WATER STRATEGY, HYDRO LICENSING AND LAKE SERVICES

Duke Energy Corporation
526 South Church Street / EC12Y
Charlotte, NC 28202

February 23, 2022

Electronically Filed

The Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street N.E.
Washington, DC 20426

Subject: **Bad Creek Pumped Storage Project (P-2740)**
Notice of Intent and Pre-Application Document

Dear Secretary Bose:

Duke Energy Carolinas, LLC (Duke Energy or Applicant) is submitting to the Federal Energy Regulatory Commission (FERC or Commission) the Notice of Intent (NOI) to file an application for a new license and Pre-Application Document (PAD) for the 1,400-megawatt (MW) Bad Creek Pumped Storage Project (FERC No. 2740) (Project), located in Oconee County, South Carolina. The existing FERC license for the Project expires on July 31, 2027.

The Bad Creek Reservoir was formed from the damming of Bad Creek and West Bad Creek and serves as the Project's upper reservoir. Lake Jocassee, licensed as part of the Duke Energy Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), serves as the lower reservoir. The Project is operated by Duke Energy under the terms of an Original License issued by the FERC on August 1, 1977, as subsequently amended. The construction of Bad Creek took roughly 10 years, and the Project began operating in 1991. The structures and features included in the Bad Creek Project license include the upper reservoir and dams, inlet/outlet structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and a 9.25-mile-long transmission line extending from Bad Creek to the KT Project's Jocassee switchyard.

Given the need for additional significant energy storage and renewable energy generation across Duke Energy's service territories over the Project's new license term, Duke Energy is evaluating opportunities to add storage and generating capacity at the Project by constructing a new power complex (including a new underground powerhouse) adjacent to the existing Bad Creek Powerhouse. Construction of the 1,400-MW Bad Creek II Power Complex is one alternative relicensing proposal presently being evaluated by Duke Energy.

The Applicant is distributing this letter to the stakeholders listed on the Project distribution list provided in Appendix A of the PAD. For those stakeholders who have provided an email address, this letter will be distributed via e-mail; otherwise, it will be distributed via U.S. mail. Stakeholders interested in the relicensing process may obtain a copy of the NOI and PAD electronically through

FERC's eLibrary at https://elibrary.ferc.gov/idmws/search/fercgensearch.asp under docket number P-2740 or on the Applicant's website at www.badcreekpumpedstorage.com. If any stakeholder would like to request a CD containing an electronic copy of the NOI and PAD, please contact the undersigned at the address listed below. The NOI and PAD are also available for review at the Applicant's business office during regular business hours located at 526 South Church Street Charlotte, NC 28202.

Appendix D of the PAD includes a single-line electrical diagram of the Project, as required by the Commission's PAD content requirements under 18 CFR § 5.6(d)(2)(iii)(D). The information contained in these drawings are deemed as Critical Energy/Electric Infrastructure Information (CEII) under 18 CFR §388.113, thus Appendix D of the PAD is not being distributed to the public and the Applicant is filing Appendix D under the Commission's relevant eFiling guidelines. Appendix E of the PAD includes Privileged information regarding cultural resources and a while a redacted version will be available to the public, the original (non-redacted) report is being filed as Privileged (non-public) to protect the locations of certain cultural resources.

In accordance with 18 CFR §5.5(e) of the Commission's regulations, the Applicant requests that the Commission designate Duke Energy as the Commission's non-federal representative for purposes of consultation under Section 106 of the National Historic Preservation Act (NHPA), 16 U.S.C. § 470f and the NHPA implementing regulations at 36 CFR Part 800.

In addition, the Applicant requests that FERC designate Duke Energy as the non-federal representative for the Project for the purpose of consultation with the U.S. Fish and Wildlife Service and National Marine Fisheries Service, pursuant to Section 7 of the Endangered Species Act (ESA) and the joint agency ESA implementing regulations at 50 CFR Part 402.

Duke Energy looks forward to working with Commission staff, resource agencies, Indian Tribes, local governments, non-governmental organizations, and interested members of the public throughout the relicensing process. If there are any questions regarding filing, please contact Alan Stuart, Senior Project Manager, Water Strategy & Hydro Licensing at Alan.Stuart@duke-energy.com or via phone at 980-373-2079.

Sincerely,

Jeffrey G. Lineberger, PE
Water Strategy & Hydro Licensing
Duke Energy Carolinas, LLC

Enclosure: Distribution List

cc (w/enclosure): Alan Stuart, Duke Energy
Garry Rice, Duke Energy

Bad Creek Pumped Storage Project (FERC No. 2740) Distribution List

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888 First St, N.E. Room 61-02
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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Duke Energy Carolinas, LLC **Project No. 2740**
Bad Creek Pumped Storage Project

NOTICE OF INTENT TO FILE APPLICATION FOR NEW LICENSE

Pursuant to 18 Code of Federal Regulations (C.F.R.) Section 5.5 of the Federal Energy Regulatory Commission (FERC or the Commission) regulations, Duke Energy Carolinas, LLC (Duke Energy), licensee for the Bad Creek Pumped Storage Project (Bad Creek or Project), FERC Project No. 2740, hereby notifies the FERC and unequivocally declares its intent to apply for a new license for the Bad Creek Pumped Storage Project.

In further accordance with 18 C.F.R. Section 5.5, the following information is provided.

1. The exact name and business address of the applicant are as follows:

   Duke Energy Carolinas, LLC
   Attention: Alan Stuart
   Mail Code EC-12Q
   526 S. Church Street
   Charlotte, NC 28202

2. The Project number is:

   FERC Project No. 2740

3. The license expires on:

   July 31, 2027

4. Duke Energy hereby states its unequivocal intent to submit an application for a new license for the Project on or before July 31, 2025.

   The application will be for a power license. Duke Energy will utilize the Commission's Integrated Licensing Process in support of this relicensing.

5. The principal works at the Project consist of the following:

The Project works consist of: (1) a 367-acre upper reservoir with a storage capacity of 33,900 acre-feet, of which 31,808 acre-feet is usable storage capacity between minimum elevation 2,150 feet mean sea level (ft msl) and full pond elevation of 2,310 ft msl; (2) a rockfill impervious core dam with crest elevation at 2,315 ft msl about 2,600 feet long and 355 feet high across Bad Creek; (3) a rockfill impervious core dam with crest elevation at 2,315 ft msl about 900 feet long and 170 feet across West bad Creek; (4) a saddle kike with crest elevation at 2,313 ft msl about 900 feet long and 90 feet high across a natural depression on the eastern rim of the reservoir; (5) an ungated water intake structure in the upper reservoir; (6) a concrete line main shaft, power tunnel, and manifold, totaling 5,026 feet long and is 29.53 feet in diameter, connecting to 4 concrete, steel-lined penstocks about 386 feet long and varying from 13.78 to 8.43 feet in diameter; (7) an underground powerhouse containing four reversible pump-generating units, with a nameplate rating of 350,000 kilowatts each for a total generating capacity of 1,400 megawatts; (8) 4 concrete-lined draft tube tunnels about 316 feet long and 16.4 feet diameter, connecting by means of a manifold structure to two concrete-lined tailrace tunnels about 875 feet long and 24.61 feet diameter; (9) an intake/outlet structure equipped with four 20-foot by 30-foot, steel lift gates located in the existing Lake Jocassee which serves as the lower reservoir; (10) transmission facilities consisting of (a) the generator leads, (b) the electrical bus housed in a vertical shaft about 528 feet high and 29.5 feet in diameter leading from the underground powerhouse to (c) four above ground 19/525-kV step-up transformers, (d) a 100-kV transmission line extending about 9.25 miles from the Bad Creek switchyard to the Jocassee switchyard, (e) a 525-kV transmission line extending about 9.25 miles from the Bad Creek Switchyard to the Jocassee Switchyard; and (11) appurtenant facilities.

As described in the Pre-Application Document that is being filed by Duke Energy concurrently with this Notice of Intent, given the need for additional significant energy storage and renewable energy generation across Duke Energy's service territories over the Project's new 40 to 50-year license term, Duke Energy is evaluating opportunities to add pumping and generating capacity at the Project. Additional energy storage and generation capacity could be developed by constructing a new power complex (including a new underground powerhouse) adjacent to the existing Bad Creek Powerhouse.

6. The location of the project by state, county, and stream, and, when appropriate, by city or nearby city.

The Project is located on Bad Creek and West Bad Creek in Oconee County, South Carolina. The Bad Creek Reservoir is located in Oconee County approximately 34 miles from Seneca, South Carolina. The four-unit Bad Creek Powerhouse is located eight miles north of the Town of Salem, also in Oconee County, South Carolina.

Lake Jocassee (lower reservoir and licensed under FERC Project No. 2503) is about 25 miles north of the City of Seneca, SC and impounds the Thompson, Horsepasture, Toxaway and Whitewater rivers. Portions of Lake Jocassee are located in Pickens and Oconee Counties, South Carolina as well as Transylvania County, North Carolina.

7. The installed plant capacity of the project:

The installed capacity of the Project is 1,400 MW[1]. Licensing and construction of the proposed Project expansion described above (Bad Creek II Complex) would increase the authorized insta1led capacity to 2,800 MW.

8. The names and mailing addresses of:

(i) Every county in which any part of the project is located, and in which any Federal facility that is used or to be used by the project is located;

Oconee County, SC
Attention: Amanda Brock
County Administrator
415 S. Pine Street
Walhalla, SC 29691

There are no federal lands or facilities associated with the Project.

(ii) Every city, town, or similar political subdivision;

(A) In which any part of the project is or is to be located and any Federal facility that is or is to be used by the project is located, or

Town of Salem, SC
Attention: Honorable Mayor Lynn Towe
5A Park Ave
Salem, SC 29676-3304

There are no federal lands or facilities associated with the Project.

[1] Duke Energy is currently performing unit upgrades at the Project to increase the original installed capacity from 1,065 MW to the currently licensed 1,400 MW.

(B) That has a population of 5,000 or more people and is located within 15 miles of the existing or proposed project dam:

There are no cities, towns, or similar political subdivisions that have a population of 5,000 or more people within 15 miles of the Project dam.

(iii) Every irrigation district, drainage district, or similar special purpose political subdivision:

(A) In which any part of the project is or is proposed to be located and any Federal facility that is or is proposed to be used by the project is located;

There are no irrigation or drainage districts or similar special purpose political subdivisions within or in the general area of the Project. There are no federal lands or facilities associated with the Project.

(B) That owns, operates, maintains, or uses any project facility or any Federal facility that is or is proposed to be used by the project;

There are no other political districts or subdivisions that are likely to be interested in or affected by the notification.

(iv) Every other political subdivision in the general area of the project or proposed project that there is reason to believe would be likely to be interested in, or affected by, the notification; and

City of Seneca, SC
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221 East North First Street
PO Box 4773
Seneca, SC 29679

(v) Affected Indian tribes.

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Catawba Indian Nation
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Cherokee Nation of Oklahoma
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Tahlequah, OK 74464

Distribution

In accordance with 18 CFR Section 5.5, Duke Energy is distributing this NOI to appropriate Federal, state, and interstate agencies, Native American Tribes, local governments, and members of the public likely to be interested in the proceeding. A complete listing of agencies, Tribes, local governments, non-governmental organizations, and individuals that are receiving this NOI is provided with the February 23, 2022 transmittal letter for this NOI. The information required to be made available to the public pursuant to 18 CFR Section 16.7 is located at the offices of Duke Energy at 526 S. Church Street, Charlotte, NC 28202.

All correspondence and service of documents relating to this NOI and subsequent proceedings should be addressed to:

Duke Energy Carolinas, LLC
Attention: Alan Stuart
Mail Code EC-12Q
526 S. Church Street
Charlotte, NC 28202
Alan.Stuart@duke-energy.com

Non-Federal Representative

In accordance with 18 CFR 5.5(e), Duke Energy is requesting designation as the Commission's non-federal representative for the purpose of consultation under Section 7 of the Endangered Species Act and the joint agency regulations thereunder at 50 CFR 402. Duke Energy also requests that FERC authorize it to initiate consultation under Section 106 of the National Historic Preservation Act and the implementing regulations at 36 CFR 800.2(c)(4).

Respectfully submitted,

Jeffrey G. Lineberger, PE
Director, Water Strategy and Hydro Licensing

PRE-APPLICATION DOCUMENT

Bad Creek Pumped Storage Project
FERC Project No. 2740

Oconee County, South Carolina

Prepared by: HDR Engineering, Inc.

Prepared for: Duke Energy Carolinas, LLC

February 23, 2022

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BAD CREEK PUMPED STORAGE PROJECT
FERC PROJECT NO. 2740
PRE-APPLICATION DOCUMENT
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APPENDICES

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
ºF	degrees Fahrenheit
AACE	Association of the Advancement of Cost Engineering
ACS	American Community Survey
acre-ft	acre-feet
APE	area of potential effects
Bad Creek (or Project)	Bad Creek Pumped Storage Project
Bad Creek II Complex	Bad Creek II Power Complex
BCE	Before Common Era
BGEPA	Bald and Golden Eagle Protection Act
BMPs	Best Management Practices
CE	Common Era
CEII	Critical Electric/Energy Infrastructure Information
CEQ	Council on Environmental Quality
CFD	computational flow dynamics
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CT	census tract
CUI	Controlled Unclassified Information
CVSZ	Central Virginia Seismic Zone
CWA	Clean Water Act
DLA	Draft License Application
DO	dissolved oxygen
Duke Energy or Licensee	Duke Energy Carolinas, LLC (formerly Duke Power Company)
EPRI	Electric Power Research Institute
ERM	Environmental Resources Management
ESA	Endangered Species Act
ESC	Erosion and Sedimentation Control
ETSZ	East Tennessee Seismic Zone
FEMA	Federal Emergency Management Agency
FERC or Commission	Federal Energy Regulatory Commission
FLA	Final License Application
FPA	Federal Power Act
fps	feet per second
ft	foot/feet
ft msl	foot/feet above mean sea level
GIS	Geographic Information System
GPS	Global Positioning System
HDR	HDR Engineering, Inc.
hp	horsepower
HUC	hydrologic unit code
ILP	Integrated Licensing Process

IPaC	Information for Planning and Consultation database
ISR	Initial Study Report
kg	kilograms
km	kilometers
KT Project	Keowee-Toxaway Hydroelectric Project
kV	kilovolt
kW	kilowatt
LiDAR	light detection and ranging
m	meter
Ma	million years ago
MBTA	Migratory Bird Treaty Act of 1918
m/s	meters per second
Mft^3	million cubic feet
mg/L	milligram per liter
mi^2	square mile
MOU	Memorandum of Understanding
MW	megawatt
MWh	megawatt-hour
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NHP	Natural Heritage Program
NHPA	National Historic Preservation Act of 1966
NOA	New Operating Agreement
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRA	Natural Resources Assessment
NRHP	National Register of Historic Places
NTU	Nephelometric Turbidity Unit
NWI	National Wetland Inventory
OHWM	Ordinary High Water Mark
OPCC	opinion of probable construction cost
OWR	Outstanding Resources Waters
PAD	Pre-Application Document
PEM	palustrine emergent
PFO	palustrine forested
PGA	Peak Ground Acceleration
PLP	Preliminary Licensing Proposal
PM&E	protection, mitigation, and enhancement
Project or Bad Creek	Bad Creek Pumped Storage Project
PSP	Proposed Study Plan
PURPA	Public Utility Regulatory Policies Act of 1978
REMI	Reservoir Environmental Management, Inc.
RM	river mile
RROC	Regulated Renewables Operations Center
RSP	Revised Study Plan
RTE	rare, threatened, and endangered

RUN	Recreation Use and Needs
SCDHEC	South Carolina Department of Health and Environmental Control
SCHT	South Carolina Heritage Trust
SCDNR	South Carolina Department of Natural Resources (formerly South Carolina Wildlife and Marine Resources Department)
SCDAH	South Carolina Department of Archives and History
SCDPRT	South Carolina Department of Parks, Recreation and Tourism
SCE&G	South Carolina Electric & Gas (now Dominion Energy SC)
SCORP	State Comprehensive Outdoor Recreation Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SEPA	Southeastern Power Administration
SHPO	State Historic Preservation Officer
SMP	Shoreline Management Plan
SWAP	South Carolina State Wildlife Action Plan
TFF	Tallulah Falls Formation
TGn	Toxaway Gneiss
TNW	Traditional Navigable Water
TPGT	Trout Put, Grow, and Take
upper reservoir	Bad Creek Reservoir
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report

1 Introduction

1.1 Project Overview

The Bad Creek Pumped Storage Project (Bad Creek or Project; Federal Energy Regulatory Commission [FERC] Project No. 2740) is located in Oconee County, South Carolina, approximately eight miles north of Salem. The Bad Creek Reservoir (or upper reservoir) was formed from the damming of Bad Creek and West Bad Creek and serves as the Project's upper reservoir. Lake Jocassee, licensed as part of the Duke Energy Carolinas, LLC (Duke Energy or Licensee) Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), serves as the lower reservoir. The Project is operated by Duke Energy under the terms of an Original License issued by the FERC on August 1, 1977, as subsequently amended. The construction of Bad Creek took roughly 10 years, and the Project began operating in 1991. The structures and features included in the Bad Creek Project license include the upper reservoir and dams, inlet/outlet structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and an approximately 9.25-mile-long transmission line corridor extending from Bad Creek to the KT Project's Jocassee switchyard.

The entire Bad Creek Powerhouse is built within a large cavern inside a mountain. Similar to other hydroelectric stations, the engineering design of the Project involves the flow of water to produce electricity, however, because about 1,200 vertical feet separate the upper and lower reservoirs, Bad Creek is better able to take advantage of gravity to produce larger quantities of electricity.

The now 30-year-old Project is one of the most powerful and flexible energy generation and storage assets in Duke Energy's system. Built primarily to store surplus energy from baseload nuclear and fossil fuel power plants during times of low energy demand, today Bad Creek is used to balance an increasingly complex energy grid. Pumping water from Lake Jocassee up to the Bad Creek Reservoir (Figure 1.1-1) provides a means of storing energy from surplus baseload generation during low demand periods and other non-dispatchable renewables generation during certain periods, and Project operation in turbine mode, from the Bad Creek Reservoir to Lake

Jocassee, provides power back to the grid when energy demand is higher or renewable generation is not available (Figure 1.1-2).

Figure 1.1-1. View of the Bad Creek Project (Upper Reservoir Not Visible from this Perspective)

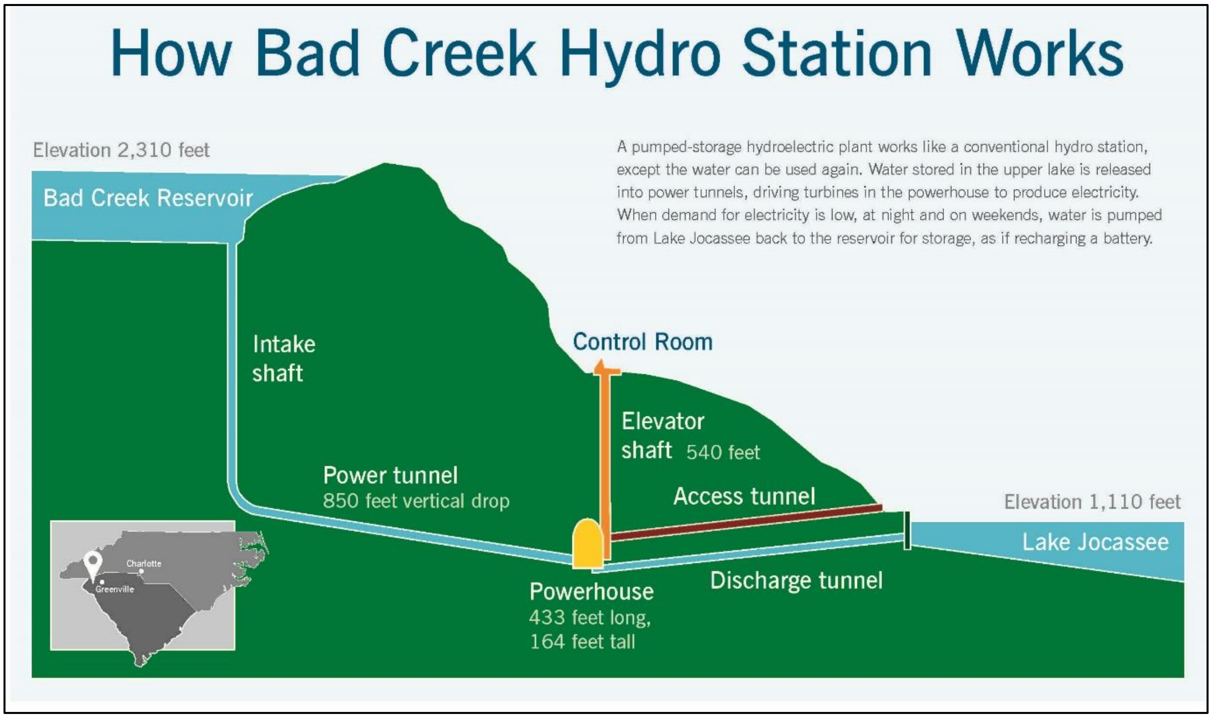

Figure 1.1-2. Schematic Cross-Section of the Bad Creek Project (Source: Moore 2016)

1.2 Value of Pumped Storage – Existing and Future License Periods

The construction of Bad Creek took roughly 10 years and cost $1 billion – it was finished one year ahead of schedule and $90 million under budget when it opened in 1991 (Moore 2016). At the time Bad Creek was constructed, Duke Energy operated 3 nuclear stations, 8 coal-fired stations and 26 hydroelectric stations in the Carolinas, with a combined capacity of 15,500 megawatts (MW). As the population in the Carolinas has grown and energy demand increased, Duke Energy has worked collaboratively with customers and other stakeholders to invest in a diverse portfolio of generation resources, enabled by the need for an increasingly resilient grid, to respond to the region's growing energy needs and economic growth. The diverse nuclear, coal, natural gas, renewables, and hydroelectric generation facilities owned by Duke Energy provides about 36,900 MW of owned electricity capacity to 4.3 million customers within its service area across North Carolina and South Carolina (Duke Energy 2020; Duke Energy Progress 2020). Even with the expansion of energy efficiency and demand reduction programs contributing to declining per capita energy usage, cumulative annual energy consumption in the

Carolinas is expected to grow by approximately 14,250 gigawatt-hours between 2021 and 2035 due to the projected population and household growth exceeding the national average.

