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Oak Ridge Reservation Natural Resource Damage Assessment

Evaluation of Contaminant-Related Losses in Watts Bar Reservoir and Gains from the Black Oak Ridge Conservation Easement

Final Draft Report | 18 September 2008

prepared for:

Watts Bar Reservoir Trustee Council

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EXECUTIVE SUMMARY

In the early 1940s, the United States Department of Energy (DOE) constructed three facilities on the approximately 37,000-acre Oak Ridge Reservation in Oak Ridge, Tennessee: Oak Ridge National Laboratory, Oak Ridge Y-12 Plant, and East Tennessee Technology Park (area and facilities together comprise the Site). Activities at these facilities have resulted in the release of hazardous substances (e.g., polychlorinated biphenyls and mercury) and radioactive compounds, leading to the contamination of natural resources both at the Site and in the surrounding environment.

As part of a natural resource damage assessment for the Site, natural resource Trustees (State of Tennessee, the Tennessee Valley Authority, the United States Fish and Wildlife Service, and DOE) are investigating the impacts of Site-related contamination on natural resources in Watts Bar Reservoir (this includes Watts Bar Reservoir downstream of its confluence with the Clinch River to the Watts Bar Dam and the Tennessee River arm upstream to the Fort Loudoun Dam). Natural resource service losses due to the presence of toxic levels of contamination include the reduction of ecological services in aquatic habitats (e.g., reproductive impairment in fish), as well as a direct reduction of human use services (e.g., fishing). Using site-specific data, literature-based adverse effects thresholds, and habitat equivalency analysis (HEA), results indicate a range of approximately 148,000 to 181,500 present value acre-years of aquatic habitat services have been lost. In addition, potential commercial fishing losses are estimated at approximately $198,700, and an earlier analysis conducted for the Trustees by PriceWaterhouseCoopers LLP (2000) calculated recreational fishing losses of approximately $6.6-$10.0 million (2006$).

As compensation for natural resource damages sustained in Watts Bar Reservoir, DOE and the State of Tennessee, in agreement with the other natural resource Trustees, have established a conservation easement (Easement) on Black Oak Ridge. This analysis estimates both the ecological (e.g., conservation of habitat for threatened and endangered species) and human use (e.g., hiking) services expected to be provided by the Easement. Using site-specific data and HEA, and accounting for regional, state and Federal policy and regulations, results indicate that approximately 441,000 present value acre-years of ecological services will be provided as a result of this Easement. In addition, human use services provided by the Easement, estimated using bioeconomic models, State recreation information, and benefits transfer, are forecast to be approximately $6.6 million (2006$).

A comparison between the ecological and human use services lost due to Site-related contamination and the corresponding services provided by the Easement indicates that both the acre-years of ecological habitat services and the dollar value of human use services provided under the Easement are sufficient to compensate for damages to natural resources in Watts Bar Reservoir. This takes into account the uncertainty inherent in the analyses of both losses and gains (e.g., the level of ecological services provided by contaminated resources and protected upland resources, and the nature and extent of potential development that may occur if the Easement were not in place).

CHAPTER 1 | INTRODUCTION

The Oak Ridge Reservation (ORR), consisting of approximately 37,000 acres of Federally-owned land, is located in Oak Ridge, Tennessee on the Clinch River downstream of the Melton Hill Dam and near the confluence of the Clinch River and Poplar Creek. In the early 1940s, the United States Department of Energy (DOE) constructed three major facilities on the ORR. Operated for research, development, and processes in support of the Manhattan Project, these facilities include the Oak Ridge National Laboratory (ORNL), Oak Ridge Y-12 Plant, and East Tennessee Technology Park (ETTP; formerly Oak Ridge K-25 Site). The ORR and associated facilities comprise the Site. Activities at Site facilities have resulted in the discharge of hazardous substances (e.g., polychlorinated biphenyls [PCBs] and mercury) and radioactive compounds, leading to the contamination of natural resources both at the Site and in the surrounding environment, including adjacent waterbodies (EPA et al. 1992).

As part of a natural resource damage assessment (NRDA) for the Site, the natural resource Trustees (State of Tennessee, the Tennessee Valley Authority, the United States Fish and Wildlife Service, and DOE) are investigating the impacts of Site-related contamination on natural resources in Watts Bar Reservoir. Formed in 1939 by the construction of the Watts Bar Dam, the dam and resulting lake were designed to provide electric power, flood control, navigation, recreation, an adequate supply of water, and other related benefits. One of the south's largest lakes, Watts Bar Reservoir is surrounded by Tennessee counties Loudon, Roane, Rhea, and Meigs. Its two main tributaries are the Clinch and Tennessee Rivers. Covering approximately 39,000 acres at full pool, the Reservoir has 722 miles of shoreline and extends 72.4 miles from the Watts Bar Dam up to the Ft. Loudon Dam, with a maximum depth of approximately 70 feet (TVA 2008).

Natural resource service losses due to the presence of toxic levels of contamination include the reduction of ecological services in aquatic habitats (e.g., reproductive impairment in fish), and the reduction of human use services (e.g., fishing). Chapter 2 of this report determines and quantifies injury to ecological services in Watts Bar Reservoir as a result of the releases from the Site using readily available information and habitat equivalency analysis. Chapter 4 describes potential damages due to the recent commercial fishery closure on the Reservoir; losses in recreational fishing have been addressed in PWC (2000) as summarized in Chapter 6.

As compensation for natural resource damages sustained in Watts Bar Reservoir, DOE and the State of Tennessee, in agreement with the other natural resource Trustees, have established a conservation easement (Easement) on Black Oak Ridge (BOR). BOR is a forested upland ridge that runs southwest-northeast just west of the Site. Consisting of West BOR, East BOR, and McKinney Ridge, the area includes multiple upland habitat types and supports a variety of threatened and endangered species. Poplar Creek flows through the gap between West and East BOR, and wetlands exist along the southern edge of the BOR area. In addition to ecological services, BOR supports a suite of human use activities, including, but not limited to, trail use recreation, hunting, and cultural and groundwater resources.

Chapters 3 and 5 of this report define and quantify the ecological (e.g., conservation of habitat for threatened and endangered species) and human use services (e.g., hiking) expected to be provided under the Easement. These services are estimated by comparing the services provided under the Easement with a scenario in which the Easement does not exist. Specifically, Chapter 3 provides a calculation of the present value acre-years of ecological services forecast to be provided under the Easement by estimating the ecological services provided by various upland habitat types and applying habitat equivalency analysis. Chapter 5 estimates the present value of human use services that can be quantified under the Easement using bioeconomic models, state recreation estimates, and benefits transfer.

The final chapter of this report compares the ecological and human use services lost in Watts Bar Reservoir due to Site-related contamination with the corresponding services provided by the BOR conservation Easement.

CHAPTER 2 | ECOLOGICAL SERVICE LOSSES IN WATTS BAR LAKE

INTRODUCTION

Natural resources in Watts Bar Reservoir have been exposed to and adversely affected by contamination from the Site. To estimate the natural resource damages incurred due to this contamination, injuries to relevant resources are determined and quantified based on the United States Department of the Interior (DOI) regulations in the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA; 43 CFR Section 11). Therefore, this chapter defines the geographic and temporal scope of the analysis, describes the natural resources and contaminants of concern, discusses baseline conditions, determines injury based on definitions in CERCLA, and quantifies ecological injury based on a reduction in ecological services provided by representative resources within Watts Bar Reservoir. Habitat equivalency analysis (HEA) is applied to estimate the present value acre-years of ecological services lost due to Site-related contamination.

GEOGRAPHIC SCOPE

The geographic scope of this analysis includes Watts Bar Reservoir between its confluence with the Clinch River, the Fort Loudoun Dam, and the Watts Bar Dam. The aquatic habitat within this approximately 33,575-acre lake has been exposed to contamination from the Site (Exhibit 2-1). This area includes the Lower Watts Bar Reservoir Operable Unit (ORNL and JEG 1995), as well as the Tennessee River arm of Watts Bar Reservoir upstream to the first impassable barrier (i.e., the Ft. Loudoun Dam). This accounts for mobile resources (e.g., fish) and for the fact that contamination can be redistributed in an aquatic system (e.g., resuspension of contaminated sediments). The Clinch River, although it is contiguous habitat with the Reservoir, is not included here as it will be addressed in a separate assessment.

TEMPORAL SCOPE

Within Watts Bar Reservoir, natural resource exposure to contaminants of concern and corresponding injury has likely occurred since the 1940s, and is expected to continue into the future. Damages based on these injuries are calculated beginning in 1981 (in concordance with the promulgation of CERCLA) continuing at least through the reasonable expected recovery of each resource service. Because of uncertainty associated with predictions of future contaminant concentrations, future losses are estimated under two scenarios: complete recovery to baseline in 2106 (i.e., the timeframe of the analysis is 100 years from today), and no recovery through 2106 (i.e., conditions are constant today through 2106).[1] Although PCBs, mercury, and radionuclides all have relatively

[1] The recovery scenario reflects the condition of the resource. The timeframe of future predictions of the resource condition is 100 years from the present.

long residence times in natural systems and no remedial actions are currently planned, it is expected that some natural attenuation of the contamination will occur. This is supported by the documented decline of contaminants in the reservoir system (ORNL and JEG 1995). Therefore the timeframe for future injury is likely in between these two scenarios. Although it is possible that losses may occur farther into the future than 100 years, this timeframe is standard in damage assessment due to the uncertainty associated with predictions of contaminant behavior in a natural system and the effects of discounting.

NATURAL RESOURCES OF CONCERN

This analysis focuses on geologic (i.e., soil), and biological resources (i.e., fish, birds, and mammals) as described in the DOI NRDA regulations (43 CFR Section 11.14 (f,z)), within the geographic scope outlined above. Although other resources may also be impacted by contamination from the Site, exposure and effects data are not available for these other resources. Therefore, soil, fish, birds, and mammals will be used as proxies to together represent the overall aquatic habitat.

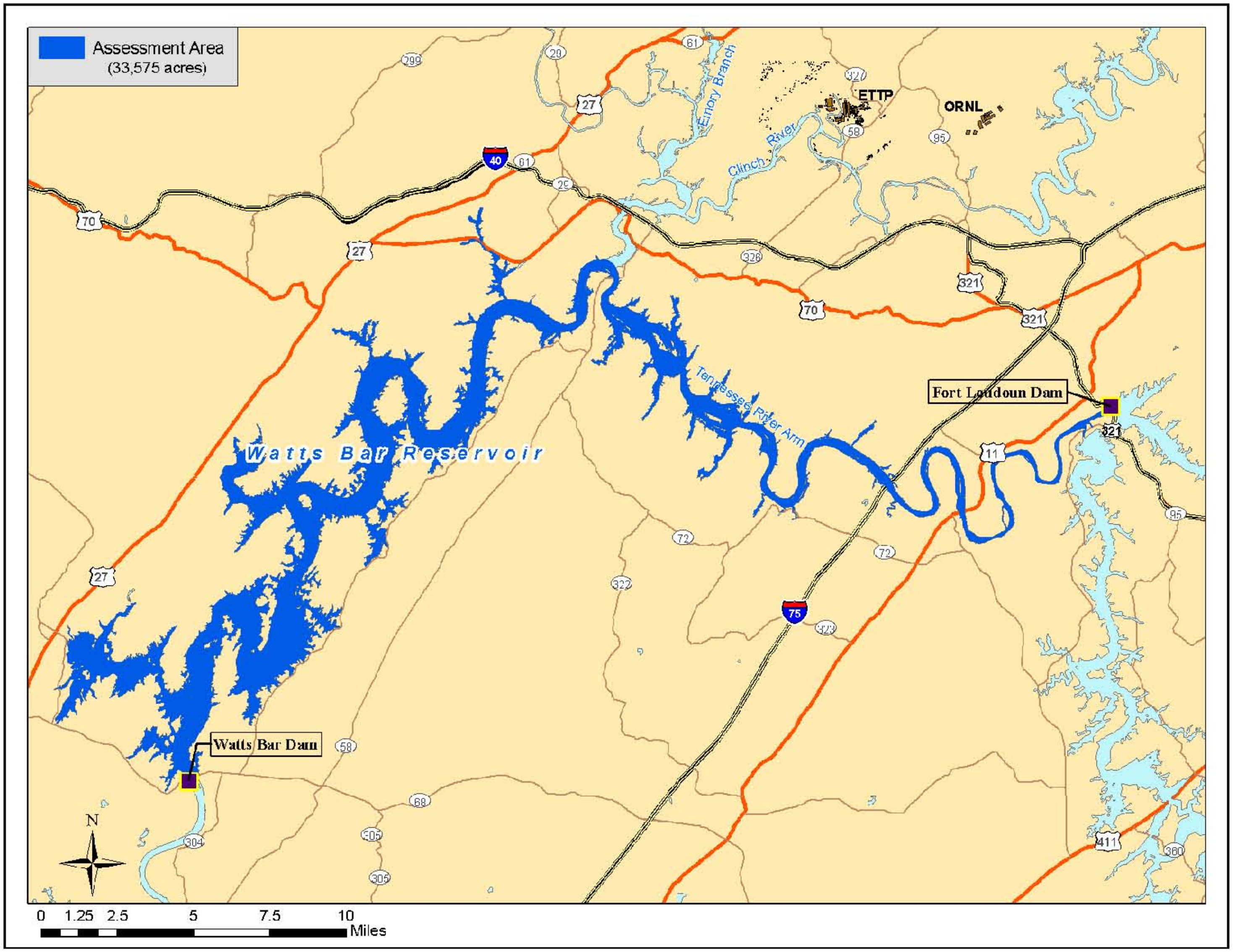
CONTAMINANTS OF CONCERN

The contaminants of concern in Watts Bar Reservoir are those hazardous substances (as defined by Section 101(14) of CERCLA) to which Trust resources have been exposed as a result of releases from the Site, and which may be above adverse effects criteria or thresholds. These contaminants include PCBs, mercury, and radionuclides (e.g., cesium-137 and uranium-235).

The toxicological implications of natural resource exposure to multiple contaminants is extremely complex. Interactions between various contaminants in abiotic media depend on environmental parameters such as organic carbon, pH, and alkalinity, and can vary over time and geographic area. In organisms, the toxicity of contaminant mixtures is affected by parameters such as species, life stage, and nutritional status. The contaminants of concern at this Site, however, all have differing modes of toxic action, and interact with natural resources in unique ways.

For example, PCBs are highly lipophilic, and in vertebrates tend to induce the cytochrome P-450-dependent monooxygenase system, causing effects such as birth defects, reproductive failure, liver damage, tumors, and death (Eisler 2000a). Mercury (both organic and inorganic forms) interferes with thiol metabolism, causing inhibition or inactivation of proteins and miotic disturbances, which can ultimately lead to embryocidal, cytochemical, and histopathological effects (Eisler 2000b). Radionuclides emit alpha, beta, and gamma rays, which can damage living cells and cause adverse effects on reproduction, development, histopathology, and genetic material, as well as increasing mortality (ATSDR 2004). Because of these differences in toxic activity, and because each contaminant can adversely affect biologically relevant endpoints (e.g., growth, reproduction, and mortality), this analysis assumes that the toxicity caused by PCBs, mercury, and radionuclides is additive.

EXHIBIT 2-1 MAP OF WATTS BAR RESERVOIR ASSESSMENT AREA



DETERMINATION OF ECOLOGICAL INJURY

Determination of injury for resources within Watts Bar Reservoir involves documentation that there is: 1) a viable pathway for the released substance 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. This section discusses the pathway of contaminants from the Site to natural resources in Watts Bar Reservoir, and determines injury to geologic and biological resources under the relevant regulations.

PATHWAY

Pathway is defined 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 (43 CFR Section 11.14 (dd)).*

As part of the Remedial Investigation/Feasibility Study (RI/FS) conducted by DOE in 1994, release of contaminants by facilities at the Site, including PCBs, mercury, and cesium-137, into local streams (e.g., Poplar Creek and Clinch River) that ultimately drain into Watts Bar Reservoir was documented (DOE 1994 as cited in PWC 2000). This information indicates a direct pathway of contaminants between the Site and natural resources within Watts Bar Reservoir.

GEOLOGICAL RESOURCES: SOIL

Under the DOI regulations, injury to soil is defined as a component of injury to geological resources, and has occurred when concentrations of a substance are sufficient to cause:

> *A toxic response to soil invertebrates (43 CFR Section 11.62 (e)(9));*
>
> *A phytotoxic response such as retardation of plant growth (43 CFR Section 11.62 (e)(10));*
>
> *Injury…to surface water, ground water, air, or biological resources when exposed to the substances (43 CFR Section 11.62 (e)(11)).*

Because site-specific toxicity data are not available, injury to Watts Bar Reservoir soils is determined by comparing PCB, mercury, and radionuclide concentrations to literature-based adverse effects thresholds. The contaminant concentrations used for comparison are averages across time and space, as no concentration trends in either dimension were evident (Appendix A). The literature-based thresholds indicate levels above which a toxic effect due to each of these contaminants is likely to occur. To develop appropriate thresholds for total PCBs and mercury in soil, literature describing soil contaminant levels and corresponding toxicity to exposed biota were reviewed. To evaluate injury due to radionuclides, existing benchmarks and screening levels were reviewed. Endpoints for all of the three contaminants of concern include physiological, reproductive, and lethal effects. A summary of injury determination is presented in Exhibit 2-2.

