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ASIAN CARP MITIGATION
FINAL PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

Prepared by:
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Symbols, Acronyms, and Abbreviations

ADA	Americans with Disabilities Act
ADCNR	Alabama Department of Conservation and Natural Resources
ADEM	Alabama Department of Environmental Management
APE	Area of Potential Effect
ARAP	Aquatic Resource Alteration Permit
BAFF	Bio-Acoustic Fish Fence
B.A.S.S.	Bass Angler Sportsman Society
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practice
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CWA	Clean Water Act
dB	Decibel(s)
dBA	A-weighted decibel
DO	Dissolved Oxygen
DOPAA	Description of Proposed Action and Alternatives
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
FRP	Flood Risk Profile
GHG	Greenhouse Gas
HUC	Hydrologic Unit Code
HUD	U.S. Department of Housing and Urban Development
IPaC	Information for Planning and Consultation
KDEP	Kentucky Department for Environmental Protection
KDFWR	Kentucky Department of Fish and Wildlife Resources
L&D	Lock and Dam
L_{dn}	Day-Night Sound Level
MBTA	Migratory Bird Treaty Act
MICRA	Mississippi Interstate Cooperative Resource Association
msl	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_X	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRI	Nationwide Rivers Inventory
NRP	Natural Resource Plan
NWI	National Wetlands Inventory
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PEA	Programmatic Environmental Assessment
Pb	Lead
PFOS	Perfluorooctanesulfonic Acid

PM	Particulate Matter
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
SHPO	State Historic Preservation Officer
SO_2	Sulfur Dioxide
sq mi	Square Miles
SWPPP	Stormwater Pollution Prevention Plan
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USDOI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOCs	Volatile Organic Compounds
WMA	Wildlife Management Area

CHAPTER 1 – PURPOSE AND NEED FOR ACTION

1.1 Introduction

"Asian carp" is a collective term that refers to several species of related fish that originated from Asia. As many as ten species of Asian carp are considered invasive around the world. Four Asian carp species are particularly problematic in North America including: silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), grass carp (*Ctenopharyngodon idella*) and black carp (*Mylopharyngodon piceus*). Because Asian carp have the capacity to dramatically expand in population and range, and have adverse effects to native aquatic ecosystems, Tennessee Valley Authority (TVA) is proposing various actions to limit distribution and abundance of Asian carp in the Tennessee River reservoir system. Accordingly, TVA is undertaking the preparation of a Programmatic Environmental Assessment (PEA) to evaluate fish barrier options at 10 Lock and Dam (L&D) sites in the Tennessee River system (Figure 1-1), and to consider potential environmental and economic impacts from their installation. TVA is considering these actions in accordance with Executive Order (EO) 13751 *Safeguarding the Nation From the Impacts of Invasive Species* (December 5, 2016), which instructs federal agencies to (i) prevent the introduction, establishment, and spread of invasive species; and (ii) detect and respond rapidly to eradicate or control populations of invasive species in a manner that is cost-effective and minimizes human, animal, plant, and environmental health risks.

1.1.1 Tennessee River System

The Tennessee River forms at the confluence of the Holston and French Broad Rivers near Knoxville, Tennessee, then meanders 652 miles through seven states to its confluence with the Ohio River near Paducah, Kentucky (Figure 1-1). The watershed drains roughly 40,890 square miles (sq mi) and is the largest tributary to the Ohio River (USGS 2001). Major tributaries of the Tennessee River include the Duck, Elk, French Broad, Holston, Little Tennessee, Hiwassee, and Clinch Rivers.

TVA's integrated reservoir system consists of 49 dams, including nine dams on the Tennessee River, 39 dams on tributary reservoirs, and one dam on the Raccoon Mountain reservoir. L&Ds on the Tennessee and Clinch Rivers allow navigable traffic throughout the Tennessee River and the lower Clinch River. Nine main and four auxiliary locks are on the Tennessee River and consist of Kentucky, Pickwick, Wilson, Wheeler, Guntersville, Nickajack, Chickamauga, Watts Bar, and Fort Loudoun. Melton Hill lock is on the Clinch River and is also included as part of the PEA. More information about the Tennessee River system is included in Chapter 2.

1.1.2 Asian Carp Challenges

Asian carp were first imported in the 1960s and 1970s as potential food fish and to improve water quality in fish farms (Kolar et al. 2005; Conover et al. 2007). Soon after, the fish were also being used to control aquatic plants and algal blooms at municipal sewage ponds. Purposeful stocking of connected waterbodies, accidental releases, and escapes allowed Asian carp to establish in the Mississippi River watershed by the 1980s (Conover et al. 2007). Following their release and establishment, Asian carp have dramatically expanded their range throughout the Mississippi River and into major tributaries, including the Tennessee River.

Asian carp are generally large-bodied fishes (Figure 1-2) that prefer large, warm, turbid, slow-moving rivers but also inhabit reservoirs, lakes, and ponds—habitats abundant in the Mississippi River watershed (Kolar et al. 2005). Under preferred conditions, adult Asian carp can reach more than 80 pounds and live for more than a decade. A large female Asian carp can produce up to a million eggs each year (Kolar et al. 2005). Spawning requires lengths of uninterrupted river to keep the semi-buoyant eggs suspended in the flow until the eggs hatch and become free swimming (Kolar et al. 2005). Large reservoirs like those found on the Tennessee River system can be excellent habitat for Asian carp.

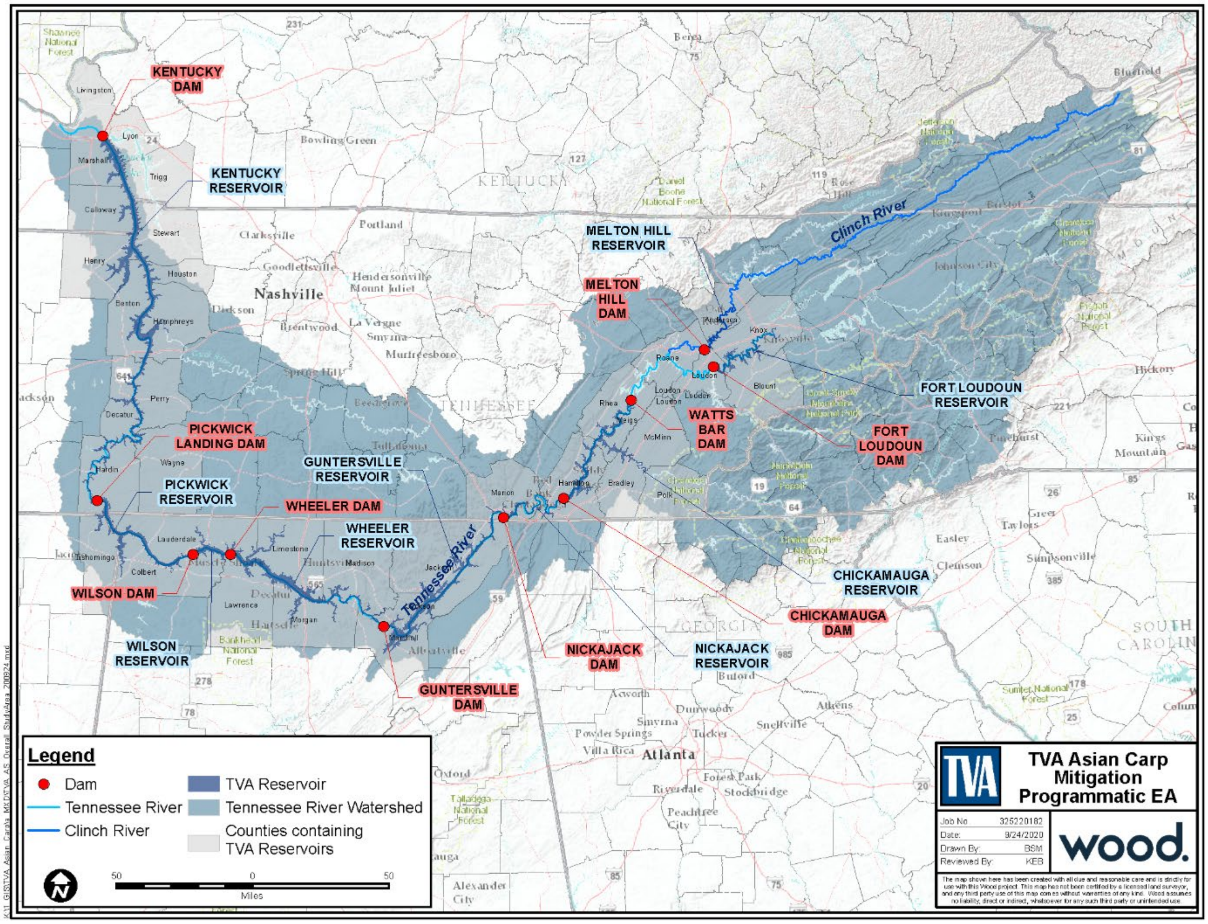

Figure 1-1. Dams and Reservoirs of the Tennessee River Valley

Figure 1-2. Asian Carp Identified within the Tennessee River System

What do Asian carp look like?

Silver carp are deep-bodied fish with moderately large, broad head and eyes located forward and low on the head. Coloration is silver with a slate gray head and back and a white belly. A keel extending from the anal fin to the throat distinguishes silver carp from bighead carp. Silver carp commonly weigh 20 pounds but can grow to more than 80 pounds.

Bighead carp are deep-bodied fish with very large heads and eyes located forward and low on the head. Coloration is primarily dark gray above and cream-colored below with irregular blotches on its sides. Bighead carp typically weigh up to 40 pounds but can grow to more than 80 pounds.

Grass carp are torpedo shaped with slightly flattened heads and moderately small eyes centered on the side of their heads. Coloration varies from blackish to olive-brown with brassy or silvery-white on the sides and belly. Grass carp are covered with large overlapping scales. Scales on the back and sides are cross hatched. Grass carp can grow to over 100 pounds.

Black carp are torpedo shaped and have a flat, pointed head. They look similar to grass carp but are darker brownish-black. Black carp also have a keel along their belly between their lower fins. Black carp typically weigh about 33 pounds but can weigh up to 150 pounds.

Silver, bighead, black, and grass carp have all been collected from the Tennessee River (TWRA 2021). The leading edge of Asian carp establishment in the Tennessee River is Pickwick Lake (USFWS 2017; Figure 1-3). However, small numbers of individual bighead carp have also been reported upstream of Pickwick in Nickajack Reservoir and individual silver carp in Wheeler and Chickamauga Reservoirs (TWRA 2021). Silver carp are the most abundant Asian carp species in the Tennessee River, and evidence of reproduction has recently been documented in Kentucky Reservoir (Ridgway and Bettoli 2017; Labeda 2020).

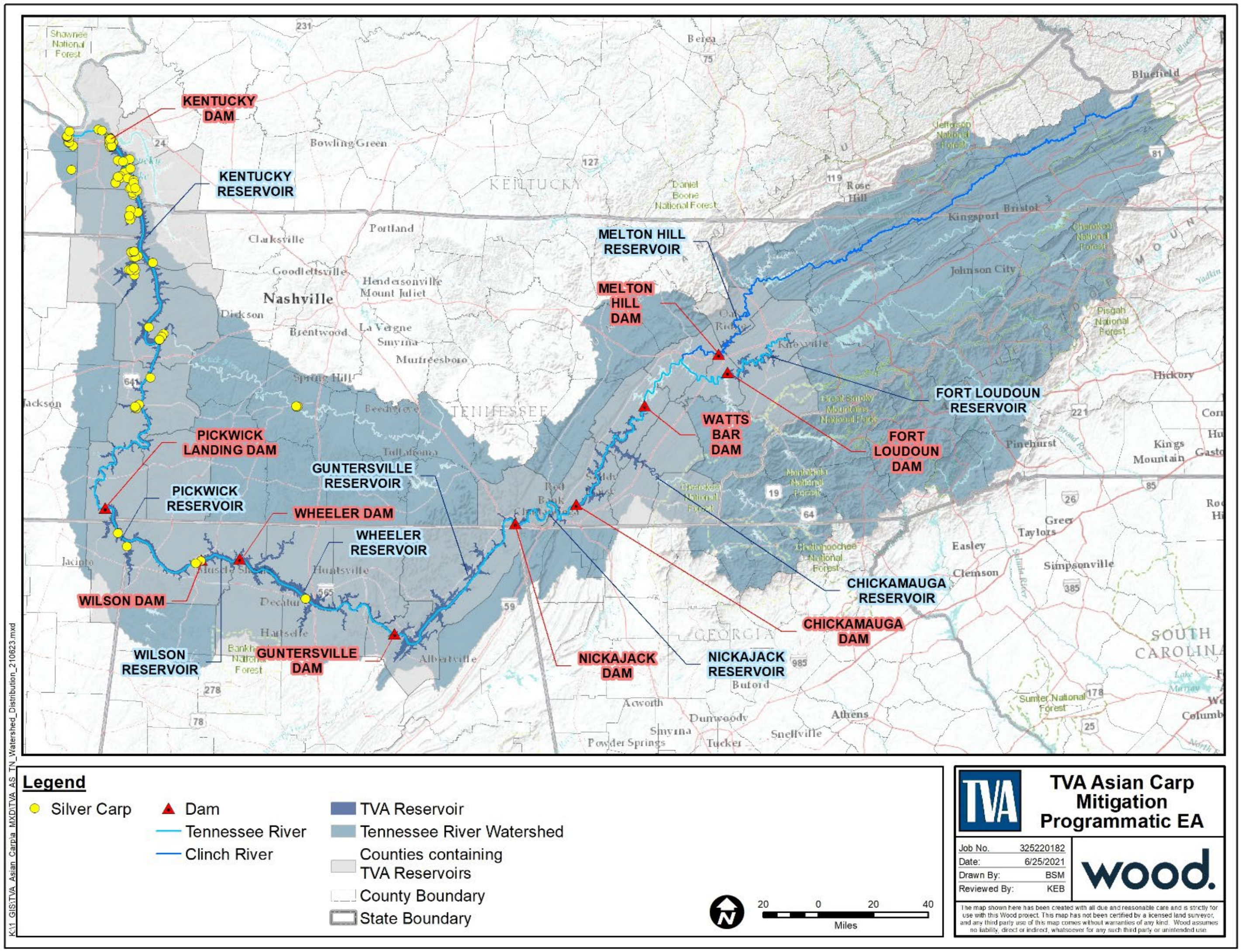

Figure 1-3. Distribution Silver Carp within the Tennessee River Valley

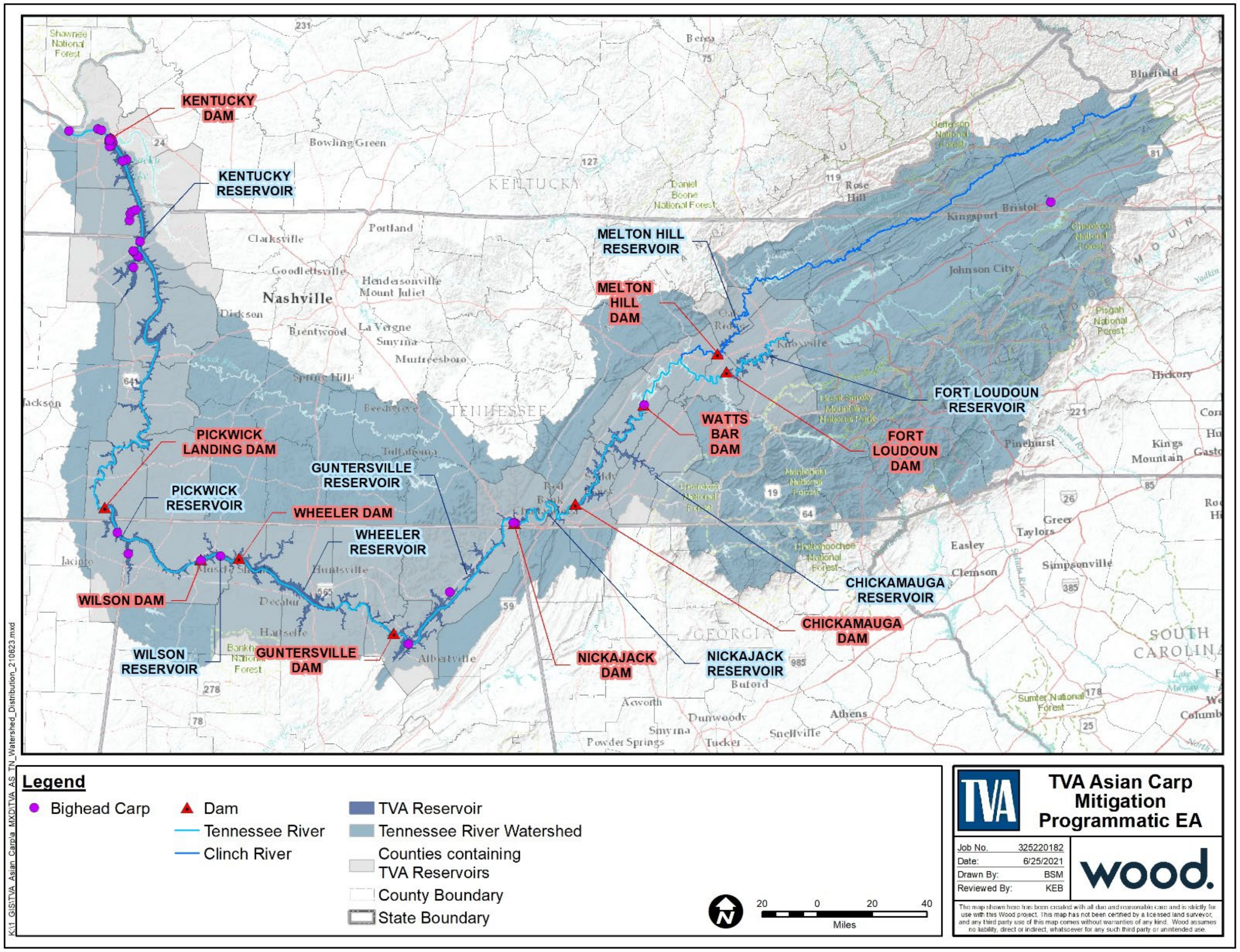

Figure 1-4. Distribution Bighead Carp within the Tennessee River Valley

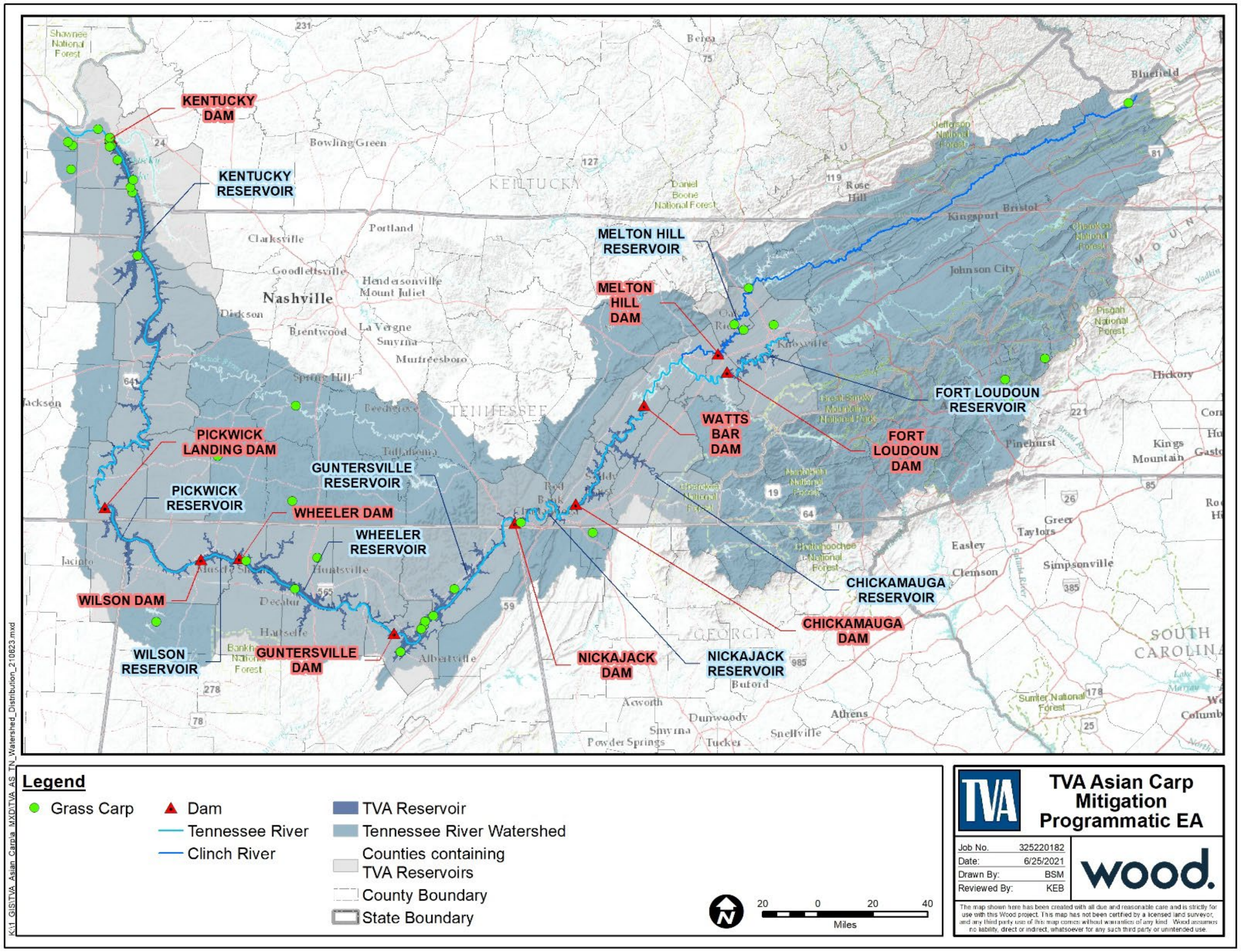

Figure 1-5. Distribution Grass Carp within the Tennessee River Valley

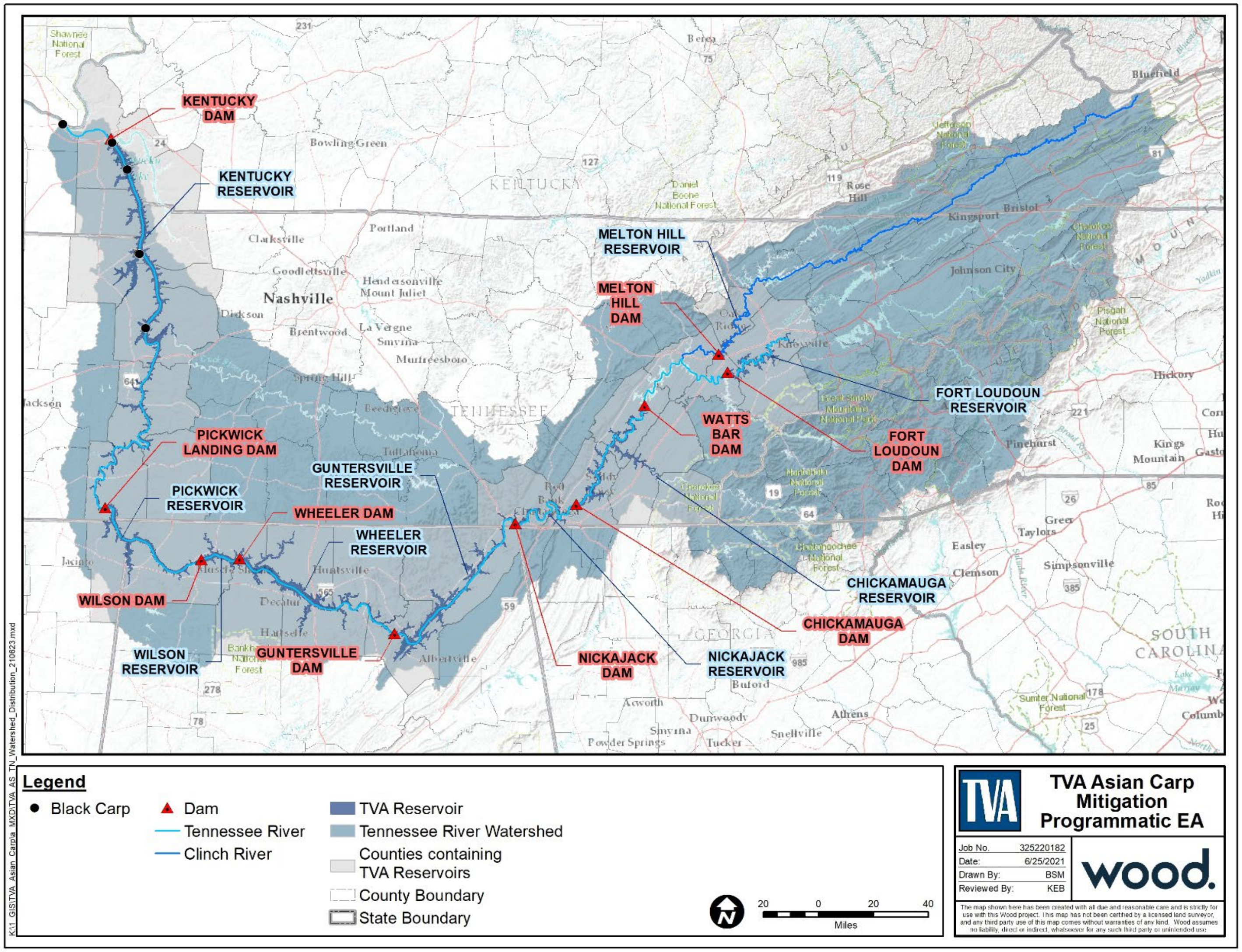

Figure 1-6. Distribution Black Carp within the Tennessee River Valley

The establishment and expansion of Asian carp populations within the Tennessee River system raises significant concerns among resource managers because of their adaptability, life history, feeding ecology, and hazard to boaters. Asian carp are hardy and easily adapt to the warm, turbid rivers, tributaries, reservoirs, backwaters, canals, and floodplain lakes and ponds common throughout the basin. Native phytoplankton, zooplankton, mollusks, and aquatic vegetation can all be heavily impacted by voracious Asian carp (Kolar et al. 2005; Phelps et al. 2017; Chick et al. 2020). Black carp are a particular risk to native freshwater mussels—many of which are threatened or endangered in the Tennessee River. Asian carp can also harbor and spread diseases in habitats they occupy (Kolar et al. 2005; Conover et al. 2007). Silver carp even pose a threat to human safety because they regularly jump out of the water when disturbed and can injure boaters (Kolar et al. 2005). In addition to the negative ecosystem impacts, recreation, tourism, property values, and local economies can all suffer from the collective effects of Asian carp.

How much do Asian carp eat?

Asian carp have voracious appetites due to their unique anatomies and large sizes. Silver and bighead carp lack true stomachs and must constantly feed. Each fish can consume 20 percent of its body mass in food each day and adult fish can weigh between 20 to 150 pounds (Kolar et al. 2005).

1.1.3 Efforts to Control Asian Carp

Negative effects of Asian carp have prompted efforts to control them. Much of the focus has been keeping Asian carp out of the Great Lakes. For example, electric barriers and fish removal efforts in the Chicago Sanitary and Ship Canal have limited northward migrations of silver and bighead carp (ACRCC 2018). The barriers are complex electrical and mechanical systems and must periodically be powered down for maintenance. Therefore, more than one barrier is needed so at least one can be active at any time.

An experimental project designed to restrict the movement of invasive Asian carp through the Barkley Lock chamber was installed at Lake Barkley. A bio-acoustic fish fence (BAFF)—a fish barrier consisting of sound signals, directional strobe lighting, and a bubble curtain—was deployed at the lock entrance (see Section 2.4.1, Fish Barriers Considered in the Decision Tree Process). Construction of the BAFF began in July 2019. Preliminary data from the field trial at Barkley L&D has shown the BAFF to be approximately 98 percent effective at keeping all sizes of Asian carp from passing into the lock.

Fish barriers in the Tennessee River system are needed to control the spread of invasive Asian carp and limit negative impacts to the Tennessee River ecosystem and economy.

1.2 Programmatic Analysis and Tiering

The purpose of this PEA is to evaluate installation of fish barrier systems at selected L&D sites along the Tennessee and Clinch rivers and assess the potential environmental and economic impacts of Asian carp range expansion throughout the Tennessee River watershed. TVA conducted this Programmatic National Environmental Policy Act (NEPA) review of the proposed installation of fish barriers at multiple L&Ds in the Tennessee River system following guidance from the Council on Environmental Quality (CEQ). Programmatic NEPA reviews address the general environmental issues relating to broad decisions, such as those establishing policies, plans, programs, or suite of projects, and can effectively frame the scope of subsequent site- and project-specific Federal actions. This approach is appropriate because environmental impacts of TVA's installation of fish barriers at multiple sites are likely to be similar within typical environmental contexts, and they can be effectively evaluated at a broad scale across the Tennessee River watershed.

Following the completion of this PEA and the Finding of No Significant Impact (FONSI) (if appropriate), any decisions regarding proposed installation of additional fish barriers at other L&D sites will tier from this PEA. This document establishes the process TVA considers when deciding if and when new fish barriers are needed, identifies potential environmental impacts of installed control measures, and establishes mitigation measures for associated environmental impacts. If needed, future site-specific reviews would integrate the processes, findings, and conclusions from this PEA. The site-specific reviews may also provide opportunities for additional public review and comment to ensure broad stakeholder input.

1.3 Purpose and Need

TVA has an established mission to enhance the lives of people within the Tennessee Valley through focus on energy, environment, and economic development. TVA's integrated management of the TVA reservoir system including the operation and management of dams and reservoirs on the Tennessee and Clinch Rivers is a key component of its mission.

The continuing expansion of Asian carp populations within the Tennessee River system has the potential to threaten native ecosystems, rare and protected species, sports fisheries, and public safety, which can lead to reduced recreation, tourism, and property values; and ultimately impact local economies. Therefore, the purpose of TVA's proposed action is to control the abundance and range expansion of Asian carp within the Tennessee River reservoir system and its tributaries by installing fish barriers at strategic L&D locations. The action is needed to reduce the potential future ecosystem and economic consequences associated with the establishment of Asian carp populations in the Tennessee River watershed.

Asian carp are migrating into the Tennessee River system by passing through navigation locks. Asian carp can swim through locks when they open to pass personal watercraft and commercial boat traffic. Blocking fish from passing through the lock would limit Asian carp traveling further upstream. The specific objectives of the fish barrier installations at locks along the Tennessee River system are to:

1) Prevent or impede the upstream migration of Asian carp; and

2) Minimize the recruitment or establishment of Asian carp in the Tennessee River—all while allowing public access, maintaining public safety, preventing interference with navigation, and protecting native species.

1.4 Decision to be Made

This PEA has been prepared to inform TVA decision makers, the public, and other stakeholders about the environmental consequences of the proposed action. TVA determined which fish barrier technologies could be used at TVA L&Ds and assessed the environmental effects of these systems. Specific fish barrier technologies and their strategic locations were selected based on their potential effectiveness, costs, environmental impacts, and economic impacts using a structured decision-making process (see Section 2.3, Decision Tree Process).

TVA will use this PEA to support the decision-making process and to determine whether an Environmental Impact Statement (EIS) should be prepared or whether a FONSI may be issued.

1.5 Related Environmental Reviews

Related environmental documents and materials were reviewed while preparing this PEA and are listed below. The contents of these documents helped describe the affected resources or provided results of environmental evaluations of fish barrier technologies assessed in this document. Specific information was incorporated by reference, as appropriate.

- *Draft Environmental Assessment Asian Carp Deterrent System, Lake Barkley Lock and Dam, Lyon/Livingston County, Kentucky* (USACE 2018)
- *Multiple Reservoir Land Management Plans Final Environmental Impact Statement Volume I. Chickamauga Reservoir, Fort Loudoun Reservoir, Great Falls Reservoir, Kentucky Reservoir, Nickajack Reservoir, Normandy Reservoir, Wheeler Reservoir Wilson Reservoir* (TVA 2017c)
- *Final Environmental Impact Statement, Watts Bar Reservoir Land Management Plan* (TVA 2009)
- *Final Programmatic Environmental Impact Statement Tennessee Valley Authority Reservoir Operations Study* (TVA 2004)
- *Pickwick Reservoir Land Management Plan and Environmental Impact Statement* (TVA 2002)
- *Guntersville Reservoir Final Environmental Impact Statement and Reservoir Land Management Plan Volume I* (TVA 2001)
- *Final Environmental Assessment Melton Hill Reservoir Land Management Plan* (TVA 1999)
- *Shoreline Management Initiative: An Assessment of Residential Shoreline Development Impacts in the Tennessee Valley, Public Summary of the Final Environmental Impact Statement* (TVA 1998)

1.6 Public and Agency Involvement

TVA’s public and agency involvement included publication of a notice of availability and a 30-day public review of the draft PEA beginning July 7 and ending on August 5, 2021. The availability of the draft PEA was announced in regional and local newspapers that serve the areas surrounding the L&Ds. The draft PEA was also posted on TVA’s website (https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/asian-carp-mitigation). During the public comment period, TVA also conducted a virtual public information session that was attended by approximately 90 members of the public. A recording is available on the project website.

TVA’s agency involvement included circulation of the draft PEA to local, state, and federal agencies, and federally recognized tribes as part of the review. Chapter 5, Programmatic Environmental Assessment Recipients, provides a list of agencies, tribes, and organizations notified of the availability of the draft PEA. Cooperating agencies are listed in Section 1.8, Cooperating Agencies.

TVA received 718 comment submissions by email, letter, and the online comment system. Eight comment submissions were from government agencies, five were from local governments, 20 were from nongovernmental organizations, and the remainder were from private citizens. All public and agency comments and TVA's responses to comments are available in Appendix A.

1.7 Scope of the Programmatic EA

Geographic scope of this PEA includes 9 L&D sites on the Tennessee River and one L&D on the Clinch River, the 10 reservoirs created behind these dams, and the surrounding Tennessee River watershed (Figure 1-1). A detailed description of the proposed action and alternatives considered are provided in Chapter 2. In consideration of the proposed action, TVA would normally assume that certain environmental resources do not warrant detailed analyses as they either may not be found in the vicinity of the dams considered in the PEA or would not be impacted by any of the Alternatives. However, because this is a Programmatic NEPA analysis from which site-specific assessments may tier, some analyses of the following resources are included:

- Air Quality
- Climate Change & Greenhouse Gases
- Aquatic Ecology
- Geology
- Groundwater
- Surface Water
- Floodplains
- Recreation
- Vegetation
- Wildlife
- Threatened & Endangered Species
- Managed & Natural Areas
- Wetlands
- Land Use & Prime Farmland
- Solid & Hazardous Waste
- Visual Resources
- Cultural & Historical Resources
- Transportation
- Navigation
- Noise
- Socioeconomics
- Environmental Justice
- Public Health & Safety

TVA's action would satisfy the requirements of EO 11988 (Floodplain Management), EO 11990 (Protection of Wetlands), EO 12898 (Environmental Justice), EO 13112 (Invasive Species), and EO 13653 (Preparing the United States for the Impacts of Climate Change); and applicable laws including the National Historic Preservation Act of 1966 (NHPA), Endangered Species Act of 1973 (ESA), Migratory Bird Treaty Act of 1918 (MBTA), Bald and Golden Eagle Protection Act (BGEPA), EO 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds), Clean Water Act (CWA), and Clean Air Act (CAA).

1.8 Cooperating Agencies

Federal and state agencies with jurisdiction and special expertise with aquatic ecosystems in the study area were invited to participate as cooperating agencies in the environmental analysis of the proposed action. Accepting cooperating agencies at the federal level include the U.S. Army Corp of Engineers and U.S. Fish and Wildlife Service. Cooperating agencies at the state level include Alabama Department of Conservation and Natural Resources, Kentucky Department of Fish and Wildlife Resources, Mississippi Department of Wildlife, Fisheries, and Parks, and Tennessee Wildlife Resources Agency.

1.9 Necessary Permits or Licenses

TVA will obtain all necessary permits, licenses, and approvals required for the alternative selected. TVA anticipates the following may be required for implementing the proposed alternative.

- A General Permit for Storm Water Discharges Associated with Construction Activities may be required for the disposal of dredge material under Alternative G. A Stormwater Pollution Prevention Plan (SWPPP) may be required to detail sediment and erosion control best management practices (BMP).

- Clean Water Act Section 404 permit from the U.S. Army Corp of Engineers (USACE) and Section 401 Water Quality Certification/Aquatic Resource Alteration Permit (ARAP) may be required from the appropriate state permitting agencies for the dredging of sediment under Alternative G and would be required for the in-water placement of fish barrier systems under Alternative G.

Other necessary permits will be evaluated based on site-specific conditions.

CHAPTER 2 – ALTERNATIVES

2.1 Description of the Lock and Dam System on the Tennessee River

2.1.1 Tennessee River System

Per the Tennessee Valley Authority Act of 1933 (TVA Act), one of TVA's primary purposes is to "improve the navigability" of the Tennessee River. Along with flood control and hydropower generation, navigation is one of the main objectives for the Agency.

Preamble to the Tennessee Valley Authority Act:

"To improve the navigability and to provide for the flood control of the Tennessee River; to provide for reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for the agricultural and industrial development of said valley; to provide for the national defense by the creation of a corporation for the operation of Government properties at and near Muscle Shoals in the State of Alabama, and for other purposes."

When the TVA Act was passed, TVA acquired Wilson Dam and began work almost immediately on Norris Dam. Seven more dams followed including Wheeler, Pickwick, Guntersville, Chickamauga, Watts Bar, Fort Loudoun, and Kentucky to allow navigation throughout the Tennessee River.

Today, TVA maintains a 652-mile navigable channel along the Tennessee River from Knoxville, Tennessee, to Paducah, Kentucky (Figure 2-1). Commercial navigation also extends into three major tributaries: 61 miles up the Clinch River (e.g., Melton Hill Dam), 29 miles up the Little Tennessee River, and 22 miles up the Hiwassee River. About 34,000 barges annually travel the Tennessee River (TVA 2021e). An additional 374 miles of channel too shallow to handle commercial traffic is marked by TVA for recreational boating (TVA 2021f).

TVA manages and operates nine major dams and associated reservoirs on the mainstem of the Tennessee River. Water levels are managed within this system of reservoirs to support the following benefits:

- Flood damage reduction through flood storage and waterflow management
- Navigation
- Hydroelectric power production
- Water quality
- Water supply
- Recreation

Reservoirs within the study area range in size (i.e., length of river, shoreline, surface area, and flood storage capacity). Kentucky Reservoir is substantially larger than all other reservoirs encompassing 184 river miles and a shoreline length of more than 2,000 miles (Table 2-1). By comparison, Wilson Reservoir is the smallest of the reservoirs extending only 16 river miles and encompassing only 166 shoreline miles (Table 2-1). As illustrated in Figure 1-3 and summarized in Table 2-1, Asian carp have been documented predominantly in Kentucky, Pickwick, Wilson, and Wheeler Reservoirs.

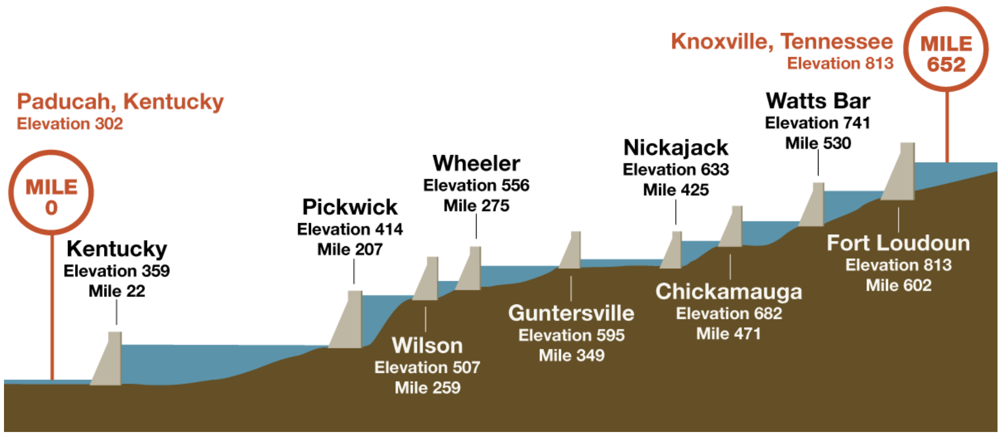

Figure 2-1. Tennessee River Waterway
(Source: TVA 2021f)

2.1.2 Overview of the Locks and Dams on the Tennessee River

In addition to the nine major L&Ds along the navigable Tennessee River mainstem (Figure 2-1), the study area also includes the Melton Hill L&D on the Clinch River. All the dams are designed for hydropower production and include between 2 and 21 generating units that range in capacity from 79 to 653 megawatts. L&Ds associated with each reservoir have varying characteristics based upon their location within the watershed, and their importance in supporting navigation (Table 2-2). Dams vary in length (i.e., 1,020 feet to 8,422 feet) and height (i.e., 81 feet to 206 feet) and include either a single or double lock system. As several of the dams support a double lock system, a total of 14 locks are considered in this PEA (Table 2-2 and Figures B-1 through B-10 in Appendix B). The largest lock, at Pickwick Dam, is 110 feet wide and 1,000 feet long. The lock at Kentucky Dam is the busiest in the entire system, handling about 35 million tons of river freight per year (see Section 3.5, Navigation).

Table 2-1. Reservoirs in the Tennessee River System Study Area

Reservoir	Length of River (miles)	Elevation (ft above sea level)	Shoreline (miles)	Surface Area (acres)	Flood Storage (acre-feet)	Asian Carp Status†
Kentucky	184	354 to 359	2,064	160,300	4,008,000	Present
Pickwick Landing	53	408 to 414	490	43,100	492,700	Present
Wilson	16	505 to 508	166	15,500	50,500	Present
Wheeler	16	550 to 556	1,027	67,070	326,500	Present
Guntersville	74	593 to 595	890	67,900	162,100	Present
Nickajack	79	632 to 634	179	10,370	-	Individual
Chickamauga	43	675 to 683	784	36,240	345,300	Individual
Watts Bar	59	735 to 741	722	39,090	379,000	Individual
Fort Loudoun	72	807 to 813	379	14,600	111,000	None
Melton Hill	57	793 to 795	193	5,470	-	None

†Based on current silver, bighead, and black carp distributions (Figure 1-3) and additional data from TWRA.

Table 2-2. Locks and Dams in the Tennessee River System Study Area

Lock & Dam	River Mile	Date Completed	Dam Dimensions	No. of Locks	Lock Dimensions	Generating Units	Generation[1] (megawatts)
Kentucky	22.4	1942	206' H x 8,422' W	1	110' x 600'	5	223
Pickwick Landing	206.7	1937 1984	113' H x 7,715' W	2	110' x 600' 110' x 1,000'	6	238
Wilson	259.4	1959 1927	137' H x 4,541' W	2	110' x 600' (x2) 60' x 300'	21	653
Wheeler	274.9	1963 1937	72' H x 6,342' W	2	110' x 600' 60' x 400'	11	400
Guntersville	349.0	1963 1937	94' H x 3,979' W	2	110' x 600' 60' x 360'	4	123
Nickajack	427.7	1967	81' H x 3,767' W	1	110' x 600'	4	107
Chickamauga	471.0	1939	129' H x 5,800' W	1	60' x 360'	4	142
Watts Bar	529.9	1942	117' H x 2,960' W	1	60' x 360'	5	196
Fort Loudoun	602.3	1943	126' H x 4,190' W	1	60' x 360'	4	162
Melton Hill[2]	23.1	1963	103' H x 1,020' W	1	75' x 400'	2	79

[1]Net dependable capacity is the amount of power a dam can produce on an average day, minus the electricity used by the dam itself.
[2]Located on the Clinch River

.

2.2 Screening of Lock and Dams

Each of the 10 L&D locations considered in this PEA were initially screened to identify only the locations and fish barrier technologies that would best impede upstream migration of Asian carp. Conceptual layouts and configurations of Asian carp barrier systems were developed and are included as Appendix B.

Initial screening followed a structured decision-making process—an approach for careful and organized analysis of natural resource management decisions to improve the quality of decision-making (USGS 2021d). TVA and other federal and state natural resource agency partners developed a Decision Tree for fish barrier placement (see Section 2.3 for more information on the Decision Tree process). The Decision Tree ranked location and fish barrier technologies from most to least effective. The Decision Tree helped TVA finalize scientifically defensible alternatives that were carried forward in this PEA. Additionally, the initial 10 L&D locations were screened to identify the most critical locations for impeding Asian carp movement. These locations are considered in more detail in Chapter 3. Outcomes from the Decision Tree included the planned deployment of fish barriers at specific locations in the near term, and potential additional installations at the other locations in the future.

2.3 Decision Tree Process

2.3.1 Background

The Mississippi Interstate Cooperative Resource Association (MICRA) is a partnership of state and federal natural resource management agencies formed in 1991 to improve management of interjurisdictional fishery resources in the Mississippi River basin through coordination, communication, and collaboration among its entities. In recent years, the MICRA member agencies formed four sub-basin Asian carp partnerships, including the Ohio River Basin Asian Carp Partnership, to collaboratively identify, implement, and evaluate Asian carp management and control actions to limit the spread and reduce the abundance of Asian carp throughout the Basin. MICRA and the U.S. Fish and Wildlife Service (USFWS) provide coordination support for the sub-basin partnerships, and the USFWS provides funding to the Basin states to support implementation of high priority Asian carp management and control projects. Additionally, federal agency partners participate in the MICRA sub-basin Asian carp partnerships and implement projects in support of Asian carp partnership efforts throughout the Basin.

What is the Decision Tree Process?

The Decision Tree process is a comprehensive and robust analysis conducted by the interagency Asian Carp Deterrent Workshop participants to rank and prioritize both fish barrier technologies and locations to optimize the control of Asian carp within the Tennessee River system. Recommendations of the Asian Carp Deterrent Workshop participants were considered by TVA as part of the NEPA process to finalize scientifically defensible Alternatives that were carried forward in this PEA.

Several years of collaborative, multi-agency work has been completed through the Ohio River Basin Asian Carp Partnership to understand Asian carp populations within the Tennessee and Cumberland River systems and identify priority fish barrier needs. This work culminated in the Tennessee River Asian Carp Deterrent Workshop 2020—a series of joint working meetings held in the summer and fall of 2020. Workshop participants included state fisheries resource managers from Kentucky, Tennessee, Mississippi, and Alabama; and aquatic resources staff from the U.S. Geological Survey (USGS), USFWS, U.S. Army Corp of Engineers (USACE), and TVA. This team included many of the leading experts on Asian carp in North America. Workshops were facilitated by USGS decision analysts to develop the final Decision Tree.

Work undertaken by participants in the Tennessee River Asian Carp Deterrent Workshop to develop the Decision Tree was comprehensive and ultimately was considered by TVA as part of the NEPA process to finalize scientifically defensible Alternatives that were carried forward in this PEA.

2.3.2 Decision Tree Modeling Approach

The Decision Tree process was used to determine the most effective fish barrier technologies and potential installation locations using multiple inputs. For example, current distribution of Asian carp in the Tennessee River was weighted heavily to strategically place fish barriers where they would be most effective at slowing the leading edge of invasion. Fish barrier technologies were also screened for efficacy, cost, safety, and other factors.

Key factors evaluated by the Workshop participants to identify strategic types and locations for installation of Asian carp barriers included:

- Status and trends in Asian carp abundance within the Tennessee River system (i.e., leading edge);
- Asian carp movement and recruitment rates;
- FluEgg model outputs (i.e., potential spawning and rearing habitats);
- Commercial harvest and fishing mortality;
- Deterrent technology effectiveness and safety; and
- Deterrent technology costs (i.e., installation, operation, and maintenance).

2.3.3 Decision Tree Modeling Inputs and Assumptions

Assumptions used in the Decision Tree process were based on published data and expert knowledge. A review of currently available data found that none of the fish barrier technologies recommended had been tested on Asian carp in working locks like those on the Tennessee River. Testing of BAFF technology at Lake Barkley on the neighboring Cumberland River is ongoing and was not available at the time of this review[1]. Effectiveness of the barrier technologies—individually and in combination—was based on laboratory testing, some field trials, and expert judgment. None of the deterrent methods were considered to be 100 percent effective.

Current understanding of Asian carp populations in the Tennessee River system were also important inputs in the Decision Tree. Previous fisheries sampling by TVA and other natural resource partners have identified current distributions of Asian carp in the Tennessee River and connecting waterbodies (see Figure 1-3). Research is ongoing tracking the movements of Asian carp in and between reservoirs, including movements through locks and lock discharge ports.

Though not explicitly discussed in this PEA, other connecting waterbodies were an important consideration for modeling because of their potential to act as source populations of Asian carp. For example, fish barriers on the Cumberland River (i.e., Lake Barkley) are relevant to the carp control in the Tennessee River because a shipping canal connects Barkley and Kentucky

[1] An experimental BAFF was installed at Barkley Lock on the Cumberland River in November 2019, and it will be evaluated through 2022.

Reservoirs. The recommendations of the Decision Tree assumed the continued operation of the fish barrier system at Lake Barkley Lock.

Costs of fish barrier technologies vary greatly. When determining locations for fish barrier technologies, costs were weighted less than other model parameters in the Decision Tree. However, initial funding for fish barrier installation is limited, so selections of barrier installations were ranked by the locations determined by the Decision Tree process to be the most effective at limiting upstream migration of the leading edge and reducing migration from the Ohio River.

Other Decision Tree inputs included results from Asian carp life history models. For example, TVA used the USGS FluEgg model, illustrated in Figure 2-2, to predict which reservoirs and tributaries of the Tennessee River might be vulnerable to Asian carp spawning and could support egg transport and development. This information was incorporated into the Decision Tree process to better inform fish barrier placement using scientifically driven decision making. FluEgg is a three-dimensional numerical model developed to evaluate how rivers transport Asian carp eggs (Domanski and Berutti 2020). The model incorporates information about Asian carp egg development and river flows to provide insights regarding the likelihood of a given river/reservoir to be suitable for spawning, the potential of river flows to transport Asian carp eggs in suspension until hatching, and the identification of the location of Asian carp eggs at different developmental stages (Figure 2-2). Further details of the FluEgg model developed by USGS is provided in Appendix C.

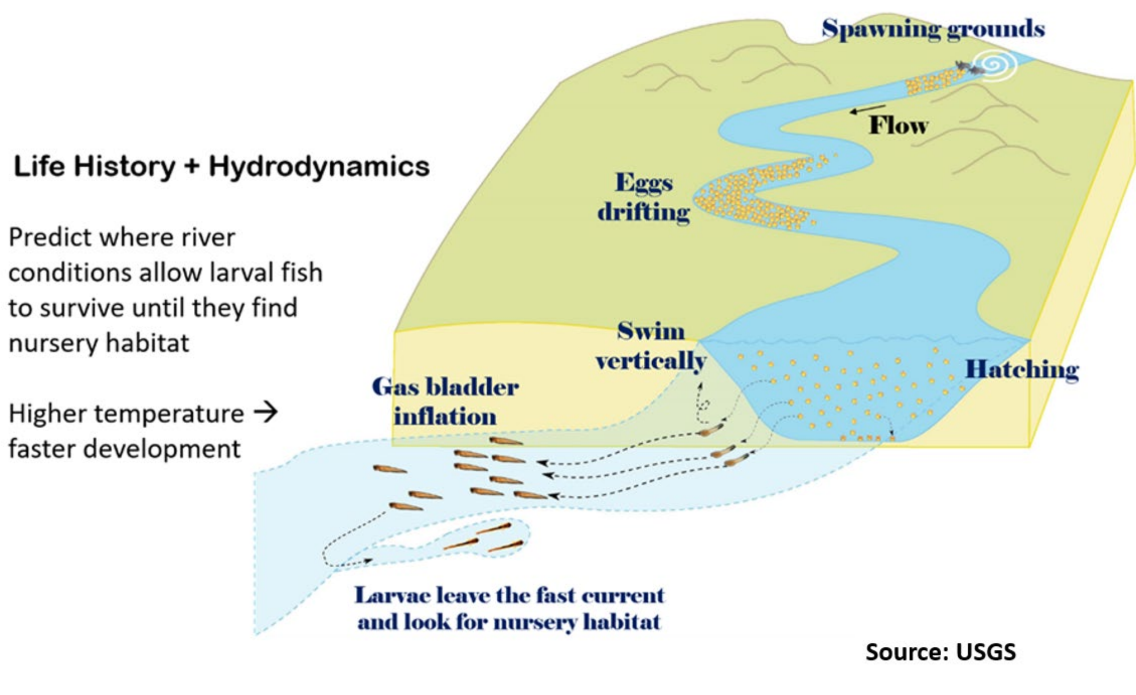

Figure 2-2. Example of FluEgg Model Predictions
(Source: USGS 2021c)

Monitoring and management practices by other natural resource agencies were also included in the Decision Tree process and would accompany fish barrier installations. Other state and federal agencies may remove Asian carp in reservoirs where notable populations or aggregations exist to further limit Asian carp spread. The FluEgg Model is also an important tool that can be used to support other management actions separate from TVA's proposed actions considered in this PEA. Locations predicted by the FluEgg model as more favorable for egg hatching, and larval recruitment would be targeted for fisheries monitoring and management control. Removals would target Asian carp abundances at spawning habitats or other locations where concentrations are highest, such as below dams. Commercial fishing has also been used to remove millions of pounds of carp annually. Other funding by resource managers apart from TVA have been earmarked for expanding commercial fishing of Asian carp in the Tennessee River. Targeted removals of Asian carp by others can be combined with fish barrier placements to increase mortality, reduce abundance, and limit upstream migration.

2.4 Overview of Fish Barriers and Alternatives Considered in the Decision Tree Process

The Decision Tree process conducted by the Workshop participants resulted in the ranking and prioritization of fish barrier technologies and locations to optimize the control of Asian carp within the Tennessee River system. All four fish barrier types at all locks on the Tennessee River were considered during the Decision Tree process.

2.4.1 Fish Barriers Considered in the Decision Tree Process

Four specific fish barrier technologies and a combination of these systems were considered by the Decision Tree.

a. **Bio-Acoustic Fish Fence[2] (BAFF)**. The BAFF is a system of fish deterrent technologies that together act as a barrier to Asian carp. This system consists of customized sound signals, directional strobe lighting, and a bubble curtain to produce an underwater linear deterrent to fish movement through the lock. A conceptual illustration of the BAFF system installed within the tailrace area is shown in Figure 2-3. Compressor air would be supplied to the BAFF system via supply lines from a land-based support system to form the bubble curtain.

   Recent data from the experimental BAFF fish barrier at Barkley Lock has been approximately 98 percent effective at keeping all sizes of Asian carp from passing into the lock.

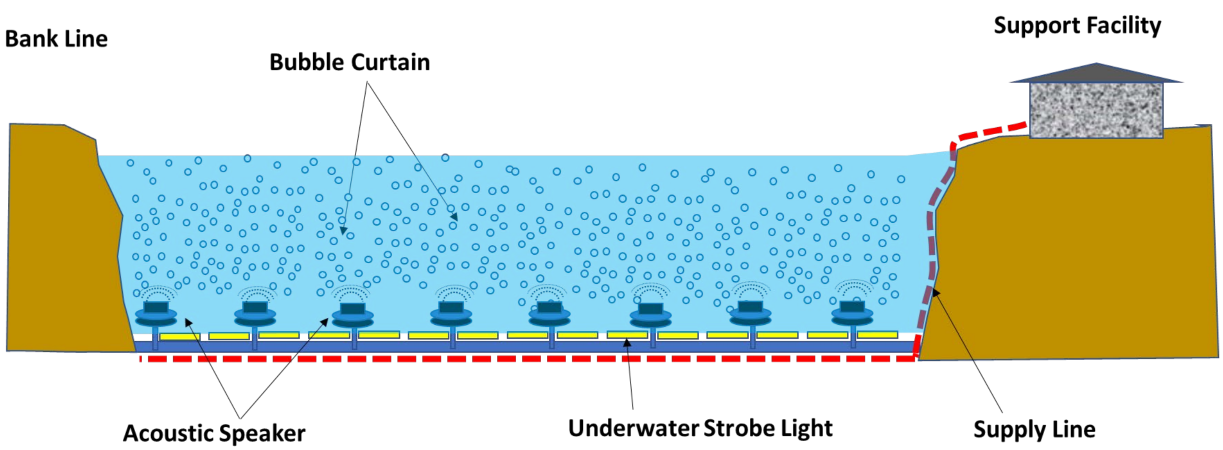

Figure 2-3. Conceptual Diagram of the BAFF System

b. **Diffused Carbon Dioxide (CO_2).** The CO_2 barrier consists of a plume of CO_2 diffused into specific areas within or around lock chambers as a chemosensory fish deterrent.

[2] BAFF is proprietary product of Fish Guidance Systems Ltd.

The addition of CO_2 to water has two main effects: (1) a reduction in pH due to the formation of carbonic acid (a weak acid), and (2) elevation of dissolved CO_2. Trials to assess the behavioral response of bighead carp, silver carp, and non-target native fishes (i.e., bigmouth buffalo, channel catfish, paddlefish, and yellow perch) were performed by USGS and demonstrated that fish would avoid areas near the CO_2 barrier and occupied the area with the lowest CO_2 concentration (USGS 2021b).