In addition to preparing for growing demand, planning for retirement of some of the older, less efficient generation resources has created an additional need of at least 7,875 MW over the 15-year planning horizon per the Integrated Resources Plan (Duke Energy 2020; Duke Energy Progress 2020). After accounting for the required reserve margin, approximately 10,800 MW of new resources are projected to be needed over the 15-year planning horizon (Duke Energy 2020; Duke Energy Progress 2020). Duke Energy the Company is now overseeing the largest coal retirement program in the industry and plans to retire all coal-only units by 2035. Duke Energy now has more than 8.0 gigawatts of renewable energy contracted, owned, or operated. By 2025, Duke Energy plans to roughly double that figure and, by 2030, triple the current renewable capacity for its regulated utilities. Duke Energy, as a company, has committed to reduce carbon dioxide emissions by at least 50 percent from 2005 levels by 2030, and to achieve net-zero by 2050 (Duke Energy 2020). By 2050, the largest source of energy in Duke Energy's regulated utilities will come from renewable energy resources, representing about 40 percent of capacity. Expansion and accelerated development of Duke Energy's energy storage portfolio is a necessary complement to this renewables growth, and Duke Energy presently projects more than 13,000 megawatts of energy storage on its system by 2050. Over the next five years, Duke Energy has plans for $600 million in new battery storage investment across its regulated businesses, including deploying 50 MW of batteries totaling $100 million in Florida, and the 9-MW Asheville storage project Duke Energy brought online in 2020 – the largest battery system in North Carolina.

The Bad Creek and Jocassee pumped storage hydro facilities have provided and will continue to provide most of the energy storage within Duke Energy's system. These two stations combined provide 2,200 MW of storage capacity, with another 280 MW planned to come online by 2023 with the completion of ongoing upgrades to the pump-turbine units at Bad Creek. When upgrades are complete, the facility will be able to produce about as much energy as some nuclear plants and power more than 1 million homes (Wells 2018).

1.3 Expansion Opportunity

Bad Creek was originally designed as a "weekly cycle" facility with approximately six hours of generation per day, allowing Duke Energy to utilize approximately 29 hours of storage in the upper reservoir to generate at full load three hours in the morning and three hours in the evening, five days per week, and then pump back for a portion of each night and over the weekend with low cost and available baseload power from Duke Energy's coal and nuclear fleet. Today, Bad Creek operates on more of a "daily cycle" mode, commonly alternating between generating and pumping on a daily basis, with the upper reservoir surface elevation typically maintained in the upper 50 to 60 feet (ft), compared to a maximum drawdown of 160 feet. This operating mode allows Duke Energy to maximize head, energy density, and plant/unit efficiency and utilize the Project like a massive battery to help balance the regional transmission system, including rapid consumption or generation of power due to variable solar energy production. As a result of this operating mode, with operation of the upper reservoir in the upper third of the possible drawdown range, only 30 to 40 percent of the storage capacity of Bad Creek is being regularly utilized.

Given the need for additional significant energy storage and renewable energy generation across Duke Energy's service territories over the Project's new 40 to 50-year license term, Duke Energy is evaluating opportunities to add pumping and generating capacity at the Project. Additional energy storage and generation capacity could be developed by constructing a new power complex (including a new underground powerhouse) adjacent to the existing Bad Creek Powerhouse. Construction of the 1,400-MW Bad Creek II Power Complex (Bad Creek II Complex) is, therefore, an alternative relicensing proposal presently being evaluated by Duke Energy.

The Bad Creek II Complex would utilize the existing Project's upper and lower reservoirs (Bad Creek Reservoir and Lake Jocassee, respectively) and would consist of a new upper reservoir inlet/outlet (within the existing upper reservoir), water conveyance system, underground powerhouse, and lower reservoir inlet/outlet (along the shoreline of Lake Jocassee). No modifications to the existing upper and lower reservoirs would be required for the Bad Creek II Complex other than construction of an upper reservoir inlet/outlet structure within the Bad Creek Reservoir and a lower reservoir inlet/outlet structure within Lake Jocassee. Duke Energy currently owns all property that would be required for construction of the Bad Creek II Complex.

In parallel with this relicensing, Duke Energy is conducting a study to further evaluate the technical and economic feasibility of the Bad Creek II Complex. This feasibility study, which is currently expected to conclude in late 2022, will fulfill the following objectives:

- Evaluate alternative locations of principle structures, their types, and conceptual configurations as a basis to develop construction cost opinions.
- Prepare a preliminary opinion of probable construction cost.
- Provide high-level construction schedules.
- Provide estimated unit operating characteristics for units to be installed within the Bad Creek II Complex.

The study is expected to provide sufficient information to support future decisions by Duke Energy regarding advancement of the proposed Project expansion, including conducting more detailed engineering studies. If Duke Energy decides not to pursue the Bad Creek II Complex prior to the filing of the Final License Application (FLA) in 2025, this relicensing alternative would not be further advanced through the relicensing studies or license application documents.

If Duke Energy decides to pursue the Bad Creek II Complex and obtains all necessary regulatory approvals for construction, the period for construction of the Bad Creek II Complex is expected to span approximately 6 years. The construction schedule and sequence are informed by the actual construction schedule for the existing Bad Creek Project (1985-1991). Assuming commencement of construction shortly following New License issuance by July 2027, the Bad Creek II Complex would be fully in service in early 2033. Major construction phases and milestones for the Bad Creek II Complex are expected to include the following:

- Lower reservoir inlet/outlet and discharge channel: Jul 2027 – Feb 2032
- Upper reservoir inlet/outlet and headrace channel: Dec 2029 – Aug 2031
- Water conveyance system: Mar 2028 – Mar 2031
- Powerhouse: Oct 2027 – Nov 2032
- Transformer yard and switchyard: Nov 2027 – Nov 2031
- Testing and commissioning: Aug 2032 – Aug 2033

1.4 Licensing Process

The Original License for the existing Project expires on July 31, 2027. Duke Energy is formally initiating relicensing of the Bad Creek Project with the filing of this Pre-Application Document (PAD) and associated Notice of Intent (NOI). The relicensing process provides a structured and collaborative framework for consulting with natural resource agencies and other Project stakeholders and developing a proposal for continued operation of the Project over the new 30 to 50-year license term. The relicensing process, inclusive of FERC's procedures for compliance with the requirements of the National Environmental Policy Act and other federal statutes, can also serve as an umbrella process for major federal and state approvals and permits required for any significant construction at and modifications proposed for the Project.

In support of preparing an application for a New License, Duke Energy has elected to use the FERC's Integrated Licensing Process (ILP). The Licensee believes the ILP will be the most effective and efficient process for this relicensing and will provide an appropriate structured framework for timely evaluation and resolution of potential issues. Bad Creek II is essential to Duke Energy's carbon reduction strategy and timely FERC approval is necessary to meet reduction goals.

Under Part 5.8 of the Commission's regulations, the FERC will review this PAD and associated NOI. Within 60 days of filing of the PAD and NOI, the FERC will acknowledge the commencement of the licensing proceeding and request comments on the PAD. Within 30 days of the notice, the FERC will conduct a public scoping meeting and site visit.

1.5 Other Major Regulatory Approvals

If the Bad Creek II Complex is proposed in Duke Energy's FLA for the Project, in addition to the license from FERC, inclusive of the federal and state agency conditions and recommendations within, construction of the Project expansion will involve numerous other federal, state, and local permits or authorizations.

Construction of the Bad Creek II Complex will require permits and authorization from the U.S. Army Corps of Engineers (USACE). Under Section 404 of the Clean Water Act (CWA), USACE must authorize any discharge of dredge or fill material into waters of the U.S., including wetlands. "Fill material" means discharged material which converts waters of the United States to dry land or which changes the bottom elevation of waters of the United States.[1] Any proposed project that will affect navigable waters of the United States must obtain authorization from USACE under Section 10 of the Rivers and Harbors Act, as applicable.[2]

According to the USACE Charleston District's Navigation Study Reports, no federal navigable waters are located within the existing Project Boundary or proposed construction area of influence[3] (USACE 1977). Lake Jocassee is depicted on the South Carolina Department of Health and Environmental Control's (SCDHEC) updated map of State Navigable Waters for South Carolina and is classified as a state navigable water (SCDHEC 2019a; 2019b). Activities occurring below or above the Ordinary High Water Mark (OHWM) are regulated by the SCDHEC.

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[1] 40 CFR § 232.2.

[2] 33 U.S.C. § 403

[3] Throughout this document multiple terms are used to describe areas at and around the Project:

- **Project Boundary** refers to the FERC Project Boundary established for the existing Project (shown in Appendix C). As defined and required by FERC, a project boundary is the geographic area that includes all lands, waters, works, and facilities that would comprise the licensed project, and thus the geographic extent of FERC's regulatory jurisdiction. For the existing Bad Creek Project, the Project Boundary encompasses the area of the upper reservoir and dams; above- and below-ground structures and equipment associated with major Project operations, and the 9.25-mile-long overhead transmission line corridor from the Bad Creek switchyard to the Jocassee switchyard.
- **Project vicinity** is defined as the Project structures, reservoirs, and the areas immediately surrounding the Project.
- **Limits of disturbance** refers to the area, which overlaps with but is not completely contained by the Project Boundary, in which construction impacts from the Bad Creek II Complex would be authorized in final regulatory permits and approvals. Limits of disturbance have not yet been established.
- **Area of influence** is used to describe the area that may be directly impacted by construction of the Bad Creek II Complex. The area of influence includes the existing Project Boundary as well as additional areas that may eventually be contained within the final limits of disturbance identified for construction.

Under the authority of the South Carolina Pollution Control Act, the SCDHEC Water Classification & Standards is responsible for establishing appropriate water uses and protection classifications, as well as general rules and specific water quality criteria in order to protect existing water uses, establish anti-degradation rules, protect public welfare, and maintain and enhance water quality. Water quality standards applicable to waters in the Project Boundary and areas that may be impacted by construction activities for the Bad Creek II Complex are described in Section 6.3.6. These surface waters are subject to SCDHEC's anti-degradation rules and activities such as discharges to these waters may be prohibited in order to maintain their classification. New construction activities will be regulated and evaluated by the SCDHEC (SCHDEC 2014).

If the Bad Creek II Complex is pursued in parallel with the relicensing process, Duke Energy intends to also initiate other necessary federal, state, or local permits and approvals in addition to the FERC license in consultation with relevant regulatory entities.

1.6 Licensing Background

This relicensing process will benefit from and build on the extensive history and ongoing implementation of environmental protection, mitigation, and enhancements (PM&E) at the existing Bad Creek Project as well as the KT Project. A 50-year license to construct and operate the Bad Creek Project was issued by FERC to Duke Power Company (now Duke Energy Carolinas, LLC [Duke Energy]) on August 1, 1977. The license has been subsequently substantively amended as follows:

- Approval of extending time for commencement and completion of construction and for filing amendment to Exhibit R (Recreation Plan) (July 23, 1979).
- Approval of amendments to Exhibit R (January 14, 1981).
- Approval of as-built Exhibit L drawings and Exhibit M description of project works and revising Project description (January 25, 1993).
- Approval and modification of Howard Creek stormflow and baseflow augmentation assessment and minimum flow release plan (February 14, 1995).
- Approval of report on post-construction water quality monitoring and approving plan for continued limited water quality monitoring (September 26, 1995).

- Approval of Memorandum of Understanding (MOU) and 10-Year Work Plan (May 1, 1997; April 14, 2006; and March 21, 2017) (see additional description below).
- Authorization to upgrade and rehabilitate the four pump-turbines in the powerhouse and increase the Authorized Installed and Maximum Hydraulic capacities for the Project (to 1,400 MW and 19,760 cubic feet per second [cfs]) (August 6, 2018).

Major PM&E measures for original Project construction as well as ongoing Project operation are primarily focused on fisheries, water quality, and recreation, and are established by the following:

- Bad Creek Project license Exhibit S (Environmental Study Plans)[4]
- Duke Energy and South Carolina Department of Natural Resources (SCDNR) MOU and 10-Year Work Plans
- KT Project Relicensing Agreement

Environmental study plans required by the FERC license under the revised Exhibit S included:

1. A detailed wildlife mitigation plan;
2. An outline of studies to assess Project effects on:
    a. Fish entrainment and resultant mortality;
    b. Coldwater fish habitat in Lake Jocassee; and
    c. Trout migration, spawning, and rearing; and
3. A detailed mitigation plan with proposed fish and wildlife PM&E measures to mitigate adverse impacts associated with Bad Creek Project operations on Lake Jocassee and nearby stream fisheries.

As a result of the fish entrainment and resultant mortality studies (Item 2a above), Duke Energy and the South Carolina Wildlife and Marine Resources Department (now SCDNR) collaborated on the development of an MOU in 1996 to establish a framework to help maintain the high quality fisheries of lakes Jocassee and Keowee (Duke Power and SCDNR 1996). The MOU and first 10-Year Work Plan were approved pursuant to Article 32(b)(1) of the license for the Bad Creek Project on May 1, 1997. The Bad Creek (formerly Keowee-Toxaway) Fishery Resources

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[4] License Article #32 (as amended on May 2, 1978, August 15, 1979, and October 2, 1995) required Duke Energy to file a revised Exhibit S within one year of license issuance to address fish and wildlife PM&E measures.

Work Plan[5] consists of successive 10-Year Work Plans (i.e., 1996 – 2005; 2006 – 2015; and 2017 – 2027).[6] The Work Plans identify specific management activities, funding initiatives, and communication protocols which both Duke Energy and SCDNR believe are important to the effective management of the KT fishery resources. Activities included in the 10-Year Work Plans are focused on fisheries surveys and inventories, water quality and aquatic habitat evaluations, fish stocking, recreation, and shoreline impacts.

A wide variety of studies and management activities were conducted under the 10-Year Work Plans developed and implemented during 1996-2005 and 2006-2015. Several of these activities were later identified as PM&E measures appropriate for transfer to the KT Project (FERC No. 2503) and are now addressed under the KT Project Relicensing Agreement associated with the FERC license issued in 2016. These included an agreement on measures to reduce fish entrainment at the Jocassee Pumped Storage Station, an agreement to maintain pelagic trout habitat in Lake Jocassee, and an agreement to maintain the lower Eastatoe Creek angler access area, as well as a requirement to monitor dissolved oxygen (DO) concentrations in the tailwaters of the Jocassee and Keowee Developments each August for the term of the new KT Project license to demonstrate compliance with South Carolina's water quality standards.

[5] The Bad Creek Fishery Resources Work Plan was formerly known as the Keowee-Toxaway Fishery Resources Work Plan.

[6] Several activities conducted under the first two 10-year work plans were identified as PM&E measures under the KT Project and are now included in the Keowee-Toxaway Relicensing Agreement issued by FERC in 2016. As a result, the original 2006 – 2015 Work Plan was extended by one year to cover 2016.

2 Purpose of the PAD

The filing of this PAD and the associated NOI by Duke Energy marks the formal start of the relicensing process for the Project, pursuant to the requirements of the Commission's regulations at 18 Code of Federal Regulations (CFR) §5.6. The purpose of the PAD is to provide a description of the existing Project facilities and operations, and to provide existing, relevant, and reasonably available information related to the Project vicinity. Further, the PAD is intended to assist the Commission, resource agencies, Indian Tribes, non-governmental organizations (NGOs), and other interested parties to identify potential resource areas of interest and informational needs, to develop study requests, and to establish the information necessary to analyze the license application [18 CFR §5.6(b)]. The distribution list is presented in Appendix A.

2.1 Search for Existing, Relevant, and Reasonably Available Information

In support of preparing this PAD, Duke Energy (inclusive of Duke Energy's consultants), has undertaken an extensive search to identify and review information reasonably available and relevant to the Project. These efforts consisted of the following activities:

1. A search and review of publicly available sources and databases.
2. A search and review of Duke Energy and Duke Energy's consultants' extensive records for the existing Project and the KT Project.
3. Consultation with primary resource agencies and other stakeholders with potential information applicable to the Project and interests in the Project.
4. A review of the State of South Carolina and Federal Comprehensive Plans relevant to the Project.
5. Completion of new field reconnaissance activities and resource evaluations.
6. Completion of a pre-feasibility study and initiation of technical feasibility study for Project expansion, including environmental field studies and data collection activities, and geological and geophysical investigations.

Information and findings from these activities are presented in detail in the applicable resource sections of this PAD.

3 Description of the Consultation Process

Duke Energy has regularly consulted with U.S. Fish and Wildlife (USFWS), SCDNR, SCDHEC, and South Carolina Department of Parks, Recreation, and Tourism (SCDPRT) since construction of the Project. The existing MOU and related Work Plans, the KT Project relicensing process and development of the KT Project Relicensing Agreement, and the recent Bad Creek amendment proceeding for the pump-turbine upgrades, have provided frameworks and opportunities for robust data collection and agency engagement, and associated annual reporting has provided a formal means for information sharing. These processes also provided a ready means of identifying potential relicensing participants and Project stakeholders.

Prior to filing this PAD, Duke Energy convened a virtual meeting on February 18, 2022 and invited the agencies listed below to participate. During this meeting, Duke Energy provided an update on the schedule and relicensing process for the Project. Documentation of this consultation is provided in Appendix B per 18 CFR §5.6(d)(5).

- USFWS
- U.S. Forest Service
- National Oceanic and Atmospheric Administration (NOAA) Fisheries
- SCDHEC
- SCDNR
- South Carolina Department of Archives and History (SCDAH)
- SCDPRT
- North Carolina State Parks

4 Process Plan, Schedule, and Communications Protocol (18 CFR §5.6(d)(1))

This section provides a description of the Process Plan, Schedule, and Communications Protocol for the Project as required by 18 CFR §5.6(d)(1).

4.1 Overall Process Plan and Schedule

Duke Energy proposes to use the Commission's ILP in support of obtaining a New License for the Project. As presented in Table 4.1-1, Duke Energy has prepared a Process Plan and Schedule incorporating the overall ILP schedule for this relicensing.

Table 4.1-1. Proposed Process Plan and Schedule (Pre-Filing Consultation) – ILP

Activity	Responsible Parties	Timeframe	Estimated Filing Date or Deadline
File NOI and PAD (18 CFR §5.5(d))	Licensee	Within 5 years to 5.5 years prior to license expiration	Feb 23, 2022
Initial Tribal Consultation Meeting (18 CFR §5.7)	FERC	No later than 30 days following filing of NOI/PAD	Mar 25, 2022
Issue Notice of NOI/PAD and Scoping Document 1 (SD1) (18 CFR §5.8(a))	FERC	Within 60 days following filing of NOI/PAD	Apr 24, 2022
Conduct Scoping Meetings and site visit (18 CFR §5.8(b)(viii))	FERC	Within 30 days following Notice of NOI/PAD and SD1	May 24, 2022
Comments on PAD, SD1, and Study Requests (18 CFR §5.9(a))	Licensee Stakeholders	Within 60 days following Notice of NOI/PAD and SD1	June 23, 2022
Issue Scoping Document 2 (SD2), if necessary (18 CFR §5.10)	FERC	Within 45 days following deadline for filing comments on PAD/SD1	Aug 7, 2022
File Proposed Study Plan (PSP) (18 CFR §5.11)	Licensee	Within 45 days following deadline for filing comments on PAD/SD1	Aug 7, 2022
PSP Meeting (18 CFR §5.11(e))	Licensee	Within 30 days following filing of PSP	Sep 6, 2022
Comments on PSP (18 CFR §5.12)	Stakeholders	Within 90 days following filing of PSP	Nov 5, 2022
File Revised Study Plan (RSP) (18 CFR §5.13(a))	Licensee	Within 30 days following deadline for comments on PSP	Dec 5, 2022
Comments on RSP (18 CFR §5.13(b))	Stakeholders	Within 15 days following filing of RSP	Dec 20, 2022

Activity	Responsible Parties	Timeframe	Estimated Filing Date or Deadline
Issue Study Plan Determination (18 CFR §5.13(c))	FERC	Within 30 days following filing of RSP	Jan 4, 2023
Conduct First Season of Studies (18 CFR §5.15)	Licensee	-	Spring-Fall 2023
File Study Progress Reports (18 CFR §5.15(b))	Licensee	Quarterly	Spring 2023 -Fall 2024
File Initial Study Report (ISR) (18 CFR §5.15(c))	Licensee	Pursuant to the Commission-approved study plan or no later than 1 year after Commission approval of the study plan, whichever comes first	Jan 4, 2024
ISR Meeting (18 CFR §5.15(c)(2))	Licensee Stakeholders	Within 15 days following filing of ISR	Jan 19, 2024
File ISR Meeting Summary (18 CFR §5.15(c)(3))	Licensee	Within 15 days following ISR Meeting	Feb 3, 2024
Comments on ISR Meeting and Additional or Modified Study Requests (18 CFR §5.15(c)(4))	Stakeholders	Within 30 days following filing of ISR Meeting Summary	Mar 4, 2024
File Response to Comments on ISR and Meeting Summary (18 CFR §5.15(c)(5))	Licensee	Within 30 days following filing of ISR Meeting Comments	Apr 3, 2024
Resolution of Meeting Summary Disagreements and Issue Amended Study Plan Determination (if required) (18 CFR §5.15(c)(6))	FERC	Within 30 days following filing of response to ISR Meeting Comments	May 3, 2024
Conduct Second Season of Studies (if necessary)	Licensee	-	Spring-Fall 2024
Deadline to File Preliminary Licensing Proposal (PLP) or Draft License Application (DLA) (18 CFR §5.16(a))	Licensee	No later than 150 days prior to the deadline for filing the Final License Application (FLA)	March 1, 2025
File Updated Study Report (USR) (18 CFR §5.15(f))	Licensee	Pursuant to the approved study plan or no later than 2 years after Commission approval, whichever comes first	Jan 4, 2025
USR Meeting (18 CFR §5.15(f))	Licensee Stakeholders	Within 15 days following filing of USR	Jan 19, 2025
File USR Meeting Summary (18 CFR §5.15(f))	Licensee	Within 15 days following USR Meeting	Feb 3, 2025
File Comments or Disagreements on USR Meeting Summary (18 CFR §5.15(f))	Stakeholders	Within 30 days following filing of USR Meeting Summary	Mar 5, 2025
File Response to Comments on USR Meeting Summary (18 CFR §5.15(f))	Licensee	Within 30 days following filing of USR Meeting Comments	Apr 4, 2025

Activity	Responsible Parties	Timeframe	Estimated Filing Date or Deadline
Resolution of USR Meeting Summary Dispute (if necessary) (18 CFR §5.15(f))	FERC	Within 30 days following filing of response to USR Meeting Comments	May 4, 2025
Comments on PLP or DLA (18 CFR §5.16(e))	Stakeholders	Within 90 days following filing of PLP or DLA	May 30, 2025
Deadline to file FLA (18 CFR §5.17)	Licensee	No later than 24 months before the existing license expires	July 31, 2025
Publish Public Notice of FLA Filing (18 CFR §5.17(d)(2))	Licensee	Within 14 days following filing of FLA filing	August 13, 2025

1. If the due date falls on a weekend or holiday, the deadline is the following business day.
2. All Director's determinations are subject to request for rehearing to FERC pursuant to 18 CFR §375.301(a) and 385.713. Any request for rehearing must be filed within 30 days of determination.