PCBs. Soils in Watts Bar Reservoir contain an average of 11.6 ppm total PCBs (OREIS 2005), and exceed adverse effects thresholds for soil invertebrates and small mammals (EPA 2003, 2001). These exceedences indicate that injury to soils in Watts Bar Reservoir due to PCBs has occurred.

Mercury. Soils in Watts Bar Reservoir contain an average of 1.9 ppm mercury (OREIS 2005), and exceed adverse effects thresholds for soil invertebrates and small mammals (Eisler 2000a, Efroymson et al. 1997, Abbasi and Soni 1983). These exceedences indicate that injury to soils in Watts Bar Reservoir due to mercury has occurred.

Radionuclides. Soil concentrations of over a dozen radionuclides (e.g., uranium-236, cesium-137; OREIS 2005) were divided by corresponding benchmarks and screening levels (SC&A 2005, DOE 1998), and the resulting quotients were summed. A sum greater than one indicates potential injury. All sums for radionuclides in assessment area soil were less than one, indicating no injury to soils due to radionuclides has occurred.

EXHIBIT 2-2 INJURY DETERMINATION FOR NATURAL RESOURCES IN WATTS BAR RESERVOIR

RESOURCE	CONTAMINANT		
	PCBS	MERCURY	RADIONUCLIDES
Soil	Yes	Yes	--
Fish	--	--	NA
Piscivorous Mammals	Yes	--	NA
Piscivorous Birds	Yes	--	NA

Notes:
-- = No injury
NA = Not assessed.
Piscivorous means fish-eating.

BIOLOGICAL RESOURCES

Under the DOI regulations, 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)).*

Injury to biological resources in Watts Bar Reservoir is determined for three representative resources, including fish, piscivorous (i.e., fish-eating) birds, and piscivorous mammals, due to exposure to PCBs and mercury.[2] Currently available data are insufficient to determine injury to biological resources due to radionuclides. A summary of injury determination is presented in Exhibit 2-2.

Fish

Injury to fish is determined by comparing total PCB and mercury (including methylmercury) concentrations in assessment area fish to literature-based adverse effects thresholds. The contaminant concentrations used for comparison are averages across time and space, as no concentration trends in either dimension were evident (Appendix A). The literature-based thresholds indicate levels above which a toxic effect due to each of these contaminants is likely to occur. To develop appropriate adverse effects thresholds, literature that recorded whole body levels of total PCBs or total mercury/methylmercury in fish and a corresponding adverse effect were reviewed. Endpoints include physiological, reproductive, and lethal effects.

PCBs. Fish in Watts Bar Reservoir contain an average of 1.22 ppm total PCBs (wet weight whole body; OREIS 2005). This is below the lowest threshold for adverse effects (1.6 ppm; Mac and Seeley 1981, Bengtsson 1980), indicating that no injury to Watts Bar Reservoir fish has occurred due to PCBs.

Mercury. Fish in Watts Bar Reservoir contain an average of 0.2 ppm mercury (wet weight whole body; OREIS 2005). This is below the lowest threshold for adverse effects (0.4 ppm; Matta et al. 2001, Fjeld et al. 1998, Friedmann et al. 1996, Boudou and Ribeyre 1985, Phillips and Buhler 1978, Weis and Weis 1978), indicating that no injury to Watts Bar Reservoir fish has occurred due to mercury.

Piscivorous Mammals

Injury to piscivorous (i.e., fish-eating) mammals is determined by comparing total PCBs and mercury (including methylmercury) concentrations in their diet to literature-based adverse effects thresholds. Watts Bar Reservoir provides habitat for multiple species of piscivorous mammals, including mink, otter, raccoon, and muskrat. To quantify injury to these mammals, mink was selected as the representative species for PCB exposure, and mink and otter were selected as representative species for mercury exposure because: 1) their diets are composed mainly of fish, and 2) a large body of toxicological information regarding the effects of PCBs on mink, and mercury on mink and otter, exists. For purposes of this analysis, the diet of piscivorous mammals is assumed to contain only fish from within Watts Bar Reservoir, as little contaminant concentration data on other food types are available.

PCBs. Adverse effects thresholds based on dietary intake of total PCBs range from less than 0.25 ppm to greater than 2.0 ppm and include physiological, reproductive, and lethal endpoints (e.g., Bursian et al. 2003, Halbrook et al. 1999, Restum et al. 1933, Hornshaw

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[2] Use of piscivorous birds and mammals as representative of higher trophic level organisms in this analysis does not preclude use of other representative species groups such as insectivorous birds and mammals in evaluations of injury due to Site releases in areas outside the geographic scope of this assessment.

et al. 1983, Aulerich and Ringer 1977). Comparison of the average PCB concentration in Watts Bar Reservoir fish (1.22 ppm) to these adverse effects thresholds indicates that injury to piscivorous mammals due to PCB exposure has occurred.

Mercury. Adverse effects thresholds based on dietary intake of mercury range from less than 0.34 pm to greater than 2.0 ppm and include physiological, reproductive, and lethal endpoints (Dansereau et al. 1999, Halbrook et al. 1997, Ropek and Neely 1993, Wren et al. 1987a, 1987b, Wren et al. 1986, Kucera 1983, Sheffy and St. Amant 1982, O'Connor and Nielsen 1981, Wobeser et al. 1976, Kirk 1971). Comparison of the average mercury concentration in Watts Bar Reservoir fish (0.2 ppm) to these adverse effects thresholds indicates that no injury to piscivorous mammals due to mercury has occurred.

Piscivorous Birds

Injury to piscivorous (i.e., fish-eating) birds is determined by comparing total mercury or methylmercury concentrations in their diet to literature-based adverse effects thresholds. Watts Bar Reservoir provides habitat for a variety of piscivorous bird species, including heron and osprey. Although the diet of many of these bird species includes biota other than fish, contaminant concentration data for benthic invertebrates, amphibians, or other prey items are not currently available. Therefore, this analysis assumes that their diet is comprised only of fish from within Watts Bar Reservoir.

PCBs. Adverse effects thresholds based on dietary intake of total PCBs range from less than 1.0 ppm to greater than 33.0 ppm and include physiological, reproductive, and lethal endpoints (Fernie et al. 2001a, 2001b; Tori and Peterle 1983). Comparison of the average PCB concentration in assessment area fish (1.22 ppm) to these adverse effects thresholds indicates that injury to piscivorous birds due to PCB exposure has occurred.

Mercury. Adverse effects thresholds based on dietary intake of mercury range from less than 0.4 pm to greater than 10.0 ppm and include physiological, reproductive, and lethal endpoints (Brant et al. 2002, Henny et al. 2002, BRI 2000, Bouton et al. 1999, Heinz and Hoffman 1998, Hoffman and Heinz 1998, Scheuhammer 1987, Barr 1986, Hill and Soares 1984, Heinz 1979, Heinz 1974, Stoewsand et al. 1974, Gardiner 1972, Koeman et al. 1971). Comparison of the average mercury concentration in assessment area fish (0.2 ppm) to these adverse effects thresholds indicates that no injury to piscivorous birds due to mercury exposure has occurred.

QUANTIFICATION OF ECOLOGICAL LOSSES

Watts Bar Reservoir provides a suite of aquatic habitat ecological services that encompass the suite of biological, chemical, and physical functions provided by a natural resource. Examples of ecological services provided by Watts Bar Reservoir include nutrient cycling, breeding and nursery habitat, and food web sustainability. Contaminants can adversely affect these services. This analysis estimates the quantity of ecological services lost in Watts Bar Reservoir due to releases from the Site, and thus provides a basis for scaling restoration (i.e., comparison of losses with ecological service gains). This section discusses baseline conditions, the assumptions and methodologies used to quantify injury to aquatic resources, and the uncertainties inherent in this analysis.

Following current convention in damage assessment and habitat equivalency analysis, ecological injuries in Watts Bar Reservoir are quantified based on service losses to representative resources in the aquatic ecosystem. A reduction in the ability of a resource to provide ecological services due to exposure to the contaminants of concern, as compared to the baseline level of services, is considered a service loss. Although injury is determined on a resource-specific basis, to avoid double-counting of injuries and to allow for consideration of injury at the habitat level, the quantity of injury is estimated on a habitat basis. These ecological service losses are quantified in terms of lost resource acre-years.

WHAT IS HABITAT EQUIVALENCY ANALYSIS?

The basic premise of habitat equivalency analysis is that the public can be compensated for past and expected future losses in ecological services through the provision of additional ecological services in the future (Unsworth and Bishop 1994). Compensable losses are "interim" losses – the loss in ecological services incurred from the time the resource is injured until the services provided by the injured resource return to their baseline level (defined below). Recovery to baseline for each resource service may be achieved through remediation, restoration, and/or natural recovery. Compensatory restoration actions for these interim lost services are *in addition* to those actions required to restore injured resources to baseline conditions (i.e., primary restoration), and need to provide a level of services equivalent to what was lost.

Within equivalency analyses, both service losses and gains are typically measured in terms of "unit-time" (e.g., acre-years), which incorporates both the geographic and temporal nature of the analysis. In this analysis, each acre-year represents the existence of one acre of a particular habitat for one year. The concept of an acre-year allows the analysis to consider not only the *number* of acres lost as a result of the contamination, but also the fact that these acres have not provided the baseline level of services *each year* for some period of time. For example, if an acre of aquatic habitat is injured (e.g., provides zero percent of baseline services due to contamination) in 1994, and remains injured until 2004, losses are accrued for the acre of injured habitat for each of the ten years of loss (e.g., ten acre-years, not accounting for the present value of these services). Use of the acre-year metric also allows losses to be scaled with gains in ecological services from restoration (i.e., the services provided by an acre of restored habitat over a period of time). For example, if one acre of fully-functional riparian habitat is expected to provide 100 percent of baseline services each year for the next ten years, it will provide ten acre-years (again, not accounting for the present value of these services).[3] Details regarding present value are presented in Appendix B.

[3] Assuming the habitat selected for restoration previously provided no ecological services (i.e., the *gain* in services is 100 percent).

BASELINE

In order to quantify ecological service losses, and therefore scale the ecological gains from restoration activities, the baseline conditions (i.e., physical, chemical, and biological conditions) of the affected resources and associated services must be established. Baseline is "*the condition or conditions that would have existed at the assessment area had the…release of the hazardous substance…not occurred*" (43 CFR Section 11.14 (e)). The baseline level of ecological services for Watts Bar Reservoir is assumed to be 100 percent of services. Note that the quality of these baseline services is not taken into account (e.g., if water quality is degraded due to factors other than contamination).

QUANTIFICATION APPROACH

Ecological service losses to aquatic habitat within Watts Bar Reservoir are quantified as the average percentage service loss for representative resources. Representative resources include soil, fish, piscivorous birds, and piscivorous mammals. In this analysis, these resources are considered representative of the entire ecosystem, and therefore service losses are attributed to the overall habitat. Although injury may have occurred to other biota associated with the aquatic ecosystem within Watts Bar Reservoir (e.g., amphibians), insufficient data are currently available to quantify these losses. However, to the extent that ecological service flows affect ecosystem health, injuries to these other species groups are qualitatively incorporated. In addition, it is expected that restoration projects implemented to compensate for damages to the aquatic system will benefit all species groups associated with that habitat.

Because site-specific toxicity data are not available, injury to each representative component of the aquatic ecosystem within Watts Bar Reservoir – soil, fish, piscivorous birds, and piscivorous mammals - is quantified by comparing adverse effects data with site-specific contaminant concentration data and estimating the quantity of ecological services lost. Therefore, for PCBs and mercury, relevant data from the peer-reviewed literature was reviewed and applied. Radionuclide concentrations are insufficient to cause injury and therefore no ecological services have been lost due to exposure to this group of contaminants.

Injury due to PCBs and mercury within Watts Bar Reservoir is quantified using the following steps:

- Calculate the average contaminant concentration in each representative resource of concern.
- Review literature-based toxicity information and assign service losses to contaminant concentration ranges.
- Compare site-specific concentration data to literature-based adverse effects data to estimate the percentage ecological service loss for each resource.
- Average the percentage service loss for all representative resources to estimate losses to aquatic habitat.
- Estimate combined percentage service loss for PCBs and mercury for aquatic habitat.

- ❖ Extrapolate past and future service losses from 1981 through 2106 under two scenarios: full recovery to baseline and no recovery.

Soil

Soil is an essential resource within the aquatic system. Among other functions, soil provides habitat for micro- and macroinvertebrates, substrate for vegetation, and material for animal dens and nests. Soil is essential in nutrient and mineral cycling, and represents an important pathway for contaminants to biological resources, including plants, insects, birds, and mammals.

Injury to soil within Watts Bar Reservoir is quantified by comparing site-specific PCB and mercury concentrations in soil to literature-based adverse effects ranges and corresponding percentage service losses. Threshold ranges and service losses were developed based on a weight-of-evidence of the type, frequency, and severity of effect.

PCBs. As described above, the average total PCB concentration in soil is 11.6 ppm (OREIS 2005). This corresponds to a 20 percent loss in ecological services (Exhibit 2-3).

Mercury. As described above, the average mercury concentration in soil is 1.9 ppm (OREIS 2005). This corresponds to a 25 percent loss in ecological services (Exhibit 2-4).

EXHIBIT 2-3 ADVERSE EFFECTS THRESHOLDS AND PERCENTAGE SERVICE LOSS FOR PCB-CONTAMINATED SOIL

TOTAL PCB CONCENTRATION IN SOIL (PPM DW)	PERCENTAGE SERVICE LOSS [1]	SOURCE
<0.0003	0	No adverse effects to biota exposed to soil expected.
0.0003-0.02	10	Likely to cause injury to masked shrew (EPA 2003).
0.02-40.0	20	Likely to cause injury to earthworms (EPA 2001) and plants (Efroymson et al. 1997).

EXHIBIT 2-4 ADVERSE EFFECTS THRESHOLDS AND PERCENTAGE SERVICE LOSS FOR MERCURY-CONTAMINATED SOIL

MERCURY CONCENTRATION IN SOIL (PPM DW)	PERCENTAGE SERVICE LOSS	SOURCE
< 0.05	0	Although it is possible for some species (e.g., American woodcock) to experience adverse effects below this level of mercury in soil, it is not anticipated that these effects would cause ecological service losses.
0.05-5.0	25	Earthworms experienced a 40% reduction in cocoon production, and approximately 50% mortality (Abbasi and Soni 1983). Short-tailed shrews and red fox are expected to experience adverse effects (Efroymson et al. 1997, Eisler 1987).
5.0-10.0	50	Additional species such as white-footed mouse and white-tailed deer begin experiencing adverse effects (Efroymson et al. 1997), and it is anticipated that the type and severity of effects incurred by affected species will increase.
10.0-20.0	75	Additional species such as red-tailed hawk begin experiencing adverse effects (Efroymson et al. 1997), and it is anticipated that the type and severity of effects incurred by affected species will increase.
> 20.0	100	It is anticipated that the type and severity of effects incurred by affected species will increase to the point where the floodplain ecosystem will cease to provide services.

Fish

Fishery resources play an important role in aquatic ecosystems. Found at almost any trophic level (e.g., fish are forage feeders, piscivores, and omnivores), fish are essential in the cycling of nutrients and energy through the system. In addition, fish serve as an important food source for non-aquatic species, and represent an important pathway for contaminants to other biological resources including piscivorous birds and mammals.

As described above, average fish concentrations of both PCBs and mercury are below adverse effects thresholds and no injury to the fishery resources in Watts Bar Reservoir has occurred. Therefore, no fishery ecological services have been lost due to these contaminants.

Piscivorous Birds

Birds provide a suite of ecological services, including, but not limited to, nutrient cycling, food web sustainability, and pest control. Piscivorous birds in Watts Bar Reservoir are exposed to contaminants mainly through their diet. This injury is quantified by comparing site-specific PCB concentrations in assessment area fish to literature-based adverse effects ranges and corresponding percentage service losses. To evaluate the magnitude of loss associated with exposure of piscivorous birds to dietary PCBs from Watts Bar Reservoir, adverse effects thresholds and corresponding percent service losses were determined based on relevant literature. Threshold ranges and service losses were developed based on a weight-of-evidence of the type, frequency, and severity of effect. The average total PCB concentration in fish of 1.22 ppm corresponds to a 15 percent loss in ecological services (Exhibit 2-5).

As described above, average mercury concentrations in assessment area fish are below adverse effects thresholds and no injury to the avian resources in Watts Bar Reservoir due to mercury has occurred. Therefore, no avian ecological services have been lost due to this contaminant.

EXHIBIT 2-5 ADVERSE EFFECTS THRESHOLDS AND PERCENTAGE SERVICE LOSS FOR PISCIVOROUS BIRDS EXPOSED TO DIETARY TOTAL PCBS

PCB CONCENTRATION IN DIET (PPM WW)	PERCENTAGE SERVICE LOSS	EFFECTS
<0.5	0	No known effects to sensitive species (Chapman et al. 2003)
0.5-1.0	5	Effects on reproduction and growth in sensitive species (Chapman et al 2003, CCME 2001, EPA 1995)
1.0-2.0	15	Effects on reproduction of moderately sensitive species (Kubiak et al. 1989, Tori and Peterle 1983, Peakall and Peakall 1973, Dahlgren et al. 1972)
2.0-4.0	30	Increased incidence and severity of effects.[1]
4.0-7.0	50	Increased incidence and severity of effects. [1]
7.0-11.0	80	Effects on reproduction of less sensitive species (Fernie et al 2001a, 2001b; Elliott et al. 1997).
>11.0	100	Increased incidence and severity of effects. [1]

Note:
1. The literature reviewed did not provide specific effects information for this range in PCB concentrations. The increase in incidence and severity of effects is inferred based on data for PCB concentrations above and below this range.

