposed by the Service and the Corps would result in no significant environmental impacts and is the alternative that represents sound engineering practices and meets environmental standards.

SAM D. HAMILTON
Regional Director, Southeast Region
U. S. Fish and Wildlife Service

LESTER S. DIXON P. E.
Director or Programs
South Atlantic Division
U. S. Army, Corps of Engineers

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Appendix D

Proceedings of the One Hundred Seventy-Eighth Meeting of the South Carolina Water Resources Commission

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PROCEEDINGS

OF THE

ONE HUNDRED SEVENTY-EIGHTH MEETING OF THE
SOUTH CAROLINA WATER RESOURCES COMMISSION

3830 Forest Drive
Columbia, South Carolina

FEBRUARY 20, 1985

Mr. Lillard commented that the proposal specifies that the WRC is concerned with the well drilling portion of the activity. It specifies also in the same paragraph or in the same page specifically what DHEC is concerned with, and that is the prevention of pollution. If this is spelled out, it might avoid a lot of objections that could be raised in the Legislature. It has advantages in being spelled out. It spells out symbolically that there is a positive attitude of cooperation between the WRC and DHEC and, secondly, it spells out positively what DHEC is going to be responsible for, and the WRC would like to hold them responsible for that.

Mr. Lillard continued that the amendments as they stand are perfectly satisfactory. What the Commission is trying to accomplish would not suffer either by leaving out or adopting what he suggested.

Mr. Floyd Williams asked if it should be put in the regulations. Mr. Shaw said he would like to see it in the statute, but if put in the regulations, he would not object. The regulations are not subject to being changed by the Legislature.

Mr. Vang said there are four things the Legislature can do with proposed regulations by an agency. They can be approved, disapproved, sent back for changes, or they can change them. A statute change at this time would be more difficult since the Commission already has several pieces of legislation before the General Assembly.

Mr. League stated that the staff is attempting to send a positive signal that the agency is cutting back on regulations of what is seen as a very beneficial activity. He indicated he thought it would receive a very favorable reception.

Mr. Gene Seifried made a motion that the Commission adopt the proposed amendment to Sections 48-43-10 and 48-43-30. The motion was seconded.

Mr. Floyd Williams made an amended motion that the language concerning DHEC's regulations of the wells in the statutes be added.

The amended motion was seconded and unanimously adopted.

The motion to adopt the proposed amendment to Sections 48-43-10 and 48-43-30 was unanimously adopted.

(Twelvemile Creek Eligibility Study
Steve Snyder)

Mr. Snyder reported that in June 1983, the Pickens County legislative delegation requested the Commission to determine the eligibility status of Twelvemile Creek in Pickens County for the State Scenic Rivers System. The field work was completed in the spring and summer of 1984 and the eligibility report (copy attached) was completed in the fall.

The staff recommends that Twelvemile Creek in Pickens County should not be eligible for the State Scenic Rivers System for the following reasons.

While the Scenic Rivers Act of 1974 does not establish specific guidelines dealing with water quality, the Act does state that a river qualifying for scenic river designation possess "relatively unpolluted waters." Such is not the case with Twelvemile Creek as the stream is contaminated by polychlorinated biphenyls (PCB's) to the extent that fish taken from the stream should not be consumed. As a Class B water body the stream is classified as unsuitable for primary contact recreation, such as swimming. In addition the stream has elevated fecal coliform levels during certain times of the year.

The recreational value of the river is limited. The Procedures for the Administration of the South Carolina Scenic Rivers Program state that the water quality of a river should meet, or have the potential to meet, minimum criteria for desired types of recreation. Fishing is impaired because of the PCB's and primary contact activities are not recommended. Canoeing and kayaking are popular along segments of Twelvemile Creek, although other streams in the area provide similar opportunities. Navigation is limited in the upper and lower stream segments due to fallen trees and dams, respectively. The fallen trees, however, are only a temporary impediment to navigation.

Twelvemile Creek is aesthetically pleasing along much of its length. However, with the possible exception of the rapids at Kelly's Mill, the river does not provide the viewer with an exceptionally scenic visual experience.

Widespread local support is essential in establishing a State Scenic River. There is some public interest in preserving Twelvemile Creek but the interest appears to be localized and has not been very vocal. Unlike other rivers under study, the Commission has received no unsolicited input from the general public and only light interest from the local public media.