4.2 Scoping Meeting and Site Visit

Pursuant to 18 CFR §5.8(b), FERC will hold a Scoping Meeting and Site Visit to the Project within 30 days after issuing notice of the PAD and NOI (estimated to be on or before April 26, 2022) in accordance with its responsibilities under the National Environmental Policy Act (NEPA).

Duke Energy is requesting Commission staff to conduct virtual public scoping meetings. There are extensive construction activities ongoing in the powerhouse in support of the unit upgrades (discussed in Section 1.2). These activities present a security and safety concern and an obstacle to a general powerhouse tour. Given these conditions, the remote location of the Project, and uncertainties around the ongoing COVID-19 pandemic, Duke Energy has prepared an overview video orientation of the Project for general viewing by interested parties in lieu of an environmental review site visit. The video can be viewed from a link on the Project's public relicensing website (www.badcreekpumpedstorage.com). If Commission staff or primary agencies are interested in a site visit during the first year of this ILP, Duke Energy will work with said parties to identify mutually acceptable accommodations.

FERC will issue a public notice regarding the Scoping Meeting(s) that will include the meeting date, meeting location, and additional instructions for attending the meeting.

4.3 ILP Participation

The licensing process for the Project is open to the general public and interested individuals and organizations are encouraged to participate. A contact list, compiled by Duke Energy, will be maintained to include agencies, organizations, individuals, or groups with whom consultation is required by FERC's licensing regulations or who have requested to be included as licensing participants.

The contact list will be used to provide notice of any public meetings, as well as notice of the availability of information for public review. The current contact/distribution list is included in Appendix A.

Any party desiring to be added to or removed from the contact list should contact the individual listed below:

Alan Stuart
Senior Project Manager
Duke Energy
Mail Code EC-12Q
526 South Church Street
Charlotte, NC 28202
Tel: (980) 373-2079
Fax: (704) 382-8614
Alan.Stuart@duke-energy.com

4.4 Communication and Meeting Protocols

During the course of the licensing process, communication will take place through public meetings, conference calls, and written correspondence. In order to establish the formal consultation record, all phases of formal correspondence require adequate documentation. The intent of the Communication and Meeting Protocols is to provide a flexible framework for the dissemination of information and for documenting consultation among the participants throughout the licensing proceeding. The Communication and Meeting Protocols will remain in effect until issuance of the Project's New License by the Commission.

4.4.1 Maintenance of Public Website

Duke Energy will maintain a public Project website (www.badcreekpumpedstorage.com) for access to major documents developed during the course of the licensing process, such as the PAD and NOI, public meeting notices and materials, study plans, study reports, and the draft and final license applications.

4.4.2 Distribution of Licensing Materials

Duke Energy will distribute formal licensing materials by notifying (via email or regular mail) individuals and organizations on the established contact mailing list of the availability of formal licensing filings and documents online at Duke Energy's Project website (www.badcreekpumpedstorage.com) or from FERC's eLibrary[7] by searching under Docket P-2740. Duke Energy expects primary licensing participants will also receive email notifications of Project filings through FERC's eSubscription service.[8] Email groups may be set up for informal Project communications with primary and interested licensing participants.

Certain documents are restricted from general distribution. These documents include (1) those covered under FERC's regulations protecting Critical Electric/Energy Infrastructure Information (CEII) (18 CFR §388.113) and (2) documents containing sensitive information (e.g., engineering design drawings and archaeological survey reports or other information identifying the locations of historic properties and reports containing information regarding the locations of protected species), which are covered under FERC's regulations protecting Privileged Information (18 CFR §388.112).

A variety of technical documents will be produced during licensing consultation, including the PAD, study plans, study reports, and the draft and final license applications. Whenever comments on documents are solicited, review periods will be established and communicated to licensing participants. Review periods will typically be at least 30 days unless longer periods are required by FERC licensing regulations.

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[7] www.ferc.gov/docs-filing/elibrary.asp

[8] https://www.ferc.gov/docs-filing/esubscription.asp

Duke Energy will consider adjustment of review periods on an as-needed or as-appropriate basis, to best utilize available time within the course of pre-filing consultation without jeopardizing the overall Project schedule. Any such adjustments will be made with the concurrence of the licensing participants.

4.4.3 Meetings

Meetings will be scheduled as required by FERC regulations[9] and as otherwise needed throughout the licensing process. Duke Energy will be responsible for scheduling all consultation meetings involving Duke Energy (inclusive of its consultants) and licensing participants. Duke Energy will notify licensing participants of formal meetings scheduled by Duke Energy at least 14 days prior to the meeting date. When necessary, Duke Energy may hold a meeting with specific stakeholders with less notice. Meetings may be held virtually if circumstances warrant.

4.4.4 FERC Communications

FERC has not yet assigned a specific staff member to serve as the licensing coordinator for the Project. The role of the FERC licensing coordinator will be in accordance with the rules and regulations for the ILP. For additional information regarding public involvement in FERC hydropower licensing proceedings and pre-filing consultation, refer to the on-line FERC guide, “Hydropower Licensing – Get Involved: A Guide for the Public.”[10]

All communications to FERC regarding Project licensing must reference the **Bad Creek Pumped Storage Project FERC No. 2740 – Application for New License.**

FERC strongly encourages paperless electronic filing of comments through its eFiling or eComment systems. Information and links to these systems can be found at the FERC webpage http://www.ferc.gov/docs-filing/ferconline.asp. In order to eFile comments, interested parties must have an eRegistration account. After preparing the comment or motion to intervene go to www.ferc.gov and select the eFiling link. Select the new user option and follow the prompts. Users are required to validate their account by accessing the site through a hyperlink sent to the registered email account.

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[9] 18 CFR §4.38

[10] https://www.ferc.gov/sites/default/files/2020-04/hydro-guide.pdf

An additional method to eFile comments is through the "Quick Comment" system available via a hyperlink on the FERC homepage. "Quick Comments" do not require the users to have a subscription; the comments are limited to 6,000 characters, and all information must be public. Commenters are required to enter their names and email addresses. They will then receive an email with detailed instructions on how to submit "Quick Comments."

Stakeholders without internet access may submit comments to FERC at the addresses below via hardcopy but should be aware documents sent to FERC by regular mail can be subject to docket-posting delays. Hardcopies must be sent via the U.S. Postal Service to:

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

5 Project Location, Facilities, and Operations (18 CFR §5.6(d)(2))

This section provides a description of the Project Location, Facilities, and Operations as required by 18 CFR §5.6(d)(2).

5.1 Authorized Agents (18 CFR §5.6(d)(2)(i))

The exact name and business address of each person authorized to act as an agent for Duke Energy are:

Jeffrey G. Lineberger, P.E.
Director of Water Strategy and Hydro Licensing
Duke Energy
Mail Code EC-12Q
526 South Church Street
Charlotte, NC 28202
Tel: (704) 382-5942
Jeff.Lineberger@duke-energy.com

Alan Stuart
Senior Project Manager
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Garry S. Rice, Esq.
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550 South Tryon Street
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Tel: (704) 382-8111
Garry.Rice@duke-energy.com

5.2 Project Location and Maps (18 CFR §5.6(d)(2)(ii))

The Bad Creek Project is located in Oconee County, South Carolina, approximately eight miles north of the Town of Salem, South Carolina. The Project is situated in the northwestern-most portion of South Carolina and is less than two miles from the North Carolina border. It is approximately 45 miles southwest of the major city center of Asheville, North Carolina. The Bad Creek Reservoir is situated immediately northwest of Lake Jocassee, which is used as the lower reservoir for pumped storage operation, and streams draining to this area make up the headwaters of the Savannah River Basin. Downstream of Lake Jocassee is Lake Keowee, which is used as the lower reservoir for the Jocassee Pumped Storage Station and also supplies cooling water for Oconee Nuclear Station. The existing Project Boundary is shown on Figure 5.2-1 and detailed Project Boundary drawings are included in Appendix C (Preliminary Exhibit G).

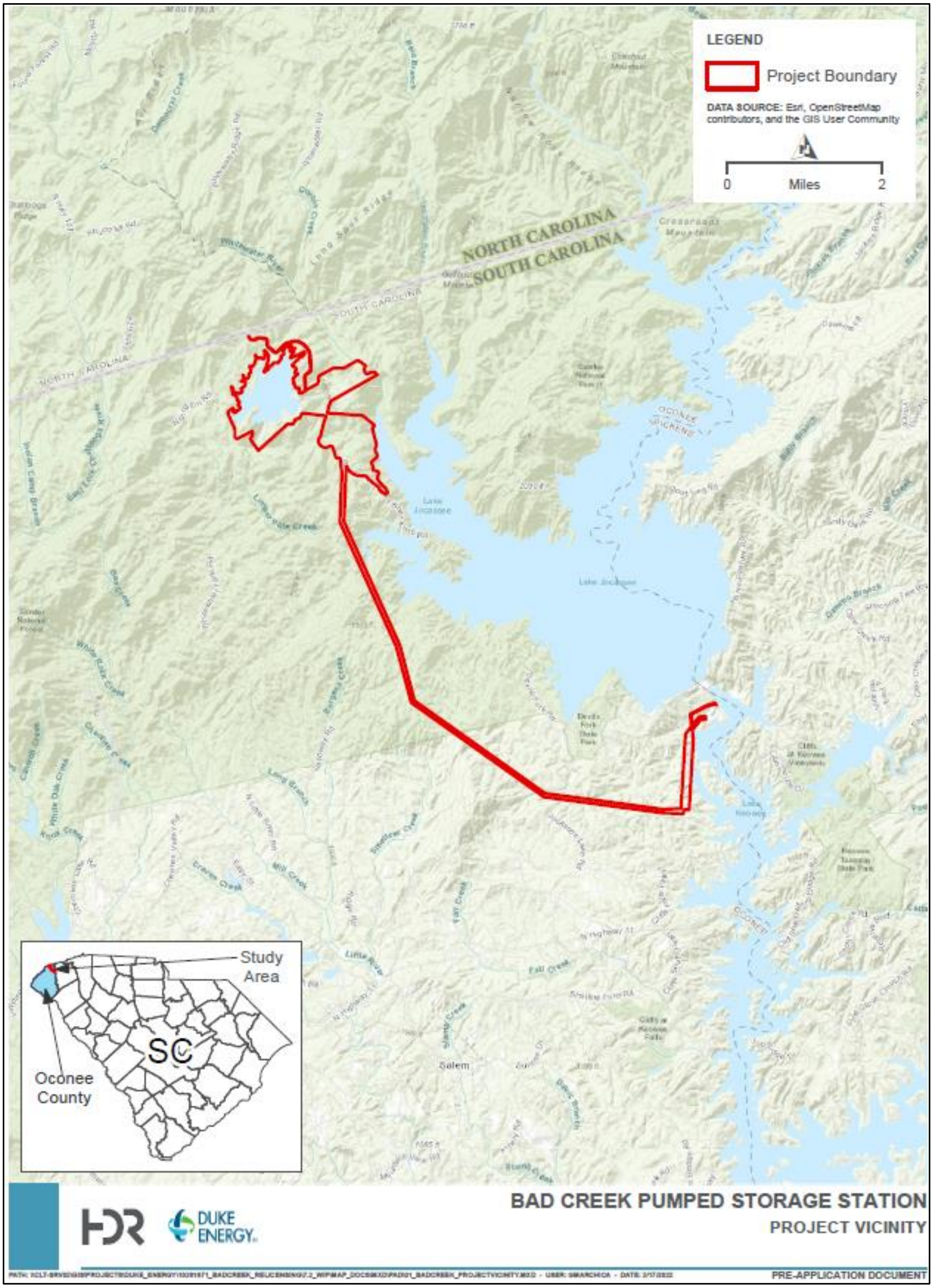


Figure 5.2-1. Bad Creek Pumped Storage Project Existing Project Boundary

5.3 Project Land Ownership

The Project site is located entirely on Duke Energy-owned property. A portion of the transmission line corridor associated with the Project is owned in fee simple and a portion is in easement.

5.4 Existing Project Facilities (18 CFR §5.6(d)(2)(iii)(A)-(D))

Existing Project facilities are described briefly in the following subsections and are shown on Figure 5.4-12.

5.4.1 Upper Reservoir and Dams

The upper reservoir (Figure 5.4-1) is impounded by two large dams (main dam and west dam) and a saddle dike (east dike). The reservoir has a surface area of approximately 363 acres and a storage capacity of approximately 35,513 acre-feet (acre-ft), of which 31,808 acre-ft is usable storage between minimum elevation of 2,150 ft above mean sea level (ft msl) and full pond elevation of 2,310 ft msl. Maximum drawdown is 160 ft with approximately 3,705 acre-ft of dead storage below elevation 2,150 ft msl. Due to the potential for frequent large water level fluctuations, no public access, including fishing, to the upper reservoir is permitted.

Figure 5.4-1. View of the Bad Creek Upper Reservoir

The main dam (Figure 5.4-2) was constructed across Bad Creek and consists of an impervious central core surrounded by a rockfill shell. Utilizing approximately 11,400,000 cubic yards of material, the dam has a crest width of 30 ft, maximum base width of 1,550 ft, maximum height of 355 ft, and length of 2,600 ft. The crest is at 2,315 ft msl, which allows for 5 ft of freeboard.

The west dam (Figure 5.4-3) is similar in configuration to the main dam. The west dam is approximately 900 ft long, 170 ft high, and was constructed across West Bad Creek. The dam has a crest width of 30 ft, maximum base width of 350 ft, and a crest elevation of 2,315 ft msl. Construction of the west dam required approximately 1,363,000 cubic yards of material.

The east dike is approximately 900 ft long and 90 ft high across a natural depression on the eastern rim of the upper reservoir. Requiring approximately 479,000 cubic yards of material to construct, the dike has a maximum base width of 450 ft and a crest width of 30 ft. A lower crest elevation of 2,313 ft msl (2 ft lower than the crests of the main and west dams) allows the dike to serve as an emergency spillway.

Figure 5.4-2. Downstream Face of Main Dam

Figure 5.4-3. Upstream Face of the West Dam

Stream augmentation facilities were constructed at the upper reservoir to augment flows to Howard Creek. These facilities consist of a raised bore shaft and tunnel. A system of intakes, pipes, and sluice gates allow water to be drawn down from three different levels in the upper reservoir and pumped to Howard Creek. The stream augmentation system is not currently used.

5.4.2 Upper Reservoir Intake and Inlet/Outlet Structure

The existing upper reservoir intake system consists of an intake channel, a dewatering dam, and a bellmouth inlet located in the southeast portion of Bad Creek Reservoir. The intake channel (Figure 5.4-4) is a rectangular basin excavated into rock with a width of 75 ft at the shaft increasing to 140 ft at the channel entrance. When tunnel dewatering is performed, a dewatering dam is used to keep the intake channel dry without fully dewatering the upper reservoir. Located midway in the intake channel, this dewatering dam is a concrete gravity structure with a height of 30 ft. The structure includes two 42-inch sluice gates, equipped with operators accessible from a steel walkway affixed to the top of the concrete structure. The bellmouth inlet has a 50.9-ft-diameter opening tapering to 29.5 ft. The tapered inlet serves as a means of transition from the slower velocities of the intake channel to the higher velocities of the power tunnel.

Figure 5.4-4. Upper Reservoir Intake Channel; (left) Prior to Initial Reservoir Fill and (right) Under Full Reservoir Drawdown Condition

5.4.3 Lower Reservoir

Lake Jocassee, licensed as part of the KT Project (FERC Project No. 2503), serves as the lower reservoir. At full pond (1,110 ft msl), the lower reservoir, Lake Jocassee (Figure 5.4-5), has a water surface area of approximately 7,980 acres and a storage capacity of approximately 1,206,798 acre-ft with 92.4 miles of shoreline. The usable storage (1,110 – 1,080 ft msl) is 225,447 acre-ft. At full pond, the Lake Jocassee water surface is approximately 40 ft above the top of the Bad Creek discharge structure openings. At the maximum drawdown elevation of 1,080 ft msl, the Lake Jocassee water surface is approximately 10 ft above the top of the Bad Creek discharge structure openings.

Figure 5.4-5. Lower Reservoir (Whitewater River Arm of Lake Jocassee), Inlet/Outlet Structure, and Powerhouse Portal Area

5.4.4 Lower Reservoir Inlet/Outlet Structure

The lower reservoir inlet/outlet structure (Figure 5.4-6) is located on the west shore of the Whitewater River arm of Lake Jocassee. The structure, which is primarily of reinforced concrete construction, measures 118 ft long, 15 ft wide, and 95 ft tall. The structure is supported by tiebacks extending into bedrock. The tailrace tunnels penetrate the structure near the invert (1,050 ft msl), which is below the Lake Jocassee maximum drawdown elevation (1,080 ft msl). The inlet/outlet structure is equipped with four (4), 18-foot by 30-foot, steel lift gates and is equipped with structural steel trashracks. A gantry crane is provided to lift the gates.

Figure 5.4-6. Lower Reservoir Inlet/Outlet Structure

5.4.5 Submerged Weir in Lower Reservoir

While not part of the licensed project works, the submerged weir in Lake Jocassee (location shown on Figure 5.4-12) is a notable feature associated with construction of the Project. This weir is located 550 meters (m) (1,804 ft) downstream of the Project discharge. It was built out of nearly half a million cubic yards of rock excavated during Project construction (excavation of underground powerhouse and tunnels). Lake Jocassee at full pond is elevation 1,110 ft msl. The crest of the submerged weir is between 1,060 and 1,070 ft msl. As discussed throughout Section 6 of this PAD, the function of the constructed weir is to help minimize the effects of Bad Creek operations on the natural stratification of Lake Jocassee. The weir prevents the mixing of warmer water from the pumped storage discharge with the cooler water in the lower layer of the lake, for the protection of cold-water fish habitat. The weir also serves to dissipate the energy of the discharging water.

5.4.6 Access Roads

Access to Bad Creek is provided by a 4.8-mile-long paved road leading from the Project entrance at SC Highway 130 to the powerhouse portal area at Lake Jocassee. The road alignment is based on a maximum 10 percent grade and a minimum 100-ft radius of curvature.

5.4.7 Equipment Building

A 43.5-ft-high, steel construction, above-ground equipment building at Bad Creek is located approximately 469.2 ft above the underground powerhouse and contains the original control complex (it should be noted the control room was subsequently relocated to the underground powerhouse) and diesel generators as well as other major electrical and heating, ventilation, and air conditioning equipment. A vertical access shaft connects the powerhouse to the equipment building and contains an elevator, stairwell, and the isolated phase bus conveying current from the generators to the step-up transformers.

5.4.8 Transformer Yard and Switchyard

The transformer yard and switchyard (Figure 5.4-7) are located adjacent to the equipment building and contain the equipment (step-up transformers, relays, protection) necessary to transmit electric power from the Bad Creek generators to the energy grid.