Piscivorous Mammals

Mammals provide a suite of ecological services, including, but not limited to, nutrient cycling, food web sustainability, and pest control. Piscivorous mammals in Watts Bar Reservoir are exposed to contaminants mainly through their diet. Injury to piscivorous mammals utilizing the aquatic habitat of Watts Bar Reservoir is based on injury to mink from exposure to PCBs, as the majority of toxicological research published on dietary effects of these contaminants on mammals focuses on this species. This injury is quantified by comparing site-specific PCB concentrations in assessment area fish to literature-based adverse effects ranges and corresponding percentage service losses. To evaluate the magnitude of loss associated with exposure of piscivorous birds to dietary

PCBs from Watts Bar Reservoir, adverse effects thresholds and corresponding percent service losses were determined based on relevant literature. Threshold ranges and service losses were developed based on a weight-of-evidence of the type, frequency, and severity of effect . The average concentration of mercury in fish of 0.2 ppm corresponds to a 35 percent loss in ecological services (Exhibit 2-6).

As described above, average mercury concentrations in assessment area fish are below adverse effects thresholds, and no injury to piscivorous mammals due to mercury has occurred. Therefore, no mammalian ecological services have been lost due to this contaminant.

EXHIBIT 2-6 ADVERSE EFFECTS THRESHOLDS AND PERCENTAGE SERVICE LOSS FOR MINK EXPOSED TO DIETARY TOTAL PCBS

PCB CONCENTRATION IN DIET (PPM WW)	PERCENTAGE SERVICE LOSS	EFFECTS
<0.25	0%	No effects at concentrations below 0.25 ppm. Hornshaw et al. (1983) found no effects on kit production, growth, or on a diet containing 0.21 ppm PCBs. Heaton et al. (1995) calculated a NOAEL of 0.015 ppm. Jensen et al. (1977) noted no adverse effects when exposed to 0.05 ppm.
0.25 - 0.5	10%	Some adverse effects recorded at these levels. Restum et al. (1998) observed effects on whelping rates and kit body weight but not on mortality, yet Bursian et al. (2003) found no effects on measured endpoints at levels < 0.61 ppm.
0.5 – 2.0	35%	Sublethal and lethal effects recorded. Bursian et al. (2003) and Bursian and Yamini (2003) found biochemical effects at 1 ppm but no kit mortality up to 1.7 ppm. At 1.86 ppm, Halbrook et al. (1999) found non-statistically significant reduced kit weight and litter size at birth but no effects on kit mortality. However, Restum et al. (1998) found reduced kit body weight and increased mortality at 0.5 ppm (4-13% survival vs. 70 to 80% in controls). Heaton et al. (1995) found reduced kit survival at 0.72 ppm (30% survival as compared to 85% for controls). Hornshaw et al. (1983) and Platonow and Karstad 1973) also found severe reductions in kit production at 0.65 ppm. Wren et al. (1987b) found that 1 ppm of Aroclor 1254 increased kit mortality to approximately 87% (compared to 11% for control).
> 2.0	75%	Aroclor levels of 2 ppm or higher can cause total reproductive failure (Aulerich and Ringer 1977, EPA 1980, Aulerich et al. 1985, Bleavins et al. 1980). Bursian et al. (2003) found increased kit mortality (46% survival vs. 85% for controls) at 3.7 ppm.

AQUATIC HABITAT LOSSES

Service losses incurred by the aquatic habitat within Watts Bar Reservoir due to PCBs and mercury are quantified based on the following steps:

- Calculate average percentage service loss across representative natural resources (soil, fish, piscivorous birds, piscivorous mammals) for each contaminant across the entire geographic area.
- Adjust percentage service loss for PCBs for contribution from Site.
- Multiply service losses for each contaminant by the corresponding acreage of aquatic habitat.
- Calculate the present value of losses for the aquatic habitat from 1981 through 2106 under two bounding recovery scenarios.
- Sum losses across time to determine total acre-years of loss.

Ecological service losses incurred by the aquatic habitat of Watts Bar Reservoir are estimated as the average percentage service losses of soil, fish, piscivorous birds, and piscivorous mammals for each contaminant for each year of the analysis. The average percentage ecological services lost due to mercury is approximately 6.3 percent, and the average percentage of ecological services lost due to PCBs is approximately 17.3 percent (Exhibit 2-7). However, only between six and nine percent of the PCBs measured in assessment area natural resources are from the Site (PWC 2000). Therefore, the percentage of ecological services lost is adjusted accordingly to range from approximately 1.0 percent to 1.6 percent (Exhibit 2-7). That is, the Site is assumed to be responsible for approximately 1.0 to 1.6 percent of the ecological services lost due to contamination in Watts Bar Reservoir.

EXHIBIT 2-7 AVERAGE PERCENTAGE SERVICE LOSS FOR AQUATIC HABITAT WITHIN WATTS BAR RESERVOIR

RESOURCE	MERCURY	PCBS	PCBS: 6% [1]	PCBS: 9% [1]
Soil	25%	20%	--	--
Fish	0%	0%	--	--
Piscivorous Mammals	0%	35%	--	--
Piscivorous Birds	0%	5%	--	--
Average	**6.3%**	**17.3%**	**1.0%**	**1.6%**

Note:
1. Because only six to nine percent of the PCBs within Watts Bar Reservoir are attributed to the Site (PWC 2000), the service losses associated with Site-derived PCBs are adjusted accordingly (17.3% * 6% = 1.04% and 17.3% * 9% = 1.55%).
2. Totals may not compute due to rounding.

Because of the uncertainty associated with the effects of multiple contaminants, this analysis assumes that the impacts due to mercury and PCBs are additive. This is not a straight addition of the percentage services lost due to each contaminant, but rather the percentage service loss of a second contaminant is applied to the ecological services unimpacted by the first contaminant. In this case, the number of acres in Watts Bar Reservoir is multiplied by the percentage service loss due to mercury to determine acres impacted by mercury. The remaining unimpacted acres (i.e., total area minus the service-acres impacted by mercury) are then multiplied by the service loss due to PCBs (Exhibit 2-7). [4]

EXHIBIT 2-7 ACRES OF AQUATIC HABITAT SERVICES LOST PER YEAR DUE TO PCB AND MERCURY CONTAMINATION

WATTS BAR RESERVOIR (ACRES) (A)	ACRES OF AQUATIC HABITAT IMPACTED BY:				
	MERCURY (B)	PCBS FROM SITE: 6% (C)	PCBS FROM SITE: 9% (D)	MERCURY + PCBS 6% (E)	MERCURY + PCBS 9% (F)
33,575	2,148	213	319	2,361	2,467

Notes:
B = A * 6.3%
C = (A-B) * 6%
D = (A-B) * 9%
E = B + C
F = B + D
1. It does not matter which contaminant's service loss is applied first, the resulting lost acres are the same.
2. Totals may not sum due to rounding.

The sum of acres impacted by mercury and PCBs reflects the total injury to aquatic habitat in Watts Bar Reservoir in one year (Exhibit 2-7). Because of the lack of a trend in observed contaminant data, the percentage service loss that corresponds to the average concentration is applied to each year from 1981 through 2006. For future years, service losses are extrapolated through 2106 under two scenarios: 1) linear recovery of ecological services from 2007 through 2106, and 2) no recovery. Reduction in contamination levels and recovery of the reservoir system has been documented (ORNL and JEG 1995), which supports the assumption that some natural attenuation of mercury and PCBs will occur in

[4] Percentages are not directly added because the maximum percentage of ecological services that can be provided by any system is 100 (e.g., if one contaminant caused a 50 percent service loss and a second contaminant caused a 75 percent service loss, the system could not lose 125 percent of its services). Instead, we apply the 50 percent loss, and then add 75 percent of the remaining 50 percent (37.5 percent) for a total of 87.5 percent service loss. It does not matter which contaminant's service loss is applied first, the resulting lost acres will be the same.

the next hundred years. However, these compounds resist degradation and are bioaccumulative, and no remedial actions are planned, making future physical, chemical, and biological parameters in Watts Bar Reservoir uncertain. Therefore, it is likely that future service losses will fall within the bounds of these two scenarios.

A constant level of losses from 1981 through 2006 and linear recovery through 2106, at a discount rate of three percent, results in an estimate of approximately 148,000 to 158,000 present value acre-years of aquatic services lost (range reflects six to nine percent range in Site-related PCBs). Alternatively, a constant level of losses from 1981 through 2106, at a discount rate of three percent, results in approximately 170,000 to 181,500 present value acre-years of loss (Exhibit 2-8). Thus, results are relatively insensitive to recovery. Present value is discussed in Appendix B. Annual losses are presented in Appendix C.

EXHIBIT 2-8 PRESENT VALUE (2006) ACRE-YEARS OF AQUATIC HABITAT SERVICES UNDER TWO MODELED FUTURE SCENARIOS

	RECOVERY TO BASELINE (PRESENT VALUE ACRE-YEARS) [1]		NO RECOVERY (PRESENT VALUE ACRE-YEARS) [1]	
LOSS	MERCURY + PCBS 6%	MERCURY + PCBS 9%	MERCURY + PCBS 6%	MERCURY + PCBS 9%
Past Loss (1981-2006)	93,461	99,741	93,461	99,741
Future Loss (2007-2106)	54,507	58,170	76,603	81,750
Total Loss (1981-2106)[2]	**147,968**	**157,911**	**170,064**	**181,491**

Notes:
1. Present value in 2006.
2. Totals may not sum due to rounding.

UNCERTAINTY

These estimates of ecological losses are sensitive to the assumptions and methodologies applied in the sections above. Changes in these or other aspects of the analysis, some of which are described below, could alter the results. In addition, while results are subject to some uncertainty, this analysis incorporates the best available data and utilizes commonly applied techniques.

Aquatic Area

The assessment area currently includes the Tennessee River arm of Watts Bar Reservoir to the Ft. Loudoun Dam. While this is reasonable for mobile resources such as fish, birds, and mammals, it is unlikely that sediment contamination from the Site travels upstream in that arm. Therefore, injury to sediment in that stretch of Watts Bar Reservoir is less likely due to contamination from the Site. Its incorporation into this assessment may lead to an overstatement of damages.

Temporal Scope

The temporal scope of these analyses is based on general estimates of the potential recovery of natural resources. Multiple variables affect these estimates, including recovery rate, remedial activities, restoration activities, and natural attenuation. The sparseness of site-specific data prevents prediction of a trend in contaminant concentrations in each resource over time. Therefore, this analysis provides estimates of losses under two recovery scenarios; true recovery is expected to fall in between these two rates.

Data Extrapolation

Geographic and temporal data gaps are filled by extrapolation of existing data, which may not accurately reflect actual contamination levels. First, although Watts Bar Reservoir is thousands of acres in size, contamination is often characterized by less than a few dozen samples in any given year. These few data points may not characterize such a large area (e.g., if depositional areas were not sampled or grain size varied). Second, the constant, linear trend in concentration over time used in this analysis may not accurately reflect actual changes in concentration over time. These assumptions may lead to an over- or underestimate of damages.

Baseline

This analysis assumes that under baseline conditions 100 percent of ecological services would be provided by the natural resources in Watts Bar Reservoir. However, the quality of those services may be impacted by other physical and chemical characteristics of the watershed (e.g., water quality), which this analysis does not take into account. Therefore, service losses attributed to PCBs and mercury may be overestimated.

Representative Species

Although multiple species within the aquatic ecosystem have been exposed to PCBs, mercury, and radionuclides, it is not possible to measure adverse effects for each individual species due to time, budget, and data constraints. Therefore, species are chosen to represent large portions of the ecosystem, and may not accurately reflect site-specific species sensitivity to contamination. This may lead to an over- or underestimate of damages.

Literature-Based Thresholds

Adverse effects thresholds and service losses are derived based on information from the peer-reviewed literature. These studies may not accurately reflect site-specific toxicity, and the severity and incidence of adverse effects recorded in a laboratory setting may differ from effects recorded in the field. Service losses are based on a weight-of-evidence of these adverse effects data, but because there are no standards for estimating service losses, interpretation of these data may cause an over- or under-estimate of service losses in Watts Bar Reservoir.

Toxicity of Multiple Contaminants

As described above, the toxicological implications of natural resource exposure to multiple contaminants is extremely complex. Interactions between various contaminants in abiotic and biotic media depend on a suite of environmental parameters. Because PCBs, mercury, and radionuclides all have different modes of toxic action but impact biologically relevant endpoints (e.g., reproduction), the toxicity of these contaminants is assumed to be additive. This may under-estimate (e.g., if toxicity is synergistic) or over-estimate (e.g., if toxicity is antagonistic) injury.

CHAPTER 3 | ECOLOGICAL SERVICE GAINS UNDER THE BLACK OAK RIDGE CONSERVATION EASEMENT

INTRODUCTION

As part of discussions regarding compensatory restoration alternatives for natural resource damages sustained in Watts Bar Reservoir, DOE and the State of Tennessee, in agreement with the other natural resource Trustees, agreed to implement a conservation easement on upland areas of Black Oak Ridge. The Easement will protect almost 3,000 acres of forest from development, allowing for the continued provision of natural resource services within this area. This chapter presents the ecological services provided by the Easement (e.g., habitat for threatened and endangered species), including defining the geographic and temporal scope of the analysis, discussing baseline conditions, and determining and quantifying the ecological service gains expected under the Easement. Habitat equivalency analysis is applied to estimate the present value acre years of ecological services gained due to the Easement.

GEOGRAPHIC SCOPE

The geographic scope of the Easement consists of 2,965.95 acres on Black Oak Ridge, Tennessee, and includes East Black Oak Ridge, West Black Oak Ridge, and McKinney Ridge. A map is provided in Exhibit 3-1 (DOE 2005).

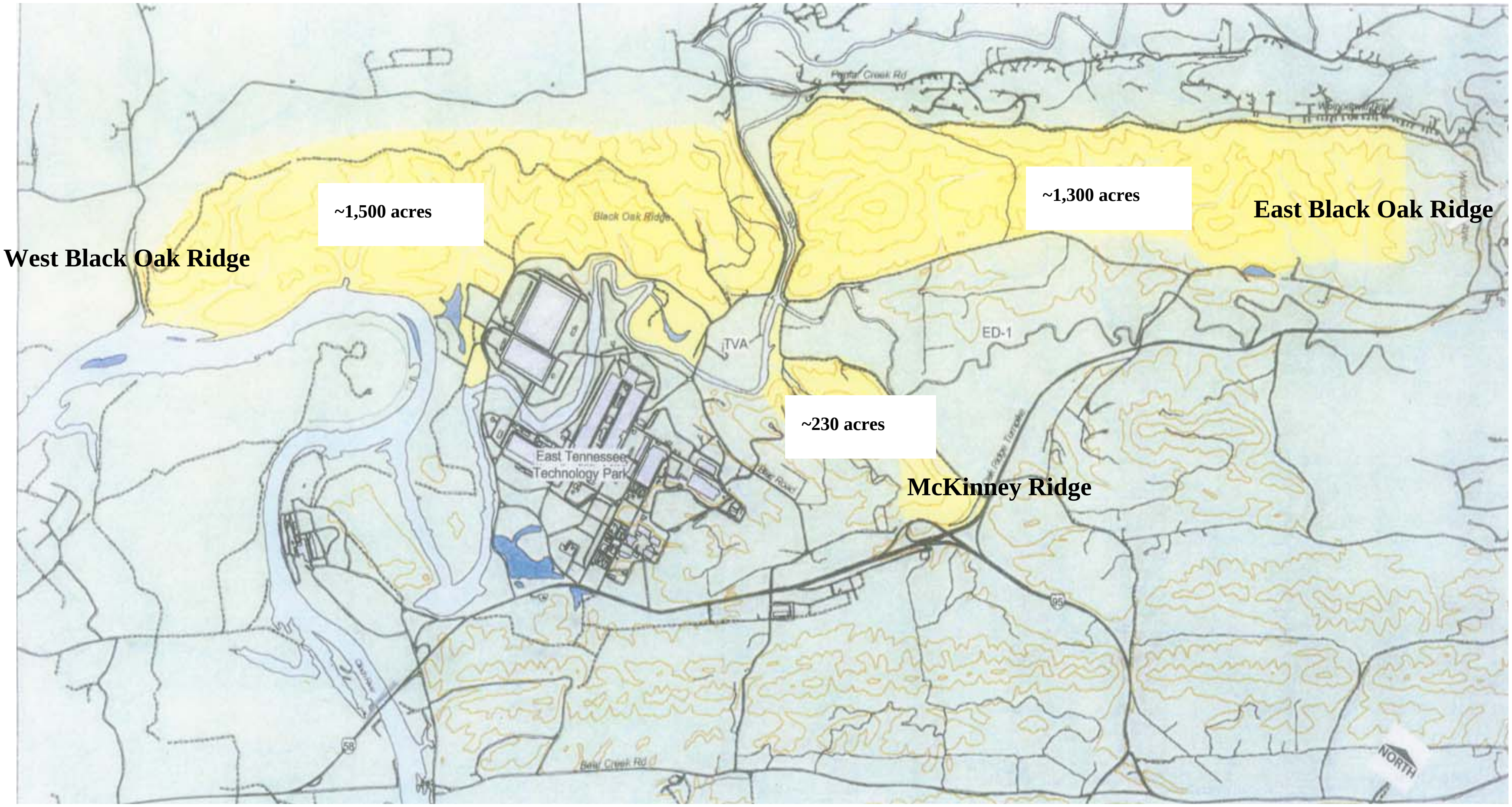
TEMPORAL SCOPE

Because the terms of the Easement are indefinite (i.e., in perpetuity), the timeframe of the ecological gains provided by the habitat within the Easement area are expected to continue from 2006 (first full year after initiation of the Easement) in perpetuity.