In summary, a State Scenic River should possess significant unique and outstanding scenic, recreational, geologic, fish and wildlife, or historical or cultural values which should be protected and preserved for all South Carolinians as a natural heritage of statewide interest and value. Although Twelvemile Creek is a significant local and perhaps regional resource, the stream does not possess attributes of statewide significance.

Dr. Gamble indicated that he hoped that Mr. Snyder and the planning staff would continue to try to increase the learning curve for the citizens of the Twelvemile Creek area with support from groups such as Save Our Saluda.

A motion was made by Mr. Levan Wilson that the Commission adopt the recommendation of the staff on Twelvemile Creek. The motion was seconded by Mayor Picken and unanimously adopted.

INTRODUCTION

On June 7, 1983, the Pickens County Legislative Delegation requested that the South Carolina Water Resources Commission conduct an investigation to determine if Twelvemile Creek or a portion thereof was eligible for inclusion in the State Scenic Rivers Program. The purpose of this report is to provide basic background information concerning the conditions and uses of Twelvemile Creek and to present staff recommendations regarding the inclusion of Twelvemile Creek in the State Scenic Rivers Program.

MAJOR FINDINGS

1. Twelvemile Creek is a typical Upper Piedmont stream, flowing 27 miles from its headwaters to Lake Hartwell. Average flow is 197 cubic feet per second (cfs) and 7Q10 flow is 33 cfs.

2. The area surrounding Twelvemile Creek is rural in nature with the main land uses consisting of farming, cattle grazing, and forest management.

3. Due to the rural nature of the area, most segments of the stream are in a natural state and are aesthetically pleasing. Timber harvesting and cattle grazing impact the scenic quality in some areas, particularly upstream of County Road 273.

4. Flora and fauna along Twelvemile Creek are typical of the upper Piedmont region of South Carolina. No rare or unique plant or animal species are known to exist in the study area.

5. The overriding water quality issue concerning Twelvemile Creek is the presence of polychlorinated biphenyls (PCB's) in the stream's sediments. High levels of PCB's in fish tissue resulting from the discharge of PCB's to Town Creek have resulted in a ban on the consumption of fish taken from the stream. Wastewater effluent discharges into tributaries, particularly Town Creek, and sand and silt which are washed from fields and roads in the area also impact the stream's water quality. Twelvemile Creek has been classified as a Class B water body by the South Carolina Department of Health and Environmental Control since October 14, 1955. Class B waters are classified as suitable for secondary contact recreation only.

6. The primary recreational opportunity that Twelvemile Creek provides is small craft boating although navigation is limited due to three dams on the lower

segment and fallen trees in the upper reaches. Access is limited as well.

CONCLUSIONS AND RECOMMENDATIONS

After evaluating the qualities of Twelvemile Creek, the Commission staff recommends that the creek should not be declared eligible for scenic river status at this time for the following reasons.

While the Scenic Rivers Act of 1974 does not establish specific guidelines dealing with water quality, the Act does state that a river qualifying for scenic river designation possess "relatively unpolluted waters". Such is not the case with Twelvemile Creek as the stream is contaminated by PCB's to the extent that fish taken from the stream cannot be consumed. As a Class B water body the stream is not classified as suitable for primary contact recreation such as swimming. In addition the stream has elevated fecal coliform levels.

Recreational value is limited, much because of PCB contamination. The Procedures for the Administration of the South Carolina Scenic Rivers Program states that the water quality of a river should meet or have the potential to meet, minimum criteria for desired types of recreation. Class B waters are not considered suitable for swimming and other primary -contact activities. The recreational fishing value is impaired because the fish should not be consumed. Canoeing and kayaking are popular along segments of Twelvemile Creek, although other streams in the area provide a similar opportunity. Navigation is limited in the upper and lower stream segments because of fallen trees and dams, respectively. The fallen trees, however, are only a temporary impediment to navigation.

Twelvemile Creek is aesthetically pleasing along much of its length. However, with the possible exception of the rapids at Kelly's Mill, the river does not provide the viewer with an exceptional visual experience.

Owing to staff the limitations of the State Scenic Rivers Program, wide-spread local support is essential to establishing a State Scenic River. There is some public interest in preserving Twelvemile Creek but the interest appears to be localized and has not been very vocal. Unlike other rivers under study, the Commission has received no unsolicited input from the general public and only light interest from the local public media.