Figure 5.4-7. Aerial View of Bad Creek Switchyard

5.4.9 Water Conveyance System

In the turbine mode, water is conveyed from the upper reservoir to Lake Jocassee via the submerged inlet/outlet structure transitioning to a 29.5-ft-diameter shaft. This shaft extends vertically 856 ft and then elbows into the power tunnel, which is sloped toward the powerhouse at approximately a 7.0 percent grade. Near the powerhouse, the power tunnel transitions into a manifold tunnel branching into four 13.6-ft-diameter penstock tunnels. The total length of the water conveyance system from the main shaft to the manifold is 5,026 ft. From the penstock tunnels, the flow passes through a reducer cone into 8.43-ft-diameter penstocks, then through the turbines, and exiting the powerhouse via four approximately 316-ft-long and 16.4-ft-diameter draft tube tunnels. The draft tube tunnels merge into two approximately 875-ft-long and 24.6-ft-diameter tailrace tunnels discharging into Lake Jocassee through the lower reservoir inlet/outlet control structure. Draft tube gates are provided in each draft tube tunnel to allow individual unit isolation of the draft tube from the tailwater.

The water conveyance tunnels and shafts are lined with cast-in-place concrete. The four penstock tunnels are steel lined with cast-in-place concrete. The steel lining extends approximately 213 ft upstream from the powerhouse. Four hydraulically operated spherical valves, each with a 9-ft inside diameter, are provided, one for each unit, to isolate the pump-turbine from headwater during inspection or maintenance work.

5.4.10 Powerhouse Access Tunnel and Vertical Shaft

Access to the powerhouse is provided by a 29.5-ft-wide by 26.2-ft-high access tunnel (Figure 5.4-8). The tunnel is approximately 1,186 ft long and enters the powerhouse at an elevation of 1,005.9 ft msl. The tunnel invert accommodates a two-lane paved road. Access to the powerhouse is also provided by a stairwell and elevator in the vertical access shaft at the equipment building. The vertical shaft is recessed in the downstream face of the powerhouse chamber. The shaft also houses the isolated phase bus lines from the generators and major heating, ventilation, and air conditioning equipment ducts for bus cooling.

Figure 5.4-8. Bad Creek Entrance Tunnel (Source: Moore 2016)

5.4.11 Powerhouse

The powerhouse (Figure 5.4-9, Figure 5.4-10) is a three-level structure located in a mined rock cavern about 600 ft underground below the equipment control building and 1,186 ft upstream of the main access tunnel portal. The cavern is approximately 75 ft wide, 164 ft high, and about 433 feet long. It contains a service bay and four pump-turbine motor-generators. The powerhouse is constructed of reinforced concrete up to and including the operating floor at 1,015 ft msl. There are intermediate floors housing mechanical and electrical equipment. The four single-speed pump/turbine-motor/generator units are supported on mass concrete foundations transferring the operating loads to the surrounding rock. Major equipment is serviced by one 475-ton overhead bridge crane.

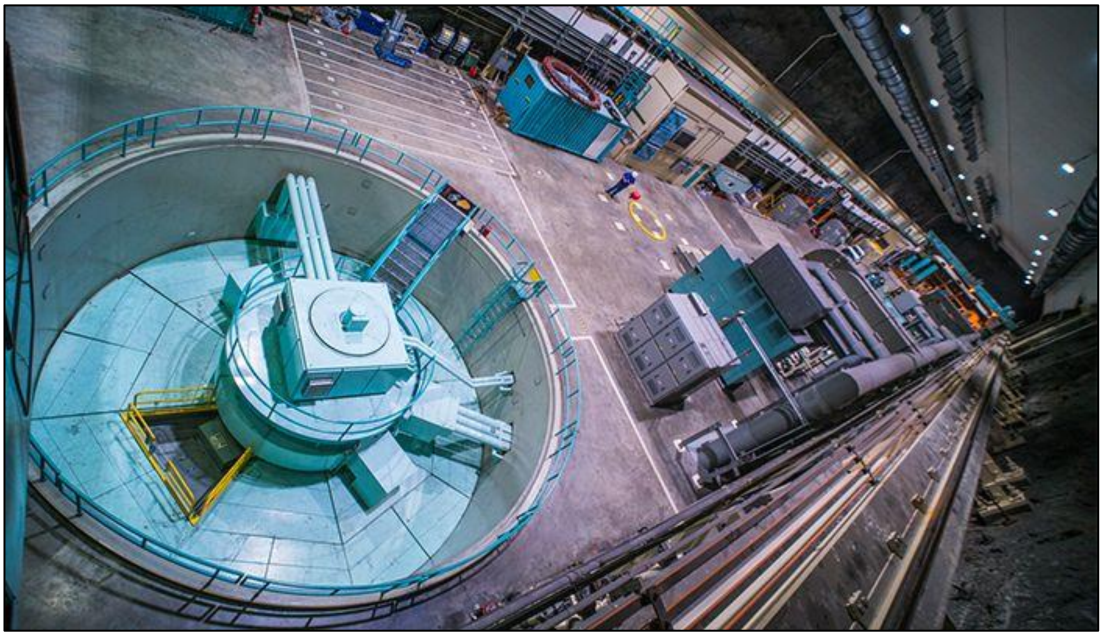


Figure 5.4-9. View of the Inside of the Bad Creek Powerhouse (Source: Moore 2016)

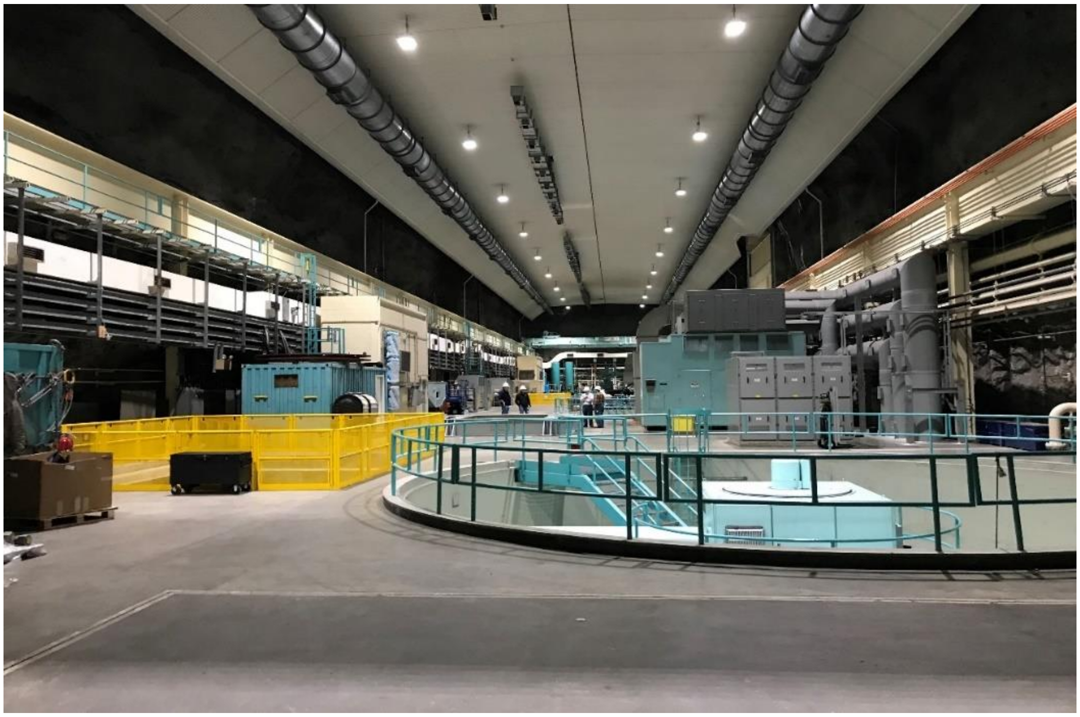


Figure 5.4-10. Bad Creek Project Operating Deck

5.4.12 Pump-Turbines and Generator-Motors

On April 23, 2018, the Licensee filed a Non-Capacity License Amendment Application to upgrade and refurbish the four Francis-type pump-turbines in the powerhouse, replace existing runners with Francis-type pump-turbine runners, and rehabilitate and/or upgrade the remaining components of the pump-turbine runners at the Bad Creek Project. The upgrades were approved by FERC in an amendment order dated August 6, 2018. The modifications are ongoing and scheduled for completion by July 31, 2023.

The values and descriptions presented below reflect the upgraded equipment, as the upgraded Project is the baseline for the relicensing. The Authorized Installed Capacity for the Project, 1,400 MW is based upon the definition provided by 18 CFR §11.1(i).

5.4.12.1 Pump-Turbines

The Project has four (4) reversible, single-stage, Francis-type, pump turbines. The pump-turbine capacities are based on a common gross head of 1,170 feet, which is the historical average gross head for the Project. When operating as a turbine, each single pump-turbine will produce a shaft output of 475,000 horsepower (hp), equal to 356,200 kilowatts (kW), when operating at a net head of 1,152 feet. For four units operating at peak efficiency, each turbine will produce a shaft output of 467,500 hp, or 350,000 kW for the same average gross head. The Maximum Hydraulic Capacity (i.e., maximum generating flow) for the Project is 19,760 cfs.

5.4.12.2 Generator-Motors

The Project has four (4) direct-connected, vertical shaft, alternating current, reversible water wheel-type generator/motors. Each has a nameplate rating of 420 MW, as a minimum, at an 80º C rise over the design maximum ambient temperature of 40°C, 0.9 power factor, 19,000 volts, 3-phase, 60 hertz.

Three-phase wound rotor induction motors (pony motors) are provided on each of the four units. The pony motors are used to accelerate the units to synchronous speed in the pumping direction. The units are then tied to the transmission system and operated as pumps. A single-line diagram showing the transfer of electricity from the Project to the transmission grid is provided in Appendix D (filed as CEII).

5.4.13 Transmission Facilities

Project transmission facilities consist of the following:

- Generator leads and the electrical bus housed in a vertical shaft about 528-ft-high and 29.5 ft in diameter leading from the underground powerhouse to four above-ground 19/525-kilovolt (kV) step-up transformers.
- A 100-kV transmission line extending about 9.25 miles from the Bad Creek switchyard to the Jocassee switchyard. The 100-kV line is supported by standard steel lattice towers along the common right-of-way it shares with the 525-kV line and by wooden H-frame structures from Jocassee to the common right-of-way.
- A 525-kV transmission line (Figure 5.4-11) extending about 9.25 miles from the Bad Creek switchyard to a grid intertie at the Jocassee switchyard. The 525-kV line is supported by standard single circuit steel lattice structures spaced between 1,000 ft and 1,500 ft apart.

The two lines share a common 254-ft-wide right-of-way corridor for 7.4 miles, at which point they diverge toward their respective destinations. The total length of the transmission corridor from Bad Creek into the Jocassee Tie Station is approximately 9.25 miles.

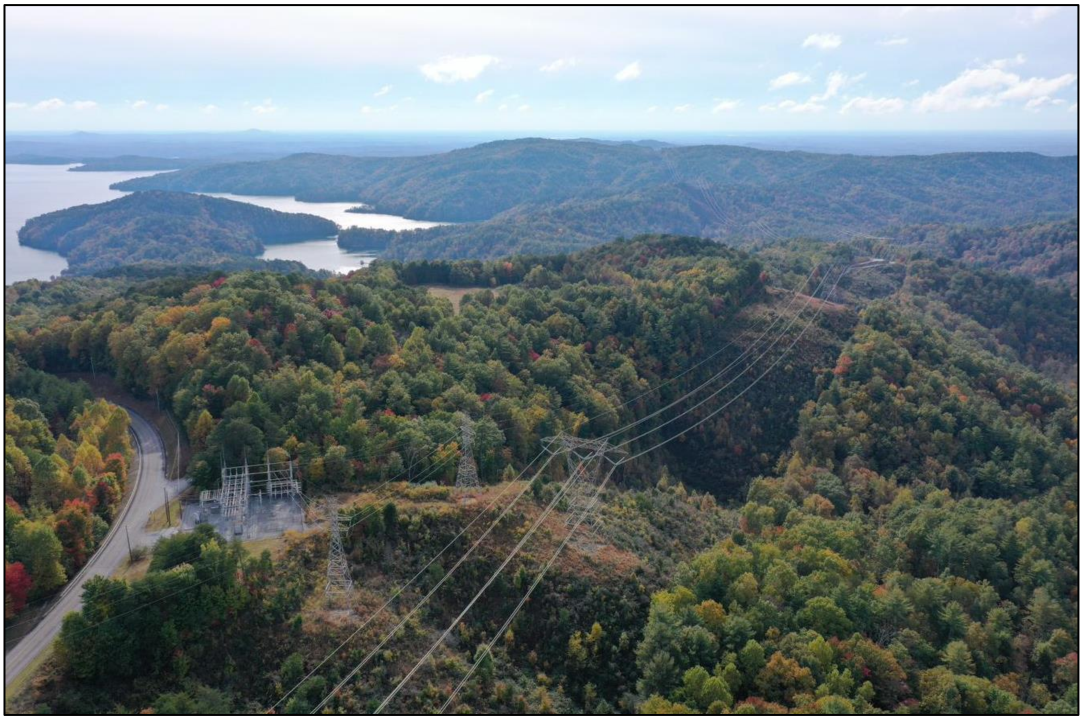


Figure 5.4-11. 525-kV Transmission Line and Corridor

5.4.14 Existing Instrumentation

The Bad Creek Project is operated in accordance with the Owner's Dam Safety Program and FERC’s regulations and engineering guidelines. Bad Creek instrumentation includes reservoir and tailrace surface water level transducers, observation wells, piezometers, inclinometers, extensometers, weirs, flumes, and survey monuments. The instrumentation data are recorded and evaluated to ensure the continuing safety of the Project. Instrumentation monitors aspects of the performance of the powerhouse, main dam, west dam, east dike, tie-back walls and the power/penstock tunnels. The instrumentation data are routinely collected, reviewed, and evaluated in accordance with the Dam Safety Surveillance and Monitoring Plan for the Bad Creek Project (HDR 2018). An initial Potential Failure Mode Analysis for the Bad Creek Project was conducted in 2005 and it is reviewed every five years by Independent Consultants in conjunction with the Part 12D Safety Inspections.

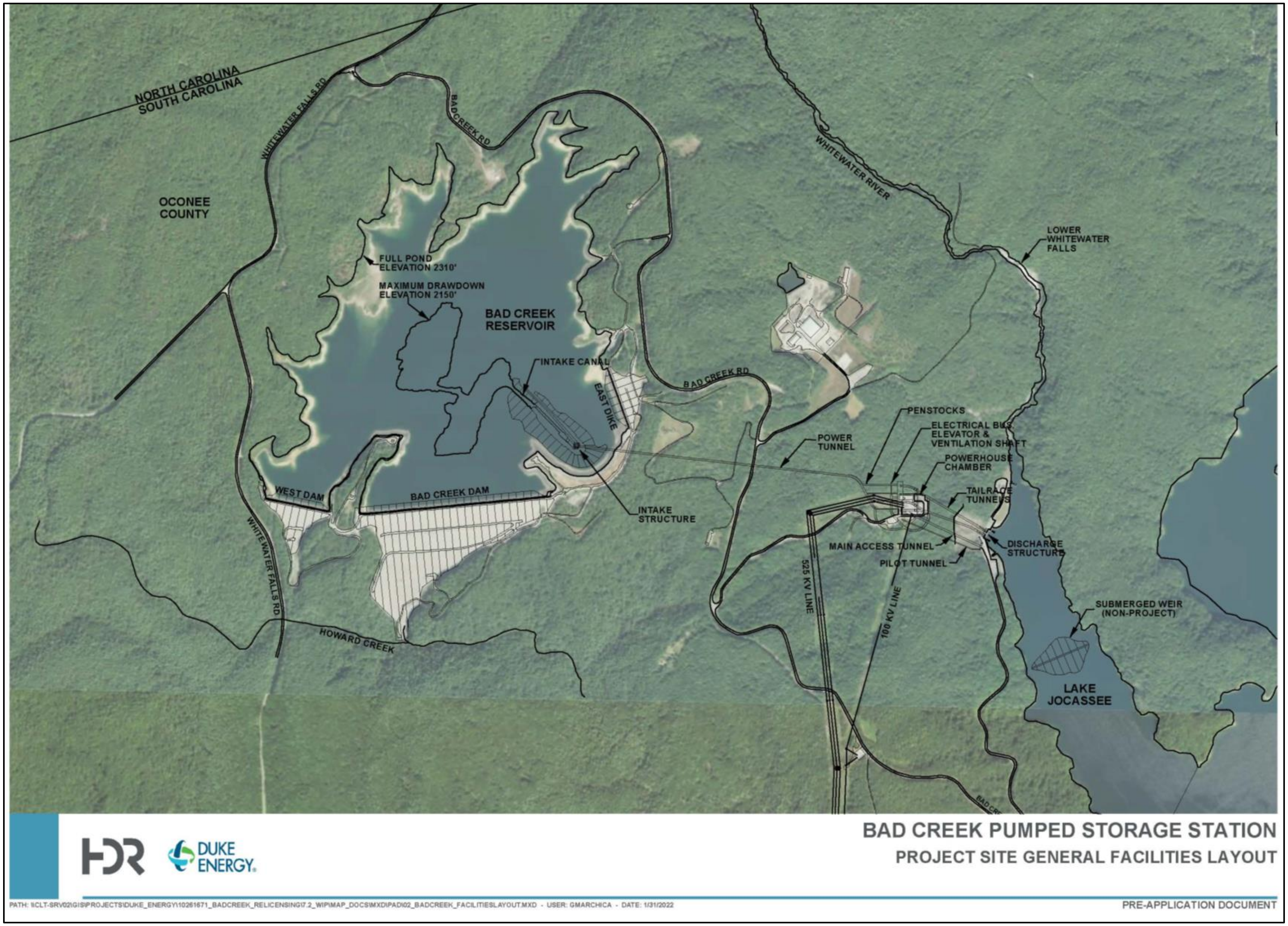


Figure 5.4-12. Bad Creek Existing Facilities Layout

5.5 Project Operations (18 CFR §5.6(d)(2)(iii)(E), (iv))

5.5.1 Current and Proposed Operations

The Bad Creek Project is an automated station operated from Duke Energy's Regulated Renewables Operations Center (RROC) in Charlotte, North Carolina. Operation and maintenance personnel staff the powerhouse 7 days a week, 24 hours a day to perform maintenance and respond to alarms at the request of the RROC. The Bad Creek Project is operated in accordance with the Owner's Dam Safety Program and FERC's regulations and engineering guidelines and safety-related operations at the Project involve routine inspections and maintenance as required. Bad Creek utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee as the lower reservoir.

Bad Creek was originally designed as a "weekly cycle" facility with approximately six hours of generation per day, allowing Duke Energy to utilize approximately 29 hours of storage in the upper reservoir to generate at full load three hours in the morning and three hours in the evening (with individual unit operations during the remaining daylight hours for load following and ramping services), five days per week, and then pump back for a portion of each night and over the weekend with low cost and available baseload power from Duke Energy's coal and nuclear fleet. Bad Creek currently operates on more of a "daily cycle" mode, commonly alternating between generating and pumping on a daily basis, with the reservoir typically maintained in the upper 50 to 60 ft at elevations of 2,310 and 2,250 ft msl (compared to a maximum drawdown of 160 ft). This operating mode permits Duke Energy to maximize head, energy density, and plant/unit efficiency and utilize the Project like a massive battery to help balance the regional transmission system, including rapid consumption or generation of power due to variable solar energy production.

As described above, the Project is presently undergoing pump-turbine unit upgrades. Table 5.5-1 presents major operating characteristics for Bad Creek (Pre-Upgrade) and the station runner upgrade program (Post-Upgrade) currently underway.

Table 5.5-1. Major Project Operating Characteristics

Characteristic	Pre-Upgrade	Post-Upgrade
Upper Reservoir Active (Usable) Storage	31,808 acre-ft	
Approximate Upper Reservoir Run Time	29 hours	23 hours[1]
Upper Reservoir Drawdown	2,310 ft – 2,150 ft = 160 ft	
Number of Units	4	
Installed Capacity	1,160 MW[2]	1,400 MW
Approximate Maximum Capacity	1,440 MW	1,680 MW
Lower Reservoir	Lake Jocassee	
Lower Reservoir Licensed Drawdown	1,110 ft – 1,080 ft = 30 ft	
Impact on Lower Reservoir	Approximately 4 ft[3]	

[1] The Bad Creek II Complex would approximately double the currently installed generating and pumping capacity at Bad Creek but would reduce the available run time.

[2] The existing units have a current authorized capacity of 290 MW (total station capacity of 1,160 MW) as currently defined by 18 CFR 11.1(i) and assuming a normal gross head of 1,180 ft (i.e., Bad Creek at 2,280 ft msl and Jocassee at 1,100 ft msl).

[3] The approximate 4-ft impact on Lake Jocassee (at 1,110 ft msl) represents the entire Bad Creek Reservoir active storage.

5.5.2 Generation and Pumping

The Bad Creek Project operates in a pumped storage mode which is characterized by the regular, scheduled movement of water from the upper reservoir to the lower reservoir (generation) and from the lower reservoir back to the upper reservoir (pumping). The Project is considered a true pumped storage facility, in that essentially all the water utilized for generation originates from the lower reservoir.

The Project had an average annual gross generation of 1,884,685 megawatt-hours (MWh) for the period 2015 through 2020. Average annual pumping energy required for this same period was 2,398,114 MWh. This results in a net consumption of 513,429 MWh. Table 5.5-2 provides a summary of monthly and annual Project generation in gross MWh for the years 2015-2020 and Table 5.5-3 provides a summary of monthly and annual average pumping in MWh, depicted as a negative value representing energy used for pumping. The average overall cycle efficiency is 78.6 percent. With the four new runners installed, generating and pumping capacity will increase due to a combination of increase in flow and improvement in the hydraulic design of the runners.

The increase in flow will lead to higher friction losses in the water conveyance system. However, the overall cycle efficiency is predicted to increase to 80.0 percent assuming operation of all four units simultaneously. The average annual gross generation is estimated to increase by 25,856 MWh (FERC 2020).