A conceptual illustration of the CO_2 system installed within the lock chamber is shown in Figure 2-4. Similar to the BAFF system, this technology would entail the use of land-based compressor systems that would supply a diffusion apparatus installed within the lock chamber. This system would require CO_2 storage facilities that would be periodically resupplied by trucking.

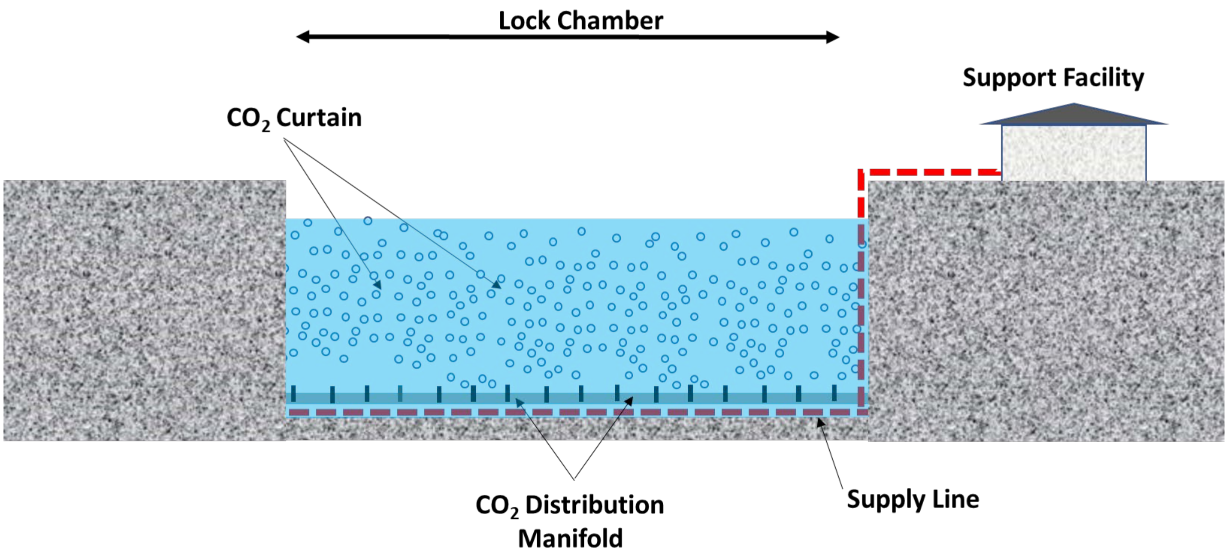

Figure 2-4. Conceptual Diagram of the CO_2 System

c. **Acoustic Deterrent System (ADS).** The ADS consists of an array of underwater speakers that deter fish with sound. This is an emerging technology that is still being evaluated. Vetter et al. (2015, 2017) demonstrated that auditory responses were possible in both silver and bighead carp in laboratory studies. However, results of recent pilot studies conducted by USGS were mixed. Deployment of a five-speaker ADS for over a month in 2018 did not result in discernable effects on Asian carp (USGS 2021a). Based on the lack of definitive evidence of the effectiveness of this technology, ADS was not recommended by the Workshop participants and was eliminated from consideration by TVA.

d. **Electrical Current.** The use of electrical current has been deployed as part of a barrier installed on the Chicago Sanitary and Shipping Canal to keep Asian carp from expanding into Lake Michigan. This technology uses DC-pulsed electricity deployed in the water to immobilize and deter fish. Electric barriers are effective in restricting the movement of fish; however, the USACE demonstrated potential vulnerabilities with this system due to fish entrainment by vessel traffic. Other potential concerns included the effects of stray voltage, fish moving near the irregular canal sidewalls, reduction in the electric field due to passing metal-vessel hulls, and temporary reverse flows in the canal

(USACE 2019). Ultimately, multiple electric barriers had to be built in a series to keep Asian carp from passing.

An electrical fish barrier system has public health and safety concerns related to electrical shock. Electric shock in the aquatic environment may cause burns, uncontrolled muscular spasms, ventricular fibrillation (i.e., heart attacks), or neurological effects (E-fish Solutions, 2021). The USACE hired the U.S. Navy Experimental Diving Unit to study the Chicago Sanitary and Shipping Canal electric barriers and report on their safety to humans. The research team was made up of engineers, physiologists, doctors and Navy divers to thoroughly evaluate the safety to human life. It concluded there was a 50 percent chance of death if someone fell into the water at an electrified barrier. There are two hazardous zones within the electric barriers, a Ventricular Fibrillation Zone and an Involuntary Muscular Contraction Zone. Pulsed electric currents as low as 1 milliamp across the heart for a fraction of a second could be potentially fatal in the Ventricular Fibrillation Zone. Drowning is the major concern in the Involuntary Muscular Contraction Zone. Electricity can also pass through the ground adjacent to the barriers and potentially shock humans on shore. At the Chicago Sanitary and Shipping Canal, electricity followed along an adjacent railway to a crossing which was discovered when multiple signals malfunctioned. Sparking can occur when barges or tows touch one another in the electric field which could ignite petroleum or other explosive substances commonly carried by barges.

High overall costs were also a concern. Based on these factors, this technology was not recommended by the Workshop participants and was eliminated from consideration by TVA.

Closure of the locks to all navigation traffic was also considered as a method to control Asian carp range expansion in the Tennessee River system. However, TVA does not have the authority to permanently close locks. Congressional approval would be needed for any extended lock closure. Additionally, as previously stated, the Tennessee River system is part of the nation’s roughly 11,000-mile Inland Waterway System that links commercial markets, suppliers, processors, and consumers via barge-navigable waters along the Tennessee, Ohio, Mississippi, Missouri, Illinois, and Arkansas rivers and their tributaries. Therefore, permanent lock closure was not a viable option and was not carried forward in the Decision Tree process.

2.4.2 Outcome of the Decision Tree Process

Outcomes and recommendations of the Asian Carp Deterrent Workshop Decision Tree process are provided in Appendix D.

The Decision Tree process resulted in the following recommendations:

1. Viable fish barrier technologies for application within the Tennessee River system include the BAFF and CO_2 systems. ADS and the electric barrier were not recommended (see Section 2.4.1).

2. BAFF may be deployed as either a stand-alone technology or in combination with CO_2 at selected sites.

3. CO_2 is not recommended as a stand-alone technology.

4. Deployment is recommended as a planned combination of installations at multiple selected L&D sites. Single deployment at isolated L&D sites is not recommended.

Workshop recommendations included the staged deployment of fish barriers at multiple L&D locations as the most effective way to control Asian carp expansion within the Tennessee River system (Appendix D). The BAFF system was recommended for immediate installation at Kentucky, Wilson, and Pickwick Landing locks, followed by Guntersville lock. However, given limited resources, BAFF installation should be prioritized at Kentucky and Wilson locks first, then Pickwick Landing lock, and then Guntersville lock. Supplemental CO_2 fish barriers were also recommended for installation at Kentucky and Guntersville to provide redundancy to the BAFF system. The BAFF system should be installed downstream of the lock, and the CO_2 system should be installed in the lock chamber.

The Workshop participants also recommended contracted or targeted removal of Asian carp to reduce populations in reservoirs where the populations are most abundant. **Active management of carp by removal is to be undertaken by other partners and is not included as part of the TVA action.**

Outcomes of the Decision Tree process are designed to adapt and change with new information. For example, additional locations could be added if Asian carp populations successfully spawn in new locations or suddenly make major migrations upstream. If a site is identified for a fish barrier technology that does not meet the listed bounding specifications, a supplemental NEPA review would be required.

2.5 TVA Programmatic EA Alternatives

2.5.1 Alternatives Initially Considered by TVA

Original alternatives formulated by TVA included the No Action Alternative and five Action Alternatives. Action Alternatives included the deployment of each fish barrier technology separately and in combination at one or more of the 10 L&D sites as alternatives to prevent the upstream movement of Asian carp throughout the Tennessee River system.

The extensive analysis and recommendations of the Workshop participants through the Decision Tree informed the development of alternatives to be evaluated as part of this PEA. As a result, TVA considered the following alternatives:

- Alternative A – No Action
- Alternative B – Install the BAFF deterrent system only at one or more of the 10 L&D sites within Tennessee River system.
- Alternative C – Install the ADS only at one or more of the 10 L&D sites within the Tennessee River system.
- Alternative D – Install the CO_2 Deterrent System only at one or more of the 10 L&D sites within the Tennessee River system.
- Alternative E – Install the Electric Barrier only at one or more of the 10 L&D sites within Tennessee River system.
- Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D sites within the Tennessee River system.

During preliminary drafting of the project alternatives, Alternative F was the extended or permanent closure of the locks which was removed from consideration prior to the Decision Tree process.

2.5.2 Alternatives Considered but Eliminated From Detailed Analysis

Multiple fish barrier technologies were initially considered by TVA to reduce the upstream migration of Asian carp within the Tennessee River system. Several alternatives were ultimate eliminated from consideration as part of the Decision Tree process. These alternatives, and the rationale for their elimination from further consideration by TVA in Chapter 3, Affected Environment and Environmental Consequences, are identified in Table 2-3.

Table 2-3. Alternatives Considered by TVA but Eliminated from Detailed Analysis in Chapter 3

Alternative	Basis for Elimination
Alternative B: Install the Bio-Acoustic Fish Fence: TVA would install only the BAFF deterrent system at one or more of the 10 L&D sites within Tennessee River system.	The BAFF is effective at preventing movement of Asian carp through a lock. Based on the outcome of the Decision Tree, the use of BAFF alone would not address the need to limit carp invasion within the Tennessee River system. Supplemental barriers (e.g., CO_2) are required in certain locations. Therefore, the stand-alone BAFF approach would not address the project purpose and need which is to substantially reduce the continued invasion of Asian carp into TVA reservoirs on the Tennessee River system. As such, it was eliminated from further consideration.
Alternative C: Install the Acoustic Deterrent System: TVA would install only the ADS at one or more of the 10 L&D sites within the Tennessee River system.	The ADS was considered less effective at preventing the movement of Asian carp throughout the Tennessee River system. As such, this alternative would not meet the purpose and need of the project and was eliminated from further consideration.
Alternative D: Install the Carbon Dioxide (CO_2) Deterrent System: TVA would install only the CO_2 system at one or more of the 10 L&D sites within the Tennessee River system.	The CO_2 system as a stand-alone system was anticipated to be less effective at preventing the movement of Asian carp throughout the Tennessee River system. The Workshop participants identified concerns related to continuous supply of CO_2 and potential downtime associated with operation of this deterrent method as a stand-alone system. As such, this alternative as a stand-alone system would not meet the purpose and need of the project and was eliminated from further consideration.
Alternative E: Install the Electric Barrier: TVA would install only an electric barrier at one or more of the 10 L&D sites within Tennessee River system.	Electric barriers were considered to have vulnerabilities in effectiveness based on factors related to fish size, entrainment by vessels, current variations, and other factors. Additionally, this technology was considered too dangerous to recreational and commercial users of the locks and too expensive. Therefore, this alternative was eliminated from further consideration.

2.6 Final Alternatives Retained for Analysis

Based on the outcome of the Decision Tree process and TVA's own evaluation, the final Alternatives to be evaluated in Chapter 3 of this PEA include:

- Alternative A – No Action Alternative. TVA would not install fish barrier technologies at any of the 10 L&D sites to deter the movement of Asian carp through the Tennessee River system.
- Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D sites within the Tennessee River system.

Barrier deployment at each location would entail the installation of BAFF or BAFF and CO_2 systems in the downstream lock and lock approach areas at each selected location. Workshop recommendations included the staged deployment of barriers at multiple L&D locations as the most effective means by which to control Asian carp expansion within the Tennessee River system. Potential movement of Asian carp through lock discharge ports may occur at selected locations, and this will be addressed as part of USACE lock operating procedures (e.g., valve closure procedures and other measures).

As an extension of the recommendations of the Workshop participants to deploy barrier systems at four locations, TVA has also prioritized potential future deployment of the BAFF system at Nickajack, Chickamauga, and Watts Bar L&Ds. Under Alternative G, barrier systems would be deployed using a combined system approach as summarized in Table 2-4.

Table 2-4. TVA Plan for Asian Carp Barrier Technology Deployment within the Tennessee River System

Deployment Location[1]	Priority[2]	Technology
Kentucky	1 (with Wilson)	BAFF/CO_2
Wilson	1 (with Kentucky)	BAFF
Pickwick Landing	2	BAFF
Guntersville	3	BAFF/CO_2
Nickajack	4	BAFF
Chickamauga	5	BAFF
Watts Bar	6	BAFF

[1] Depending upon future conditions, TVA may elect to deploy additional fish barrier systems at other L&Ds under Alternative G following any necessary site-specific review.

[2] Priority order was established by the Workshop participants as explained in Section 2.4.2, Outcome of the Decision Tree Process.

2.7 Programmatic Bounding Analysis

In order to programmatically assess potential direct and indirect effects associated with the construction and operation of the selected technologies (BAFF and CO_2), attributes of facility siting requirements, construction characteristics, and operational features were compiled and summarized as bounding attributes and characteristics to support the analysis of potential environmental impacts. Components of these support systems include an equipment building, supply lines, anchoring systems, temporary laydown areas, and other features.

Table 2-5 provides a bounding summary of attributes of fish barrier systems based upon the configurations and layouts presented in Appendix B and is based on conceptual drawings, with the understanding that impact areas at each L&D site are predominantly previously disturbed lands. Similarly, Table 2-6 provides a summary of the bounding values associated with various environmental attributes of the fish barrier technologies. As such, the values in Table 2-5 reflect the upper limits (i.e., most impactful) of potential impacts of construction and operation of fish barrier technologies at each L&D site to selected environmental resources. Prior to construction, TVA would review the final designs at each project location to ensure that the bounding attributes and resource characteristics at each location are consistent with the values contained in Tables 2-5 and 2-6. If a site is identified for a fish barrier technology that does not meet the listed bounding specifications, a supplemental NEPA review would be required.

Table 2-5. Asian Carp Barrier Technology Bounding Attributes

Feature	Characteristic	Specifications
Facility Attributes		
Deterrent System Technologies (BAFF and CO_2)	Land Requirements	Land-based site up to 1 acre (e.g., air compressor, CO_2 compressor, and electric controls).
	Estimated length of in-stream supply lines (BAFF and CO_2)	BAFF and CO_2: • Maximum—2,500 feet
	Estimated fishing exclusion area (BAFF and CO_2)	BAFF and CO_2: • Maximum—12 acres
	Storm Water Management	Onsite storm water basins or storm sewers.
	Facility access	Direct access to site from existing roadway network.
	Power requirements	Required power would be obtained from local distribution line.
	Potable water use	None.
	Safety Issues	BAFF—None. CO_2 System—None.
Wastewater Management	Treatment and Discharge	Portable units during construction. Operations would use existing infrastructure and treatment systems.
Material storage onsite	BAFF	None.
	CO_2	Requires onsite CO_2 storage tanks if not supplied by routine trucking.
Construction Phase Attributes		
Construction	Duration	Up to 24 months.
	Construction Laydown Areas	Laydown areas onsite, developed lands only. • Maximum—1 acre.
Excavation	Foundations and anchoring systems	Shallow foundation development (i.e., leveling of river bedrock) across the lock for the anchoring system for barrier technologies. Excavations in upland areas for support facilities only in previously disturbed areas.
Dredging	Applicability to all L&D sites	All locks and associated approaches would be dredged to accommodate service lines and equipment.
Borrow	Amount of borrow needed to support construction	No borrow is needed.

Feature	Characteristic	Specifications
Technology Operational Characteristics		
Schedule	Hours of Operation	Normal working hours, 5 days per week.
Lock Closure Duration (Construction)	Duration	Full or intermittent closure during construction period (maximum of 6 months).
Lock Closure Duration (Maintenance)	Duration	Scheduled BAFF maintenance once every 18 months which would require lock closure up to 5 days. Potential for unscheduled maintenance to repair barrier installations and supply lines, as needed.
Maintenance	Duration	Two hours per month for general maintenance. Quarterly air compressor maintenance.
Operation	Duration	365 operating days per year Technology Specific: • BAFF—continuous • CO_2—intermittent on lock gate operations
Trucking	Trucking characteristics for supplies during operations	Technology Specific: • BAFF—none • CO_2—intermittent to weekly delivery, dependent upon availability of on-site storage and frequency of technology application based on lock gate operations. Distributed on regional roadway network.

Table 2-6. Asian Carp Barrier Technology Environmental Characteristics and Bounding Values

Resource	Parameter	Characteristic / Bounding Value
Air Quality; Climate Change & Greenhouse Gases	Emissions	Localized construction-related emissions would not impact regional air quality. Operational emissions *de minimis* in the context of the regional setting.
Land Use & Prime Farmland	Land Use type	Developed and Open Water only. Short-term equipment staging on developed areas. Permanent installation on developed and open water land use types.
	Farmland within permanent or temporary use areas	None.
Zoning	Zoning classification	Technology facilities would be located in an area zoned for compatible uses.
Water Quality	Discharges to receiving streams	Onsite stormwater runoff subject to detention as per existing stormwater permit. Wastewater treated by existing treatment systems. BMPs to minimize soil erosion during construction that causes land disturbance. Dredging required to install technologies at lock entrance. Section 401 Water Quality Certification and Section 404 permit required for installation. TDEC would also require an ARAP which is paired with the States 401 WQC.
Floodplains	Location of land-based support systems	Located outside the 100-year floodplain; or made floodable; or elevated at least two feet above the 500-year flood elevation; and not located in the 100-year floodway. All facilities would be consistent with local floodplain regulations.
	Laydown areas	Located outside the 100-year floodplain.
	Dredge spoils	On land above the 500-year flood elevation.
Vegetation	Type of plant communities within land side support area	Plant communities absent (i.e., Developed land use) or disturbed and of low quality.
Wildlife	Type of wildlife communities within land side support area	Wildlife communities absent or disturbed and very common to the region.
Species of Concern	Potential to impact Listed Species (e.g., native mussels, bats, migratory birds, and bald eagles)	Project would attempt to avoid impacts to state- and federally listed species. Most land-based impacts would be on heavily disturbed areas not suitable for rare species. Avoid impacts to trees, caves, waterbodies, sinkholes, buildings, and bridges that could impact bats. Actions would be a sufficient distance from known heronries, osprey nests, and other populations of migratory birds protected by the Migratory Bird Treaty Act. Activities would comply with the

Resource	Parameter	Characteristic / Bounding Value
		National Bald Eagle Management Guidelines. Disturbances to sites with listed species of bats, mussels, or fish would require site-specific analysis including consultation with USFWS for potential impacts under the Endangered Species Act, as appropriate.
Surface Water/Wetlands	Location of land-based support systems	Outside jurisdictional Waters of the U.S. and State.
	Fill area within waters of the U.S.	Limited to anchoring system and associated service lines. USACE permitting under Section 404 CWA, Section 401 Water Quality Certification, and TN ARAP permitting.
Geology	Degree of alteration	Localized use of developed or previously disturbed upland sites. Localized leveling of river bedrock for anchoring systems (see technology attribute table, Table 2-5).
Groundwater	Alteration and use of groundwater	No groundwater use or alteration.
Historic Properties	NRHP Listed Properties	All L&Ds are NRHP-listed properties. Permanent installations would have a small footprint (see Visual/Aesthetics) and would be of like materials and colors of existing structures and associated infrastructure. No significant physical, visual, or audible effects that would alter the design, association, location, materials workmanship, or setting of the L&Ds. All excavation and construction would take place in either the river bed or the built environment and would have no potential for effects on intact archaeological sites.
Hazardous Waste	Management of Hazardous Waste	Generation of regulated hazardous substances or wastes is not expected; however, any regulated hazardous waste would be managed in accordance with RCRA requirements.
Solid Waste	Management of Solid Waste	Solid wastes and dredged material from construction and maintenance would be minimal and disposed in an approved upland sanitary landfill.
Noise	Noise Emissions	Noise emissions only from construction equipment used during normal working hours. Attenuation to offsite sensitive receptors not to exceed 65 dBA at property boundary. Acoustic deterrents are underwater and targeted, so there would be no discernable noise emissions during operation.

Resource	Parameter	Characteristic / Bounding Value
Socioeconomics	Employment	Construction phase employment up to 20 people. Operational phase would be automated. Maintenance employment up to 6 divers and 10 engineers. Workforce would be local or regional.
Environmental Justice	Interface with EJ populations	None.
Recreation	Fishing access and use of navigation locks	Reduction in fishing access up to a maximum of 12 acres. Temporary lock closures for recreational boaters during construction and maintenance (see Navigation).
Managed & Natural Areas	Presence at proposed technology installation sites	None.
Transportation	Intensity of vehicle use for construction and operations	Low during construction for transport of equipment. Potential for frequent truck deliveries of CO_2 during operations of carbon dioxide technology if on-site storage not available.
Visual/Aesthetics	Maximum size of facility components	Single story support structure up to 30 feet long (e.g., large shipping container).
	Appearance	Developed industrial facility.
Public Health and Safety	Barrier technologies and supply lines	BAFF and CO_2 would not impede public health and safety. Operation is designed not to impede safe lock passage.
Navigation	Lock closure	Temporary lock closure for construction. Operation is designed not to impede lock operation. Maintenance would require temporary lock closure, as needed.
Economics	Temporary lock closure; reduced recreational and fishing opportunities on the reservoirs	The Tennessee River system is a significant economic factor for the region. Tourism, recreation, and navigation all benefit the economy by increasing local expenditures, tax revenues, property values, and employment opportunities. Reservoirs throughout the system also host professional fishing tournaments, bringing in revenues from outside the region.

TVA recognizes that the design phase of the project at each dam location is conceptual at this time. As such, based on the completion of site-specific designs, TVA will review each project location to ensure that the bounding attributes and resource characteristics at each location are consistent with the values contained in Tables 2-5 and 2-6. Should site-specific conditions and potential effects exceed the bounding values, TVA will perform a site-specific review as needed to ensure that the level of impact assessment is consistent with that of the PEA.

Attributes of the fish-barrier technologies and their environmental characteristics as summarized in each of these tables were used to assess direct and indirect impacts for each resource analyzed in Chapter 3.

2.8 Comparison of Alternatives

The environmental impacts of each of the alternatives under consideration are summarized in Table 2-7. These summaries are derived from the information and analyses provided in the Affected Environment and Environmental Consequences sections of each resource in Chapter 3.

Table 2-7. Summary and Comparison of Alternatives by Resource Area

Resource	Alternative A: No Action	Alternative G: Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System
Aquatic Ecology	Large negative impacts to sportfish in lower reservoirs (i.e., Kentucky to Guntersville) long term. Moderate negative impacts to sportfish in middle reservoirs (i.e., Nickajack and Chickamauga) long term. Minor negative impacts to sportfish in upper reservoirs (i.e., Watts Bar, Fort Loudoun, and Melton Hill) long term. Moderate and long-term negative impacts to other planktivorous fish and native mussels throughout the study area.	Localized, minor, and short-term impacts during construction and operation. Large, broad benefits to the existing aquatic community long-term.
Recreation	Initial minor adverse impacts increasing to moderate long term.	Short-term, intermittent, and localized disruption to recreational activities during construction. Long-term minor reductions in fishing access at lock entrances. Overall moderate benefits.

Resource	Alternative A: No Action	Alternative G: Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System
Economic Impact	Initial minor adverse impacts associated with expenditures related to freshwater fisheries and recreation increasing to large adverse impacts long term.	Positive minor impacts from construction in the short term. Impacts on regional economies is anticipated to be positive, moderate, and long term
Managed and Natural Areas	No impact.	Minor and temporary construction-related impacts.
Navigation	No impact.	Moderate and temporary adverse impact to recreational navigation. Large, but temporary adverse impact to commercial navigation. Temporary and minor adverse impacts to recreational and commercial navigation at locations with multiple locks.
Air Quality	No impact.	Minor, localized adverse impacts to air quality below applicable ambient air quality standards.
Climate Change	No impact.	Minor local emissions of GHGs negligible in a regional context.
Geology and Soils	No impact.	Minor and temporary impacts to soil stability and erosion during construction.
Groundwater	No impact.	No impact.
Surface Water	Long term and minor negative impacts to water quality due to loss of aquatic macrophytes from feeding grass carp.	Minor, temporary, and localized impacts during dredging and installation. Long-term beneficial impacts.
Floodplains	No impact.	Minor impacts.
Land Use and Prime Farmland	No impact.	Minor impacts to land use. No impact to prime farmland.
Vegetation	No impact.	Minor impacts.
Wildlife	No impact.	Minor impacts to common wildlife.
Threatened and Endangered Species	Adverse, moderate, and long-term impacts to protected mussels. No impacts to other protected plants and animals.	Minor adverse impacts to migrating protected fish species due to operation of the fish barrier systems. Moderate and long-term benefits to protected mussels.
Wetlands	No impact.	No impact.

Resource	Alternative A: No Action	Alternative G: Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System
Solid and Hazardous Waste	No impact.	Minor and temporary impacts.
Visual Resources	No impact.	Minor impacts.
Cultural and Historic Resources	No impact.	Minor visual impacts to historic L&Ds, subject to supplemental assessment and consultation.
Transportation	No impact.	Minor impacts.
Noise	No impact.	Minor and temporary impacts.
Demographics and Environmental Justice	No impact from transient workforces. Minor potential impact to environmental justice communities relying on subsistence fishing.	Minor impacts associated with transient workforces. No impacts to environmental justice populations. .
Public Health and Safety	Moderate and long-term adverse impacts from jumping silver carp.	No impacts during construction. Long term moderate benefits from operation of fish barriers.
Cumulative Effects	Moderate, long term adverse impacts to recreation.	Minor, temporary impacts to recreation and navigation. Long term beneficial impact to aquatic ecosystems, recreation, and local economies.

2.9 TVA's Preferred Alternative

Alternative G is TVA's preferred alternative. Alternative G is consistent with the established purpose and need to control the abundance and range expansion of Asian carp within the Tennessee River reservoir system and its tributaries by installing fish barriers at strategic L&D locations. Alternative G would reduce potential future ecosystem and economic consequences associated with the establishment of Asian carp in the Tennessee River system in accordance with the plan summarized in Table 2-4. In summary, BAFF systems would be installed in Kentucky, Wilson, Pickwick Landing, Guntersville, Nickajack, Chickamauga, and Watts Bar locations. Supplemental CO_2 fish barriers would be installed in Kentucky and Guntersville locks. Fish barriers in Kentucky, Wilson, and Pickwick locks should be immediately installed followed by installation in Guntersville, Nickajack, Chickamauga, and Watts Bar locks.

The selection of these locations was based on modeled scenarios favoring Asian carp expansion within the Tennessee River system (e.g., high fish movement rates and successful reproduction) and scenarios that would limit their spread (e.g., low movement and no reproduction). Under these scenarios, Decision Tree outcomes recommended installation of fish barriers at the above locks over doing nothing (i.e., No Action Alternative).

2.10 Summary of Environmental Commitments, Mitigation Measures, and BMPs

This section provides a summary of environmental commitments, mitigation measures, and BMPs that TVA would employ to avoid or reduce adverse impacts from the alternatives analyzed. TVA's analysis of potential impacts considers implementation of these measures as required to reduce or avoid adverse effects. Environmental commitments, mitigation measures, and BMPs proposed for the Asian carp barriers are summarized below and further discussed in Chapter 3. Additionally, based on the completion of site-specific designs, TVA will review each project location to ensure that the bounding attributes and resource characteristics at each location are consistent with the values contained in Tables 2-5 and 2-6. Should site-specific conditions and potential effects exceed the bounding values, TVA will perform a site-specific NEPA review as needed to encompass the additional scope.

TVA has identified the following mitigation measures and BMPs that would be used to minimize impacts and restore areas disturbed during proposed project activities:

- Public notice of lock closures, including estimated length of construction, would be provided to the public prior to closure.
- At locations with multiple locks (i.e., Pickwick, Wilson, Guntersville, and Wheeler), installation of fish barriers would be staggered to allow continued navigation.
- During construction at Kentucky Lock, vessels could bypass the Kentucky Lock through Lake Barkley by way of a canal connecting the two adjacent waterbodies.
- A SWPPP would be implemented to minimize erosion during site preparation using appropriate site-specific BMPs.
- TVA would use turbidity curtains or other protective measures during dredging and installation of fish barriers to minimize transport of sediment downstream.
- Dredged material would be properly disposed at a location above the 500-year flood elevation, graded for proper drainage, and re-vegetated to prevent future erosion.
- Construction would include customary industrial safety standards, applicable BMPs, and job-site safety plans to maintain worker and public safety. Site safety plans would codify steps to ensure specific water-safety procedures are followed.
- Equipment refueling and maintenance operations would be carried out at designated locations using applicable BMPs.
- Appropriate spill prevention, containment, and disposal requirements for hazardous wastes would be implemented to protect construction workers, the public, and the environment in accordance with applicable state and federal regulations.
- TVA would manage all solid wastes generated in accordance with applicable state regulations and following procedures outlined in TVA's current Environmental Procedures and applicable BMPs.
- Components of the fish barrier systems would be adjusted to best target more sound- and CO_2-sensitive Asian carp and maintain passage of some native fish species.
- Land-based support systems would be located outside the 100-year floodplain; or made floodable; or elevated at least to one foot above the 100-year flood elevation or two feet above the 500-year flood elevation; and not located in the 100-year floodway.
- All facilities would be consistent with local floodplain regulations.
- Laydown areas would be located outside the 100-year floodplain.
- A number of activities associated with the proposed project were addressed in TVA's programmatic consultation with the U.S. Fish and Wildlife Service on routine actions and federally listed bats in accordance with ESA Section 7(a)(2) and completed in April 2018. For those activities with potential to affect gray bats, northern long-eared

bat, Indiana bat, and Virginia big-eared bat, TVA committed to implementing specific conservation measures. Once the specific design has been identified at each L&D site, relevant conservation measures will be identified and implemented as part of the project.

CHAPTER 3 – AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Chapter 3 discusses the existing environmental, social, and economic conditions of the proposed project study area with potential to be impacted by the proposed activities. In addition to the existing conditions, potential environmental effects associated with each considered alternative are identified and discussed throughout the chapter.

In this document, four descriptors will be used to characterize the level of impacts as follows:

- No Impact (or “absent”) – Resource not present or affected by project alternatives under consideration.
- Minor (or “small”) – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- Moderate – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- Large – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

3.1 Aquatic Ecology

3.1.1 Affected Environment

3.1.2 Tennessee River Dam and Reservoir System

The Affected Environment for this analysis encompasses the entirety of the serially impounded mainstem Tennessee River and lower Clinch River and the ten dams and associated reservoirs on these river systems.

Construction of the Tennessee River dam and reservoir system fundamentally altered the aquatic habitat of the Tennessee and Clinch rivers. Dams and their associated reservoirs have benefits for power generation, navigation, flood control, and recreation; however, they also disrupt the daily, seasonal, and annual flow patterns that are essential characteristics of the impounded waterway. Dams modify the natural hydroperiod by converting free-flowing lotic ecosystems into lake-like lentic ecosystems. For example, high flows are captured and stored by reservoirs upstream of dams, whereas flows fluctuate rapidly downstream of the dams due to hydropower peaking or flood-control releases. Dams have shaped the composition of the aquatic communities above and below impoundments throughout the study area. Reservoirs and smaller impoundments have expanded some species’ ranges in the system, primarily shad and sunfishes, creating popular sport fisheries. Conversely, undammed sections support a much higher diversity of aquatic life including federally and state-listed species.

The Tennessee River watershed is recognized as a global hotspot for freshwater biodiversity (Schilling and Williams 2002). The Tennessee and Cumberland rivers have the highest number of endemic fish, mussel, and crayfish species in North America (Schilling and Williams 2002). The Tennessee River alone has approximately 319 fish species, including native and introduced species, and 129 freshwater mussel species (Etnier and Starnes 1993, Parmalee and Bogan 1998).

3.1.3 Fish

The Tennessee River watershed has an estimated 205 native fish species (Etnier and Starnes 1993). Fishes within the study area are represented by approximately 30 families—the largest being the perch family (>90 species, mostly darters), followed by the minnows (>80 species), catfishes (>20 species), suckers (21 species), and sunfishes (>20 species). Undammed streams and tributaries in the study area typically have a fish community that follows this same structure (i.e., high numbers of minnows and darters). Some of these species are common and may be found throughout the study area, whereas others are more limited in their distribution to certain unimpounded tributaries.

TVA has used a Reservoir Ecological Health monitoring program since 1990 to evaluate ecological conditions in major reservoirs in the Tennessee River system. A component of this monitoring program is a multi-metric approach to data evaluation for fish communities known as the Reservoir Fish Assemblage Index. Samples of fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Though altered from human activity, mainstem reservoirs support healthy fish communities and generally rate good or fair based on attained Reservoir Fish Assemblage Index scores (McDonough and Hickman 1999). Species richness data from 2010 to 2015 from representative mainstem reservoirs including Kentucky, Wilson, Wheeler, Nickajack, Chickamauga, and Fort Loudoun ranged from 43 to 68 species per reservoir. Good to excellent fisheries exist in each reservoir, primarily for black bass, crappie, sauger, temperate bass, sunfish, and catfish. The primary commercial fishery species are channel catfish, blue catfish, and buffalo.

Table 3-1 lists the number of species by family from the six representative reservoirs. Four families make up two-thirds of the total diversity. Minnows are the largest portion of total diversity, followed by sunfish, suckers, and perch. The other one-third of total diversity includes 15 other families (30 species).

Table 3-1. Number of Species by Family from Representative Tennessee River Reservoirs

Family	Common Name	Number of Species
Cyprinidae	Minnow	21
Centrachidae	Sunfish	14
Catastomidae	Sucker	13
Percidae	Perch	12
Ictaluridae	Catfish	5
Moronidae	Temperate Bass	5
Clupeidae	Herring	4
Lepisosteidae	Gar	2
Petromyzontidae	Lamprey	2
Atherinidae	Silverside	2
Fundulidae	Topminnow	2
Amiidae	Bowfin	1
Sciaenidae	Drum	1
Anguillidae	Eel	1
Poeciliidae	Mosquitofish	1
Belonidae	Needlefish	1
Esocidae	Pikes	1

Family	Common Name	Number of Species
Cottidae	Sculpin	1
Acipenseridae	Sturgeon	1

Source: TVA Reservoir Fish Assemblage Index 2010 to 2015.

Table 3-2 lists the most common species caught in the representative reservoirs. Six sunfish species were collected in every reservoir including: largemouth bass, smallmouth bass, spotted bass, redear sunfish, warmouth, and white crappie. Three suckers (black redhorse, golden redhorse, and spotted sucker); three minnows (common carp, golden shiner, and spotfin shiner); and three catfish (blue catfish, channel catfish, and flathead catfish) were commonly collected. Two herring (gizzard shad and threadfin shad) and two perch (logperch and yellow perch) were common. Additionally, longnose gar and white bass are commonly collected.

Table 3-2. Common Fish Species Found in Tennessee River Reservoirs

Family	Common Name	Scientific Name
Centrachidae	Largemouth bass	*Micropterus salmoides*
Centrachidae	Redear sunfish	*Lepomis microlophus*
Centrachidae	Smallmouth bass	*Micropterus dolomieu*
Centrachidae	Spotted bass	*Micropterus punctulatus*
Centrachidae	Warmouth	*Lepomis gulosus*
Centrachidae	White crappie	*Pomoxis annularis*
Catastomidae	Black redhorse	*Moxostoma duquesni*
Catastomidae	Golden redhorse	*Moxostoma erythrurum*
Catastomidae	Spotted sucker	*Minytrema melanops*
Cyprinidae	Common carp	*Cyprinus carpio*
Cyprinidae	Golden shiner	*Notemigonus crysoleucas*
Cyprinidae	Spotfin shiner	*Cyprinella spiloptera*
Ictaluridae	Blue catfish	*Ictalurus furcatus*
Ictaluridae	Channel catfish	*Ictalurus punctatus*
Ictaluridae	Flathead catfish	*Pylodictis olivaris*
Clupeidae	Gizzard shad	*Dorosoma cepedianum*
Clupeidae	Threadfin shad	*Dorosoma petenense*
Percidae	Logperch	*Percina caprodes*
Percidae	Yellow perch	*Perca flavescens*
Lepisosteidae	Longnose gar	*Lepisosteus osseus*
Moronidae	White bass	*Morone chrysops*

Source: TVA Reservoir Fish Assemblage Index 2010 to 2015

3.1.4 Macroinvertebrates

A component of the Reservoir Health Ecological Monitoring Program includes sampling the benthic macroinvertebrate community. Benthic or bottom dwelling macroinvertebrate populations of TVA's reservoir system are assessed using the Reservoir Benthic Index methodology. Benthic macroinvertebrates include: worms, aquatic insects, crayfish, snails, mussels, and clams. These species are a vital part of the food chain of aquatic ecosystems.

Macroinvertebrate communities of reservoirs are generally low in diversity and comprised of tolerant taxa. This trend is typical of most reservoir systems, as few macroinvertebrates tolerate conditions in the deeper waters that are characterized as having lower dissolved oxygen (DO) concentrations, reduced habitat variability, and limited food resources (Thorp and Covich 2001).

In the Tennessee River watershed, the 91 taxa of mussels belonging to Unionidae were widespread from headwater streams to the mainstem of the Tennessee River. Currently, of these original 91 native mussels, 10 are extinct, 20 are extirpated, 24 are endangered (see Section 3.15, Threatened and Endangered Species), nine are relic, and 28 are stable (Neves 1999).

Mussel communities in reservoirs are generally poor (TVA 2004b). Native mussels that are adapted to the natural warmwater conditions cannot maintain diverse populations in reservoirs. However, the statuses of individual populations vary by species. For example, mussels adapted to pool conditions have been doing better in Kentucky Reservoir including: mapleleaf, bankclimber, and three ridge (Sickel et al. 2007). Mainstem tailwaters, like those of Kentucky Reservoir, are areas of highest mussel diversity in the regulated Tennessee River system. Remaining riverine mussel species reach greater abundance and diversity in flowing mainstem reaches, but their status remains only fair due to overall low diversity, low abundances, and low reproductive success for some species (TVA 2004b).

3.1.5 Aquatic Macrophytes

Aquatic plants are often referred to as aquatic macrophytes and include aquatic vascular plants, a few mosses, and macroscopic algae. Aquatic plants benefit water quality and provide habitat to wildlife, waterfowl, and fisheries. Floating-leaved plants and submersed vegetation provide sediment stabilization and food, shelter, and reproductive habitat for fish, insects, and other aquatic fauna. Riverine aquatic plants in the Tennessee River watershed are mostly rooted species that occur on gravel shoals. Plant communities are dominated by native species; however, Eurasian watermilfoil, hydrilla, and coontail are common invasive species.

3.1.6 Invasive Aquatic Species

There are several exotic, non-native, and pest species that occur in the Tennessee River watershed. Although there are many exotic or introduced aquatic species within the region, a few species are considered more detrimental due to their ability to have broad impacts to overall aquatic systems as well as direct impacts to humans. These include Asian carp. Asian carp cause serious damage to the native fish populations in the lakes and rivers that they infest because they out-compete other fish for food and space. Asian carp are also thought to lower water quality, which can kill off sensitive organisms like native freshwater mussels. Asian carp have been known to dominate entire streams, effectively pushing out the native species. Asian carp are also known to pose danger to humans due to their habit of jumping out of the water striking boaters and water skiers and damaging boats and equipment.

3.1.7 Reservoir Ecological Health

Each reservoir has unique physical and biological characteristics that define their aquatic ecosystems. Each reservoir is described below by its Reservoir Ecological Health score and rating (TVA 2021b). TVA assesses the ecological health of its reservoirs on a cyclical basis. Reservoirs receive qualitative ratings based on a range of physical and biological characteristics at multiple locations (TVA 2021b).

The health ratings are based on five factors:

1. **Dissolved Oxygen (DO)**. A good rating means there’s plenty of oxygen to support fish and other aquatic life.

2. **Chlorophyll**. A measure of algae in the water, a good rating means that algal growth is within the expected range. If levels are too low, the reservoir's food web can be affected; if levels are too high, water treatment costs may increase and oxygen levels in the bottom layer of water may suffer from decaying algae.
3. **Fish Community**. A good rating means there are a large number and good variety of fish.
4. **Benthic Community**. A good rating means that there are plenty of worms, insects and snails thriving on the reservoir floor.
5. **Sediment**. A good rating means sediment is free from PCBs, pesticides, and large concentrations of metals.

Sample locations are dependent on the reservoir's size and include:

1. **Forebay**: The deep, still water near a dam.
2. **Mid-reservoir**: This is where the transition occurs from a river-like environment to a lake-like one.
3. **Embayment**: A large slough or cove (e.g., Chickamauga, Kentucky, Pickwick, and Wheeler).
4. **Inflow**: The river-like area at the extreme upper end of a reservoir.

Health ratings include good, fair, and poor (from high to low). An overall reservoir rating and score are provided based on the combined health ratings from all measured reservoir locations. Common sportfish targeted by anglers are also listed below to help characterize the fish community at each of these locations.

3.1.7.1 Fort Loudoun Reservoir

In 2019, Fort Loudoun Reservoir received an overall reservoir ecological health score of 77 and a reservoir rating of "Good" (Table 3-3).

Three locations on Fort Loudoun Reservoir were sampled including: the forebay, the transition, and the inflow. Water quality data were not collected at the inflow. Habitat parameters including DO and sediment quality were "Good". Chlorophyll rating was "Fair" indicating elevated chlorophyll concentrations which are common in Fort Loudoun Reservoir (TVA 2021g). Sediment quality rated "Good" at the forebay and mid-reservoir locations because no PCBs or pesticides were detected, and concentrations of metals were within expected background levels (TVA 2021g). Benthic community ratings were "Poor" at the forebay and inflow and "Good" at the transition. Relatively few organisms are collected from the forebay and inflow locations, and those collected are primarily species able to tolerate a wide variety of environmental conditions. Bottom life at the mid-reservoir location was "Good" due to greater diversity and more intolerant species such as mayflies (TVA 2021g). Fish community ratings were "Good" meaning there were a large number and good variety of fish collected in the reservoir. Common sportfish targeted by anglers in Fort Loudoun Reservoir include largemouth bass, crappie, and sauger.

Table 3-3. Reservoir Ecological Health Ratings/Scores for Tennessee River Reservoirs

Year	Location	River Mile	DO Rating	Sediment Rating	Chlorophyll Rating	Benthic Community Rating	Fish Community Rating	Reservoir Rating	Reservoir Score
2019	Kentucky Forebay	TRM 23.0	Good	Good	Poor	Good	Good	Good	78
	Kentucky Transition	TRM 85.0	Good	Good	Good	Good	Good		
	Kentucky Big Sandy Embayment	Big Sandy 7.4	Good	Good	Poor	Fair	Good		
	Kentucky Inflow	TRM 200-206	ns	ns	ns	Fair	Good		
2018	Pickwick Forebay	TRM 207.3	Good	Fair	Fair	Fair	Fair	Fair	67
	Pickwick Transition	TRM 230.0	Good	Good	Poor	Good	Fair		
	Pickwick Bear Creek Embayment	Bear Creek 8.4	Fair	Good	Poor	Fair	Good		
	Pickwick Inflow	TRM 253-259	ns	ns	ns	Good	Good		
2018	Wilson Forebay	TRM 260.8	Fair	Good	Poor	Poor	Good	Fair	63
	Wilson Inflow	TRM 273-274	ns	ns	ns	Good	Fair		
2019	Wheeler Forebay	TRM 277.0	Poor	Good	Poor	Poor	Good	Fair	63
	Wheeler Transition	TRM 295.9	Good	Fair	Good	Good	Good		
	Wheeler Elk River Embayment	Elk River 6.0	Poor	Good	Poor	Poor	Good		
	Wheeler Inflow	TRM 347-348	ns	ns	ns	3	Fair		
2018	Guntersville Forebay	TRM 350.0	Good	Fair	Fair	Fair	Fair	Good	81
	Guntersville Transition	TRM 375.2	Good	Good	Good	Good	Fair		
	Guntersville Inflow	TRM 420-424	ns	ns	ns	Good	Fair		
2018	Nickajack Forebay	TRM 425.5	Good	Good	Good	Good	Poor	Good	88
	Nickajack Inflow	TRM 469-470	ns	ns	ns	Good	Good		
2019	Chickamauga Forebay	TRM 472.3	Good	Good	Fair	Good	Fair	Good	87

Year	Location	River Mile	DO Rating	Sediment Rating	Chlorophyll Rating	Benthic Community Rating	Fish Community Rating	Reservoir Rating	Reservoir Score
	Chickamauga Transition	TRM 490.5	Good	Good	Good	Good	Good		
	Chickamauga Hiwassee Embayment	Hiwassee 8.5	Good	Good	Good	Fair	Good		
	Chickamauga Inflow	TRM 518-529	ns	ns	ns	Good	Good		
2018	Watts Bar Forebay	TRM 532.5	Fair	Good	Fair	Fair	Fair	Fair	72
	Watts Bar Transition	TRM 560.8	Good	Good	Fair	Good	Good		
	Watts Bar Inflow Tennessee	TRM 600-601	ns	ns	ns	Poor	Good		
	Watts Bar Inflow Clinch	CRM 19-22	ns	ns	ns	Fair	Good		
2019	Fort Loudoun Forebay	TRM 605.5	Good	Good	Fair	Poor	Good	Good	77
	Fort Loudoun Transition	TRM 624.6	Good	Good	Fair	Good	Good		
	Fort Loudoun Inflow	TRM 652	ns	ns	ns	Poor	Good		
2018	Melton Hill Forebay	CRM 24.0	Good	Good	Fair	Poor	Good	Fair	71
	Melton Hill Transition	CRM 45.0	Good	Good	Good	Fair	Fair		
	Melton Hill Inflow	CRM 59-60	ns	ns	ns	Poor	Fair		

ns = not sampled; denotes locations where a given ecological indicator is not sampled

3.1.7.2 Melton Hill Reservoir

In 2018, Melton Hill Reservoir received an overall reservoir ecological health score of 71 and a reservoir rating of “Fair” (Table 3-3).

Three locations were sampled including: the forebay, the transition, and the inflow. Water quality data were not collected at the inflow. Habitat parameters including DO and sediment quality were “Good”. Chlorophyll rating was “Good” to “Fair”. Sediment quality rated “Good” at the forebay and mid-reservoir locations because no PCBs or pesticides were detected, and concentrations of metals were within expected background levels (TVA 2021g). Benthic communities rate “Poor” at the forebay and inflow monitoring locations and “Fair” at the mid-reservoir. Low diversity of mostly tolerant species was collected at these locations. Mid-reservoir generally rates “fair” due to greater abundance and diversity, which includes sensitive and long-lived species such as mayflies and snails (TVA 2021g). Fish community ratings were “Good” meaning there were a large number and good variety of fish collected in the reservoir. A total of forty-seven fish species was observed reservoir-wide in previous years (TVA 2021g). Some of the more interesting species included muskellunge (muskie), western blacknose dace, and snubnose darters. The most common sportfish targeted by anglers in Melton Hill Reservoir include muskie, largemouth bass, and redear sunfish.

3.1.7.3 Watts Bar Reservoir

In 2018 Watts Bar Reservoir received an overall reservoir ecological health score of 72 and a reservoir rating of “Fair” (Table 3-3).

Four locations were sampled including: the forebay, the transition, and the inflow from the Tennessee and Clinch rivers. Water quality data were not collected at the inflows. Dissolved oxygen ratings were “Fair” to “Good”. Poorer DO conditions typically occur due to reduced flows through the reservoir during dry conditions (TVA 2021g). Sediment quality rated “Good” at the two locations monitored. No PCBs or pesticides were detected, and concentrations of metals were within suggested background levels. Chlorophyll rated “Fair” at the forebay and mid-reservoir monitoring locations. Runoff is a major factor in the variation observed (TVA 2021g). Benthic communities rated “Fair” at the forebay and Clinch inflow, “Good” at the mid-reservoir, and “Poor” at the Tennessee inflow. At the Tennessee inflow, a variety of organisms were collected (e.g., mussels, clams, snails, and caddisflies) but in very low numbers—likely due to shifting substrates (TVA 2021g). The fish assemblage rated “Fair” at the forebay and “Good” everywhere else. A total of 47 different species was observed reservoir-wide in previous years (TVA 2021g). Overall, fish composition was dominated by a few species such as bluegill, gizzard shad, bluntnose minnow, and spotfin shiner. Black redhorse were also present in high numbers at the Clinch River inflow. Common sportfish in Watts Bar Reservoir include largemouth bass, crappie, and sauger.

3.1.7.4 Chickamauga Reservoir

In 2019, Chickamauga Reservoir received an overall reservoir ecological health score of 87 and a reservoir rating of “Good” (Table 3-3).

Four locations were sampled including: the forebay, the transition, the Hiwassee embayment, and the inflow. Water quality data were not collected at the inflow. Dissolved oxygen ratings were “Fair” to “Good”. Poorer DO conditions typically occur due to reduced flows through the reservoir during dry conditions (TVA 2021g). Sediment quality rated “Good” at the two locations monitored indicating no PCBs or pesticides were detected and concentrations of metals were within suggested background levels. Chlorophyll rated “Fair” at the forebay and “Good” at all other locations. Chlorophyll typically fluctuates with flow conditions in Chickamauga Reservoir

(TVA 2021g). Benthic communities rated “Fair” at the Hiwassee embayment and “Good” at all other locations. The fish community rated “Fair” at the forebay and “Good” at all other locations. A total of forty-nine species was observed reservoir-wide in previous years (TVA 2021g). Common sportfish in Chickamauga Reservoir include largemouth bass, crappie, and sauger.

3.1.7.5 Nickajack Reservoir

In 2018, Nickajack Reservoir received an overall reservoir ecological health score of 88 and a reservoir rating of “Good” (Table 3-3).

Two locations were sampled including: the forebay and the inflow. Habitat parameters including DO, sediment, and chlorophyll were all rated “Good”. Nickajack has consistently high scores among the reservoirs monitored by TVA (TVA 2021g). Nickajack is a small, narrow reservoir with a short retention time. It usually takes only three or four days for water to flow through the reservoir, which helps keep the water mixed, preventing it from stratifying during the summer. This allows oxygen in the lower water column to be replenished and limits algal growth. Benthic communities rated “Good” at the forebay and inflow. A variety of organisms were found, including long-lived and sensitive species such as snails and mayflies (TVA 2021g). Fish communities rated “Poor” at the forebay and “Good” at the inflow. Fewer species in lower numbers were collected at the forebay than expected and a greater proportion of those were tolerant individuals (TVA 2021g). Common sportfish in Nickajack Reservoir include largemouth bass, crappie, and sauger.

3.1.7.6 Guntersville Reservoir

In 2018, Guntersville Reservoir received an overall reservoir ecological health score of 81 and a reservoir rating of “Good” (Table 3-3).

Three locations were sampled including: the forebay, transition, and the inflow. Dissolved oxygen ratings were “Good”. Sediment quality rated “Fair” to “Good”. Sediment quality commonly rates “Fair” at the forebay due to one or more contaminants: PCBs, chlordane, or zinc (TVA 2021g). Chlorophyll rated “Fair” at the forebay and “Good” at the mid-reservoir. Chlorophyll concentrations typically fluctuate in response to reservoir flows (TVA 2021g). Benthic communities rated “Fair” at the forebay and “Good” at the mid-reservoir and inflow. Fish communities rated “Fair: at all locations because the number of individuals and variety of species collected were slightly fewer than expected. Historically, ratings generally have fluctuated within the mid to upper end of the fair range at each location (TVA 2021g). Common sportfish in Guntersville Reservoir include largemouth bass, crappie, and catfish.

3.1.7.7 Wheeler Reservoir

In 2019, Wheeler Reservoir received an overall reservoir ecological health score of 63 and a reservoir rating of “Fair” (Table 3-3).

Four locations were sampled including: the forebay, the transition, Elk River embayment, and the inflow. Water quality data were not collected at the inflow. Dissolved oxygen ratings were “Poor” at the forebay and embayment and “Good” at the transition. Lower ratings were due to low DO in the summer—a period of lower flows and higher temperatures (TVA 2021g). Sediment quality rated “Fair” at the transition and “Good” at the forebay and embayment. Low levels of PCBs have been detected in the sediments at the mid-reservoir location (TVA 2021g). Chlorophyll rated “Poor” at the forebay and embayment and “Good” at the transition. Elevated chlorophyll concentrations are common in Wheeler Reservoir (TVA 2021g). Benthic communities rate “Poor” at the forebay and Elk River embayment monitoring locations and “Good” at the transition. Lower ratings were due to relatively low population densities, predominantly composed of species tolerant of the low DO concentrations that develop during summer (TVA 2021g). Fish community ratings were "Fair" at the inflow and "Good" at all other locations. A total of fifty-one species was observed reservoir-wide in previous years (TVA 2021g). Top carnivores (e.g., largemouth bass), benthic invertivores (species that feed primarily on bottom-dwelling insects) and intolerant species (species known to require good water quality conditions) were well represented at each location. Some of the more interesting species observed included bowfin, stripetail darter, and orange-spotted sunfish. Common sportfish in Wheeler Reservoir include largemouth bass, crappie, catfish, and sauger.

3.1.7.8 Wilson Reservoir

In 2018, Wilson Reservoir received an overall reservoir ecological health score of 63 and a reservoir rating of "Fair" (Table 3-3).

Two locations were sampled including: the forebay and the inflow. Water quality data were not collected at the inflow. Dissolved oxygen ratings were "Fair" at the forebay. Sediment quality rated "Good" at the forebay indicating no PCBs or pesticides were detected and concentrations of metals were within suggested background levels (TVA 2021g). Chlorophyll rated "Poor" at the forebay. Elevated chlorophyll concentrations are common in Wilson Reservoir (TVA 2021g). Benthic communities rated "Poor" at the forebay and "Good" at the inflow. Lower ratings were probably due to low oxygen levels near the reservoir bottom and lack of good habitat (TVA 2021g). Fish communities rated "Fair" at the inflow and "Good" at the forebay. Common sportfish in Wilson Reservoir include largemouth bass, crappie, and catfish.

3.1.7.9 Pickwick Reservoir

In 2018, Pickwick Reservoir received an overall reservoir ecological health score of 67 and a reservoir rating of "Fair" (Table 3-3).

Four locations were sampled including: the forebay, the transition, Bear Creek embayment, and the inflow. Water quality data were not collected at the inflow. Dissolved oxygen ratings were "Fair" at the embayment and "Good" at the other locations. Lower ratings were due to low DO during lower flows (TVA 2021g). Sediment quality rated "Fair" at the forebay and "Good" at all other locations. Concentrations of arsenic in the forebay were slightly above the background concentrations (TVA 2021g). Chlorophyll rated "Fair" at the forebay and "Poor" at the mid-reservoir and embayment monitoring locations. Benthic communities rated "Good" at the mid-reservoir and inflow locations and "Fair" at the forebay and Bear Creek Embayment. The main channel of the Tennessee River typically has greater abundance and diversity than Bear Creek (TVA 2021g). Fish communities rated "Fair" at the forebay and the mid-reservoir and "Good" at the inflow and embayment. A total of fifty species was observed reservoir-wide in previous years (TVA 2021g). Common sportfish in Pickwick Reservoir include largemouth bass, smallmouth bass, and crappie.

3.1.7.10 Kentucky Reservoir

In 2019, Kentucky Reservoir received an overall reservoir ecological health score of 78 and a reservoir rating of "Good" (Table 3-3).

Four locations were sampled including: the forebay, the transition, Big Sandy embayment, and the inflow. Water quality data were not collected at the inflow. Habitat parameters DO and sediment were rated "Good" at all locations. Chlorophyll rated "Poor" at the forebay and embayment and "Good" at the transition. Elevated chlorophyll concentrations are common on Kentucky Reservoir except mid-reservoir due to increased mixing (TVA 2021g). Benthic communities rated "Good" at the forebay and transition and "Fair" at the inflow and embayment.

Samples from the inflow and embayment contained fewer individuals and a lesser variety of organisms than those from the other monitoring locations (TVA 2021g). Fish communities rated “Good” at the four locations monitored. A total of sixty different species was observed reservoir-wide in previous years (TVA 2021g). Some of the more interesting species observed included American eel, rainbow darter, river darter and silver chub. Silver carp were observed at the forebay, mid-reservoir and embayment locations. Common sportfish in Kentucky Reservoir include largemouth bass, crappie, and catfish.

3.1.8 Environmental Consequences

3.1.8.1 Alternative A – No Action

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the 10 L&D sites to deter the movement of Asian carp through the Tennessee River system. No construction related impacts would occur. Asian carp populations are anticipated to increase over time if no attempts are made to impede their movement. As large populations of Asian carp become established, negative impacts include reduced aquatic plants that provide spawning and nursery habitat for fishes (van der Lee et al. 2017) and food for waterfowl (Sullivan et al. 2020), reduced planktonic food sources for native fishes (Sullivan et al. 2020), and reduced fishing, boating, and waterfowl hunting (Poudyal et al. 2017).