In summary, a state scenic river should possess significant unique and outstanding scenic, recreational, geologic, fish and wildlife, or historical or cultural values which should be protected and preserved for all South Carolinians as a natural heritage of state-wide interest and value. Although Twelvemile

Creek is a significant local and perhaps regional resource, the stream does not possess attributes of state-wide significance.

Appendix E

Response to Public Comments

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Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Ecological Injury	
The 1994 risk assessment is outdated and not defensible. A new risk assessment should be conducted and hazard quotients for birds and mammals should be calculated.	The 1994 risk assessment is only one of the many sources of information that the Trustees relied upon to assess injury and corresponding damages for this case. To evaluate the reasonableness of the proposed restoration plan, the Trustees reviewed multiple sources of available information pertaining to the nature and extent of PCB contamination and corresponding effects on ecological and human use services in Twelvemile Creek and Lake Hartwell (See References, Table 1, and Appendix A of this Plan). With respect to evaluation of lost ecological services, the Trustees determined that the combination of existing site-specific information and non-site-specific injury studies (e.g., peer-reviewed literature) was sufficient to estimate injury, and that the additional time and money that would be required to conduct additional primary research was unwarranted. In addition, as described in the DOI natural resource damage assessment regulations, the Trustees determined whether injury has occurred to site resources and their associated services (43 CFR 11.61). Risk assessment, while an important tool in the evaluation of potential contaminant effects on the environment, is not a component of these DOI regulations.
Little site-specific data are presented.	The Trustees have presented a summary of available site-specific data in Sections 2.3 and 3.2, and Appendix A of this Plan.
The literature cited is old and not pertinent; more recent peer-reviewed data on PCBs should be used.	Because this assessment begins in 1981, older data are pertinent and relevant, informing the Trustees of conditions (e.g., regarding ecology, toxicology, and contaminant levels) in the past. These past data also help the Trustees predict how conditions may change in the future. The Trustees have reviewed all available site-specific data, which are available through 2004. In addition, the Trustees have reviewed articles from the peer-reviewed literature (as mentioned below) published since January 2004 (See updated reference list in this Plan).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Additional site-specific data exist and should be included (e.g., EPA reports and articles from the peer-reviewed literature).	The EPA reports mentioned in this comment were included in the initial data review by the Trustees (e.g., EPA 2002). The additional references mentioned by the commenter are recently published articles from the peer-reviewed literature. Information from and citations for relevant documents have been added to this Plan (e.g., Section 3.2.2, Appendix A; See updated reference list in this Plan).
Injuries to Twelvemile Creek and Lake Hartwell have been underestimated.	The Trustees have reviewed all available information and feel that their assessment does not understate the nature and extent of injuries to natural resource services at this Site due to PCBs (See Sections 2.3 and 3.2 in this Plan, and the response to first comment).
Was *Corbicula* (an invasive) present prior to the bioaccumulation studies? Irresponsible to spread an invasive species.	Yes, *Corbicula* were present prior to the initiation of bioaccumulation studies (Self and Vezertzis 1993).
Twelvemile Creek should be its own sub-assessment area because that's where the highest injury is.	Ecological losses within Twelvemile Creek were reviewed independently. Data for Twelvemile Creek are distinguished in Sections 2.3 and 3.2 and Table 1 of this Plan.
The cost of the ecological injury is not provided, but should be to allow for comparison with cost of restoration to determine equivalency.	As described above, the Trustees have reviewed all available information relevant to the Site, and based on this information have determined that the best restoration package possible is the suite of restoration projects described in this Plan. "An interpretation of [CERCLA] more in keeping with the intent of, as well as the language employed by, Congress is one that requires the United States to assess the strengths and weaknesses of its case and drive the hardest bargain that it can." (See In Re Acushnet River & New Bedford Harbor: Proceedings Re Alleged PCB Pollutions, 712 F. Supp. 1019, 1036). In this case, the restoration of the stream corridor of Twelvemile Creek from the Easley Central Dam to Lake Hartwell is expected to provide ecological benefits sufficient to compensate for the ecological losses sustained by Twelvemile Creek and Lake Hartwell due to PCBs (See Sections 3.3 and 3.4 of this Plan). The cost of restoration is simply the cost required to establish this equivalency. Note that this is different from the evaluation of recreational fishing losses, which estimates a dollar value of lost services.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
The cost of settlement restoration projects should be the same as the magnitude/value of the injury minus the cost of the remedy.	Although overlap in activities is possible, remedy and restoration under CERCLA are two distinct processes conducted under separate regulations. Remedy is determined and implemented or overseen by EPA and state agencies, with the goal of achieving specific remedial, or clean-up, objectives. The remedial process is separate from the restoration process. Restoration is governed by the DOI natural resource damage regulations, under which the Trustees are responsible for restoring, replacing, or acquiring the equivalent of natural resources and their associated services that were lost due to exposure to a hazardous substance, in this case PCBs. Therefore, the cost of restoration is considered separate and apart from the cost of any remedial activities. See also the response to the previous comment regarding the Trustees' determination of sufficient restoration. For more detail regarding remedy and restoration, please refer to the U.S. Fish and Wildlife Natural Resource Damage Assessment and Restoration Program (http://www.fws.gov/contaminants/Issues/Restoration.cfm), and Natural Resource Damages Frequently Asked Questions (http://www.epa.gov/superfund/programs/nrd/faqs.htm).