Table 5.5-2. Monthly and Annual Generation (MWh) (2015-2020)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Gross
2015	100,655	130,038	126,013	27,316	165,939	242,494	243,170	228,911	204,897	131,591	92,562	186,530	1,880,116
2016	141,791	140,095	166,621	120,740	192,213	250,548	280,666	275,966	236,956	75,581	130,096	150,084	2,161,355
2017	143,280	126,845	170,104	179,434	192,119	228,127	244,174	250,919	210,675	166,714	145,293	152,845	2,210,528
2018	147,120	99,841	-1,281	-1,220	-1,182	41,286	230,212	218,657	193,770	199,986	154,368	143,307	1,424,863
2019	167,955	169,037	141,052	162,458	225,670	182,404	216,698	176,367	197,223	154,139	128,876	127,905	2,049,783
2020	131,602	124,319	36,211	91,282	141,764	153,911	188,147	169,694	131,768	136,253	125,562	150,954	1,581,467
Average	138,734	131,696	106,453	96,668	152,754	183,128	233,845	220,086	195,882	144,044	129,460	151,938	1,884,685

Table 5.5-3. Monthly and Annual Pumping (MWh) (2015-2020)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Gross
2015	-147,689	-162,229	-152,260	-39,336	-210,528	-313,033	-304,618	-301,852	-239,795	-170,417	-129,292	-239,268	-2,410,317
2016	-169,019	-192,667	-201,499	-154,861	-243,238	-317,078	-355,179	-344,490	-301,423	-102,546	-161,742	-186,067	-2,729,808
2017	-193,154	-152,621	-217,424	-225,426	-258,191	-290,042	-310,980	-310,182	-264,283	-217,133	-175,150	-213,946	-2,828,533
2018	-172,901	-105,277	0[a]	0[a]	0[a]	-79,437	-296,959	-269,142	-254,421	-247,004	-197,500	-193,777	-1,816,418
2019	-203,317	-223,769	-193,895	-189,820	-287,878	-244,389	-266,870	-220,898	-248,400	-187,130	-189,855	-164,474	-2,620,696
2020	-148,590	-169,737	-45,791	-122,102	-164,750	-200,074	-226,254	-230,111	-155,228	-174,421	-161,591	-184,259	-1,982,909
Average	-172,445	-167,717	-162,174	-146,309	-232,917	-240,676	-293,477	-279,446	-243,925	-183,109	-169,188	-196,965	-2,398,114

[a]Station outage for full upper reservoir drawdown and commencement of upgrade activities.

5.5.3 Dependable Capacity

The average energy generation (output) and pump energy (consumption) of the Project for the period 2015-2020 is 1,884,685 MWh and 2,398,114 MWh respectively. The dependable capacity (claimed capacity) has previously been stated as 340 MW per unit (Duke Energy 2020) in both summer and winter for all four units; however, the currently ongoing unit upgrade(s) will result in an increase of 70 MW per unit for both summer and winter for all four units (i.e., 410 MW per unit) as shown in Table 5.5-4.

Table 5.5-4. Unit Capacity and Planned Uprates

Unit	Winter/Summer Capacity (MW)	Age (Years)	Estimated Remaining Life (Years)	Planned Uprate	Planned Uprate Winter/Summer (MW)
Unit 1	340 MW	28	39	June 2023	70
Unit 2	340 MW	28	39	June 2020	70
Unit 3	340 MW	28	39	June 2021	70
Unit 4	340 MW	28	39	June 2022	70

The total contributing drainage area for the Bad Creek Reservoir is 1.5 square miles (mi^2) and the average annual flow of Bad Creek and West Bad Creek, combined, is approximately 5 cfs. Annual evaporation from the Project's upper reservoir is estimated to be 42 inches. Leakage through the Project embankments is approximately 5 cfs. Combined, water losses due to evaporation, turbine leakage, and evaporation are considered insignificant when compared to the total volume of water cycled at the Project annually. As such, these variables are not considered when estimating the Project's dependable capacity.

5.6 Proposed Bad Creek II Power Complex (18 CFR §5.6(d)(2)(vi))

The Bad Creek II Complex would utilize the existing station's upper and lower reservoirs (Bad Creek Reservoir and Lake Jocassee, respectively). The proposed Bad Creek II Complex would consist of a new upper reservoir inlet/outlet (within the existing upper reservoir), water conveyance system, underground powerhouse, and lower reservoir inlet/outlet (along the shoreline of Lake Jocassee). No modifications to the existing upper and lower reservoirs would be required for the Bad Creek II Complex other than construction of an upper reservoir inlet/outlet structure within the Bad Creek Reservoir and a lower reservoir inlet/outlet structure within Lake Jocassee. A preliminary layout of the project facilities is shown in plan view on Figure 5.6-1. This layout was developed for a preliminary feasibility study for the site conducted for Duke Energy and will continue to be refined through the ongoing technical feasibility study. The location of major structures that would compose the Bad Creek II Complex is not, however, expected to significantly change during the course of this study, because these locations are constrained by existing infrastructure and topography. The locations of new structures and disturbed areas have and will continue to be sited to reduce impacts to natural resources to the greatest extent possible while also optimizing Bad Creek II Complex operations and controlling construction and operation and maintenance costs.

Construction of the Bad Creek II Complex (as currently conceptualized) will require modification of the existing FERC Project Boundary to encompass additional facilities, including those listed below.

- Upper reservoir inlet/outlet
- Low and high pressure headrace tunnels
- Manifold and penstock tunnels
- Vertical shaft
- Transformer yard
- New 525-kV switchyard
- New 525-kV transmission line from the new switchyard to the Jocassee switchyard (utilize existing transmission line right-of-way)
- Underground power complex
- Draft tube and tailrace tunnels

- Lower reservoir inlet/outlet

Regarding the new 525-kV transmission line necessary for the Bad Creek II complex, preliminary evaluations suggest locating the new line in the existing transmission line corridor, alongside the existing transmission lines may have the least environmental impact. However, prior to making any line siting proposals, Duke Energy intends to conduct a more detailed and comprehensive transmission line siting study complete with an evaluation of associated environmental impacts to determine the preferred route of the new transmission line.

Duke Energy currently owns all property required for construction of the Bad Creek II Complex; however a portion of the transmission line is maintained under a property easement. For the purposes of design and major permitting, the limits of disturbance will be defined to encompass all areas where construction activities will occur. As final project design progresses, a final Project Boundary for the Bad Creek II Complex will also be determined and proposed in the license application as applicable, to include all land necessary for access or control to construct and operate the expanded Project.

5.6.1 Existing Transmission Line Corridor

Should locating the new transmission line alongside the existing transmission lines within the existing transmission line corridor prove to be the least impactful option for siting a new transmission line for the Bad Creek II complex, on-site reconnaissance activities revealed siting planning may need to consider potential impacts that could affect up to the 47 jurisdictional streams, 17 jurisdictional wetlands, and/or 1 open water area established currently crossed by the existing transmission facilities and within the existing transmission line corridor and 436-acre area covered by this survey. A summary of jurisdictional water of the U.S is provided in Table 6.6-1 (Streams) and Table 6.6-2 (Wetlands). Refer to Appendix E for complete descriptions, maps, and photographs of streams and wetlands.

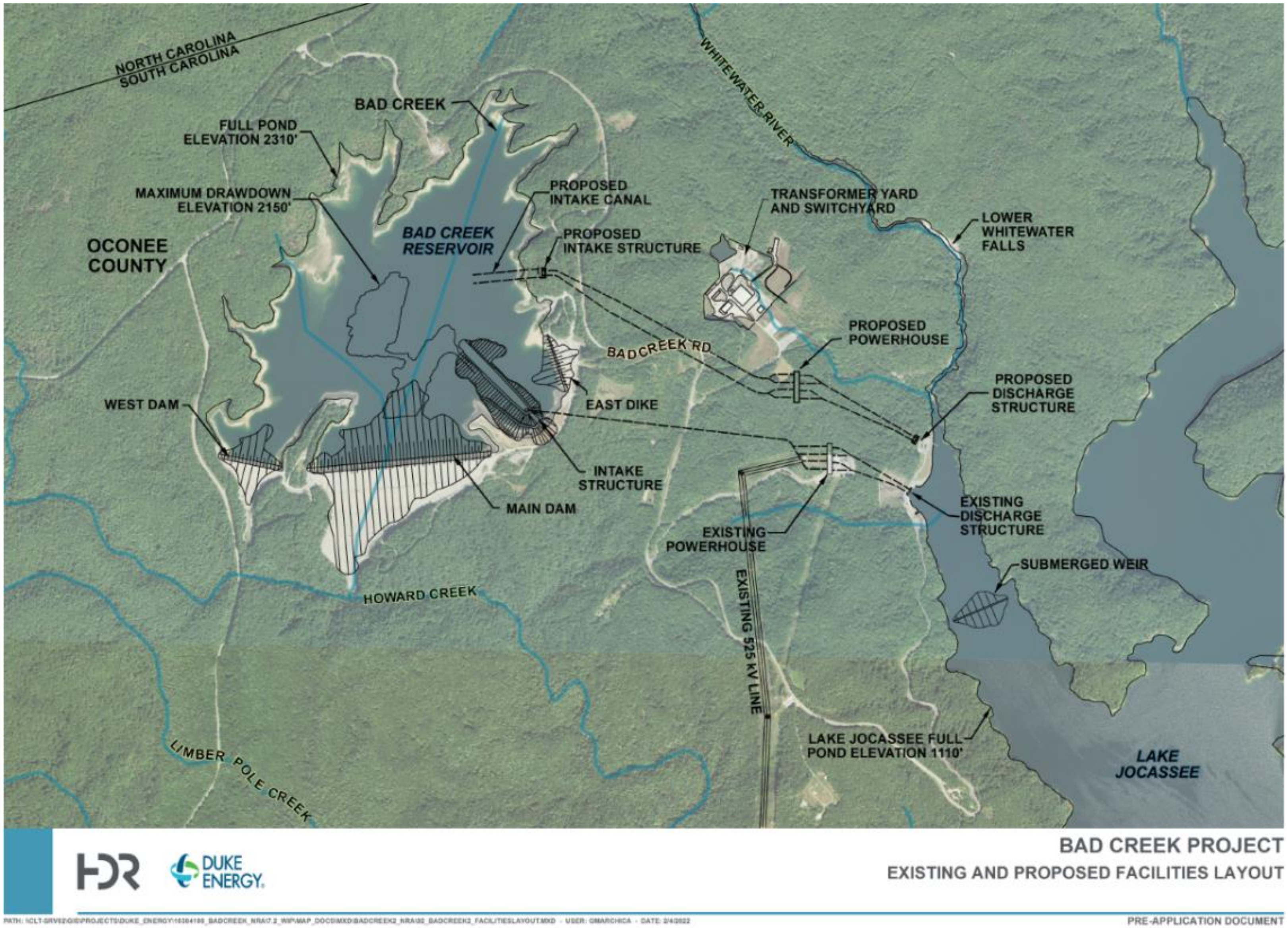


Figure 5.6-1. Proposed Bad Creek II Complex Facilities Layout (Major Existing Bad Creek Project Facilities also Shown)

5.6.2 Proposed Project Facilities

5.6.2.1 Water Conveyance Profile

The Bad Creek II Complex, as presently envisioned, will be designed to maximize installed capacity while maintaining approximately 12 to 14 hours of usable storage in the upper reservoir. The water conveyance profile will consist of an upper reservoir horizontal intake, two low-pressure tunnels, two vertical shafts, two high-pressure power tunnels, four penstocks, an underground powerhouse, four draft tube tunnels, two tailrace tunnels and a horizontal lower reservoir inlet/outlet. All tunnels will be fully lined with concrete for stability and to reduce hydraulic losses. The penstocks will be steel-lined upstream of the powerhouse for a distance of approximately 220 ft. The following tunnel diameters are under evaluation: 30 ft for the two headrace tunnels and shafts, 15 ft for the four unit penstocks, 18 ft for the four draft tube tunnels, and 31 ft for the two tailrace tunnels. Sizing will be determined based on the number of generating units proposed as well as the pump-turbine unit technology selected (i.e., single-speed or variable-speed). Turbine maximum discharge (station total) at the proposed station is estimated at 18,600 cfs.

A cross-section view of the water conveyance profile and underground Bad Creek II Complex facilities is shown in Figure 5.6-2.

5.6.2.2 Upper Reservoir Inlet/Outlet Configuration

The upper reservoir inlet/outlet is currently projected to be a submerged, reinforced concrete structure located along the shore of Bad Creek Reservoir measuring approximately 150 ft wide, 30 ft deep, and 40 ft tall. The general location of the structure was selected to minimize the length of water conveyance tunnel and facilitate access to the entire upper reservoir drawdown. Four tunnels will penetrate the structure at approximate invert elevation of 2,083 ft msl. Each tunnel inlet is to be fitted with a coarse opening trash rack to protect against entraining large stones and/or debris into the water conveyance tunnels. Isolation gates and access shafts will be provided downstream of the inlet/outlet to permit dewatering of either or both of the headrace tunnels without impact to the upper reservoir operations. The intake channel is assumed to have a maximum invert elevation of 2,130 ft msl (at the reservoir interface), measure approximately 150 ft wide at the base, and extend approximately 700 ft from the structure into the waters of Bad Creek Reservoir.

5.6.2.3 Lower Reservoir Inlet/Outlet Configuration

The Bad Creek II Complex lower reservoir inlet/outlet is expected to be a reinforced concrete structure similar to the Bad Creek inlet/outlet (i.e., discharge structure) along the shore of Lake Jocassee. The structure will be located in the portal area adjacent to the existing Bad Creek inlet/outlet, requiring the relocation of minor facilities in the area, including but not limited to, a grounding mat, septic facilities, water treatment ponds, and storm water drainage. The new structure will be constructed a sufficient distance from the existing inlet/outlet and Lake Jocassee to permit a "sinking cut" (to construct the inlet/outlet) to be installed behind a natural earthen cofferdam (which is similar to the construction method used for the existing inlet/outlet) and with sufficient access to avoid the existing inlet/outlet structure and channel. The existing portal yard will be expanded and will require a cut in the adjacent western slope, supported by a retaining wall.

The inlet/outlet structure will be approximately 150 ft wide, 20 ft deep, and 95 ft tall. The location of the structure was selected to minimize the length of water conveyance tunnel, permit access and reduce construction-related environmental impacts to the Whitewater River arm of Lake Jocassee. Four tunnels will penetrate the structure at invert elevation of 1,009 ft msl. Each tunnel opening will be fitted with a steel bulkhead to permit dewatering of either or both of the headrace tunnels. The connecting channel will extend from the lower reservoir inlet/outlet front face and slope up to the open waters of Lake Jocassee. The channel invert will be approximately 150 ft wide with near vertical side slopes in rock and 2:25H:1V side slopes in soil. Permanent tieback retaining walls will extend from the inlet/outlet structure similar to the existing Bad Creek inlet/outlet.

5.6.3 Underground Powerhouse

5.6.3.1 Underground Powerhouse Main Cavern

The main cavern of the Bad Creek II Complex underground powerhouse was arranged and sized similarly to that of the Bad Creek powerhouse and contains the pump-turbine/generator-motor units, and electrical and mechanical balance of plant and station services. The overall size of the underground powerhouse will be approximately 433 ft long by 75 ft wide by 170 ft high. The underground powerhouse will be connected by two equipment tunnels to the draft tube gate gallery, which will be approximately 400 ft long by 20 ft wide by 26 ft high.

5.6.3.2 Powerhouse Access Tunnels and Shafts

Permanent underground powerhouse access will be provided by a modified horseshoe (D-shape) access tunnel extending from the portal area to the powerhouse. Secondary access will be provided by the vertical access shaft also housing the low voltage isolated phase bus extending to the new transformer yard. The access tunnel will have a bottom width and height of 30 ft and 26 ft, respectively, sized to accommodate construction/service vehicles and all powerhouse equipment. A maximum grade of 10% is presently assumed for the powerhouse access tunnel with an approximately length of 1,200 ft. The invert of these tunnels will be lined with concrete, and the walls and crown rock bolted and lined with shotcrete as required. The tunnels will include ventilation and lighting.

Construction adits will be installed around the powerhouse to facilitate construction of the headrace and tailrace tunnels. These adits will be permanently plugged where they intersect the water conveyance tunnels after construction is complete.

In addition to the access tunnels and adits discussed above, a permanent drainage tunnel will be constructed upstream of the powerhouse cavern with drilled drains to intercept seepage in the rock mass and prevent hydrostatic pressure against the upstream wall of the powerhouse. In addition, some drain holes will be aligned to relieve hydrostatic pressure along the exterior of the penstocks during an unwatering event.

5.6.3.3 Rock and Soil Disposal Areas

Excavation required for construction of the Bad Creek II Complex will result in a significant quantity of earth and rock (or "spoil") material. As for construction of the existing Bad Creek Project, rock removed from the underground excavations will be added to, expanding the downstream slope of, the existing submerged weir in Lake Jocassee. Duke Energy is presently evaluating a range of upland areas within the Project Boundary and/or on property owned by Duke Energy adjacent to the Project Boundary for spoil of excavated earth and additional rock.

5.6.3.4 Transformer Yard

The transformer yard will be located aboveground with convenient access via the original construction yard / Lower Whitewater Falls access road. This area was selected both to facilitate access and due to the favorable terrain. The transformer yard is sized to provide an area similar to the existing 525-kV transformer yard for Bad Creek and will be located just south of proposed location. The transformer yard will contain all necessary transformation equipment and an equipment building constructed above the vertical shaft. In addition, the yard will accommodate a temporary concrete batch plant and cement/aggregate storage during construction of the power complex. Concrete would be surface batched, dropped down a shaft, and remixed for placement in the powerhouse and water conveyance tunnels.

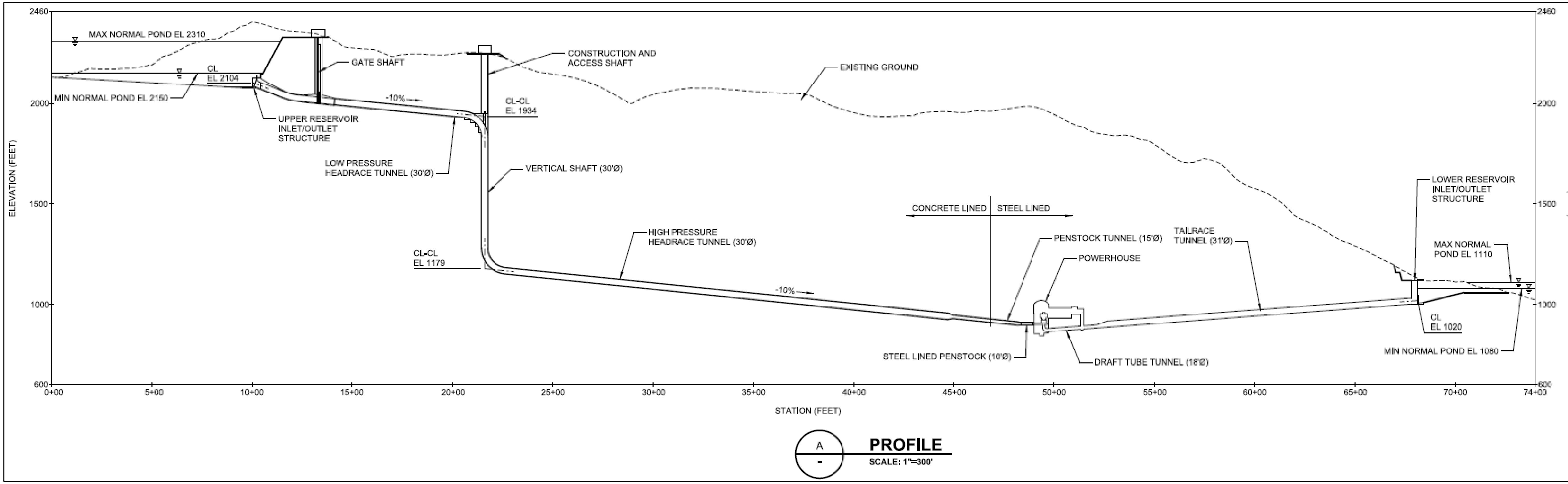


Figure 5.6-2. Bad Creek II Complex Proposed Facilities Cross-section

5.6.4 Proposed Project Operations

As described above, the Bad Creek upper reservoir was originally designed and licensed to operate between 2,310 ft msl (full pond) and 2,150 ft msl (minimum pond level), resulting in a 160-foot maximum drawdown and an active storage of approximately 31,808 acre-ft with approximately 29 hours of generation without pumping (5 hours of generation Monday through Friday) with pump-back over the weekend. However, since January 1995, the upper reservoir has predominantly operated more on a daily cycle above 2,250 ft msl for approximately 97 percent of the time. Such operations result in maximized head and efficiency.

Constructing the new four-unit underground power complex could approximately double the currently installed generating and pumping capacity at Bad Creek and would reduce the available run time. In addition, the new power complex may contain variable-speed units, which would have the invaluable ability to regulate in both the generating and pumping modes, thus providing frequency regulation to support the integration of Duke Energy's ever expanding, intermittent renewable energy resources.

The pump-turbine/motor-generator unit at the Bad Creek II Complex is estimated to generate between a minimum of 106 MW to 163 MW to a maximum of 425 MW (depending on the starting head differential), allowing it to provide between 163 MW to 319 MW of incremental reserves individually. As each additional unit is brought online, up to 425 MW of capacity and between 163 MW to 319 MW of incremental reserve capability can be added. If variable-speed unit technology is selected, this will give the plant the capability of bringing each unit from standstill to full load generation in less than 1.5 minutes.