Silver carp and bighead carp are the Asian carp species of greatest concern (Table 3-4). Under the No Action Alternative, by 2030, silver carp are anticipated to have a high (i.e., large) impact to aquatic communities from Kentucky Reservoir to Guntersville Reservoir and a moderate impact to Nickajack and Chickamauga Reservoirs. Bighead carp are anticipated to have a moderate impact to aquatic communities from Kentucky Reservoir to Guntersville Reservoir over the same period. Black carp are more recent invaders and are anticipated to have a moderate impact to Kentucky Reservoir by 2030. Grass carp have been present in the Tennessee River for a longer period and are anticipated to have only low (i.e., minor) impacts to aquatic communities by 2030. All other reservoirs listed in Table 3-4 with low anticipated impacts to aquatic communities from Asian carp would still be vulnerable to Asian carp establishment over the next decade under the No Action Alternative.

Table 3-4. Invasive Asian Carp Impacts to TVA Reservoirs by 2030 Under the No Action Alternative

	Level of Impact			
Reservoir	**Bighead Carp**	**Silver Carp**	**Black Carp**	**Grass Carp**
Kentucky	M	H	M	L
Pickwick	M	H	L	L
Wilson	M	H	L	L
Wheeler	M	H	L	L
Guntersville	M	H	L	L
Nickajack	L	M	L	L
Chickamauga	L	M	L	L
Watts Bar	L	L	L	L
Fort Loudoun	L	L	L	L
Melton Hill	L	L	L	L

Note: Impacts are summarized qualitatively as Low (L), Moderate (M), and High (H).

Continued expansion of Asian carp throughout the Tennessee River could negatively impact sportfish standing stock, condition, and reproduction due to complex and unpredictable indirect effects across multiple trophic levels (DeBoer et al. 2018). For example, bighead carp and silver carp are ravenous filter-feeding planktivores that have the potential to alter existing food webs. Plankton is the main food source for most fishes during early development (Solomon et al. 2016) and is the main forage base for adult fish such as gizzard shad and paddlefish. Reductions in available forage could negatively impact growth and survival of native species including sportfish. Similarly, paddlefish snagging is anticipated to decrease due to an overlap in filter-feeding behavior with silver and bighead carp, as is the commercial harvest of paddlefish in Kentucky and Tennessee. Long term reductions in fish diversity and abundance are likely to follow establishment of Asian carp in reservoirs of the Tennessee River system.

Table 3-5 summarizes the anticipated population growth and negative effects of Asian carp on sportfish stocks and recruitment over the next 10 years under the No Action Alternative. As compared to the baseline (i.e., 2020), Asian carp populations in future years are anticipated to be high in lower reservoirs of the Tennessee River and moderate in middle reservoirs within the Tennessee River system. Indirect effects on sportfish standing stock and recruitment are initially low but increase to moderate in lower reservoirs by 2030. Middle reservoirs reflect a delayed indirect impact to sportfish whereby effects are more pronounced (i.e., moderate) with time. Presumably, indirect effects on sportfish would increase geographically within the system beyond the modeled years. Negative indirect impacts to paddlefish fisheries are expected to be high (i.e., large) from Kentucky to Wilson Reservoirs and moderate in Wheeler Reservoir due to overlapping diets as explained above.

Mussels native to the mainstem Tennessee River would also be directly impacted if fish barrier technologies were to not be installed. Black carp are molluscivores and have been documented consuming native mussels and snails in the Mississippi River drainage (Poulton et al. 2020). There is a potential for black carp to consume rare or listed species that reside in the Tennessee River if established. Under the No Action Alternative, by 2030, direct impacts to aquatic ecosystems by black carp are anticipated to be moderate in Kentucky Reservoir (Table 3-4). Filter-feeding silver and bighead carp could also indirectly impact native mussels in multiple reservoirs through competition for the same prey items. Predation and direct competition for food could potentially reduce native mussel populations including listed species that are at risk of extinction.

Overall, direct and indirect adverse impacts to fish, sportfish, and native mussels are considered moderate and long term under the No Action Alternative.

3.1.8.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Under Alternative G, installation of the fish barrier technologies would include construction of support facilities and infrastructure at each L&D site that could impact the behavior of nearby aquatic species. Supporting components include installation of supply lines for bubble curtains and CO_2 diffusion and anchoring systems for BAFF installation. Localized dredging would accommodate the installation of supply lines and BAFF manifolds. Dredging would disturb the bottom and temporarily increase suspended sediment within the proposed action area. Reduced flow at the lock approaches would minimize the movement of suspended sediments downstream. There would also be a short-term increase in noise pollution from construction activities. Impacts to the aquatic ecology within the project areas would be minor and temporary.

The ongoing operation of the proposed Asian carp deterrent systems may impact native aquatic species, especially those that rely on travel through the lock to access other habitat (Lucas and Baras 2008). Lab tests conducted by the University of Minnesota (Dennis et al. 2019) found the BAFF to be 97 percent effective in deterring bighead carp and silver carp due to those species being particularly sensitive to sound. However, the deterrent system was significantly less effective on native fishes, likely due to the lack of morphological hearing specializations and low hearing sensitivity (Popper 2003). Because these systems are only meant to be utilized when Asian carp are present, there would be times when deterrent systems would be turned off. This would allow the system to be selectively adjusted to line up with seasonal migrations of native freshwater fishes throughout the Tennessee River system. Still, there would almost certainly be times when individuals of native species are deterred from lock passage while the deterrent systems are in operation. Overall, the impact of blocked passage for native species through locks would be minor relative to the long-term operation of the existing dams and could be mitigated through adjustment of the sound frequency of the BAFF system and variable use during native species migrations.

Potential fish habitat at the locks and lock entrances exists for some protected species (see Section 3.15, Threatened and Endangered Species). For example, TVA biologists have been monitoring the presence of snail darters in the tailwaters of the main stem Tennessee River since 2016. It is thought that the recolonization of the main stem Tennessee River occurred via downstream larval drift from one reservoir to another, rather than adults passing through navigation locks. Most individuals captured during survey efforts in main stem tailwaters have occupied large gravel patches, usually around 20 feet deep. Though this type of habitat has been documented in the lock approaches at certain dam sites, most individuals have been collected from habitats located considerable distances from entrances to lock chambers. Only indirect impacts to this species are anticipated. Any individuals that may happen to persist in the project footprint when construction is initiated are capable of relocating during the duration of the construction activities. No adverse impacts from the ongoing use of the proposed Asian carp barrier systems are anticipated for this species.

Locks are not typically suitable habitats for freshwater mussels, but there could be potential construction impacts due to mussels at some L&D locations. Recent surveys at locks and lock approaches showed low density and low diversity of freshwater mussels due to the highly disturbed conditions. However, lock entrances at Kentucky and Pickwick had healthy mussel populations. Pickwick recently recorded an endangered mussel species—a single pink mucket (*Lampsilis abrupta*)—in the vicinity of a proposed project footprint. Construction would directly impact mussels at these locations; however, pre-construction surveys also entailed the relocation of mussels to suitable habitats downstream of the proposed project footprint. Intact freshwater mussel assemblages occur at suitable habitats downstream of the locks in the tailwaters of some dams. These assemblages would not be directly affected by the preferred action alternative. Overall, construction impacts to mussel populations would be minor and mitigated with pre-construction surveys.

Operation of the fish barriers could have minor impacts to the existing mussel communities at the locks. Prolonged exposure of native mussels (i.e., more than 28 days) to high CO_2 concentrations may limit growth, inhibit shell formation, and cause shell pitting and erosion in native mussels (Waller et al. 2019). However, theses impacts were reversed once mussels were returned to untreated water (Waller et al. 2019). Shorter-duration exposure, such as temporary use of CO_2 fish barriers only during active lockages, may have only minor impacts to native mussels in the lock. Additionally, the CO_2 barrier would be localized at the lock entrance where it is designed to diffuse throughout the water column and not concentrate at the bottom where mussels reside. No impacts to mussels outside of the lock are anticipated because CO_2 does not persist in the aquatic environment (Fredericks et al. 2019; see Section 3.10, Surface Water Quality).

Under Alternative G, installation of fish barrier systems—coupled with other management actions by TVA partners—is anticipated to control the spread of Asian carp and reduce populations through time (Table 3-6). Correspondingly, negative impacts of Asian carp to the existing aquatic ecology of the Tennessee River system would decrease. For example, following barrier installation, Asian carp populations would decrease from a baseline high in 2020 to low in 2030 in Kentucky Reservoir. Pickwick Reservoir is expected to have a similar decrease from moderate to low over the same period. Subsequently, negative impacts of Asian carp to sportfish standing stocks, fish conditions, reproduction, and recruitment would remain low through time. Impacts to the existing paddlefish fishery would also remain low.

Overall aquatic ecology impacts under Alternative G are anticipated to be localized, minor, and short-term during construction and operation of the fish barrier systems, but have broad, larger, long-term benefits to the existing aquatic community due to the reduced impacts of invasive Asian carp throughout the Tennessee River system.

Table 3-5. Summary of Effects of Asian Carp to Sportfish in Select Reservoirs Under Alternative A

Reservoir	Asian carp population			Impacts to sportfish standing stock and fish condition			Impacts to sportfish reproduction and recruitment			Impacts to paddlefish fishery (if present)		
	2020	2025	2030	2020	2025	2030	2020	2025	2030	2020	2025	2030
Kentucky	H	H	H	L	M	M	L	M	M	L	M	H
Pickwick	M	H	H	L	M	M	L	M	M	L	M	H
Wilson	L	M	H	L	M	M	L	M	M	L	M	H
Wheeler	L	M	M	L	L	M	L	L	M	L	L	M
Chickamauga	L	M	M	L	L	L	L	L	L	L	L	L

Note: Impacts are summarized qualitatively as Low (L), Moderate (M), and High (H).

Table 3-6. Summary of Effects of Asian Carp to Sportfish in Select Reservoirs Under Alternative G

Reservoir	Asian carp population			Impacts to sportfish standing stock and fish condition			Impacts to sportfish reproduction and recruitment			Impacts to paddlefish fishery (if present)		
	2020	2025	2030	2020	2025	2030	2020	2025	2030	2020	2025	2030
Kentucky	H	M	L	L	L	L	L	L	L	L	L	L
Pickwick	M	L	L	L	L	L	L	L	L	L	L	L
Wilson	L	L	L	L	L	L	L	L	L	L	L	L
Wheeler	L	L	L	L	L	L	L	L	L	L	L	L
Chickamauga	L	L	L	L	L	L	L	L	L	L	L	L

Note: Impacts are summarized qualitatively as Low (L), Moderate (M), and High (H).

3.2 Recreation

3.2.1 Affected Environment

TVA is congressionally mandated to provide electricity, flood control, environmental stewardship, management of the Tennessee River, and support economic development in the Tennessee Valley region. Sustaining outdoor recreation within TVA land and water resources contributes to TVA's mission to promote economic development and to foster environmental stewardship. Engaging citizens in outdoor recreation develops public appreciation of natural resources and the environment, and, thus, supports environmental stewardship in the Tennessee Valley. TVA land and water resources include approximately 650,000 acres of reservoir surface water (of which 459,640 acres are in the study area), 11,000 miles of shoreline (of which 6,893 miles are in the study area), and 293,000 acres of TVA-owned land (of which 208,627 acres are in the study area) available for recreation and other purposes. Selected recreational characteristics of each reservoir in the study area are shown on Table 3-7.

TVA reservoirs are nationally known and provide popular venues for anglers to pursue a variety of sportfish including bass, crappie, walleye, trout, and catfish. Of these species, bass has been one of the most sought after, and the Bass Angler Sportsman Society (B.A.S.S.), one of the most recognized bass tournament organizations, identifies three of the TVA reservoirs in the study area (i.e., Chickamauga, Guntersville, and Pickwick) as top 25 lakes in the U.S. for bass fishing for the decade between 2010 and 2020 (B.A.S.S. 2020). Additionally, as discussed in Section 3.3, Economic Impact, the expenditures recreationists bring into the communities surrounding TVA reservoirs generate considerable economic impacts to the region, such as direct and indirect expenditures, jobs, and tax revenue (Poudyal et al. 2017).

Public lands adjacent to TVA reservoirs also support an array of high-quality and diverse developed and dispersed recreation opportunities. Developed recreation includes modern facilities and amenities such as campgrounds, picnic areas, scenic overlooks, playgrounds, sports fields, lodges, marinas, boat launching ramps, beaches, visitor buildings and other day use facilities. Dispersed recreation consists of passive informal activities such as hunting, hiking, nature observation, primitive camping, and bank fishing (TVA 2017b).

In 2011, TVA completed its first Natural Resource Plan (NRP) to guide its stewardship efforts for managing the waters and public lands of the Tennessee River Valley (TVA 2011b). The purpose of the NRP is to integrate the goals of these resource areas, provide for the optimum public benefit, and achieve a balance between public and private land use and natural resource protection. In May 2020, the TVA Board of Directors adopted changes to the NRP to support a more strategic, flexible, and comprehensive management approach to TVA's natural and cultural resource stewardship work (TVA 2020). The 2020 NRP represents TVA's high-level strategy for guiding stewardship efforts over the next 20 years.

TVA also prepares Reservoir Land Management Plans for TVA retained lands on TVA reservoirs. This effort allocates TVA lands into categories based on suitable uses that are consistent with TVA policies and guidelines and applicable laws and regulations. TVA Reservoir Land Management Plans can be accessed on the TVA website at https://www.tva.com/Environment/Environmental-Stewardship/Land-Management/Reservoir-Land-Management-Plans.

Millions of people annually participate in numerous outdoor recreation activities within TVA reservoirs and surrounding lands, including boating, fishing, hunting, swimming, hiking, bird watching, camping, and picnicking. A 2017 study estimated 6,683 average annual recreation days per shoreline mile for TVA reservoirs (Table 3-7; Poudyal et al. 2017), which equates to approximately 46 million average annual recreation days for the reservoirs within the study area.

Table 3-7. Recreation Characteristics for TVA Reservoirs in the Study Area

Reservoir	Shoreline Miles	Estimated Average Annual Recreation Days[1] (million)	TVA-owned Land[2] (Acres)	Number of Public/Private Recreation Facilities[3]
Kentucky	2,064	13.8	74,714	157
Pickwick	490	3.3	19,238	43
Wilson	166	1.1	1,223	13
Wheeler	1,027	6.9	36,045	36
Guntersville	890	5.9	40,236	68
Nickajack	179	1.2	3,605	18
Chickamauga	784	5.2	16,061	56
Watts Bar	722	4.8	13,425	62
Fort Loudoun	379	2.5	1,502	47
Melton Hill	193	1.3	2,578	15
Total	**6,894**	**46.0**	**208,627**	**515**

Source: [1] Based on an estimated 6,683 average annual recreation days per shoreline mile from Poudyal et al. 2017; [2] TVA 2021i; [3] TVA 2011a

Recreation areas and facilities within the study area include public and private facilities. Public facilities are owned and/or operated by TVA or other government agencies (TVA 2017b). Other public recreation areas within the study area include federal, state, and local parks. Recreation area facilities and amenities in the vicinity of the 10 reservoirs in the study area include: 124 campgrounds, 152 marinas, 391 developed boat launching ramps, and many day use facilities such as picnic areas, swimming beaches, fishing piers, and trails (Table 3-8). Locations of recreation areas are provided on the TVA website at https://www.tva.com/environment/recreation/tva-recreation-map.

Table 3-8. Number of Public and Private Recreation Areas with Facilities at each Reservoir in the Study Area

Reservoir	Camping	Boat Ramps	Marinas	Picnic Shelter	Play-grounds	Swimming Areas	Fishing Piers	Trails	Visitor Centers
Kentucky	51	135	59	42	39	39	25	12	17
Pickwick	13	25	18	17	10	7	6	5	7
Wilson	2	8	4	3	3	1	4	2	3
Wheeler	9	29	7	9	3	5	14	4	3
Guntersville	16	57	20	29	16	14	20	17	4
Nickajack	4	15	3	10	5	3	7	5	1
Chickamauga	13	40	15	23	15	9	8	7	1
Watts Bar	12	57	20	28	20	22	20	10	6
Fort Loudoun	3	12	4	7	4	2	0	4	1
Melton Hill	1	13	2	11	6	3	5	4	1
Total	**124**	**391**	**152**	**179**	**121**	**105**	**109**	**70**	**44**

Source: TVA 2011

3.2.1.1 Recreation on TVA Reservoirs

Among the 10 TVA reservoirs within the study area, Kentucky Reservoir is the largest and contains many varieties of fish, including largemouth and smallmouth bass, white bass, catfish, bluegill, sauger, and crappie. There are numerous boat docks and ramps within the coves of the lake. Located on lands adjacent to Kentucky Reservoir are the Land Between the Lakes National Recreation Area, six state parks, the Tennessee National Wildlife Refuge, numerous public access areas and two state wildlife management areas. There are resorts and campgrounds, areas for swimming and picnicking, and a back-country undeveloped recreation area for off-road vehicles. Water skiing, sailing, and windsurfing are popular, as well as bicycling, horseback riding, bird watching, hunting, and fishing (TVA 2021d). The tailwater area in the Tennessee River from the Kentucky Dam downstream to the confluence with the Ohio River is managed as a snagging fishery for paddlefish by the Kentucky Department of Fish and Wildlife Resources (KDFWR; KDFWR 2021c).

Pickwick Reservoir is a popular waterskiing and fishing destination. The reservoir offers a variety of public parks and commercial recreation operations to meet recreational needs. Pickwick Reservoir has excellent sport-fishing areas, including the Wilson Dam tailwater at the upper end of the reservoir, noted for record-size smallmouth bass and catfish (TVA 2021d).

Wilson Reservoir is known as the “Smallmouth Capital of the World” for the number of trophy smallmouth bass caught. Visitors also enjoy camping, boating, and a network of walking and hiking trails on lands around the reservoir and dam (TVA 2021d).

Wheeler Reservoir is a major recreation and tourist center. Along with camping, boating, and fishing, visitors enjoy the Wheeler National Wildlife Refuge, located several miles upstream from the dam (TVA 2021d).

Guntersville Reservoir is a popular fishing lake for crappie, bass, and bluegill. A variety of public and commercial recreation facilities have been developed around the reservoir shoreline. The Guntersville Dam tailwater area is known for sauger fishing during autumn and winter, white bass in early spring, and catfish during the summer. The area below the dam also offers opportunities for day hiking (TVA 2021d).

Nickajack Reservoir is popular for shoreline fishing near the dam. A boat ramp is located below the dam and fishing berms are located on both sides of the river below the dam, and a concrete fishing pier with footbridges and wheelchair access is available. Facilities for camping and picnicking, boating and other activities are available around the reservoir (TVA 2021d).

Chickamauga Reservoir is popular for fishing, boating and swimming. There are boat ramps on the reservoir as well as a wide range of accommodations for water-based recreation. Hiking trails are available on the Big Ridge Small Wild Area, which is a 200-acre upland hardwood forest situated on a ridge above the north shore of the reservoir at the dam (TVA 2021d).

Watts Bar Reservoir is a major swimming destination, although boating, fishing, camping and other outdoor activities are also popular. A scenic overlook at the dam provides a panoramic view of the reservoir and the surrounding area (TVA 2021d).

Fort Loudoun Reservoir is a popular recreation destination, known for bass fishing, boating, and birdwatching. The tailwater area immediately below the dam is an excellent site for viewing a variety of waterbirds, including herons, cormorants, gulls, osprey, and bald eagles. There is an Americans with Disabilities Act (ADA) compliant bank fishing facility on the right bank below the Fort Loudoun Dam.

Melton Hill Reservoir features a zero-energy camping facility with solar power and wind energy that is built with recycled materials. There is also a pavilion that can be used for family reunions or wedding parties. The reservoir has a nationally recognized rowing course that serves as a spring training site for collegiate teams from throughout the eastern United States. The area around Melton Hill Reservoir offers year-round camping and sheltered picnic tables and pavilions. Two boat ramps—one below the dam and one above—provide access to Watts Bar and Melton Hill reservoirs. Roads on both sides of the river are popular for walking, jogging, or bike riding. Popular game fish in the reservoir include sauger, crappie, and bass (TVA 2021c).

3.2.1.2 Recreation at TVA L&D Sites

Fishing from the bank and by boat are popular recreation activities that occur along the shoreline of TVA reservoirs, and many TVA dams also offer fishing berms and piers for tailwater fishing immediately below the dams (Table 3-9). Fishing berms or shelves are constructed along the bank to allow anglers to stand close to the shoreline, and piers are often concrete or wooden, ADA compliant, and extend out over the water. (Table 3-9). The tailwaters of some TVA dams provide excellent fishing for sauger (winter/spring), smallmouth bass, white and yellow bass (spring), striped bass (spring through fall), and catfish year-round. Tailwater fishing can be accomplished from the bank and by boat. Snagging is permitted in the Tennessee River downstream of the Kentucky Dam in Kentucky, but it is generally prohibited within 100 yards downstream of the dams in Tennessee and is not permitted within the Tennessee River system in Alabama. Snagging of paddlefish in Kentucky and Tennessee is subject to local limits. Bank and tailwater fishing facilities at dams within the study area are shown in Table 3-9.

Table 3-9. TVA Bank/Tailwater Fishing Facilities at Dams within the Study Area

Dam	Left Bank Below Dam	Right Bank Below Dam
Kentucky	parking area, ADA compliant fishing berms, restrooms	parking area, ADA compliant fishing berm, restrooms
Pickwick	parking area, fishing berm	parking area, fishing berms, restrooms

Dam	Left Bank Below Dam	Right Bank Below Dam
Wilson	TVA Rockpile Recreation Area. Shoreline fishing from recreation area to Wilson Dam.	None
Wheeler	parking area, shoreline fishing area, restrooms	None
Guntersville	parking area, fishing berms, restrooms	parking area, shoreline fishing berms
Nickajack	parking area, fishing pier, restrooms	parking, shoreline fishing area downstream from boat ramp, restrooms
Chickamauga	parking area, fishing pier	parking area, fishing pier
Watts Bar	parking area, fishing berms	None
Fort Loudoun	parking area, shoreline fishing berms	parking area, ADA compliant shoreline fishing berms, restrooms
Melton Hill	parking area, shoreline fishing berms, restrooms	None

3.2.2 Environmental Consequences

3.2.2.1 Alternative A – No Action

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the 10 TVA L&D sites to deter the movement of Asian carp through the Tennessee River system. Though footprint-based impacts resulting from the installation of fish barriers would not occur, there would be direct and indirect impacts to fish populations in the Tennessee River.

As summarized in Table 3-5 (see Section 3.1, Aquatic Ecology), forage fish and sportfish populations would be reduced over time, which would result in reduced catch rates and reduced recreational angling in the future. As compared to the baseline (i.e., 2020), Asian carp populations in future years are anticipated to be high in lower reservoirs of the Tennessee River and moderate in middle reservoirs within the Tennessee River system. Indirect effects on sportfish standing stock and recruitment are initially low but increase to moderate in lower reservoirs by 2030. Middle reservoirs reflect a delayed indirect impact to sportfish whereby effects are more pronounced (i.e., moderate) with time. Presumably, indirect effects on sportfish would increase geographically within the system beyond the modeled years. Negative indirect impacts to paddlefish fisheries are expected to be high (i.e., large) from Kentucky to Wilson Reservoirs and moderate in Wheeler Reservoir due to overlapping diets. Therefore, under the No Action Alternative, potential dense populations of Asian carp in the lower portion of the Tennessee River system by 2030 would result in adverse impacts to recreation by decreasing recreational fishing opportunities for the general public. In addition, the jumping behavior exhibited by silver carp when startled would pose a perceived and actual threat to recreational boaters and waterskiing throughout the Tennessee River system (see Section 3.23, Public Health and Safety).

Overall, adverse impacts to recreation under the No Action Alternative would be initially minor but would increase to moderate and long term for the lower and middle portions of the study area by 2030. Impacts to recreation are presumed to increase as Asian carp expand geographically within the system in the future.

3.2.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D sites within the Tennessee River System

During construction of the proposed systems for up to 24 months, there would be minor impacts to fishing and other recreational activities immediately surrounding the construction footprints due to noise and presence of construction vehicles and personnel. In addition, lock closure duration for construction of the selected systems would be up to six months. During operation of the barrier systems, there would be scheduled maintenance for approximately two hours per month for general maintenance, and locks would close for up to five days once every 18 months and also for possible unscheduled maintenance to repair barrier installations and supply lines, as needed.

During lock closures for construction and maintenance, recreational boaters would not be able to pass through the locks, and this would result in minor adverse impacts to recreational boaters. Closures at Watts Bar and Guntersville locks (i.e., locks with high recreational use) would have a greater impact on recreational vessels than at Kentucky, Pickwick, and Wilson. However, these impacts would be short term, intermittent, and localized, and recreators could use other parts of the reservoirs and/or recreational facilities in the vicinity of the reservoir during these periods. Notice of lock closures, including estimated length of construction, would be provided to the public prior to closure, and some recreational boaters wanting to traverse between reservoirs during lock closures could use boat ramps upstream or downstream of the L&D during these periods.

While conceptual plans for each L&D site vary (Appendix B), each of the technologies includes the development of support facilities and infrastructure at each site and the establishment of a permanent fishing restricted area up to 12 acres around the barrier infrastructure. Restricted area sizes are subject to revision during final design and efforts will be made to reduce each area, as appropriate. Additionally, USACE will post appropriate signage and will notify the boating community to enhance awareness of the restricted areas. Therefore, there would be a long-term reduction in fishing access at the reservoir L&D sites where fish barrier systems are installed. However, these potential restricted areas are small and located in the immediate vicinity of the L&D sites. In general, they would not affect established fishing piers or bank fishing berms downstream of the dams.

A bank fishing facility on the left bank below Fort Loudoun L&D is located within a conceptual fishing restricted area (Figure B-9, Appendix B). Fort Loudoun is not a priority location for installation of a fish barrier system (Table 2-4), and installation of the barrier system as conceptually identified is outside of the programmatic bounding analysis in this PEA. However, if installation of a fish barrier system is proposed at the Fort Loudoun L&D in the future, TVA will conduct a site-specific environmental review to determine impacts to recreation at this site.

During the operational phase, Alternative G, would support long-term increases to tourism and recreational opportunities in the Tennessee Valley. As shown in Table 3-6 (see Section 3.1, Aquatic Ecology), in lower reservoirs with high populations of Asian carp (e.g., Kentucky and Pickwick Reservoirs), Alternative G is expected to reduce Asian carp populations over time and prevent long-term adverse effects on sportfish and paddlefish populations. For middle and upper reservoirs with low existing populations of Asian carp, Alternative G is expected to maintain low populations of Asian carp and prevent long-term adverse effects to sportfish and paddlefish populations. Therefore, Alternative G would have moderate, long-term beneficial impacts to recreational use of the Tennessee River system compared to the No Action Alternative.

In conclusion, there would be short-term, intermittent, and localized disruption to recreational activities during construction and a long-term minor reduction in fishing access at the proposed fish barrier system sites under this alternative. However, moderate, long-term regional beneficial impacts under this alternative would include control of Asian carp populations in the Tennessee River system and, thus, continuation and possible improvement of recreational fishing and boating opportunities.

3.3 Economic Impact

3.3.1 Affected Environment

3.3.1.1 Economic Benefits of Recreational Boating and Fishing

Millions of people annually participate in numerous outdoor recreation activities within TVA reservoirs and surrounding lands, including boating, fishing, hunting, swimming, hiking, bird watching, camping, and picnicking. A 2017 study estimated 6,683 average annual recreation days per shoreline mile for TVA reservoirs (Poudyal et al. 2017), which equates to approximately 46 million average annual recreation days for the reservoirs within the study area. Quality fisheries and facilities are important to the Tennessee Valley recreation industry. In 2011 approximately 826,000 anglers fished in Tennessee; 683,000 in Alabama; and 554,000 in Kentucky, for a total of 17 million angler-days in Tennessee; 10.9 million angler days in Alabama; and 10.2 million angler days in Kentucky that year (USFWS and USCB 2011a, 2011b, 2011c; USCB 2021). Freshwater anglers contribute more than $1.1 billion of economic impact to the Tennessee economy, more than $300 million to the Alabama economy, and more than $500 million to the Kentucky economy. Additionally, freshwater fishing supports more than 7,000 jobs and generates more than $60 million in state and local sales tax in Tennessee; more than 2,000 jobs and more than $16 million in state and local sales tax in Alabama; and more than 4,000 jobs and more than $28 million in state and local sales tax in Kentucky (ASA 2020).

Recreational boating, including pleasure boating, sailing, water-skiing/tubing, canoeing/kayaking, and personal watercraft sports are also important to the economy of the Valley. Tennessee ranks 15th nationally in the number of registered boats and Alabama ranks 16th, both with more than 245,000 registered boats in 2019. Kentucky ranks 24th, with more than 166,000 boats registered in 2019. Most boats (95 percent) in the U.S. are towable (i.e., smaller than 26 feet) and are therefore likely to be used at public reservoirs. Approximately 61 percent of boat owners have an annual household income of $75,000 or less. The recreational boating industry contributes an estimated $6 billion in economic impact to the Tennessee economy, $2 billion to the Alabama economy, and $1.7 billion to the Kentucky economy. Recreational boating supports more than 20,000 jobs and 660 businesses in Tennessee; more than 10,000 jobs and 590 businesses in Alabama; and 8,700 jobs and 400 businesses in Kentucky (National Marine Manufacturers Association 2018).

3.3.1.2 Economic Benefits of TVA Reservoirs

A study of water-based recreation for three representative TVA reservoirs (i.e., Chickamauga, Norris, and Watts Bar) was conducted to provide estimates of the economic activity resulting from expenditures by recreational users (TVA 2017b). During the summer of 2016, a team of researchers from the University of Tennessee Institute of Agriculture used a combination of on-site observations, brief visitor interviews, and a mail survey to obtain information about the nature and length of visitors' recreational reservoir use and related economic expenditures. The surveys also obtained information about user attitudes, amenity preferences, and recreation satisfaction (Poudyal et al. 2017).

According to the study, TVA reservoirs are highly popular among the local as well as non-local public for a variety of water and land-based recreational uses. Pleasure boating, fishing (from boat and shore), and swimming were the most popular recreation activities, with water-skiing/tubing, camping, and wildlife viewing being very popular at certain reservoirs. The most popular land-based activities among reservoir visitors were hiking, camping, picnicking, mountain biking, and sightseeing. Overall, visitors were highly satisfied with the amenities provided by the reservoirs; however, concerns were raised regarding low water levels, bank erosion, and recent growth of invasive aquatic plants in some reservoirs (Poudyal et al. 2017).

Average expenditures per visit per day were calculated from the survey data for lodging, food, transportation, watercraft expenses, entertainment, retail purchases, supplies, rentals, souvenirs, and other related items. In addition, shoreline property owners were asked about their annual expenditures for docks and shoreline maintenance, watercraft purchases, access/marina fees, property taxes, and outdoor property improvements. These expenditures were then used to model estimated economic impacts.

Based on the estimated total industry output for the three reservoirs in the 2017 study, the weighted averages of economic output per shoreline mile were $96,616 for shoreline property owners and $1.01 million for on-site visitors. Therefore, the analysis determined that more than $1.1 million of economic activity associated with recreation is generated per mile of TVA-managed reservoir. With approximately 6,893 miles of shoreline property in the study area, it is estimated that the total economic impact of recreation on these reservoirs and associated lands is $7.7 billion in total industrial output, 83,682 jobs, $2.9 billion in labor income, and $589.4 million in state and local taxes (Poudyal et al. 2017).

3.3.1.3 Conceptual Economic Benefits Model

Recreation at TVA reservoirs is an expansive and complex system. Asian carp control alternatives interact with this system to produce economic effects. The conceptual modeling approach depicted in Figure 3-1 was used to establish the appropriate baseline conditions for assessing economic effects of project alternatives.

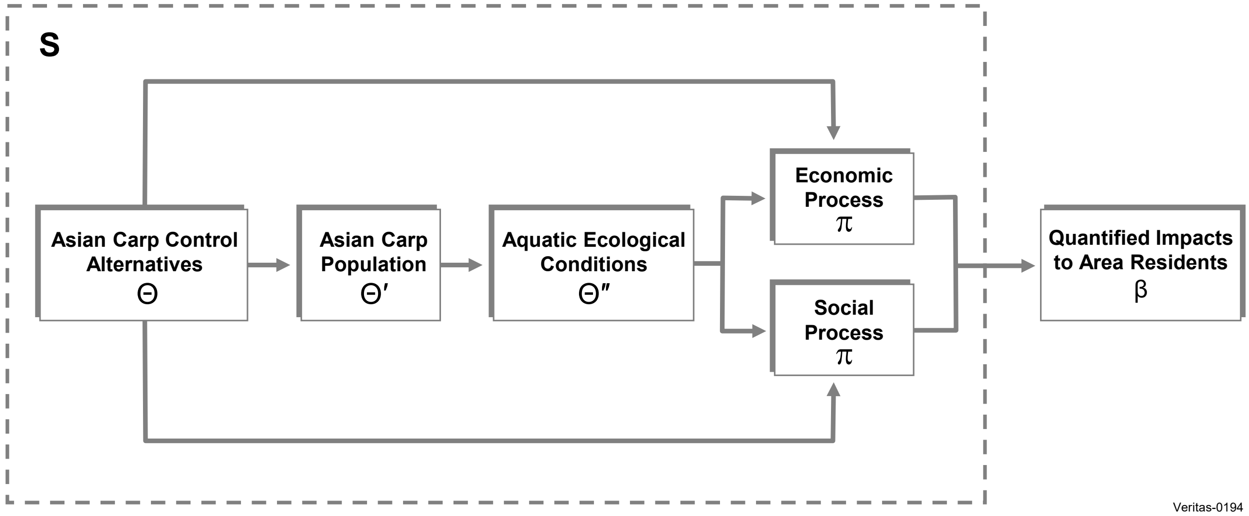

Figure 3-1. Comprehensive Modeling Framework for the Evaluation of Economic Impacts

This modeling framework includes concepts that link project alternatives under consideration, Asian carp abundance (represented by Q'), and resulting aquatic ecological conditions (represented by Q') that ultimately affect the socioeconomic processes represented by π. A person choosing how and where to recreate is an example of a socioeconomic process. To assess the project baseline and the effects of each alternative, indicators of these processes such as estimates of recreational pressure and expenditures (identified as β) are used.

For example, the effectiveness of fish barrier systems has a potential effect on the standing stock and populations of each Asian carp species within the reservoirs of the Tennessee River system. Based upon the relative effectiveness of each alternative in controlling Asian carp, there would be subsequent effects to Aquatic Ecological Conditions. As described in Section 3.1, Aquatic Ecology, Asian carp population abundance has the potential to affect recreationally important fish species. As such, this change in population and standing stock of recreationally important fish species could impact fishing trips and expenditures.

As indicated in Figure 3-1, the Aquatic Ecological Conditions resulting from each alternative have the potential to affect both Economic Processes and Social Processes. For this analysis, “direct effects” are those that occur to Asian carp within the reservoir system as a result of the alternatives under consideration. For example, changes in populations of Asian carp within each reservoir are direct effects. In contrast, secondary changes in more desirable sportfish or the economic and recreational changes related to human uses of waterbodies (e.g., recreational fishing, boating, and water skiing) that are attributable to the presence of Asian carp (Brown 2018; U.S. Army Corps of Engineers 2017; Hayder 2014) are considered indirect effects.

Indirect effects may also arise from other direct effects. For example, potential indirect impacts to sportfish populations (angling, paddlefish snagging) may result in other indirect effects on recreational fishing and even further indirect effects on tourism and property values.

This modeling framework is comprehensive in the breadth of its coverage and complete in that it incorporates the chain of potential impacts from ecological effects through direct and indirect impacts to humans. However, as described below, this conceptual model was further refined to an operational model by identifying and characterizing the most important pathways.

3.3.1.4 Operational Economic Benefits Model

The Workshop Decision Tree process described in Chapter 2 produced the first three processes of the conceptual framework (i.e., Asian Carp Control Alternatives, Asian Carp Populations, and Aquatic Ecological Conditions) for the No Action Alternative and Alternative G. Qualitative impacts (High, Medium, and Low) to gamefish and paddlefish populations were estimated for 2020, 2025, and 2030 (see Section 3.1 Aquatic Ecology). Conditions reported for the year 2020 are the baseline against which alternatives were evaluated into the future for the years 2025 and 2030.

An additional potentially important economic effect is related to perceived and actual impacts of “flying” silver carp on boating and skiing (see Section 3.23, Public Health and Safety). Silver carp can leap 10 feet into the air when startled by passing boats, and where Asian carp abundance is particularly high, have the potential to impact trip quality. Silver carp are the most impactful Asian carp species expanding into TVA reservoirs with high potential for explosive population growth (see Section 3.1, Aquatic Ecology).

Impacts to recreation also has the potential to affect tourism. However, TVA reservoirs have scores of “competitors” throughout the area that are also used by recreators. Although tourism certainly occurs at the specifically affected reservoirs, overall impacts to tourism due to reductions in recreation quality are expected to be minimal. Therefore, tourism was not included in the final Operational Economic Benefits Model.

Effects to property values could occur because part of the value of a property near a reservoir is due to the amenity value of the reservoir. The amenity value of a given reservoir has the potential to decline if recreation quality is substantially reduced. Just as proximity to a waterbody can increase property value, degradation of the associated waterbody effects the closest properties most severely. This makes identifying impacts to property values challenging as there are typically no datasets that include property value and proximity to the affected waterbody. Although property value impacts are possible, they were not included in the final Operational Economic Benefits Model.

Based on these considerations, the conceptual modeling framework (Figure 3-1) was refined to the operational modeling framework depicted below (Figure 3-2). As shown in the final Operational Modeling Framework, the Affected Environment was limited to effects on traditional sportfishing, paddlefish snagging, boating, and waterskiing.

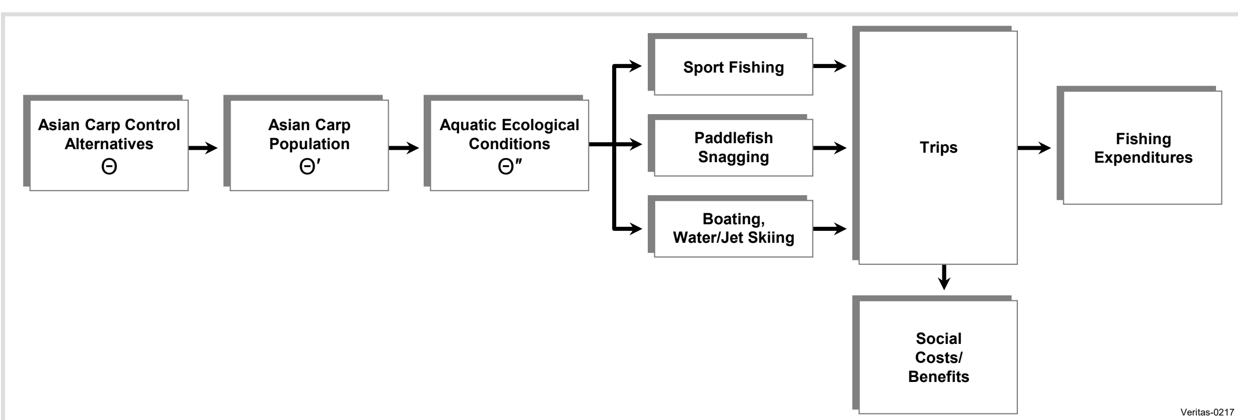

Figure 3-2. Operational Modeling Framework

3.3.2 Environmental Consequences

3.3.2.1 Alternative A – No Action

Under the No Action Alternative, the expansion of Asian carp populations would not be impeded by fish barriers. Asian carp would continue to invade Tennessee River reservoirs and increase their abundance, thereby adversely impacting sportfishing, paddlefish snagging, boating, and waterskiing. Sportfishing impacts are expected to have the largest economic effects and were evaluated quantitatively. Due to a lack of quantitative data, paddlefish snagging, boating, and waterskiing were evaluated qualitatively.

3.3.2.1.1 Sportfishing

Under the No Action Alternative, there would be direct effects to Asian carp populations and indirect effects on sportfish (see Table 3-5). As compared to the baseline (i.e., 2020), direct effects to populations of Asian carp in future years under the No Action Alternative is noted to be high in lower reservoirs of the Tennessee River and moderate with time in reservoirs within the central portion of the system. Indirect effects on sportfish standing stock and recruitment are initially low in the baseline year but increase to moderate in lower reservoirs in the modeled years (2025 and 2030). Middle and upper reservoirs reflect a delayed indirect impact to sportfish whereby effects are more pronounced (i.e., moderate) in the year 2030. Presumably, with increasing time, the indirect effects on sportfish would increase geographically within the system. Because paddlefish are filter feeders and directly compete for the same food source as Asian carp, the indirect effects are more pronounced relative to those of other sportfish (see Section 3.1, Aquatic Ecology).

The indirect economic and recreational effects of these changes in the aquatic community were evaluated using site-choice modeling in a spatial representation of anglers and reservoirs. The approach expanded on the model recently used in a simulation-based fishing assessment for Clean Water Act 316(b) compliance at TVA's Sequoyah Nuclear Plant.[3] This model contains the structure that spatially links anglers to fishing sites, a fishing preference function that determines how travel cost and catch rates affect site choices, and data on catch rates at sites and travel costs. Figure 3-3 depicts the block groups and sites and effects evaluated under the No Action Alternative.

The model operates by simulating fishing choices over the representative study sites depicted in Figure 3-3. Impacts to recreational fishing were modeled as reduced catch rates proportional to impacts to sportfish populations. Effects to sportfish populations are Low in the baseline year of 2020 but increase to Moderate impacts by 2030 at Kentucky, Pickwick, Wilson, and Wheeler Reservoirs (Figure 3-3). Figure 3-4 illustrates the modeled impacts to gamefish catch rates under the No Action Alternative on an annual basis using Wilson Reservoir as an example. Catch rates decline until 2025, whereafter they stabilize at a lower rate compared to the baseline. This impact is proportional to the impacts summarized in Aquatic Ecology Section 3.1, which predicted Low impacts in 2020 and Moderate impacts in 2025 and 2030.

Results predicted changes in future fishing trips (Figure 3-5). For example, in Wilson Reservoir, declines in catch rates under the No Action Alternative lead to trip losses between 2020 and 2025. After 2025, catch rates at Wilson Reservoir stabilize. There is a slight recovery in trips between 2025 and 2030 because the expansion of Asian carp into other substitute sites within the Tennessee River system reduces fishing quality at those substitute sites. As a result,

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[3] This model was subjected to peer-review as part of the Clean Water Act 316(b) compliance process.

anglers are expected to move away from those sites and back to Wilson Reservoir. Results were similar for other modeled sites.

Changes in fishing quality are associated with changes in economic welfare as some anglers travel greater distances for similar quality fishing and incur additional time and travel costs. Other anglers elect not to travel to substitute sites and experience reduced quality fishing. The loss of regional fishing quality under the No Action Alternative was monetized using the site choice simulation model. Expenditures associated with fishing trips were based on the recreational fishery at Guntersville Reservoir (McKee 2013). McKee estimated anglers spent about $60.26 per trip on 204,113 boat and shore fishing trips to Guntersville Reservoir in 2012 (Table 3-10). Compared to the baseline, by 2025, losses in annual total trips at the three lower reservoirs were between $13 to $25K which corresponded to a loss of expenditures between $0.78M to $1.56M (Table 3-11). However, the area around Wheeler Reservoir had an increase in trips and expenditures by $8K and $430K, respectively as anglers substituted away from reservoirs with higher Asian carp populations. By 2030, all lower reservoirs in the Tennessee River system had economic losses to trips estimated between $9K to $25K and losses to expenditures between $0.55M to $1.57M (Table 3-11). The values contained in Table 3-11 represent regionalized economic impact values that reflect the changes in economic welfare related to choices by anglers to travel to substitute locations. Overall, the present value of these social costs is $6.23 million (discounted at 3 percent). Potential localized effects to individual bait shops and marinas at reservoirs that anglers may choose to avoid as Asian carp populations expand under the No Action Alternative are also expected.

Overall, changes to the economic value of recreational fishing trips and total expenditures at representative reservoirs in the Tennessee River system under the No Action Alternative were moderate and long term.

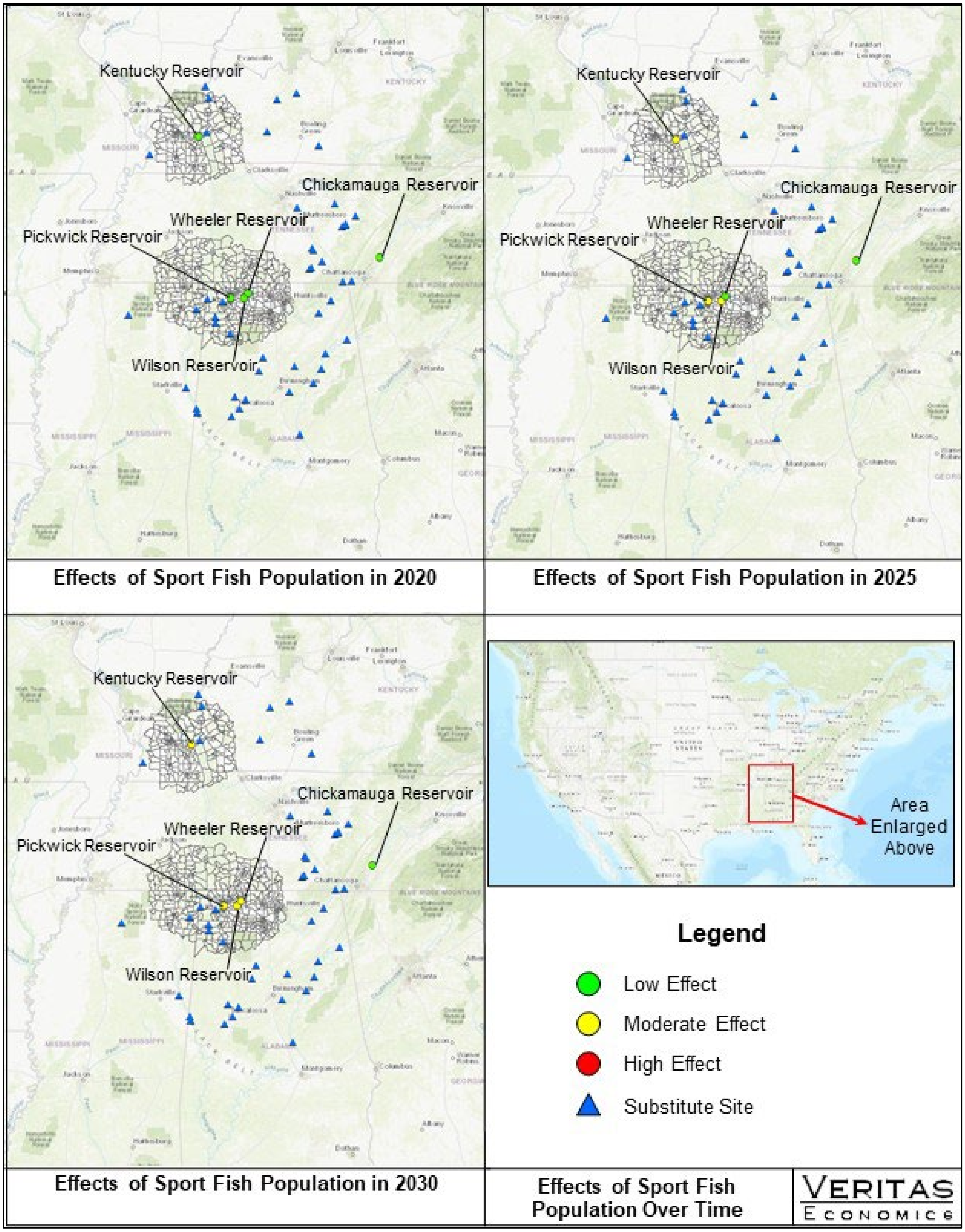

Figure 3-3. Block Groups, Sites, and Effects Used to Model the No Action Alternative

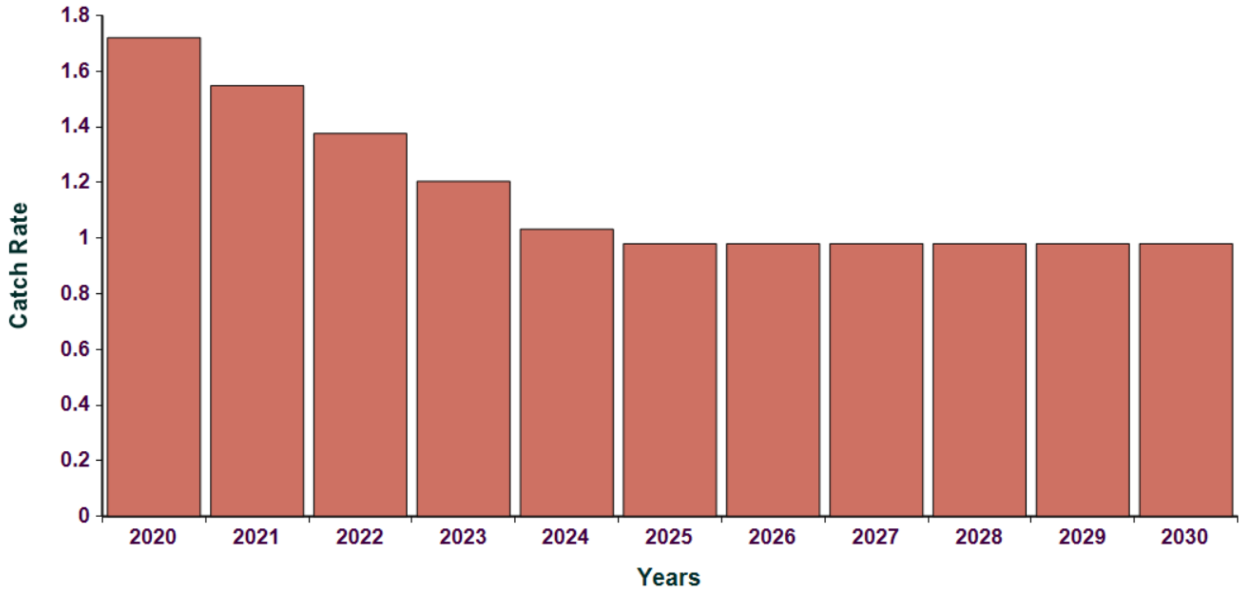

Figure 3-4. Modeled Impacts to Gamefish Catch Rates at Wilson Reservoir Under the No Action Alternative

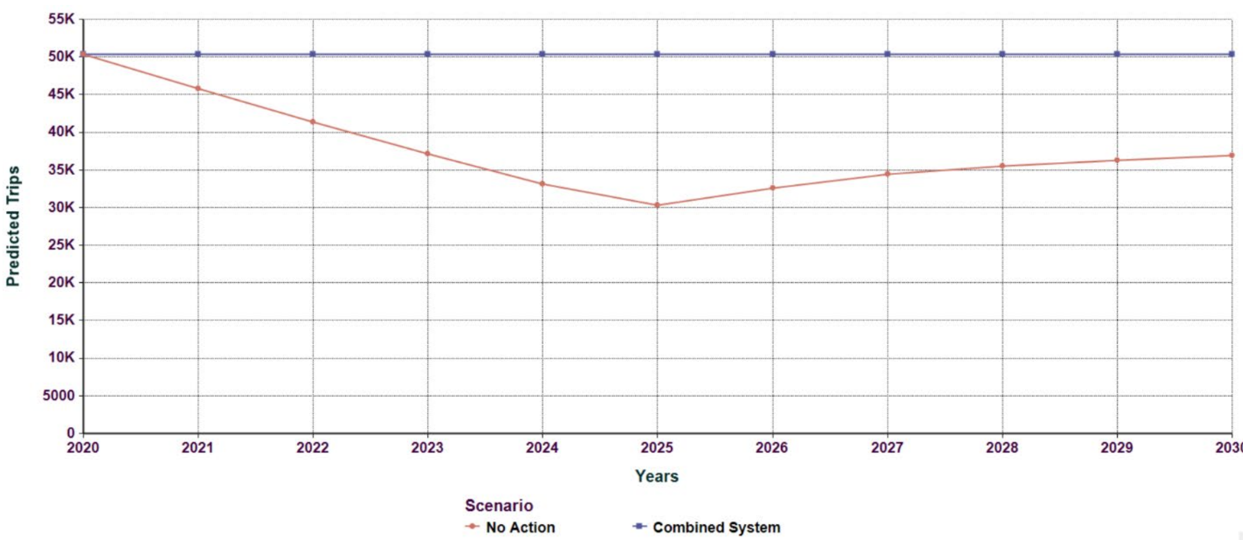

Figure 3-5. Predicted Changes in Future Fishing Trips to Wilson Reservoir by Alternative

Table 3-10. Estimated Expenditure per Angler Trip to Guntersville Reservoir

Category	Estimated Expenditure
Fuel	$71.40
Lodging	$50.60
Groceries	$27.80
Restaurant	$17.60
Fishing equipment	$16.41
Guide	$0.20
Tournament fee	$2.40
Rental	$2.00
Repair	$9.60

Note: Launch fees were estimated at $0.
Source: McKee 2013

Table 3-11. Annual Net Present Value of Trips and Expenditures at Representative Reservoirs

Reservoirs	2020 Trips	2020 Expenditures	2025 Trips	2025 Expenditures	2030 Trips	2030 Expenditures
Kentucky	98.3K	$5.92M	85.3K	$5.14M	89.1K	$5.37M
Pickwick	37.06K	$2.23M	11.54K	$0.67M	12.87K	$0.78M
Wilson	50.38K	$3.04M	30.37K	$1.83M	39.93K	$2.41M
Wheeler	36.77K	$2.28M	45.03K	$2.71M	11.72K	$0.71M

3.3.2.1.2 Paddlefish Snagging

Nico et al. (2017) noted that bighead carp pose “a threat to the ecology of the Mississippi River Basin and connecting aquatic ecosystems. These fish are capable of significantly reducing zooplankton abundance, which adversely affects all fish in their early life stages when their diets are strictly planktonic. Furthermore, bighead carp compete with fish that are filter-feeders as adults, such as paddlefish. Several studies have showed that when zooplankton is limited, bighead carp have a competitive advantage over paddlefish, negatively affecting the relative growth” of paddlefish.

O’Keefe (2006) stated that “legal commercial and recreational snag fisheries exist in some states. Snagging is the most effective means of sportfishing for paddlefish because they do not commonly accept bait.” KDFWR (2021a) states that “snagging is a tried-and-true method for many fishermen to land a paddlefish. However, with the increasing numbers of Asian carp you now have a better chance of landing one of them.”

Table 3-12 lists the status of recreational fishing for paddlefish in states bordering the Tennessee River, including impoundments.

Table 3-12. Recreational Fishing for Paddlefish in Tennessee River States

State	Fishing Method	Creel Limit	Additional Information
Alabama	Closed season for paddlefish	Zero	Unlawful to take fish by snagging in Tennessee River and other waterbodies
Kentucky	Snagging, gigging, or bow and arrow	2 per day, possession limit of 4 (8 per day in Kentucky tailwaters)	Tennessee River below Kentucky Dam; I-24 bridge to confluence with Ohio River is open to snagging year-round: culling is prohibited
Mississippi	No paddlefish harvest is allowed in the Tenn-Tom Waterway, Tombigbee River or tributaries, Pickwick Lake	Zero (Tennessee River and Pickwick Lake)	
Tennessee	Snagging	2 per day, 1 per day (Watts Bar)	Culling is prohibited; season: April 24 through May 31; May 1 through May 15 (Watts Bar)

Sources: Alabama Department of Conservation and Natural Resources (2020); Kentucky Department of Fish and Wildlife Resources (2021c); Mississippi Commission on Wildlife, Fisheries, and Parks (undated); TWRA (2021b)

KDFWR (2017) conducted a creel survey of Kentucky Reservoir tailwater and Lake Barkley. The survey found that 11.1 percent of anglers used snagging to fish at the Kentucky Reservoir tailwater. Those anglers caught 1,629 paddlefish during 1,094 trips (3,581 hours) for a snagging catch rate of 0.4549 per hour. The study report noted that “angler success fishing for paddlefish was much lower in the 2016 survey (18 percent success) than in 2007 (45 percent success). The lower success rate is likely due in part to the increased density of Asian carp species congregating in the tailwater” (KDFWR 2017). Under the No Action Alternative, by 2025 expansion of the range and abundance of Asian carp would result in a moderate adverse effect to paddlefishing in the lower reservoirs of the Tennessee River system (i.e., Kentucky to Wilson). Adverse impacts would increase to high (i.e., large) by 2030 for these same reservoirs, and include a moderate adverse effect to Wheeler Reservoir.

3.3.2.1.3 Boating and Skiing

Silver carp are a hazard to boaters because they leap into the air when startled (see Section 3.23, Public Health and Safety). Press accounts, testimony, and other sources have noted the hazards that silver carp pose to boating and waterskiing in many waterbodies including the Arkansas, Illinois, Mississippi, Missouri, Ohio, Tennessee, and Wabash rivers (Bassmaster 2018; Egan 2009; Hansen 2010; Kolar at al. 2005; Parsons et al. 2016; Smith 2017; Stern et al. 2014). Among the documented injuries to boaters and water skiers or jet skiers, one person was “knocked unconscious from her jet ski” by a silver carp. A teenager suffered a broken nose and fractured skull/forehead when a silver carp struck him in the face (Hansen 2010; Joseph 2017). The “driver of a boat full of youngsters was knocked backward out of his seat by a jumping silver carp” (Egan 2009). A brief in a case heard by the U.S. Supreme Court noted injuries caused by silver carp: “black eyes, broken bones, back injuries, and concussions” (Michigan Shoreline Caucus 2010).