Restoration for wildlife is not considered (i.e., terrestrial wildlife). Asserting that risk has declined since 1994 is inappropriate and indicates that the Trustees did not give further consideration to injury to wildlife.	Injury to wildlife is considered qualitatively in this RCDP (See Sections 3.2.3.6 and 3.4.1), and wildlife was considered in the evaluation of restoration alternatives. For example, restoration of Twelvemile Creek will benefit all components of the riverine ecosystem, including wildlife such as birds and mammals. Water quality and shoreline vegetation improvements, erosion reductions, and water temperature regulation will improve aquatic and shoreline habitats for resident and migratory species (e.g., improved feeding, breeding, and nesting habitat), as well as the biological communities that provide food for upper trophic level species (See Section 3.4.1). Although the rate of decline of injury is uncertain, information reviewed by the Trustees (e.g., annual sediment and fish monitoring data) indicates that PCB concentrations in sediment and fish were lower in 2003 than in 1993. Therefore, if contaminant concentrations have declined, the risk that a resource will experience that adverse effect has also declined (See Section 3.2.3.3).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
The Plan fails to include table of injury thresholds for birds and mammals.	The Trustees have evaluated injury to birds and mammals on a qualitative basis using site-specific information (See Section 3.2.3.6). As described in the response to the previous comment, proposed restoration alternatives are expected to compensate for injuries to birds and mammals (See Section 3.4.1). In addition, note that while compilation of an injury threshold table is possible using non-site-specific data, primary research would be required to provide comparative exposure data. With respect to evaluation of lost ecological services, the Trustees determined that the combination of existing site-specific information and non-site-specific injury studies (e.g., peer-reviewed literature) was sufficient to estimate injury, and that the additional time and money that would be required to conduct additional primary research was unwarranted.
Ecological risks were not accurately addressed (sport fisheries are not the only species at risk).	The Trustees have evaluated injury to fish based on the DOI natural resource damage assessment regulations (43 CFR 11.61(f)). Injury is a "measurable adverse change...in the chemical or physical quality or viability of a natural resource resulting directly or indirectly from...a release of a hazardous substance" (43 CFR 11.14 (v)). Data on PCB exposure and the adverse effects of PCBs for multiple fish species were reviewed, both sport (e.g., largemouth bass and channel catfish) and non-sport (e.g., sunfish, bluegill, and hogsuckers) species (See Sections 2.3.3 and 3.2.3.3-3.2.3.5). Injury to these species (i.e., loss of ecological services), is then extrapolated to all fish species within the aquatic habitats of Twelvemile Creek and Lake Hartwell.
Congener-specific PCB data are necessary to accurately evaluate injury.	For purposes of this RCDP, sufficient site-specific data exist to assess natural resource injury and evaluate corresponding restoration alternatives. Primary research would be required to obtain congener-specific data, and the Trustees have determined that the cost of completing such a study is greater than the benefit those additional data would provide. In addition, congener-specific data are not expected to significantly change the results of the injury assessment.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Ecological recovery will take longer than a decline in concentration for allowable fish consumption and ecological restoration should not be based solely on fish consumption advisories.	The Trustees agree that ecological recovery is not associated with fish consumption advisories. Ecological recovery is evaluated separately from the recovery of recreational fishing opportunities and is not related to the FDA action limits for fish consumption advisories.
Injury to fish in Twelvemile Creek is not declining at a measurable rate. Injury is not declining, and has not in the past decade.	For this natural resource damage assessment, the Trustees evaluated the effects of PCB on relevant resources. Injury to specific resources has been determined based on a site-specific toxicity data, and a comparison of those PCB concentrations with multiple endpoints. Site-specific data, such as annual sediment and fish monitoring, indicate that PCB concentrations are lower today than they were in the 1990s (ERM 1995-2003). The Trustees have considered this information in their assessment of lost ecological services.
The entire river corridor of Twelvemile Creek should be restored.	The Trustees agree with this restoration goal. For purposes of this assessment, however, restoration in Twelvemile Creek from the Easley Central Dam to Lake Hartwell is considered sufficient to compensate for losses in ecological services within the assessment area due to PCBs (See Section 3.3). In addition, parameters within Twelvemile Creek other than PCBs will need to be addressed before restoration of the remainder of Twelvemile Creek can occur. This additional restoration will be considered in other venues.
Prioritize restoration based on degree of contamination.	The Trustees are focusing ecological restoration activities in Twelvemile Creek, the area which historically and presently shows the highest concentrations of PCBs within the assessment area. (See Sections 3.3.5 and 3.4.1).
Projects of highest priority should be "primary restorations" that reduce the impact of PCB-contamination on the natural resources of Twelvemile Creek and Lake Hartwell.	The Trustees are considering primary restoration alternatives (e.g., dam removal). Within the framework of the natural resource damage assessment claim, feasibility limitations, and NRD regulations, the Trustees have designed a restoration program that is expected to reduce PCB contamination in Twelvemile Creek and Lake Hartwell.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Dam Removal	
All three dams on Twelvemile Creek should be removed.	The Trustees have reviewed all available information and have determined that removal of Woodside I and Woodside II, dredging sediment behind those dams, and initiating stream corridor restoration projects within that stretch of Twelvemile Creek is sufficient to compensate for natural resource injuries sustained due to PCBs. As noted above, the Trustees are expected to develop the best restoration package possible.
Will there be monitoring of PCBs in sediments behind the dams before/during dredging? Will there be appropriate handling/disposal of contaminated sediments?	Yes, PCBs in sediment will be monitored before dredging, and contaminated sediments will be appropriately handled and disposed of, as required by current state and Federal regulations and according to an approved plan (as referred to in Section 3.3.4 of this Plan).