In the pump mode, it is estimated each unit will be capable of starting at a minimum input power of 308 MW to 372 MW (depending on the head) at low speed and rapidly ramping to 464 MW at high speed as necessary to support grid operations. From synchronous condense operation, each unit can reach full load in approximately one minute. From a cold start, each unit can reach full load operation in less than six minutes. Similar to the continuum of incremental reserves achievable in turbine mode, the units can provide a significant range of decremental reserves in the pump mode by coupling each unit's 93 MW to 108 MW input range with the ability to operate more or less units.

Operational studies for the existing (and planned uprated) Bad Creek Project, the Bad Creek II Complex (4 x 350 MW), and for both plants operating simultaneously have been performed for Duke Energy. The purpose of this study was to estimate the following operational characteristics in both the turbine and pump modes over the entire range of upper reservoir operations (2,310 ft msl to 2,150 ft msl):

- Run time durations in both the turbine and pump mode (hours)
- Station output and input over the entire head range (MW)
- Energy output and input over the entire head range (MWh)

Table 5.6-1 presents a summary of results of this study.

Table 5.6-1. Preliminary Energy and Run Time Studies Summary

Existing Uprated Bad Creek – Maximum Flow		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	20	26
MWh	30,379	38,803
Maximum Power (MW)	1,695	1,595
Existing Uprated Bad Creek – Best Efficiency		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	23	26
MWh	31,440	38,803
Maximum Power (MW)	1,426	1,595
Proposed Bad Creek II Complex Project – Maximum Flow		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	20	26
MWh	31,295	38,360
Maximum Power (MW)	1,687	1,617
Proposed Bad Creek II Complex Project – Best Efficiency		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	23	26
MWh	31,945	38,360
Maximum Power (MW)	1,433	1,617
Existing Uprated Bad Creek and Proposed Bad Creek II Complex Project – Maximum Flow		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	10	13
MWh	30,833	38,579
Maximum Power (MW)	3,382	3,212
Existing Uprated Bad Creek and Proposed Bad Creek II Complex Project – Best Efficiency		
Item	**Turbine Mode**	**Pump Mode**
Duration (hours)	11.5	13
MWh	31,692	38,579
Maximum Power (MW)	2,859	3,212

5.7 Current License Requirements (18 CFR §5.6(d)(2)(v)(A))

A 50-year license to construct and operate the Bad Creek Project was issued by FERC to Duke Energy on August 1, 1977. This license is subject to the following terms and conditions set forth in Form L-11 (Revised October 1975, 54 FPC 1864) entitled "Terms and Conditions of License for Unconstructed Major Project Affecting the Interests of Interstate or Foreign Commerce," and terms and conditions designated therein. Duke Energy has assumed responsibility of complying with all the requirements of the Original License (effective August 1, 1977) as well as all subsequent orders, amendments and Water Quality Certifications pursuant to Section 401 of the CWA. Please see Section 1.6 for a list of license amendments submitted since the original licensing.

5.8 Generation and Outflow ((18 CFR §5.6(d)(2)(v)(B))

A summary of Project generation and outflow for the five years preceding filing of the PAD is provided in Table 5.5-2 and Table 5.5-3.

5.9 Current Net Investment (18 CFR §5.6(d)(2)(v)(C))

Net investment is assumed to be the original cost plus the cost of additions and betterments minus the accumulated depreciation balance for the Project assets. The current net investment in the Project (through December 31, 2020) is approximately $526,789,016. This value should not be interpreted as the fair market value of the Project.

5.10 Compliance History (18 CFR §5.6(d)(2)(v)(D))

To the best of Duke Energy's knowledge and based on a review of historical records, the Licensee has been and continues to be in compliance with the applicable terms and conditions of the FERC license, and there have been no license violations or recurring situations of non-compliance over the license term.

5.11 Potential for New Project Facilities (18 CFR §5.6(d)(2)(vi))

Duke Energy is considering the construction of a new powerhouse (Bad Creek II Complex) within the existing footprint of the Bad Creek Project. See Section 5.6.

5.12 PURPA Benefits (18 CFR §5.6(e))

Duke Energy will not be seeking benefits under Section 210 of the Public Utility Regulatory Policies Act (PURPA) of 1978 for qualifying hydroelectric small power production facilities in §292.203 of this chapter.

6 Description of the Existing Environment and Resource Impacts (18 CFR §5.6(d)(3))

This section provides a description of the Project's Existing Environment and Resource Impacts as required by 18 CFR §5.6(d)(3). This section provides a description of the Project's existing conditions and the results of investigations, evaluations, and consultations conducted by Duke Energy to date, addressing the following resource areas:

- Geology, Topography, and Soils;
- Water Resources;
- Fish and Aquatic Resources;
- Wildlife and Botanical Resources;
- Floodplains, Wetlands, Riparian and Littoral Habitat;
- Rare, Threatened and Endangered Species
- Recreation and Land Use;
- Aesthetic Resources;
- Cultural and Tribal Resources; and
- Socioeconomic Resources.

Each resource section contains a description of the existing environment, an account of potential Project-related effects and a description of existing and proposed PM&E measures.

The following sections include brief assessments of potential impacts of continued operation of the existing Project, as well as potential impacts resulting from the construction and operation of the Bad Creek II Complex. Duke Energy notes these resource impact assessments are preliminary and will be refined through the ILP based on additional information becoming available through ongoing or future studies and consultation with relicensing stakeholders.

In addition to the extensive references listed in Section 9, the resource assessments described in this PAD draw from preliminary studies and evaluations performed for Duke Energy in the summer and fall of 2021:

- A Natural Resources Assessment (NRA), including surveys for wetlands and jurisdictional waters of the U.S., federally protected species habitat, and classification of natural/vegetation communities, carried out by HDR Engineering, Inc. (HDR). The two-phase assessment covered (1) the 436-acre, approximately 9.25-mile-long Bad Creek to Jocassee transmission line corridor in June of 2021 and (2) 1,314 acres of the balance of the area of influence including the structures and features of the existing Project (i.e., Bad Creek Reservoir and dams, inlet/outlet structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, driveways, parking lots, maintenance buildings, open areas, access roads, and undisturbed forested areas) in September of 2021 (Appendix E).

- A desktop fish entrainment evaluation performed by Kleinschmidt Associates (Appendix F).
- Bat surveys (acoustic, habitat, and mist net surveys) of the area of influence performed by Environmental Resources Management (ERM) (Appendix G).

As further described in the following sections, major PM&E measures, which are primarily focused on fisheries, water quality, and recreation, are established by the existing Bad Creek Project license Exhibit S (Environmental Study Plans), Duke Energy and SCDNR MOU and 10-Year Work Plans, and the KT Project Relicensing Agreement. These agreements and plans, in combination with studies performed for the relicensing of the KT Project and information available from natural resource agencies, provide a sound basis for preliminary evaluation of potential environmental impacts and identification of potential protection measures for the construction and operation of the Bad Creek II Complex.

The ILP will provide a collaborative opportunity for early scoping of potential impacts of construction and operation of the Bad Creek II Complex. Resource impacts will be studied through focused relicensing studies, where required, to provide additional information to complement historical, ongoing, and recent site-specific studies, and evaluated in Duke Energy's license application. The ILP will also provide a collaborative opportunity for Duke Energy to consult with agencies and other stakeholders to identify PM&E measures to be continued through the New License term, additional PM&E measures required to address impacts of construction and operation of the Bad Creek II Complex, and environmental monitoring requirements for construction.

The ILP documents, including the FLA to be filed by Duke Energy in 2025, will serve as the basis for the NEPA document, which will be prepared by FERC. The ILP documents may also support other major regulatory permits and approvals required for construction of the Bad Creek II Complex.

6.1 Description of the River Basin (18 CFR §5.6(d)(3)(xiii))

6.1.1 Area of Basin and Length of Streams (18 CFR §5.6(d)(3)(xiii)(A))

The Project is located in the headwaters of the Savannah River Basin (Hydrologic Unit Code [HUC] 030601), which has an area of approximately 10, 577 mi^2 and drains portions of the Blue Ridge, Piedmont, and Coastal Plain (Figure 6.1-1). Approximately 55 percent of the Savannah River Basin is in Georgia (5,821 mi^2), 43 percent is in South Carolina (4,581 mi^2), and 2.0 percent (175 mi^2) is in North Carolina. The Project, along with the other two Duke Energy reservoirs associated with the KT Project (i.e., Lake Jocassee and Lake Keowee) drain approximately 439 mi^2 or just four percent of the entire Savannah River Basin.

Lake Jocassee, which operates as the lower reservoir for the Bad Creek Project, was formed by impounding the Keowee River at river mile (RM) 343.6, just downstream of the confluence of the Whitewater and Toxaway rivers. Lake Jocassee has a drainage area of 145 mi^2, a surface area of approximately 7,980 acres, and approximately 92 miles of shoreline at full pond (1,110 ft msl) (HUC 0306010101). Water from Lake Jocassee flows directly into Lake Keowee, which was formed by impounding the Keowee River and the Little River, and the two impoundments are connected through an excavated canal creating one large impoundment. Lake Keowee has approximately 388 miles of shoreline with a surface area of approximately 17,660 acres at full pond (800 ft msl).

Downstream of Lake Keowee is the Hartwell Dam (RM 289) and based on 73 years of continuous inflow data, annual average inflows to the KT Project account for 28 percent of inflows into Lake Hartwell (Duke Energy 2014a). There are several Georgia Power dams located in North Georgia on tributaries that flow into Lake Hartwell as well as other smaller impoundments on tributaries within the Savannah River Basin that contribute to the overall water resources of the Savannah River Basin. Other major dams on the mainstem Savannah River including the Richard B. Russel Dam (RM 259) and the J. Strom Thurmond Dam (RM 222), along with other smaller dams and diversion structures, are located downstream of the Bad Creek and KT Projects along the Savannah River before the river terminates at the Atlantic Ocean near Savannah, Georgia, approximately 220 miles downstream of J. Strom Thurmond Dam and Lake (also known as Clarks Hill Lake) near Augusta, Georgia.

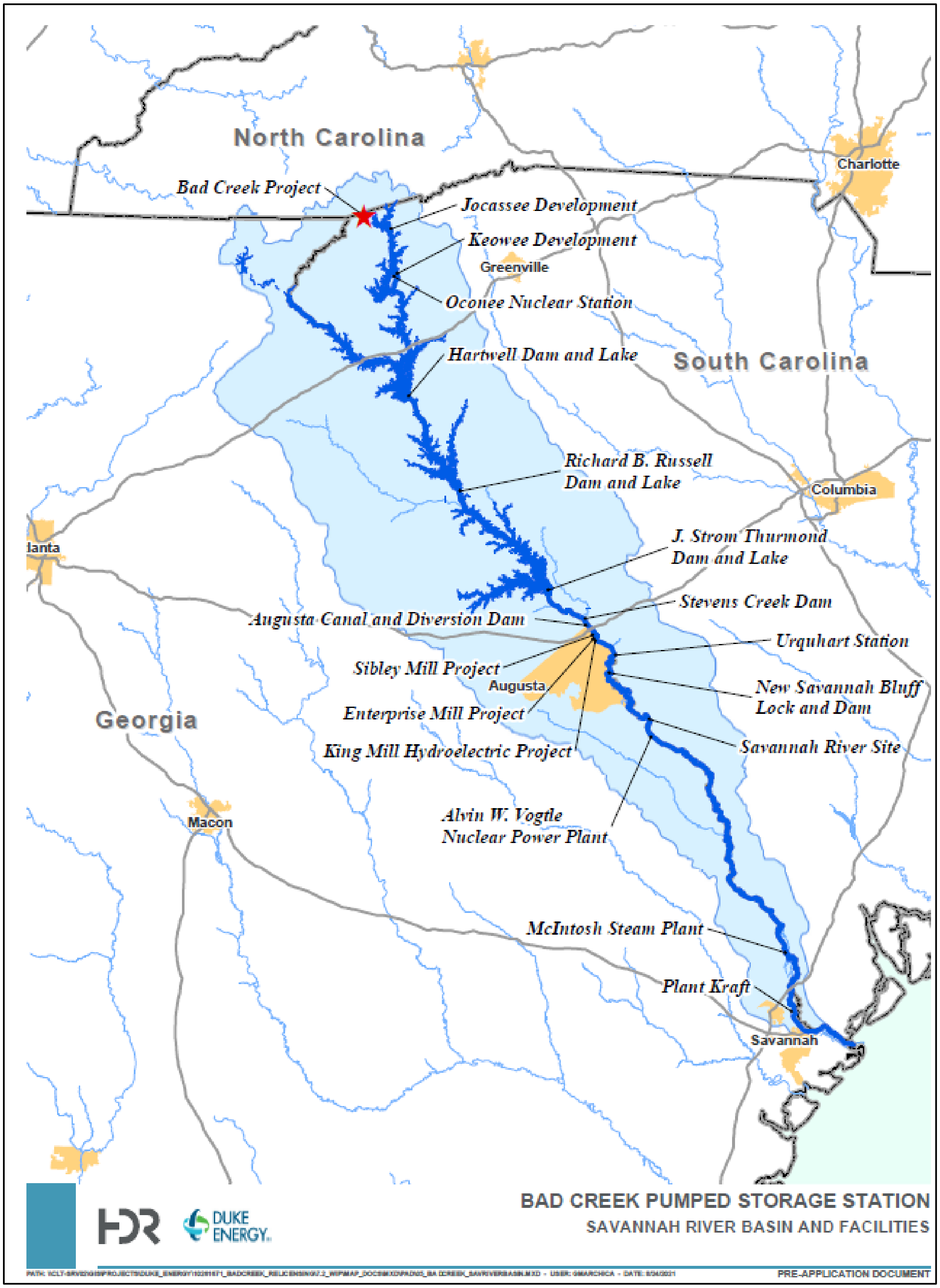


Figure 6.1-1. Savannah River Basin and Project Location

The Project, Project facilities, and the western portion of Lake Jocassee are situated in the Whitewater River watershed (HUC 030601010104), which has an area of 80.3 mi^2. The Whitewater River is approximately 14.6 miles long from its headwaters in Transylvania County, North Carolina to its confluence with Lake Jocassee in South Carolina. The elevation near the headwaters is approximately 3,550 ft msl and the mouth is at 1,108 ft msl; the large elevation difference between the headwaters and the river mouth has helped to form two of the region's tallest waterfalls, the Upper Whitewater Falls and the Lower Whitewater Falls. The Upper Whitewater Falls in North Carolina near Cashiers is the highest waterfall east of the Rocky Mountains with a height of approximately 411 ft. The Lower Whitewater Falls, located just downstream of the upper falls in South Carolina, drops another 400 ft. The average flow at the mouth of the Whitewater River is approximately 76 cfs (USEPA 2019a).

The eastern portion of Lake Jocassee is fed primarily by the Toxaway River, which originates in Transylvania County, North Carolina, at an elevation of approximately 4,000 ft msl. The Toxaway River is approximately 21 miles long, and discharges into the lake at approximately 508 cfs (USEPA 2019b). Similar to the Whitewater River Basin, the terrain is rugged and significant elevation drops over the length of the river result in waterfalls and cascades (e.g., Mill Creek Falls, Laurel Fork Falls). The Horsepasture River is also major tributary to Lake Jocassee (HUC 030601010103) with an area of 36 mi^2 and an average discharge of approximately 141 cfs (USEPA 2019c).

The Project transmission line corridor extends through a small portion of the Upper Little River-Lake Keowee watershed (HUC 030601010302) and terminates at a grid intertie station at the Jocassee Pumped Storage Station in the Cane Creek-Lake Keowee watershed (HUC 030601010201) (Figure 6.1-2). These three watersheds are located within the northwestern portion of the Seneca sub-basin (HUC 03060101) (1,028 m^2) within the larger Savannah River Basin (see Figure 6.1-1).

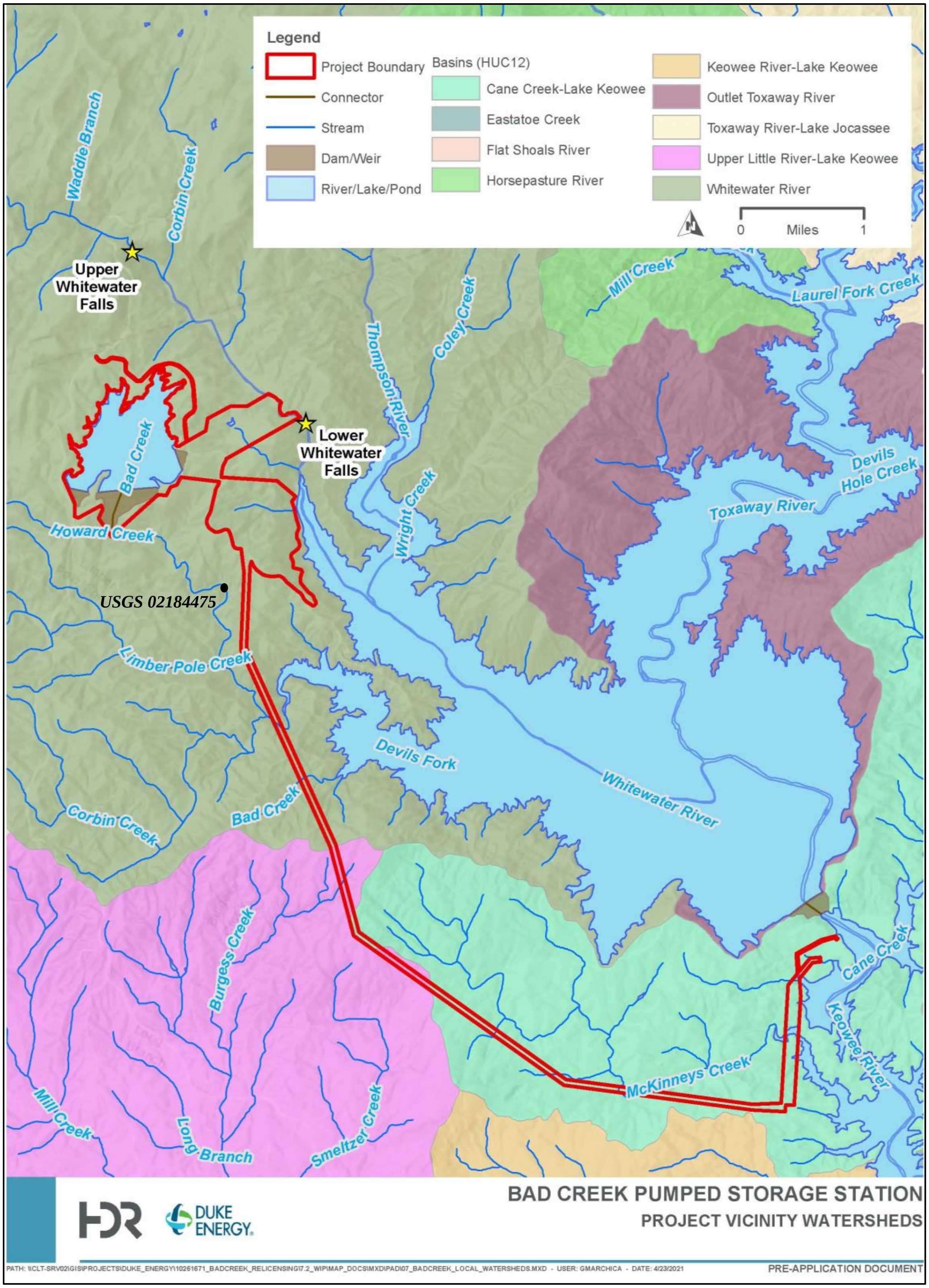


Figure 6.1-2. Watersheds of the Project Area

The Bad Creek upper reservoir has a drainage area of approximately 1.5 mi^2. Prior to impoundment, the (now submerged) Bad Creek and West Bad Creek were tributaries of Howard Creek (a tributary to Lake Jocassee) near the toe of the Main Dam and West Dam, respectively. Seepage through the two earthen dams now flows into Howard Creek near the toe of each dam. Average seepage flows from the Main Dam and the West Dam are approximately 5.0 cfs combined. Flow data from the now-retired U.S. Geological Survey (USGS) gage on Howard Creek (USGS 02184475 HOWARD CREEK NEAR JOCASSEE, SC), which drains an area of approximately 2.16 mi^2, for the available period of record (1989-1996) are included in Table 6.1-1 (see Figure 6.1-2 for gage location). Howard Creek joins Limber Pole Creek approximately 0.8 miles downstream of the USGS gauge and flows into Lake Jocassee approximately 1 mile downstream of the confluence with estimated annual discharge of 38 cfs (USEPA 2019d).

Table 6.1-1. Annual Flow Data for Howard Creek (1989-1996)

Water Year	Discharge (cfs)
1989	10.9
1990	12.9
1991	6.85
1992	7.08
1993	7.79
1994	6.08
1995	6.06
1996	7.4

Source: USGS 02184475 HOWARD CREEK NEAR JOCASSEE, SC
https://waterdata.usgs.gov/nwis/inventory/?site_no=02184475&agency_cd=USGS

6.1.2 Climate

The climate in the Savannah River Basin varies due to the differences in the topography from the headwaters near the Project to the river mouth at the Atlantic Ocean. Upstate South Carolina has four distinct seasons and the climate of the entire state is classified as a humid, subtropical climate. The climate at the Project is affected by the presence of the Blue Ridge Mountains, the relative location of the state in the northern mid-latitudes, and elevation; the mountains protect the area from cold air masses from the northwest, which helps keep the winters relatively warm.

The National Weather Service maintains a weather station at the Oconee County regional airport in Clemson, SC, about 3 miles southeast of Lake Keowee. At this location, average July high temps are about 91 degrees Fahrenheit (ºF) and average lows are about 70ºF. The average high temperature for January is 54ºF, and the average low is about 34ºF with limited snowfall. The Upstate region has the highest average annual precipitation in the state. Average annual precipitation at this location is about 53 inches with average monthly values relatively evenly distributed. Smaller watersheds draining the headwaters above Lake Jocassee may receive as much as 100 inches of precipitation per year.