Not only do silver carp injure people, but they also damage boats, breaking fishing rods, windshields, and electronics. One boater noted that a silver carp "tore the cowling off his motor" (Bassmaster 2018; Hansen 2010; U.S. Geological Survey undated). Some boaters have built a cage over their boat's steering area as protection from silver carp (Smith 2017). Others have installed a plexiglass shield to protect boaters or began wearing a helmet while boating (Bassmaster 2018; Egan 2009).

USACE (2019) reported that boater safety "appears to be reduced by the jumping behavior of silver carp, as 56.9 and 94.3 percent of respondents from river towns near Asian carp populations reported being hit by a jumping silver carp in 2010 and 2011, respectively, and almost 20 percent of respondents reported being injured by a jumping Asian carp in 2011. Many respondents to a survey of 31 marinas along the Illinois River also indicated recent changes in pleasure boating and skiing, greater safety precautions, and boat modifications due to the presence of Asian carp. In addition, several respondents noted a reduction in marina usage due at least in part to Asian carp." In middle and southern states of the U.S., "many cancellations" have been reported because boating, waterskiing, and fishing in waters with silver carp has become dangerous (Smith 2017). However, no empirical estimates of the economic effects of silver carp on boating and water skiing or jet skiing are available (Stern et al. 2014; U.S. Army Corps of Engineers 2019).

Under the No Action Alternative, expansion of the range and abundance of Asian carp would remain high (i.e., large) within lower reservoirs of the Tennessee River (i.e., Kentucky and Pickwick) and increase to moderate or high populations in 2030 for mid-system reservoirs (i.e., Wilson, Wheeler, and Chickamauga). It is anticipated that moderate populations of Asian carp would have a low adverse impact to recreational expenditures and high populations would have a moderate adverse impact, over the long term (Table 3-13).

3.3.2.1.4 Qualitative Summary of Severity of Economic Effects

Overall, adverse economic impacts under the No Action Alternative are anticipated to be initially low in the study area but increase to moderate for the lower reservoirs (i.e., Kentucky, Pickwick, and Wilson Reservoir s) in the year 2025, and become high within these same reservoirs in 2030. Due to continued range expansion of Asian carp in the future, adverse economic impacts in Wheeler Reservoir are anticipated to increase to moderate by 2030. The trend of increasing adverse economic impacts is expected to intensify beyond 2030 as Asian carp range and abundance grows throughout the Tennessee River watershed. Table 3-13 summarizes adverse economic impacts by aquatic resource including: sportfishing, paddlefish snagging, and boating and waterskiing.

Table 3-13. Summary of Economic Effects of Alternative A – No Action

	Aquatic Resource Impact Summary											
	Effects on Sportfishing			Effects on Paddlefish Snagging			Effects on Boating and Waterskiing			Overall Economic Effects		
Reservoir[1]	**2020**	**2025**	**2030**	**2020**	**2025**	**2030**	**2020**	**2025**	**2030**	**2020**	**2025**	**2030**
Kentucky Reservoir	L	M	M	L	M	H	M	H	H	L	M	H
Pickwick Reservoir	L	M	M	L	M	H	M	H	H	L	M	H
Wilson Reservoir	L	M	M	L	M	H	L	M	H	L	M	H
Wheeler Reservoir	L	L	M	L	L	M	L	M	M	L	L	M
Chickamauga Reservoir	L	L	L	L	L	L	L	M	M	L	L	L

3.3.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple TVA Locks within the Tennessee River System

Alternative G would result in economic effects during construction of the fish barrier systems. During the construction phase, procurement of materials and services to install fish barrier systems would result in expenditures and associated economic activities. Expenditures and qualitative assessments of impacts to local economies are listed in Table 3-14. Overall economic impacts of fish barrier installations to regional economies are expected to be positive, minor, and short term.

Table 3-14. Economic Effects of Construction Under Alternative G

Deployment Location	Technology	Capital Costs	Economic Impact
Kentucky	BAFF/CO_2	$8.1M	L
Wilson	BAFF	$7.0M	L
Pickwick	BAFF	$7.0M	L
Guntersville	BAFF/CO_2	$8.1M	L
Nickajack	BAFF	$7.0M	L
Chickamauga	BAFF	$7.0M	L
Watts Bar	BAFF	$7.0M	L

Operational economic impacts of Alternative G are summarized in Table 3-15. Direct economic impacts of operation of fish barriers to regional economies (e.g., maintenance) are expected to be positive, minor, and long term.

Table 3-15. Economic Effects of Barrier Operation Under Alternative G

Deployment Location	Technology	Operation Costs†	Economic Impact
Kentucky	BAFF/CO_2	$3.5M	L
Wilson	BAFF	$1.0M	L
Pickwick	BAFF	$1.0M	L
Guntersville	BAFF/CO_2	$3.5M	L
Nickajack,	BAFF	$1.0M	L
Chickamauga	BAFF	$1.0M	L
Watts Bar	BAFF	$1.0M	L

† Annual operational costs.

Under Alternative G, the proposed fish barrier systems would effectively control Asian carp populations and reduce negative impacts associated with the No Action Alternative; therefore, the overall economic impacts from construction and operation of the fish barrier systems on regional economies is anticipated to be positive, moderate, and long term.

3.4 Managed and Natural Areas

3.4.1 Affected Environment

Managed areas include lands held in public ownership that are managed by an entity (e.g., TVA, U.S. Department of Agriculture [USDA], U. S. Forest Service [USFS], State of Tennessee) to protect and maintain certain ecological and/or recreational features. Ecologically significant sites are either tracts of privately owned land that are recognized by resource biologists as having significant environmental resources or identified tracts on TVA lands that are ecologically significant but not specifically managed by TVA's Natural Areas program. Nationwide Rivers Inventory (NRI) streams are free-flowing segments of rivers recognized by the National Park Service (NPS) as possessing remarkable natural or cultural values. Natural areas include ecologically significant sites; federal, state, or local park lands; national or state forests; wilderness areas; scenic areas; wildlife management areas (WMA); recreational areas; greenways; trails; NRI streams; and Wild and Scenic Rivers.

The TVA Natural Heritage database was queried to identify managed and natural areas within 3 miles of the locks and dams in the study area. Given the nature of the proposed action, 3 miles was considered a sufficient distance to assess environmental consequences of the proposed actions. Managed and natural areas located within 3 miles of the L&Ds within the Tennessee River system are identified in Table 3-16. As shown in the table, managed and natural areas located within or immediately adjacent to (within 0.5 mile) have been identified at seven locks within the study area including: Chickamauga, Nickajack, Guntersville, Wheeler, Wilson, Pickwick, and Kentucky locks.

Table 3-16. Managed and Natural Areas Within 3 Miles of the Locks and Dams on the Tennessee River System

Lock and Dam	Natural Area
Melton Hill Lock	Melton Hill Dam Reservation
	Oak Ridge National Laboratory Potential National Natural Landmark
	Oak Ridge National Laboratory Reservation & Oak Ridge Reservation
	Oak Ridge Reservation Haw Ridge Uplands / Raccoon Creek Golden Seal Area

Lock and Dam	Natural Area
	Oak Ridge Reservation Raccoon Creek Golden Seal Area [NA-6} Oak Ridge Reservation Environmental Science Division (ESD) Lily Site Oak Ridge Reservation Spring Pond [RA-28] Oak Ridge Reservation Melton Valley Lilly Area Clinch State Scenic River Oak Ridge Reservation Cooper Ridge Area Oak Ridge Reservation North Hickory Creek Bend Bluffs [NA-15] Oak Ridge Reservation Melton Dam Bluffs [NA-32] Oak Ridge Reservation Flashlight Heaven Cave T&E [Site-20] Oak Ridge Reservation Sweet Flag Marsh Oak Ridge National Laboratory Potential National Natural Landmark Oak Ridge National Laboratory Reservation & Oak Ridge Reservation Oak Ridge Reservation Haw Ridge Uplands / Raccoon Creek Golden Seal Area Oak Ridge Reservation Raccoon Creek Golden Seal Area [NA-6} Oak Ridge Reservation Environmental Science Division (ESD) Lily Site Oak Ridge Reservation Spring Pond [RA-28] Oak Ridge Reservation Melton Valley Lilly Area Clinch State Scenic River
Ft. Loudoun Lock	Ft. Loudoun Dam Reservation Cline Property – Foothills Land Conservancy Hall Bend TVA Habitat Protection Area Browder Woods Protection Planning Site Browder Woods Registered State Natural Area Lenoir City Park Hall Bend TVA Habitat Protection Area Mizell Cave
Watts Bar Lock	Watts Bar Dam Reservation Watts Bar State Wildlife Management Area Meigs County Park Chickamauga Wildlife Management Area ICSES TVA Project (Carbon Offsite Sites)
Chickamauga Lock*	Chickamauga Dam Reservation North Chickamauga Creek Wildlife Management Area North Chickamauga Creek Oak Forest Potential National Natural Landmark Fairview Slopes Protection Planning Site Fairview Slopes TVA Habitat Protection Area Booker T. Washington State Recreation Park Chickamauga & Chattanooga National Military Park Amnicola Marsh State Wildlife Park Rivermont Park North Chickamauga Greenway Greenway Farm City Park Chattanooga Big Ridge Big Ridge TVA Habitat Protection Area

Lock and Dam	Natural Area
	Chattanooga State Community College and Arboretum Tennessee River Park Nickajack Reservoir State Mussel Sanctuary
Nickajack Lock*	Nickajack Dam Reservation Little Cedar Mountain Little Cedar Mountain TVA Habitat Protection Area Shellmound Road Bluff Shellmound Road Bluff TVA Habitat Protection Area Nickajack Cave Nickajack Cave State Wildlife Observation Area Nickajack Cave TVA Habitat Protection Area / Small Wild Area Nickajack Oak Wetland TVA Habitat Protection Area Guntersville Reservoir State Mussel Sanctuary (on the Sequatchie River) Guntersville Reservoir State Mussel Sanctuary (on the Tennessee River)
Guntersville Lock*	Guntersville Dam Reservation Honeycomb Creek TVA Small Wild Area Honey Bluff TVA Habitat Protection Area Cave Mountain TVA Small Wild Area Guntersville Dam Tailwater Restricted Mussel Harvest Area
Wheeler Lock*	Wheeler Dam Reservation Joe Wheeler State Park Wheeler Dam Tailwater Restricted Mussel Harvest Area
Wilson Lock*	Wilson Dam Reservation Muscle Shoals Reservation Old First Quarters Potential National Natural Landmark Old First Quarters TVA Small Wild Area McFarland Park Veterans Park River Heritage Park Tennessee River / Wilson Dam Nonessential Experimental Population Wilson Dam Tailwater Restricted Mussel Harvest Area
Pickwick Lock*	Pickwick Dam Reservation Pickwick Landing State Resort Park Kentucky Reservoir No. 2 State Mussel Sanctuary Designated Critical Habitat for Rabbitsfoot, Slabside Pearlymussel, and Fluted Kidneyshell
Kentucky Lock*	Kentucky Dam Reservation Kentucky Dam Village State Resort Park Kentucky Dam State Nongame Wildlife Natural Area Tennessee River Outstanding State Resource Water Proposed Tupelo Gum Swamp Habitat Protection Area Tupelo Gum Swamp TVA Habitat Protection Area Designated Critical Habitat for Rabbitsfoot, Slabside Pearlymussel, Fluted Kidneyshell Cumberland River Mussel Sanctuary

[1] Source: TVA Natural Heritage Database, queried February 2021
*Locks having Managed and Natural Areas on or immediately adjacent (within 0.5 miles)

The installation of the fish barriers would occur on the lock, in the river adjacent to or within the lock, or on previously disturbed land immediately adjacent to the locks (i.e., dam reservations). Therefore, only natural areas associated with aquatic environments in the immediate vicinity of the locks were considered in this analysis. These natural areas include:

- **Exceptional Tennessee Waters** – waters that are in any of the following categories:
    - waters within state or national parks, wildlife refuges, forests, wilderness areas, or natural areas
    - State Scenic Rivers or federal Wild and Scenic Rivers
    - Federally designated critical habitat or other waters with documented non-experimental populations of state or federally listed threatened or endangered aquatic or semi-aquatic plants, or aquatic animals
    - waters within areas designated as Lands Unsuitable for Mining pursuant to the federal Surface Mining Control and Reclamation Act where such designation is based in whole or in part on impacts to water resource values
    - waters with naturally reproducing trout
    - waters with exceptional biological diversity as evidenced by a score of 40 or 42 on the Tennessee Macroinvertebrate Index (or a score of 28 or 30 in subecoregion 73a) using protocols found in the Tennessee Department of Environment and Conservation (TDEC) 2006 Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys, provided that the sample is considered representative of overall stream conditions
    - **Designated Critical Habitats** – Areas designated by the USFWS to protect the essential physical and biological features of a landscape and essential areas of federal listed species in the appropriate quantity and spatial arrangement that a species needs to survive and reproduce and ultimately be conserved. These areas are essential to a species conservation. Critical habitat is a tool that supports the continued conservation of imperiled species by guiding cooperation within the federal government. Designations affect only federal agency actions or federally funded or permitted activities. Under Section 7 of the ESA, all federal agencies are required to use their authorities to help conserve imperiled species. The ESA helps to ensure that the federal government does not contribute to the decline of endangered and threatened species or their potential for recovery.
    - **State Mussel Sanctuaries** – These designated areas protect populations of both rare and commercially valuable species from harvest. The taking of aquatic mollusks by any means, and/or the destruction of their habitat, is prohibited at all times in these areas.
    - **Nonessential Experimental Populations** – These areas are designated by the USFWS to facilitate reintroduction and recovery of federally listed species, and these populations are treated as a threatened species when the population is located within a National Wildlife Refuge or National Park. When nonessential experimental populations are located outside a National Wildlife Refuge or National Park, the USFWS will treat the population as proposed for listing and only two provisions of Section 7 of the ESA would apply: Section 7(a)(1) and Section 7(a)(4). In these instances, nonessential experimental populations provide additional flexibility because federal agencies are not required to consult with the USFWS under section 7(a)(2). Section 7(a)(4) requires federal agencies to confer with the USFWS on actions that are likely to jeopardize the continued

existence of a proposed species. The results of a conference are advisory in nature and do not restrict agencies from carrying out, funding, or authorizing activities.

- **Restricted Mussel Harvest Area** – This is an area restricted by the state for the taking of freshwater mussels.

- **Kentucky Dam State Nongame Wildlife Natural Area** – This area is located on the upstream and downstream sides of Kentucky Dam. This natural area provides wintering habitat for up to 50,000 gulls from the Great Lakes and the Canadian Arctic and prairie provinces. Eleven gull species have been recorded although the vast majority are ring-billed and herring gulls. At least 10,000 gulls roost at night on the open water just south of Kentucky Dam.

3.4.2 Environmental Consequences

3.4.2.1 Alternative A – No Action

Under this alternative, fish barrier systems would not be installed and there would be no change to the size, location, or character of natural areas. Therefore, there would be no impacts to managed or natural areas under this alternative.

3.4.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

As noted in Table 2-5, land-based components of the fish barrier systems would be built on previously disturbed sites and would not be constructed in a designated managed or natural area. Natural areas associated with aquatic environments have been identified at seven of the 10 locks within the study area. Potentially affected natural and managed areas associated with the priority locations identified in Table 2-4 are shown in Table 3-17.

Table 3-17. Potentially Affected Natural and Managed Areas Located in the Study Area

Natural and Managed Area	Location
Nickajack Reservoir State Mussel Sanctuary	Downstream of the Chickamauga Lock
Guntersville Reservoir State Mussel Sanctuary (on the Tennessee River)	Located downstream of Nickajack Lock
Guntersville Dam Tailwater Restricted Mussel Harvest Area	Located downstream of Guntersville Lock
Wheeler Dam Tailwater Restricted Mussel Harvest Area	Located downstream of Wheeler Lock
Tennessee River / Wilson Dam Nonessential Experimental Population and the Wilson Dam Tailwater Restricted Mussel Harvest Area	Located downstream of Wilson Lock
Designated critical habitat for rabbitsfoot, slabside pearlymussel, and fluted kidneyshell and Kentucky Reservoir No. 2 State Mussel Sanctuary	Located downstream of Pickwick Lock

Natural and Managed Area	Location
A section of the Tennessee River with an Exceptional Tennessee Waters Designation	Located downstream of Kentucky Lock
Designated critical habitat for rabbitsfoot, slabside pearlymussel, and fluted kidneyshell mussels	Located downstream of Kentucky Lock
Kentucky Dam State Nongame Wildlife Natural Area	Located on the upstream and downstream sides of Kentucky Dam

The operation of locks at each of these dams has altered the riverbed substrate required to support benthic communities due to prop wash from commercial barge traffic and personal watercraft and lock discharge. As a result, the managed and natural areas associated with the river and riverbed environments in the approach areas are not conducive to supporting diverse aquatic assemblages— especially sensitive species which require more specialized habitat for survival.

Impacts to riverbed environments would be minimized as substrate that is comprised of pure bedrock would be utilized (where possible) during the installation of the BAFF and CO_2 supply lines and supportive systems to protect aquatic environments. As identified in Chapter 1.9, the appropriate state regulatory agencies would be contacted to inquire about dredging permits prior to initiating any installation activities at the locks. In addition, only localized dredging would be utilized in areas without bedrock to minimize the movement of suspended sediments downstream. As a result, impacts to the managed and natural areas in the lock approach areas that support aquatic life would be minor. Potential impacts to aquatic threatened and endangered species associated with these areas are discussed in more detail in Section 3.15.

The gulls that winter in the Kentucky Dam State Nongame Wildlife Natural Area roost at night on the open water just south of Kentucky Dam. The installation of the barrier systems at Kentucky lock would be done during the spring through fall season, or during daylight hours in the winter months, so as not to disturb roosting gulls in the Kentucky Dam State Nongame Wildlife Area. As a result, there would be no adverse impacts to this managed area.

Overall, the proposed construction and operation of the land-based components of the fish barrier systems would not impact natural areas as these facilities would not be built within a designated managed or natural area. The proposed construction and operation of fish barrier systems at selected locks would have minor and temporary construction-related impacts to natural areas associated with aquatic environments. These impacts would be minimized through coordination with regulatory agencies to obtain necessary dredging permits.

3.5 Navigation

3.5.1 Affected Environment

The Tennessee River system is part of the nation’s roughly 11,000-mile Inland Waterway System that links commercial markets, suppliers, processors, and consumers via barge-navigable waters along the Tennessee, Ohio, Mississippi, Missouri, Illinois, and Arkansas rivers and their tributaries. The main navigation channel of the Tennessee River stretches 652 miles from near Knoxville, Tennessee to the Ohio River at Paducah, Kentucky (TVA 2021f). Commercial navigation extends into three major tributaries: 61 miles up the Clinch River, 29 miles up the Little Tennessee River, and 22 miles up the Hiwassee River. An additional 374 miles of shallower channel is marked by TVA for recreational boating (TVA 2021f). Nine main and four auxiliary locks on the Tennessee River make it possible for both commercial and recreational vessels to pass easily from one reservoir to another. TVA, USACE, and U.S. Coast Guard work together to provide a safe and reliable passage for commercial and recreational vessels on the Tennessee River. TVA owns and manages the dams, owns the locks, and the USACE operates the navigation locks.

The Tennessee River system provides the least expensive form of transportation for dozens of industries in the Tennessee Valley that either produce or use raw materials. Common commodities shipped on the river include sand and gravel, coal, chemicals, petroleum, and ores and minerals (Figure 3-6). Water transportation is also often the only practical method for shipping extremely large and bulky pieces of machinery or equipment. One barge can ship as much tonnage as 60 semi-trucks or 15 railcars. Shipping by barge rather than by rail or truck reduces costs by an estimated $400 million each year (TVA 2021c). Water transportation can reduce highway traffic, fuel consumption, air pollution, wear and tear on roads and the number of tires sent to landfills.

All locks on the Tennessee River are available for lockage. Locks at Chickamauga, Wheeler, Wilson, Pickwick and Kentucky dams operate 24 hours a day, 365 days a year. Fort Loudoun, Watts Bar, Nickajack, and Guntersville locks operate 20 hours a day. Lockage at Melton Hill is by appointment. An expansion project is underway at Kentucky Lock, and a replacement project is underway at Chickamauga Lock.

The Tennessee River accommodates the transport of a large number of goods on an annual basis through its interconnected system of reservoirs and locks. Table 3-18 summarizes the total annual average tonnage moved through each lock from 2015 to 2018. Lock usage by tonnage decreased stepwise moving from the Ohio River upstream. For example, Kentucky Lock was the busiest on the entire system, passing an average of 28 million tons of river freight on 2,975 commercial vessels; and Fort Loudoun Lock was the least used lock on the Tennessee River passing an average of 0.5 million tons of river freight on 289 commercial vessels. Data for Melton Hill was only available from 2019. Melton Hill on the Clinch River was the least used lock of the ten dams considered in this PEA, passing only 1,626 tons of river freight on 3 commercial vessels in 2019 (Table 3-18).

Recreational vessel traffic uses the lock system differently than the commercial traffic. From 2015 to 2018, average recreational vessel lock usage was highest in the upper half of the Tennessee River system versus the lower half (Table 3-18). For example, Chickamauga Lock had the highest average number of recreational users (3,282 vessels) followed by locks at Nickajack (1,364 vessels), Fort Loudoun (1,331 vessels), Watts Bar (1,230 vessels), Guntersville (1,108 vessels), Wilson (1,049 vessels), Pickwick Landing (978 vessels), Wheeler (863 vessels), and lastly Kentucky (138 vessels). Data for Melton Hill was only available from 2019. Melton Hill on the Clinch River had the lowest recreational use (9 vessels).

Total lockages (i.e., opening and closing of the lock) largely follow the commercial vessel trend that decreases moving upstream, except for Chickamauga Lock (Table 3-18). Kentucky and Pickwick Landing locks were one and two in terms of total lockages. Chickamauga lock was third in total lockages due to heavy recreational vessel use.

Navigation has contributed greatly to the economic development of the Tennessee Valley. Substantial investments have been made in waterfront marinas, plants, terminals, and distribution facilities all along the Tennessee River. These industries provide direct employment for many thousands of residents of the TVA region and provide approximately $8 billion to the Tennessee Valley each year in economic output (UTCTR 2015).

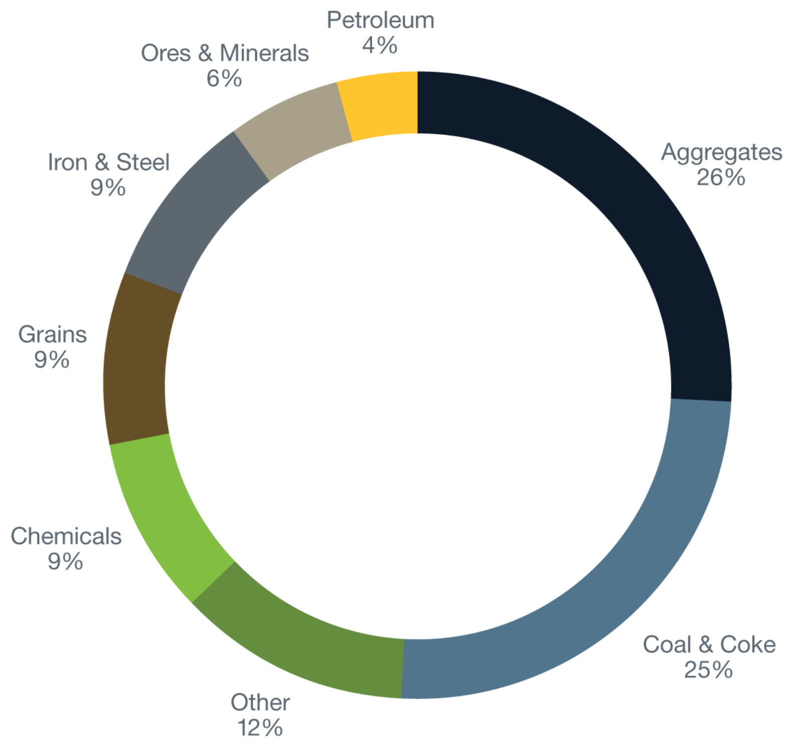

Figure 3-6. Commodities Shipped on the Tennessee River

Table 3-18. Average Lockage Data on the Tennessee River from 2015 to 2018

	Lockage Counts			Vessel Counts			Shipping	
	Recreational	**Commercial**	**Total**	**Recreational**	**Commercial**	**Total**	**Tons**	**Mil Tons**
Kentucky Lock	91	2,790	2,917	138	2,975	3,238	28,047,640	**28.0**
Pickwick Landing Lock	578	1,620	2,219	978	1,633	2,645	11,909,882	**11.9**
Wilson Lock	528	1,419	1,988	1,049	1,505	2,643	9,243,392	**9.2**
Wheeler Lock	594	1,353	1,981	863	1,408	2,310	9,196,226	**9.2**
Guntersville Lock	845	591	1,469	1,108	655	1,803	4,422,604	**4.4**
Nickajack Lock	762	277	1,068	1,364	311	1,711	2,234,886	**2.2**
Chickamauga Lock	1,773	366	2,185	3,282	396	3,755	864,359	**0.9**
Watts Bar Lock	802	209	1,043	1,230	238	1,505	567,880	**0.6**
Fort Loudoun Lock	778	236	1,035	1,331	289	1,646	484,195	**0.5**
Melton Hill Lock†	9	3	12	9	3	12	1.63	**<0.1**
TOTAL	**6,751**	**8,862**	**15,905**	**11,342**	**9,408**	**21,254**	**66,971,063**	**67.0**

† Data limited to 2019 only.

3.5.2 Environmental Consequences

3.5.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barrier technologies at any of the locks considered. There would be no closure of locks for construction and installation of fish barriers and no impacts to navigation at the lock. However, with no fish barriers, Asian carp would continue to expand their range within the Tennessee River system and establish uncontrolled population in reservoirs with negative consequences to recreational navigation. Specifically, one species of Asian carp (i.e., silver carp) has a propensity to leap out of the water when distributed, which could injure recreational users of the Tennessee River system and impact safe navigation (see Section 3.23, Public Health and Safety). Decreased recreational traffic accompanying establishment of silver carp throughout the Tennessee River watershed is anticipated to be moderate and long term (see Section 3.2, Recreation).

3.5.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

As identified in Table 2-5, construction and installation of the fish barrier technologies would be up to 6 months and would require temporary full or intermittent closure of the locks to accommodate construction activities. Length of lock closure would depend on the technologies selected, site-specific conditions, and the specific type of construction activities. Construction duration for installation of the BAFF system is anticipated to be of moderate length. Construction duration for installation of the CO_2 system is anticipated to be longer than BAFF installation. Lock closures would temporarily and intermittently impact navigation between reservoirs on the Tennessee River system.

Recreational users and commercial users would be impacted differently by lock closures. Site-specific lock usage can determine the impacts to the type of navigation. For example, temporary lock closures at Kentucky, Pickwick, and Wilson locks (i.e., locks with high commercial use) would have a greater impact on commercial barge traffic than recreational vessels (Table 3-18). Conversely, temporary lock closures at Watts Bar and Guntersville locks (i.e., locks with high recreational use) would have a greater impact on recreational vessels (Table 3-18). Public notice including estimated length of construction would be provided prior to lock closure which would allow potential lock users to plan for temporary disruptions to navigation. Commercial vessels that could not avoid closed locks during installation would be moored until installation was complete. Commercial and recreation vessels could continue to use other parts of the reservoirs or adjacent waterbodies during lock closures. For example, vessels could bypass the Kentucky Lock through Lake Barkley by way of a canal connecting the two adjacent waterbodies.

Some recreational users wanting to traverse between reservoirs during lock closures could use boat ramps upstream or downstream of the dam during installation (see Section 3.2, Recreation). Larger recreational vessels that could not use boat ramps to travel between different reservoirs would be provided prior notice warning of the lock closure. Impacts to recreational navigation would be short term, intermittent, and localized.

Temporary lock closure could increase costs to commercial users. Lock closures are intermittent, not to exceed six months and could be much shorter. Even temporary lock closures could increase shipping costs for commercial and government agencies reliant on barge shipping (UTCTR 2015). Truck traffic may increase on a limited basis in response to commercial navigation disruptions. Prior public notice would help reduce impacts by allowing for appropriate planning. Additionally, targeting installation to certain seasons where barge traffic is reduced or coordinating with other lock maintenance activities would help avoid impacts to commercial users.

Some of the dams considered for fish barriers have multiple locks (Table 2-2). For example, Wilson, Pickwick Landing, and Guntersville dams have two locks each. An additional lock is also under construction at Kentucky dam, but completion of the additional lock is not anticipated for several years. Multiple locks could facilitate staggered installation of fish barriers at each dam to allow for continued navigation during construction. Users could still experience delays during installation, depending on demand and because auxiliary locks are smaller in size and can pass fewer barges. However, passage could be maintained at dams with two locks, depending on operability. Overall, impacts to commercial navigation are anticipated to be moderate, but temporary and localized to certain locks.

Operation of the fish barrier technologies are designed not to impede lock operation; however, maintenance would require temporary lock closure, as needed. Regular maintenance for the supply lines and fish barrier systems is anticipated every 18 months with lock closures for up to two weeks. Any unplanned repairs could also require temporary lock closure.

The proposed construction and operation of fish barrier technologies at each L&D site considered would be subject to federal, state, and county regulations. Coordination with USACE, U.S. Coast Guard, and TVA would ensure navigational safety during construction activities. These regulations impose requirements and specific standards for continued navigation through the Tennessee River system. Overall, construction impacts to navigation at locations with multiple locks are expected to be minor and temporary. For those locations with only one lock, impacts to commercial navigation are expected to be moderate and temporary; while impacts to recreational navigation are expected to be minor and temporary.

Operational closures for regular and unplanned maintenance to fish barriers are expected to have minor and temporary impacts on navigation at all locations. Because operation of the systems would not impede navigation, there would be no long-term impacts to navigation and associated navigation-related commercial trade, waterfront marinas, plants, terminals, or distribution facilities along the Tennessee River system.

Overall, the proposed construction and operation of the fish barrier systems would have a moderate and temporary adverse impact to recreational navigation at priority L&D locations with only one lock (i.e., Kentucky and Watts Bar). Temporary adverse impacts to commercial navigation would be high at these locations. Impacts would be mitigated through prior public notice and planning. At priority L&D locations with multiple locks (i.e., Pickwick, Wilson, and Guntersville), installation of fish barriers would be staggered to allow continued navigation through one lock. Temporary adverse impacts to recreational and commercial navigation would be low at these locations.

3.6 Air Quality

3.6.1 Affected Environment

The Clean Air Act (CAA), as amended, is the comprehensive law that affects air quality by regulating emissions of air pollutants from stationary sources (e.g., power plants) and mobile sources (e.g., automobiles). It requires the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) and directs the states to develop State Implementation Plans to achieve these standards. This is primarily accomplished through permitting programs that establish limits for emissions of air pollutants. The CAA also requires EPA to set standards for emissions of hazardous air pollutants.

NAAQS have been established to protect the public health and welfare with respect to six criteria air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, particulate matter (PM), sulfur dioxide (SO_2), and lead (Pb). Primary standards protect public health, while secondary standards protect public welfare (e.g., visibility, crops, forests, soils, and materials).

In accordance with the CAA Amendments of 1990, all counties are designated with respect to compliance, or degree of noncompliance, with NAAQS. These designations include:

- Attainment – any area where air quality exceeds the NAAQS;
- Nonattainment – any area with air quality worse than the NAAQS; and
- Unclassified – not enough data to determine attainment status.

As shown in Table 3-19, all reservoirs impounded by the dams considered in this PEA are in counties designated as in attainment for all criteria air pollutants.

Table 3-19. Air Quality Attainment Status by County

Lock and Dam	Reservoir Counties	Air Quality Status
Kentucky Dam	Callow, Livingston, Lyon, Marshall, Trigg (KY); Benton, Decatur, Hardin, Henry, Houston, Humphreys, Perry, Stewart, Wayne (TN)	KY – All counties in attainment TN – All counties in attainment
Pickwick Landing Dam	Hardin (TN) Tishomingo (MS) Colbert, Lauderdale (AL)	TN – All counties in attainment MS – All counties in attainment AL – All counties in attainment
Wilson Dam	Colbert, Lauderdale, Lawrence, (AL)	All counties in attainment
Wheeler Dam	Lauderdale, Lawrence, Limestone, Madison, Marshall, Morgan (AL)	All counties in attainment
Guntersville Dam	Jackson and Marshall County, (AL), and Marion County, (TN)	All counties in attainment
Nickajack Dam	Hamilton, Marion (TN);	All counties in attainment
Chickamauga Dam	Bradley, Hamilton, Meigs, McMinn, Polk, Rhea (TN)	All counties in attainment
Watts Barr Dam	Loudon, Meigs, Rhea, and Roane (TN)	All counties in attainment
Fort Loudoun Dam	Blount, Knox, Loudon (TN)	All counties in attainment
Melton Hill Dam	Anderson, Roane, Loudon, and Knox Counties (TN)	All counties in attainment

Source: EPA 2020

Prevention of Significant Deterioration (PSD) regulations are used to limit air pollutant emissions from new or expanding sources in areas in attainment or unclassifiable. Under these regulations, some national parks and wilderness areas are designated PSD Class I air quality areas and are afforded special protection. There are four Class I areas within the region encompassing the study area including: Joyce Kilmer/Slickrock Wilderness, North Carolina; Shining Rock Wilderness Area, North Carolina; the Great Smoky Mountains National Park, North Carolina/Tennessee; and Cohutta Wilderness Area, Tennessee/Georgia (Figure 3-7).

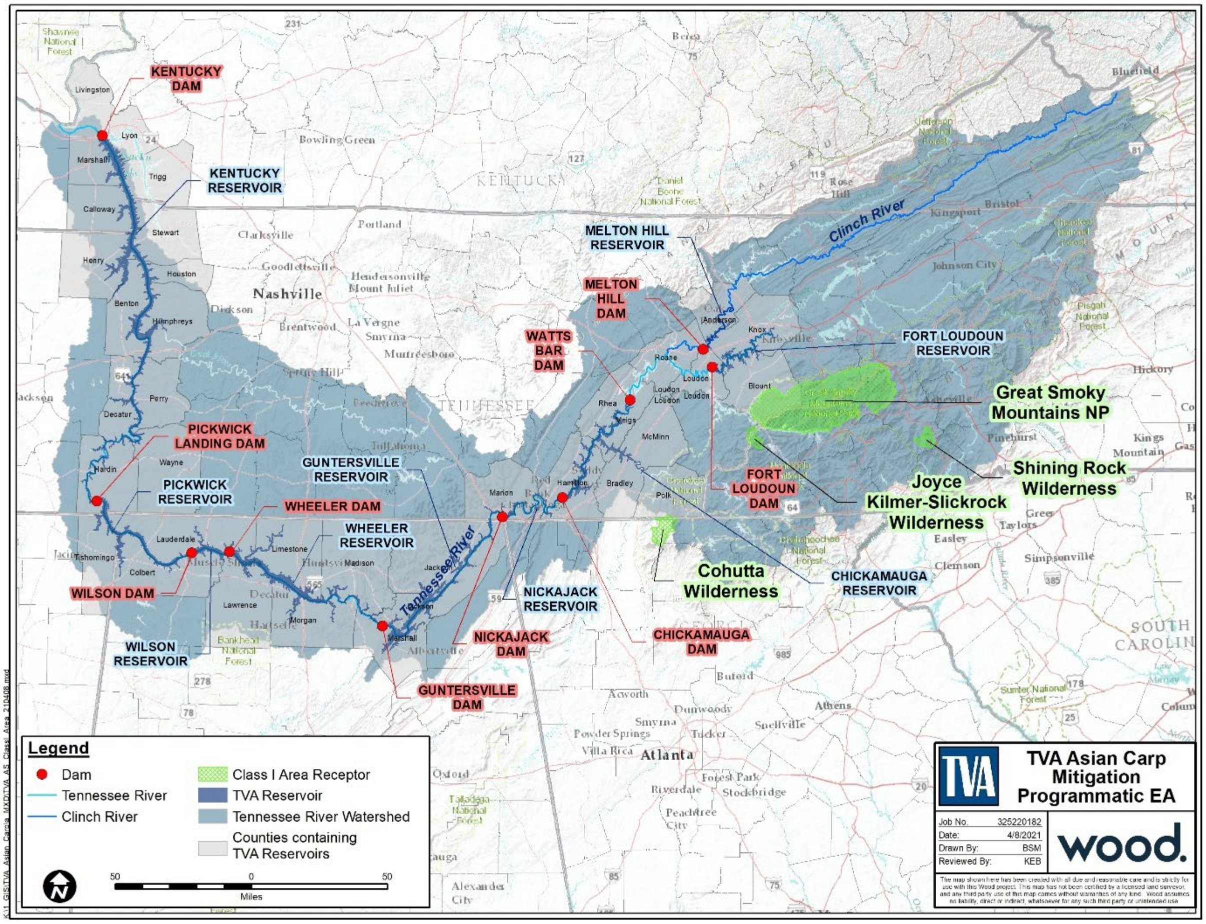

Figure 3-7. Class I Air Quality Areas in and Near the Study Area

Existing sources of air emissions within the study area include developed port cities along the Tennessee River (e.g., Decatur, Alabama and Chattanooga, Tennessee), recreation sites (e.g., marinas), motorized watercraft (e.g., boats, jet skis, tugboats), and other vehicle traffic on associated roadways. Typical emissions generated from these sources include volatile organic compounds (VOCs), nitrogen oxides (NO_x), CO, SO_2, CO_2, and PM from large diesel or gas combustion engines. Short-term construction activities generate air emissions from the use of equipment, trucks, and personal vehicles as well as fugitive dust or particulate matter from disturbed areas and travel on unpaved roads.

The proposed construction and operation of fish barriers at each L&D site considered would be be subject to federal, state, and county regulations. These regulations may impose permitting requirements and specific standards for expected air emissions.

3.6.2 Environmental Consequences

3.6.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barriers at any of the locks considered. There would be no additional emissions from project-related activities. Therefore, no impacts to air quality would occur.

3.6.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Air quality impacts associated with this alternative would occur from emissions during site preparation, use of vehicles by the construction workforce, and the operation of construction and dredging equipment. Site preparation and vehicular traffic over paved and unpaved roads at the project site would result in the emission of fugitive dust during active construction periods. Installation of any of the proposed barrier systems would require the use of dredging equipment, barges, track and backhoes, cranes, and work boats as well as trucks for hauling materials. Anchoring systems to support the deterrents would be installed at or in the lock chamber and, where bedrock is present, would require a barge and jackhammer.

Mobilization of work crews (anticipated to be up to 20 people) to and from the work site would also produce emissions from internal combustion engines. Combustion of gasoline and diesel fuels by internal combustion engines would generate local emissions of PM, NOx, CO, VOCs, and SO_2 during the site preparation and construction period. However, new emission control technologies and fuel mixtures have significantly reduced vehicle and equipment emissions. It is expected that all vehicles and construction equipment would be properly maintained, which also would reduce emissions.

Operation of vehicles and equipment could lead to increases in pollutant emissions, but air quality impacts from construction activities and transportation of materials and the construction workforce to the project area would be temporary and relatively minor. Air quality impacts are dependent upon both man-made factors (e.g., intensity of activity, control measures, vehicle maintenance) and natural factors (e.g., wind speed, wind direction, soil moisture). However, even under unusually adverse conditions, these emissions would have, at most, a minor transient impact on offsite air quality that is well below the applicable ambient air quality standard.

Powering the deterrent systems would result in minimal air emissions. Both the BAFF and CO_2 fish deterrents would require power primarily provided onsite via the TVA grid. However, a generator would be needed to supply backup power to the system. The backup generator would primarily emit NO_x, CO, PM, and hydrocarbons but would be operated infrequently and typically for short periods. The backup generator would operate in compliance with all state regulations.

Operation of the deterrent systems would result in minimal air emissions. The BAFF system uses compressed air from the site to generate the underwater bubble curtain. Use of compressed air to form the bubble curtain and diffusion of CO_2 underwater into the water column leaves no residues and does not persist in the environment (Fredericks et al. 2019). However, the operation of the CO_2 barrier may result in minimal CO_2 emissions. In addition, operation would require repeat delivery of CO_2 to the site. The number of trucks needed to refill the supply of CO_2 would depend on the frequency of use. Locks with higher navigation traffic (e.g., Kentucky Lock) would require more CO_2 than those with lower frequency of lock operations (e.g., Guntersville Locks). Although the number of trucks needed to transport CO_2 is unknown, it is anticipated that trucks used to transport CO_2 would be few and intermittent and all trucks used to transport CO_2 would be maintained in good working condition with current emission control technologies.

Overall, construction and operation of the fish barrier systems would result in minor, localized impacts to air quality and would not exceed applicable air quality standards.

3.7 Climate Change and Green House Gases (GHG)

3.7.1 Affected Environment

Climate change and global warming are sometimes used interchangeably, but warming is just one aspect of climate change. Climate change refers to any significant change in the measures of climate (e.g., temperature, precipitation, and wind) lasting for an extended period (i.e., decades, or longer; EPA 2017c). Global warming refers to the recent and ongoing rise in average temperature near the earth's surface (EPA 2017c). Global warming is caused mostly by increasing concentration of heat-trapping greenhouse gas (GHG) in the atmosphere (EPA 2017a). Carbon dioxide, methane, nitrous oxide, and various fluorinated gases are all GHGs. The amount of warming projected beyond the next few decades is directly linked to the cumulative global emissions of GHGs. Even small increases in global temperature can cause large changes to climate (EPA 2017a).

Climate change is primarily a function of too much CO_2 in the atmosphere. CO_2 is the primary GHG emitted through human activities causing warming (EPA 2021a). Combustion of fossil fuels (e.g., coal, natural gas, and oil) for energy and transportation is the main source of man-made CO_2 in the atmosphere (EPA 2021a). Certain industrial processes (e.g., steel and cement production) also emit CO_2. Forests, vegetation, and soils naturally uptake CO_2 and act as long`-term storage for atmospheric carbon—a process called sequestration. Therefore, land use change, particularly forest clearing, both increases global CO_2 emissions while decreasing storage capacity.

Total GHG emissions in the U.S. have been in decline. In 2019, U.S. GHG emissions totaled 6,577 million metric tons (or 5,788 million metric tons) of CO_2 equivalent[4] after accounting for sequestration (i.e., the storage of CO_2 in forests, vegetation, and soils; EPA 2021b). Total emissions decreased from 2018 to 2019 by 1.8 percent and were nearly 13 percent below 2005 levels (EPA 2021b). The decline in recent years is due to an increasing shift to natural gas for generating electricity and a rapid increase in renewable energies in the electric power sector (EPA 2021b).

3.7.2 Environmental Consequences

3.7.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barrier technologies at any of the locks considered. Though footprint-based impacts resulting from the installation of fish barriers would not occur, the establishment of Asian carp throughout the Tennessee River System could result in a decrease in recreational fishing opportunities for the general public. Accordingly, there would be a decrease in localized emissions from recreational vehicles; however, this would be negligible in comparison to regional emissions and would not impact climate change.

3.7.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Vehicles and boats would be the primary sources of temporary and minor increases in GHG emissions under this alternative. Construction of the deterrent systems would result in GHG emissions from internal combustion engines. Similarly, the operation of the system would result in GHG emissions associated with vehicles used to transport the workforce to support maintenance activities. Delivery of CO_2 to refill the CO_2 deterrent system would be an additional

[4] Carbon dioxide equivalent is the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas.

vehicular source of GHGs. However, these activities would be temporary and minor (i.e., construction) or infrequent and minor (i.e., operation).

Construction of support buildings would be targeted for previously developed areas and would require little to no clearing of forested land. Based on the bounding condition identified in Table 2-5, land-based support systems associated with the proposed deterrent systems would be constructed within an area of up to one acre. Additionally, any laydown areas would be set within an area of up to one acre. These small footprints combined with the availability of previously developed lands at the L&D sites would likely require no significant tree removal. However, if some tree removal is necessary, loss of carbon sequestration would be negligible in the context of the regional setting, given the minimal estimated land required for constructing the supporting facilities.

Operation of both the BAFF and CO_2 fish barriers would require power primarily provided onsite via the TVA grid. Power needs for these technologies is minimal in the context of the regional setting. However, a generator would be needed to supply backup power to the system. The backup generator would emit GHGs but would be operated infrequently and typically for short periods. The backup generator would operate in compliance with all state regulations.

The BAFF system uses compressed air from the site to generate the underwater bubble curtain and operation of this system would not emit GHGs. As for the CO_2 fish barrier, diffusion of CO_2 into water will produce bubbles which may emit CO_2 as they reach the surface. In addition, as described in Air Quality Section 3.6, the operation of the CO_2 barrier would require repeat delivery of CO_2. The number of trucks needed to refill the supply of CO_2 would depend on the frequency of use. Locks with higher navigation traffic (e.g., Kentucky Lock) would require more CO_2 than those with lower frequency of lock operations (e.g., Guntersville Locks). Although the number of trucks needed to transport CO_2 is unknown, it is anticipated that the number of trucks delivering CO_2 would be limited and intermittent in nature. In addition, all trucks used to transport CO_2 would be maintained in good working condition with current emission control technologies to minimize GHGs.

Overall, construction and operation of the deterrent systems would produce minor and localized emissions of GHGs; however, these emissions would be negligible in comparison to regional emissions and would not impact global climate change.

3.8 Geology and Soils

3.8.1 Affected Environment

The 40,890 sq mi Tennessee River watershed drains portions of seven states (USGS 2001) and five physiographic provinces including: Coastal Plain (along the western edge); Interior Low Plateaus (central); and the Blue Ridge, Valley and Ridge, and Appalachian Plateaus (along the eastern edge (Fenneman 1938, TVA 2019a). Physiographic provinces are distinct regions with similar geologic characteristics (i.e., specific subsurface rock type or structural elements). These physiographic provinces are then subdivided into eight smaller physiographic sections as described below.

Coastal Plain Province – the Coastal Plain Province encompasses much of west Tennessee and most of the Coastal Plain portion of the TVA region is in the extensive East Gulf Coastal Plain section. The underlying geology is a mix of poorly consolidated gravels, sands, silts and clays. Soils are primarily of windblown (loess) and alluvial (deposited by water) origin, low to moderate fertility and easily eroded. The terrain varies from hilly to flat in broad river bottoms.

Interior Low Plateau Province – two sections of the Interior Low Plateau province occur in the Tennessee River watershed. The Highland Rim section is a plateau that occupies much of central Tennessee and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is Mississippian limestones, chert, shale, and sandstone. The terrain varies from hilly to rolling to extensive, relatively flat areas in the northwest and southeast. The Nashville Basin (also known as the Central Basin) section is an oval area in middle Tennessee with an elevation about 200 feet below the surrounding Highland Rim. The bedrock is generally flat-lying limestones. Soil cover is usually thin and surface streams cut into bedrock. Karst is well developed in parts of both the Highland Rim and the Nashville Basin.

Blue Ridge Province – the easternmost part of the watershed is in the Southern section of the Blue Ridge physiographic province. The province is the remnants of an ancient mountain range and has the greatest variation in terrain in the region. Terrain ranges from nearly level along floodplains at elevations of about 1,000 feet to rugged mountains with elevations of more than 6,000 feet. The rocks of the Blue Ridge have been subjected to much folding and faulting and are mostly shales, sandstones, conglomerates, and slate (sedimentary and metamorphic rocks of Precambrian and Cambrian age).

Valley and Ridge Province – the Valley and Ridge province includes the Middle and Tennessee sections comprised of complex folds and faults with alternating valleys and ridges trending northeast to southwest. Ridges have elevations of up to 3,000 feet and are generally capped by dolomites and resistant sandstones, while valleys have developed in more soluble limestones and dolomites. The dominant soils in this province are residual clays and silts derived from in-situ weathering. Karst features such as sinkholes and springs are numerous in the Valley and Ridge province.

Appalachian Plateau Province – the Appalachian Plateau province is an elevated area west of the Valley and Ridge province and is comprised of the extensive Cumberland Plateau section and the smaller Cumberland Mountain section. The Cumberland Plateau rises about 1,000 to 1,500 feet above the adjacent provinces and is formed by layers of near horizontal Pennsylvanian sandstones, shales, conglomerates and coals, underlain by Mississippian and older shale and limestones. The sandstones are resistant to erosion and have produced a relatively flat landscape broken by stream valleys. Toward the northeast, the Cumberland Mountain section is more rugged due to extensive faulting and has several peaks that exceed 3,000 feet in elevation.

3.8.1.1 Karst

Karst is a unique hydrogeologic terrane in which the surface water and ground water regimes are highly interconnected and often constitute a single, dynamic flow system. The presence of karst usually is indicated by the occurrence of distinctive physiographic features that develop as a result of the dissolution of soluble bedrock such as limestone or dolostone. In well-developed karst, these physiographic features may include sinkholes, sinking (or disappearing) streams, caves, and karst springs. The hydrologic characteristics associated with the presence of karst also are distinctive and generally include: (1) internal drainage of surface runoff through sinkholes; (2) underground diversion or partial subsurface piracy of surface streams (that is sinking streams and losing streams); (3) temporary storage of ground water within a shallow, perched *epikarst* zone; (4) rapid, turbulent flow through subsurface pipelike or channel-like solutional openings called *conduits*; and (5) discharge of subsurface water from conduits by way of one or more large perennial springs (Taylor and Green, 2008).

Karst is well developed in parts of both the Highland Rim and the Nashville Basin. No surficial karst features were present within the vicinity of the proposed L&D sites (Weary and Doctor 2014).

3.8.2 Environmental Consequences

3.8.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barriers at any of the locks considered. Therefore, there would be no impacts to the geology or soils from project-related activities.

3.8.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Construction of the fish barrier systems at one or more locks could potentially impact the previously disturbed bedrock at the lock and impact previously disturbed soils at the dam sites for support buildings and placement of dredge materials. Prior to construction, TVA would review the final designs at each project location to ensure that the bounding attributes and resource characteristics at each location are consistent with the values contained in Tables 2-5 and 2-6.

Installation of the fish barrier systems could potentially require minor modification of the river bedrock. Anchoring systems and supply lines would be installed at or in the lock chamber below the river bottom. Where bedrock is present a barge and jackhammer would be used to excavate a trough to install the system below the river bottom. The supply lines would then be capped with cement. The limited depth, width, and length of the trough needed to bury the supply lines would have a minor impact to the bedrock. Shallow excavation depth would reduce the risk of encountering any unknown karst features below the lock bedrock. Moreover, the bedrock at the lock has been heavily modified for the original construction of the L&D. Therefore, installation of the fish barriers would have only minor impacts to previously disturbed bedrock at the site and no impacts to groundwater.

Dredging of the locks and approaches would be required to allow for construction of service lines and equipment. Sediment dredged from the lock would be dewatered on the water on a barge or on land in previously disturbed areas at the dam site. When the dewatering is complete, the dredged material would be properly disposed at a location above the 500-year flood elevation, graded for proper drainage, and re-vegetated to prevent future erosion. Therefore, dredging impacts to soils at previously disturbed upland sites would be minor and temporary.

Construction of the support buildings would occur on previously disturbed graveled or paved areas. As such, site preparation would generally not impact soil stability and increase erosion. No borrow would be needed for construction. If necessary, BMPs described in the project-specific SWPPP would be implemented to minimize erosion during site preparation.

Overall, implementation of Alternative G would result in minimal impacts to soil stability and small increases to erosion during construction activities minimized by applicable BMPs. Operation of the fish barrier systems would not impact soils or geology.

3.9 Groundwater

3.9.1 Affected Environment

3.9.1.1 Regulatory Framework for Groundwater

The Safe Drinking Water Act of 1974 established the sole source aquifer protection program which regulates certain activities in areas where the aquifer (water-bearing geologic formations) provides at least half of the drinking water consumed in the overlying area. No sole source aquifers exist in the study area (EPA 2021c).

This act also established the Wellhead Protection Program, a pollution prevention and management program implemented by each state, used to protect underground sources of drinking water and the Underground Injection Control Program to protect underground sources of drinking water from contamination by fluids injected into wells. Several other environmental laws contain provisions aimed at protecting groundwater, including Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act and the Federal Insecticide, Fungicide, and Rodenticide Act.

3.9.1.2 Regional Aquifers

Three basic types of aquifers occur in the TVA region:

- Unconsolidated sedimentary sand;
- Carbonate rocks; and
- Fractured non-carbonate rocks.

Unconsolidated sedimentary sand formations, composed primarily of sand with lesser amounts of gravel, clay and silt, constitute some of the most productive aquifers. Groundwater movement in sand aquifers occurs through the pore spaces between sediment particles.

Carbonate rocks are another important class of aquifers. Carbonate rocks, such as limestone and dolomite, contain a high percentage of carbonate minerals (e.g., calcite) in the rock matrix. Carbonate rocks in some parts of the region readily transmit groundwater through enlarged fractures (cracks) and cavities created by dissolution of carbonate minerals by acidic groundwater, also known as karst topography.

Fractured non-carbonate rocks represent the third type of aquifer found in the region. These aquifers include sedimentary and metamorphic rocks (e.g., sandstone and granite gneiss), which transmit groundwater through fractures and openings in the bedrock.

In the Tennessee River watershed, groundwater derived from carbonate rocks of the Valley and Ridge, Highland Rim and Nashville Basin provinces is generally slightly alkaline and high in dissolved solids and hardness. Groundwater from mainly noncarbonated rocks of the Blue Ridge, Appalachian Plateaus and Coastal Plain provinces typically exhibits lower concentrations of dissolved solids compared to carbonate rocks. However, sandstones interbedded with pyritic shales often produce acidic groundwater high in dissolved solids, iron and hydrogen sulfide. These conditions are commonly found on the Appalachian Plateaus and in some parts of the Highland Rim and Valley and Ridge (Zurawski 1978). The chemical quality of most groundwater in the region is within health-based limits established by the EPA for drinking water.

The term “potentiometric surface” is often used to describe the elevation of the groundwater table. However, local site-specific hydrogeologic conditions or other factors within the aquifer system may cause the potentiometric surface to vary.

For the purpose of the programmatic approach, the assumption can be made that groundwater flow direction is reflective of site topography and local geology and is anticipated to discharge to the adjacent river systems.

3.9.1.3 Groundwater Use

Groundwater data are compiled by the USGS and cooperating state agencies in connection with the national public water use inventory conducted every 5 years (Bowen and Springston 2018). The largest use of groundwater is for public water supply. Almost all of the water used for domestic supply and 55 percent of water used for irrigation in the study area is groundwater. Groundwater is also used for industrial and mining purposes, livestock and aquaculture. The use of groundwater to meet public water supply needs varies across the TVA region and is the greatest in western Tennessee (TVA 2019a).

Six major aquifers occur in the TVA region (TVA 2019b). These aquifers generally align with the major physiographic divisions of the region. The aquifers include (in order of increasing geologic age):

- Quaternary age alluvium occupying the floodplains of major rivers, notably the Mississippi River.
- Tertiary and Cretaceous age sand aquifers of the Coastal Plain Province.
- Pennsylvanian sandstone units found mainly in the Cumberland Plateau section Carbonate rocks of Mississippian, Silurian and Devonian age of the Highland Rim section.
- Ordovician age carbonate rocks of the Nashville Basin section.
- Cambrian-Ordovician age carbonate rocks within the Valley and Ridge Province.
- Cambrian-Precambrian metamorphic and igneous crystalline rocks of the Blue Ridge Province.

Approximately 60 percent of all groundwater withdrawals in 2010 were supplied by sand aquifers in West Tennessee and North Mississippi. Shelby County, Tennessee (Memphis, Tennessee) accounted for about 38 percent of the total public water supply regional pumping. The dominance of groundwater use over surface water in the western portion of the TVA region is due to the availability of prolific aquifers and the absence of adequate water resources in some areas (TVA 2019b).

This variation of groundwater use across the region is the result of several factors including groundwater availability and quality, surface water availability and quality, determination of which water source can be developed most economically and public water demand, which is largely a function of population. There are numerous sparsely populated, rural counties in the region with no public water systems. Residents in these areas are self-served by individual wells or springs.

In 2015, estimated average daily water withdrawals in the Tennessee River watershed totaled about 10,016 million gallons per day (Bowen and Simpson 2015). About 1.9 percent of these water withdrawals were groundwater and the remainder were surface water. Groundwater and surface water withdrawals by public supply systems in Tennessee is about 16 percent lower than it was in 2010, which is primarily attributed to reduction in thermoelectric withdrawals. Although these data are for Tennessee public water supplies, they are representative of the overall growth in water use for the TVA region (TVA 2019a).

The quality of groundwater in the TVA region largely depends on the chemical composition of the aquifer in which the water occurs. The chemical quality of most groundwater in the region is within health-based limits established by the EPA for drinking water. Pathogenic microorganisms are generally absent, except in areas underlain by shallow carbonate aquifers susceptible to contamination by direct recharge through open sinkholes (Zurawski 1978).

Physiographic regions with karst topography provide a direct connection from the surface to groundwater. As identified in Section 3.8, Geology and Soils, karst is well developed in parts of both the Highland Rim and the Nashville Basin. However, no surficial karst features were present within the vicinity of the proposed L&D sites (Weary and Doctor 2014).