QUANTIFICATION OF ECOLOGICAL GAINS

The Easement area represents a diverse ecological system that provides a suite of upland habitat ecological services. Ecological services encompass the full suite of biological, chemical, and physical functions provided by a natural resource. Examples of ecological services provided under the Easement include nutrient cycling, denning and roosting habitat, and food web sustainability. This analysis estimates the quantity of ecological services expected to be provided by the Easement as compared to baseline conditions, and provides a basis for scaling these gains with ecological service losses in Watts Bar Reservoir. This section discusses baseline conditions, the assumptions and methodologies used to quantify the gains in ecological services due to the Easement, and the uncertainties inherent in this analysis.

EXHIBIT 3-1 MAP OF THE BLACK OAK RIDGE CONSERVATION EASEMENT



Note: Easement area in yellow.

As described for ecological losses, ecological gains are quantified based on the services provided under the Easement. Continuation of the flow of ecological services under the Easement as compared to a potential reduction in services under baseline conditions is considered a gain in ecological services. To avoid double-counting of service losses and to allow for habitat-based restoration scaling, the quantity of ecological services provided by the easement is evaluated on a habitat basis. These ecological service gains are quantified in terms of gained resource years (e.g., acre-years of terrestrial habitat).

BASELINE

In order to quantify ecological service gains, and therefore scale these gains with ecological losses due to contamination, the baseline conditions (i.e., physical, chemical, and biological conditions) of the affected resources and associated services must be established. In this case, baseline is considered to be the level of ecological services provided by the Easement area had the Easement not been put in place.

Based on available information, it is reasonable to assume that areas included in the Easement would be under development pressure in the future. For example, the increase in population and building permits since 1990 in both Oak Ridge and Anderson County has been relatively steady (US Census Bureau 2008a, 2008b).[5] The timing and extent of such development will depend on factors such as regional population changes, regional economic conditions, and the pattern in which development occurs in the area. While available data are insufficient to predict the specific timing and nature of development on a scale as small as the BOR, this analysis assumes that absent the protections afforded by the Easement, this area would eventually be developed.

This analysis further assumes that development will interfere with the ecological and human uses which would otherwise be provided by BOR. Specifically, this analysis applies a measure of ecological services that is based mainly on the presence of relatively large, contiguous stretches of forested habitat (e.g., songbird habitat), ecological characteristics that are unlikely to be retained under a development scenario. Absent detailed information on the nature and extent of future development, this analysis assumes that the area under the Easement would provide no ecological services if the Easement were not in place.

QUANTIFICATION APPROACH

Ecological service gains from the Easement are quantified as the ecological services provided by the various types of terrestrial habitat found in the Easement area. Currently available data are insufficient to evaluate ecological services provided by each individual species associated with upland habitat, so ecological service gains are estimated on a habitat basis. To the extent that ecological service flows affect ecosystem health, the

[5] For example, roughly 48 new single-family housing units are constructed each year in Oak Ridge (City-Data 2008). As shown on the City of Oak Ridge's interactive property map, many of the new homes are located in the subdivisions encroaching on the eastern edge of East Black Oak Ridge (City of Oak Ridge 2008).

flora and fauna associated with terrestrial habitat are all expected to benefit from the continued flow of ecological services.

The ecological benefits provided by each terrestrial habitat type are quantified using the following steps:

- Define habitat types within the Easement and estimate the geographic extent of each habitat type.
- Develop equivalency ratios between terrestrial habitat types.
- Estimate acres of services gained per year for all habitat types.
- Extrapolate ecological services gained from 2006 in perpetuity.

Habitat Types

To evaluate and scale the ecological services provided by the Easement, the area is divided into three "types" of upland habitat: 1) interior forest, 2) sensitive habitat and confirmed or potential habitat for threatened and endangered species, and 3) "basic" upland habitat (i.e., upland habitat that is neither interior forest nor sensitive habitat).

Interior forest, also called deep forest, is defined as forested areas that possess more than 70 percent canopy cover in contiguous areas greater than 50 acres (SAIC 2002). In addition, interior forest requires at least a 200-meter buffer from any edge or feature that breaks the tree cover (e.g., roads, rivers, buildings; SAIC 2002). Based on habitat maps provided in SAIC (2002), there are approximately 786 acres of interior forest within the Easement area (Exhibits 3-2 and 3-3).[6]

Sensitive habitat includes areas that support or are expected to support threatened or endangered species, and is defined as an ecosystem with the unique characteristics required by these species (SAIC 2002). This analysis includes areas where threatened or endangered species have been confirmed present, as well as habitats that possess the criteria needed for these species but where species presence has not been confirmed (SAIC 2002). State and Federal definitions of threatened and endangered species, along with a list of these species found in the Easement area are presented in Appendix D. Based on maps provided in SAIC (2002), there are approximately 1,111 acres of confirmed and potential habitat for threatened and endangered species within the Easement area (Exhibits 3-2 and 3-3).[7]

Upland habitat within the Easement that is not interior forest or habitat for threatened and endangered species is labeled basic upland habitat. This habitat provides the full suite of general terrestrial ecosystem services. Based on maps provided in SAIC (2002), there are approximately 1,584 acres of basic upland habitat within the Easement area (Exhibits 3-2 and 3-3).[8]

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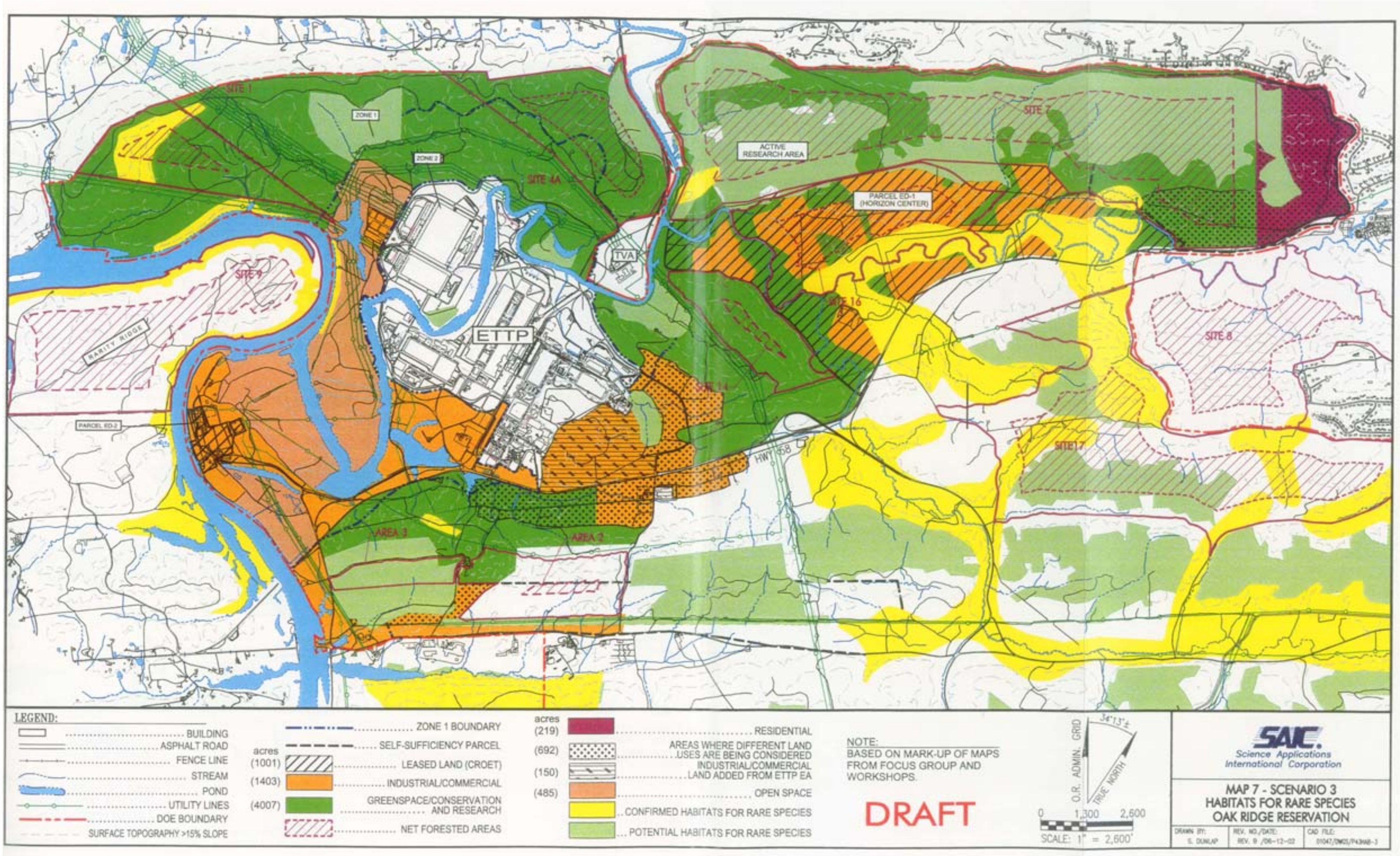
[6] Includes overlapping areas of interior forest and habitat for sensitive and endangered species.

[7] See previous footnote.

[8] Acreages of upland habitat do not include any disturbed areas (e.g., security road).

EXHIBIT 3-2 MAP OF INTERIOR FOREST AND SENSITIVE HABITAT WITHIN THE EASEMENT AREA



Source: SAIC (2002).

EXHIBIT 3-3 UPLAND HABITAT TYPES WITHIN THE EASEMENT AREA

DESCRIPTION	ACRES
Interior forest (including overlaps with confirmed and potential habitat for rare species)	786
Interior forest (with no overlaps)	271
Confirmed and potential habitat for rare species (overlaps with interior forest)	515
Confirmed habitat for rare species (excluding overlaps with interior forest)	88
Potential habitat for rare species (excluding overlaps with interior forest)	508
Basic upland habitat	1,584

Notes:

1. Source: SAIC (2002), Geographic Information System analysis.
2. May not sum to Easement acreage due to rounding.

Upland Habitat Equivalence Ratios

Because each of the habitat types described above provides a different suite of ecological services, equivalence ratios based on those services are used to scale one habitat type with another. This allows all terrestrial services to be combined in a single metric for which ecological gains across time can be estimated. Each habitat type is evaluated in terms of basic upland habitat.

The ecological services provided by one acre of interior forest are estimated to be equal to the services provided by two acres of basic upland habitat. Many plant and animal species rely on the habitat services provided by interior forest. For example, migratory songbirds require interior forest habitat for survival and success. Because of the habitat characteristics required by species such as migratory birds, and the continuing decline of interior forest habitat, contiguous forested areas are considered "more environmentally valuable than acres in smaller forested plots" (SAIC 2002). This is evident in conservation and preservation priorities described in local and regional land use planning. Therefore, interior forest is scaled at a ratio of 1:2 (acres of interior forest to acres of basic upland habitat; Exhibit 3-4).

EXHIBIT 3-4 UPLAND HABITAT EQUIVALENCE RATIOS

HABITAT	EQUIVALENCE TO BASIC UPLAND HABITAT	JUSTIFICATION
Basic Upland Habitat	1:1	N/A
Interior Forest	1:2	Local/regional emphasis on preservation (e.g., SAIC 2002), and provision of habitat characteristics for specific species groups (e.g., migratory songbirds) indicates greater value
Confirmed/Potential Habitat for Threatened and Endangered Species	1:10	Increased fines for take of threatened and endangered species relative to non-listed species (e.g., ESA 1973, TN WSCA 1974).

The ecological services provided by one acre of sensitive habitat are estimated to be equal to the services provided by ten acres of basic upland habitat. The Federal Endangered Species Act (ESA) of 1973 recognizes that "endangered species of fish, wildlife, and plants are of aesthetic, ecological, historical, recreational, and scientific value to the Nation and its people" (GPNC 2006). The Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 and the Tennessee Rare Plant Protection and Conservation Act of 1985 also reflect the importance of threatened and endangered species. These Federal and state regulations contain provisions for punishment of violations (e.g., take, possession, sale), including fines, which are at least ten times greater for threatened and endangered species as non-threatened or non-endangered species (Exhibit 3-5, Appendix D). These fines indicate the relative value that natural resource agencies attribute to threatened and endangered species versus non-threatened and endangered species. Therefore, sensitive habitat is scaled at a ratio of 1:10 (acres of sensitive habitat to acres of basic upland forest; Exhibit 3-4).

EXHIBIT 3-5 FINES FOR TAKE OF THREATENED OR ENDANGERED SPECIES

PROTECTION LEVEL	FINE
Federal Endangered or Threatened Species	$50,000
Tennessee Endangered or Threatened Animals	$500 to $2,500
Tennessee Endangered or Threatened Plants	$1,000
Other Tennessee Wildlife	$10 to $25
Sources: ESA 1973, TN WCSA 1974.	

Ecological Gains

To evaluate the ecological service gains from the Easement, upland forest habitat types are scaled to basic upland habitat using the ratios described above, and these acres of ecological services per year are extrapolated in perpetuity (the time frame of the Easement). The present value of these services, using a discount rate of three percent, is approximately 441,000 acre-years of ecological services (Exhibit 3-6).

EXHIBIT 3-6 PRESENT VALUE (2006) ACRE-YEARS OF UPLAND HABITAT SERVICES PROVIDED BY THE EASEMENT

	ACRES OF HABITAT	EQUIVALENCE (RATIO TO BASIC UPLAND HABITAT)	ACRES OF BASIC UPLAND HABITAT	ACRE-YEARS GAINED (2006-PERPETUITY)[2]
Basic Upland Forest	1,584	1:1	1,584	52,803
Interior Forest	271	1:2	542	18,083
Sensitive Habitat [1]	1,111	1:10	11,106	370,208
Total [3]				**441,094**

Notes:
1. Approximately 515 of the 1,111 acres of sensitive habitat are also classified as interior forest, but are included here only as sensitive habitat.
2. Acre-Years Gained in Perpetuity = Acres of Basic Upland Habitat / Discount Rate (discount rate for ecological services is three percent).
3. Totals may not sum due to rounding.

UNCERTAINTY

These estimates of ecological gains are sensitive to the assumptions and methodologies applied in the sections above. Changes in these or other aspects of the analysis, some of which are described below, could alter the results. In addition, while results are subject to some uncertainty, this analysis incorporates the best available data and utilizes commonly applied techniques.

Equivalence of Upland Habitat Types

Equivalence of upland habitat types (e.g., ratio of ecological services provided by interior forest versus sensitive habitat versus basic upland forest) is based on qualitative ecological data, policy, and regulatory violations. This combination of information may not accurately reflect the actual equivalence of ecological services between these habitat types, and may lead to either an over- or under-estimation of these equivalency ratios.

Baseline

As described earlier, if the Easement were not in place, development pressure and infrastructure expansion (e.g., roads, clearings for utility lines) are assumed to severely degrade the area under the Easement. Therefore, under baseline conditions, the Easement area is assumed to provide zero ecological services. Because it is unlikely that the entire area would be completely developed tomorrow in the absence of the Easement, this scenario is more likely to underestimate than overestimate baseline services (and therefore overestimate rather than underestimate ecological service gains from the Easement).

Scope of Ecological Gains

This analysis quantifies the ecological benefits of the Easement based on protection of upland habitat within the boundaries of the Easement. However, conservation of that upland habitat will likely also benefit ecosystems outside the boundaries of the Easement. For example, because the Easement protects a substantial portion of land within the Clinch River watershed, the quality and quantity of groundwater and surface water flowing from the Easement area to the Clinch River, Poplar Creek, and the East Fork Poplar Creek is maintained (i.e., rather than degraded due to development). Lack of quantification of these ecological services may lead to an underestimation of benefits provided by the Easement.

CHAPTER 4 | HUMAN USE SERVICE LOSSES IN WATTS BAR LAKE

INTRODUCTION

As described in Chapter 2, contamination has adversely impacted the services that natural resources in Watts Bark Reservoir can provide. In addition to the ecological services lost, human uses of these resources has also been negatively affected, including losses in recreational and commercial fishing opportunities. Recreational fishing losses have been estimated in PWC (2000). This chapter estimates potential losses incurred by commercial fishers as a result of a contamination-induced fishery closure in Watts Bar Reservoir.

In April of 2008, the Tennessee Wildlife Resources Agency (TWRA) closed the commercial fishery at Watts Bar Reservoir due to a contaminant advisory on certain species and an existing ban on entanglement equipment (trammel and gill nets) intended to protect the striped bass (Scholten 2008, TWRA 2008).[9] Closure of the Watts Bar commercial fishery is expected to result in losses to human use services into the indefinite future, and these losses are therefore quantified in this section as welfare losses in perpetuity. In the analysis that follows, damages are estimated assuming that closure of Watts Bar Reservoir to commercial fishing was entirely in response to PCB contamination from the Site. Given that the ban on entanglement equipment and several other sources of contamination played a role in the lake's closure, this approach likely overstates impacts due solely to the release of contaminants from the Site.