The 30-year climate data for Oconee County (recorded at Walhalla, SC) are presented in Table 6.1-2.

Table 6.1-2. Climate data (30-year) for Oconee County, South Carolina (SCDNR 2021a)

Years	Max Temp (ºF)	Mean Temp (ºF)	Min Temp (ºF)	Precipitation (ºF)
1971-2000	72.4	58.8	45.1	60.65
1981-2010	71.8	59.5	47.1	57.81

6.1.3 Major Land and Water Uses (18 CFR §5.6(d)(3)(xiii)(B)

6.1.3.1 Land Cover

The Project vicinity includes mature deciduous forests with some pine forests on open steep south and southwest facing slopes. The area around Lake Jocassee is dominated by mature growth forested land with parts of the KT Project bordering but not including the Sumter National Forest; however, portions of the Devils Fork State Park occupy lands at Lake Jocassee. The Bad Creek Reservoir has no residential development, and Lake Jocassee has minor residential development (compared to Lake Keowee). The primary reason for this is that Duke Energy, in partnerships with SCDNR, SCDPRT, and the State of North Carolina has designated a significant amount of the land adjoining Lake Jocassee for public recreation and resource conservation.

The total Project Boundary encompasses approximately 1,280 acres. Table 6.1-3 shows the land use classifications for the main area around the upper reservoir, powerhouse, and lower reservoir inlet/outlet structure based on the USGS's National Land Cover Database, and Table 6.1-4 includes the area within the transmission line corridor.

As presented in Table 6.1-4, nearly a third of the area enclosed by the Project Boundary (excluding the transmission line corridor) is open water.

Table 6.1-3. Land Use in the Project Boundary, Excluding Transmission Line Corridor

Land use Type	Percent
Barren Land	1.4
Cultivated Crops	3.7
Deciduous Forest	30.0
Developed, High Intensity	1.2
Developed, Low Intensity	1.1
Developed, Medium Intensity	0.6
Developed, Open Space	3.3
Evergreen Forest	1.5
Hay/Pasture	10.1
Herbaceous	3.0
Mixed Forest	14.0
Open Water	29.8
Shrub/Scrub	0.3

Table 6.1-4. Land Use in the Transmission Line Corridor

Land use Type	Percent
Barren Land	0.1
Deciduous Forest	48.0
Developed, High Intensity	0.2
Developed, Low Intensity	2.0
Developed, Medium Intensity	0.8
Developed, Open Space	4.2
Evergreen Forest	4.1
Hay/Pasture	2.0
Herbaceous	14.9
Mixed Forest	17.6
Open Water	1.8
Shrub/Scrub	4.3

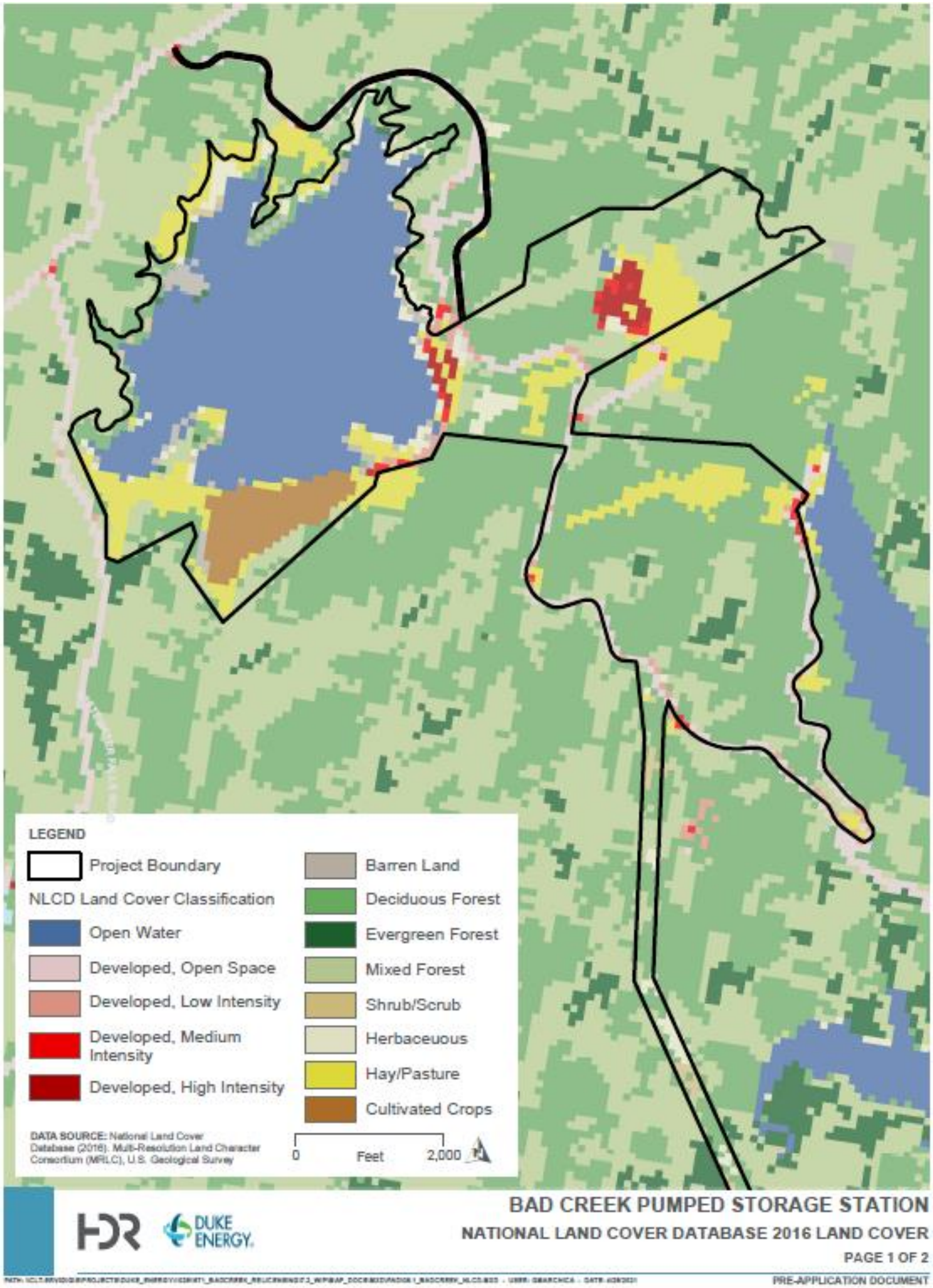


Figure 6.1-3. Land Use Map of Project Boundary (Excluding Full Transmission Line Corridor)

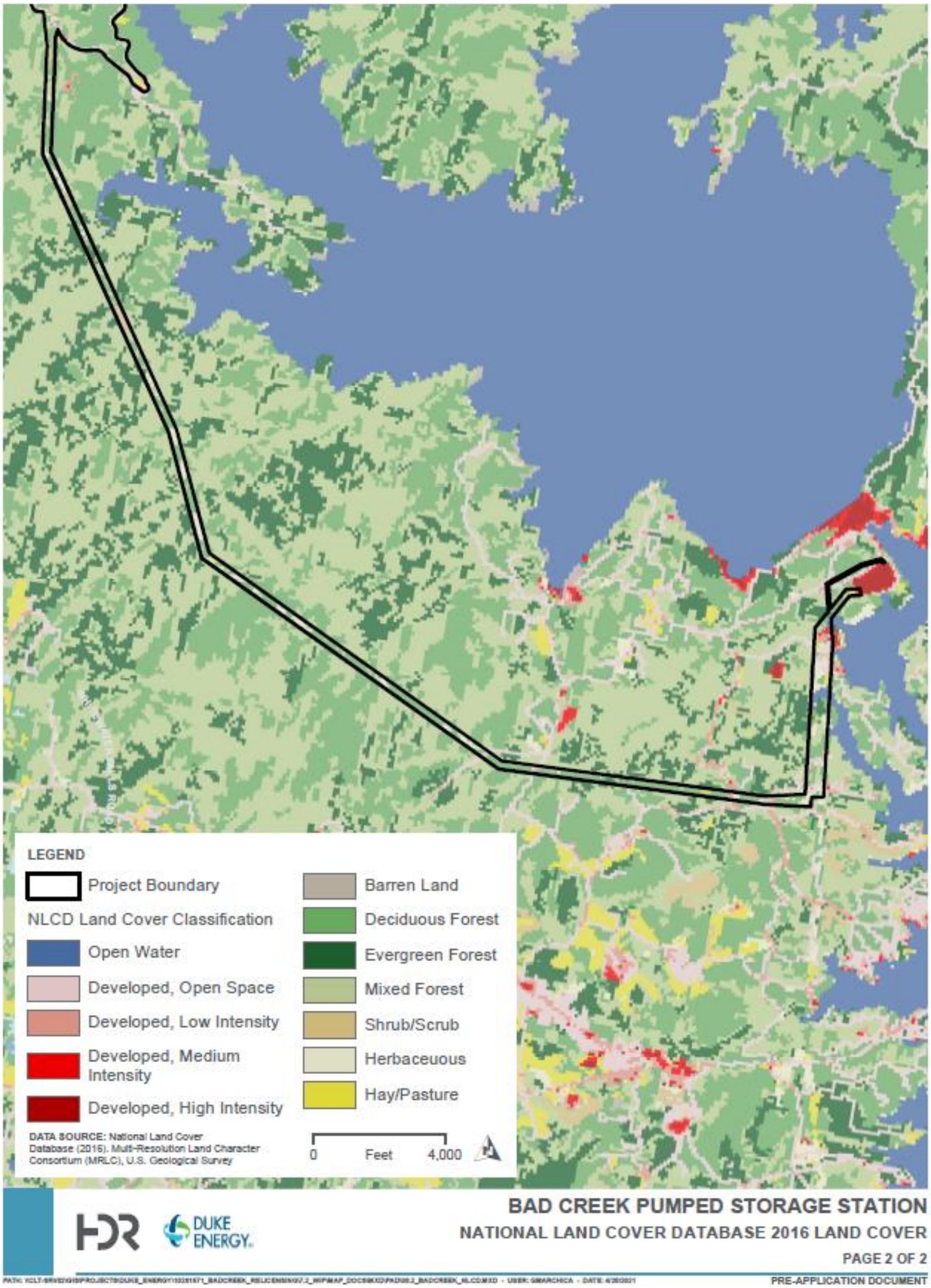


Figure 6.1-4. Land Use Map of Project Boundary (Transmission Line)

6.1.3.2 Water Use

Both North Carolina and South Carolina have assigned state water quality standards commensurate with a designated use of a water body and both states have similar categories of designated use; however, the waters of the Bad Creek Reservoir are not included in state-assigned water quality standards or water use designations, therefore, description of water use in this section is limited to Lake Jocassee and its tributaries.

Some of the tributaries flowing into Lake Jocassee are wholly within North Carolina, some are wholly within South Carolina, and some flow through both states. Variations of sub-sets of general classifications between the two states exist; however, both states have recognized and distinguished between general use to maintain and support aquatic life and general contact recreation, trout habitats, and high value resource areas.

Under the authority of the South Carolina Pollution Control Act, the SCDHEC Water Classification & Standards is responsible for establishing appropriate water uses and protection classifications, as well as general rules and specific water quality criteria in order to protect existing water uses, establish anti-degradation rules, protect public welfare, and maintain and enhance water quality. Streams with the following Water Classifications are found within the Project Vicinity: Outstanding Resources Waters (ORW); Trout Natural (TN); and Trout Put, Grow, and Take (TPGT). The Whitewater River is classified as ORW, Howard Creek is classified as TN, and Whitewater River tributaries are classified as ORW and TPGT (SCDHEC 2021; NCDEQ 2021). Lake Jocassee is designated as TPGT. TPGT are freshwaters suitable for supporting growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora. These waters are also suitable for contact recreation and as a drinking water supply source after conventional treatment. A summary of the designated use classification for the Lake Jocassee watershed is provided in Table 6.1-5. These waters are subject to SCDHEC’s anti-degradation rules and activities such as discharges to these waters may be prohibited to maintain their classification.

Table 6.1-5. Designated Use Classifications of Waterbodies within the Lake Jocassee Watershed

Name	State	Description	Surface Water Classification
Bear Camp Creek	NC	From source to state line	C; TR
Bear Creek	NC	From source to state line	C; TR
Bear Creek	SC	That portion of river from state line to Lake Jocassee	TN
Corbin Creek	SC	The entire creek tributary to Devils Fork	ORW (TPGT)
Devils Fork Creek	SC	That portion of the creek from confluence of Corbin Creek and Howard Creek to Lake Jocassee	TN
Horsepasture River	NC	From a point approximately 0.60 mile downstream of N.C. Hwy 281 (Bohaynee Rd) to state line	B; TR, ORW
Howard Creek	SC	That portion of the creek from its headwaters to 0.3 mile below Hwy 130 above the flow augmentation system at the Bad Creek pumped storage station dam	ORW (TPGT)
Lake Jocassee	SC	The entire lake	TPGT
Laurel Fork Creek	SC	The entire creek tributary to Lake Jocassee	TN
Limber Pole Creek	SC	The entire creek tributary to Devils Fork	TN
Rock Creek	SC	That portion of the creek within South Carolina	TN
Thompson River	NC	From source to state line	C, TR
Thompson River	SC	That portion of the river from state line to Lake Jocassee	TN
Toxaway River	NC	From dam at Lake Toxaway Estates, Inc. to state line	C
Whitewater River	NC	From Little Whitewater Creek to state line	C, TR, HWQ
Whitewater River	SC	That portion of the river from state line to Lake Jocassee	ORW (TPGT)
Write Creek	SC	The entire creek tributary to Lake Jocassee	ORW (TPGT)

B- Primary Recreation, Fresh Water; C- Aquatic Life, Secondary Recreation, Fresh Water; HQW- High Quality Waters; ORW- Outstanding Resource Waters; TN- Trout-Natural; TPGT- Trout-Put, Grow, and Take; TR- Trout Waters

Sources: SCDHEC. 2021. SC Watershed Atlas. Accessed 03/02/2021. [URL]: https://gis.dhec.sc.gov/watersheds/; NCDEQ. 2021. NC Surface Water Classifications. Accessed 03/02/2021. [URL]: https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=6e125ad7628f494694e259c80dd64265.

6.1.4 Dams and Diversion Structures within the Basin (18 CFR §5.6(d)(3)(xiii)(C))

The dams and diversion structures associated with the Bad Creek Project are described in Section 5.4 (Existing Project Facilities). The KT Project immediately downstream of the Bad Creek Project also has several dams and diversion structures including the Jocassee Dam, spillway and associated saddle dikes (Saddle Dike #1 and #2), Keowee Dam, spillway, saddle dikes A-D, and Oconee Nuclear Station Intake Dike, and the Little River Dam.

Because the Bad Creek and KT projects are in the headwaters of the Savannah River Basin, there are no upstream dams, however, there are numerous dams and projects downstream of the Project affected by Bad Creek and KT project operations. In 1968, the USACE and the Southeastern Power Administration (SEPA) entered into an Operating Agreement (1968 Operating Agreement) with Duke Energy's predecessor company, Duke Power Company. The purpose of this agreement was to ensure the uppermost projects (KT Project) were operated such that the USACE and SEPA would be able to meet their hydropower generating requirements at the time. Although there were many changes in both the USACE and Duke Energy systems since its inception, the 1968 Operating Agreement had never been modified. Therefore, a New Operating Agreement (NOA) was signed in 2014 by the USACE, SEPA, and Duke Energy which incorporated the modified conditions of the KT Project operations and superseded the 1968 Operating Agreement with the goal of determining how water would be managed between the uppermost projects and the lowermost projects on the Savannah River.

The NOA is described in detail in Section 6.3.5 (Existing Instream Flow Uses). The downstream projects and dams in the Savannah River Basin affected by the KT (and Bad Creek) project operations include:

1. Hartwell Dam and Lake (USACE)
2. Richard B. Russell Dam and Lake (USACE)
3. J. Strom Thurmond Dam and Lake (USACE)
4. Stevens Creek Dam (Dominion Energy SC [formerly SCE&G])
5. Augusta Canal and Diversion Dam (City of Augusta, GA)
6. Sibley Mill Project (August Canal Authority)

7. Enterprise Mill Project (Augusta Canal Authority)
8. King Mill Hydroelectric Project (Augusta Canal Authority)
9. Urquhart Station (coal plant decommissioned and now the site of natural gas power plant) (Dominion Energy SC)
10. New Savannah Bluff Lock and Dam (USACE)
11. Savannah River Site (Department of Energy)
12. Alvin W. Vogtle Nuclear Power Plant (Southern Nuclear Operating Company-Operator)
13. McIntosh Steam Plant (Southern Company)
14. Plant Kraft (Southern Company/Savannah Electric and Power Company)

6.1.5 Tributary Rivers and Streams (18 CFR §5.6(d)(3)(xiii)(D))

There are no tributaries upstream of the Bad Creek Project. Significant tributaries draining directly into Lake Jocassee include the Whitewater, Thompson, Horsepasture and Toxaway rivers, and Bad and Coley creeks. The major tributaries of the Whitewater River include Silver Run, Happy Hollow, Democrat Creek, Waddle Branch, and Corbin Creek (river left); the only tributary on river right is the Little Whitewater Creek. The major tributaries to the Toxaway River include the Indian Creek, Panther Branch, Auger Fork, Toxaway Creek, Rock Creek, Laurel Fork Creek and the Devils Hole Creek (river left) and the Mill Creek, Deep Ford Creek, Bear Meadow Creek, Cobb Creek, and Horsepasture River (river right).

6.2 Geology and Soils (18 CFR §5.6(d)(3)(ii))

This section summarizes the regional geology, the geology and soils of the Project vicinity, and describes the characteristics of the shorelines surrounding Project reservoirs. In this section, Project vicinity is defined as the Project structures, reservoirs, and the areas immediately surrounding the Project.

6.2.1 Geologic Features (18 CFR §5.6(d)(3)(ii)(A))

6.2.1.1 Physiography and Topography

The Project is located in the Blue Ridge physiographic province, a mountainous zone extending northeast-southwest from southern Pennsylvania to central Alabama, varying in width from less than 15 miles up to 70 miles. It is characterized by rugged terrain with valleys ranging from 1,000 ft msl in the south to greater than 1,500 ft msl in the north. Several mountain peaks have elevations greater than 6,000 ft msl with relief of up to 3,500 ft msl. The highest peak is Mt. Mitchell in North Carolina at 6,684 ft msl.

In North and South Carolina, massive and resistant gneissic and metasedimentary rocks underlie most of the Blue Ridge, with valleys trending along weaker-rock outcrops (e.g., schist or minor carbonate rocks) and fractures or fault/shear zones. Drainage is generally to the west; however, the slopes separating the Blue Ridge from the Piedmont physiographic province are typically steep and provide the initial run-off (headwaters) for some of the largest streams of the Piedmont province, which drain to the east and southeast. The underlying geologic structure in the region influences local topography. Streams are deeply incised, and the average relief is about 1,800 ft. A topographic map of the Project vicinity is presented on Figure 6.2-1.