3.9.2 Environmental Consequences

3.9.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barriers at any of the locks considered. Therefore, there would be no impacts to the groundwater from project-related activities.

3.9.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

The minimal use of petroleum fuels, lubricants, and hydraulic fluids during construction and by maintenance vehicles would result in a low potential for small on-site spills. However, the use of BMPs to properly maintain vehicles to avoid leaks and spills and procedures to immediately address any spills that did occur, would minimize the potential for adverse impacts to groundwater.

Operation of fish barrier systems would not rely on groundwater use and would not involve actions that would alter or modify groundwater flow patterns. Therefore, operation would not affect groundwater quantity or quality.

3.10 Surface Water

3.10.1 Affected Environment

Water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits. The study area for this analysis encompasses the entirety of the Tennessee River and a portion of the lower Clinch River. Each reservoir in the Tennessee River system has unique water quality characteristics. Freshwater abounds in much of this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation (e.g., swimming).

3.10.1.1 Tennessee River

The Tennessee River watershed covers approximately 41,000 sq mi. This area includes 129 counties within much of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia. The Tennessee River watershed begins with headwaters in the mountains of western Virginia and North Carolina, eastern Tennessee, and northern Georgia. At Knoxville, Tennessee, the Holston and French Broad Rivers join to form the Tennessee River, which then flows southwest through the state—gaining water from three other large tributaries: the Little Tennessee, Clinch, and Hiwassee Rivers. The Tennessee River eventually flows into Alabama, where it picks up another large tributary, the Elk River. At the northeast corner of Mississippi, the river turns north, and re-crosses Tennessee—picking up the Duck River, and continues to Paducah, Kentucky, where it enters the Ohio River.

The entire length of the Tennessee River is regulated by a series of nine locks and dams built mostly in the 1930s and 40s that allow navigation from the Ohio River to Knoxville. Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and 7 single-purpose power reservoirs. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

3.10.1.2 Surface Waters

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. Toxic substances have also been found in sediment and fish in reservoirs that otherwise have good water quality. Other water quality concerns include occurrences of low dissolved oxygen levels downstream of dams, which stresses aquatic life and limits the ability of the water to assimilate wastes.

TVA regularly evaluates several water quality indicators as well as the overall ecological health of reservoirs through its Reservoir Ecological Health Ratings. This program evaluates five metrics: chlorophyll concentration, fish community health, bottom life, sediment contamination and DO. Scores for each metric from monitoring sites in the deep area near the dam (forebay), mid-reservoir, and at the upstream end of the reservoir (inflow) are combined for a summary score and rating. Reservoir Ecological Health ratings are detailed in Section 3.1, Aquatic Ecology.

3.10.1.3 Regulatory Framework for Water Quality

The Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), is the primary law that affects water quality. It establishes standards for the quality of surface waters and prohibits the discharge of pollutants from point sources unless a National Pollutant Discharge Elimination (NPDES) permit is obtained. Section 404 of the CWA further prohibits the discharge of dredge and fill material to waters of the United States, which include regulated wetlands, unless authorized by a permit issued by the USACE.

The CWA requires all states to identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards and to establish priorities for the development of limits based on the severity of the pollution and the sensitivity of the established uses of those waters. States are required to submit reports to the EPA. The term “303(d) list” refers to the list of impaired and threatened streams and water bodies identified by the state.

State regulators also advise the public of biological and fish advisories. Bacteriological contamination is the presence of pathogens, disease-causing organisms, affects the public’s ability to safely swim, wade, and fish in streams and reservoirs. Pathogen sources include failing septic tanks, collection system failure, failing animal waste systems, or urban runoff. About 122 river miles in Tennessee have posted advisories due to bacterial contamination (TDEC 2020).

3.10.1.4 Fort Loudoun Reservoir

Fort Loudoun Dam is located at Tennessee River mile 602.3 and is situated in Blount, Knox and Loudon counties in east Tennessee. The Fort Loudoun Reservoir lays within the 0601020102 10-digit HUC watershed. Major tributary streams flowing into the reservoir include the Holston River, French Broad River, and Little River. Designated uses for Fort Loudoun Reservoir and the Tennessee River downstream of the dam are domestic water supply, industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). Fort Loudoun Reservoir is included on the State of Tennessee's Section 303(d) list as impaired due to sediment contamination by polychlorinated biphenyls (PCBs) and mercury due to atmospheric deposition (TDEC 2018). Additionally, a precautionary fish consumption advisory for Fort Loudoun Reservoir is in place due to PCBs and mercury contamination. Commercial fishing for catfish is prohibited by Tennessee Wildlife Resources Agency (TWRA). Several tributary streams to Fort Loudoun Reservoir are listed as impaired for causes including siltation, habitat loss due to alteration of the substrate and stream-side vegetative cover, for biological advisories and the presence of *E. coli* bacteria (TDEC 2018). The Fort Loudoun tailwater is listed as impaired due to sediment contaminated with PCBs and low DO resulting from the upstream impoundment.

Aeration equipment was installed at Fort Loudoun Hydro Plant to improve the DO content of turbine releases during the summer months. The equipment consists of an oxygen diffuser system installed in the forebay. DO and temperature monitoring instrumentation provide input for evaluating and operating the system. The lowest average DO concentrations were found in the warmest months from July through August. The target DO concentration goal for the Fort Loudoun facility is 4 mg/L.

In 2019 Fort Loudoun Reservoir received an overall reservoir ecological health score of 77 and a reservoir rating of "Good" (see Section 3.1, Aquatic Ecology).

3.10.1.5 Melton Hill Reservoir

Melton Hill Reservoir is on the Clinch River in east Tennessee and is situated in Anderson and Knox counties. The Melton Hill Reservoir lays within the 0601020700 10-digit HUC watershed. Designated uses for Melton Hill Reservoir and the Clinch River downstream of the dam are domestic and industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). Melton Hill Reservoir is included on the State of Tennessee's Section 303(d) list as impaired due to sediment contamination by PCBs and Chlordane (TDEC 2018). Additionally, a precautionary fish consumption advisory for Melton Hill Reservoir is in place due to PCB contamination. Commercial fishing for catfish is prohibited by TWRA. Several tributary streams to Melton Hill Reservoir are listed as impaired for causes including siltation, habitat loss due to alteration of the substrate and stream-side vegetative cover, and the presence of *E. coli* bacteria (TDEC 2018). The Melton Hill tailwater is listed as impaired due to sediment contaminated with Chlordane and mercury resulting from the atmospheric deposition and industrial point source discharge.

In 2018 Melton Hill Reservoir received an overall reservoir ecological health score of 71 and a reservoir rating of "Fair" (see Section 3.1, Aquatic Ecology).

3.10.1.6 Watts Bar Reservoir

Watts Bar Reservoir is on the Tennessee River and is situated in Meigs, Rhea, Roane, Anderson, and Loudon counties in east Tennessee. The Watts Bar Reservoir lays within the 0601020100 10-digit HUC watershed. Designated uses for Watts Bar Reservoir and its tailwaters are domestic and industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). Portions of Watts Bar Reservoir are also listed as Exceptional Waters of the State due to state and federally listed aquatic species (TDEC, 2015). Watts Bar Reservoir is included on the state Section 303(d) list as impaired due to sediment contamination by PCBs (TDEC 2018). Additionally, a precautionary fish consumption advisory for the Clinch River arm of Watts Bar Reservoir is in place due to PCB contamination. Commercial fishing for catfish and striped bass is prohibited by TWRA.

Aeration equipment was installed at Watts Bar Hydro Plant to improve the DO content of turbine releases during the summer months. The equipment consists of an oxygen diffuser system installed in the forebay. DO and temperature monitoring instrumentation provide input for evaluating and operating the system. The lowest average DO concentrations were found in the warmest months from mid-June through early August. The target DO concentration goal for the Watts Bar facility is 4 mg/L.

In 2018 Watts Bar Reservoir received an overall reservoir ecological health score of 72 and a reservoir rating of “Fair” (see Section 3.1, Aquatic Ecology).

3.10.1.7 Chickamauga Reservoir

Chickamauga Reservoir is on the Tennessee River just north of Chattanooga and is situated in Bradley, Meigs, Rhea, McMinn, and Hamilton counties in east Tennessee. The Chickamauga Reservoir lays within the 0601020001 10-digit HUC watershed. Designated uses for Chickamauga Reservoir and its tailwaters are domestic and industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). Portions of Chickamauga Reservoir are also listed as Exceptional Waters of the State due to state and/or federally listed aquatic species (TDEC 2015). The Hiwassee River embayment of Chickamauga Reservoir is included on the state Section 303(d) list as impaired due to mercury due to atmospheric deposition and industrial point source discharges (TDEC 2018). The Chickamauga tailwater is listed as impaired due to sediment contamination by PCBs and Dioxin (TDEC 2018).

In 2019 Chickamauga Reservoir received an overall reservoir ecological health score of 87 and a reservoir rating of “Good” (see Section 3.1, Aquatic Ecology).

3.10.1.8 Nickajack Reservoir

Nickajack Reservoir extends 46 miles upstream from the dam to Chickamauga and is situated in Hamilton and Marion counties in east Tennessee. The Nickajack Reservoir lays within the 0601020802 10-digit HUC watershed. Designated uses for Nickajack and the Tennessee River downstream of the dam are domestic water supply, industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). Portions of Nickajack Reservoir are also listed as Exceptional Waters of the State due to state and/or federally listed aquatic species (TDEC 2015). Nickajack Reservoir is included on the State of Tennessee’s Section 303(d) list as impaired due to sediment contamination by PCBs and Dioxins (TDEC 2018). Additionally, a precautionary fish consumption advisory for Nickajack Reservoir is in place due to PCB and Dioxin contamination. Commercial fishing for catfish is prohibited by TWRA. Several tributary streams to Nickajack Reservoir are listed as impaired for causes including siltation, habitat loss due to alteration of the substrate and stream-side vegetative cover, for biological advisories, and the presence of *E. coli* bacteria (TDEC 2018).

In 2018 Nickajack Reservoir received an overall reservoir ecological health score of 88 and a reservoir rating of “Good” (see Section 3.1, Aquatic Ecology).

3.10.1.9 Guntersville Reservoir

Guntersville Reservoir is located in northeast Alabama, extending 76 miles up the Tennessee River into Tennessee and is situated in Jackson and Marshall counties in Alabama, and Marion County in Tennessee. The Guntersville Reservoir lays within the 06030001 8-digit HUC watershed. Designated uses for Guntersville and the Tennessee River downstream of the dam are public water supply, fish and aquatic life, swimming and other whole body water-contact sports (ADEM 2017). Guntersville Reservoir is included on the State of Alabama’s Section

303(d) list as impaired for mercury due to atmospheric deposition (ADEM 2018). Several tributary streams to Guntersville Reservoir are listed as impaired for causes including siltation, nutrients, organic enrichment, metals, and the presence of pathogens (ADEM 2018).

In 2018 Guntersville Reservoir received an overall reservoir ecological health score of 81 and a reservoir rating of “Good” (see Section 3.1, Aquatic Ecology).

3.10.1.10 Wheeler Reservoir

Wheeler Reservoir stretches 60 miles from Guntersville Dam to Wheeler Dam near Rogersville, Alabama, and is situated in Lawrence, Marshall, Madison, Morgan, Lauderdale, and Limestone counties. The Wheeler Reservoir lays within the 06030002 8-digit HUC watershed. Designated uses for Wheeler Reservoir and the Tennessee River downstream of the dam are public water supply, fish and aquatic life, swimming and other whole body water-contact sports (ADEM 2017). Wheeler Reservoir is included on the State of Alabama’s Section 303(d) list as impaired for nutrients due to agricultural influences and perfluorooctanesulfonic acid (PFOS) due to industrial sources (ADEM 2018). Several tributary streams to Wheeler Reservoir are listed as impaired for causes including siltation, nutrients, organic enrichment, PFOS, metals, and the presence of pathogens (ADEM 2018). The sections of the Wheeler Reservoir and Tennessee River from Tennessee River Mile 296 to 320 have fish consumption advisories for largemouth bass (APH 2020).

In 2019, Wheeler Reservoir received an overall reservoir ecological health score of 63 and a reservoir rating of “Fair” (see Section 3.1, Aquatic Ecology).

3.10.1.11 Wilson Reservoir

Wilson Reservoir is located in northern Alabama near the towns of Florence and Muscle Shoals, extending upstream for 15 miles to Wheeler Dam and is situated in Colbert, Lawrence, and Limestone counties. The Wilson Reservoir lays within the 06030002 8-digit HUC watershed. Designated uses for Wilson and the Tennessee River downstream of the dam are public water supply, fish and aquatic life, swimming and other whole body water-contact sports (ADEM 2017). Wilson Reservoir is included on the State of Alabama’s Section 303(d) list as impaired for nutrients due to agricultural reasons (ADEM 2018). Several tributary streams to Wilson Reservoir are listed as impaired for causes including siltation, nutrients, organic enrichment, PFOS, metals, and the presence of pathogens (ADEM 2018). The Wilson tailwater is listed as impaired for nutrients due to agriculture and mercury due to atmospheric deposition.

In 2018 Wilson Reservoir received an overall reservoir ecological health score of 63 and a reservoir rating of “Fair” (see Section 3.1, Aquatic Ecology).

3.10.1.12 Pickwick Reservoir

Pickwick Reservoir is located in southwest Tennessee and extends 53 miles south from the dam along the Mississippi-Alabama state line and then east into Alabama. It is situated in Colbert and Lauderdale counties in Alabama; Hardin County in Tennessee; and Tishomingo County in Mississippi. The Pickwick Reservoir lays within the 06030005 8-digit HUC watershed. Designated uses for Pickwick and the Tennessee River downstream of the dam are public water supply, fish and aquatic life, swimming and other whole body water-contact sports in Alabama (ADEM 2017); and domestic water supply, industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation in Tennessee (TDEC 2013). Pickwick Reservoir is included on the State of Alabama’s Section 303(d) list as impaired for nutrients due to agriculture (ADEM 2018). Pickwick Reservoir is also included on the State of Tennessee’s Section 303(d) list as impaired for total phosphorous due to agriculture (ADEM

2018). Several tributary streams to Wilson Reservoir are listed as impaired for causes including siltation, nutrients, organic enrichment, metals and the presence of pathogens (ADEM 2018); and alteration in stream-side or littoral vegetative covers and nickel (TDEC 2018). A section of the Pickwick Reservoir and Tennessee River have fish consumption advisories for largemouth bass (APH 2020).

In 2018 Pickwick Reservoir received an overall reservoir ecological health score of 67 and a reservoir rating of “Fair” (see Section 3.1, Aquatic Ecology).

3.10.1.13 Kentucky Reservoir

Kentucky Dam is 22 miles upstream from the confluence of the Tennessee River with the Ohio River and is situated in Hardin, Wayne, Decatur, Perry, Humphreys, Benton, Houston, Stewart Counties in Tennessee and Calloway, Trigg, Lyon and Marshall Counties, Kentucky. The Kentucky Reservoir lays within the 06040001, 06040003, 06040004 and 06040005 8-digit HUC watersheds. Designated uses for Kentucky Reservoir and the Tennessee River downstream of the dam are domestic water supply, industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and navigation (TDEC 2013). The portions of Kentucky Reservoir and the Tennessee River designated for warm water aquatic habitat, primary contact recreation, secondary contact recreation, and outstanding state resource water (KDEP, 2013). Kentucky Reservoir is included on the State of Tennessee’s Section 303(d) list as impaired due to low DO due to upstream impoundments (TDEC 2018). The Kentucky Reservoir/Tennessee River is included on the State of Kentucky’s Section 303(d) list as impaired due to mercury/methylmercury in fish tissue (KDEP 2016). Several tributary streams to Kentucky Reservoir are listed as impaired for causes including siltation, habitat loss due to alteration of the substrate and stream-side vegetative cover, for biological advisories and the presence of *E. coli* bacteria (TDEC 2018).

In 2019 Kentucky Reservoir received an overall reservoir ecological health score of 78 and a reservoir rating of “Good” (see Section 3.1, Aquatic Ecology).

3.10.2 Environmental Consequences

3.10.2.1 Alternative A – No Action

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the 10 TVA locks to deter the movement of Asian carp through the Tennessee River system. Though construction and installation impacts resulting from the installation of deterrent systems would not occur, there could be water quality changes due to increasing populations of invading Asian carp.

Asian carp, particularly grass carp, can potentially impact water quality characteristics such as nutrients, DO, pH, water clarity, and chlorophyll (an indicator of phytoplankton activity). High densities of grass carp can eliminate aquatic macrophytes communities which can increase nutrient concentrations in the water column (i.e., increased nitrite, nitrate, and phosphorus concentration; Pipalova 2006). Stored nutrients in the aquatic plants are released from sediments disturbed during active feeding and through undigested plant-matter (Dibble and Kovalenko 2009). Increased nutrients can result in algal blooms that can have multiple water quality implications. Algal blooms can change oxygen concentrations, pH, alkalinity, and turbidity (Pipalova 2006). Increased turbidity can then further shade remaining aquatic plants. Fewer macrophytes produce less DO, which can have negative impacts to aquatic habitats (Dibble and Kovalenko 2009). Overall water quality impacts are dependent on habitat type and grass carp densities. Shallower, non-flowing habitats along the shoreline would be more at risk than deeper, flowing habitats. However, shallow, vegetated habitats are important for juvenile fish survival and other aquatic and terrestrial species (Dibble and Kovalenko 2009).

Overall, the No Action Alternative has potential adverse impacts to water quality due to anticipated increases in Asian carp populations throughout the Tennessee River system; however, as described in Table 3-4 in the Aquatic Ecology Section 3.1, grass carp are expected to have lower overall impacts to aquatic ecosystems than other Asian carp species. Therefore, impacts to surface waters under this alternative are anticipated to be negative, minor, and long term.

3.10.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System.

Under Alternative G, TVA would install the BAFF or CO_2 fish deterrent systems that could impact water quality by displacing sediments during dredging. The primary impairment of concern while performing dredging work would be the suspension of bottom sediments that contain toxic substances, such as PCBs, Dioxins, and Chlordane. Because some of the project areas are either impaired streams or Exceptional Tennessee Waters, particular attention would need to be given to avoid making poor water quality conditions worse or impacts to exceptional waters. Resuspension has the potential to be harmful to both aquatic and human health and mitigative measures should be taken to limit or reduce the resuspension of sediments. Mitigation measures would include using floating silt screens around the dredging area that would promote suspended solids to resettle in the same general area and not migrate downstream of the work area. Effective use of appropriate BMPs during dredging would cause only localized, minor, and temporary negative impacts to surface waters.

TVA would further comply with all appropriate local, state, and federal permit requirements to reduce potential surface water impacts. More specifically, fish barrier installations may require specific permitting and regulatory compliance. Possible permits would include NPDES Construction General Storm water coverage; 401 Water Quality Certification; TN ARAP; and Section 404 USACE permitting. This would be assessed on a site-specific basis.

Operation of the fish barrier systems would not significantly impact water quality. Use of compressed air to form the bubble curtain may cause a small, localized increase in DO concentrations at the lock, but this change would be negligible in the context of the entire aquatic habitat at the dam. Diffusion of CO_2 into water causes localized changes to water quality, by design. However, diffused CO_2 leaves no residues and does not persist in the aquatic environment (Fredericks et al. 2019). In high concentrations CO_2 is lost rapidly to both the atmosphere and by interactions with calcium carbonate (Hamid et al. 2020). Remaining CO_2 in the lock would equalize with the surrounding water conditions once the lock is opened. Diffused CO_2 would be localized and temporary as it only needed at the lock entrance during active lockages. A substantial and persistent decrease in water pH is therefore unlikely. Operational impacts to surface water quality are anticipated to be localized, minor, and temporary.

Surface water quality impacts could be further mitigated by optimizing the CO_2 concentration need to be an effective barrier to Asian carp. Asian carp are more sensitive to CO_2 concentrations than some native fishes; therefore, CO_2 concentrations would be tweaked to find the lowest level needed to deter Asian carp but not all fish that use the lock. Recent studies demonstrated that CO_2 at a concentration of 100–200 mg/L effectively deterred adult and juvenile Asian carp.

Native mussels at the lock not previously removed during construction may be more at risk because they cannot actively flee from temporary increases in CO_2 concentrations. Prolonged exposure (i.e., more than 28 days) to high CO_2 concentrations may limit growth, inhibit shell formation, and cause shell pitting and erosion in native mussels (Waller et al. 2019). However, theses impacts were reversed once mussels were returned to untreated water (Waller et al. 2019). Shorter-duration exposure, such as temporary use of CO_2 fish deterrents only during active lockages, may have only temporary, minor adverse impacts to native mussels in the lock and no impacts to mussels outside of the lock (see Section 3.1, Aquatic Ecology).

Overall, adverse impacts to surface waters under Alternative G during construction and operation are anticipated to be minor, temporary, and localized at the lock entrance; however, long-term impacts are anticipated to be moderately beneficial due to the reduced impacts of invasive Asian carp on water quality throughout the Tennessee River system.

3.11 Floodplains

3.11.1 Affected Environment

A floodplain is the relatively level land area along a stream or river that is subject to periodic flooding. The area subject to a one-percent chance of flooding in any given year is normally called the 100-year floodplain. The area subject to a 0.2-percent chance of flooding in any given year is normally called the 500-year floodplain. It is necessary to evaluate development in the floodplain to ensure that the project is consistent with the requirements of EO 11988, Floodplain Management.

Congress established purposes for each TVA reservoir when funding was allocated for construction; therefore, some TVA reservoirs were authorized for power generation, flood control, navigation, or a combination of purposes. TVA reservoirs have either power storage or flood storage or both. Power storage is space allocated to a range of elevations and water occupying space in that range is used to generate electric power through a dam's hydroturbines. Flood storage is space allocated to a range of elevations, and space within that range is used to store flood water during a flood or high-flow rain event.

To control flood-damageable development on TVA lands, TVA applies its Flood Risk Standard, which is based on the TVA Flood Risk Profile (FRP). The FRP is the elevation of the 500-year flood that has been adjusted for surcharge at the dam. Surcharge is the ability to raise the water level behind the dam above the top-of-gates elevation. Surcharge can be sustained only for a short period of time during a flood. Some of TVA's Tennessee River dams are able to be surcharged. The TVA Flood Risk Standard states that flood-damageable development where TVA owns property or property rights is to be located a minimum of two feet above the FRP or 500-year flood elevation, whichever applies at the particular location. For the fish deterrent sites, the FRP is the 500-year flood elevation. Table 3-20 presents flood elevations at the 10 L&Ds in the Tennessee River system.

Table 3-20. Flood Elevations at Dams on the Tennessee River System

Fish Deterrent Site	River Mile	100-year Flood Elevation, ft msl*	FRP Elevation, ft msl*
Fort Loudoun	602.2	759.9	769.2
Melton Hill‡	22.9	755.2	759.1
Watts Bar†	529.5	697.8	701.6
Chickamauga	470.9	659.9	666.3

Nickajack	424.6	616.2	619.7
Guntersville	349.0	581.1	583.9
Wheeler	274.9	510.6	511.2
Wilson	259.3	434.7	437.0
Pickwick	206.3	401.2	403.4
Kentucky US†	22.7	375.0	375.0
Kentucky DS	22.3	345.4	349.5

*Elevations on the downstream side of the dam
‡Clinch River;
†Applicable elevation where the training wall ends

3.11.2 Environmental Consequences

As a federal agency, TVA adheres to the requirements of EO 11988, Floodplain Management. The objective of EO 11988 is "…to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative". The EO is not intended to prohibit floodplain development in all cases, but rather to create a consistent government policy against such development under most circumstances (U.S. Water Resources Council 1978). The EO requires that agencies avoid the 100-year floodplain unless there is no practicable alternative.

3.11.2.1 Alternative A – No Action

TVA would not install fish barrier technologies at any of the 10 TVA locks; therefore, there would be no impact to floodplains because there would be no activities within or alterations to the local floodplains.

3.11.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

The BAFF and CO_2 fish barriers both involve installing piping and/or manifolds on the bottom of the reservoir, along with hose to take gases from the compressors to the manifolds. The fish barrier systems must be in the water because the fish are in the water; therefore, the water-based portion of the systems are considered to be functionally dependent uses of the floodplain. Adverse impacts to floodplains would be minimized because the water-based portion of the systems would be situated on the bottom of the reservoir in dredged areas, below the lower limit of the navigation draft depth.

Land-based portions of the fish barriers would consist of equipment buildings, compressor buildings, and temporary laydown areas. As noted in Chapter 2, the design phase of the project at each dam location is conceptual at this time, and figures in this PEA depict possible locations of facilities, not final locations of facilities. Once designs have been advanced, TVA will review plans to ensure the design adheres to the bounding values in Tables 2-5 and 2-6.

Although specific locations for facilities have not been determined, as per the bounding parameters identified in Table 2-6, compressor buildings and laydown areas would be constructed in an area outside the FEMA-mapped 100-year floodplain. Any dredge spoils would be deposited on land above the 500-year flood elevation. The compressor buildings would be located outside the 100-year floodplain; or made floodable. If the compressor buildings cannot be located outside the 100-year floodplain or made floodable, TVA would conduct more detailed studies to evaluate the specific effects on flood elevation and would adjust the design accordingly (for example the design may entail elevation of the structure to at least two feet above the 500-year flood elevation). Compared to the overall extent of a reservoir, potential impacts are expected to be limited in scope and area; therefore, the potential impacts to reservoir flood storage volumes, as well as to floodplains and their natural and beneficial values, would be minor.

3.12 Land Use and Prime Farmland

3.12.1 Affected Environment

3.12.1.1 Land Use

Use of federal lands is generally regulated by the acts establishing the various agencies as well as other laws. For example, the TVA Act gives TVA the authority to regulate the use of lands it manages as well as development across, along, or in the Tennessee River or any of its tributaries. Various state laws and local ordinances regulate land use, although the majority of land in the TVA region is not subject to local zoning ordinances (TVA 2019a).

TVA manages and operates nine major dams and their associated reservoirs within the mainstem Tennessee River, as well as the Melton Hill Dam on the Clinch River. These reservoirs and their associated locks and dams create a series of lakes that form one navigation channel from Knoxville, Tennessee, to Paducah, Kentucky, allowing for regulation of the river for navigation, flood control, power generation, drinking water, and recreation. TVA has developed Reservoir Land Management Plans for each reservoir, allocating all public lands under TVA stewardship into broad categories or “zones” used to guide land use approvals and resource management decisions. The lands immediately adjacent to each of the Tennessee River system L&D sites have been designated to Zone 2 (Project Operations), which consists of land currently used or planned for future use for TVA operations and public works projects (TVA 2021h).

Land abutting the Tennessee River system reservoirs consists of both TVA-owned and managed shoreline, and land that has been sold for private use or transferred to other federal and state agencies for public use. Land uses along the reservoirs remain primarily rural and natural, consisting predominately of undeveloped forested land. Other land uses include TVA power generation operations, developed and dispersed recreation, residential, and a small number of industrial uses (TVA 2017c). The Tennessee River system L&D sites are owned by TVA and consist of both open water and developed land.

3.12.1.2 Prime Farmland

The 1981 Farmland Protection Policy Act (7 Code of Federal Regulations [CFR] Part 658) requires all federal agencies to evaluate impacts to prime and unique farmland prior to permanently converting to land use incompatible with agriculture. Prime farmland soils have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. These characteristics allow prime farmland soils to produce the highest yields with minimal expenditure of energy and economic resources. In general, prime farmlands have an adequate and dependable water supply, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. Prime farmland soils are permeable to water and air, not excessively erodible or saturated for extended periods, and are protected from frequent flooding.

In general, the lands immediately adjacent to the Tennessee River system L&D sites have been significantly altered through the construction of the dams themselves. According to USDA Natural Resources Conservation Service (NRCS) soil mapping, map units adjacent to many of the L&D sites consist of human altered soils and non-soil areas. These include udorthents (cut and fill areas), arents (soils lacking horizons due to deep plowing or grading), pits (mining operations), urban land, and made land, all of which indicate that the original soil characteristics are no longer present due to human manipulation (USDA NRCS 2020). For this reason, the soils adjacent to the L&D sites would not typically exhibit the soil characteristics necessary to be considered prime farmland.

3.12.2 Environmental Consequences

3.12.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barrier technologies at any of the locks considered. Therefore, there would be no impacts to land use or prime farmland.

3.12.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

3.12.2.2.1 Land Use

The BAFF system would primarily be installed in open water areas downstream of the lock, while the CO_2 system would be installed in the lock chamber. Other equipment, such as compressors and electric controls, would be housed in a building adjacent to the lock on an approximately 1-acre site. In addition, up to 1 acre of land would be needed for use as temporary construction laydown areas. Based on the proposed facility attributes and bounding characteristics listed in Tables 2-5 and 2-6, both the permanent installations and short-term equipment staging would be confined to previously developed land, in areas allocated for compatible uses per the reservoir land management plans. Due to the small project footprint and the location of proposed facilities in areas of existing developed and open water land uses, impacts to land use would be minor.

3.1.2.2.2 Prime Farmland

Based on the proposed facility attributes and characteristics listed in Tables 2-5 and 2-6, land-based construction would be limited to developed land use types adjacent to the existing L&D infrastructure. As these areas do not typically contain soils with the physical characteristics of prime farmland and are not currently being utilized for agriculture. Therefore, no impacts to prime farmland would occur.

3.13 Vegetation

3.13.1 Affected Environment

The study area of this PEA intersects seven Level IV ecoregions including the Eastern Highland Rim, North Hilly Gulf Coastal Plain, Plateau Escarpment, Sequatchie Valley, Southern Limestone/Dolomite Valleys and Low Rolling Hills, Wabash-Ohio Bottomlands, and Western Highland Rim (Omernik 1987). These ecoregions support a diverse array of plant communities including deciduous, mixed evergreen-deciduous, and evergreen forest, as well as herbaceous vegetation. Many specific plant communities occur throughout these ecoregions including bottomland hardwood, mixed mesophytic, upland oak-hickory, and swamp forests along with an array of herbaceous plant habitats.

Desktop review of the proposed project areas at each of the L&D sites where Asian carp barriers have been proposed indicates virtually all areas are heavily disturbed by prior construction and current operation of the respective dams. In addition, much of the proposed work would occur in aquatic environments that do not support terrestrial species or in unvegetated, operational areas on or adjacent to dam infrastructure. Within areas that do contain vegetation, aerial photos indicate that mowed lawns are the most common habitat type. These manicured areas are dominated by non-native plants, do not contain natural plant communities, and possess no conservation value. One possible exception is the proposed footprint for the Compressor Building for the BAFF System at the Wheeler L&D site. Aerial photography indicates this site is currently forested and likely contains natural vegetation.

3.13.2 Environmental Consequences

3.13.2.1 Alternative A – No Action

Under the No Action Alternative, no project-related work would occur, and the study area would remain in its current condition. Therefore, there would be no impacts to vegetation.

3.13.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Alternative G would have no appreciable effect on the vegetation of the region and would have no direct or indirect impacts. Nearly all terrestrial areas within the proposed study area are unvegetated operational zones adjacent to the respective L&D sites or they are vegetated with regularly mowed lawns. These sparsely vegetated areas are dominated by non-native species and do not support natural plant communities.

TVA recognizes that the design phase of the project at each dam location is conceptual. As such, based on the completion of site-specific designs, TVA would review each project location to ensure that the bounding attributes and resource characteristics at each location are consistent with the values contained in Tables 2-5 and 2-6. Should site specific conditions and potential effects exceed the bounding values, TVA would perform a site-specific review as needed to ensure that the level of impact assessment is consistent with that of the PEA.

For example, the Wheeler L&D proposed support building location has some forest habitats. Should these conceptual plans be finalized, TVA would conduct a site-specific environmental review to determine impacts to vegetation at this site. Because potentially impacted vegetated areas are very limited in area and do not support natural plant communities, impacts to vegetation are minor.

3.14 Wildlife

3.14.1 Affected Environment

The L&D site project areas within the study area are heavily disturbed with little to no remaining natural habitat. Early successional vegetative habitats, forested edge habitat, and forest do occur in areas surrounding the L&D sites. Heavily altered aquatic habitats found at and around the immediate vicinity of these L&D sites are not likely to support habitat for populations of rare amphibians or reptiles, though common species could be found nearby foraging. Because the disturbed terrestrial and aquatic habitat near the L&D sites regularly receive high levels of noise disturbance and boat traffic, only small numbers of common wildlife species are likely to occur.

Some species of wildlife have adapted to such disturbed areas and are able to use structures and buildings for nesting locations. Review of the TVA Regional Natural Heritage database in March 2020 indicated that heronries or osprey nests are known within 3 miles of all L&D project areas within the study area except for Melton Hill. All of these known nests are greater than 660 feet from the construction footprints shown on the conceptual arrangements of fish barrier systems shown in Figures B-1 through B-10 (Appendix B). Caves are known within 3 miles of Ft. Loudoun, Guntersville, Melton Hill, and Wheeler dams, and all are greater than 200 feet from any of the construction footprints shown on the conceptual arrangements.

Review of the USFWS Information for Planning and Consultation (IPaC) website indicated 21 migratory bird species of concern have the potential to occur in the project areas associated with the L&D sites. These include American kestrel, bald eagle, black-billed cuckoo, blue-winged warbler, bobolink, Canada warbler, cerulean warbler, eastern whip-poor-will, golden-winged warbler, Henslow's sparrow, Kentucky warbler, Le Conte's sparrow, lesser yellowlegs, prairie warbler, prothonotary warbler, red-headed woodpecker, red-throated loon, rusty blackbird, semi-palmated sandpiper, wood thrush, and yellow-bellied sapsucker. Suitable foraging or nesting habitat for these species could occur within some of the L&D project areas. A discussion of affected environment and consequences for the bald eagle can be found in Section 3.15, Threatened and Endangered Species.

3.14.2 Environmental Consequences

3.14.2.1 Alternative A – No Action

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the 10 TVA L&D sites to deter the movement of Asian carp through the Tennessee River system. Soil and vegetation would remain in their current state. Asian carp would be expected to continue pushing eastward in the Tennessee River. Common reptiles, such as turtles and snakes, that are found in and along the Tennessee River are not expected to be affected by this influx. They do not share many of the same food sources as Asian carp, nor would the carp eat these wildlife species. Larger birds that forage on carp would perhaps have an additional food source. Overall, there would be negligible impacts to common wildlife under the No Action Alternative.

3.14.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Under Alternative G, TVA would install a combined system of fish barriers (i.e., BAFF and CO_2) at multiple TVA L&D sites within the Tennessee River system. Terrestrial habitat that supports common wildlife could be removed for the installation of BAFF compressor buildings at one or more L&D sites. Site specific designs have not been finalized at this time; however, the footprints for the compressor buildings are relatively small, and all but one currently occurs on pavement, gravel, or mowed lawn. Once designs have been completed, impacts to wildlife and wildlife communities would be assessed at a site-specific level. Should impacts to wildlife habitat be anticipated, minimization and avoidance measures would be implemented as needed. Project activities have the potential to affect only disturbed habitats and common wildlife communities, and impacts are expected to be minor.

At this time no nests of osprey or migratory birds of conservation concern are known within 660 feet of the conceptual project areas. Should new nests be built, or project designs shift such that disturbance could occur within 660 feet of these resources, seasonal avoidance measures would be put into effect, if possible. If seasonal avoidance measures are not feasible and impacts must occur during the breeding/active season of osprey or other migratory birds of conservation concern, coordination with USDA – Wildlife Services or USFWS would occur, as appropriate, to ensure actions are in compliance with Executive Order 13186 - Responsibilities of Federal Agencies to Protect Migratory Birds.

3.15 Threatened and Endangered Species

3.15.1 Affected Environment

The ESA (16 USC §§ 1531-1543) was passed to conserve the ecosystems upon which endangered and threatened species depend, and to conserve and recover those species. An endangered species is defined by the ESA as any species in danger of extinction throughout all or a significant portion of its range, whereas a threatened species is likely to become endangered within the foreseeable future throughout all or a significant part of its range. Critical habitats, essential to the conservation of listed species, can also be designated under the ESA.

The ESA establishes programs to conserve and recover endangered and threatened species and makes their conservation a priority for Federal agencies. Section 7 of the ESA requires federal agencies to consult with the USFWS when their proposed actions may affect endangered or threatened species or their critical habitats.

The States of Tennessee, Kentucky, and Alabama each provide protection for species considered threatened, endangered, or deemed in need of management within the state other than those federally listed under the ESA. The listings in Tennessee are managed by the TWRA; additionally, the Tennessee Natural Heritage Program maintains a database of species that are considered threatened, endangered, in need of management, or tracked in Tennessee.

The species listings in Kentucky are managed by the state wildlife agency, KDFWR. Additionally, the Office of Kentucky Nature Preserves maintains a database of aquatic and terrestrial animal species that are considered threatened, endangered, special concern, or are otherwise tracked in Kentucky because the species is rare and/or vulnerable within the state. Plant species are protected in Kentucky through the Kentucky Rare Plant Recognition Act of 1994.

The species listings in Alabama are managed by the Alabama Department of Conservation and Natural Resources (ADCNR); however, the Alabama Natural Heritage Program maintains a database of aquatic animal species that are considered threatened, endangered, special concern, or tracked in Alabama.

TVA also maintains a database of threatened and endangered plant and animal species in TVA's power service area, which includes all of Tennessee and parts of six surrounding states, including Kentucky and Alabama. The USFWS IPaC website and the TVA Natural Heritage database were queried in March 2021 for species of conservation concern, including federal and state-listed species. Records of terrestrial animal species that occur or have the potential to occur within the impact area of dam sites within the study area are shown on Tables 3-21 to 3-30. A discussion of these species and the potential for their habitats to occur within the impact areas is included in the following sections.

3.15.1.1 Terrestrial Species of Conservation Concern

The TVA Natural Heritage database indicated that there are 25 records of Tennessee, Kentucky, and/or Alabama state-listed terrestrial animal species within 3 miles of dams in the study area. In addition, nests of the federally protected bald eagle are known within 3 miles of all dams in the study area except for Chickamauga. Federally listed gray bats have been recorded within 3 miles of Guntersville, Melton Hill, Nickajack, Wheeler, and Wilson dams. Historical records of the federally endangered Indiana bat are known from within 3 miles of Nickajack Dam. According to the USFWS IPaC website, four additional federally listed terrestrial animal species (least interior tern, northern long-eared bat, rusty-patched bumble bee, and red-cockaded woodpecker) have also been reported from Hamilton, Hardin, Loudon, Marion, Meigs, and Roane Counties, Tennessee; Marshall and Lauderdale Counties, Alabama; and Livingston County, Kentucky (Tables 3-21 to 3-30). No designated critical habitat for terrestrial species occurs within the proposed project areas.

The TVA Natural Heritage database indicates that state-listed plant species occur within five miles of all dams included in the study area (Tables 3-21 to 3-30). One federally listed plant species (large-flowered skullcap [*Scutellaria montana*]) has been reported from within a 5-mile vicinity of Chickamauga Dam, and seven federally listed plants have been documented from the counties where work would occur (Tables 3-21 to 3-30). No designated critical habitat for plants occurs within the proposed project area.

Table 3-21. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of the Chickamauga Dam and Federally Listed Terrestrial Species Reported from Hamilton County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Birds				
Bald eagle[4]	*Haliaeetus leucocephalus*	DM	D	S3
Common barn-owl	*Tyto alba*	–	–	S3
King rail	*Rallus elegans*	–	D	S2
Least bittern	*Ixobrychus exilis*	–	D	S2B
Peregrine falcon	*Falco peregrinus*	–	–	S1B
Virginia rail	*Rallus limicola*	–	–	S1B, S3N
Mammals				
Gray bat[4]	*Myotis grisescens*	E	E	S2
Indiana bat[5]	*Myotis sodalis*	E	E	S1
Northern long-eared bat[4]	*Myotis septentrionalis*	T	T	S1S2
Plants				
Fremont's virgin's-bower	*Clematis fremontii*	–	E	S1
Small whorled pogonia[4]	*Isotria medeoloides*	T	E	S1
American ginseng	*Panax quinquefolius*	–	S-CE	S3S4
White fringeless orchid[4]	*Platanthera integrilabia*	T	E	S2S3
Creekgrass	*Potamogeton epihydrus*	–	S	S1S2
Large-flowered skullcap	*Scutellaria montana*	T	T	S4
Prairie-dock	*Silphium pinnatifidum*	–	T	S2
Prairie goldenrod	*Solidago ptarmicoides*	–	E	S1S2
Virginia Spiraea[4]	*Spiraea virginiana*	T	E	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Federally listed or protected species known from Hamilton County, Tennessee, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.
[5] Federally listed species not known from Hamilton County Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-22. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Fort Loudoun Dam and Federally Listed Terrestrial Species Reported from Loudoun County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Hellbender[4]	*Cryptobranchus alleganiensis*	PS	E	S3
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	D	S3
Invertebrates				
Rusty-patched bumble bee[5]	*Bombus affinis*	E	–	S1
Mammals				
Gray bat[5]	*Myotis grisescens*	E	E	S2
Indiana bat[6]	*Myotis sodalis*	E	E	S1
Northern long-eared bat[6]	*Myotis septentrionalis*	T	T	S1S2
Plants				
Spreading false-foxglove	*Aureolaria patula*	–	S3	S
Mountain honeysuckle	*Lonicera dioica*	–	S2	S
American ginseng	*Panax quinquefolius*	–	S3S4	S-CE

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Species of hellbender found in the Ozarks of Missouri and Arkansas are federally listed. Species of hellbender found in Tennessee are not federally listed.
[5] Federally listed species known from Loudon County, Tennessee, but not within 3 miles of the project footprint.
[6] Federally listed species not known from Loudon County Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-23. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Guntersville Dam and Federally Listed Terrestrial Species Reported from Marshall County, Alabama[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Green salamander	*Aneides aeneus*	–	SP	S3
Hellbender[4]	*Cryptobranchus alleganiensis*	PS	SP	S2
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	SP	S4B
Red-cockaded woodpecker[5]	*Picoides borealis*	E	SP	S2
Invertebrates				
A cave obligate beetle	*Pseudanophthalmus meridionalis*	–	–	S2
A cave obligate pseudoscorpion	*Alabamocreagris pecki*	–	–	S1S2
A cave obligate spider	*Nesticus barri*	–	–	S3

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Mammals				
Gray bat	*Myotis grisescens*	E	SP	S2
Indiana bat[5]	*Myotis sodalis*	E	SP	S2
Northern long-eared bat[5]	*Myotis septentrionalis*	T	SP	S2
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	–	SP	S2
Southeastern bat	*Myotis austroriparius*	–	SP	S2
Tricolored bat	*Perimyotis subflavus*	–	SP	S3
Plants				
Smooth Blephilia	*Blephilia subnuda*	–	SP	S1S2
Pink turtlehead	*Chelone lyonii*	–	SP	S1
American smoke-tree	*Cotinus obovatus*	–	SP	S2
Branching whitlow-wort	*Draba ramosissima*	–	SP	S1
Church's wildrye	*Elymus churchii*	–	SP	S1
Alabama snow-wreath	*Neviusia alabamensis*	–	SP	S2
Green pitcher plant[5]	Sarracenia oreophila	E	SP	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; SP = State Protected; PS = Partial Status.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Species of hellbender found in the Ozarks of Missouri and Arkansas are federally listed. Species of hellbender found in Alabama are not federally listed.
[5] Federally listed species known from Marshall County, Alabama, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.

Table 3-24. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Kentucky Dam and Federally Listed Terrestrial Species Reported from Livingston County, Kentucky[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Bird-voiced treefrog	*Hyla avivoca*	–	N	S3S4
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	S	S3B, S3S4N
Bell's vireo	*Vireo bellii*	-	S	S2S3B
Least interior tern[4]	*Sterna antillarum athalassos*	E	E	S1S2B
Invertebrates				
Dukes' skipper	*Euphyes dukesi*	–	T	S2
Reptiles				
Midland smooth softshell	*Apalone mutica mutica*	–	N	S3
Mammals				
Gray bat[4]	*Myotis grisescens*	E	T	S2
Indiana bat[5]	*Myotis sodalis*	E	E	S1S2

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Northern long-eared bat[5]	*Myotis septentrionalis*	T	E	S1
Plants				
Price's potato-bean[4]	*Apios priceana*	T	E	S1
Cream wild indigo	*Baptisia bracteata* var. *leucophaea*	–	S	S3
Screwstem	*Bartonia virginica*	–	T	S2
Epiphytic sedge	*Carex decomposita*	–	T	S2
Carolina silverbell	*Halesia carolina*	–	E	S1S2
Hydrolea	*Hydrolea ovata*	–	E	S1
Swamp loosestrife	*Lysimachia terrestris*	–	E	S1
Eastern mock bishop's-weed	*Ptilimnium costatum*	–	E	S1?
Buckley's goldenrod	*Solidago buckleyi*	–	S	S2S3
Trepocarpus	*Trepocarpus aethusae*	–	S	S3

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; N = No Status.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Federally listed species known from Livingston County, Kentucky, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.
[5] Federally listed species not known from Livingston County, Kentucky; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-25. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Melton Hill Dam and Federally Listed Terrestrial Species Reported from Roane County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Hellbender[4]	*Cryptobranchus alleganiensis*	PS	E	S3
Birds				
Bachman's sparrow	*Peucaea aestivalis*	–	E	S1B
Bald eagle[5]	*Haliaeetus leucocephalus*	DM	D	S3
Sharp-shinned hawk	*Accipiter striatus*	–	–	S3BS4N
Mammals				
Gray bat	*Myotis grisescens*	E	E	S2
Indiana bat[6]	*Myotis sodalis*	E	E	S1
Northern long-eared bat[5]	*Myotis septentrionalis*	T	T	S1S2
Plants				
American hart's-tongue fern[5]	*Asplenium scolopendrium* var. *americanum*	T	E	S1
Spreading false-foxglove	*Aureolaria patula*	–	S	S3
River bulrush	*Bolboschoenus fluviatilis*	–	S	S1
Tall larkspur	*Delphinium exaltatum*	–	E	S2

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Northern bush-honeysuckle	*Diervilla lonicera*	–	T	S2
Waterweed	*Elodea nuttallii*	–	S	S2
Naked-stem sunflower	*Helianthus occidentalis*	–	S	S2
Butternut	*Juglans cinerea*	–	T	S3
Short-head rush	*Juncus brachycephalus*	–	S	S2
Loesel's twayblade	*Liparis loeselii*	–	T	S1
Mountain honeysuckle	*Lonicera dioica*	–	S	S2
American ginseng	*Panax quinquefolius*	–	S-CE	S3S4
Pale green orchid	*Platanthera flava* var. *herbiola*	–	T	S2
White fringeless orchid[5]	*Platanthera integrilabia*	T	E	S2S3
Virginia Spiraea[5]	*Spiraea virginiana*	T	E	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited; PS = Partial Status.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Species of hellbender found in the Ozarks of Missouri and Arkansas are federally listed. Species of hellbender found in Tennessee are not federally listed.
[5] Federally listed or protected species known from Roane County, Tennessee, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.
[6] Federally listed species not known from Roane County Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-26. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Nickajack Dam and Federally Listed Terrestrial Species Reported from Marion County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Barking treefrog	*Hyla gratiosa*	–	–	S3
Tennessee cave salamander	*Gyrinophilus palleucus*	–	T	S2
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	D	S3
Invertebrates				
Nickajack cave beetle	*Pseudanophthalmus nickajackensis*	–	–	S1
Mammals				
Eastern small-footed bat	*Myotis leibeii*	–	D	S2S3
Gray bat	*Myotis grisescens*	E	E	S2
Indiana bat	*Myotis sodalis*	E	E	S1
Northern long-eared bat[4]	*Myotis septentrionalis*	T	T	S1S2
Tricolored bat	*Perimyotis subflavus*	–	T	S2S3
Plants				
Price's potato-bean[5]	*Apios priceana*	T	E	S3

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Spreading rockcress	*Arabis patens*	–	E	S1
American hart's-tongue fern[5]	*Asplenium scolopendrium* var. *americanum*	T	E	S1
Liverwort	*Cololejeunea ornata*	–	T	S1
American smoke-tree	*Cotinus obovatus*	–	S	S2
Sharp's Homaliadelphus	*Homaliadelphus sharpii*	–	E	S1
featherfoil	*Hottonia inflata*	–	S	S2
Small whorled pogonia[5]	*Isotria medeoloides*	T	E	S1
Slender blazing-star	*Liatris cylindracea*	–	T	S2
Hairy false gromwell	*Onosmodium hispidissimum*	–	E	S1
White fringeless orchid[5]	*Platanthera integrilabia*	T	E	S2S3
John Beck's leafcup	*Polymnia johnbeckii*	–	E	S1
Large-flowered skullcap[5]	*Scutellaria montana*	T	T	S4
Nevius' stonecrop	*Sedum nevii*	–	E	S1
Great Plains ladies'-tresses	*Spiranthes magnicamporum*	–	E	S1

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Federally listed species not known from Marion County, Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.
[5] Federally listed or protected plant species known from Roane County, Tennessee, but not within 5 miles of the project footprint.

Table 3-27. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Pickwick Dam and Federally Listed Terrestrial Species Reported from Hardin County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Hellbender[4]	*Cryptobranchus alleganiensis*	PS	E	S3
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	D	S3
Mammals				
Gray bat[5]	*Myotis grisescens*	E	E	S2
Indiana bat[6]	*Myotis sodalis*	E	E	S1
Northern long-eared bat[5]	*Myotis septentrionalis*	T	T	S1S2
Reptiles				
Western pigmy rattlesnake	*Sistrurus miliarius streckeri*	–	T	S2S3
Plants				
Price's potato-bean[5]	*Apios priceana*	T	E	S3
Fraser loosestrife	*Lysimachia fraseri*	–	E	S2

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Barbed rattlesnake-root	*Prenanthes barbata*	–	S	S2
Blue sage	*Salvia azurea* var. *grandiflora*	–	S	S3
Ovate catchfly	*Silene ovata*	–	E	S2
Southern morning-glory	*Stylisma humistrata*	–	T	S1
Horsesugar	*Symplocos tinctoria*	–	S	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited; PS = Partial Status.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Species of hellbender found in the Ozarks of Missouri and Arkansas are federally listed. Species of hellbender found in Tennessee are not federally listed.
[5] Federally listed or protected species known from Hardin County, Tennessee, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.
[6] Federally listed species not known from Hardin County Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-28. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Watts Bar Dam and Federally Listed Terrestrial Species Reported from Meigs County, Tennessee[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Amphibians				
Hellbender[4]	*Cryptobranchus alleganiensis*	PS	E	S3
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	D	S3
Mammals				
Gray bat[5]	*Myotis grisescens*	E	E	S2
Indiana bat[6]	*Myotis sodalis*	E	E	S1
Northern long-eared bat[5]	*Myotis septentrionalis*	T	T	S1S2
Plants				
Spreading false-foxglove	*Aureolaria patula*	–	S	S3
Northern bush-honeysuckle	*Diervilla lonicera*	–	T	S2
Slender blazing-star	*Liatris cylindracea*	–	T	S2
Prairie goldenrod	*Solidago ptarmicoides*	–	E	S1S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited; PS = Partial Status
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Species of hellbender found in the Ozarks of Missouri and Arkansas are federally listed. Species of hellbender found in Tennessee are not federally listed.

[5] Federally listed or protected animal species known from Meigs County, Tennessee, but not within 3 miles of the project footprint.
[6] Federally listed species not known from Meigs County Tennessee; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-29. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Wheeler Dam and Federally Listed Terrestrial Species Reported from Lauderdale County, Alabama[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	SP	S4B
Mammals				
Gray bat	*Myotis grisescens*	E	SP	S2
Indiana bat[4]	*Myotis sodalis*	E	SP	S2
Northern long-eared bat[5]	*Myotis septentrionalis*	T	SP	S2
Tricolored bat	*Perimyotis subflavus*	–	SP	S3
Reptiles				
Alligator snapping turtle	*Macrochelys temminckii*	–	SP	S3
Plants				
Lake-cress	*Armoracia lacustris*	–	SP	S1
Climbing bittersweet	*Celastrus scandens*	–	SP	S2
Fleshy-fruit Gladecress[4]	*Leavenworthia crassa*	E	SP	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020.
[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited.
[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
[4] Federally listed species known from Lauderdale County, Alabama, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.
[5] Federally listed species not known from Lauderdale County Alabama; however, the USFWS has determined that this species has the potential to occur in the study area.

Table 3-30. Terrestrial Plant and Animal Species of Conservation Concern Known from Within 3 Miles (Animals) and 5 Miles (Plants) of Wilson Dam and Federally Listed Terrestrial Species Reported from Lauderdale County, Alabama[1]

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Birds				
Bald eagle	*Haliaeetus leucocephalus*	DM	SP	S4B
Mammals				
Gray bat	*Myotis grisescens*	E	SP	S2
Indiana bat[4]	*Myotis sodalis*	E	SP	S2
Northern long-eared bat[5]	*Myotis septentrionalis*	LT	SP	S2
Reptiles				
Alligator snapping turtle	*Macrochelys temminckii*	–	SP	S3

Common Name	Scientific Name	Federal Status[2]	State Status[2]	State Rank[3]
Plants				
Blue-eyed Mary	*Collinsia verna*	–	SP	S1
Dutchman's Breeches	*Dicentra cucullaria*	–	SP	S2
False Rue-anemone	*Enemion biternatum*	–	SP	S2
Fleshy-fruit Gladecress[4]	*Leavenworthia crassa*	E	SP	S2

[1] Source: TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] Status Codes: D = Deemed in need of management; DM = Delisted, recovered, and still being monitored; E = Endangered; T = Threatened; S = Special Concern; S-CE = Special Concern/Commercially Exploited.

[3] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; S#B = Rank of Breeding Population; S#N = Rank of Non-breeding population; S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).

[4] Federally listed species known from Lauderdale County, Alabama, but not within 3 miles (animals) or 5 miles (plants) of the project footprint.

[5] Federally listed species not known from Lauderdale County Alabama; however, the USFWS has determined that this species has the potential to occur in the study area.

3.15.1.1.1 Terrestrial Animals

As mentioned, most of the construction footprints at each of the dams are heavily disturbed areas where little to no natural habitat remains. Concrete pads, graveled areas, isolated shrubs, or mowed grass areas where most conceptual BAFF compressor buildings have been drawn do not provide habitat for the species of conservation concern listed in Tables 3-21 to 3-30. Should final designs place BAFF compressor buildings in natural habitats such as forests, there is some potential that habitat for federally listed bats could be removed. Proposed actions also have the potential to impact species that could occur in the large reservoirs or on man-made structures at or near the dams. Based on proximity of species occurrence records and current conceptual drawings, species of conservation concern that have potentially suitable habitat in project areas that could be affected by proposed actions include one amphibian, two turtles, one bird, and three bats (Tables 3-21 to 3-30).

Hellbenders, which are state-listed in Tennessee and Alabama, are found in larger, fast-flowing, streams and rivers with large shelter rocks. Eggs are laid in depressions created beneath large rocks or submerged logs (Petranka 1998). Hellbender records are known within 3 miles of Ft. Loudoun, Guntersville, Melton Hill, Pickwick, and Watts Bar dams. All of these records are listed as historical or possibly historical due to the age of the records. Hellbenders are generally not expected to occur in the mainstem of the Tennessee River because suitable nesting habitats were flooded when the impoundments were constructed. However, individuals could potentially occur there occasionally, since the mainstem connects to smaller rivers with documented use.

Alligator snapping turtles, which are state-listed in Alabama, are almost entirely aquatic. Only nesting females are known to leave the water to lay eggs. Alligator snapping turtles use large, deep bodies of water such as lakes, rivers, and deep sloughs. They are often found among submerged logs and root snags in areas with muddy substrate (Buhlmann et al. 2008). The closest records of alligator snapping turtles are from the Tennessee River and are approximately 1.8 and 2.9 miles from Wheeler and Wilson dams, respectively. These records are both listed as historical due to the age of the records, and are largely considered dubious as the records are based on informal observations. Based on its range, this species could potentially be found in Kentucky and Pickwick reservoirs.

Midland smooth softshell turtles are classified as a species of conservation concern, but they are not state or federally listed in the study area. In the Tennessee Valley, these turtles are found in larger streams and rivers in western Kentucky, western Tennessee, and northwestern and north central Alabama. They prefer rivers with sandy bottoms (Buhlmann et al. 2008). The closest record of this species is approximately 1.1 miles from Kentucky Dam in the tailwaters. This species is also known from Kentucky Reservoir and could occur in Pickwick, Wheeler, and Wilson Reservoirs.

Osprey and their nests are protected by the MBTA. Osprey occupy riparian habitats alongside bodies of water such as rivers, lakes, and reservoirs. They frequently build nests on a variety of man-made structures (e.g., transmission line structures, lighting towers, navigation buoys) near and in water (NatureServe 2020). Osprey nests are known within 3 miles of all dams within the study area except Melton Hill and are quire abundant throughout the Tennessee River system. However, no active nests occur within 660 feet of proposed construction footprints.