DAMAGE DETERMINATION

Determination of economic damages involves estimating the fish harvests that could have been yielded from Watts Bar Reservoir in the absence of the commercial fishing closure. Although insufficient harvest data is available to establish long-term yield trends from Watts Bar Reservoir, commercial harvests for the 2005 to 2006 and 2006 to 2007 seasons for the four harvestable fish species in Watts Bar Reservoir are provided in Exhibit 4-1 below. The average of these two seasons provides a rough estimate of the annual fish harvest that would likely be lost in future seasons given the closure.

[9] The validity of the Tennessee Wildlife Resource Commission's proclamation banning commercial fishing at Watts Bar Reservoir is being challenged in Tennessee Commercial Roe Fishermen's Ass'n, et al. v. Tenn. Wildlife Resources Agency, No. 08-1252-IV (Davidson County Chanc. Ct. filed June 6, 2008).

EXHIBIT 4-1 SEASONAL COMMERCIAL FISHING HARVEST IN WATTS BAR RESERVOIR

SEASON	COMMERCIAL HARVEST (LBS)			
	CATFISH	BUFFALO	DRUM	CARP
2005-2006	80,000	4,000	2,000	6,000
2006-2007	138,000	5,000	2,000	1,000
Average	**109,000**	**4,500**	**2,000**	**3,500**
Source: Mann 2007.				

Following DOI regulations, this analysis measures economic damages based on changes in social welfare rather than changes in total revenue (DOI 2003).[10] Changes in social welfare include changes to both *consumer surplus*, which is the difference between the true value of a good and its total monetary cost, and *producer surplus*, which is the difference between the market price for a good and the minimum price at which a producer is willing to supply the good. For a change in consumer surplus to result from the Watts Bar Reservoir commercial fishery closure, a change in the price of catfish, buffalo, drum, or carp would need to occur (i.e., shifts in supply curves). Given that the Watts Bar Reservoir commercial fishery represents a very small fraction of fish production in the southeast (e.g., over 300 million pounds of catfish were produced in southeastern states in both 2006 and 2007), it is unlikely that a shift in supply curves will result from closure of Watts Bar Reservoir (USDA 2007). As noted in a recent U.S. Environmental Protection Agency (EPA) study that considered the economic benefit associated with increased commercial landings:

> "…such modest overall changes in landings are not expected to greatly influence the market for fish. Thus, it seems reasonable to presume that there will be no appreciable impacts on wholesale or retail prices. Under such a scenario of no price impacts, economic theory indicates that all changes in economic surplus will be confined to changes in producer surplus (i.e., changes in consumer and related post-harvest surplus will be zero)" (EPA 2004, p. A10-12).[11]

The closure may, however, result in changes in producer surplus experienced by commercial fishers. The EPA analysis mentioned above reported producer surplus estimates ranging from 0 to 40 percent of wholesale fish prices; however, the study also suggests that "…there may be economic benefits to commercial fishermen in the short term, but in the long run producer surplus will be zero" (EPA 2004 p. A10-12). Furthermore, given the open-access nature of the fishery and the low barriers to entry for

[10] To understand why total revenue is not a good measure of producer surplus, consider that fishers experience some costs associated with harvesting fish that are avoided if a fishery is closed.

[11] The study analyzed a regulation that would potentially increase fish harvests by reducing the number of fish killed by cooling water intakes at power plants.

fishers on lakes such as Watts Bar Reservoir (including low capital requirements) short-term producer surplus may be zero. Setting aside these issues, to provide a conservative estimate of potential damages (i.e., more likely to overestimate than underestimate damages), this analysis assumes producer surplus is at the midpoint of the range of values reported by EPA, or 20 percent of wholesale prices.

The analysis estimates producer surplus losses assuming that the average of 2006 and 2007 harvest volumes are lost annually in perpetuity (discounted at five percent).[12] To establish damages, 20 percent of the wholesale price fishers receive is multiplied by these lost harvest volumes (Mann 2007, Scholten 2008). Given these assumptions, Exhibit 4-2 shows potential damages in perpetuity (starting in 2008) associated with closure of the Watts Bar Reservoir commercial fishery, which are estimated at roughly $198,700 (2006$).[13]

EXHIBIT 4-2 POTENTIAL DAMAGES ASSOCIATED WITH CLOSURE OF THE WATTS BAR COMMERCIAL FISHERY (2006$) [6]

SPECIES	LOST HARVEST (LBS)[1]	WHOLESALE PRICE (PER LB)[2]	LOST PRODUCER SURPLUS (PER LB)[3]	ANNUAL VALUE	TOTAL PRESENT VALUE 2008-PERPETUITY [4]
Catfish	109,000	$0.44	$0.09	$9,553	$191,058
Buffalo	4,500	$0.24	$0.05	$219	$4,382
Drum	2,000	$0.15	$0.03	$58	$1,169
Carp	3,500	$0.15	$0.03	$102	$2,045
Total				**$9,933**	**$198,654**

Notes:

1. Average of harvests from the 2006 and 2007 seasons. LBS indicates pounds.
2. Source: Mann 2007 and Scholten 2008.
3. Lost producer surplus is 20 percent of the wholesale prices.
4. Present Value = Annual Value / Discount Rate (for human use services the discount rate is five percent).
5. Totals may not sum due to rounding.
6. Although losses do not begin until 2008, damages are estimated in 2006$ to be consistent with the estimate of human use gains under the Easement and the evaluation of ecological losses and gains. Note that if losses and gains were both estimated in 2008$, the ratio between the two values would remain the same.

[12] Because a five percent discount rate was applied in the PWC (2000) estimate of recreational fishing losses in Watts Bar Reservoir, this analysis applies a five percent discount rate to human use service losses. Typically, a three percent discount rate would be used to estimate present values under CERCLA, but since the same rate is applied to both human service losses and gains, any impacts of using the higher rate are expected to be modest.

[13] Although losses do not begin until 2008, damages are estimated in 2006$ to be consistent with the estimate of human use gains under the Easement and the evaluation of ecological losses and gains. Note that if losses and gains were both estimated in 2008$, the ratio between the two values would remain the same.

CHAPTER 5 | HUMAN USE SERVICE GAINS UNDER THE BLACK OAK RIDGE CONSERVATION EASEMENT

INTRODUCTION

As described in Chapter 3, DOE and the State of Tennessee have implemented a conservation easement on Black Oak Ridge as part of the natural resource damage assessment for the Oak Ridge Reservation. In addition to ecological services, the Easement area provides multiple human use services such as trail use and hunting opportunities. This analysis estimates the present value of human use services provided by the Easement (e.g., hiking, bird-watching, biking) by defining the geographic and temporal scope of the analysis, describing funds provided for management and maintenance of the Easement area, discussing baseline conditions, and determining and quantifying the human use service gains expected under the Easement. All values are presented in 2006 dollars.

GEOGRAPHIC SCOPE

The geographic scope of the Easement consists of 2,965.95 acres on Black Oak Ridge, Tennessee, and includes East Black Oak Ridge, West Black Oak Ridge, and McKinney Ridge (DOE 2005). A map of the overall Easement is provided in Chapter 3, Exhibit 3-1.

TEMPORAL SCOPE

Because the terms of the Easement are indefinite (i.e., in perpetuity), the timeframe of the human use gains provided under the Easement are expected to continue from 2006 (first full year after the initiation of the Easement) in perpetuity.

EASEMENT OPERATIONS AND MANAGEMENT

As part of the Easement agreement, DOE has agreed to fund TWRA $20,500 annually for management of the area under the Easement, and to provide $16,000 annually in maintenance and operations services (DOE 2005, Darby 2005). Assuming the Easement and corresponding funding is provided in perpetuity, the present value of these management funds and services is $730,000 using a five percent discount rate.[14]

[14] Because a five percent discount rate was applied in the PWC (2000) estimate of recreational fishing losses in Watts Bar Reservoir, this analysis applies a five percent discount rate to human use service gains under the Easement.

QUANTIFICATION OF HUMAN USE GAINS

Within the area under the Easement, multiple human use services are provided to the public in perpetuity. These services include, but are not limited to, trail use recreation, hunting opportunities, water-based recreation, and groundwater recharge.[15] This analysis quantifies the gains associated with trail use recreation and hunting. For example, existing greenways, patrol roads, and rights-of-ways can be used for hiking, biking, dog walking, bird watching, and wildlife viewing. Upland habitat supports white-tailed deer and turkey populations, which provide for hunting opportunities. Potential benefits to water-based recreation and groundwater recharge are discussed qualitatively. For example, if a canoe trail is developed in the future it may provide fishing and boating opportunities. Quantifiable gains in human use services under the Easement are determined using benefits transfer and are expressed as present value dollars as of 2006.

WHAT IS BENEFITS TRANSFER?

Benefits transfer uses existing values for natural resources and the services these resources provide to calculate the value associated with environmental change. That is, to estimate the value of a change in human use of the environment (e.g., number of hunting trips provided by an area), benefits transfer applies a value of that effect derived from existing empirical studies. There are advantages and limitations to the application of benefits transfer techniques. For example, original studies are time consuming and expensive. Benefits transfer can reduce both the time and funding needed to develop loss estimates for affected activities. However, loss estimates derived using benefits transfer techniques are unlikely to be as accurate as primary research (e.g., some of the site-specific characteristics of the empirical study area and impacted area may be different).

Application of benefits transfer typically includes the following steps:

- Identify and describe the affected activity and population within the assessment area (e.g., users of a particular recreation site).
- Conduct a literature search to identify relevant studies (i.e., studies of a similar activity, population, and assessment area).
- Assess the quality of available studies and their applicability to the affected activity.
- Transfer the benefits estimates to the activity/population within the assessment area using the appropriate methodology.

Because primary research is beyond the scope of this effort, this analysis draws upon existing valuation research performed in other similar resource contexts and combines this information with site-specific data to develop an estimate of recreational gains.

[15] There are cultural and historic resources on Black Oak Ridge but these are not included under the terms of the Easement (DOE 2005).

Four different types of benefits transfers are available: point estimate, benefit function, meta-analysis, and Bayesian techniques (EPA 2000). This analysis uses a point estimate for the value of all activities except biking, which is the result of a meta-analysis.

BASELINE

In order to quantify human use service gains, and therefore scale these gains with losses in recreational and commercial fishing due to contamination, the baseline conditions of the relevant resources and associated services must be established. In this case, baseline is considered to be the level of human use services provided by the Easement area had the Easement not been put in place. Development pressure and infrastructure expansion (e.g., roads, clearings for utility lines) are assumed to severely degrade the area and corresponding services, and private development will likely make the area unavailable to the general public. Therefore, under baseline conditions, the area under the Easement is assumed to provide zero human use services to the general public.

HUNTING

This analysis estimates the value expected to be generated by white-tailed deer and turkey hunting under the Easement in perpetuity.[16] Both deer and turkey hunting are popular activities in the area (Evans 2005). The ORR supports one of the top five deer hunts in the State of Tennessee. Attracted by the size and density of deer in the area, roughly 8,000 to 10,000 people enter the annual lottery for one of the 3,500 ORR hunting permits issued by TWRA. Turkey hunting on ORR is also popular, with 250 permits for ORR issued annually by TWRA (Evans 2005).

Gains in hunting opportunities under the Easement are estimated using a bioeconomic model, which is used to estimate the number of trips based on historic harvests of white-tailed deer and turkey, and the value of a hunting trip, which is based on information in the peer-reviewed literature. This value is then applied to the number of hunting trips (i.e., benefits transfer), and monetary gains are calculated as the total value of all hunting trips expected under the Easement in perpetuity.

Number of Trips

Because the actual number of hunting trips taken on BOR is unknown, a bioeconomic model is used to estimate the number of deer and turkey hunting trips for the area under the Easement. The model uses the average number of harvested white-tailed deer and turkey within the area of the Easement, and the average hunter success rate on ORR to determine the number of trips generated. Results indicate that approximately 267 white-tailed deer-hunting trips and 34 turkey-hunting trips will be taken within the Easement area annually (Exhibit 5-1).

[16] Although the habitat is suitable for other game species, no hunting other than for deer and turkey is allowed (Evans 2005).

EXHIBIT 5-1 ANNUAL DEER AND TURKEY HUNTING TRIPS EXPECTED UNDER THE EASEMENT IN 2006

	YEARS OF HARVEST DATA [1]	CUMULATIVE HARVEST [1]	ANNUAL HARVEST [2]	AVERAGE HUNTING SUCCESS [3]	ANNUAL TRIPS [4]
Deer [5]	1985-2006	842	40	15%	**267**
Turkey	1997-2005	34	5	15%	**34**

Notes:
1. Source: TWRA (2006a, 2006b).
2. Annual Harvest = Cumulative Harvest / Number of years of available data.
3. Source: Evans (2005).
4. Annual Trips = Annual Harvest / Average Hunting Success.
5. Cumulative white-tailed deer harvest totals are provided on a grid of roughly one square mile at http://www.ornl.gov/sci/rmal/deermaps.htm.
6. Calculations may not compute exactly sum due to rounding.

Value Per Trip

To identify an appropriate hunting trip value for white-tailed deer and turkey a review of the economics literature was conducted. The most applicable study for the Black Oak Ridge area is Berrens (2002), which estimates the value of various recreation activities in the southeastern United States. Berrens (2002) forecasted the average per day value (i.e., consumer surplus) of big game hunting (e.g., white-tailed deer and wild turkey) in the southeast to be approximately $46 per day (Exhibit 5-2). This estimate appears reasonable relative to other studies in the literature; for example, Luzar et al. (1992) estimated the value of white-tailed deer hunting in Louisiana Wildlife Management Areas to range from $26 to $101 per trip.

Benefit Determination

To estimate aggregate gains associated with white-tailed deer and turkey hunting under the Easement, the annual estimated number of trips (301 trips) is multiplied by the per day value ($46 per day). The annual estimated benefit generated by these two species is approximately $14,000 (Exhibit 5-2). Annual gains are then estimated in perpetuity from 2006. The present value of these gains is calculated using a five percent discount rate. This discount rate is consistent with the damage calculation.[17] The total present value of hunting gains provided by the Easement is approximately $279,000 (Exhibit 5-2).

[17] Typically a three percent discount rate would be used to estimate the present value of lost or gained services in the context of damage assessment under CERCLA. Using a five percent discount rate decreases future damages. Since the same discount rate is applied to both losses and gains any impacts of using a higher discount rate are expected to be modest.

EXHIBIT 5-2 VALUE OF WHITE-TAILED DEER AND TURKEY HUNTING TRIPS EXPECTED IN THE EASEMENT AREA

SPECIES	ANNUAL HUNTING TRIPS[1]	PER TRIP VALUE[2]	ANNUAL VALUE	TOTAL PRESENT VALUE 2006 - PERPETUITY[3]
White-Tailed Deer	267	$46	$12,400	$247,400
Turkey	34	$46	$1,600	$31,600
Total	**301**	**-**	**$14,000**	**$279,000**

Notes:

1. Sources: TWRA (2006a, 2006b; Evans (2005).
2. Source: Berrens (2002).
3. Present Value = Annual Value / Discount Rate (for human use services the discount rate is five percent).
4. Total may not sum due to rounding.

TRAIL USE

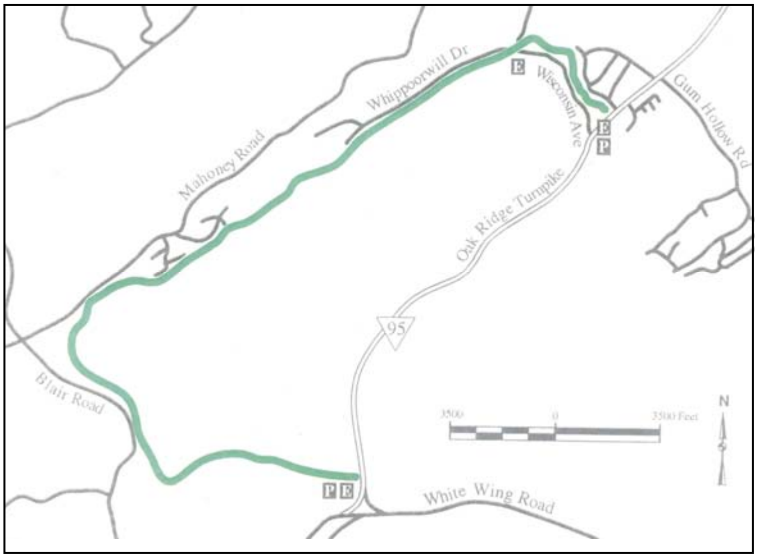
Under the Easement, the public has opportunities to participate in recreational activities such as hiking, biking, dog walking, bird watching, and wildlife viewing on BOR. Two greenways are currently located within or adjacent to the Easement area, the North Boundary and Wheat District Greenways, and existing patrol roads and right-of-ways are in the process of being converted to recreational trails.

The North Boundary Greenway is a gravel trail that borders the northern edge of the eastern segment of the Easement (Exhibit 5-3; Greenways Oak Ridge 2002). Approximately 10.3 miles one way (i.e., not a continuous loop), this greenway passes through ridgetop woodlands, karst bluffs covered in mountain laurel, and creek-side habitats (Robbins 2005). The Wheat District Greenway is approximately 1.2 miles (one way), and passes through the McKinney Ridge portion of the Easement. Walking, jogging, bicycling, and pets are allowed on both greenways (Greenways Oak Ridge 2002).