Dam removal is primary restoration, not compensation for damages.	Dam removal in Twelvemile Creek provides both primary and compensatory restoration benefits. Primary restoration includes "actions undertaken to return an injured resource to its baseline conditions, as measured in terms of the injured resource's physical, chemical, or biological properties or the service it previously provided..." (43 CFR 11.14 (ll)), and is considered an acceptable form of compensation for natural resource injuries or service losses under CERCLA. Dam removal and associated activities (e.g., dredging contaminated sediment) will return Twelvemile Creek to its baseline condition (i.e., the condition that would have existed but for the contamination; See Section 3.4.1). Compensatory restoration includes "actions that would restore, rehabilitate, replace, and/or acquire the equivalent of the services provided by the injured natural resource that have been lost, and the period of time over which these services would continue to be lost" (43 CFR 11.82(b)(2)(i)). Dam removal also provides compensatory ecological services by improving the hydrology, stability, and ecology of Twelvemile Creek and returning that section of the Creek to its pre-dam condition (See Section 3.3.4 and 3.4.1).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Dam removal won't help because it will just release more PCBs into the river and the lake.	Sediment behind both Woodside I and Woodside II will be dredged prior to dam removal in order to avoid release of contaminated sediment downstream. In addition, the sediment load flowing downstream after the dams are removed will contain little or no PCBs. PCBs in sediment will be monitored before dredging, and contaminated sediments will be appropriately handled and disposed of, as required by current state and Federal regulations and according to an approved plan (as referred to in Section 3.3.4 of this Plan).
These dams are historical and should not be removed, especially since it won't reduce PCB contamination.	The Trustees agree that the dams are historical structures, and have completed a specific review of potential adverse historical impacts under the dam removal plan. This review indicated that adverse impacts may occur. However, these impacts will be mitigated based on a programmatic agreement between Federal Trustees and Schlumberger Technology Corporation, with concurrence from the South Carolina State Historic Preservation Officer. Dredging the sediment behind these dams and subsequent removal of these structures will reduce PCB contamination as described Section 3.3.4 of the RCDP.
The cost of regulating sediment was already agreed to by Schlumberger and therefore dam removal is already covered in Schlumberger's acceptance of the remedy.	Remedial requirements for this site are determined by EPA, and set forth in a Record of Decision (ROD). Schlumberger is required to comply with those remedial requirements outlined in the ROD, which do not include dredging or dam removal.
Leave the dams in place until the PCBs are cleaned up.	The Trustees are unaware of any significant continuing releases of PCBs to Twelvemile Creek, and contaminated sediments behind the dams will be dredged prior to dam removal. In addition, the sediment load flowing downstream after the dams are removed will contain little or no PCBs. This Site will be monitored during and after dredging.
The Easley Central dam should be removed because if it remains, slugs of sediment will be flushed downstream and will degrade the ecology of the river.	Easley Central will develop a more formalized sediment release process to address this. The goal is to have high flow releases, which will minimize downstream impacts.
Settlement should not be finalized until knowledge of PCB dynamics is incorporated into the compensation plan.	To reach this settlement, the Trustees have considered all available information, including information on PCB dynamics (e.g., EPA 2002).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Increased public access due to dam removal may increase littering or other adverse impacts from public use.	Any potential adverse impacts due to increased public use are expected to be minimal compared to the benefits gained through dam removal and stream corridor restoration.
The Easley Central dam should only be removed if an adequate alternative water supply is determined and/or developed to avoid disruption in service or decrease in water quality.	The Trustees agree, however this is outside the current scope of restoration activities and is therefore not addressed in this Plan.
Remedy	
The original plant site should be cleaned up and the release of PCBs stopped.	The following comments and questions pertain to remedial activities at the Site. The focus of natural resource damage assessments in general, and this request for comments in particular, however, is on the damages required as compensation for natural resource injuries (i.e., restoration). Remedial decisions and actions at this Site are conducted under EPA's authority (rather than the Trustees), and these comments have been directed to that agency.
The proposed remedy is not based on sound science or analysis.	See above.
The use of natural capping as a remedy should be re-evaluated because it appears unsuccessful.	See above.
EPA should provide the public with more information regarding the remedy, OU1, study of PCB dynamics, etc.	See above.
Have remedies for Lake Hartwell other than natural attenuation been considered (e.g., thermal blanket recovery)?	See above.
Cover the PCB contaminated material (cap it).	See above.
The "natural" recovery of sediments has required an "unnatural" technology as three small dams have served as sediment-traps preventing the natural flow of clean sediment into Lake Hartwell.	See above.
Why don’t we just get rid of all the PCBs?	See above.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Lake Hartwell should be cleaned up.	See above.
Will there be soil testing for PCBs on private property?	See above.
Source of contamination still needs to be addressed - groundwater is still contaminated, oily seeps, etc.	See above.
Deltas and sandbars that are contaminated are higher than the water line and therefore won't be covered by clean sediment.	See above.
Schlumberger should not be absolved of further remediation at the Sangamo Plant.	Liability for the cleanup of the plant site is fully covered by the 1992 Record of Decision (EPA remedial action plan), and is outside the purpose of this NRDA under CERCLA. However, note that Schlumberger will remain responsible for remediation to EPA and the State.
Human Use Damages/Restoration	
Largemouth and hybrid bass have not responded to lower sediment concentrations and are therefore expected to be contaminated for decades.	Although hybrid bass have not shown a measurable response to lower PCB concentrations in sediments, PCB concentrations in largemouth have declined. The Trustees agree that elevated levels of contamination will continue to be present for some time, and have incorporated these concerns into the evaluation of recreational fishing losses (See Sections 2.3.3, 3.2.3.4, and 4.2.1).
Dollars for lost fishing should be used for resource improvements in the Lake Hartwell area, not fishing opportunities off-site	Both types of restoration projects are being considered by the Trustees (See revisions to Section 4.3.4). Potential restoration activities include: (1) creation of opportunities for the public generally to harvest fish that are not subject to the fish consumption advisories currently in place for Lake Hartwell and Twelvemile Creek, (2) enhancement of the recreational fishery of Lake Hartwell, Twelvemile Creek, and the surrounding area, and/or (3) implementation of projects designed to improve the habitat and natural resources within the Twelvemile Creek corridor.
The Trustees' priority should be improving Lake Hartwell and associated fishing opportunities, not off-site locations.	See above.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