Bald eagles are protected by the BGEPA (USFWS 2013). This species is quite common throughout the Tennessee River system, especially in adjacent forested habitats with larger mature trees capable of supporting its massive nests. They occasionally construct nests on transmission towers as observed on Wheeler National Wildlife Refuge in North Alabama. Nests are usually found near larger waterways where the eagles forage (USFWS 2007a). Bald eagle nesting records are known within 3 miles of Fort Loudoun, Guntersville, Kentucky, Nickajack, Pickwick, Watts Bar, Wheeler, and Wilson dams. The closest bald eagle records occur at Guntersville and Watts Bar dams. The bald eagle nest closest to Watts Bar Dam has been active in recent years but is greater than 0.5 miles from the dam. The nest closest to Guntersville Dam is 1,500 feet away, but it has not been active in the past several years.

Federally endangered gray bats roost in caves year-round and migrate between summer and winter roosts during spring and fall (Brady et al. 1982, Tuttle 1976b). Bats disperse over bodies of water at dusk where they forage for insects emerging from the surface of the water (Tuttle 1976a). The range of the gray bat includes the entire Tennessee River system; thus, this species has the potential to occur at any of the dams in the study area. Gray bats have been reported within 3 miles of Guntersville, Melton Hill, Nickajack, Wheeler, and Wilson dams. The closest record of gray bats to a proposed study area is at Guntersville Dam. A known hibernaculum occurs approximately 0.7 miles from Guntersville Dam. All other gray bat records are greater than 1 mile from these dams. No known hibernacula occur within 200 feet of dams in the study area. Foraging habitat for gray bats occurs over the Tennessee River adjacent to all dams in the study area and can be observed foraging under lights at most mainstem river dams.

Federally endangered Indiana bats hibernate in caves in winter and use areas around them for swarming (mating) in the fall and staging in the spring, prior to migration back to summer habitat. During the summer, Indiana bats roost under the exfoliating bark of dead snags and living trees in mature forests with an open understory and a nearby source of water (Pruitt and TeWinkel 2007, Kurta et al. 2002). Although less common, Indiana bats have also been documented roosting in buildings (Butchkoski and Hassinger 2002). Indiana bats are known to change roost trees frequently throughout the season, while still maintaining site fidelity, returning to the same summer roosting areas in subsequent years (Pruitt and TeWinkel 2007). The range of Indiana bats includes the entire Tennessee River system; thus, this species has the potential to occur at any of the dams in the study area. This species has not been reported within 3 miles of any of the dams in the study area except for Nickajack Dam. A historical record of Indiana bat is known from a cave approximately 1.1 miles from Nickajack Dam. No known hibernacula occur within 200 feet of dams within the study area. Foraging habitat for Indiana bats occurs over the Tennessee River and along forested shorelines.

Federally threatened northern long-eared bats predominantly overwinter in large hibernacula such as caves, abandoned mines, and cave-like structures. During the fall and spring they utilize entrances of caves and the surrounding forested areas for swarming and staging. In the summer, northern long-eared bats roost individually or in colonies beneath exfoliating bark or in crevices of both live and dead trees (typically greater than 3 inches in diameter). Roost selection by northern long-eared bat is similar to that of Indiana bat, however northern long-eared bats are thought to be more opportunistic in roost site selection. This species also roosts in abandoned buildings and under bridges. Northern long-eared bats emerge at dusk to forage below the canopy of mature forests on hillsides and roads, and occasionally over forest clearings and along riparian areas (USFWS 2014). The range of northern long-eared bats includes the entire Tennessee River system, thus this species has the potential to occur at any of the dams in the study area. This species has not been reported within 3 miles of any of the dams with proposed actions. No known hibernacula occur within 200 feet of dams in the study area. Foraging habitat for northern long-eared bats occurs over the Tennessee River and along forested shorelines.

3.15.1.1.2 Plants

All plant species listed in Tables 3-21 to 3-30 have specific habitat requirements. These specialized habitats are varied and include plant communities like rocky grasslands, rich cove forests, limestone glades over shallow bedrock, calcareous forests, and forested wetlands. None of the proposed project areas at the ten dam sites in the study area support natural vegetation capable of providing habitat for species listed in Tables 3-21 to 3-30. All these proposed sites are heavily degraded, and those that are vegetated are dominated by non-native plants.

3.15.1.1.3 Aquatic Species of Conservation Concern

The TVA Regional Natural Heritage Project database and the USFWS IPaC website indicated state and federally listed species are currently known from or have the potential to occur within the 10-digit hydrologic unit code (HUC) watersheds encompassing each reservoir in the study area (Tables 3-31 to 3-41). Species with an element rank of historical (H), possibly historical (H?), extirpated (X), or possibly extirpated (X?) are considered to be extremely rare or no longer occur within the 10-digit HUC(s) that they were once documented in.

Table 3-31. Records of Aquatic Animal Species of Conservation Concern Within Fort Loudoun Reservoir (Tennessee River – 0601020102 10-Digit HUC Watershed[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Lake Sturgeon	*Acipenser fulvescens*	S1	E	E	–
Blue Sucker	*Cycleptus elongatus*	S2	T	H?	–
Flame Chub	*Hemitremia flammea*	S3	D	H	–
Tangerine Darter	*Percina aurantiaca*	S3	D	H?	–
Snail Darter	*Percina tanasi*	S2S3	T	H?	LT
Yellowfin Madtom	*Noturus flavipinnis*	S1	T	X	LT
Mollusks					
Anthony's River Snail	*Athearnia anthonyi*	S1	E	X?	LE

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Dromedary Pearlymussel	*Dromus dromas*	S1	E	X	LE
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	H	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE
Tubercled Blossom †	*Epioblasma torulosa*	SX	E	X	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020
[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SX = Extirpated
[3] Status Codes: D = Deemed in Need of Management; E = endangered; T = Threatened
[4] Heritage Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; X = Extirpated
[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered
† Denotes extinct species

Table 3-32. Records of Aquatic Animal Species of Conservation Concern Within Melton Hill Reservoir (Clinch River – 0601020704 10-Digit HUC Watershed[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Blue Sucker	*Cycleptus elongatus*	S2	T	H?	–
Highfin Carpsucker	*Carpiodes velifer*	S2S3	D	H?	–
Lake Sturgeon	*Acipenser fulvescens*	S1	E	E	–
Tennessee Dace	*Chrosomus tennesseensis*	S3	D	H	–
Mollusks					
Cracking Pearlymussel	*Hemistena lata*	S1	E	X	LE
Dromedary Pearlymussel	*Dromus dromas*	S1	E	X	LE
Fanshell	*Cyprogenia stegaria*	S1	E	H	LE
Fine-rayed Pigtoe	*Fusconaia cuneolus*	S1	E	X	LE
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	H	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	H?	LE
Ring Pink	*Obovaria retusa*	S1	E	H	LE
Sheepnose	*Plethobasus cyphyus*	S2S3	E	E	LE
Shiny Pigtoe Pearlymussel	*Fusconaia cor*	S1	E	H	LE
Spectaclecase	*Cumberlandia monodonta*	S2S3	E	H	LE
White Wartyback	*Plethobasus cicatricosus*	S1	E	H	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020
[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable
[3] Status Codes: D = Deemed In Need of Management; E = endangered; T = Threatened
[4] Heritage Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; X = Extirpated
[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

Table 3-33. Records of Aquatic Animal Species of Conservation Concern Within Watts Bar Reservoir (Tennessee River – 0601020106 and 0601020103 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Blue Sucker	*Cycleptus elongatus*	S2	T	H?	–
Flame Chub	*Hemitremia flammea*	S3	D	H	–
Lake Sturgeon	*Acipenser fulvescens*	S1	E	E	–
Snail Darter	*Percina tanasi*	S2S3	T	H?	LT
Tangerine Darter	*Percina aurantiaca*	S3	D	H?	–
Mollusks					
Anthony's River Snail	*Athearnia anthonyi*	S1	E	X?	LE
Dromedary Pearlymussel	*Dromus dromas*	S1	E	X	LE
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	H	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable

[3] Status Codes: D = Deemed in Need of Management; E = endangered; T = Threatened

[4] Heritage Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; X = Extirpated

[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

Table 3-34. Records of Aquatic Animal Species of Conservation Concern Within Chickamauga Reservoir (Tennessee River – 0601020106 and 0601020103 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Highfin Carpsucker	*Carpiodes velifer*	S2S3	D	E	–
Lake Sturgeon	*Acipenser fulvescens*	S1	E	E	–
Snail Darter	*Percina tanasi*	S2S3	T	H?	LT
Mollusks					
Dromedary Pearlymussel	*Dromus dromas*	S1	E	H?	LE
Fanshell	*Cyprogenia stegaria*	S1	E	H?	LE
Longsolid	*Fusconaia subrotunda*	S3			PT
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	H?	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE
Rough Pigtoe	*Pleurobema plenum*	S1	E	H?	LE
Sheepnose	*Plethobasus cyphyus*	S2S3	E	E	LE
Shiny Pigtoe Pearlymussel	*Fusconaia cor*	S1	E	H	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable

[3] Status Codes: D = Deemed in Need of Management; E = endangered; T = Threatened

[4] Heritage Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; X = Extirpated

[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered; PT = Petitioned Species

Table 3-35. Records of Aquatic Animal Species of Conservation Concern Within Nickajack Reservoir (Tennessee River – 0602000112 10-Digit HUC Watershed[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Snail Darter	*Percina tanasi*	S2S3	T	AC	LT
Lake Sturgeon	*Acipenser fulvescens*	S1	E	E	–
Mollusks					
Cumberland Monkeyface	*Quadrula intermedia*	S1	E	X	LE
Dromedary Pearlymussel	*Dromus dromas*	S1	E	X	LE
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	E	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE
Rough Pigtoe	*Pleurobema plenum*	S1	E	E	LE
Tuberculed Blossom Pearlymussel †	*Epioblasma torulosa*	SX	E	X	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable

[3] Status Codes: D = Deemed in Need of Management; E = endangered; T = Threatened

[4] Heritage Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; X = Extirpated; AC = Excellent, good, or fair estimated viability

[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

† Denotes extinct species

Table 3-36. Records of Aquatic Animal Species of Conservation Concern Within Guntersville Reservoir (Tennessee River – 0603000102, Tennessee River - Mud Creek – 0603000104, Lower Guntersville Lake – 0603000109, and Upper Guntersville Lake – 0603000106 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Snail Darter	*Percina tanasi*	S2S3	T	H?	LT
Mollusks					
Anthony's River Snail	*Athearnia anthonyi*	S1	E	E	LE
Butterfly	*Ellipsaria lineolata*	S4	PSM	E	–
Cumberland Monkeyface	*Quadrula intermedia*	SX	SP	X	LE
Dromedary Pearlymussel	*Dromus dromas*	SX	SP	X	LE
Fanshell	*Cyprogenia stegaria*	S1	E	H	LE
Hickorynut	*Obovaria olivaria*	SX	PSM	H	–
Kidneyshell	*Ptychobranchus fasciolaris*	S2	PSM	H	–
Monkeyface	*Quadrula metanevra*	S3	PSM	E	–
Ohio Pigtoe	*Pleurobema cordatum*	S2	PSM	E	–

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Orange-foot Pimpleback	*Plethobasus cooperianus*	SX	SP	H	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE
Pocketbook	*Lampsilis ovata*	S2	PSM	H	–
Pyramid Pigtoe	*Pleurobema rubrum*	S1	SP	H	–
Ring Pink	*Obovaria retusa*	SH	SP	X	LE
Rough Pigtoe	*Pleurobema plenum*	S1	SP	X	LE
Sheepnose	*Plethobasus cyphyus*	S1	SP	H	LE
Slabside Pearlymussel	*Pleuronaia dolabelloides*	S1	SP	H	LE
Smooth Rabbitsfoot	*Quadrula cylindrica cylindrica*	S1	SP	H	LT
Snuffbox	*Epioblasma triquetra*	S1	PSM	H	LE
Winged Mapleleaf	*Quadrula fragosa*	SNA	SP	H	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SX = Extirpated; SNA = Status not assessed

[3] State Status Codes: E = Endangered; SP = State Protected; PSM = Partial Status Mussels

[4] Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status

[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

Table 3-37. Records of Aquatic Animal Species of Conservation Concern Within Wheeler Reservoir (Tennessee River-Wheeler Lake – 0603000209, Upper Lake Wheeler – 0603000211, and Tennessee River - Second Creek – 0603000212 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Southern Cavefish	*Typhlichthys subterraneus*	S3	SP	E	–
Spring Pygmy Sunfish	*Elassoma alabamae*	S1	SP	BC	LT
Tuscumbia Darter	*Etheostoma tuscumbia*	S2	SP	E	–
Mollusks					
Black Sandshell	*Ligumia recta*	S2	PSM	E	–
Butterfly	*Ellipsaria lineolata*	S4	PSM	E	–
Deertoe	*Truncilla truncata*	S1	PSM	E	–
Dromedary Pearlymussel	*Dromus dromas*	SX	SP	X	LE
Fanshell	*Cyprogenia stegaria*	S1	SP	H	LE
Hickorynut	*Obovaria olivaria*	SX	PSM	H	–
Kidneyshell	*Ptychobranchus fasciolaris*	S2	PSM	E	–
Lilliput	*Toxolasma parvum*	S3	PSM	H	–
Longsolid	*Fusconaia subrotunda*	S1	PSM	E	PT
Monkeyface	*Quadrula metanevra*	S3	PSM	E	–
Mucket	*Actinonaias ligamentina*	S2	PSM	E	–
Ohio Pigtoe	*Pleurobema cordatum*	S2	PSM	E	–

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Orange-foot Pimpleback	*Plethobasus cooperianus*	SX	SP	H?	LE
Pink Heelsplitter	*Potamilus alatus*	S5	PSM	E	–
Pink Mucket	*Lampsilis abrupta*	S1	SP	E	LE
Pink Papershell	*Potamilus ohiensis*	S3	PSM	E	–
Pocketbook	*Lampsilis ovata*	S2	PSM	E	–
Purple Lilliput	*Toxolasma lividus*	S2	PSM	E	–
Pyramid Pigtoe	*Pleurobema rubrum*	S1	SP	E	–
Ring Pink	*Obovaria retusa*	SH	SP	H	LE
Rough Pigtoe	*Pleurobema plenum*	S1	SP	E	LE
Sheepnose	*Plethobasus cyphyus*	S1	SP	E	LE
Slabside Pearlymussel	*Pleuronaia dolabelloides*	S1	SP	H	LE
Smooth Rabbitsfoot	*Quadrula cylindrica cylindrica*	S1	SP	H	LT
Snuffbox	*Epioblasma triquetra*	S1	PSM	E	LE
Spectaclecase	*Cumberlandia monodonta*	S1	SP	E	LE
Spike	*Elliptio dilatata*	S1	PSM	E	–
Tennessee Clubshell	*Pleurobema oviforme*	S1	PSM	H	–
Tuberculed Blossom Pearlymussel †	*Epioblasma torulosa torulosa*	SX	SP	X	LE
White Heelsplitter	*Lasmigona complanata*	S2	PSM	E	–

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SX = Extirpated

[3] State Status Codes: E = Endangered; SP = State Protected; PSM = Partial Status Mussels

[4] Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; BC = Good or fair estimated viability

[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

† Denotes extinct species

Table 3-38. Records of Aquatic Animal Species of Conservation Concern Within Wilson Reservoir (Tennessee River - Wilson Lake – 0603000508, 10-Digit HUC Watershed[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Mollusks					
Black Sandshell	*Ligumia recta*	S2	PSM	H	–
Butterfly	*Ellipsaria lineolata*	S4	PSM	H	–
Ohio Pigtoe	*Pleurobema cordatum*	S1	PSM	H	–
Monkeyface	*Quadrula metanaevra*	S3	PSM	H	–
Pocketbook	*Lampsilis ovata*	S2	PSM	H	–

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Secure

[3] State Status Codes: E = Endangered; SP = State Protected; PSM = Partial Status Mussels

[4] Element (=population) Rank: H = historical record >25 years old

[5] Federal Status: N/A

Table 3-39. Records of Aquatic Animal Species of Conservation Concern Within Pickwick Reservoir (Tennessee River - Pickwick Lake – 0603000512, Tennessee River - Pickwick Lake – 0603000508, and Tennessee River - Bluff Creek – 0603000510 10-Digit HUC Watershed[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Snail Darter	*Percina tanasi*	S1	SP	AB	LT
Spotfin Chub	*Erimonax monachus*	SX	SP	X	LT
Spring Pygmy Sunfish	*Elassoma alabamae*	S1	SP	X	LT
Tuscumbia Darter	*Etheostoma tuscumbia*	SX	D	X	PT
Mollusks					
Acornshell †	*Epioblasma haysiana*	SX	PSM	H	–
Alabama Lampmussel	*Lampsilis virescens*	S1	SP	H	LE
Angled Riffleshell †	*Epioblasma biemarginata*	SX	PSM	H	–
Anthony's River Snail	*Athearnia anthonyi*	S1	SP	E	LE
Birdwing Pearlymussel	*Lemiox rimosus*	S1	SP	E	LE
Black Sandshell	*Ligumia recta*	S2	PSM	E	–
Butterfly	*Ellipsaria lineolata*	S4	PSM	E	–
Clubshell	*Pleurobema clava*	SX	SP	X	LE
Cracking Pearlymussel	*Hemistena lata*	S1	SP, P1	H	LE
Cumberland Leafshell †	*Epioblasma stewardsonii*	SX	PSM	H	–
Cumberland Moccasinshell	*Medionidus conradicus*	S1	SP	H	–
Cumberlandian Combshell	*Epioblasma brevidens*	S1	SP	H	LE
Deertoe	*Truncilla truncata*	S1	PSM	E	–
Dromedary Pearlymussel	*Dromus dromas*	SX	SP	H	LE
Elktoe	*Alasmidonta marginata*	S1	PSM	H	–
Fanshell	*Cyprogenia stegaria*	S1	SP	E	LE
Fine-rayed Pigtoe	*Fusconaia cuneolus*	S1	SP	H	LE
Fluted Kidneyshell	*Ptychobranchus subtentum*	SX	SP	H	LE
Hickorynut	*Obovaria olivaria*	SX	PSM	H	–
Kidneyshell	*Ptychobranchus fasciolaris*	S2	PSM	E	–
Kidneyshell	*Ptychobranchus fasciolaris*	S2	PSM	E	–
Longsolid	*Fusconaia subrotunda*	S1	PSM	H	PT
Monkeyface	*Quadrula metanevra*	S3	PSM	E	–
Mountain Creekshell	*Villosa vanuxemensis*	S3	PSM	H?	–
Mucket	*Actinonaias ligamentina*	S2	PSM	H	–
Ohio Pigtoe	*Pleurobema cordatum*	S2	PSM	E	–
Orange-foot Pimpleback	*Plethobasus cooperianus*	SX	SP	H	LE
Oyster Mussel	*Epioblasma capsaeformis*	SX	SP	E	LE
Painted Creekshell	*Villosa taeniata*	S2	PSM	H	–
Pale Lilliput	*Toxolasma cylindrellus*	S1	SP	H	LE
Pheasantshell	*Actinonaias pectorosa*	SX	PSM	H	–

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Pink Mucket	*Lampsilis abrupta*	S1	SP	E	LE
Pink Papershell	*Potamilus ohiensis*	S3	PSM	E	–
Pocketbook	*Lampsilis ovata*	S2	PSM	E	–
Purple Catspaw	*Epioblasma obliquata obliquata*	SX	SP	H	LE
Purple Lilliput	*Toxolasma lividus*	S2	PSM	E	–
Pyramid Pigtoe	*Pleurobema rubrum*	S1	SP	E	–
Rayed Bean	*Villosa fabalis*	SX		H	LE
Ring Pink	*Obovaria retusa*	SH	SP	C	LE
Rock Pocketbook	*Arcidens confragosus*	S3	PSM	D	–
Rough Pigtoe	*Pleurobema plenum*	S1	SP	E	LE
Round Combshell	*Epioblasma personata*	SX	PSM	H	–
Round Hickorynut	*Obovaria subrotunda*	S2	PSM	H	PT
Round Pigtoe	*Pleurobema sintoxia*	S1	SP	E	–
Scaleshell	*Leptodea leptodon*	SX	SP	H	LE
Sheepnose	*Plethobasus cyphyus*	S1	SP	E	LE
Shiny Pigtoe Pearlymussel	*Fusconaia cor*	S1	SP	X	LE
Shiny Pigtoe Pearlymussel	*Fusconaia cor*	S1	SP	H	LE
Slabside Pearlymussel	*Pleuronaia dolabelloides*	S1	SP	H	LE
Slippershell Mussel	*Alasmidonta viridis*	S1	SP	H	–
Smooth Rabbitsfoot	*Quadrula cylindrica cylindrica*	S1	SP	C	LT
Snuffbox	*Epioblasma triquetra*	S1	PSM	H	LE
Spectaclecase	*Cumberlandia monodonta*	S1	SP	E	LE
Spike	*Elliptio dilatata*	S1	PSM	E	–
Squawfoot	*Strophitus undulatus*	S1	PSM	H	–
Sugarspoon †	*Epioblasma arcaeformis*	SX	PSM	H	–
Tennessee Clubshell	*Pleurobema oviforme*	S1	PSM	H	–
Tennessee Pigtoe	*Pleuronaia barnesiana*	S1	PSM	H	–
Tennessee Riffleshell †	*Epioblasma propinqua*	SX	PSM	H	–
Tuberculed Blossom Pearlymussel †	*Epioblasma torulosa torulosa*	SX	SP	H	LE
Turgid Blossom Pearlymussel †	*Epioblasma turgidula*	SX	SP	X	LE
Wavy-rayed Lampmussel	*Lampsilis fasciola*	S2	PSM	H	
White Wartyback	*Plethobasus cicatricosus*	S1	SP	E	LE
Yellow-blossom Pearlymussel †	*Epioblasma florentina florentina*	SX	SP	H	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020

[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Secure; SX = Extirpated

[3] State Status Codes: D = Deemed in Need of Conservation; E = Endangered; SP = State Protected; PSM = Partial Status Mussels

[4] Element (=population) Rank: E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; AB = Excellent or good estimated viability; C = Fair estimated viability; D = Poor estimated viability
[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered; PT = Petitioned Species
† Denotes extinct species

Table 3-40. Records of Aquatic Animal Species of Conservation Concern Within Kentucky Reservoir (Tennessee River - Pickwick Lake – 604000105, 604000509, and 604000510 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Alligator Gar	*Atractosteus spatula*	S1	D	H?	–
Blotched Chub	*Erimystax insignis*	S1	E	X?	–
Blue Sucker	*Cycleptus elongatus*	S2	T	H?	–
Chain Pickerel	*Esox niger*	S3	S	H?	–
Chestnut Lamprey	*Ichthyomyzon castaneus*	S2	S	D	–
Highfin Carpsucker	*Carpiodes velifer*	S2S3	D	E	–
Inland Silverside	*Menidia beryllina*	S2	T	D	–
Lake Sturgeon	*Acipenser fulvescens*	S1	E	H	–
Scaly Sand Darter	*Ammocrypta vivax*	SX	X	X?	–
Silver Lamprey	*Ichthyomyzon unicuspis*	S2	D	H?	–
Mollusks					
Clubshell	*Pleurobema clava*	SH	E	H	LE
Cracking Pearlymussel	*Hemistena lata*	S1	E	H?	LE
Fanshell	*Cyprogenia stegaria*	S1	E	E	LE
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	BC	LE
Pink Mucket	*Lampsilis abrupta*	S2	E	E	LE
Rabbitsfoot	*Quadrula cylindrica*			E	LT
Ring Pink	*Obovaria retusa*	S1	E	H	LE
Rough Pigtoe	*Pleurobema plenum*	S1	E	H?	LE
Sheepnose	*Plethobasus cyphyus*	S2S3	E	BC	LE
Slabside Pearlymussel	*Pleuronaia dolabelloides*	S2	E	H	LE
Spectaclecase	*Cumberlandia monodonta*	S2S3	E	E	LE
Tennessee Clubshell	*Pleurobema oviforme*	S1	E	–	–
White Wartyback	*Plethobasus cicatricosus*	S1	E	H?	LE

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020
[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SX = Extirpated
[3] State Status Codes: D = Deemed in need of conservation; E = Endangered; S = State Protected; X = Extirpated
[4] Element Rank (=population) Rank; E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; BC = Good estimated viability; D = Poor estimated viability
[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered

Table 3-41. Records of Aquatic Animal Species of Conservation Concern Within Kentucky Reservoir Tailwater (Tennessee River - Pickwick Lake – 604000105, 604000509, and 604000510 10-Digit HUC Watersheds[1])

Common Name	Scientific Name	State Rank[2]	State Status[3]	Element Rank[4]	Federal Status[5]
Fishes					
Lake Sturgeon	*Acipenser fulvescens*	S1	E	H	–
Alligator Gar	*Atractosteus spatula*	S1	D	H?	–
Mollusks					
Armored Rocksnail	*Lithasia armigera*	S3S4	S	B	–
Fanshell	*Cyprogenia stegaria*	S1	E	H	LE
Fat Pocketbook	*Potamilus capax*	S2	T	B	LE
Longsolid	*Fusconaia subrotunda*	S3	S	H?	PT
Muddy Rocksnail	*Lithasia salebrosa*	S2S4	S	H?	–
Orange-foot Pimpleback	*Plethobasus cooperianus*	S1	E	E	LE
Ornate Rocksnail	*Lithasia geniculata*	S1	S	H	–
Pink Mucket	*Lampsilis abrupta*	S1	E	H?	LE
Pocketbook	*Lampsilis ovata*	S1	E	E	–
Pyramid Pigtoe	*Pleurobema rubrum*	S1	E	H	–
Rabbitsfoot	*Quadrula cylindrica*	S2	E	E	LT
Ring Pink	*Obovaria retusa*	S1	E	H?	LE
Sheepnose	*Plethobasus cyphyus*	S1	E	E	LE
Shortspire Hornsnail	*Pleurocera curta*	S2	S	H	–
Smooth Rabbitsfoot	*Quadrula cylindrica cylindrica*	S2	T	C	LT
Texas Lilliput	*Toxolasma texasense*	S2	T	D	–
Varicose Rocksnail	*Lithasia verrucosa*	S3S4	S	B	–

[1] TVA Regional Natural Heritage Database and USFWS Information for Planning and Consultation (https://ecos.fws.gov/ipac/), extracted March 2020
[2] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Secure
[3] State Status Codes: S = Special Concern; E = Endangered; T = Threatened; E = Endangered
[4] Element Rank (=population) Rank; E = extant record ≤25 years old; H = historical record >25 years old; ? = uncertain status; B = Good estimated viability; C = Fair estimated viability; D = Poor estimated viability
[5] Federal Status: LT = Listed Threatened; LE = Listed Endangered; PT = Petitioned Species

The availability of specific habitat needed for many aquatic organisms to persist has been absent ever since dams became commonplace in the mainstem Tennessee River, which explains the disappearance of some aquatic species, especially freshwater mollusks. Aquatic species that may be present in a given reservoir but absent from the proposed project areas (i.e., in the vicinity of the locks/dams) are not described in detail, as impacts to those species would be indirect or discountable. Species that may occur within the proposed project areas are described in more detail below.

The state-listed lake sturgeon prefers large freshwater lakes and rivers with sand and gravel substrate and they spawn over hard substrates. TVA and its partners have released more than 200,000 lake sturgeon into the French Broad, Holston, and Tennessee rivers downstream of Douglas and Cherokee reservoirs since 2000 as part of their reintroduction program (TVA 2021). Lake sturgeon are supra-benthic cruisers who are constantly on the move in search of food. Lake sturgeon are slow-moving fish but will migrate up rivers during spawning season (USFWS 2020).

The state-listed blue sucker is adapted for life in swift currents where it feeds on insects in cobble areas. Though its preferred habitat is absent from the lock approaches at most of the proposed dams in the study area, TVA biologists have captured blue suckers from the inflow directly below dams at Wheeler Reservoir, Pickwick Reservoir, and Kentucky Reservoir.

The highfin carpsucker is listed as “in need of management” in Tennessee. This fish species is found in medium-depth water (4 to 10 feet) of small to large rivers, usually in areas with rocky gravel substrates. Suitable habitat for this species may exist in the approach channel at each dam in the study area. This species may migrate between spawning and nonspawning habitats (NatureServe 2021).

The alligator gar is listed as “in need of management” in Tennessee and “critically imperiled” in Kentucky. This species inhabits large, slow moving rivers and reservoirs where it is an ambush predator of other fish. Suitable habitat for this species may be present in the channel at each dam in the study area, but it is capable of relocating while any proposed work occurs.

The Kentucky Department of Fish and Wildlife Resources has also detected alligator gar (critically imperiled), chestnut lamprey (imperiled), and inland silverside (imperiled) in the Kentucky Dam tailwaters.

The federally threatened snail darter has recently been detected in many tailwaters within the main stem Tennessee River, all the way from Loudoun Reservoir downstream to Pickwick Reservoir. TVA biologists have been monitoring the presence of this species in the tailwaters of the main stem Tennessee River since 2016. Snail darters have been captured by TVA biologists while using a Missouri Trawl technique that is effective in deep, swift rivers. It was designed to skim the bottom of streams and rivers where no other gear can be effectively deployed.

It is thought that the recolonization by snail darters of the main stem Tennessee River occurred via downstream larval drift from one reservoir to another, rather than adults passing through navigation locks. Most individuals captured during survey efforts in main stem tailwaters have occupied large gravel patches, usually 20 feet deep. Though this type of habitat has been documented in the lock approaches at certain dam sites, most individuals have been collected from habitats located considerable distances from entrances to lock chambers.

Freshwater mussel surveys have been conducted by TWRA at all proposed lock/dam sites in the state of Tennessee, whereas the USACE has recent survey data from Kentucky Dam. Most sites contained low density and low diversity of freshwater mussels due to the highly disturbed state of locks and lock approaches. Lock entrances at Kentucky and Pickwick yielded healthy mussel populations. Additionally, Pickwick Dam was the only dam site that yielded a listed species, a single live individual of a pink mucket. This individual (in addition to all of the freshwater mussels encountered during the entirety of the effort across all sites) was relocated to suitable habitat downstream of the proposed project area.

Though Alabama locks/dams were not quantitatively surveyed as part of the scope of this PEA, the locks and lock approaches of Alabama dams (Wilson, Wheeler, Guntersville) were qualitatively described by the Alabama state malacologist as containing habitat that is not suitable for freshwater mussel habitation, except for perhaps a few silt-tolerant species

(ADCNR, personal communication 2020). More intact freshwater mussel assemblages occur further downstream in the tailwaters of the aforementioned dams.

The only state or federally listed mollusk known to inhabit the marginal habitat present within the proposed project areas is the pink mucket. Though it typically inhabits shallow riffles and shoals of major rivers and tributaries and is found in rubble, gravel or sand substrates that have been swept free of silt by the current, it is also known to persist in impounded habitats. This mussel buries itself in sand or gravel, with only the edge of its shell and its apertures exposed, where it feeds on suspended plankton, bacteria, and other organic matter.

Other species listed in Tables 3-31 to 3-41 only inhabit specialized habitats, such as caves or springs, that are not present in the vicinity of any of the proposed project areas.

3.15.2 Environmental Consequences

3.15.2.1 Alternative A – No Action

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the 10 TVA locks in the study area to deter the movement of Asian carp through the Tennessee River system. Asian carp would be expected to continue pushing upstream in the Tennessee River. Current communities of terrestrial animals of conservation concern and their habitats would not be affected under the No Action Alternative. Threatened and endangered reptiles and amphibians discussed above do not share most of the same food sources as carp, nor would the carp eat these animals as juveniles or hatchlings. Larger birds that forage on carp such as bald eagles or osprey would perhaps have an additional food source.

Adoption of the No Action Alternative would not impact federally listed plants, designated critical habitat, or state-listed plants species because no project-related work would occur. In addition, no listed plants or designated critical habitat occurs within the proposed project areas.

The No Action Alternative could impact unionid mussels native to the main stem Tennessee River if fish barrier technologies are not installed. Though black carp are flexible in their benthic feeding modes, they have been described as molluscivores and have been documented consuming native mollusks (both unionid mussels and native snails) in the Mississippi River drainage (Poulton et al. 2019). Though the cited study documented the consumption of common native mollusks that typically inhabit lentic, impounded habitats, the potential for black carp to consume rare and/or federally listed species that reside in the Tennessee River would be a concern if an Asian carp invasion were to eventually occur. Apart from direct consumption of native mollusks by black carp, silver and bighead carp are filter feeders and could indirectly compete with native unionid mussels for the same prey item.

Overall, adverse impacts to threatened or endangered mussels are anticipated to be moderate and long term under the No Action Alternative. No other impacts to threatened or endangered plants and animals are anticipated.

3.15.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

3.15.2.2.1 Terrestrial Species of Conservation Concern

Under Alternative G, TVA would install a combined system of fish barriers (i.e., BAFF and CO_2) at multiple TVA locks within the Tennessee River system (as described in Table 2-4). Site specific designs have not been finalized at this time, however the footprints for the compressor buildings could occur in areas with a small amount of natural vegetation, including forest. At present, conceptual designs suggest the footprints for these buildings are relatively small and all but one currently occurs on pavement, gravel, or mowed lawn. Once designs have been completed, impacts to threatened and endangered animals would be assessed at a site-specific level.

Hellbenders, alligator snapping turtles, and midland smooth softshell turtles all have the potential to occur in reservoirs near dams where BAFF and CO_2 systems are proposed. No known studies exist that examine impacts of these deterrents on these species. Neither system is expected to cause direct mortality to these species based on the types of technologies used (sound, light, bubble, and CO_2 injections) and the species tendency to occur in streams and smaller tributaries. These technologies could deter individuals from going near the dams and through the locks. However, due to the lower likelihood of the presence of hellbenders in the mainstem and the rarity of alligator snapping turtles and midland smooth softshell turtles documented in the Tennessee River, it is unlikely that proposed deterrents would impact populations of these species already disjointed by impoundments along the Tennessee River.

Osprey nests are known around every dam in the study area, except Melton Hill although they are frequently observed foraging in the vicinity, though none are known within 660 feet of construction footprint areas suggested in conceptual designs. Should new nests be created or project designs be shifted such that disturbance could occur within 660 feet of these resources, seasonal avoidance measures would be attempted. If seasonal avoidance measures are not feasible and impacts must occur during the breeding/active season of the appropriate species, coordination with USDA – Wildlife Services would occur to ensure actions are in compliance with EO 13186 - Responsibilities of Federal Agencies to Protect Migratory Birds. Therefore, proposed actions under Alternative G are not expected to impact populations of osprey.

Bald eagle nests have been recorded within 1 mile of Watts Bar Dam and Guntersville Dam. As mentioned above, nests near Watts Bar Dam have been active in recent years, while nests near Guntersville Dam have not. Once site-specific designs have been proposed, site-specific review, including bald eagle surveys, would occur to determine nest activity. Avoidance and minimization measures, such as seasonal restrictions, would be implemented to ensure compliance with the National Bald Eagle Management Guidelines. With adherence to these guidelines, impacts to bald eagle are not anticipated.

A number of activities associated with the proposed project, including tree removal, were addressed in TVA's programmatic consultation with the USFWS on routine actions and federally listed bats in accordance with ESA Section 7(a)(2) and completed in April 2018. Any proposed tree removal identified once site-specific designs are completed would be reviewed to determine if impacts to suitable Indiana bat and northern long-eared bat habitat may occur. For those activities with potential to affect gray bats, Indiana bats, and northern long-eared bats, TVA committed to implementing specific conservation measures. These activities and associated conservation measures would be identified on site-specific TVA Bat Strategy Project Screening Forms and would be implemented as part of the site-specific proposed actions. With the application of conservation measures, proposed actions would not likely impact gray bat, Indiana bat, or northern long-eared bat.

Alternative G would have no impact on federally listed plants, designated critical habitat, or state-listed plants species because no suitable habitat for protected plant species occurs within the proposed project areas. All habitats within the construction footprints at the 10 dam sites in the study area have been heavily disturbed and are incapable of supporting protected plant species.

3.15.2.2.2 Aquatic Species of Conservation Concern

While suitable habitat for lake sturgeon, highfin carpsuckers, and snail darters may exist in the approach channel at each dam in the study area, these species would be capable of swimming away from the construction footprint while work is ongoing. Therefore, no direct impacts to these species are anticipated. However, TVA and its partners have been actively stocking lake sturgeon for more than 20 years and some of these individuals are approaching sexual maturity. Installation of Asian carp deterrent systems could potentially impact spawning migration of some species, including lake sturgeon and highfin carpsuckers, by deterring fish passage through the locks in the study area. Overall, the impact of blocked passage for native species through locks would be minor relative to the long-term operation of the existing dams and could be mitigated through adjustment of the sound frequency of the BAFF system and variable use during native species migrations (see Section 3.1, Aquatic Ecology).

The only federally listed mussel species encountered during freshwater mussel surveys at proposed lock/dam sites was a single live individual of a pink mucket at the lock approach at Pickwick Dam. This individual (in addition to all of the freshwater mussels encountered during surveys at all sites) was relocated to suitable habitat downstream of the proposed project footprint. Although more intact freshwater mussel assemblages occur further downstream in the tailwaters of the project areas, these assemblages would not be directly affected by Alternative G.

Other species listed in Tables 3-31 to 3-41 either do not have suitable habitat within the dam approaches at the proposed sites in the study area or they would be capable of swimming away while work is ongoing.

TVA has fulfilled its Section 7 ESA obligations by receiving concurrence from the USFWS on May Affect, Not Likely to Adversely Affect determinations for federally listed species due to proposed actions at dams in Kentucky (Kentucky Dam), Tennessee (Pickwick Dam), and Alabama (Wilson Dam and Guntersville Dam; Appendix E).

Overall, under Alternative G, minor adverse impacts to migrating protected fish species due to operation of the fish barrier systems are anticipated. These impacts could be potentially mitigated through variable use of the fish barriers or adjustment to allow passage of native species. Additionally, moderate and long-term benefits to threatened and endangered mussels are anticipated due to the reduced impacts of invasive Asian carp throughout the Tennessee River system.

3.16 Wetlands

3.16.1 Affected Environment

Wetlands are areas inundated or saturated by surface or groundwater such that vegetation adapted to saturated soil conditions are prevalent. Wetland areas associated with the affected reservoirs consist of transitional systems between terrestrial and aquatic communities. Examples include aquatic bed habitat of shallow embayments, bottomland forested floodplains, swamps, emergent meadows, and shoreline fringe along the edges of riverine or reservoir systems. Wetland determinations require documentation of hydrophytic (wet site) vegetation, hydric soil, and wetland hydrology (Environmental Laboratory 1987; Lichvar et al. 2016; USACE 2010; USACE 2012).

Due to their landscape position, vegetation structure, and influence on downstream hydrology, wetlands provide a suite of benefits valued by society. These include toxin absorption and sediment retention for improved downstream water quality, storm water impediment and attenuation for flood control, shoreline buffering for erosion protection, and provision of fish and wildlife habitat for commercial, recreational, and conservation purposes. Because of these functional values, activities in affecting wetlands are regulated by state and federal agencies to ensure no net loss of wetland resources. Under CWA §404, activities resulting in the discharge of dredge, fill, and potential secondary impacts resulting in degradation to waters of the U. S., including wetlands, must be authorized by the USACE through a Nationwide, Regional, or Individual Permit. CWA §401 of the CWA requires state water quality certification for projects requiring USACE approval. Lastly, Executive Order 11990 requires federal agencies avoid construction in wetlands and minimize wetland degradation to the extent practicable.

The National Wetlands Inventory (NWI) (USFWS 1982) maps nearly 129,000 acres of vegetated wetland habitats within the reservoir and tailwater systems associated with the dams proposed for fish barrier installation (Table 3-42) along the Tennessee River. Kentucky Reservoir and its tailwaters contains the largest acreage of mapped wetland area, followed by Guntersville and Pickwick, respectively. The Fort Loudoun and Melton Hill systems contain the smallest amount of mapped wetland habitat.

Table 3-42. Mainstem and Tailwater NWI Wetland Acreages for Reservoir and Tailwaters

Reservoir Systems	Aquatic Bed Acres	Emergent Acres	Forested Acres	Scrub/Shrub Acres	Total Acres
Chickamauga	5,765	124	644	551	7,084
Fort Loudoun	328	91	214	31	664
Guntersville	7,369	2,158	9,064	2,609	21,200
Kentucky	3,603	3,780	45,983	3,858	57,224
Melton Hill	160	83	149	40	432
Nickajack	1,779	641	48	1,014	3,482
Pickwick	565	2,295	14,889	2,315	20,064
Watts Bar	1,989	162	728	223	3,102
Wheeler	2,523	1,811	4,593	1,700	10,627
Wilson	556	755	2,785	754	4,850
Total Acres	**24,637**	**11,900**	**79,097**	**13,095**	**128,729**

Source: TVA Reservoir Operation Study (2004)

Representative wetland types are comprised of aquatic beds, emergent, forested, and scrub-shrub wetland habitat. Forested wetland is the most prevalent total wetland habitat type across the ten reservoir and tailwater systems combined. However, aquatic beds are the most abundant wetland habitat mapped within the Chickamauga, Nickajack, and Watts Bar systems. Scrub-shrub and emergent wetlands represent smaller components of the wetland habitat types.

Aquatic beds are found in relatively permanent shallow waters, dominated by vegetation living on or below the water surface, and comprised of rooted plants or floating mats. Vegetation may consist of water lilies, water lotus, milfoils, pondweeds, duckweeds, mosquito ferns, or hydrilla (Cowardin 1979).

Scrub-shrub wetlands contain woody plants less than 20 feet tall. These wetland communities may comprise woody vegetation with a limited growth potential, such as buttonbush or tag alder. Wetlands containing these or similar shrub species represent a relatively stable community and can be typical of shallow embayments or frequently inundated riparian areas (Cowardin 1979).

Forested wetlands comprise floodplain bottomland areas and swamps. The hydrologic regime of bottomland hardwood habitat typically experiences ephemeral inundation and/or flooding during major rain events. These forests are often characterized by an overstory of red maple, sycamore, oaks (e.g., willow, water, overcup), cottonwood, sugarberry and/or sweetgum. Inundated swamps are typically dominated by black willow, cypress, and/or water tupelo (Cowardin 1979).

An office-level review of the site-specific installation footprint for the Asian carp barriers at each dam was completed to determine potential wetland presence at those locations. Most of the necessary fish barrier components would be installed within open water; however, a compressor to operate a BAFF is required to be installed on land. The majority of the proposed compressor installation sites are on open lawn or gravel/cement pads at the dams. Previously graded lawns would be sloped for water runoff and not conducive to wetland presence. Likewise, existing cement or gravel pads would preclude wetland presence at those locations. The compressor at Wheeler Dam, which is proposed to be installed in a forested area, is the only location where previous disturbance is not apparent on aerial imagery. However, wetland presence is unlikely due to steep topography mapped at that location.

3.16.2 Environmental Consequences

3.16.2.1 Alternative A – No Action

Under the No Action Alternative, the proposed project would not proceed, and no associated potential for wetland impacts would occur. Existing trends in wetland area, wetland community type, and wetland condition within the affected environment would not change as a result of the No Action Alternative.

3.16.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Adoption of Alternative G would result in construction, installation, and operation of Asian carp barrier systems at select TVA locks. Proposed locations for technology deployment support systems at the locks consist predominantly of open water and previously developed areas within the existing infrastructure at dam sites (Table 2-5). Wetland habitat is generally lacking at these sites. Location for land-side support systems would avoid jurisdictional Waters of the U.S. and State, which include wetlands (Table 2-6). Therefore, no direct impact to wetlands from this alternative would occur. Similarly, no changes to existing trends in wetland area, wetland community type, and wetland condition within the affected environment are anticipated as a result of installing the proposed fish barriers.

3.17 Solid and Hazardous Waste

3.17.1 Affected Environment

3.17.1.1 Solid Waste

Solid waste consists of a broad range of materials that include refuse, sanitary wastes, contaminated environmental media, scrap metals, nonhazardous wastewater treatment plant sludge, nonhazardous air pollution control wastes, various nonhazardous industrial waste, and other materials (solid, liquid, or contained gaseous substances). Solid waste is regulated by the

EPA and RCRA Subtitle D. Each state is required to ensure the federal regulations for solid waste are met and may implement more stringent requirements.

In some states, special wastes may include sludges, bulky wastes, pesticide wastes, industrial wastes, combustion wastes, friable asbestos and certain hazardous wastes exempted from RCRA Subtitle C requirements. Any of these wastes, if generated, would be disposed as required by state and federal regulations.

3.17.1.2 Hazardous Waste

Hazardous materials are regulated under a variety of federal laws including Occupational Safety and Health Administration (OSHA) standards, Emergency Planning and Community Right to Know Act (EPCRA), the RCRA, the Comprehensive Environmental Response, Compensation and Liability Act of 1980 and the Toxic Substances Control Act.

Regulations implementing the requirements of EPCRA are codified in 40 CFR 355, 40 CFR 370 and 40 CFR 372. Under 40 CFR 355, facilities that have any extremely hazardous substances present in quantities above the threshold planning quantity are required to provide reporting information to the State Emergency Response Commission, Local Emergency Planning Committees, and local fire departments. Inventory reporting to emergency response parties is required for facilities with greater than the threshold planning quantity of any extremely hazardous substances or greater than 10,000 pounds of any OSHA regulated hazardous material. EPCRA also requires inventory reporting for all releases and discharges of certain toxic chemicals.

RCRA regulations define what constitutes a hazardous waste and establishes a “cradle to grave” system for management, tracking and disposal of hazardous wastes. Subtitle C of RCRA includes separate, less stringent regulations for certain potential hazardous wastes. Used oil, for example, is regulated as hazardous waste if it is disposed of, but it is separately regulated if it is recycled. Specific requirements are provided under RCRA for generators, transporters, processors and burners of used oil that are recycled. Universal wastes are a subset of hazardous wastes that are widely generated. Universal wastes include batteries, pesticides, mercury-containing equipment, lamps, and aerosol cans. Universal wastes may be managed in accordance with the RCRA requirements for hazardous wastes or by special, less stringent provision.

3.17.2 Environmental Consequences

3.17.2.1 Alternative A – No Action

Under this alternative, TVA would not install fish barriers at any of the locks considered. Therefore, no solid waste or hazardous material would be generated.

3.17.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Under Alternative G, installation of the fish barrier systems would generate solid wastes during site preparation, construction of the support building, and dewatering of any dredged sediments. Installation of anchoring systems to support the deterrent systems may require excavation of the bedrock. Sediments would also be dredged from the lock chamber as needed to facilitate barrier installation. A single support building would house compressors, generators, and otherwise supply the fish barrier systems at each dam site.

Paper, wood, glass, plastic, scrap metal, rock, and electrical wiring could be generated during project construction. Construction waste and debris would be placed in roll-offs and disposed of at a permitted offsite landfill. Other solid wastes generated by the construction crew would be disposed of in portable units during construction. Operations would use existing infrastructure and treatment systems present at the dam site. TVA would manage all solid wastes generated in accordance with applicable state regulations and following procedures outlined in TVA's current Environmental Procedures and applicable BMPs (TVA 2017a). Solid wastes from construction and maintenance would be minimal, short-term, and temporary; therefore, with implementation of standard TVA procedures including recycling, direct or indirect effects associated with solid wastes would be minimal.

Motorized heavy equipment used during site preparation, construction, and maintenance include dredging equipment, barges, track and backhoes, cranes, and work boats as well as trucks for hauling people and materials. This equipment requires fuels and lubricants which are potentially hazardous wastes. Equipment refueling and maintenance operations would be carried out at designated locations using applicable BMPs. Oily wastes generated during servicing of heavy equipment would be managed by TVA approved off-site vendors who service on-site equipment using appropriate self-contained used oil reservoirs. It is expected that all vehicles and construction equipment would be properly maintained, which would reduce risk of hazardous wastes produced on site. However, appropriate spill prevention, containment, and disposal requirements for hazardous wastes would be implemented to protect construction workers, the public, and the environment in accordance with applicable state and federal regulations. Therefore, no significant impacts associated with the use of fuels, oils, lubricants, or other hazardous materials would be expected.

Dredged sediments from the lock chamber could potentially contain hazardous wastes. Dredged materials would be sampled prior to removal to identify potential constituents of concern. For example, PCBs, dioxins, and chlordane are toxic substances present in reservoir sediments in the Tennessee River watershed and potential present in lock sediments (see Section 3.10, Surface Water). Toxicity Characteristic Leaching Procedure (TCLP) testing would determine the mobility of both organic and inorganic analytes present in dredged sediments. Dredging removes a slurry of sediments and water which would be dewatered onsite. Dredged sediment samples must indicate TCLP concentrations below the EPA allowable limits for disposal as non-hazardous waste to be disposed of on site. Dredged sediments classified as hazardous wastes would be disposed of in approved hazardous waste landfills as appropriate, in accordance with all applicable laws and regulations. Any regulated hazardous waste associated with dredged material would be managed in accordance with RCRA requirements.

Operation of the deterrent systems would not generate solid or hazardous wastes. Diffusion of CO_2 into water leaves no residues and does not persist in the environment (Fredericks et al. 2019). However, the operation of the CO_2 barrier would require repeat delivery of CO_2. The number of trucks needed to refill the supply of CO_2 would depend on the frequency of use. Locks with higher navigation traffic (e.g., Kentucky Lock) would require more CO_2 than those with lower frequency of lock operations (e.g., Guntersville Locks). Although the number of trucks needed to transport CO_2 is variable and determined based on frequency of CO_2 use and capacity of onsite storage, it is anticipated that all trucks used to transport CO_2 would be maintained in good working condition to minimize any hazardous wastes.

Overall, solid and hazardous wastes generated during fish barrier installation would be minimal and managed in accordance with established procedures and applicable regulations. Any wastes generated during maintenance would be similarly managed under existing programs. Therefore, impacts from solid and hazardous wastes would be temporary and minor.

3.18 Visual Resources

3.18.1 Affected Environment

This assessment provides a review and classification of the visual attributes of existing scenery, along with the anticipated attributes resulting from the proposed action. The classification criteria used in this analysis are adapted from a scenic management system developed by the USFS and integrated with planning methods used by TVA (USFS 1995). Potential visual impacts to cultural and historic resources are not included in this analysis as they are assessed separately in Section 3.19.

The visual landscape of an area is formed by physical, biological, and man-made features that combine to influence both landscape identifiability and uniqueness. The scenic value of a particular landscape is evaluated based on several factors that include scenic attractiveness, scenic integrity, and visibility. Scenic attractiveness is a measure of scenic quality based on human perceptions of intrinsic beauty as expressed in the forms, colors, textures, and visual composition of each landscape. Scenic attractiveness is expressed as one of the following three categories: distinctive, common, or minimal. Scenic integrity is a measure of scenic importance based on the degree of visual unity and wholeness of the natural landscape character. The scenic integrity of a site is classified as high, moderate, low, or very low. The subjective perceptions of a landscape's aesthetic quality and sense of place are dependent on where and how it is viewed.

Views of the landscape are described in terms of what is seen in the foreground, middleground, and background distances. In the foreground, an area within 0.5 mile of the observer, details of objects are easily distinguished. In the middleground, from 0.5 mile to 4 miles from the observer, objects may be distinguishable, but their details are weak and tend to merge into larger patterns. In the distant part of the landscape, the background, details and colors of objects are not normally discernible unless they are especially large, standing alone, or have a substantial color contrast. In this assessment, the background is measured as 4 to 10 miles from the observer. Visual and aesthetic impacts associated with an action may occur as a result of the introduction of a feature that is not consistent with the existing viewshed. Consequently, the visual character of an existing site is an important factor in evaluating potential visual impacts.

The Tennessee River system reservoirs on which TVA's L&D sites are located include a variety of landscapes and natural features, including rivers, floodplains, islands, wetlands, and forests. Among the scenic resources of each of the reservoirs, the water body itself is the most distinct and outstanding aesthetic feature. The horizontal surface provides visual balance and contrast to the islands and wooded hillsides. The reservoirs weave around ridges and bends, changing views periodically seen from the water. The reservoirs also link the other landscape features together. To most observers, views across the water are generally satisfying and peaceful. Other important scenic features include the secluded coves and steep, wooded ridges that occur around the reservoirs. The isolated coves with wooded shoreline provide relatively private locations for dispersed recreation activities. Significant elevation changes along some stretches of shoreline provide a dramatic contrast to the surrounding reservoir and gently sloping countryside, particularly when they are viewed from background distances.

Various combinations of development and land use patterns present in the viewed landscapes along the shorelines of the Tennessee River system reservoirs contribute to the overall visual character of the project area. These can range from the more urban and industrial developments often associated with the mainstem reservoirs to residential developments that are common to both mainstem and tributary reservoirs. Urban and industrial developments generally create a lower level of scenic integrity. The presence of residential areas and water-related facilities that include docks, boathouses, stairways, and shoreline protection structures also reduces scenic integrity of the landscape.

TVA's L&D structures contrast visually with the lands that border them. The dams and associated features appear predominately industrial. Nearby residents and motorists along local roads typically have views up to middleground distances of the dams. Most buildings are broadly horizontal and can be seen in the foreground. Transmission structures, including towers and lines, generally can be seen up to middleground distances, depending on topography and viewer position. Thus, the L&D areas combine natural elements, such as the water body and wooded hillsides, with notable human development, creating a varied and somewhat disjointed visual landscape. Scenic integrity at the foreground and middleground distances are reduced by the industrial elements associated with the L&D sites.

3.18.2 Environmental Consequences

The potential impacts to the visual environment from a given action are assessed by evaluating the potential for changes in the scenic value class ratings based upon landscape scenic attractiveness, integrity, and visibility. Sensitivity of viewing points available to the general public, their viewing distances, and visibility of the proposed action are also considered during the analysis. These measures help identify changes in visual character based on commonly held perceptions of landscape beauty and the aesthetic sense of place. The extent and magnitude of visual changes that could result from the proposed alternatives were evaluated based on the process and criteria outlined in the scenic management system as part of the environmental review for this PEA.

3.18.2.1 Alternative A – No Action Alternative

Under this alternative, TVA would not install fish barrier technologies at any of the locks considered, and landscape character would remain in its current state. Therefore, there would be no impact to visual resources.

3.18.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Implementation of Alternative G would result in short-term and long-term impacts to visual resources. During the approximately 24-month construction period, there would be some visual discord from existing conditions due to an increase in personnel and construction equipment coupled with disturbances within the footprint of the land-based support facilities and temporary laydown areas. These areas may experience visual alterations associated with the removal of vegetation and potential increased emissions of dust during construction. However, land-based construction would take place on developed or previously disturbed land, would be contained within the immediate vicinity of the construction activities, and would only last until all construction activities have been completed. Because of their short-term nature, construction-related impacts to local visual resources would be minor.

Long-term impacts consist of the visible alterations associated with the installation of land-based facilities needed to support the selected fish barrier technologies. A single-story support structure, up to 30 feet long, would be of like materials and colors of existing L&D structures and associated infrastructure. Due to the small footprint and low profile, support structures would generally only be visible from the foreground and would be visually subordinate to the other industrial elements associated with the L&D sites. Other components of the fish barrier technologies would be located under the surface of the water and would not be visible from surrounding areas.

The industrial elements and utility structures already in place within the project areas currently contribute visual discord with the landscape, contributing to the landscape's ability to absorb negative visual change. Therefore, the forms, colors, and textures of the landscape that make up the scenic attractiveness of the existing L&D sites would be minimally affected by the construction of the land-based support facilities. Scenic integrity in the vicinity has already been lowered by the industrial dam facilities that dominate the landscape in the foreground. Based on the criteria used for this analysis, while the installation of fish barrier technologies would contribute to minor differences in the visual environment, it would not change the overall scenic value class as the industrial character of the L&D sites would remain consistent. Therefore, overall visual impacts resulting from the implementation of this alternative would be minor.

3.19 Cultural and Historic Resources

3.19.1 Affected Environment

Cultural resources include prehistoric and historic archaeological sites, districts, buildings, structures, and objects as well as locations of important historic events. Federal agencies, including TVA, are required by the NHPA (54 USC 300101 et seq) and by NEPA to consider the possible effects of any of their projects, activities, and programs (including licenses, permits, or other assistance) on historic properties. An agency may fulfill its statutory obligations under NEPA by following the process outlined in the regulations implementing Section 106 of NHPA at 36 CFR Part 800. Additional cultural resource laws that protect historic resources include the Archaeological and Historic Preservation Act (54 USC 300101 et seq.), Archaeological Resources Protection Act (16 USC 470aa-470mm), and the Native American Graves Protection and Repatriation Act (25 USC 3001-3013).

Section 106 of the NHPA requires that federal agencies consider the potential effects of their actions on historic properties and to allow the Advisory Council on Historic Preservation an opportunity to comment on the action. Section 106 involves four steps: (1) initiate the process, (2) identify historic properties, (3) assess adverse effects, and (4) resolve adverse effects. This process is carried out in consultation with the State Historic Preservation Officer (SHPO) and other interested consulting parties, including federally recognized Indian tribes with an interest in the project area.

Cultural resources are considered historic properties if they are listed or eligible for listing in the National Register of Historic Places (NRHP), which is maintained by the NPS. The NRHP eligibility of a resource is based on the Secretary of the Interior's criteria for evaluation (36 CFR 60.4), which state that significant cultural resources possess integrity of location, design, setting, materials, workmanship, feeling, association, and:

a. Are associated with events that have made a significant contribution to the broad patterns of our history; or

b. Are associated with the lives of persons significant in our past; or

c. Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic value; or

d. Have yielded, or may yield, information (data) important in prehistory or history.