Potential expansions of the greenway system that would provide additional recreational opportunities for visitors include the following:

- Extend the North Boundary Greenway through the southern end of East BOR to create a loop trail (Greenways Oak Ridge 2005).
- Create a trail through the middle of the East BOR to complete a short loop trail (Greenways Oak Ridge 2005).
- Extend the Wheat District Greenway to meet the North Boundary Greenway through the McKinney Ridge portion of the Easement (Greenways Oak Ridge 2005).

EXHIBIT 5-3 MAP OF NORTH BOUNDARY GREENWAY (GREENWAYS OAK RIDGE 2002)



- Convert the power line access road in the McKinney Ridge section to a mountain bike trail (Dunigan 2005).
- Allow public access in the western section of the BOR Easement area (Robbins 2005, Smith 2005).
- Develop the existing patrol road in West BOR into a public use trail.

Site specific data on the number of trail users within the Easement area and the value of trail use are not currently available. Therefore, relevant information from the literature was used to estimate: 1) the amount and types of trips likely to be taken on the trails within and adjacent to the Easement area, and 2) the value of a trip in 2006 dollars. Using benefits transfer, this analysis combines the estimated number of trail-based recreation trips taken within the Easement area with an estimated value of a trail recreation trip to determine the monetary benefit gained through use of trails associated with the Easement.

Number of Trips Taken

Count data on the number of hikers, walkers, bikers, bird watchers, and wildlife viewers to the Easement area are not available. Therefore, the number of trips likely to occur within the Easement area is estimated based on the number of visits taken to a Tennessee State Park with similar attributes, Frozen Head State Park. Located in Eastern Tennessee near Wartburg, Frozen Head State Park is less than 25 miles from Oak Ridge, and has similar terrain and habitats. However, Frozen Head State Park provides more amenities to visitors than the BOR Easement area. As shown in Exhibit 5-4, of the six types of amenities provided by Frozen Head State Park, the area of BOR within the Easement provides only two (i.e., one-third): hiking trails and designated state natural area.

Therefore, this analysis assumes that total visitation to the Easement area will likely be one-third of the visitation to Frozen Head State Park. The average annual visitation at Frozen Head State Park from July 2003 through June 2006 is approximately 134,593, or 11.3 people per acre per year (Tennessee State Parks 2006). The annual number of visitors to the BOR Easement area is calculated as follows:

Acres under the Easement	X	Frozen Head Visitors per Acre	X	% Attributes Available	=	Annual Easement Area Visits
2,966		11.3		33%		11,093

Therefore, this analysis estimates that approximately 11,093 visits will be taken to the Easement area in 2006.[18] This annual number of trips is then assumed to increase at the same rate as the surrounding population, in this case 0.3 percent per year (Tennessee Department of Health 2003).[19]

EXHIBIT 5-4 COMPARISON OF AMENITIES IN FROZEN HEAD STATE PARK TO THE BLACK OAK RIDGE CONSERVATION EASEMENT AREA

AMENITIES	FROZEN HEAD STATE PARK[1]	BLACK OAK RIDGE CONSERVATION EASEMENT
Size	11,876 acres	2,966 acres
Camping	19 developed campsites, 11 backcountry campsites, one overflow campground for large groups, one bath house.	None.
Hiking Trails	20 trails combined for over 50 miles, featuring waterfalls, giant sandstone rock formations, bluffs, abundant wildlife and 14 mountain peaks over 3,000 feet in elevation.	Two existing greenways combined for 11.5 miles. Three potential trails, which would increase total mileage to 20.
Horseback Riding	One 6.9 mile trail	Unlikely horseback riding will be allowed.
Picnic Facilities	32 picnic sites that include grills and tables, four group shelters, two playgrounds, restrooms.	None.
Fishing	Mountain stream fishing for rainbow trout.	Fish consumption advisory on East Fork Poplar and Poplar Creeks and Clinch River.
Designated State Natural Area	11,546 acres of relatively undisturbed forest.	2,929 acres.
Source: Tennessee State Parks (2006).		

[18] Equation may not compute exactly due to rounding.

[19] The population of Anderson and Roane Counties are forecast to increase on average 0.3 percent annually (Tennessee Department of Health 2003).

As discussed above, this analysis estimates that 11,093 total recreational trips will be taken within the Easement area in 2006. These trips are likely to include hiking, walking, biking, bird watching, and wildlife viewing recreation. Because site-specific participation numbers for each of these activities are not available, participation for 2006 is estimated according to participation rates reported for the State of Tennessee in the Tennessee State Recreation Plan 2003-2008 (Gardner 2004). Future annual trips are estimated to increase at the same rate as regional population growth (0.3 percent per year; Tennessee Department of Health 2003). Trail use visitation is then estimated based on a weighted average of participation in the activities available on the Easement (Exhibit 5-5):

- *Walking*. Walking will likely be a popular activity within the Easement area, since approximately 81 percent of Tennessee residents participate in walking for pleasure (Gardner 2004). With a weighted participation of 37 percent, approximately 4,100 walking trips are expected to be taken within the Easement area in 2006, increasing 0.3 percent annually.

- *Hiking.* Approximately 34 percent of Tennessee residents participate in day hiking (Gardner 2004). With a weighted participation of 15 percent, approximately 1,700 day trips are expected to be taken within the Easement area in 2006, increasing at 0.3 percent annually.

- *Biking*. Biking is permitted on greenways and is a popular activity in the area. Gardner (2004) found that approximately 29 percent of Tennessee residents participated in biking. With a weighted participation of 13 percent, approximately 1,500 biking trips are expected to be taken within the Easement area in 2006, increasing 0.3 percent annually.

- *Bird watching*. Bird watching trips to the North Boundary Greenway and the Easement have been led by the Knoxville Chapter of the Tennessee Ornithological Society, and the American Museum of Science and Energy in conjunction with ORNL and TWRA (Joslin 2005, Evans 2005). Bird watching trips are taken in the fall, winter, and/or spring and typically attract between 25 and 40 birdwatchers. Beyond these sponsored trips it is unknown how many people participate in bird watching within the Easement area. Gardner (2004) found that approximately 32 percent of Tennessee residents participated in viewing and/or photographing birds. With a weighted participation of 14 percent, approximately 1,600 bird watching trips are expected to be taken within the Easement area in 2006, increasing 0.3 percent annually.

- *Wildlife viewing.* It is likely that visitors to the Easement area participate in wildlife viewing activities. Gardner (2004) found that approximately 45 percent of Tennesseans participated in viewing and/or photographing wildlife other than birds. With a weighted participation of 20 percent, approximately 2,300 wildlife viewing trips are expected to be taken within the Easement area in 2006, increasing 0.3 percent annually.

EXHIBIT 5-5 **SUMMARY OF EXPECTED PARTICIPATION IN BOR TRAIL ACTIVITIES**

ACTIVITY	TENNESSEAN PARTICIPATION RATE [1]	WEIGHTED PARTICIPATION [2]	ANNUAL NUMBER OF TRIPS EXPECTED PER ACTIVITY [3]
Walking	80.9%	37%	4,100 - 15,700
Hiking	34.2%	15%	1,700 - 6,600
Biking	29.1%	13%	1,500 - 5,600
Bird Watching	31.6%	14%	1,600 - 6,100
Wildlife Viewing	45.3%	20%	2,300 - 8,800
Total [4]	**221.1%**	**100%**	**11,100 - 42,800**

Notes:

1. Source: Gardner (2004).
2. Weighted participation is based on the proportional percentage of each activity to the total percentage of participation in all activities. (Weighted Participation = Tennessean Participation Rate for each Activity / Total Participation over all Activities).
3. Number of Trips per Activity = (Weighted Participation x Total Number of Trips). This range represents the annual number of trips expected to be taken within the Easement area from 2006 into perpetuity. The annual number of visitors is expected to increase at the same rate as regional population growth.
4. Totals may not sum due to rounding.

Value of Trail Use Trips

To identify appropriate values for walking, hiking, biking, and bird watching and wildlife viewing trips, a brief review of the economics literature was conducted. The Berrens (2002) study, discussed above, estimated the value of various recreation activities in the southeastern United States, including hiking and wildlife viewing. Hiking in the southeast is estimated to have a median value (i.e., consumer surplus) of $22 per day (Exhibit 5-6),[20] while wildlife viewing, including bird watching, is estimated to have an average value of $38 per day (Berrens 2002; Exhibit 5-6). The value of a biking trip is based on an analysis by Rosenberger and Loomis (2001), and is estimated at $14 per day.[21] Because no value for walking is reported in these studies, this analysis estimates that walkers likely spend half a day or less within the Easement area. Therefore, their per

[20] The median value of hiking is used in this analysis, rather than the mean, to reduce the effect of outlier observations. The range of the five southeastern hiking values was $2 to $283, with a median of $23 and a mean of $80 (2006$).

[21] Rosenberger and Loomis (2001) conducted a meta-analysis of the value of biking in the southeast United States based on studies from across the country. Berrens (2002) built on the work of Rosenberger and Loomis (2001) by estimating activity values for the southeast based only on studies conducted in the southeast. For most activities, the values generated by Berrens (2002) are more applicable to BOR than those estimated by Rosenberger and Loomis (2001). In the case of biking, however, only one study in the southeast was available (a study of walking and bicycling on a rail trail in northern Florida (Siderelis and Moore, 1995)), and it is not considered appropriate for transfer to BOR. Therefore, the $14 per trip value (2006$) reported in Rosenberger and Loomis (2001) is applied in this analysis.

day value for walking (which includes activities such as dog walking) is approximately half of the value estimated for a hiking day, or $11 per day.

Benefit Determination

To estimate the aggregate gains associated with trail use within the Easement area, the valuation estimates for walking, hiking, biking, bird watching, and wildlife viewing trips are multiplied by the number of trips taken for each activity. Results indicate that the annual value of all recreational trail use activities ranges from $249,000 in 2006 to $959,000 in 2406 (2006$); Exhibit 5-6, Appendix E).[22]

EXHIBIT 5-6 **VALUE OF FORECAST RECREATIONAL TRAIL USE ACTIVITIES WITHIN THE BLACK OAK RIDGE EASEMENT AREA (2006$)**

ACTIVITY	ANNUAL NUMBER OF TRIPS (2006-PERPETUITY) [1]	VALUE PER TRIP [2]	ANNUAL VALUE (2006-PERPETUITY) [3]	TOTAL PRESENT VALUE 2006 - PERPETUITY
Walking	4,100 - 15,700	$11.21	$46,000 - $176,000	$2,044,500
Hiking	1,700 - 6,600	$22.42	$38,100 - $148,000	$864,300
Biking	1,500 - 5,600	$13.50	$20,300 - $75,600	$735,400
Bird Watching	1,600 - 6,100	$37.55	$60,100 - $229,100	$798,600
Wildlife Viewing	2,300 - 8,800	$37.55	$86,400 - $330,400	$1,144,800
Total	**11,200 - 42,800**	**-**	**$249,000 - $959,000**	**$5,587,600**

Notes:

1. Range represents annual number of trips forecast from 2006 in perpetuity. The annual number of trips is expected to increase at the same rate as regional population growth, an average of 0.3 percent per year (Tennessee Department of Health 2003).
2. Source: Berrens (2002) except for biking, which is from Rosenberger and Loomis (2001).
3. Range represents annual value of trips from 2006 in perpetuity and reflects modeled increase in the number of trips per year based on the rate of regional population growth.
4. Totals may not sum due to rounding.

Annual gains are then summed over the relevant time period. Future gains are calculated in perpetuity from 2006. Consistent with the calculation of human use damages, present value is calculated using a five percent discount rate.[23] The total present value of trail use gains associated with the Easement is approximately $5.6 million (Exhibit 5-6).

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[22] Gains under the Easement are expected to continue in perpetuity. However, because a discount rate is applied to future services, eventually (e.g., by 2406) the present value of those services is effectively zero.

[23] Typically a three percent discount rate would be used to estimate the present value of lost or gained services in the context of a damage assessment under CERCLA. Using a five percent discount rate decreases future damages. Since the same discount rate is applied to both losses and gains any impacts of this assumption are expected to be modest.

WATER RECREATION

One potential long-term goal under the Easement is development of a canoe trail, which could provide fishing, boating, and other water-based recreation opportunities on East Fork Poplar Creek, Poplar Creek, and the Clinch River. However, these opportunities are currently limited by fish consumption and water contact advisories (Exhibit 5-7). In addition, although some people access East Fork Poplar and Poplar Creeks by boat, there is no existing public access (e.g., boat launches) to these waterbodies from the Easement area (Evans 2005). Because of the setting (i.e., flat water in the creeks, undeveloped area), removal of advisories, establishment of a canoe trail, and/or increased public access could increase the popularity of boating and fishing activities. Available data are insufficient to quantify any potential public gains from these possible activities.

EXHIBIT 5-7 CURRENT ADVISORIES ON STREAMS ASSOCIATED WITH THE BLACK OAK RIDGE CONSERVATION EASEMENT

STREAM	CONTAMINANT	FISH ADVISORIES	WATER CONTACT ADVISORIES
East Fork Poplar Creek	Mercury, PCBs	Fish should not be eaten.	Avoid contact with water.
Poplar Creek	Mercury, PCBs	Fish should not be eaten.	Avoid contact with water.
Clinch River Arm of Watts Bar Reservoir	PCBs	Striped bass should not be eaten. Precautionary advisory for catfish and sauger.	None.
Tennessee River Portion of Watts Bar Reservoir	PCBs	Catfish, striped bass, hybrid striped bass, and white bass should not be eaten. Precautionary advisory for sauger, carp, small mouth buffalo, and largemouth bass.	None.

Source: TWRA (2005).

GROUNDWATER RECHARGE

The Easement area provides groundwater recharge gains to the surrounding terrain, filtering water entering East Fork Poplar Creek, Poplar Creek, and the Clinch River, and recharging private drinking water wells along Blair Road (Gilmore 2005). However, any groundwater recharge gains due to the Easement are likely to be modest. A small number of homes obtain drinking water from private wells likely to be impacted by the Easement, and a fraction, 25 to 30 percent, of the well water may be generated by the Easement area (Gilmore 2005). Most public water supplies for the surrounding communities are derived from sources unaffected by the Easement area. For example, the public water in the Blair Road area comes from Oliver Springs; the City of Oak Ridge obtains water from the Clinch River at the Melton Hill Reservoir, upstream of the

Easement area; and Rarity Ridge gets drinking water from the Cumberland Utility District, which obtains water from an intake on the Emory River. Therefore, no gains associated with groundwater recharge are included in this analysis.

SUMMARY

This analysis estimates the Easement generates approximately $0.28 million in gains from hunting and approximately $5.6 million in gains from trail use recreation, in addition to the approximate $0.41 million DOE is providing for human use management and $0.32 million for maintenance of the Easement. Total gains, therefore, are approximately $6.6 million (Exhibit 5-8). Additional gains may be generated from future water-based recreation, but information currently available is insufficient to quantify those gains.

EXHIBIT 5-8 SUMMARY OF HUMAN USE SERVICE GAINS UNDER THE EASEMENT

HUMAN USE SERVICE	PRESENT VALUE (2006$)
Management	$410,000
Maintenance	$320,000
Hunting	$279,000
Trail Use	$5,588,00
Water Recreation	Unknown
Groundwater Recharge	None
Total	**$6,597,000**
Note: Totals may not sum due to rounding.	

UNCERTAINTY

These estimates of gains in human use services are sensitive to the assumptions and methodologies applied in the sections above. Changes in these or other aspects of the analysis, some of which are described below, could alter the results. In addition, while results are subject to some uncertainty, this analysis incorporates the best available data and utilizes commonly applied techniques.

Baseline

As described earlier, if the Easement were not in place, development pressure and infrastructure expansion (e.g., roads, clearings for utility lines) are assumed to severely degrade the area under the Easement. Therefore, under baseline conditions, the Easement area is assumed to provide zero human use services. Because it is unlikely that the entire Easement area would be completely developed tomorrow, this scenario is more likely to underestimate than overestimate baseline services (and therefore overestimate rather than underestimate human use service gains from the Easement).

Number of Trips

Site-specific data on the number of trail use and hunting trips to the Easement area are not available. Therefore, the number of hunting trips is derived using a bioeconomic model and the numbers of various trail use trips are derived using a study of Tennessee state-wide participation in various recreational activities. These estimates may not accurately reflect site-specific conditions or public preferences, and may therefore over- or under-estimate the number of trips on BOR.

Benefits Transfer Value

Site-specific values for an activity expected to occur under the Easement (e.g., hiking or hunting) are not available. Use of a value from the literature may not accurately reflect site-specific conditions or preferences of the relevant population. For example, the values applied in this analysis for hiking, bird-watching, etc. were derived for the entire southeastern United States, and the value for biking is estimated based on information from across the country. Application of these types of general values may lead to an over- or under-estimate of gains under the Easement.

Future Trips

Because the Easement will be in place in perpetuity, this analysis forecasts the number of trail use and hunting trips expected to be taken in the future by assuming that the number of trips increases at a rate equal to the annual rate of population growth in the region. Recreational behavior, however, is unpredictable, more so in future generations (e.g., future generations may choose to hike more or less). Therefore, the rate of increase in the number of trips applied here may over- or under-estimate future trips.

Non-use Values

This analysis does not consider the non-use value of the continued existence of natural resources within the Easement area (e.g., the existence value of trails to people who may not actually hike), and is therefore likely to understate the benefit of the Easement.