To enhance fishing opportunities why don't we create new hatcheries and an expanded stocking program?	This is evaluated as a restoration alternative (See Sections 4.3.3 and 4.3.4), but a new hatchery is not required for this type of restoration.
The Plan does not provide sufficient information regarding the fishing model.	The Trustees have provided information on the parameters evaluated for, steps involved in, and application of the model used in the analysis of recreational fishing losses (See Section 4.1.2). The Trustees have also provided additional detail on the site-choice random utility model, including data, variables, and empirical results in Appendix B. Finally, the Trustees have provided a list of references for additional information on this type of model in general and the model used for this assessment area specifically in a reference list on page B-3 of Appendix B.
Compensation is only for sport fisheries, when it should be for all species.	The evaluation of losses to recreational fishing only includes those fish species relevant to anglers (i.e., sport fish species). Ecological injury, as described above, is evaluated based on site-specific data for a variety of species and is then extrapolated to all fish species within the aquatic habitat of Lake Hartwell and Twelvemile Creek.
Please provide more information on the locations of sites for alternative lakes.	The Trustees are still in the process of evaluating specific locations for these alternative lakes. The criteria for evaluating each project proposal are described in Section 4.3.5 and include potential for increased angling opportunity, technical feasibility, and cost effectiveness. The Trustees will work with local governments and municipalities to identify potential sites, and plans for these sites will be made available to the public.
Where restoring fishing is not a feasible option, look at enhancing other natural resources.	The Trustees are evaluating alternatives to restore fishing opportunities to Lake Hartwell anglers both in and near the Lake. Losses to recreational fishing are compensated for by provision of additional recreational fishing opportunities (See Section 4.3.3). Enhancement of natural resources is typically compensation for injury to ecological services (e.g., stream corridor restoration).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
The damage is to fish population and fishermen; stream restoration does not improve either than ability to consume sport fish in Lake Hartwell, or the negative stigma associated with a polluted lake.	Damages due to recreational fishing losses will be compensated for by providing additional opportunities for angling (See Section 4.3.3). Stream corridor restoration is compensation for the ecological losses incurred by Twelvemile Creek and Lake Hartwell. These two types of losses (recreational fishing and ecological) and their corresponding restoration are considered independently.
Prioritize improving Lake Hartwell for the benefit of area residents and users, not anglers.	The Trustees believe that the restoration actions proposed in this Plan will benefit area residents and users of assessment area resources in addition to anglers. For example, dam removal and stream corridor restoration will provide a suite of ecological services from which all members of the public may benefit, such as acceleration of the remedy for Twelvemile Creek and Lake Hartwell and re-establishment of a natural flow regime and associated biodiversity in Twelvemile Creek (See Section 3.4.1).
The value of the recreational fishing loss is understated; request that Trustees re-evaluate the Injury Determination Model.	The Trustees have reviewed multiple methods for evaluating recreational fishing losses and have determined that this is the most appropriate model/method (See Section 4.2.1).
Public Participation	
The public/stakeholders should be included in discussions of restoration project determination and allocation of funds, and should have more overall involvement in this process.	The Trustees have adhered to the public participation process as described by the DOI natural resource damage assessment regulations (43 CFR Part 11), including holding public meetings and soliciting public comments on this Plan. The Trustees will continue to solicit public input as part of the restoration determination process.
The Trustees should hold another public meeting prior to finalization of the allocation of funds.	See above.
Allocation of Funds	
The proposed distribution of recovery funds, 1/3 to Georgia, 2/3 to South Carolina, is inappropriate because Twelvemile Creek is in South Carolina.	Allocation of funds is not a component of this Plan.
Concern that settlement funds will not be used for restoration in South Carolina and Georgia.	CERCLA requires that these funds be used for restoration of natural resource injuries and lost human use, and the Trustees are committed to applying these funds in South Carolina and Georgia (Section 3.3.2).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
Human Health	
How can it be safe to swim in Lake Hartwell if you can't eat the fish? What if you swallow some of the water?	PCB concentrations in surface water are below EPA's Maximum Contaminant Level drinking water criteria, and therefore swimming and accidental ingestion of water in Lake Hartwell do not pose a risk to human health. The Trustees' concern is that fish in Lake Hartwell, which accumulate PCBs from continued ingestion of contaminated prey, have concentrations of PCBs in their tissues greater than FDA tolerance levels. Human ingestion of fish with these levels of PCBs may cause adverse effects, and therefore SCDHEC has imposed a fish consumption advisory for Lake Hartwell.
Concern regarding the quality of drinking water and possible connection between PCBs in drinking water and poor health.	See above.
How are comments addressed (e.g. Do I need to retain a lawyer to get some investigation about this probable damage?)?	Concerns regarding private property damage or personal injury are not within the scope of this Plan or the Trustees' authority, and should be addressed privately.
Groundwater	
The draft Plan does not include groundwater injury.	In the early stages of this evaluation, the State of South Carolina determined that a claim for groundwater would not be pursued.
The settlement should not be finalized until OU1 damages have been addressed (e.g., groundwater).	With regards to OU1 damages, there is no significant, continuing source of PCB contamination. In forming this restoration plan, the Trustees considered all available information, including data that informed on potential future injury. However, note that in the early stages of this evaluation, the Trustees determined that a claim for injuries to resources in OU1 (including groundwater) would not be pursued (See response to above comment).
Whitewater Paddling	
Injury to recreational paddlers is equally as great as that of anglers and should be included in the discussion of damages (i.e., economic loss of missed paddling opportunities).	The human use focus of this Plan on recreational fishing is based on the existence of a fish consumption advisory and the large number of anglers that utilize the assessment area. In addition, restoration actions in Twelvemile Creek are expected to address any losses by providing benefits to paddlers (e.g., a restored stretch of Twelvemile Creek with more natural hydrology).