An early step in the Section 106 process is to determine the project's area of potential effects (APE). The APE is the geographic area or areas within which an undertaking may (directly or indirectly) cause changes in the character or use of historic properties if such properties exist.

Agencies must identify historic properties in the APE, and if any are present, must then assess whether the undertaking would result in any adverse effects on a historic property, in consultation with the SHPOs and tribes. Examples of adverse effects would be ground disturbing activity in an archaeological site or erecting structures within the viewshed of a historic building in such a way as to diminish the structure's integrity of feeling or setting. Agencies must seek ways to resolve any adverse effects through avoidance, minimization, or mitigation.

3.19.1.1 Area of Potential Effect (APE)

The APE for cultural resources for this analysis includes the areas where new system components would be installed (i.e., where footprint-based impacts to resources could occur), as well as all areas within a 0.5-mile radius of those locations from which above-ground components would be visible (i.e., where visual effects could occur). Among the activities associated with the installation of these systems, TVA has identified three that have potential for physical effects on archaeological sites or for physical or visual effects on above-ground historic architectural or engineering resources:

- Installation of any compressor buildings that would require ground disturbance in areas where native soils or sediments are intact.
- Installation of any buried compressed air lines or cables below ground in areas where native soils or sediments are intact

At each lock site TVA has identified either some alternative locations or a general area where the compressor buildings would be positioned. The compressors need to be close to the lock or locks where the underwater system components would be installed. At each site, the buried compressor lines would run from the compressors to one or both locks. If connection to a power source is required, electrical lines would be installed underground, running from the compressors to the nearest power source at the lock. While the specific locations may change slightly, the final position of the buildings and lines would be located near one or both locks.

The current project design does not require the use of borrow material (e.g., construction fill).

Other activities may be required for the installation of the various systems, such removing debris and/or bedrock from the river channel, or installation of components in the water or in sediments within the river channel. Each of the locks is a chamber that was built by removing many tons of river sediment and bedrock, then pouring several feet of concrete to construct a floor. TVA proposes that these activities have no potential for any ground disturbance in areas where archaeological sites could be present, nor any potential for visual effects on above-ground historic properties.

3.19.1.2 Archaeological Sites

3.19.1.2.1 Watts Bar Compressor Building

TVA is considering three options for the location of the Watts Bar lock compressor buildings. All three would be just south of Highway 68 on the left-descending bank of the Tennessee River, near the lock. Option 1 is in a grassy area between the existing oxygen compressor and the lock. The other two options are on the paved parking area adjacent to the lock (Option 2), and in a riprap-covered area adjacent to the parking lot (Option 3). The latter two options are on an artificial landform that was built during lock construction. Locating the compressor buildings in Options 2 or 3 would not result in ground disturbance.

TVA finds there is no potential for archaeological sites at options 2 and 3 and associated buried compressor and utility lines, given that these are located on an artificial landform (TVA 1949b). Option 1 is also an area that was heavily modified during dam construction. Site 40MG1 was recorded east and south of the Option 1 location in 1936 by the University of Tennessee. Based on TVA's prior consultation with the Tennessee SHPO and federally-recognized Indian tribes regarding a survey marker and control point project (letter dated February 27, 2019), no NRHP-eligible or potentially-eligible site deposits remain in the northern portion of the site area (near the dam and highway). Option 1 and its associated compressor and utilities lines are outside the mapped area of 40MG1, in an area that was subjected to major earth-moving activities during construction of the L&D. TVA finds that no NRHP-eligible or potentially-eligible sites are present in the project footprint at Watts Bar Lock. TVA consulted with the Tennessee SHPO and federally recognized Indian tribes regarding this finding. The SHPO agreed by letter dated April 21, 2021. None of the consulted tribes objected or identified resources of concern at the Watts Bar Lock site.

3.19.1.2.2 Wilson Compressor Building

At Wilson Dam the compressor building(s) would be located in the grass-covered space between the two locks. This space is an artificial landform that was built with construction fill, within what was originally the Tennessee River channel. There is no potential for archaeological sites at the locations of the compressor buildings and associated buried compressor and utility lines, given that these are located on an artificial landform. The Alabama SHPO agreed with TVA's finding by letter dated May 6, 2021. None of the consulted tribes objected or identified resources of concern at the Wilson Lock site.

3.19.1.2.3 Guntersville Compressor Building

At Guntersville Dam, as at Wilson, the compressor building(s) would be located in the grass-covered space between the two locks. This space is an artificial landform that was built with construction fill, within what was originally the Tennessee River channel. There is no potential for archaeological sites at the locations of the compressor buildings and associated buried compressor and utility lines, given that these are located on an artificial landform. The Alabama SHPO agreed with TVA's finding by letter dated May 6, 2021. None of the consulted tribes objected or identified resources of concern at the Guntersville Lock site.

3.19.1.2.4 Kentucky Compressor Building

The proposed location of the compressor building(s) and associated buried compressor and electrical lines is on the former right-descending bank of the Tennessee River, just downstream of a large island, at the mouth of a creek. This location was heavily modified during construction of the Kentucky Hydroelectric Project. The island was largely destroyed during construction and is inundated by Kentucky Reservoir, and a boat harbor was created by excavation into the river bank. Photographs taken during lock construction in 1940-41 show that major excavation took place in the area of the project footprint. Construction of the lock channel required removing all soil and river sediments and blasting of bedrock (TVA 1949). The lock's riverward wall was built in this excavation, and then backfilled. The location where TVA proposes to install the compressor building(s) sits atop several tens of feet of artificial fill, capped with asphalt, gravel, and riprap. There is no potential for archaeological sites at the locations of the compressor buildings and associated buried compressor and utility lines. TVA finds that no NRHP-eligible or potentially-eligible sites are present in the project footprint. None of the consulted tribes objected or identified resources of concern at the Kentucky Lock site. The Kentucky SHPO replied by letter on May 19, 2021. In their response, the Kentucky SHPO stated general agreement with TVA's finding that the portion of the project footprint related to the installation of the compressor building(s) and associated cables and piping have no potential to contain archaeological resources. However, Kentucky SHPO requested detailed information about the location and design of the compressor systems and withheld comment on the undertaking until TVA is able to provide such details. TVA provided the requested additional information by letter dated July 21, 2021 and Kentucky SHPO ultimately agreed with TVA's finding that the undertaking would not affect NRHP-eligible archaeological sites.

3.19.1.2.5 Chickamauga Compressor Building

The USACE is currently constructing a new lock at Chickamauga Dam, on the landward side of the existing lock. Once the project is completed, the existing lock will be retired. For this reason, TVA has not currently chosen the final location of the compressor building(s) at the Chickamauga lock site. However, TVA has committed to placing the compressor buildings on top of a constructed feature of the Chickamauga Hydroelectric Project (lock or dam or associated structure). Therefore, the compressor building(s) and associated cabling and piping will be located in an area with no potential for the presence of archaeological sites. The Tennessee SHPO agreed with TVA's finding by letter dated July 8, 2021. None of the consulted tribes objected or identified resources of concern at the Chickamauga Lock site.

3.19.1.2.6 Nickajack Compressor Building

The proposed location of the compressor building(s) at the Nickajack lock site is an artificial landform created by the construction of the north embankment. Therefore, the compressor building(s) and associated cabling and piping will be located in an area with no potential for the presence of archaeological sites. The Tennessee SHPO agreed with TVA's finding by letter dated July 8, 2021. None of the consulted tribes objected or identified resources of concern at the Nickajack Lock site

3.19.1.2.7 Pickwick Landing Compressor Building

The proposed location of the compressor building(s) at the Pickwick Landing lock site is on a constructed surfaced created by the excavation of the fishing basin and installation of rip rap during construction of the Pickwick Hydroelectric Project. Therefore, the compressor building(s) and associated cabling and piping will be located in an area with no potential for the presence of archaeological sites. TVA will consult with the Tennessee SHPO and federally recognized Indian tribes regarding this finding. The Tennessee SHPO agreed with TVA's finding by letter dated July 8, 2021. None of the consulted tribes objected or identified resources of concern at the Pickwick Landing Lock site.

3.19.1.3 Historic Architectural Resources

The Watts Bar navigational lock is a contributing structure of the Watts Bar Hydroelectric Project, which was listed in the NRHP in 2017. Other contributing resources/structures include the Dam, Powerhouse, Visitor/Control Building, Switchyard, Oil Purification Building, Lock Operation Building, Lock Control Buildings 1 and 2, and other buildings and structures, as well as a recreational area. Watts Bar Hydroelectric Project was listed in the NRHP under criteria A and C for its historical, architectural, and engineering significance on the local and state levels as an integral part of the Tennessee Valley Authority Hydroelectric Project (Martens and Thomason 2015)

Wilson Dam (built 1918-1925 and acquired by TVA in 1933) was listed in the NRHP in 1978 (Rettig and Sheely 1976) and is also a National Historic Landmark. Although not listed as contributing elements to Wilson Dam in the NRHP nomination, the smaller lock is an original feature of the complex and all river traffic originally went through it. The compressor buildings, therefore, would be located within the NRHP boundary of a historic property.

The Guntersville navigational lock is a contributing structure of the Guntersville Hydroelectric Project (built 1935-1939), which was listed in the NRHP in 2015 (Martens and Thomason 2016b). Other contributing resources include the Dam, Powerhouse, Lock Control Building, two Lock Operation Buildings, Switchyard, Oil Purification Building, Pedestrian Overlook, Office Building, and other buildings and structures, as well as a recreational area. Guntersville Hydroelectric Project was listed in the NRHP under criteria A and C for its historical, architectural, and engineering significance on the national, state, and local levels as an integral part of the Tennessee Valley Authority Hydroelectric Project (Martens and Thomason 2016). The initial (Auxiliary) Lock was constructed concurrently with dam construction (TVA 1941). It is separated from the Main Lock by a 150-foot-wide service area, which is the located between the landward wall of the Auxiliary Lock and riverward wall of the Main Lock. The service area was constructed in the former Tennessee River channel, using fill dirt and rock. The Main Lock, constructed at a later time, is separated from the river shoreline by the lock's landwall, the downstream land approach wall, and a boat harbor.

The Kentucky Dam navigational lock is an original and contributing structure of the Kentucky Hydroelectric Project (built 1938-1944), which was listed in the NRHP in 2016 (Martens and Thomason 2015). The Dam, Powerhouse, Switchyard and Transmission Lines, original Navigational Lock, Lock Operation Building, Public Service Safety Building, Picnic Area Restroom, and Illinois Central Railroad Bridge are contributing structures. Construction on a new lock, landward of the existing lock, began in 1998 and is in progress. As the lock construction project was underway at the time Kentucky Hydroelectric Project was listed in the NRHP, TVA considers that the Dam and Lock retain sufficient historical significance and integrity to remain listed.

The Chickamauga Dam navigational lock is a contributing structure of the Chickamauga Hydroelectric Project (built 1936-1940), which was listed on the NRHP in 2017 (Martens and Thomason 2016a). The Asian carp deterrent system will be constructed the NRHP boundary of the Chickamauga Hydroelectric Project; there are no other inventoried historic architectural properties in the viewshed. The Dam, Powerhouse, Navigational Lock, Lock Operation Building, Lock Control Buildings 1 and 2, Lock Storage Building, Lock Visitor Building, Visitor Storage Building, Lock Maintenance Building, Bath house, Picnic Building, and Wilkes T. Thrasher Bridge are contributing structures or buildings.

The Nickajack Dam navigational lock is a contributing structure of the Nickajack Hydroelectric Project (built 1964-1967), which was listed on the NRHP in 2017 (Martens and Thomason 2016c). In addition to the Dam the Switchyard, Navigational Locks, Lock Control Buildings 1 and 2, and Lock Visitor Building are contributing buildings. The Picnic Area is a contributing site, and the TVA Road Bridge is a contributing structure. There are no other inventoried historic architectural properties in the viewshed.

The Pickwick Landing Dam navigational lock is a contributing structure of the Pickwick Landing Dam Hydroelectric Project (built 1935-1938), listed in the NRHP in 2017 (Martens and Thomason 2016d). Other contributing structures or buildings include the Dam, Powerhouse, Switchyard, and Bath house are contributing buildings or structures, and the Picnic/Fishing Area is a contributing site. There are no other inventoried historic architectural properties in the viewshed.

3.19.2 Environmental Consequences

3.19.2.1 Alternative A – No Action Alternative

As the No Action alternative would include no ground-disturbing activities and no new visual elements, TVA does not consider it a type of action with potential to affect historic properties.

3.19.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

At each of the seven lock sites, TVA's analysis shows that the potential for intact archaeological sites is either very low, or null. Therefore, TVA does not anticipate any effects on archaeological sites listed in, or eligible for listing in, the NRHP. The Alabama, Tennessee, and Kentucky SHPOs have all agreed with this finding for the portions of the project in their respective states, and the consulted tribes have either agreed or declined to comment.

TVA also evaluated the undertaking's potential for physical and visual effects on the Watts Bar, Wilson, Guntersville, Kentucky, Chickamauga, Nickajack, and Pickwick Landing hydroelectric projects (all NRHP-listed). At the Watts Bar site, the compressor building would be sited within the NRHP boundary of the Watts Bar Hydroelectric Project. The lock's landward wall would block views of the compressor buildings from the west, and the dam and highway would block any views of the buildings from the north. The buildings would be visible from the south and east, which consists mainly of an open grassy area. No historic properties other than the Watts Bar Hydroelectric Project are present in the APE. The buildings would be within the viewshed of a small portion of the lock, including the Lock Operation Building, and a small portion of the dam. They would not be visible from any of the contributing buildings or structures including the Powerhouse, Visitor/Control Building, Switchyard, Oil Purification Building, or recreational area. TVA finds that the undertaking would result in an effect on Watts Bar Hydroelectric Project, but that the effect would not be adverse. The Tennessee SHPO agreed with this finding in their letter dated July 8, 2021.

At the Guntersville Lock site, the compressor building would be sited within the NRHP boundary of the Guntersville Hydroelectric Project. The lock's landward wall would block views of the compressor buildings from the west, and the dam and highway would block any views of the buildings from the north. The buildings would be visible from the south and east, which consists mainly of an open grassy area. No historic properties other than the Guntersville Hydroelectric Project are present in the APE. At the Wilson Lock site, the buildings would be within the viewshed of a small portion of both locks, including the Lock Operation Building, and from a small segment of the dam's deck and the highway over the dam. However, even from the dam and highway, views would be partially blocked by the Lock Operations Building and vegetation. The buildings would not be visible from any of other contributing buildings or structures including the Powerhouse, Visitor/Control Building, Switchyard, Oil Purification Building, or recreational area. Furthermore, at each site (as at all the proposed lock sites), the compressor buildings would be painted in a color that compliments the color of surrounding features of the hydroelectric facility (a neutral gray shade). This would help the buildings blend in with the surrounding features. TVA finds that although the buildings would result in a visual effect on the NRHP-listed Guntersville Hydroelectric Project and NRHP-listed, National Historic Landmark Wilson Dam, the effects would not be adverse. The Alabama SHPO has agreed with this finding in their letter dated May 7, 2021. TVA also consulted with the U.S. National Park Service (which administers the National Historic Landmarks program) regarding the undertaking's potential effects on Wilson Dam. The National Park Service acknowledged TVA's communication but did not provide a comment.

At the Kentucky Lock site, the viewshed is very constricted due to the height of surrounding structures, compared with the comparatively modest height of the compressor buildings (eight feet). Views to the southwest will be limited to the switchyard and rip-rapped slope between the switchyard and the paved strip adjacent to the lock. The building(s) may be visible from some locations on the lock's deck. Views to the east and south would be blocked by the wall adjacent to the lock's downstream approach. Currently, views to the northeast are limited to the sloped river bank, which is part of the USACE lock construction area. Upon completion of the new lock, those views will be blocked by the riverward wall of the new lock, which will be taller than the walls of the existing lock. Views of the buildings would be limited to a narrow corridor that essentially consists of the lock's downstream approach and the river bank, and from the top of the dam. Views to the compressor building(s) from the Lock Maintenance Building and Lock Operations Building would be blocked by the earthen embankment that supports the former US Highway 62, and the wall adjacent to the downstream approach. Some views of the building(s) may be possible from the recently relocated US Highway 62, north (downstream) of the project area, but these would be very limited. Views of the compressor building(s) north of the lock would be limited to a small segment of the river and shoreline, which is being used by USACE as a staging area for the construction project. The landscape surrounding the project location is dominated by the lock, four 122-foot-tall steel transmission towers (recently relocated as part of the lock construction project) and other transmission towers, switchyard, highway overpass, railroad bridge, and USACE lock construction areas. The compressor buildings would be painted in a color that compliments the color of surrounding features of the hydroelectric facility (a neutral gray shade). This would help the buildings blend in with the surrounding features. In this setting, given the small size and grey color of the compressor buildings, they would be a very insignificant addition to the viewscape. TVA finds that although the buildings would result in a visual effect on the NRHP-listed Kentucky Hydroelectric Project, the effect would not be adverse. The Kentucky SHPO replied by letter on May 19, 2021. In their response, the Kentucky SHPO requested detailed information about the location and design of the compressor systems and withheld comment on TVA's finding until TVA is able to provide such details. TVA provided the requested additional information, and KY SHPO agreed with TVA's finding of no adverse effect on above-ground historic properties, by letter dated August 18, 2021. The KY SHPO's agreement with TVA's finding of no adverse effect on above-ground historic properties is conditioned on TVA's agreement with the following condition: "Utilize the same type of lighting and sound system design at Kentucky Dam that was used in the Barkley Lock and Dam project. The sound projectors, light bars, and bubble pipe will be mounted on a metal deployment frame, and that this frame be contained within a protective concrete box and submerged below water in the lock chamber. These components would therefore not be visible from land or the deck of the lock. The lights and sound would also not be detectable from land or lock deck, but the bubble curtains would be visible as the bubble plume reaches the water's surface."

TVA has not currently chosen the final location of the compressor building(s) at the Chickamauga lock site. However, TVA has committed to placing the compressor buildings on top of a constructed feature of the Chickamauga Hydroelectric Project (lock or dam or associated structure). View of the compressor building(s) will likely be blocked from multiple directions by constructed features. The Tennessee SHPO agreed with TVA's finding of no adverse effect on above ground historic properties by letter dated July 8, 2021.

At the Nickajack lock site the compressor buildings would be placed on the north embankment a short distance from the Lock Visitor Building. The compressor building(s) would be visible from that building and the Lock Operations Building, but that building and the lock's landward wall would block views of the compressor buildings to the south. Views to the west (downstream) would be largely blocked by the concrete wall of the north embankment. The compressor buildings would be visible in a small area to the east and north. The compressor buildings would be painted in a color that compliments the color of surrounding features of the hydroelectric facility (a neutral gray shade). This would help the buildings blend in with the surrounding features. In this setting, given the small size and grey color of the compressor buildings, they would be a very insignificant addition to the viewscape. The Tennessee SHPO agreed with TVA's finding of no adverse effect on above ground historic properties by letter dated July 8, 2021.

At the Pickwick lock site, the compressor buildings would be placed on the steeply sloped, rip-rapped wall of the fishing basin, located between the lock's landward wall and the Tennessee River shoreline. Due to the low elevation of this location and the height of the surrounding features (lock wall, shoreline) the compressor building(s) would not be visible except from the top of the lock wall and within the fishing basin. At times of high water, the compressor building(s) would be immersed under the surface of Kentucky Reservoir. TVA finds that while the installation of the building(s) will have an effect on Pickwick Landing Hydroelectric Project, the effect would not be adverse. The Tennessee SHPO agreed with TVA's finding of no adverse effect on above ground historic properties by letter dated July 8, 2021.

3.20 Transportation

3.20.1 Affected Environment

The extensive transportation network within the study area includes thousands of miles of roads, bridges, rail lines, navigable waterways, marinas, boat ramps, and ports. Various regional airports also exist within the broader study area but do not provide direct service to any of the dams. No railroads or railway bridges exist at any of the dams. Road access to the L&Ds at each site varies from two-lane roads to four-lane divided highways. Tennessee River crossings exist at Kentucky, Pickwick, Wilson, Wheeler, Chickamauga, and Watts Bar dams. Public road managers for this system include state departments of transportation, conservation, forestry; county highway departments; and municipal road departments. Specifics on navigable waterways are discussed in detail in Section 3.5, Navigation.

3.20.2 Environmental Consequences

3.20.2.1 Alternative A – No Action Alternative

Under this alternative, TVA would not install fish barriers at any of the locks considered. Therefore, there would be no impacts to transportation.

3.20.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Transportation impacts associated with this alternative would occur from use of vehicles by the construction workforce and the operation of construction. Aside from temporary lock closure for installation (see Section 3.5, Navigation), access to road, rail, or other water facilities (e.g., docks and marinas) are not expected to be affected.

Construction phase activities would result in a limited number of additional vehicles on the roads generally at the beginning and ending of the workday. Mobilization of work crews of up to 20 people to and from the work site are expected. Overall, the traffic volume generated by the construction workforce and the construction-related vehicles would be relatively minor. Most of the vehicle traffic miles are expected on interstate highways or major arterial roadways and would not result in congestion or the degradation of existing traffic patterns.

Should construction or maintenance require offsite disposal of construction debris or dredging spoils, use of additional haul trucks would be required. As such, this would contribute to a short-term and localized increases in traffic volumes. However, the number of trucks used to haul debris offsite is generally expected to be low and would be insignificant relative to existing traffic volumes. Further, the additional trucks would not represent a notable change in traffic conditions on the broader transportation network associated with the Tennessee River reservoir system.

Operation of the CO_2 barrier would require periodic delivery of CO_2. The number of trucks needed to refill the supply of CO_2 would depend on the frequency of use and whether or not storage facilities are constructed at the L&D facility. Locks with higher navigation traffic (e.g., Kentucky Lock) would require more frequent CO_2 delivery than those with lower frequency of lock operations (e.g., Guntersville Locks; see Navigation Section 3.5). Although the number of trucks needed to transport CO_2 is unknown, it is anticipated that trucks used to transport CO_2 would be few and intermittent. Therefore, impacts to transportation at locks with CO_2 deterrents would be minor.

In general, TVA would construct and maintain the fish barriers in a way that minimizes inconvenience and disruption to traffic. Therefore, impacts of fish barrier installation on transportation and traffic conditions would be minor.

3.21 Noise

3.21.1 Affected Environment

Noise is unwanted or unwelcome sound usually caused by human activity and added to the natural acoustic setting of a locale. It is further defined as sound that disrupts normal activities or diminishes the quality of the environment. Community response to noise is dependent on the intensity of the sound source, its duration, the proximity of noise-sensitive land uses, and the time of day the noise occurs. For instance, higher sensitivities to noise would be expected during the quieter overnight periods at noise sensitive receptors such as residences.

Sound is measured in logarithmic units called decibels (dB). Given that the human ear cannot perceive all pitches or frequencies of sound, noise measurements are typically weighted to correspond to the limits of human hearing. This adjusted unit of measure is known as the A-weighted decibel (dBA) which filters out sound in frequencies above and below human hearing. A noise level change of 3 dBA or less is barely perceptible to average human hearing. However, a 5 dBA change in noise level is clearly noticeable. The noise level associated with a 10 dBA change is perceived as being twice as loud; whereas the noise level associated with a 20 dBA change is considered to be four times as loud and would therefore represent a "dramatic change" in loudness.

To account for sound fluctuations, environmental noise is commonly described in terms of the equivalent sound level. The equivalent sound level is the constant noise level that conveys the same noise energy as the actual varying instantaneous sounds over a given period. Fluctuating levels of continuous, background, and/or intermittent noise heard over a specific period are averaged as if they had been a steady sound. The day-night sound level (L_{dn}), expressed in dBA, is the 24-hour average noise level with a 10-dBA correction penalty for the hours between 10 p.m. and 7 a.m. to account for the increased sensitivity of people to noises that occur at night. Typical background day-night noise levels for rural areas are anticipated to range between an L_{dn} of 35 and 50 dB, whereas higher-density residential and urban areas background noise levels range from 43 dB to 72 dB (EPA 1974). Common indoor and outdoor noise levels are listed in Table 3-43.

The perceived loudness or intensity between a noise source and a receptor may change because of distance, topography, vegetation, water bodies, and structures. The closer a receptor is to a noise source the louder the noise seems; for every doubling of distance from a source the intensity drops by about 6 dBA over land and about 5 dBA over water (USDOI 2008). Topography, vegetation, and structures can change noise intensity through reflection, absorption, or deflection. Reflection tends to increase the intensity, while absorption and deflection tend to decrease the intensity.

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, USC. 42 4901-4918), delegates authority to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. Many local noise ordinances are qualitative, such as prohibiting excessive noise or noise resulting in a public nuisance. Because of the subjective nature of such ordinances, they are often difficult to enforce.

Table 3-43. Common Indoor and Outdoor Noise Levels

Source(s)	Sound Levels[2] (dBA)	Notes
Shotgun, rifle, handgun, fireworks (at 3 feet)	> 160	Impulse sounds
Jet engine (taking off), artillery fire (at 500 ft)	150	
Airplane (taking off)	140	Harmfully loud
Stock car races, jet takeoff (at 100-200 ft)	130	Threshold of pain
Power plant machinery (near source), chainsaw, jet plane (at ramp), Band concert	120	Threshold of sensation or feeling
Car horn, symphony concert, baby crying	110	Regular exposure of more than 1 minute risks permanent hearing loss. Physical discomfort. Maximum vocal effort.
Snowmobile. garbage truck, jet takeoff (at 2,000 feet), school dance	100	> 95 dBA – no more than 15 minutes/day unprotected exposure recommended. 1 hour per day risks hearing loss.
Heavy truck (at 50 feet), motorcycle (operator), power lawnmower, jet ski, pleasure motorboat, shouted conversation	90	Very annoying.
Heavy traffic, many industrial work places, electric razor	85	Level at which hearing damage begins with 8-hour exposure.
Ringing telephone, average city noise, freight train (at 50 feet)	80	Annoying; interferes with conversation
Freeway traffic (at 50 feet), urban housing on major avenue (L_{dn}), inside a car, TV audio	70	Interferes with telephone conversation. EPA L_{dn} for lifetime exposure without hearing loss.
Normal conversation, sewing machine	60	Intrusive. Interference with human speech begins at about 60 dBA.

Source(s)	Sound Levels[2] (dBA)	Notes
Rainfall, refrigerator, wooded residential (L_{dn}), light auto traffic (at 100 feet)	50	Quiet. Comfortable. Sleep disturbance may occur at less than 50 dBA.
Quiet office, library, quiet residential area, rural residential (L_{dn})	40	
Soft whisper (at 15 feet)	30	Very quiet.
Normal breathing	10	Just audible.
	0	Threshold of hearing.

Source: USDOI 2008
[1] These are typical levels and some may be approximate averages of ranges; actual levels may depend on several factors, including distance from the sound source.

There is considerable variation in individual response to noise. Noise that one person would consider mildly annoying, another person may consider highly annoying or not annoying at all. The EPA noise guideline recommends outdoor noise levels do not exceed L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas. These levels are not regulatory goals but are “intentionally conservative to protect the most sensitive portion of the American population” with “an additional margin of safety” (EPA 1974). The U.S. Department of Housing and Urban Development (HUD) considers an L_{dn} of 65 dBA or less to be compatible with residential areas (HUD 1985).

3.21.1.1 Sources of Noise

Sources of noise along the Tennessee River system reservoirs and the associated L&D sites include industrial development, power generation facilities, substations, developed recreation sites, recreational watercraft use, navigation uses, and automobile traffic. Industrial areas have the greatest potential to support uses that produce higher levels of noise. Noise emission levels from sources such as power generation, navigation locks, and associated barge operations can range from 70 dBA to 100 dBA (USDOI 2008). Noise from generators at TVA facilities produce a constant, low frequency drone during generation. However, because they are housed in buildings, they are not audible at a distance. Noise that occurs from barge traffic, lock operation and water releases from the dam would approach 100 dBA but would be intermittent and would attenuate with distance.

Noise emissions associated with developed recreation land uses depend on the location of the facilities and the type and intensity of recreational use. For example, recreational facilities that support low intensity uses, such as parks or open spaces, generate less noise than more intensive uses such as marinas and developed recreation areas. Noise levels and patterns at developed recreation areas are typical of campground and day use recreation areas. These developed recreational use areas could be compared to residential areas with an L_{dn} range of about 50 dBA (quiet suburb, not close to major roads, and little nighttime activity) to about 65 dBA (relatively noisy residential area). The most conspicuous recreational noise producers are power boats and personal watercraft (jet skis) on the reservoirs. While power boats and jet skis may both have an average sound level of about 90 dBA, noise emissions from these sources can exceed 115 dBA depending on speed and other operational factors (USDOI 2008).

3.21.1.2 Noise Receptors
Sensitive noise receptors include residences or other developed sites where frequent human use occurs, such as churches, parks, and schools. In general, the closest sensitive noise receptors to the Tennessee River system L&D sites are developed recreational areas along the shoreline. These include public boat ramps, campgrounds, bank fishing areas, playgrounds, and picnic areas. The distance to the nearest residential development varies widely by L&D site but is a minimum of approximately 0.25 mile.

3.21.2 Environmental Consequences

3.21.2.1 Alternative A – No Action
Under the No Action Alternative, TVA would not install fish barrier technologies at any of the locks considered and no project-related impacts from noise would occur.

3.21.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System
Noise impacts associated with this alternative would occur in conjunction with the short-term use of construction equipment and increased workforce traffic during the construction period. Installation of any of the proposed barrier systems would require the use of dredging equipment, barges, track and backhoes, cranes, and work boats as well as trucks for hauling materials. According to the bounding attributes in Table 2-6, noise emissions from construction equipment would attenuate to 65 dBA or less at the property boundary of offsite sensitive receptors, falling within the HUD guidelines for compatibility with residential areas. Recreationists on the reservoirs in close proximity to the construction activities have the potential to experience construction noise levels exceeding both the EPA and HUD dBA guidelines. However, boaters would only be exposed to these noise levels for a brief duration as they passed the project area. Additionally, construction noise would be intermittent over the approximately 24-month construction period and generally limited to normal working hours. Thus, construction noise impacts would be temporary and minor.

Workforce traffic traveling to and from the construction site and the transportation of trucks and construction equipment would generate intermittent traffic noise on local roadways in the vicinity of the L&D sites. However, due to the relatively small scale of the workforce (up to 20 personnel per day), such noise impacts would be infrequent and minor.

Similarly, during operation, small amounts of traffic would be generated by occasional maintenance activities and, in the case of the CO_2 fish barrier, intermittent to weekly CO_2 delivery. However, due to the small number of vehicles associated with these tasks, noise impacts on local roadways would be infrequent and minor.

Compressors and other controls needed to operate the deterrent systems would be housed within a building. Other support systems (e.g., supply lines and acoustic speakers) would be underwater. Therefore, there would be no other discernable noise emissions during operation of the fish barrier systems.

Overall, adverse noise impacts under Alternative G from construction and operation of the fish barriers would be temporary and minor.

3.22 Demographics and Environmental Justice

3.22.1 Affected Environment

Given the nature of the proposed actions, the study area for the demographic and environmental justice analysis is defined as the 139 counties that encompass the Tennessee River watershed (Figure 1-1). As the study area spans portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia, these seven states are included as appropriate secondary geographic areas of reference. Comparisons at multiple spatial scales provide a more detailed characterization of populations that may be affected by the proposed actions, including any environmental justice populations (e.g., minority and low-income). Demographic and socioeconomic characteristics of populations within the study area were assessed using the 2014-2018 American Community Survey 5-year estimates provided by the U.S. Census Bureau (USCB) (USCB 2020a).

3.22.1.1 Population Characteristics

Demographic characteristics of the study area and of the secondary reference geographies are summarized in Table 3-44. The study area had a total resident population of approximately 7.2 million in 2018 (USCB 2020a). Population varies greatly among the counties in the study area. The larger population concentrations tend to be located along the Tennessee River and its tributaries from northeast Tennessee through Knoxville and Chattanooga into north Alabama. The counties south of Nashville, Tennessee and surrounding Asheville, North Carolina also have larger populations (Figure 3-8). Since 2010, the study area has experienced population growth of approximately 3.3 percent, which is less than the 4.1 percent increase for the U.S. as a whole. Additionally, while the proportion of the region's population living in metropolitan areas is lower than the national average of 85 percent, it has been increasing and this trend appears likely to continue in the future (TVA 2019a).

Approximately 85 percent of the population within the study area is white. Minorities in the study area include: Black or African American (6.7 percent), Hispanic or Latino (5.1 percent), Asian (1.1 percent), American Indian and Alaska Native (0.5 percent), some other race (0.1 percent), and persons who identified as two or more races (1.8 percent). Minority population percentages in the study area are generally comparable to or less than those of the surrounding states and the country (Table 3-44).

The average median household income in the counties that make up the study area is $43,434, though there is wide variation between counties. This median income is notably lower than that of the national median household income ($60,293), though with the exception of Virginia, all states within the study area fall below the national average (Table 3-44). Correspondingly, the percentage of the study area population falling below the poverty level is 16.0 percent, which is higher than that of the country as a whole, where 14.1 percent of the population lives below the poverty level.

Table 3-44. Demographic and Socioeconomic Characteristics of Study Area and Reference Geographies

	Study Area (Counties Encompassing TN River Watershed)	Alabama	Georgia	Kentucky	Mississippi	North Carolina	Tennessee	Virginia	United States
Population[1,2]									
Population, 2018 estimate	7,163,377	4,864,680	10,297,484	4,440,204	2,988,762	10,155,624	6,651,089	8,413,774	322,903,030
Population, 2010	6,933,930	4,779,736	9,687,653	4,339,367	2,967,297	9,535,483	6,346,105	8,001,024	308,745,538
Percent Change 2010-2018	3.3%	1.8%	6.3%	2.3%	0.7%	6.5%	4.8%	5.2%	4.6%
Racial Characteristics[1]									
Not Hispanic or Latino									
White alone, 2018 (a)	84.7%	65.7%	53.2%	84.8%	56.8%	63.3%	74.0%	62.2%	61.1%
Black or African American, 2018 (a)	6.7%	26.4%	31.0%	7.9%	37.5%	21.1%	16.6%	18.8%	12.3%
American Indian and Alaska Native, 2018 (a)	0.5%	0.5%	0.2%	0.2%	0.4%	1.1%	0.2%	0.2%	0.7%
Asian, 2018 (a)	1.1%	1.3%	3.9%	1.4%	0.9%	2.8%	1.7%	6.3%	5.4%
Native Hawaiian and Other Pacific Islander, 2018 (a)	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.2%
Some Other Race alone, 2018 (a)	0.1%	0.2%	0.3%	0.1%	0.1%	0.2%	0.1%	0.3%	0.2%
Two or More Races, 2018	1.8%	1.7%	2.0%	2.0%	1.2%	2.2%	1.9%	3.0%	2.4%
Hispanic or Latino, 2018	5.1%	4.2%	9.4%	3.6%	3.0%	9.2%	5.3%	9.2%	17.8%
Income and Employment[1]									
Median household income, 2018	$43,434	$48,486	$55,679	$48,392	$43,567	$52,413	$50,972	$71,564	$60,293
Persons below poverty level, 2018	16.0%	17.5%	16.0%	17.9%	20.8%	15.4%	16.1%	10.6%	14.1%
Persons below low-income threshold, 2018 (b)	37.3%	37.8%	35.6%	37.7%	43.1%	35.6%	36.4%	24.8%	31.9%
Civilian Labor Force, 2018	3,320,306	2,224,606	5,043,919	2,087,800	1,338,573	4,978,432	3,239,353	4,336,393	162,248,196
Percent Employed, 2018	94.3%	93.4%	93.6%	93.9%	91.8%	93.7%	94.1%	95.0%	94.1%
Percent Unemployed, 2018	5.7%	6.6%	6.4%	6.1%	8.2%	6.3%	5.9%	5.0%	5.9%

(a) Includes persons reporting only one race.

(b) Low-income threshold is defined as two times the poverty level

Sources: [1]USCB 2020a; [2]USCB 2011

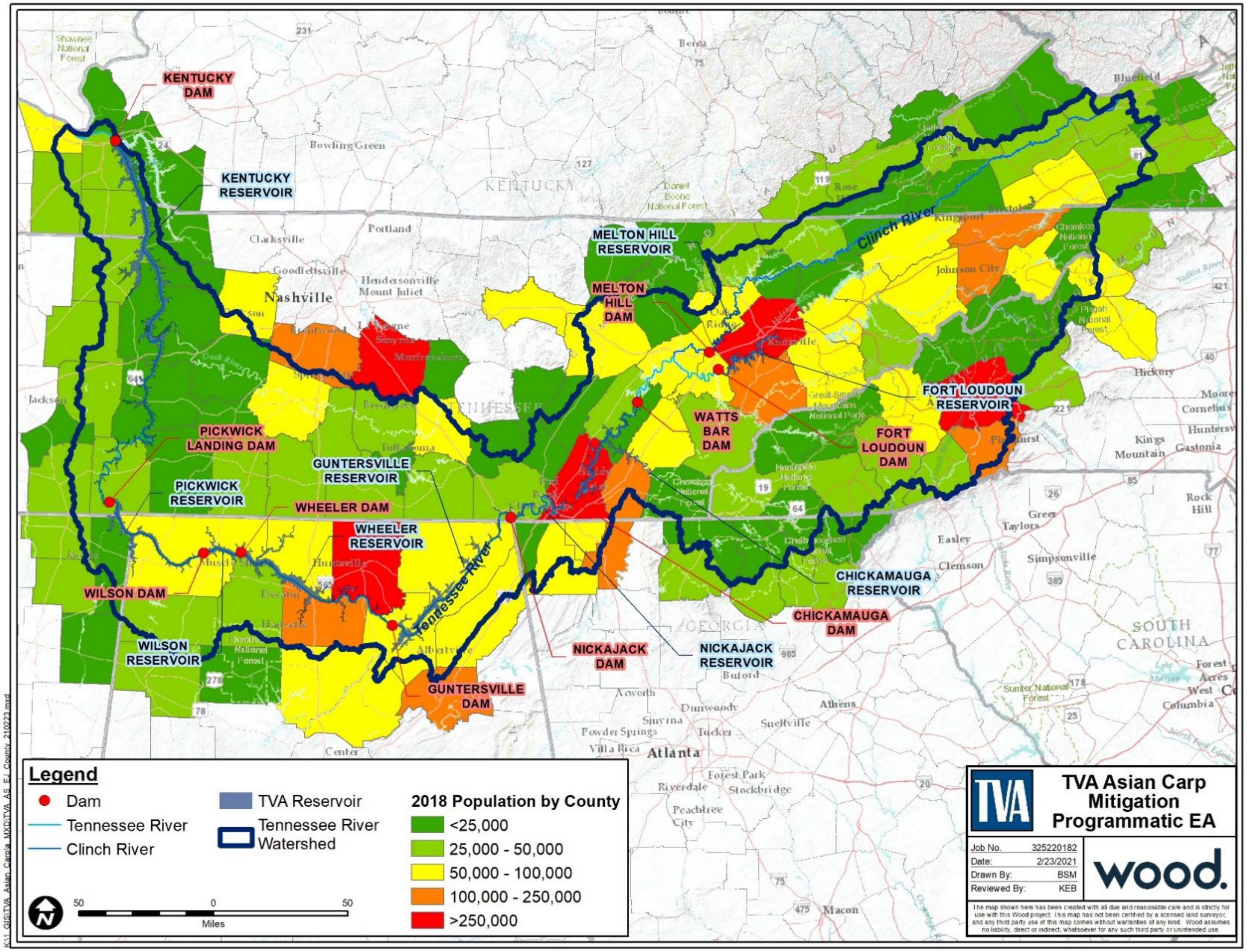

Figure 3-8. Population by County Within the Study Area

3.22.1.2 Environmental Justice Populations

On February 11, 1994, President Clinton signed EO 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. EO 12898 mandates some federal-executive agencies to consider environmental justice as part of the NEPA. Environmental justice has been defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income (EPA 2018) and ensures that minority and low-income or other vulnerable populations do not bear disproportionately high and adverse human health or environmental effects from federal programs, policies, and activities. Although TVA is not one of the agencies subject to this order, TVA routinely considers environmental justice impacts as part of the project decision-making process.

Guidance for addressing environmental justice is provided by the CEQ's Environmental Justice Guidance under the National Environmental Policy Act (CEQ 1997). The CEQ defines minority as any race and ethnicity, as classified by the USCB, that is: Black or African American; American Indian or Alaska Native; Asian; Native Hawaiian and Other Pacific Islander; some other race (not mentioned above); two or more races; or a race whose ethnicity is Hispanic or Latino (CEQ 1997).

Identification of minority populations requires analysis of individual race and ethnicity classifications as well as comparisons of all minority populations in the region. Minority populations exist if either of the following conditions is met:

- The minority population of the impacted area exceeds 50 percent of the total population.
- The ratio of minority population is meaningfully greater (i.e., greater than or equal to 20 percent) than the minority population percentage in the general population or other appropriate unit of geographic analysis (CEQ 1997).

The total minority population (i.e., all non-white and Hispanic or Latino racial groups combined) of the study area is approximately 1.1 million, or about 15 percent of the total study area population (USCB 2020a). This is well below the national average minority population share of approximately 39 percent. As shown in Figure 3-9, minority populations within the study area are largely concentrated in northern Alabama and in metropolitan areas.

The nationwide poverty level is determined annually by the USCB and varies by the size of family and number of related children under 18 years of age. The 2019 USCB Poverty Threshold for an individual is an annual income of $13,300, and for a family of four it is an annual household income of $26,370 (USCB 2020b). For the purposes of this assessment, low-income individuals are those whose annual household income is less than two times the poverty level. More encompassing than the base poverty level, this low-income threshold, also used by the EPA in their delineation of low-income populations, is an appropriate measure for environmental justice consideration because current poverty thresholds are often too low to adequately capture the populations adversely affected by low-income levels, especially in high-cost areas (EPA 2017b). According to EPA, the effects of income on baseline health and other aspects of susceptibility are not limited to those below the poverty thresholds. For example, populations having an income level from one to two times the poverty level also have worse health overall than those with higher incomes (Centers for Disease Control and Prevention 2011). A low-income environmental justice population exists if either of the following two conditions is met:

- The low-income population exceeds 50 percent of the total population.

- The ratio of low-income population significantly exceeds (i.e., greater than or equal to 20 percent) the appropriate geographic areas of analysis.

The percentage of the population of the study area living below the low-income threshold is approximately 37 percent, somewhat higher than the national percentage of approximately 32 percent but generally consistent with the majority of the surrounding states (Table 3-44). As shown in Figure 3-10, counties with the higher percentages of low-income populations are generally more rural, located outside of the metropolitan areas.

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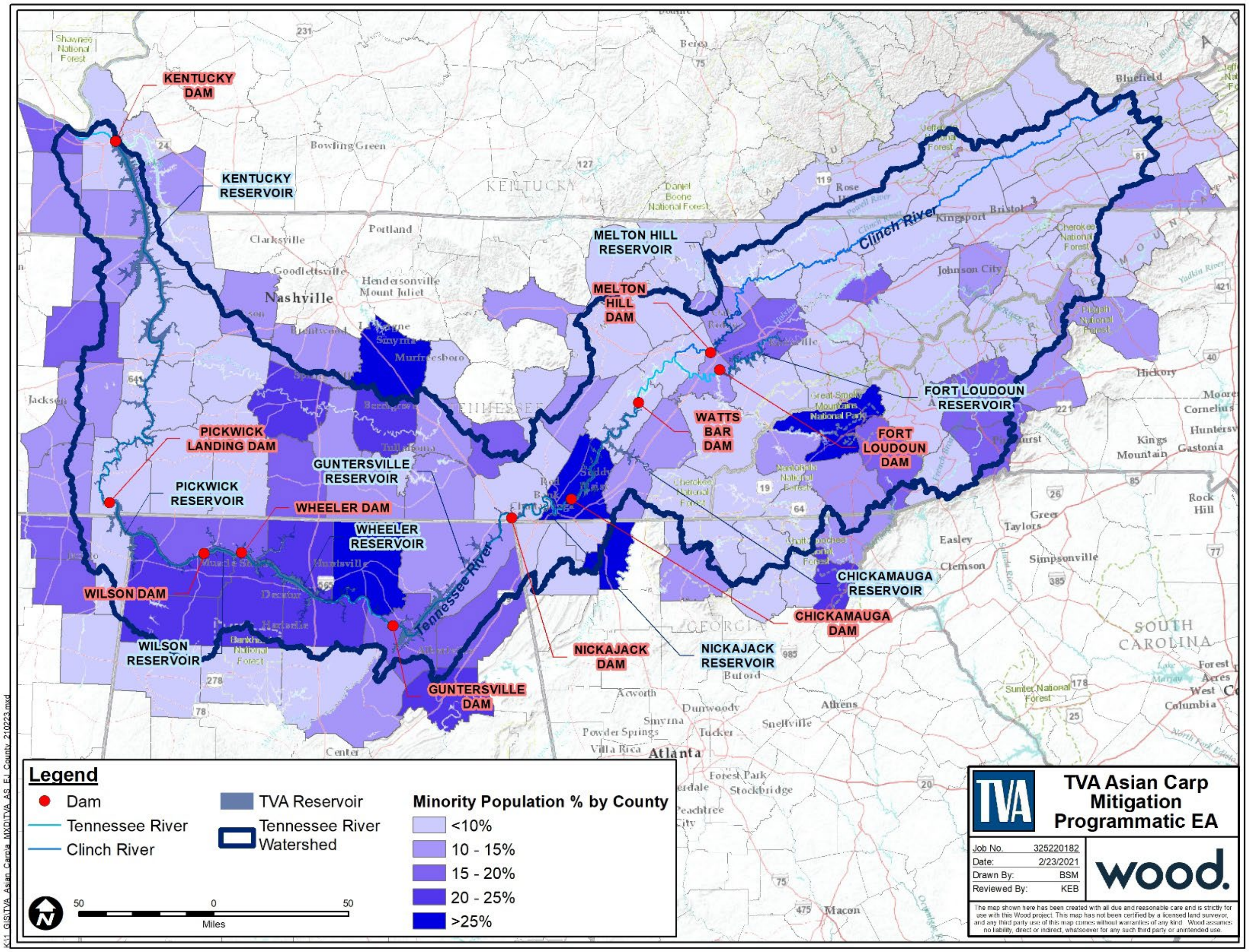

Figure 3-9. Minority Population Percentage by County Within the Study Area

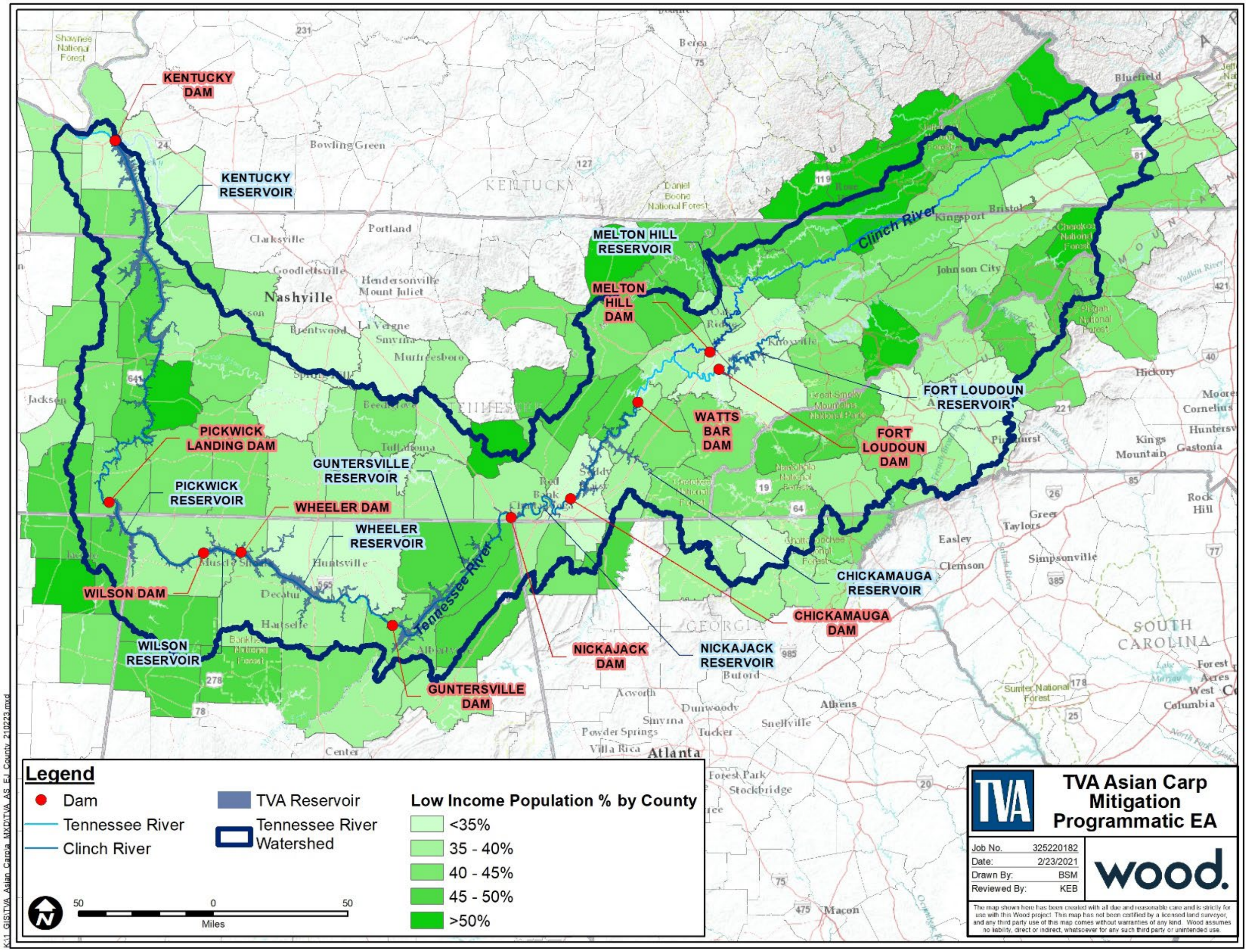

Figure 3-10. Low Income Population Percentage by County Within the Study Area

3.22.2 Environmental Consequences

3.22.2.1 Alternative A – No Action Alternative

Under the No Action Alternative, TVA would not install fish barrier technologies at any of the locks considered. Therefore, there would be no change in local demographics or employment associated with the proposed actions, and there would be no direct impacts to environmental justice populations. However, without these fish barrier technologies, the further establishment of Asian carp throughout the Tennessee River system has the potential to reduce recreation, tourism, and property values within the study area, ultimately impacting the economy of local communities which may include environmental justice populations.

Additionally, the influx in Asian carp and the associated impacts to existing fish communities may negatively impact populations who engage in subsistence fishing. Subsistence fishing harvests can be of both cultural and economic value to some environmental justice communities. However, given the lack of available data pertaining to subsistence fishing in the Tennessee River system, it is anticipated that subsistence fishing is relatively uncommon and as such this impact would be minor.

3.22.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Under Alternative G, construction and operation of the fish barrier technologies would entail a minor increase in workforce personnel, resulting in a small direct positive impact to employment in the region. Proposed construction activities at each L&D site would occur over approximately 24 months and would entail the use of a construction workforce of up to 20 workers. It is anticipated that the majority of these workers would be drawn from the labor force that currently resides in the region. Following construction, maintenance staff would include up to six divers and ten engineers. In both cases, given the relatively small workforce and that most workers would likely be drawn from the existing labor force, impacts to demographics and local employment would be minor and the demand for public services would not be appreciably affected.

Construction activities associated with the installation of fish barrier technologies could result in temporary impacts to nearby residents, including increased background noise levels and fugitive dust. However, these impacts would be intermittent and minor given the nature of the project and the distance between residences and the L&D sites. In addition, the proposed project would not result in any substantial long-term emissions or releases of air pollutants, noise, or hazardous materials that would have a direct impact on human health or welfare. Effective operation of fish barrier technologies would also benefit communities in the study area, minimizing negative impacts associated with Asian carp and thus supporting local recreation, tourism, and related industries. As there would be no notable adverse impacts to local communities associated with implementation of Alternative G, and beneficial impacts would be consistent across all communities (i.e., environmental justice and non-environmental justice), the proposed project would have no disproportionate adverse impacts on environmental justice populations.

3.23 Public Health and Safety

3.23.1 Affected Environment

3.23.1.1 TVA Health and Safety Culture

Workplace health and safety regulations are designed to eliminate personal injuries and illnesses from occurring in the workplace. The Occupational Health and Safety Act of 1970 was created by Congress to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education, and assistance. The Occupational Health and Safety Act of 1970 is the main statute protecting the health and safety of workers in the workplaces. TVA has a robust safety conscious culture that is focused on awareness and understanding of workplace hazards, prevention, intervention, and active integration of BMPs to avoid and minimize hazards. TVA has developed an Incident, Good Catch, and Near Miss reporting system for contractors and TVA personnel.

General guidelines for workplace safety that are communicated to work crews include:

- Pre-Job Brief – allows the worker to think through a job and use that knowledge to make the job as safe as possible.
- Two-Minute Rule (situational awareness) – take time before starting a job to familiarize yourself with the work environment and to identify conditions that were not identified during the pre-job brief.
- Stop When Unsure – when confronted with a situation that creates a question and what to do is uncertain, stop and get help.
- Self-Check – use of “STAR” acronym to promote self-check awareness: Stop and focus, Think what will happen with right or wrong action, Act correctly, Review that the results are as expected.
- Procedure Use and Adherence – allows for proper application of procedures and work packages based on expected activities.
- Flagging and Operational Barriers – key to ensure control of the work zones and avoidance of exposure to work hazards by public.
- Three-Way Communication – essential for all job tasks to ensure they are completed safely and productively.

TVA’s Safety Standard Programs and Processes would be strictly adhered to during the proposed actions. The safety programs and processes are designed to identify actions required for the control of hazards in all activities, operations, and programs. It also establishes responsibilities for implementing OSHA and state requirements. The potential offsite consequences and emergency response plan are discussed with local emergency management agencies. These programs are audited by TVA no less than once every three years and by EPA periodically.

Mitigative measures are used to ensure protection of human health which includes the workplace, public and the environment. Applicable regulations and attending administrative codes that prescribe monitoring requirements may include those associated with emergency management, environmental health, drinking water, water and sewage, pollution discharge, air pollution, hazardous waste management and remedial action.

3.23.1.2 TVA Navigation Safety

Every TVA dam is checked regularly to make sure it that it is safe, and the equipment used to operate it is working properly (TVA 2021b). Warning signs and danger buoys near some dams identify additional hazards. TVA has installed horns, strobe lights, warning signs, and electronic spillway signs with strobe lights and horns to warn of impending changes in water conditions. Navigation safety landings and harbors have been established at various locations along the reservoir to provide safe locations for commercial tows and recreational vessels to tie off and wait during periods of lock closure, severe weather, fog, or equipment malfunction.

Access to the locks is restricted. The lockmaster has full authority over the immediate management and control of the lock and lock area. The lockmaster is authorized to give all necessary and appropriate orders and instructions to every person in the lock area, whether navigating the lock or not. No one shall cause any movement of any vessel within the lock area unless instructed to do so by the lockmaster.

3.23.2 Environmental Consequences

3.23.2.1 Alternative A – No Action Alternative

Under the No Action Alternative, TVA would not install fish barriers at any of the locks considered. There would be no health and safety hazards associated with construction, dredging, or excavating in or near water. However, Asian carp would continue to move and expand their range within the Tennessee River system and establish uncontrolled population in reservoirs with negative consequences to public health and safety. Specifically, one species of Asian carp (i.e., silver carp) has a propensity to leap out of the water when disturbed which could injure recreational users of the Tennessee River system.

Areas with substantial silver carp populations have reported numerous injuries to the public and property due to silver carp jumping out of the water, particularly in response to outboard motors (USFWS 2007b). Injuries include cuts, black eyes, broken bones, neck and back injuries, and concussions. Among the documented injuries to boaters and water skiers include one person being knocked unconscious from her jet ski by a jumping silver carp; and a teenager suffering a broken nose and fractured skull when a silver carp struck him in the face (Hansen 2010; Joseph 2017). Property damage includes broken radios, depth finders, fishing equipment, and antennae. Some boaters are retrofitting vessels with Plexiglas pilot's cab to protect against jumping silver carp. A 2011 survey of boaters from river towns reported 94.3 percent of respondents were hit by a jumping silver, of which 20 percent were injured (USACE 2019). Disease-causing agents including bacteria and fungi have been found in farmed silver carp which pose health risks to humans. Although these agents were not found in wild caught fish from the US, silver carp should still be considered potential carriers. Due to these potential impacts to human health and safety, among their numerous ecological impacts, Silver carp were listed as injurious wildlife under the Lacey Act (USFWS 2007b). Black carp and bighead carp are also listed as injurious wildlife under the Lacey Act (USWFS 2011).

Overall, under the No Action Alternative, expanding silver carp populations are anticipated to have a moderate and long-term adverse impact to public health and safety in the Tennessee River system.