CHAPTER 6 | COMPARISON OF NATURAL RESOURCE LOSSES AND GAINS

In order to evaluate the sufficiency of the Black Oak Ridge conservation easement as compensation for natural resource damages in Watts Bar Reservoir, this chapter compares the ecological and human use services lost in Watts Bar Reservoir due to contamination from the Site with the gains in services provided under the Easement. Losses include degradation of ecological services (Chapter 2), prevention of recreational fishing opportunities as estimated in PWC (2000), and potential losses in commercial fishing (Chapter 4). Gains under the Easement include the continued provision of ecological habitat services on Black Oak Ridge (Chapter 3), as well as recreational use of the Easement area (e.g., hiking, biking, bird-watching) in perpetuity (Chapter 5).

Exhibit 6-1 summarizes these losses and gains, and indicates that both the acre-years of ecological habitat services and the dollar value of human use services provided under the Easement are sufficient to compensate for damages to natural resources in Watts Bar Reservoir. Although there is uncertainty surrounding each of these estimates individually, as described in previous chapters, as well as within the comparison itself (e.g., the ecological services provided by aquatic and upland habitat are assumed to be equal), this analysis incorporates the best available data and utilizes commonly applied techniques.

In addition, the ecological services provided by the Easement are more than twice the acre-years required to compensate for losses in Watts Bar Reservoir. It is likely that even if the assumptions underlying the estimate of gains were adjusted, the ecological credit would still out-weigh the loss.

EXHIBIT 6-1 PRESENT VALUE LOSSES AND GAINS OF NATURAL RESOURCE SERVICES[1]

	PRESENT VALUE OF ECOLOGICAL SERVICES (ACRE-YEARS)		PRESENT VALUE OF HUMAN USE SERVICES	
Loss Due to Site-Related Contamination in Watts Bar Reservoir	Aquatic Habitat [2]	147,968 – 181,491	Recreational Fishing[3]	$6,643,000 - $9,964,000
			Commercial Fishing	$198,700
Gains Under the Easement on Black Oak Ridge	Upland Forested Habitat	441,094	Management Maintenance Hunting Trail Use	$6,597,000

Notes:

1. Present value is estimated in 2006.
2. Range of ecological losses reflects the six to nine percent range in allocation of contaminants to the Site (PWC 2000), and the range in potential future contamination between full recovery to baseline in 100 years and no recovery in perpetuity.
3. The Trustees have previously agreed that recreational fishing losses in Watts Bar Reservoir due to contaminant releases from ORR range from approximately $6.6 million to $10.0 million (2006$; PWC 2000). Range reflects the six to nine percent allocation of contaminants to the Site.

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EXHIBIT A-1 PCB AND MERCURY CONCENTRATIONS IN WATTS BAR RESERVOIR SOIL

YEAR	NUMBER OF SAMPLES: PCBS	MEAN TOTAL PCB CONCENTRATION IN SOIL (MG/KG)	NUMBER OF SAMPLES: MERCURY	MEAN MERCURY CONCENTRATION IN SOIL (MG/KG)
1983	1	35.0	1	5.6
1984	14	0.7	39	2.2
1990	77	32.3	82	1.5
1991	2	0.7	4	0.4
1992	2	0.7	2	0.6
1993	11	0.2	17	0.3
1996	-	-	5	2.7
Average		**11.6**		**1.9**

Notes:
-- = No data available.
Source: OREIS (2005).

EXHIBIT A-2 PCB AND MERCURY CONCENTRATIONS IN WATTS BAR RESERVOIR FISH

YEAR	NUMBER OF SAMPLES: PCBS	MEAN TOTAL PCB CONCENTRATION IN FISH (MG/KG)	NUMBER OF SAMPLES: MERCURY	MEAN MERCURY CONCENTRATION IN FISH (MG/KG)
1991	6	2.0	-	-
1993	56	1.0	80	0.2
1998	7	0.6	7	0.2
1999	9	0.5	6	0.3
2000	4	0.9	2	0.1
2002	4	2.3	4	0.1
Average		**1.2**		**0.2**

Notes:

-- = No data available.

Source: OREIS (2005).

Research indicates that the public places a different value on environmental services available today versus these same services in the past or in the future. Typically, services have a higher equivalent present value if received in the past and have a lower equivalent present value if received in the future (i.e., the public would rather have services yesterday than today, and would rather have them today than tomorrow; Unsworth and Bishop 1994). Therefore, to place past and future services in equivalent terms, past services are compounded forward and future services are discounted back to their present value.

The rate at which services are compounded and discounted is the social discount rate. While there is some debate in the economics community regarding the true social discount rate, a rate of two to three percent is considered appropriate for discounting streams of environmental benefits, at least where the stream of benefits and costs accrue to people in the same generation (Freeman 1993). In addition, NOAA (1999) recommends a three percent discount rate for HEA applications. Based on this information, additional review of the economics literature, and experience in other damage assessments, a discount rate of three percent is applied in this case to ecological services. Note, however, that a five percent discount rate is applied to the human use service gains estimated in this analysis in order to be consistent with previous assessments of human use service losses (i.e., PWC 2000). By applying the same discount rate to evaluate service losses and gains, the impact of this higher discount rate is expected to be minimal.

Therefore, the present value of ecological service losses over time is calculated (and then summed across years) as:

$$\text{Present Value (PV)} = [(\text{Impacted Area}) * (\text{Percentage Services Lost in Year X} * ((1 + \text{Discount Rate})^{(\text{Present Year} - \text{Year X})})].$$

For example:

$$\text{PV losses for aquatic habitat in 1981} = [(\text{Impacted Area} * \text{Percentage Service Loss in 1981} * 1.03^{(2004-1981)}].$$

Correspondingly, if ecological service gains (i.e., through restoration) are provided for a finite period of time, the present value of these additional services are calculated for each year as:

$$\text{Present Value (PV)} = [(\text{Restored Area}) * (\text{Percentage Services Gained in Year X} * ((1 + \text{Discount Rate})^{(\text{Present Year} - \text{Year X})})].$$

For example:

$$\text{PV gains from aquatic habitat provided in 2006} = [(\text{Impacted Area} * \text{Percentage Service Loss in 1981} * 1.03^{(2004-2006)}]$$

Note, however, that the gains from restoration projects are often expected to be provided in perpetuity. This allows the number of compensatory acres to be calculated as:

Acre-years of habitat lost * Discount rate = Acres of equivalent, fully functional habitat provided for today in perpetuity

For example:

100 acre-years of habitat lost * 3% = 3 acres of equivalent, fully functional habitat starting today and provided in perpetuity

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APPENDIX C. PRESENT VALUE LOST ACRE-YEARS OF ECOLOGICAL SERVICES UNDER TWO RECOVERY SCENARIOS

EXHIBIT C-1 PRESENT VALUE LOST ACRE-YEARS IN WATTS BAR LAKE DUE TO MERCURY AND SIX PERCENT OF MEASURED PCB CONCENTRATIONS

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
1981	2,424	5,076	2,424	5,076
1982	2,424	4,928	2,424	4,928
1983	2,424	4,784	2,424	4,784
1984	2,424	4,645	2,424	4,645
1985	2,424	4,510	2,424	4,510
1986	2,424	4,378	2,424	4,378
1987	2,424	4,251	2,424	4,251
1988	2,424	4,127	2,424	4,127
1989	2,424	4,007	2,424	4,007
1990	2,424	3,890	2,424	3,890
1991	2,424	3,777	2,424	3,777
1992	2,424	3,667	2,424	3,667
1993	2,424	3,560	2,424	3,560
1994	2,424	3,456	2,424	3,456
1995	2,424	3,356	2,424	3,356
1996	2,424	3,258	2,424	3,258
1997	2,424	3,163	2,424	3,163
1998	2,424	3,071	2,424	3,071
1999	2,424	2,981	2,424	2,981
2000	2,424	2,895	2,424	2,895
2001	2,424	2,810	2,424	2,810
2002	2,424	2,728	2,424	2,728
2003	2,424	2,649	2,424	2,649
2004	2,424	2,572	2,424	2,572
2005	2,424	2,497	2,424	2,497
2006	2,424	2,424	2,424	2,424
2007	2,400	2,330	2,424	2,354
2008	2,376	2,239	2,424	2,285
2009	2,351	2,152	2,424	2,219
2010	2,327	2,068	2,424	2,154
2011	2,303	1,987	2,424	2,091

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2012	2,279	1,908	2,424	2,030
2013	2,255	1,833	2,424	1,971
2014	2,230	1,761	2,424	1,914
2015	2,206	1,691	2,424	1,858
2016	2,182	1,623	2,424	1,804
2017	2,158	1,559	2,424	1,751
2018	2,133	1,496	2,424	1,700
2019	2,109	1,436	2,424	1,651
2020	2,085	1,378	2,424	1,603
2021	2,061	1,323	2,424	1,556
2022	2,036	1,269	2,424	1,511
2023	2,012	1,217	2,424	1,467
2024	1,988	1,168	2,424	1,424
2025	1,964	1,120	2,424	1,382
2026	1,939	1,074	2,424	1,342
2027	1,915	1,029	2,424	1,303
2028	1,891	987	2,424	1,265
2029	1,867	946	2,424	1,228
2030	1,842	906	2,424	1,193
2031	1,818	868	2,424	1,158
2032	1,794	832	2,424	1,124
2033	1,770	797	2,424	1,091
2034	1,745	763	2,424	1,060
2035	1,721	730	2,424	1,029
2036	1,697	699	2,424	999
2037	1,673	669	2,424	970
2038	1,648	640	2,424	941
2039	1,624	612	2,424	914
2040	1,600	586	2,424	887
2041	1,576	560	2,424	862
2042	1,552	535	2,424	836
2043	1,527	512	2,424	812
2044	1,503	489	2,424	788
2045	1,479	467	2,424	765
2046	1,455	446	2,424	743
2047	1,430	426	2,424	722
2048	1,406	406	2,424	701

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2049	1,382	388	2,424	680
2050	1,358	370	2,424	660
2051	1,333	353	2,424	641
2052	1,309	336	2,424	622
2053	1,285	320	2,424	604
2054	1,261	305	2,424	587
2055	1,236	290	2,424	570
2056	1,212	276	2,424	553
2057	1,188	263	2,424	537
2058	1,164	250	2,424	521
2059	1,139	238	2,424	506
2060	1,115	226	2,424	491
2061	1,091	215	2,424	477
2062	1,067	204	2,424	463
2063	1,042	193	2,424	450
2064	1,018	183	2,424	437
2065	994	174	2,424	424
2066	970	165	2,424	411
2067	945	156	2,424	399
2068	921	147	2,424	388
2069	897	139	2,424	377
2070	873	132	2,424	366
2071	848	124	2,424	355
2072	824	117	2,424	345
2073	800	110	2,424	335
2074	776	104	2,424	325
2075	752	98	2,424	315
2076	727	92	2,424	306
2077	703	86	2,424	297
2078	679	81	2,424	289
2079	655	76	2,424	280
2080	630	71	2,424	272
2081	606	66	2,424	264
2082	582	62	2,424	256
2083	558	57	2,424	249
2084	533	53	2,424	242
2085	509	49	2,424	235

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2086	485	46	2,424	228
2087	461	42	2,424	221
2088	436	39	2,424	215
2089	412	35	2,424	208
2090	388	32	2,424	202
2091	364	29	2,424	197
2092	339	27	2,424	191
2093	315	24	2,424	185
2094	291	22	2,424	180
2095	267	19	2,424	175
2096	242	17	2,424	170
2097	218	15	2,424	165
2098	194	13	2,424	160
2099	170	11	2,424	155
2100	145	9	2,424	151
2101	121	7	2,424	146
2102	97	6	2,424	142
2103	73	4	2,424	138
2104	48	3	2,424	134
2105	24	1	2,424	130
2106	0	0	2,424	126
Past Loss (1981-2006) [2]		**93,461**		**93,461**
Future Loss (2007-2106) [2]		**54,507**		**76,603**
Total Loss (1981-2106) [2]		**147,968**		**170,064**

Notes:

1. Present Value is 2006.
2. Totals may not sum due to rounding.

EXHIBIT C-2 PRESENT VALUE LOST ACRE-YEARS IN WATTS BAR LAKE DUE TO MERCURY AND NINE PERCENT OF MEASURED PCB CONCENTRATIONS

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
1981	2,587	5,417	2,587	5,417
1982	2,587	5,259	2,587	5,259
1983	2,587	5,106	2,587	5,106
1984	2,587	4,957	2,587	4,957
1985	2,587	4,813	2,587	4,813
1986	2,587	4,673	2,587	4,673
1987	2,587	4,537	2,587	4,537
1988	2,587	4,404	2,587	4,404
1989	2,587	4,276	2,587	4,276
1990	2,587	4,152	2,587	4,152
1991	2,587	4,031	2,587	4,031
1992	2,587	3,913	2,587	3,913
1993	2,587	3,799	2,587	3,799
1994	2,587	3,689	2,587	3,689
1995	2,587	3,581	2,587	3,581
1996	2,587	3,477	2,587	3,477
1997	2,587	3,376	2,587	3,376
1998	2,587	3,277	2,587	3,277
1999	2,587	3,182	2,587	3,182
2000	2,587	3,089	2,587	3,089
2001	2,587	2,999	2,587	2,999
2002	2,587	2,912	2,587	2,912
2003	2,587	2,827	2,587	2,827
2004	2,587	2,745	2,587	2,745
2005	2,587	2,665	2,587	2,665
2006	2,587	2,587	2,587	2,587
2007	2,561	2,487	2,587	2,512
2008	2,535	2,390	2,587	2,439
2009	2,509	2,297	2,587	2,368
2010	2,484	2,207	2,587	2,299
2011	2,458	2,120	2,587	2,232
2012	2,432	2,037	2,587	2,167
2013	2,406	1,956	2,587	2,104
2014	2,380	1,879	2,587	2,042

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2015	2,354	1,804	2,587	1,983
2016	2,328	1,733	2,587	1,925
2017	2,303	1,663	2,587	1,869
2018	2,277	1,597	2,587	1,815
2019	2,251	1,533	2,587	1,762
2020	2,225	1,471	2,587	1,710
2021	2,199	1,411	2,587	1,661
2022	2,173	1,354	2,587	1,612
2023	2,147	1,299	2,587	1,565
2024	2,121	1,246	2,587	1,520
2025	2,096	1,195	2,587	1,475
2026	2,070	1,146	2,587	1,432
2027	2,044	1,099	2,587	1,391
2028	2,018	1,053	2,587	1,350
2029	1,992	1,009	2,587	1,311
2030	1,966	967	2,587	1,273
2031	1,940	927	2,587	1,236
2032	1,914	888	2,587	1,200
2033	1,889	850	2,587	1,165
2034	1,863	814	2,587	1,131
2035	1,837	779	2,587	1,098
2036	1,811	746	2,587	1,066
2037	1,785	714	2,587	1,035
2038	1,759	683	2,587	1,005
2039	1,733	654	2,587	975
2040	1,707	625	2,587	947
2041	1,682	598	2,587	919
2042	1,656	571	2,587	893
2043	1,630	546	2,587	867
2044	1,604	522	2,587	841
2045	1,578	498	2,587	817
2046	1,552	476	2,587	793
2047	1,526	454	2,587	770
2048	1,501	434	2,587	748
2049	1,475	414	2,587	726
2050	1,449	395	2,587	705
2051	1,423	376	2,587	684

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2052	1,397	359	2,587	664
2053	1,371	342	2,587	645
2054	1,345	326	2,587	626
2055	1,319	310	2,587	608
2056	1,294	295	2,587	590
2057	1,268	281	2,587	573
2058	1,242	267	2,587	556
2059	1,216	254	2,587	540
2060	1,190	241	2,587	524
2061	1,164	229	2,587	509
2062	1,138	217	2,587	494
2063	1,112	206	2,587	480
2064	1,087	196	2,587	466
2065	1,061	185	2,587	452
2066	1,035	176	2,587	439
2067	1,009	166	2,587	426
2068	983	157	2,587	414
2069	957	149	2,587	402
2070	931	140	2,587	390
2071	905	133	2,587	379
2072	880	125	2,587	368
2073	854	118	2,587	357
2074	828	111	2,587	347
2075	802	104	2,587	337
2076	776	98	2,587	327
2077	750	92	2,587	317
2078	724	86	2,587	308
2079	699	81	2,587	299
2080	673	75	2,587	290
2081	647	70	2,587	282
2082	621	66	2,587	274
2083	595	61	2,587	266
2084	569	57	2,587	258
2085	543	53	2,587	250
2086	517	49	2,587	243
2087	492	45	2,587	236
2088	466	41	2,587	229

YEAR	RECOVERY TO BASELINE		NO RECOVERY	
	LOST ACRES	PRESENT VALUE LOST ACRES [1]	LOST ACRES	PRESENT VALUE LOST ACRES [1]
2089	440	38	2,587	222
2090	414	35	2,587	216
2091	388	31	2,587	210
2092	362	29	2,587	204
2093	336	26	2,587	198
2094	310	23	2,587	192
2095	285	20	2,587	186
2096	259	18	2,587	181
2097	233	16	2,587	176
2098	207	14	2,587	171
2099	181	12	2,587	166
2100	155	10	2,587	161
2101	129	8	2,587	156
2102	103	6	2,587	152
2103	78	4	2,587	147
2104	52	3	2,587	143
2105	26	1	2,587	139
2106	0	0	2,587	135
Past Loss (1981-2006) [2]		**99,741**		**99,741**
Future Loss (2007-2106) [2]		**58,170**		**81,750**
Total Loss (1981-2106) [2]		**157,911**		**181,491**

Notes:

1. Present Value is 2006.
2. Totals may not sum due to rounding.

APPENDIX D. THREATENED AND ENDANGERED SPECIES

DEFINITION

Federal

Under the Federal Endangered Species Act, the term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range (ESA 1973 Section 3 (6)), and the term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (ESA 1973 Section 3 (19)).