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
The draft Plan does not address damages due to the loss of Twelvemile Creek's eligibility for Scenic River Status.	Although the presence of PCBs in Twelvemile Creek was a factor in the decision not to list the Creek as a State Scenic River, other conditions, which would have been present irrespective of PCB levels, also precluded the granting of Scenic River Status. For example, Twelvemile Creek has elevated levels of fecal coliform during various months of the year; the recreational value of the river for paddling is limited due to limited navigation (e.g., dams and fallen trees); the Creek does not provide an exceptional visual experience; there was little interest from the general or local public; and the Creek was deemed not to possess attributes of state-wide significance. Documentation of the decision not to assign Twelvemile Creek Scenic River Status has been added to this Plan in Appendix D.
Improve Twelvemile Creek access (for paddlers); enhance whitewater paddling opportunities.	Restoration activities and improvements in Twelvemile Creek as described in this Plan (See Section s 3.3.4 and 3.4.1) are expected to provide benefits to paddlers (e.g., restoring the hydrology of Twelvemile Creek from the Easley Central dam to lake Hartwell).
Other	
There is no precedence for the actions proposed in this plan.	The Trustees' actions are consistent with the natural resource damage assessment process described in the DOI regulations (43 CFR Part 11), taking in to account site-specific injuries and restoration priorities.
Compared to other NRDAs the settlement amount should be greater.	The Trustees' goal in this process is restoration of natural resource services, getting the best restoration package possible based on available information. Each natural resource damage assessment site has different data, facts, challenges in proving injury and estimating damages, litigation costs and risks, and uncertainties. All of these components need to be taken into account when determining what is sufficient compensation for those injuries. In this case, the Trustees believe that the suite of restoration projects described in this Plan constitutes the best alternative and will provide the most benefit to the public within a reasonable time-frame.