3.23.2.2 Alternative G – Install a Combined System of Fish Barriers (i.e., BAFF and CO_2) at Multiple L&D Sites within the Tennessee River System

Under Alternative G, a fish barrier system (i.e., BAFF or BAFF and CO_2) would be installed to block upstream movement of Asian carp. Installation of the fish barriers at the L&D would have potential health and safety hazards associated with construction, dredging, and excavating in or near water. Construction of the support buildings and installation of the fish barrier technologies would include customary industrial safety standards, applicable BMPs, and job-site safety plans to maintain worker and public safety. Site safety plans would codify steps to ensure specific water-safety procedures are followed. For example, railings, deck housekeeping, and personal protective equipment (e.g., personal floatation devices) would always be in place; programs and procedures for right-to-know, water rescue, dive safety, hearing conservation, and safe dredging would be followed; employee safety orientations and regular safety inspections would be performed; and corrective actions would be taken for any identified hazards. Through its Safety Standard Programs and Processes, TVA would foster a culture of safety-minded employees to keep workers and the public safe during installation.

Construction wastes including solid wastes, hazardous waste, and air emissions would be managed in accordance with applicable federal, state, and local laws and regulations and all applicable permit requirements (see Section 3.17, Solid and Hazardous Wastes and Section 3.6, Air Quality). TVA is committed to complying with all applicable regulations, permitting, and monitoring requirements. Waste reduction practices are also employed including recycling and waste minimization. Construction and dredging activities would adhere to TVA guidance and be performed consistent with standards established by OSHA; therefore, public health and safety during construction and dredging would be maintained. Overall, worker and public health and safety during construction would be maintained and there would be no impact to public health and safety.

The equipment needed for the system is designed to not impede the daily operation of the locks or the public's health and safety. No electrical current would flow through the water or be exposed to the users of the locks. Sound levels and strobe lighting associated with BAFF would be evaluated and adjusted, as needed, but are not anticipated to impact public health and safety. Routine safety inspections would ensure the fish barriers continue to maintain public health and safety at the lock. Therefore, operational impacts to public health and safety are negligible.

Overall, impacts to public health and safety under Alternative G would be minor and temporary during construction and moderately beneficial long term relative to the negative impacts of jumping silver carp to recreational users of the Tennessee River system under the No Action alternative.

3.24 Cumulative Impacts

The CEQ regulations (40 CFR Parts 1500-1508) implementing NEPA define cumulative impact as:

"…the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR § 1508.7)."

Baseline conditions reflect the impacts of past and present actions. The impact analyses summarized in preceding sections are based on baseline conditions, including the establishment of reservoirs and navigation on the Tennessee River system, and, therefore, incorporate the cumulative impacts of past and present actions.

3.24.1 Geographic Area of Analysis

The appropriate geographic area over which past, present and future actions could reasonably contribute to cumulative effects is variable and dependent on the resource evaluated. Actions related to installation of fish deterrent systems to manage Asian carp populations at 10 reservoirs within the study area vary with respect to location and timing. However, they are unified under this cumulative effects analysis as “similar” actions. Therefore, for this programmatic level cumulative effects analysis TVA’s study area is considered to be the appropriate context for analysis of cumulative effects of fish barrier system installation for most resource areas. The TVA study area includes the 10 L&D sites within the Tennessee river system, the associated reservoirs, and the counties in which they are located. The 10 reservoirs within the Tennessee River system addressed in this PEA have a total of approximately 6,900 shoreline miles, 459,600 acres of water surface area, and over 200,000 acres of surrounding TVA-owned land.

3.24.2 Identification of “Other Actions”

Past, present and reasonably foreseeable future actions that are appropriate for consideration in a cumulative effects analysis are those that when viewed with the proposed action, have cumulatively significant impacts. Due to the geographic scope of the 10 L&D sites and reservoirs managed by TVA that are considered in this PEA, predicting future resource conditions involves substantial uncertainty. Future cumulative impacts can result not only from possible actions of TVA in accordance with the proposed installation and operation of Asian carp barriers under Alternative G, but also from those actions of other agencies and the public. However, the assessment of potential impacts from installation and operation of Asian carp barrier systems is inherent in the analyses performed for each of the resource sections considered in Chapter 3. Therefore, this cumulative effects analysis considers the effects of potential future actions by others based on general trends that are anticipated within the reservoirs and the counties in which they are located. These general trends include increasing human population, increasing demand for public recreation opportunities and navigation on the Tennessee River system, and increasing development of natural habitat in rural areas and on shorelines. In addition, state and federal agencies would continue efforts to conserve natural and cultural resources, including invasive species management efforts, and to provide dispersed and developed recreation opportunities. State agency efforts would also include reducing regional impacts to water quality through water quality monitoring, certifications, and other programs.

Efforts by state and federal agencies to control invasive Asian carp species are ongoing and are expected to continue into the foreseeable future. KDFWR, TWRA, MDFWP, and the ADCNR have joined MICRA and are working with private fish processors, commercial anglers, state and federal legislators, foreign businesses, and many local, state, and federal agencies to foster interest in the removal of Asian carp and promote the ‘2007 National Asian Carp Management Plan’; a plan developed and approved by personnel from many governmental agencies (Conover et al. 2007; MICRA 2021). These agencies have implemented bait fish regulations and BMPs, formed partnerships with and provided incentives to commercial anglers for harvest of Asian carp, and promoted recreational bowfishing and consumption of carp, including organization of carp-only fishing tournaments (TWRA 2021; KDFWR 2021a; and Alabama Department of Conservation and Natural Resources 2021).

Planned improvements at existing L&Ds within the Tennessee River system include the replacement of Chickamauga Lock and an addition of a new lock at Kentucky Dam. At Chickamauga, a concrete aggregate problem causes structural concerns at the existing lock, Also, the existing 60-foot by 360-foot lock is a non-standard size that is not suited to the barges used by the transportation industry today. The planned new 110-foot by 600-foot Chickamauga Lock, designed and constructed by the USACE Nashville District, will replace the existing lock, improve locking efficiency, and solve the structural issues caused by the concrete aggregate at Chickamauga Lock (USACE 2021a). Although completion of this project is dependent upon funding, it is estimated that the project would be completed by 2024.

A feasibility report completed in 1992 recommended a new 110-foot by 1,200-foot lock adjacent and landward of the existing 110-foot by 600-foot lock at Kentucky Dam (USACE 2021b). Construction is ongoing, and it is estimated that the project could be completed in six years with full funding (USACE 2021b).

3.24.3 Analysis of Cumulative Effects

Regional resource quality is influenced by the aggregate actions of all landowners within the Tennessee River watershed. For example, continued shoreline development spurred by population growth, whether for recreational or industrial purposes, could involve extensive clearing and grading, increased impervious surfaces, and result in possible point source pollution to the adjoining reservoir. Additionally, development or other changes in land use on non-TVA lands within the watershed could impact water quality or other environmental resources in lands surrounding each reservoir. However, the extent of impacts associated with any of these land uses would be dependent on the specifics of future development and as such any analysis of impacts would be speculative.

The installation and operation of the fish barrier systems considered in this analysis would require minor, localized ground disturbance and construction activities. Therefore, there would be no cumulative impacts to air quality, climate change, floodplains, solid and hazardous waste, noise, visual resources, navigation or public health and safety associated with any construction or ground disturbing activity. Accordingly, the potential for cumulative effects is largely driven by the change in recreation use and the associated economic impacts.

Under the No Action Alternative, recreational use of the Tennessee River would decline as a result of invasion of Asian carp. However, future development of regional recreation opportunities provided by TVA and other federal and state agencies associated with increases in human population and demand would likely offset some of the potential recreation and economic impacts, as recreationists would move to other reservoirs further upstream or participate in other activities, such as camping, hiking, and other land-based recreational activities. However, without aggressive control efforts, adverse cumulative economic impacts associated with the loss of sport fisheries, together with declines in other recreational use, could be moderate.

Under Alternative G, controlling the invasion of Asian carp within the Tennessee River system due to installation of the fish barrier systems together with implementation of programs by other agencies to target and remove carp from the Tennessee River system would enhance recreational opportunities and associated economic benefits. As such cumulative impacts associated with implementation of Alternative G would have a beneficial impact to aquatic ecosystems, recreation, and associated tourism dollars.

Because the current lock would remain open throughout construction of improvements planned at Kentucky Dam, cumulative impacts would be minimal. However, if closure of the Chickamauga lock overlaps with construction of the fish barrier systems at other L&D sites, there could be a cumulative impact to recreation and navigation. This impact would be temporary and minimized with proper planning and construction scheduling designed to minimize interruptions in lock usage across the Tennessee River system, resulting in a minor, temporary impact to recreation and navigation.

3.25 Unavoidable Adverse Environmental Impacts

Unavoidable adverse impacts are the effects of the proposed action on natural and human resources that would remain after mitigation measures or best management practices have been applied. Mitigation measures and best management practices are typically implemented to reduce a potential impact to a level that would be below the threshold of significance as defined by the CEQ and the courts. Impacts associated with the proposed installation of fish barriers within the Tennessee River system have the potential to cause unavoidable adverse effects to natural and human environmental resources.

Under the No Action Alternative, the abundance of Asian carp within TVA reservoirs would increase which would have a moderate and long-term negative impact on recreation and economics. This impact would primarily be associated with the loss of sportfishing revenue as well as use and enjoyment of the reservoirs associated with boating and other recreational activities.

Installation of the proposed fish deterrent systems under alternative G would result in soil disturbance and displaced sediment caused by construction and dredging activities. Land disturbance associated with the construction of components of the deterrent systems, including equipment buildings and use of temporary laydown areas, could result in increased erosion and sedimentation. Sediment controls and BMPs to minimize erosion would be implemented, and water released by construction activities would meet permit limits.

Installation of supply lines and anchoring systems within the lock approaches would temporarily impact water quality by increasing soil disturbance and displacing sediments. However, this would be minimized by the lentic nature of lock approaches, which would minimize the movement of suspended sediments downstream. Activities associated with the use of construction equipment may also result in varying amounts of dust, air emissions, and noise. Emissions from construction activities and equipment are minimized through implementation of mitigation measures, including proper maintenance of construction equipment and vehicles.

3.26 Relationship of Short-Term Uses and Long-Term Productivity

NEPA requires a discussion of the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. This EA focuses on the analysis of environmental impacts associated with the installation of fish barriers at multiple TVA locks within the Tennessee River system. For the purpose of this section, these activities are considered short-term uses of the environment, and the long-term impacts to site productivity are those that last beyond the life of the project.

Most environmental impacts during construction activities would be relatively short-term and would be addressed by BMPs and mitigation measures. Construction activities would have a limited, yet favorable short-term impact to the local economy through the creation of construction jobs and associated revenue.

The actions proposed under Alternative G would assist in creating a long-term positive impact to the productivity of the Tennessee River, by decreasing Asian carp populations and preventing long-term negative impacts to natural ecosystems and recreational fishing in the Tennessee River system.

3.27 Irreversible and Irretrievable Commitments of Resources

An irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed. Irreversible is a term that describes the loss of future options. It applies primarily to the impacts of use of nonrenewable resources, such as minerals or cultural resources, or to those factors such as soil productivity, that are renewable only over long periods of time. A commitment of a resource would be considered irretrievable when the project would directly eliminate the resource, its productivity, or its utility for the life of the project and possibly beyond. Resources required by construction activities, including labor and construction materials, would be irretrievably lost. Nonrenewable fossil fuels would be irretrievably lost through the use of gasoline and diesel-powered equipment during construction. Additionally, nonrenewable fossil fuels would be irretrievably lost through the use of a backup generator and repeated delivery of CO_2 via truck for the operation of the CO_2 system. However, it is unlikely that their limited use in these projects would adversely affect the overall future availability of these resources

CHAPTER 4 – LIST OF PREPARERS

4.1 NEPA Project Management

Name:	**Elizabeth Smith**
Education:	B.A., Environmental Studies and Geography
Project Role:	TVA Project Manager, TVA NEPA Coordinator, NEPA Compliance
Experience:	11 years in NEPA compliance and document preparation

Name:	**Bill Elzinga**
Education:	M.S. and B.S., Biology
Project Role:	Wood Project Manager
Experience:	35 years of experience managing and performing NEPA analyses for electric utility industry, and state/federal agencies; ESA compliance; CWA evaluations

Name:	**Karen Boulware**
Education:	M.S., Resource Planning and B.S., Geology
Project Role:	Wood Deputy Project Manager. Air Quality; and Climate Change and GHG
Experience	26 years of professional experience in NEPA.

4.2 Other Contributors

TENNESSEE VALLEY AUTHORITY

Name:	**Steve Cole**
Education:	PhD, Anthropology; MA, Anthropology; and BA, Anthropology
Project Role:	Cultural Resources
Experience:	32 years in Archaeology and Cultural Resources Management

Name:	**Adam Dattilo**
Education:	M.S., Forestry
Project Role:	Vegetation; Threatened and Endangered Plants; Managed and Natural Areas
Experience:	10 years botany, restoration ecology, threatened and endangered plant monitoring/surveys, invasive species control, as well as NEPA and ESA compliance

Name:	**Elizabeth B. Hamrick**
Education:	M.S., Wildlife and Fisheries Science and B.A. Biology
Project Role:	Terrestrial Ecology (Animals), Terrestrial Threatened and Endangered Species; Wildlife
Experience:	17 years conducting field biology, 12 years technical writing, 8 years compliance with NEPA and ESA

Name:	**Britta Lees**
Education:	M.S., Botany

Project Role:	Wetland Biologist
Experience:	15 years in wetland assessment, impact analysis, and compliance

Name:	**A. Chevales Williams**
Education:	B.S. Environmental Chemical Engineering
Project Role:	Surface Waters
Experience:	16 years of experience in water quality monitoring and compliance; 13 years in NEPA planning and environmental services

Name:	**Carrie Williamson, P.E., CFM**
Education:	B.S. and M.S., Civil Engineering
Project Role:	Floodplains and Flood Risk
Experience:	8 years in Floodplains and Flood Risk; 3 years in River Forecasting; 11 years in Compliance Monitoring

Name:	**Todd Amacker**
Education:	M.S. Wildlife and Fisheries Science, B.S. Environmental Science
Project Role:	Aquatic Ecology, Aquatic T&E Species
Experience:	8 years working with threatened and endangered aquatic fauna in the American Southeast; 4 years in Environmental Reviews

WOOD ENVIRONMENT AND INFRASTRUCTURE SOLUTIONS, INC.

Name:	**Chris Musselman**
Education:	**B.S. Biology and M.S. Fisheries and Aquatic Ecology**
Project Role:	Technical Review, Chapters 1 and 2; Geology; Groundwater; Solid/Hazardous Waste; Transportation; Navigation; and Public Health and Safety
Experience:	Over 10 years of fisheries experience (including direct experience with Asian carp in the Illinois, Missouri, and Mississippi rivers) and over 5 years of NEPA analysis and documentation.

Name:	**Matt Basler**
Education:	M.S., Fisheries Science/Management and B.S., Wildlife and Fisheries
Project Role:	Aquatic Resources; Threatened and Endangered Species and Wildlife Resources Review
Experience:	Expertise in fisheries and wildlife science (population studies/surveys, habitat measurements and improvement, stream and wetland delineation, fisheries management, lake renovation, aquatic vegetation sampling and identification)

Name:	**Natalie Kleikamp**
Education:	B.A., Biology

Project Role:	Land Use and Prime Farmland; Mitigation Measures; Socioeconomics and Environmental Justice; Noise; and Visual Resources
Experience:	6 years of experience in NEPA analysis and documentation
Name:	**Stephanie Miller**
Education:	M.S., Biology and B.S., Marine Biology
Project Role:	Surface Waters; Wetlands; Threatened and Endangered Species; Aquatic Ecology; and Wildlife reviews
Experience:	9 years of experience in aquatic and terrestrial ecology
Name:	**Rebecca Porath**
Education:	M.S. and B.S., Wildlife and Fisheries Sciences
Project Role:	Cumulative Effects and Recreation; Threatened and Endangered Species; Vegetation, Aquatic Ecology; and Wildlife reviews; technical editing and document management
Experience:	22 years of experience in NEPA analysis and documentation, ecological studies, and preparation of technical documents
Name:	**Matthew Bingham**
Education:	M.S. Economics
Project Role:	Economic Impact
Experience:	25 years of experience in economic impact analyses

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CHAPTER 5 – PROGRAMMATIC ENVIRONMENTAL ASSESSMENT RECIPIENTS

Following is a list of the agencies, tribes, and organizations who received copies of the Draft PEA or notice of its availability with instructions on how to access the PEA on the TVA project webpage. TVA also sent notification to elected officials.

5.1 Federal Agencies

U.S. Department of Agriculture
National Forests in Alabama (USDA)
U.S. Environmental Protection Agency
U.S. Department of Interior
U.S. Forest Service

5.2 Federally Recognized Tribes

Absentee Shawnee Tribe of Indians of Oklahoma,
Alabama-Coushatta Tribe of Texas,
Alabama-Quassarte Tribal Town, Cherokee Nation, T
The Chickasaw Nation,
Coushatta Tribe of Louisiana,
Delaware Nation,
Eastern Band of Cherokee Indians,
Eastern Shawnee Tribe of Oklahoma,
Jena Band of Choctaw Indians,
Kialegee Tribal Town,
Muscogee (Creek) Nation,
Osage Nation,
Poarch Band of Creek Indians,
Quapaw Nation,
Seminole Nation of Oklahoma,
Shawnee Tribe,
Thlopthlocco Tribal Town,
United Keetoowah Band of Cherokee Indians in Oklahoma.

5.3 State Agencies

Alabama Forestry Commission
Top of Alabama Regional Council of Governments
Alabama Department of Conservation and Marine Resources
Alabama Department of Economic and Community Affairs
Northwest Alabama Council of Local Governments
Alabama Department of Conservation and Natural Resources
Alabama Department of Environmental Management
Alabama Department of Transportation
Alabama Department of Agriculture and Industries
North-Central Alabama Regional Council of Governments
Alabama Historical Commission
Kentucky Department for Natural Resources
Kentucky Heritage Council
Kentucky Department for Environmental Protection
Kentucky State Clearinghouse

Kentucky Energy and Environment Cabinet
Kentucky Department for Environmental Protection
Kentucky Energy and Environment Cabinet
Office of Environmental Policy and Compliance
Commissioner's Office Department for Environmental Protection
Northeast Mississippi Planning and Development District
Mississippi Department of Environmental Quality
Tombigbee River Valley Water Management District
Mississippi Department of Wildlife, Fisheries, and Parks
Mississippi Department of Finance and Administration
Mississippi Department of Archives and History
Office of Environmental Policy and Compliance
Upper Cumberland Development District
Southwest Tennessee Development District
Tennessee Division of Archaeology
Tennessee Division of Forestry
East Tennessee Development District
Natural Resources Conservation Service
Northwest Tennessee Development District
Tennessee Department of Environment and Conservation
Greater Nashville Regional Council
Tennessee Department of Transportation
Tennessee Department of Economic and Community Development
South Central Tennessee Development District
Tennessee Historical Commission
Tennessee Department of Transportation
Tennessee Department of Agriculture
First Tennessee Development District
Memphis Area Association of Governments
Tennessee Wildlife Resources Agency

5.4 Individuals and Organizations

Watts Bar Ecology and Fishery Council
Tellico Cruising Club

CHAPTER 6 – LITERATURE CITED

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Appendix A – Public and Agency Comments on the Draft PEA and TVA's Response to Comments

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Appendix B – Conceptual Designs for Fish Barrier Systems by Lock and Dam

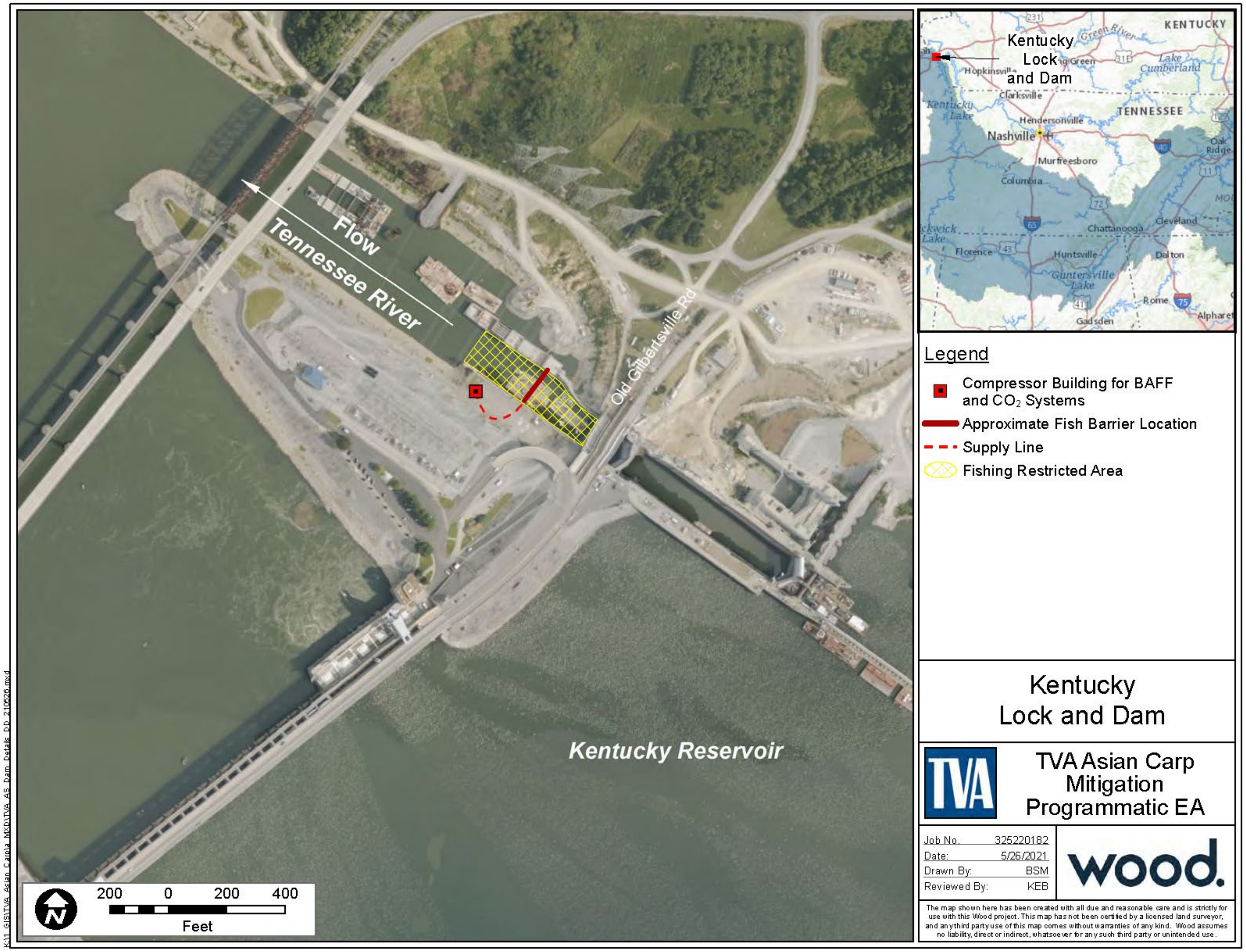

Figure B-1. Conceptual Design for Fish Barrier Systems at Kentucky Lock and Dam

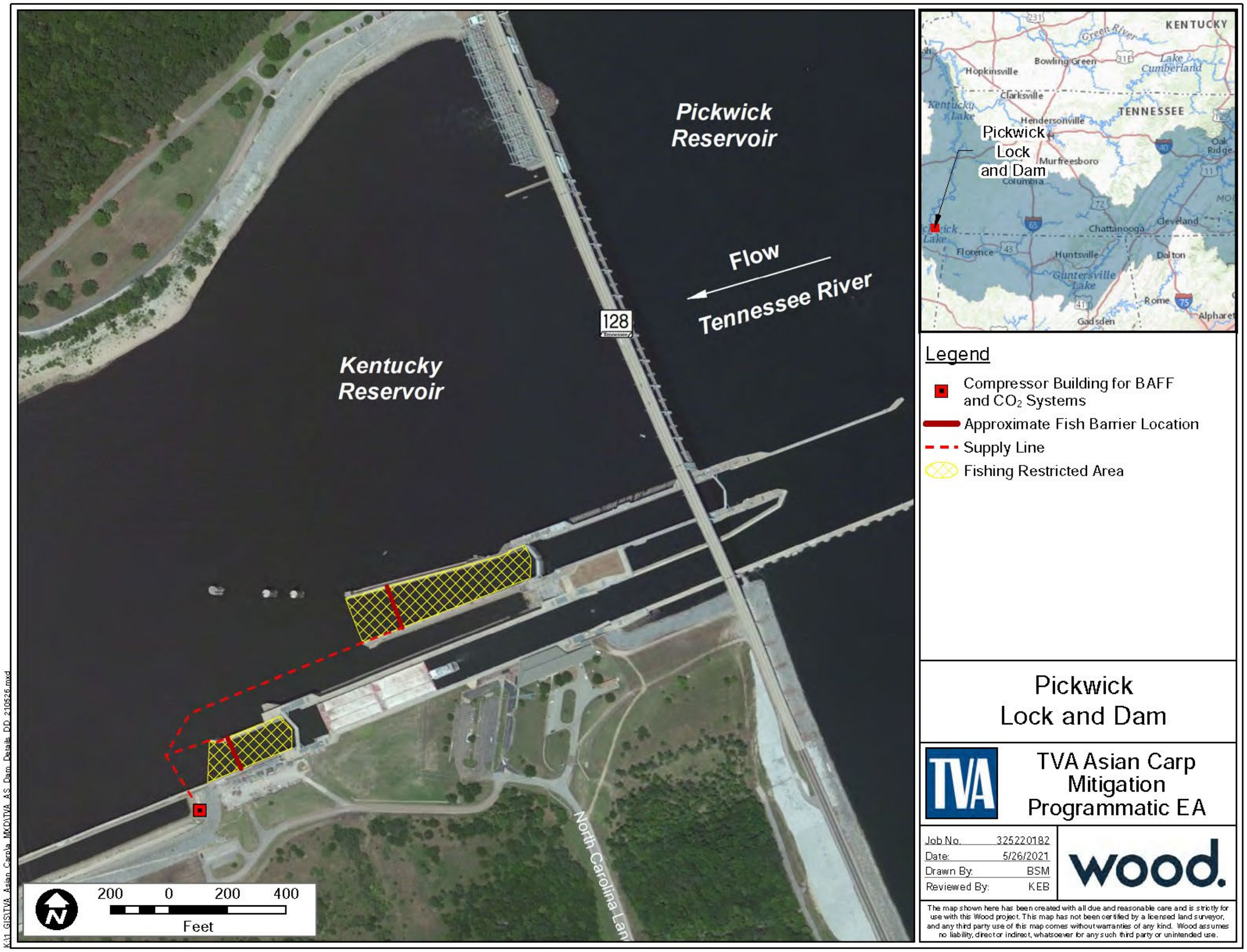

Figure B-2. Conceptual Design for Fish Barrier Systems at Pickwick Lock and Dam

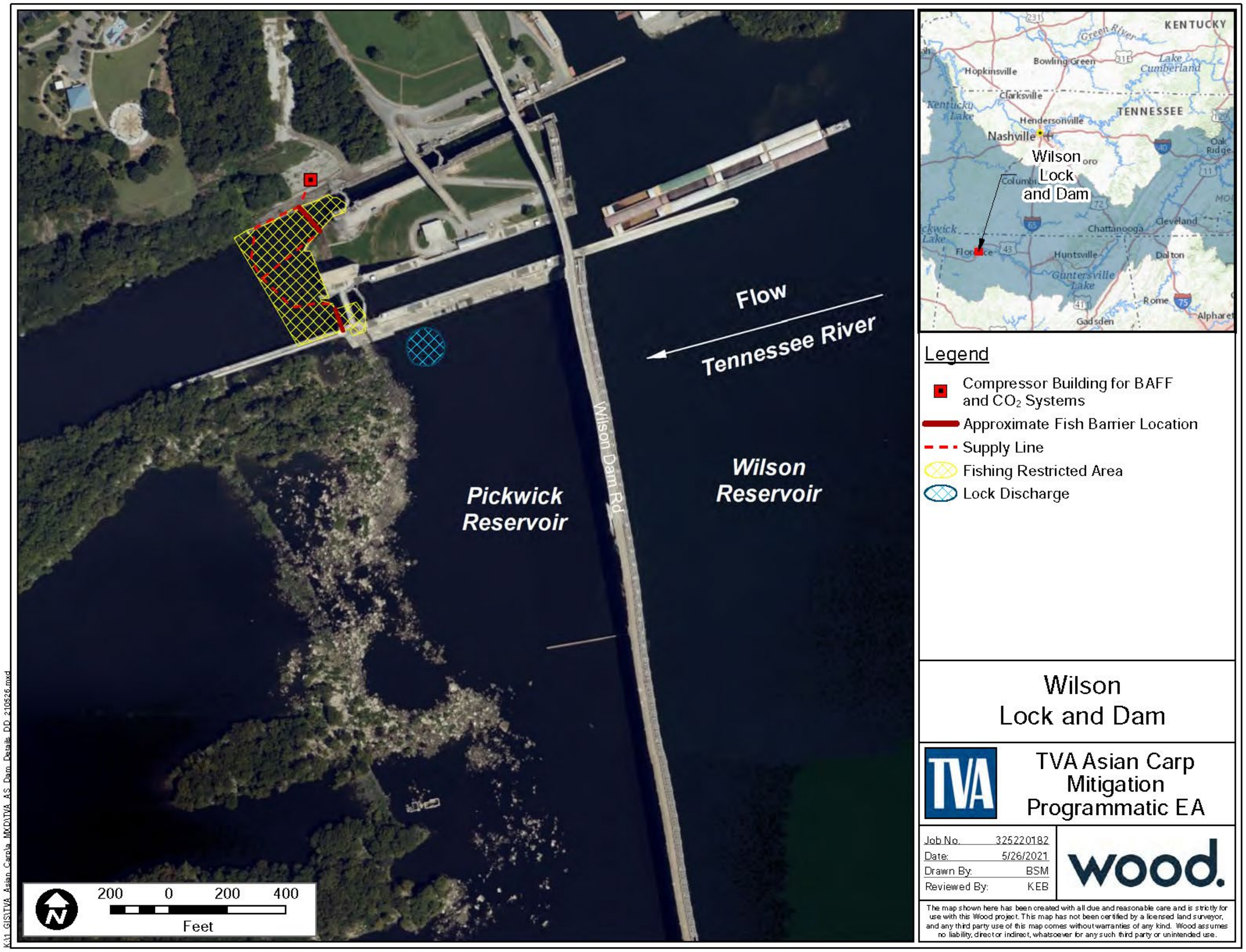

Figure B-3. Conceptual Design for Fish Barrier Systems at Wilson Lock and Dam

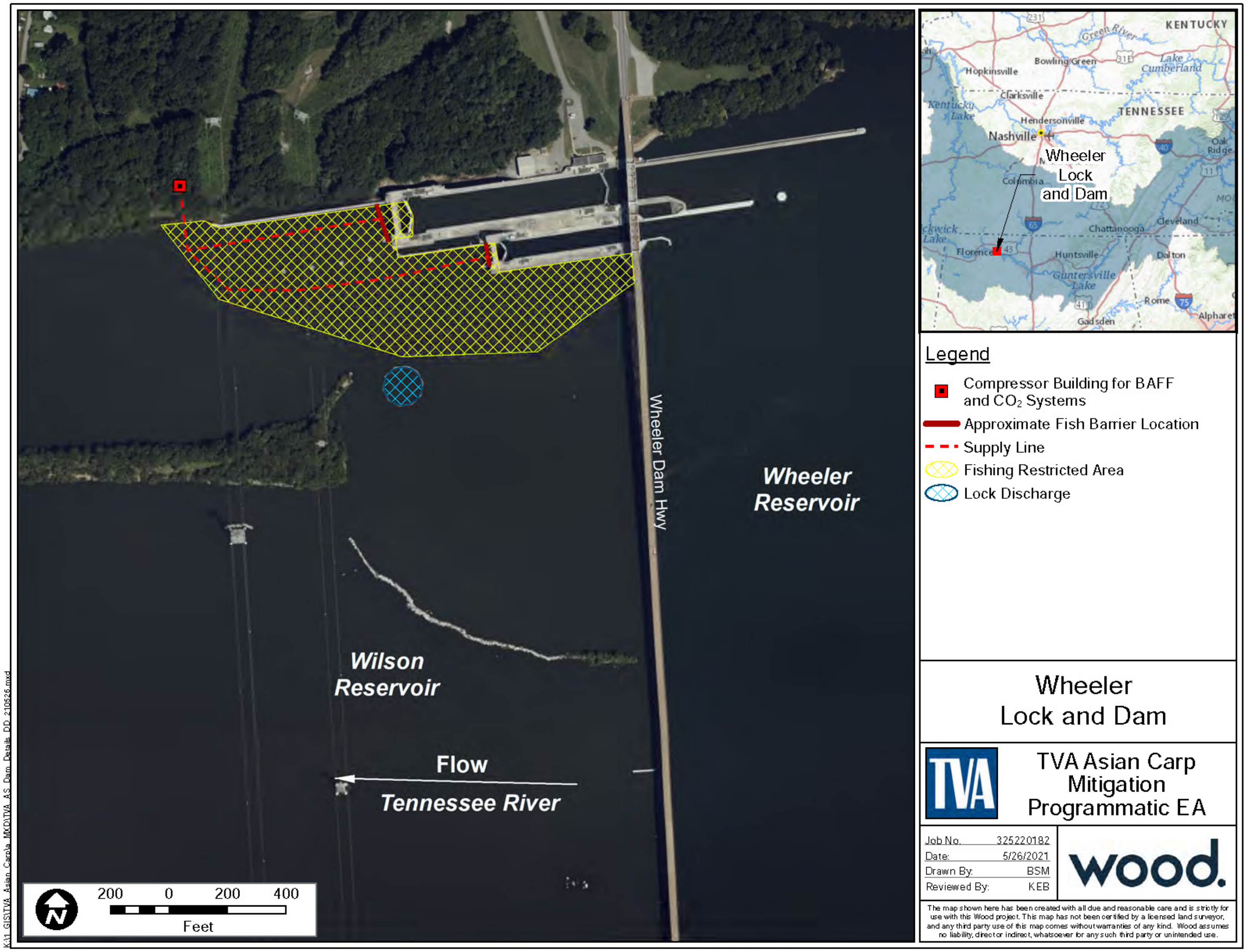

Figure B-4. Conceptual Design for Fish Barrier Systems at Wheeler Lock and Dam

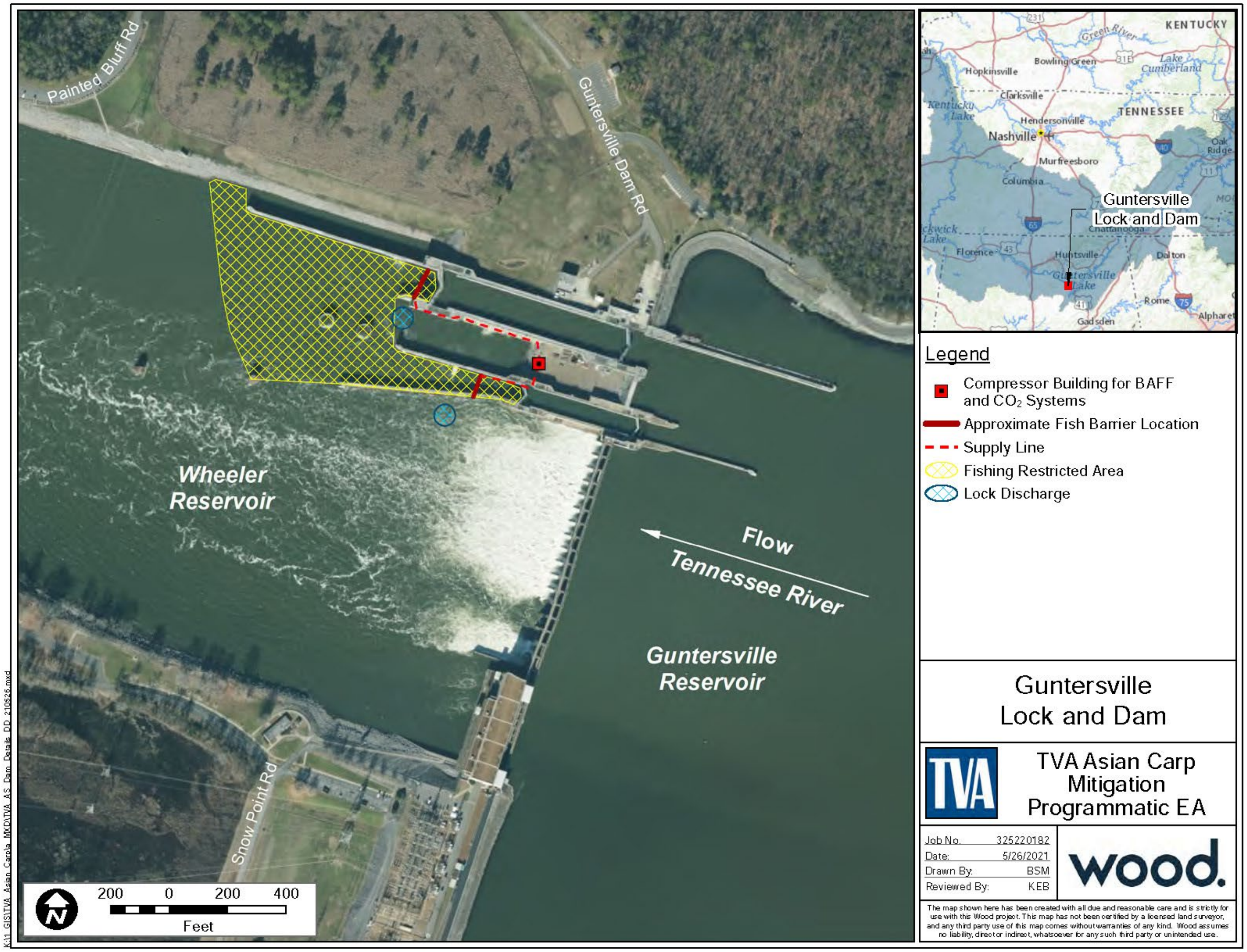

Figure B-5. Conceptual Design for Fish Barrier Systems at Guntersville Lock and Dam

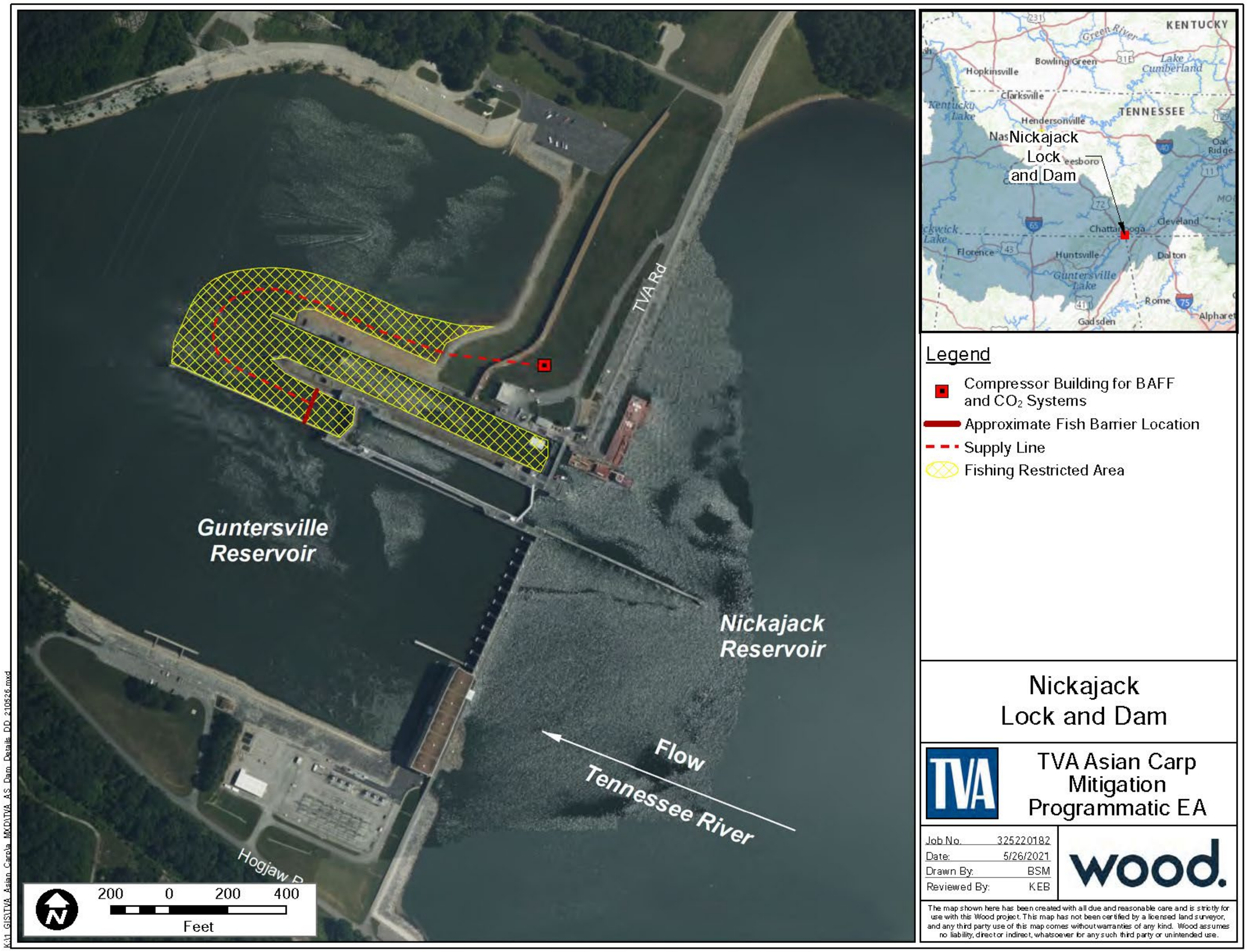

Figure B-6. Conceptual Design for Fish Barrier Systems at Nickajack Lock and Dam

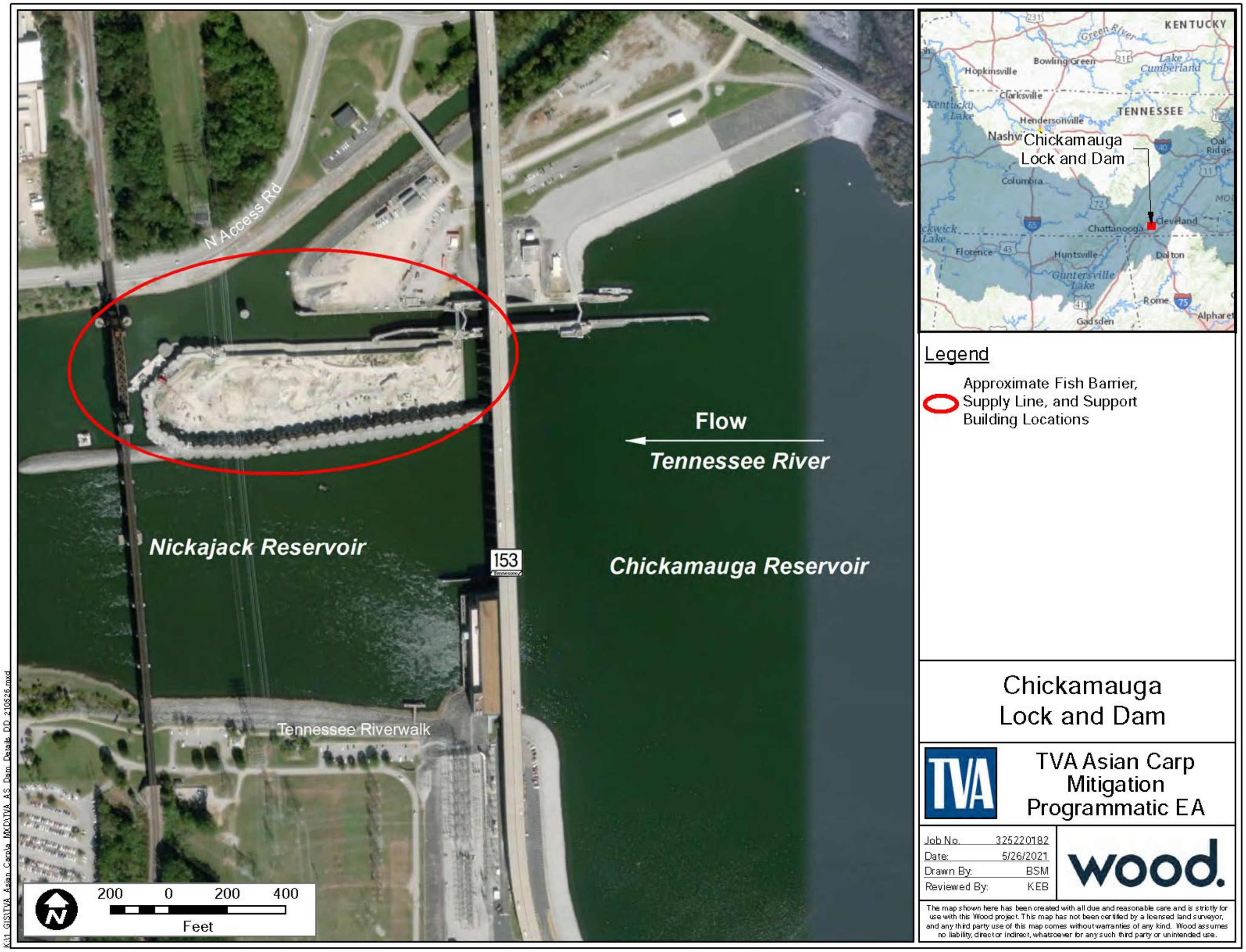

Figure B-7. Conceptual Locations for Fish Barrier Systems at Chickamauga Lock and Dam (Currently Under Construction)

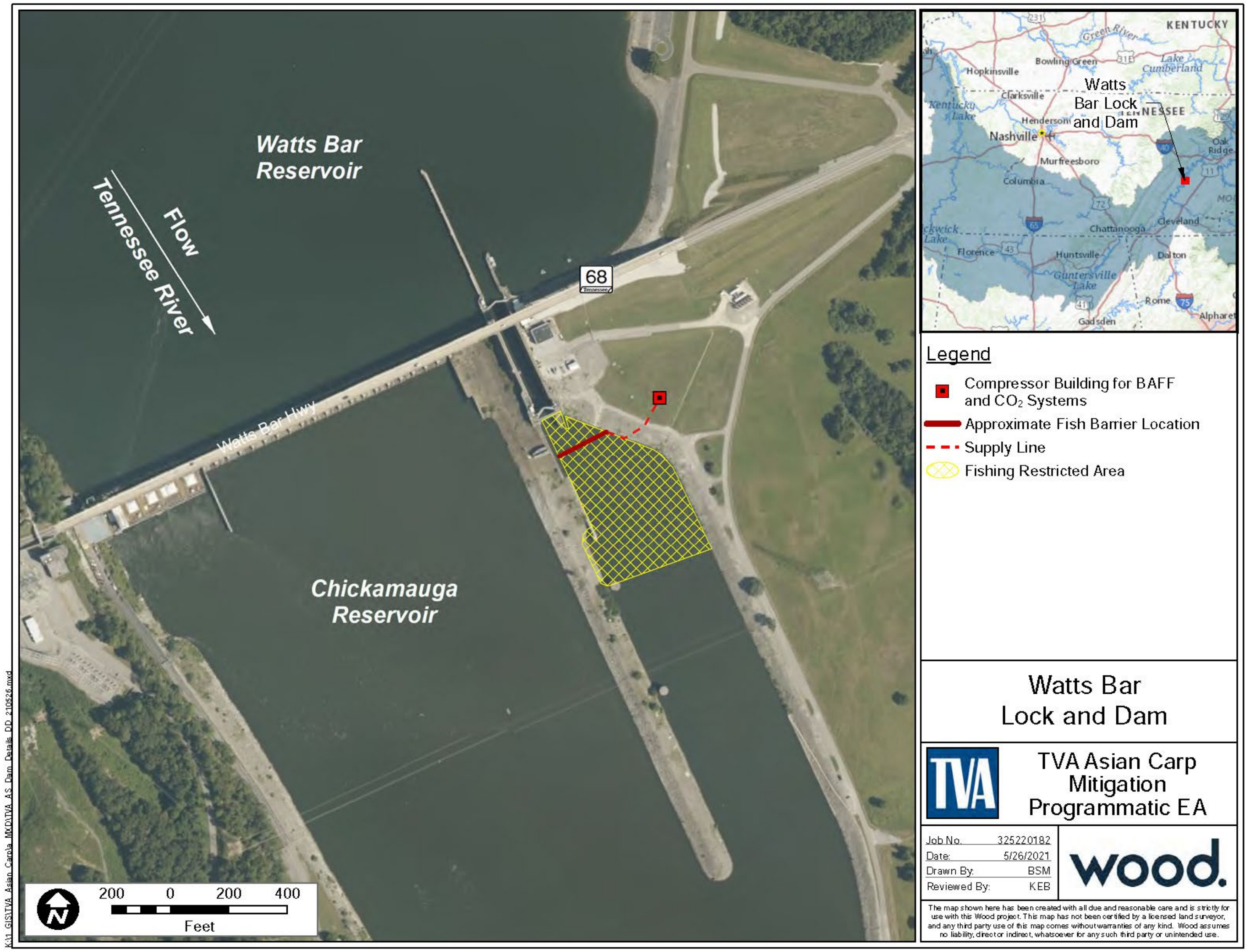

Figure B-8. Conceptual Design for Fish Barrier Systems at Watts Bar Lock and Dam

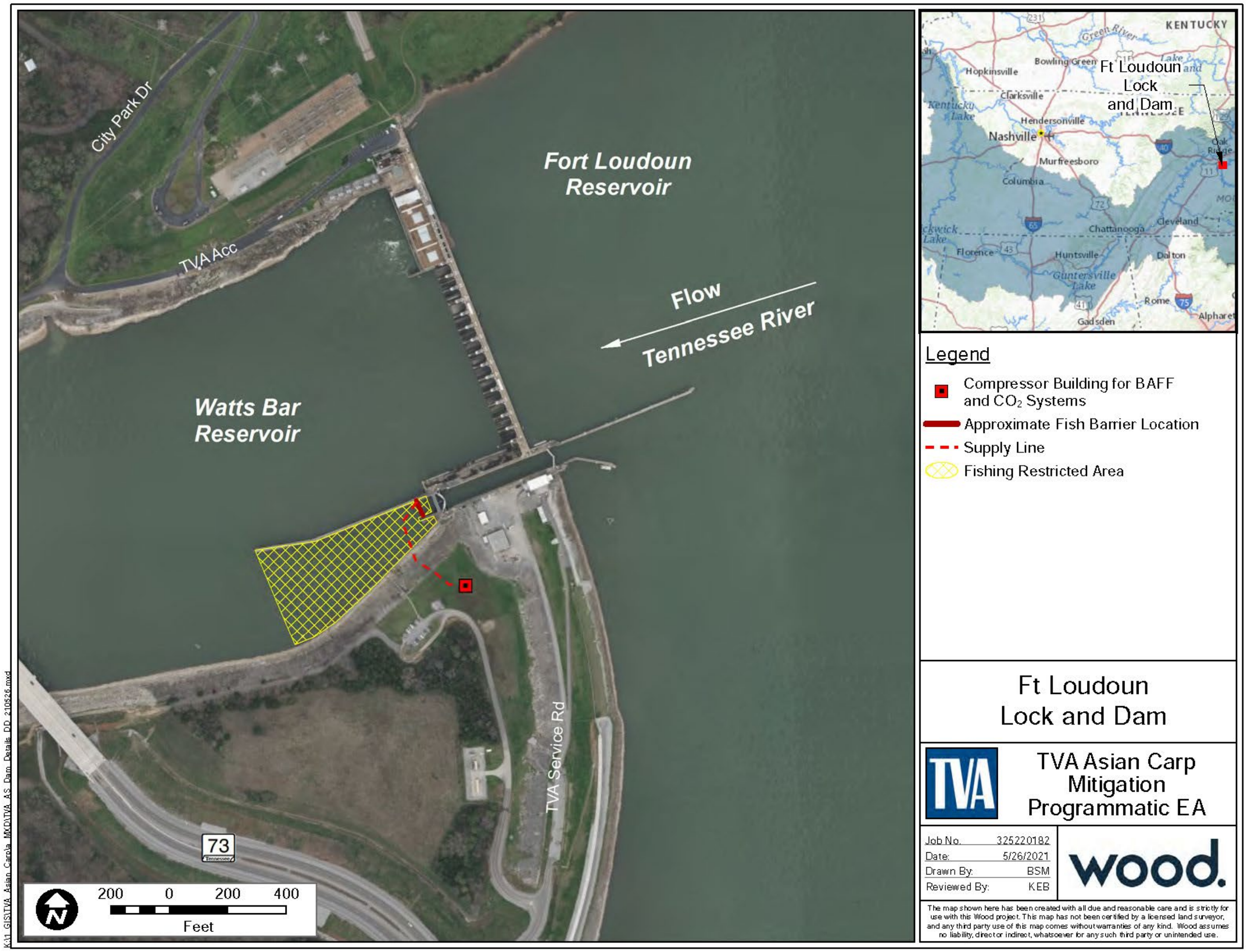

Figure B-9. Conceptual Design for Fish Barrier System at Ft. Loudoun Lock and Dam

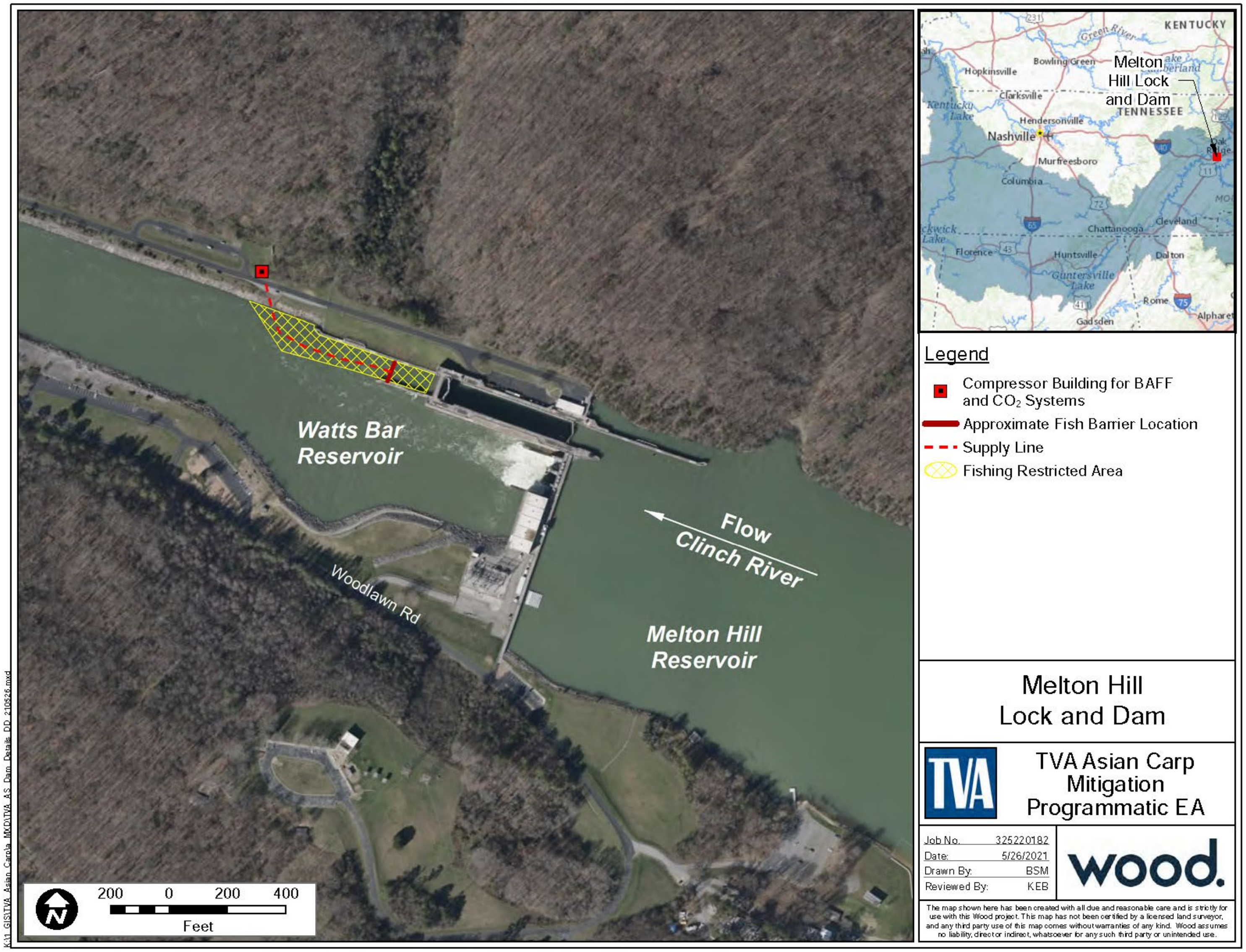

Figure B-10. Conceptual Design for Fish Barrier System at Melton Hill Lock and Dam

Appendix C – FluEgg Asian Carp Egg Transport Modeling in the TVA River System

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Appendix D – Tennessee River Asian Carp Deterrent Workshop Recommendations

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Appendix E – Agency Coordination

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