State

Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974, an "endangered species" is any species or subspecies of wildlife whose prospects of survival or recruitment within the state are in jeopardy or are likely within the foreseeable future to become so due to any of the following factors: (i) the destruction, drastic modification, or severe curtailment of its habitat; (ii) its overutilization for scientific, commercial or sporting purposes; (iii) the effect on it of disease, pollution, or predation; (iv) other natural or man-made factors affecting its prospects of survival or recruitment within the state; or (v) any combination of the foregoing factors; or (B) Any species or subspecies of fish or wildlife appearing on the United States' List of Endangered Native Fish and Wildlife as it appears on April 5, 1974 (Part 17 of Title 50, CFR, Appendix D), as well as any species or subspecies of fish and wildlife appearing on the United States' List of Endangered Foreign Fish and Wildlife (Part 17 of Title 50, CFR, Appendix A), as such list may be modified hereafter (TN WCSA 1974 70-8-103.3). "Threatened" means any species or subspecies of wildlife which is likely to become an endangered species within the foreseeable future (TN WCSA 1974 70-8-103.10).

EXHIBIT D-1 ANIMALS OF CONSERVATION CONCERN ON THE OAK RIDGE RESERVATION (SAIC 2002)

COMMON NAME	SCIENTIFIC NAME	FEDERAL STATUS	STATE STATUS
Fine-rayed pigtoe	*Fusconaia cuneolus*	E	E
Shiny pigtoe	*Fusconaia edgariana*	E	E
Spiny riversnail	*Io fluvialis*	C	NL
Pink mucket	*Lampsilis abrupta*	E	E
Orangefoot pimpleback	*Plethobasus cooperianus*	E	E
Pyramid pigtoe	*Leurobema rubrum*	C	NL
Rough rabbitsfoot	*Quadrula cylindricala strigillata*	NL	NL
Birds			
Cooper's hawk	*Accipiter cooperianus*	NL	D
Sharp-shinned hawk	*Accipiter striatus*	NL	D
Bachman's sparrow	*Aimophila aestivalis*	C	E
Grasshopper sparrow	*Ammodramus savannarum*	NL	D
Red-shouldered hawk	*Buteo lineatus*	NL	NL
Black vulture	*Coragyps atratusa*	NL	NL
Cerulean warbler	*Dendroica cerulea*	C	NL
Bald eagle	*Haliaeetus leucocephalus*	T	T
Red-headed woodpecker	*Melanerpes erythrocephalus*	NL	D
Black-crowned night heron	*Nycticorax nycticorax*	NL	D
Osprey	*Pandion haliaetus*	NL	T
Amphibians			
Mole salamander	*Ambrystoma talpoideum*	NL	D
Green salamander	*Aneides aeneus*	NL	NL
Hellbender	*Cryptobranchus alleganiensis*	C	D
Fish			
High-finned carpsucker	*Carpiodes velifer*	NL	D
Blue sucker	*Cycleptus elongates*	C	T
Flame chub	*Hemitremia flammea*	C	D
Tennessee dace	*Phoxinus tennesseensis*	NL	D
Paddlefish	*Polydon spathula*	C	NL
Reptiles			
Eastern slender grass lizard	*Ophisaurus attenuatus longicaudis*	NL	D
Northern pine snake	*Pituophis m. melanoleucus*	C	T
Cumberland slider	*Trachemys scripta trootsii*	NL	NL
Mammals			
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	NL	D

COMMON NAME	SCIENTIFIC NAME	FEDERAL STATUS	STATE STATUS
Eastern cougar	*Felis concolor couguar*	E	E
Northern river otter	*Lutra canadensis*	NL	T
Rock vole	*Microtus chrotorrhinus*	NL	D
Gray bat	*Myotis grisescens*	E	E
Indiana bat	*Myotis sodalis*	E	E
Eastern small-footed bat	*Myotis leibii*	NL	D
Woodland jumping mouse	*Napazaoezapus insignis*	NL	D
Eastern woodrat	*Neotoma magister*	NL	D
Masked shrew	*Sorex cinereus*	NL	D
Long-tailed shrew	*Sorex dispar*	NL	D
Smoky shrew	*Sorex fumeus*	NL	D
Southeastern shrew	*Sorex longirostris*	NL	D
Southern bog lemming	*Synaptomys cooperi*	NL	D
Meadow jumping mouse	*Zapus hudsonius*	NL	D
NL = Not listed; E = Endangered; T = Threatened; D = Deemed in need of management; C = Candidate			

EXHIBIT D-2 PLANTS OF CONSERVATION CONCERN ON THE OAK RIDGE RESERVATION (SAIC 2002)

COMMON NAME	SCIENTIFIC NAME	FEDERAL STATUS	STATE STATUS
Spreading false-foxglove	*Aureolaria patula*	NL	T
Heavy sedge	*Carex gravida*	NL	S
Hairy sharp-scaled sedge	*Carex oxylepis* var. *pubescens*	NL	S
Appalachian bugbane	*Cimicifuga rubifolia*	NL	S
Whorled horsebalm	*Collinsonia verticillata*	NL	NL
Pink lady's-slipper	*Cypripedium acaule*	NL	E-CE
Tall larkspur	*Delphinium exultatum*	C	E
Northern bush-honeysuckle	*Diervilla lonicera*	NL	T
Branching Whitlow-grass	*Draba ramosissima*	NL	S
Nuttall's waterweed	*Elodea nuttallii*	NL	S
Mountain witch-alder	*Fothergilla major*	NL	T
Goldenseal	*Hydrastis Canadensis*	NL	T-CE
Butternut	*Juglans cinerea*	C	T
Short-headed rush	*Juncus brachycephalus*	NL	S
Canada lily	*Lilium canadense*	NL	T
Fen orchid	*Liparis loeselii*	NL	E
American ginseng	*Panax quinquefolius*	NL	T-CE
Tubercled rein-orchid	*Platanthera flava* var. *herbiola*	NL	T
Purple fringeless orchid	*Platanthera peramoena*	NL	T
Carey's saxifrage	*Saxifraga careyana*	NL	S
Lesser ladies'-tresses	*Spiranthes ovalis*	NL	S
NL = Not listed; E = Endangered; T = Threatened; S = Special concern; CE = Commercially exploited; C = Candidate			

APPENDIX E. PRESENT VALUE GAINS FROM TRAIL USE RECREATION UNDER THE EASEMENT

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2006	11,093	$248,562
2007	11,116	$237,228
2008	11,144	$226,493
2009	11,177	$216,360
2010	11,215	$206,746
2011	11,258	$197,652
2012	11,296	$188,877
2013	11,334	$180,492
2014	11,372	$172,479
2015	11,411	$164,822
2016	11,449	$157,505
2017	11,488	$150,513
2018	11,527	$143,831
2019	11,566	$137,446
2020	11,605	$131,344
2021	11,645	$125,513
2022	11,684	$119,941
2023	11,724	$114,616
2024	11,763	$109,528
2025	11,803	$104,665
2026	11,843	$100,019
2027	11,883	$95,579
2028	11,923	$91,335
2029	11,964	$87,281
2030	12,004	$83,406
2031	12,045	$79,703
2032	12,086	$76,165
2033	12,127	$72,784
2034	12,168	$69,552
2035	12,209	$66,465
2036	12,250	$63,514
2037	12,292	$60,694
2038	12,333	$58,000
2039	12,375	$55,425
2040	12,417	$52,964
2041	12,459	$50,613
2042	12,501	$48,366

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2043	12,544	$46,219
2044	12,586	$44,167
2045	12,629	$42,206
2046	12,671	$40,333
2047	12,714	$38,542
2048	12,757	$36,831
2049	12,801	$35,196
2050	12,844	$33,633
2051	12,887	$32,140
2052	12,931	$30,713
2053	12,975	$29,350
2054	13,019	$28,047
2055	13,063	$26,802
2056	13,107	$25,612
2057	13,151	$24,475
2058	13,196	$23,388
2059	13,241	$22,350
2060	13,285	$21,358
2061	13,330	$20,410
2062	13,376	$19,504
2063	13,421	$18,638
2064	13,466	$17,810
2065	13,512	$17,020
2066	13,558	$16,264
2067	13,604	$15,542
2068	13,650	$14,852
2069	13,696	$14,193
2070	13,742	$13,563
2071	13,789	$12,961
2072	13,835	$12,385
2073	13,882	$11,835
2074	13,929	$11,310
2075	13,976	$10,808
2076	14,024	$10,328
2077	14,071	$9,870
2078	14,119	$9,431
2079	14,167	$9,013
2080	14,215	$8,613
2081	14,263	$8,230
2082	14,311	$7,865
2083	14,360	$7,516
2084	14,408	$7,182

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2085	14,457	$6,863
2086	14,506	$6,559
2087	14,555	$6,267
2088	14,604	$5,989
2089	14,654	$5,723
2090	14,703	$5,469
2091	14,753	$5,226
2092	14,803	$4,994
2093	14,853	$4,773
2094	14,904	$4,561
2095	14,954	$4,358
2096	15,005	$4,165
2097	15,055	$3,980
2098	15,106	$3,803
2099	15,158	$3,634
2100	15,209	$3,473
2101	15,260	$3,319
2102	15,312	$3,172
2103	15,364	$3,031
2104	15,416	$2,896
2105	15,468	$2,768
2106	15,521	$2,645
2107	15,573	$2,527
2108	15,626	$2,415
2109	15,679	$2,308
2110	15,732	$2,205
2111	15,785	$2,108
2112	15,839	$2,014
2113	15,892	$1,925
2114	15,946	$1,839
2115	16,000	$1,757
2116	16,054	$1,679
2117	16,109	$1,605
2118	16,163	$1,534
2119	16,218	$1,466
2120	16,273	$1,401
2121	16,328	$1,338
2122	16,383	$1,279
2123	16,439	$1,222
2124	16,494	$1,168
2125	16,550	$1,116
2126	16,606	$1,066

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2127	16,662	$1,019
2128	16,719	$974
2129	16,775	$931
2130	16,832	$889
2131	16,889	$850
2132	16,946	$812
2133	17,004	$776
2134	17,061	$742
2135	17,119	$709
2136	17,177	$677
2137	17,235	$647
2138	17,294	$618
2139	17,352	$591
2140	17,411	$565
2141	17,470	$540
2142	17,529	$516
2143	17,588	$493
2144	17,648	$471
2145	17,708	$450
2146	17,768	$430
2147	17,828	$411
2148	17,888	$393
2149	17,949	$375
2150	18,009	$359
2151	18,070	$343
2152	18,132	$327
2153	18,193	$313
2154	18,255	$299
2155	18,316	$286
2156	18,378	$273
2157	18,441	$261
2158	18,503	$249
2159	18,566	$238
2160	18,629	$228
2161	18,692	$218
2162	18,755	$208
2163	18,819	$199
2164	18,882	$190
2165	18,946	$181
2166	19,010	$173
2167	19,075	$166
2168	19,139	$158

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2169	19,204	$151
2170	19,269	$145
2171	19,334	$138
2172	19,400	$132
2173	19,466	$126
2174	19,531	$121
2175	19,598	$115
2176	19,664	$110
2177	19,730	$105
2178	19,797	$101
2179	19,864	$96
2180	19,932	$92
2181	19,999	$88
2182	20,067	$84
2183	20,135	$80
2184	20,203	$77
2185	20,271	$73
2186	20,340	$70
2187	20,409	$67
2188	20,478	$64
2189	20,547	$61
2190	20,617	$58
2191	20,687	$56
2192	20,757	$53
2193	20,827	$51
2194	20,898	$49
2195	20,968	$46
2196	21,039	$44
2197	21,111	$42
2198	21,182	$41
2199	21,254	$39
2200	21,326	$37
2201	21,398	$35
2202	21,470	$34
2203	21,543	$32
2204	21,616	$31
2205	21,689	$30
2206	21,763	$28
2207	21,836	$27
2208	21,910	$26
2209	21,984	$25
2210	22,059	$24

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2211	22,134	$22
2212	22,208	$21
2213	22,284	$21
2214	22,359	$20
2215	22,435	$19
2216	22,511	$18
2217	22,587	$17
2218	22,664	$16
2219	22,740	$16
2220	22,817	$15
2221	22,895	$14
2222	22,972	$14
2223	23,050	$13
2224	23,128	$12
2225	23,206	$12
2226	23,285	$11
2227	23,364	$11
2228	23,443	$10
2229	23,522	$10
2230	23,602	$9
2231	23,682	$9
2232	23,762	$9
2233	23,842	$8
2234	23,923	$8
2235	24,004	$8
2236	24,085	$7
2237	24,167	$7
2238	24,249	$7
2239	24,331	$6
2240	24,413	$6
2241	24,496	$6
2242	24,579	$5
2243	24,662	$5
2244	24,746	$5
2245	24,829	$5
2246	24,913	$5
2247	24,998	$4
2248	25,082	$4
2249	25,167	$4
2250	25,253	$4
2251	25,338	$4
2252	25,424	$3

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2253	25,510	$3
2254	25,596	$3
2255	25,683	$3
2256	25,770	$3
2257	25,857	$3
2258	25,945	$3
2259	26,033	$3
2260	26,121	$2
2261	26,209	$2
2262	26,298	$2
2263	26,387	$2
2264	26,476	$2
2265	26,566	$2
2266	26,656	$2
2267	26,746	$2
2268	26,837	$2
2269	26,928	$2
2270	27,019	$2
2271	27,110	$1
2272	27,202	$1
2273	27,294	$1
2274	27,387	$1
2275	27,479	$1
2276	27,572	$1
2277	27,666	$1
2278	27,759	$1
2279	27,853	$1
2280	27,948	$1
2281	28,042	$1
2282	28,137	$1
2283	28,233	$1
2284	28,328	$1
2285	28,424	$1
2286	28,520	$1
2287	28,617	$1
2288	28,714	$1
2289	28,811	$1
2290	28,909	$1
2291	29,006	$1
2292	29,105	$1
2293	29,203	$1
2294	29,302	$1

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2295	29,401	$0
2296	29,501	$0
2297	29,601	$0
2298	29,701	$0
2299	29,802	$0
2300	29,902	$0
2301	30,004	$0
2302	30,105	$0
2303	30,207	$0
2304	30,310	$0
2305	30,412	$0
2306	30,515	$0
2307	30,618	$0
2308	30,722	$0
2309	30,826	$0
2310	30,931	$0
2311	31,035	$0
2312	31,140	$0
2313	31,246	$0
2314	31,352	$0
2315	31,458	$0
2316	31,564	$0
2317	31,671	$0
2318	31,778	$0
2319	31,886	$0
2320	31,994	$0
2321	32,102	$0
2322	32,211	$0
2323	32,320	$0
2324	32,429	$0
2325	32,539	$0
2326	32,649	$0
2327	32,760	$0
2328	32,871	$0
2329	32,982	$0
2330	33,094	$0
2331	33,206	$0
2332	33,318	$0
2333	33,431	$0
2334	33,544	$0
2335	33,658	$0
2336	33,772	$0

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2337	33,886	$0
2338	34,001	$0
2339	34,116	$0
2340	34,232	$0
2341	34,348	$0
2342	34,464	$0
2343	34,581	$0
2344	34,698	$0
2345	34,815	$0
2346	34,933	$0
2347	35,051	$0
2348	35,170	$0
2349	35,289	$0
2350	35,409	$0
2351	35,528	$0
2352	35,649	$0
2353	35,769	$0
2354	35,891	$0
2355	36,012	$0
2356	36,134	$0
2357	36,256	$0
2358	36,379	$0
2359	36,502	$0
2360	36,626	$0
2361	36,750	$0
2362	36,874	$0
2363	36,999	$0
2364	37,125	$0
2365	37,250	$0
2366	37,376	$0
2367	37,503	$0
2368	37,630	$0
2369	37,757	$0
2370	37,885	$0
2371	38,013	$0
2372	38,142	$0
2373	38,271	$0
2374	38,401	$0
2375	38,531	$0
2376	38,661	$0
2377	38,792	$0
2378	38,924	$0

YEAR	NUMBER OF VISITORS	PRESENT VALUE (2006)
2379	39,055	$0
2380	39,188	$0
2381	39,320	$0
2382	39,454	$0
2383	39,587	$0
2384	39,721	$0
2385	39,856	$0
2386	39,991	$0
2387	40,126	$0
2388	40,262	$0
2389	40,398	$0
2390	40,535	$0
2391	40,672	$0
2392	40,810	$0
2393	40,948	$0
2394	41,087	$0
2395	41,226	$0
2396	41,366	$0
2397	41,506	$0
2398	41,646	$0
2399	41,787	$0
2400	41,929	$0
2401	42,071	$0
2402	42,213	$0
2403	42,356	$0
2404	42,499	$0
2405	42,643	$0
2406	42,788	$0
Total		**$5,587,579**

Notes:

1. Present value for 2006 calculated using a five percent discount rate.
2. Total may not sum due to rounding.