Summary of Public Comments on the Draft Lake Hartwell Restoration, Compensation, and Determination Plan (February 2005)	
Comment	**Response**
More restoration options should be considered and restoration projects should be better prioritized.	The Trustees evaluated a wide range of restoration alternatives and have included the ones considered most appropriate (based on selection criteria, resource management priorities, and linkage to injury) in the Plan.
The importance of ecological health should outweigh recreational opportunities (such as whitewater paddling).	The Trustees considered injuries to both ecological and recreational services and developed a suite of restoration options that address each of these important resource service categories.
Do what is best for the people, wildlife, and environment instead of what is an ideal or advantageous economic situation.	All restoration services and monies received by the Trustees as compensation for natural resource damages will be spent on restoration of natural resource services, both ecological and human use, in or near the assessment area. Under the DOI natural resource damage assessment regulations, the Trustees are expected to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources to compensate for the loss of natural resources and their associated services (both ecological and human use). The Trustees have followed this mandate to provide the best restoration plan possible that compensates for natural resource service losses.
The Trustees should take advantage of expertise on the Clemson University staff.	If the Trustees determine that additional information or research is required, and that outside expertise is appropriate, they will review all available sources, including staff at Clemson University.
Positive and/or supportive comments.	The Trustees thank those commentors who have expressed support for this Plan.

References

ERM (1995-2003). Lake Hartwell fish and sediment study, Operable Unit 2 ROD monitoring program. Environmental Resources Management, Brentwood, TN.

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