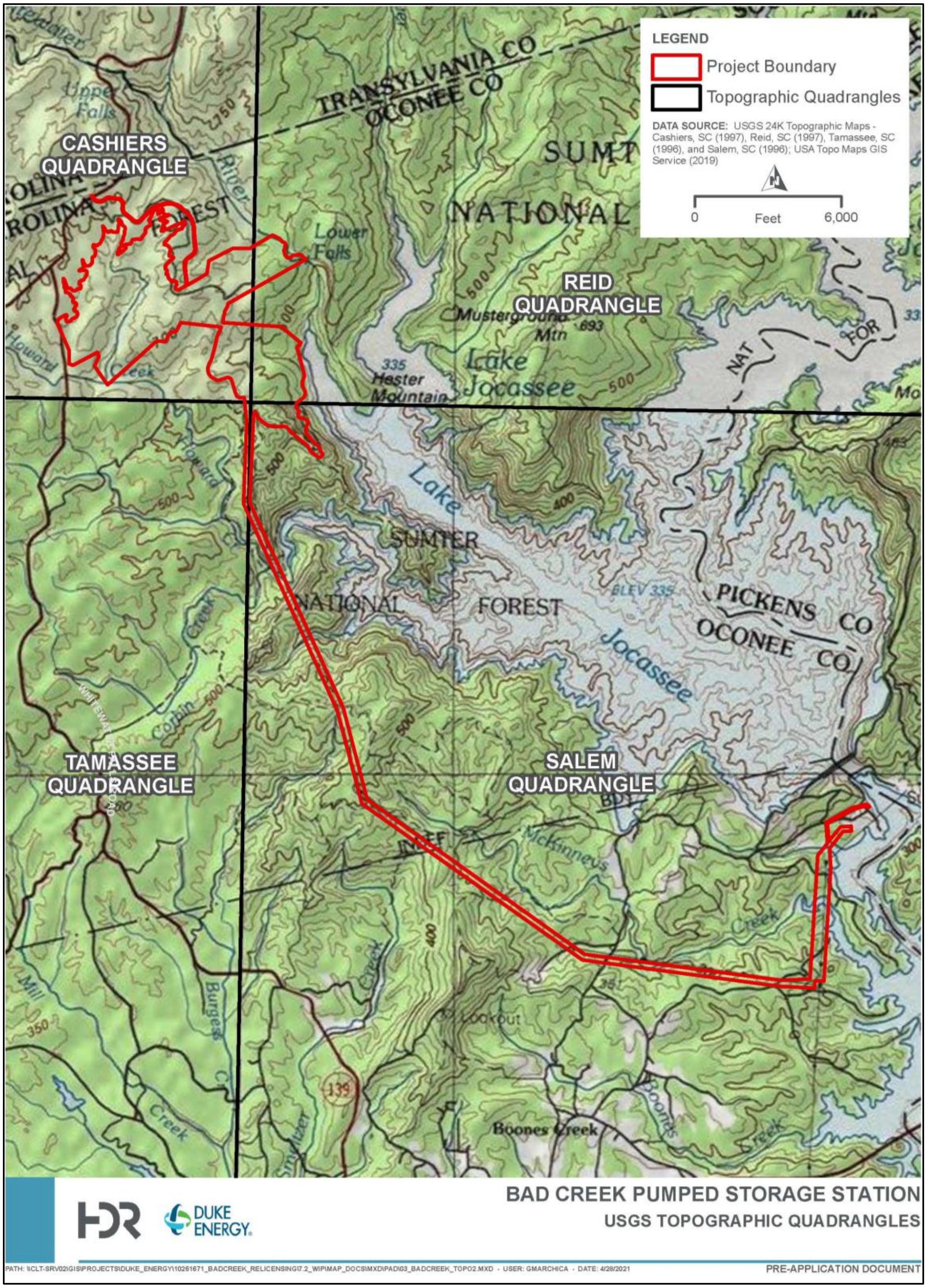


Figure 6.2-1. Topographic Map of Bad Creek Project Boundary

6.2.1.2 Regional Geology

The crystalline rocks of the southern Appalachians occur in northeast-trending parallel geologic terranes. The Bad Creek Project is situated within the Tugaloo terrane, which includes rocks of the eastern Blue Ridge province northwest of the Brevard zone (Hatcher et al. 2007; Hatcher 2002). The Blue Ridge province is a complex crystalline terrane consisting of Precambrian gneissic basement rocks structurally overlain by metasedimentary and metavolcanic rocks of Precambrian to lower Paleozoic age (Hatcher 1978a, 1978b). Numerous igneous bodies of mafic to felsic composition intrude into the basement core and into the overlying metasedimentary and metavolcanic sequences. The structure of the Blue Ridge province is controlled by major thrust faults, associated complex polyphase folding, and subsequent brittle faulting (Hatcher 1978a; Clendenin and Garihan 2007a, 2007b).

The southern Blue Ridge province is divided into three belts: 1) a western belt of imbricate thrust sheets involving upper Precambrian and lower Paleozoic rock and some basement rocks, 2) a central belt containing most of the basement rocks exposed in the Blue Ridge terrane along with higher grade upper Precambrian and possible lower Paleozoic metasedimentary rocks, and 3) an eastern belt of high-grade early Paleozoic metasedimentary and metavolcanic rocks (Hatcher 1978a, 1978b; Hatcher et al. 2007). The eastern belt of the southern Blue Ridge province comprises those portions of the Tugaloo terrane occurring northwest of the Brevard zone (Figure 6.2-2).

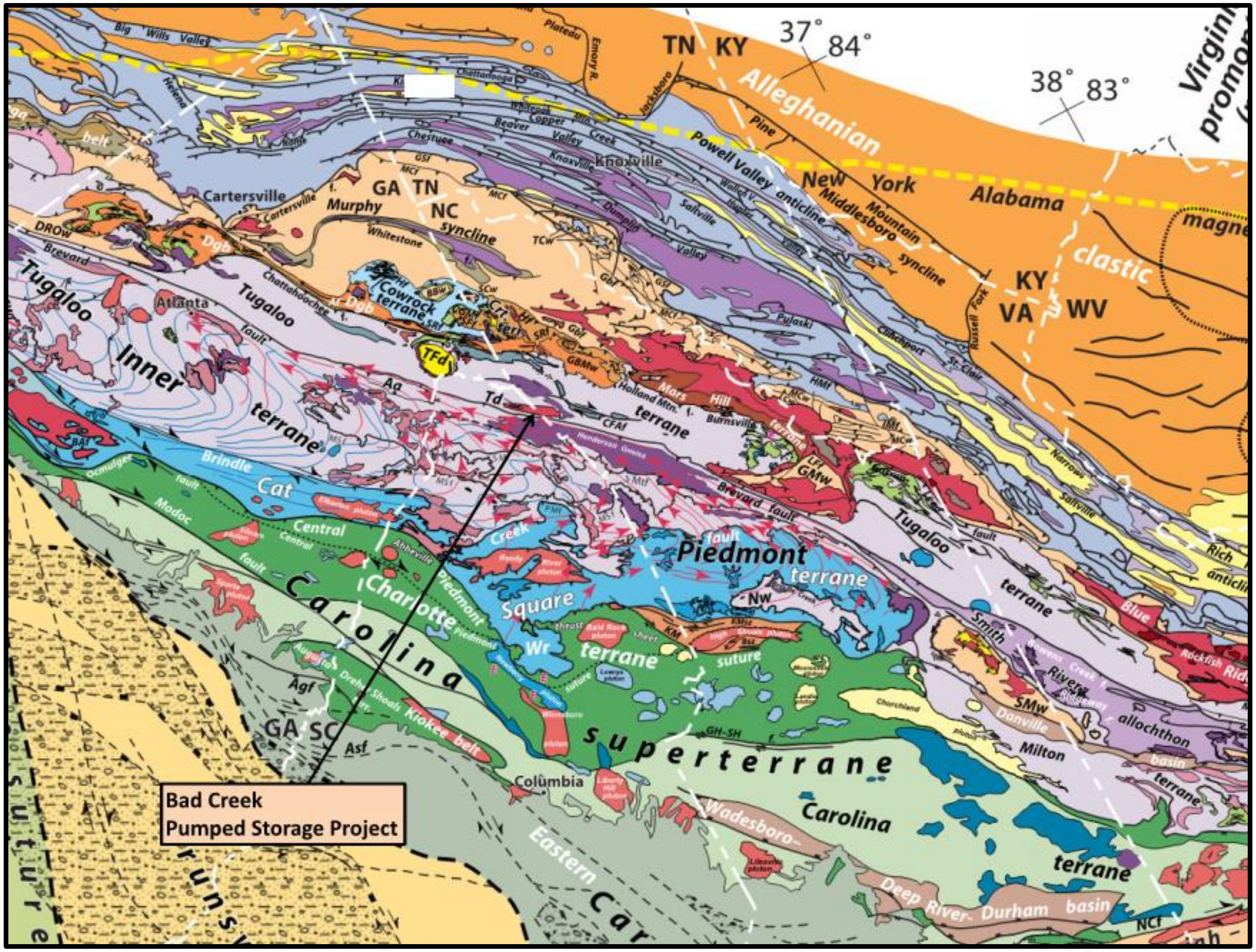
The principal rock unit of the western Tugaloo terrane (eastern Blue Ridge belt) is the Tallulah Falls Formation (TFF). The TFF consists of biotite gneiss (metagraywacke), pelitic schist, mafic volcanic rocks, and quartzite; in places the rocks of the TFF are migmatitic[11]. These rocks are intruded by Paleozoic granitoid rocks and overlie 1,150 to 1,200 million years ago (Ma) Precambrian Grenville basement rocks in the Toxaway Dome. The TFF consists of four members: 1) the quartzite-schist member, 2) the lower graywacke-schist-amphibolite member, 3) the garnet-aluminous schist member, and 4) the upper graywacke-schist member (Hatcher 1977). The lowest member contains quartzite with interlayered schist. The lower graywacke-schist-amphibolite member contains biotite gneiss, amphibolite, muscovite schist, and biotite schist.

[11] Migmatite – Rock consisting of alternating layers or lenses of granitic material in gneisses and schists; related to partial melting of the rock during deformation and metamorphism and then re-crystallization of the melt during the waning stages of metamorphism.

Layers of granitic gneiss and pegmatites also occur in this member. Overlying the lower member is the garnet-aluminous schist member. It consists of muscovite-garnet-kyanite schist with interlayered amphibolite, muscovite schist, biotite gneiss, granitic gneiss, and pegmatites. It is generally easily recognizable by abundant garnet and kyanite. The upper graywacke-schist member contains biotite gneiss, mica schist, garnet mica schist, and minor amounts of amphibolite, granitic gneiss, quartzite, calc-silicate rocks, and pegmatites.

The Toxaway Gneiss (TGn), part of the Precambrian basement of the eastern Blue Ridge province, is exposed in the core of the Toxaway Dome. It is typically a medium- to coarse-grained banded biotite-plagioclase-microcline-quartz gneiss with some massive and augen varieties, which do not appear to be significantly different in composition (Schaeffer 1987, 2016; Merschat et al. 2003). The TGn has an Rb/Sr whole-rock isochron age of 1,203±54 Ma (Fullagar et al. 1979). A derived zircon age for the TGn is 1,150 Ma (Carrigan et al. 2003 in Hatcher et al. 2007).

The TFF rocks are metamorphosed to the upper amphibolite facies (kyanite-sillimanite zone; Hatcher 1977; Butler 1991). Dominant metamorphic fabric and peak metamorphism in the eastern Blue Ridge province is circa 450 Ma, based on metamorphic ages of detrital monazite and zircon grains from TFF rocks (Miller et al. 1997, 2000; Moecher et al. 2011; Cattanach et al. 2012). The Grenvillian basement rocks of the Blue Ridge province, including the TGn, were subjected to granulite facies metamorphism approximately 1,000 Ma (Hatcher and Butler 1979).



Note: Td = Toxaway Gneiss

Figure 6.2-2. Tectonic Map of the Southern and Central Appalachians and location of the Bad Creek Pumped Storage Project (Source: Hatcher et al. 2007)

6.2.1.3 Site Geology

The Bad Creek Project is located immediately northwest of the Brevard zone in the Tugaloo terrane within the Toxaway Dome (Figure 6.2-2). The Toxaway Dome consists of a core of TGn and a sliver of TFF. It is an elongated feature having a steeply dipping to overturned northwest limb and a more moderately inclined southeast limb. At the ends, the structure plunges gently northeast and southwest, resulting in a structural dome defined by the upward arching of the dominant foliation in the TGn. Detailed mapping performed during the construction of the Bad Creek Project indicates the basement (TGn)/cover (TFF) contact is repeated several times due to isoclinal folding and transposition. Textural evidence (grain size reduction and truncated foliation and fold axis in the TGn at the contact) suggests the original basement/cover contact was a pre-metamorphic fault (before Taconic age [~450 Ma] and after Grenville age [~1,000 Ma] metamorphisms).

The majority of the site is underlain by TGn (Figure 6.2-3). All of the tunnels, shafts, and the powerhouse cavern for the Bad Creek Project were excavated in the TGn (based on the geologic information available). The Main Dam and East Dike of the Bad Creek Project are founded on the TGn. The West Dam and a portion of the reservoir are underlain by a sequence of schistose rocks belonging to the TFF. The TFF rocks are predominantly the garnet-aluminous schist member; however, in some places, portions of the upper graywacke-schist member are present.

The TGn, part of the Precambrian basement of the eastern Blue Ridge province, is a medium- to coarse-grained gneiss of granitic to quartz monzonitic composition. It is composed of microcline, plagioclase, quartz, and biotite with minor amounts of epidote, garnet, allanite, muscovite, zircon, sphene, apatite, and opaques. The TGn can be divided into two major types: 1) a banded, medium- to coarse-grained granitic gneiss composed of alternating light-colored quartz-feldspar rich bands and dark biotite-quartz-feldspar bands; and 2) a coarse-grained augen granitic gneiss consisting of a poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 centimeters (cm) in length and a medium- to coarse-grained quartz-feldspar-biotite gneiss with a more distinct foliation and feldspar augen up to 1 cm. Layers of biotite-hornblende schist (sills or dikes, possibly feeders for the mafic volcanic rocks of the TFF) are present with thicknesses up to 20 ft. Their orientation is parallel to the dominant foliation/banding in the TGn. At least two generations of quartz-feldspar-mica pegmatites occur within the gneiss. They are distinguished by the fact the later generation is undeformed except by fracturing, whereas the earlier generation is folded. Most of the early pegmatites parallel the dominant foliation; the later generation cuts across foliation. Small cross-cutting quartz veins are also present.

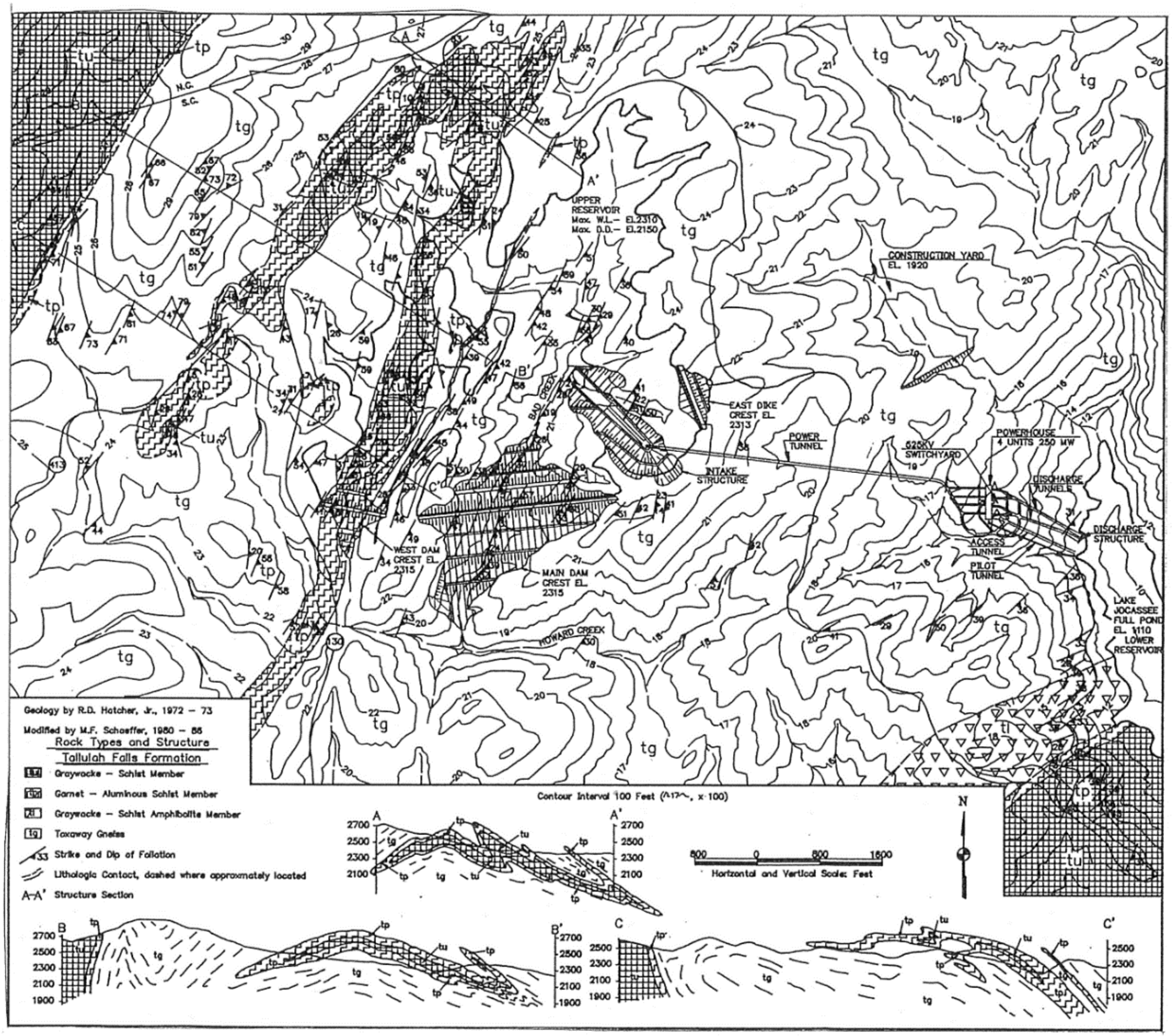


Figure 6.2-3. Geologic Map of the Bad Creek Site and Vicinity (Schaeffer 1987; 2016)

The TFF consists of three members in the site vicinity (Hatcher 1977; Schaeffer 1987). The lower graywacke-schist-amphibolite unit consists of meta-graywacke (biotite gneiss), amphibolite, muscovite schist, biotite schist, pegmatites, and minor granitic gneiss. The garnet-aluminous schist member includes muscovite-garnet-kyanite schist with minor interlayered amphibolite, muscovite schist, and meta-graywacke. The upper graywacke-schist member consists of metagraywacke (biotite gneiss), muscovite schist, and muscovite biotite schist with minor amounts of interlayered amphibolite, granitic gneiss, and pegmatite. The units have undergone regional metamorphism to the kyanite zone of the amphibolite facies.

During the original design studies for the Bad Creek Project (pre-1985), the subsurface exploration program had the following primary objectives related to the underground excavations and structures: 1) examine the rock characteristics and geologic structure of the proposed powerhouse location, 2) determine the best powerhouse orientation and location with respect to the geologic structure and in-situ stresses, 3) provide the data and experience necessary to facilitate an efficient design of the underground portions of the Project, and 4) serve as a model for the instrumentation and monitoring to be incorporated into the permanent underground structures.

Early in the Bad Creek Project design, it was decided a pilot tunnel into the proposed powerhouse location would be the primary activity of the underground exploration program. Preliminary core drilling, laboratory testing of core samples, and deep borehole hydrofracturing stress measurements had been conducted before the design of the pilot tunnel program (Duke Power Company 1978; Schaeffer and Steffens 1979). Data from these tests showed generally good rock conditions, but with high horizontal in-situ stresses present. However, due to the magnitude of the project, the pilot tunnel program was considered a prudent investment. The pilot tunnel excavation and testing lasted from October 1976 through September 1977. The work was divided into three main components: 1) excavation monitoring, 2) rock testing including the measurement of the in-situ rock mass stress orientation and magnitude utilizing the overcoring methodology and 3) geologic mapping and investigations (Duke Power Company 1978; Schaeffer and Steffens 1979; Schaeffer et al. 1979).

The geologic program conducted during construction of the Bad Creek Project (from 1985 to 1991) provided additional geologic information for construction and design personnel to make necessary changes to design and construction techniques due to geologic conditions and to document the conditions encountered. The geologic studies included observation, measurement, sampling, photographs, mapping, and evaluation of the exposed rock and foundation surfaces. The geologic conditions encountered in the underground works were documented by geologic mapping of at least one rib of all tunnels, the walls of the two vertical shafts, and the walls, crown, and floor of the powerhouse cavern at a scale of 1 inch = 6.56 ft. The aboveground structures including dam foundations, intake excavation, and discharge excavation were mapped at a scale of 1 inch = 20 ft. The upper reservoir area was mapped at a scale of 1 inch = 200 ft after all excavation and borrow work was completed. The geologic work during construction, including additional studies beyond the geologic mapping (for documentation), are described and discussed in Duke Power Company (1991) and Schaeffer (2016).

6.2.1.4 Lithology

Detailed geologic mapping of the Bad Creek Project underground excavations resulted in a detailed subdivision of rock types within the TGn. The following units were recognized and mapped during construction:

- Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of alternating layers of light-colored quartz-feldspar bands and darker biotite-quartz-feldspar bands, well-foliated;
- Banded Augen Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of a foliated (banded) quartz-feldspar-biotite gneiss containing feldspar augen up to 1 cm long;
- Augen Granitic Gneiss, medium light gray, coarse-grained gneiss consisting of a coherent, massive, poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 cm long;
- Biotite Schist, medium dark gray to dark gray, coarse-grained biotite-hornblende schist;
- Biotite Gneiss, medium dark gray to dark gray, medium- to coarse-grained biotite-hornblende gneiss;
- Biotite Augen Gneiss, medium gray to medium dark gray, medium- to coarse-grained, foliated biotite-feldspar-quartz gneiss with feldspar augen up to 1 cm long, biotite content generally greater than 30 percent;
- Quartz-Feldspar Gneiss, very light gray to white, very coarse-grained, distinctly foliated quartz-feldspar gneiss with minor biotite (less than 10 percent);
- Very Coarse-Grained Granitic Gneiss, light gray, very coarse-grained, distinctly foliated quartz-feldspar-biotite gneiss, biotite content greater than 10 percent;
- Weathered Sheared Rock, moderate to moderately severe weathering, light gray to yellowish gray to greenish gray, original rock type granitic or augen granitic gneiss; and
- Hard Sheared Rock, medium light gray to light gray, medium- to coarse-grained rock, original rock type granitic or augen granitic gneiss.

6.2.1.5 Structural Geology

Foliation in the TGn and TFF rocks is defined by the parallel orientation of platy minerals and by compositional layering. The average orientation of foliation in the Bad Creek Reservoir area is N37E; 38SE and varies from N35-50E; 28-41SE in the underground works. Minor folds are present; some lie within foliation, whereas others fold the dominant foliation. The earliest set of folds is characterized by isolated “z-”, “s-”, and crescent-shaped fragments that are axial planar to the dominant foliation. The presence of these isolated fold fragments indicates transposition of an older foliation has occurred. The second set of folds is isoclinal to open with variable development of a secondary foliation. In areas where this folding is isoclinal, an axial planar foliation (defined by secondary biotite) is present. Later open folding was recognized in several tunnels of the Bad Creek Project.

6.2.1.5.1 Shear Zones

Shear zones with thicknesses up to 200 ft occur throughout the TGn and generally parallel the dominant foliation. Four major shear zones are present in the reservoir and dam areas (Shear Zones C through F) and two shear zones (A and B) were mapped in the underground tunnels (Figure 6.2-4 and Figure 6.2-5).

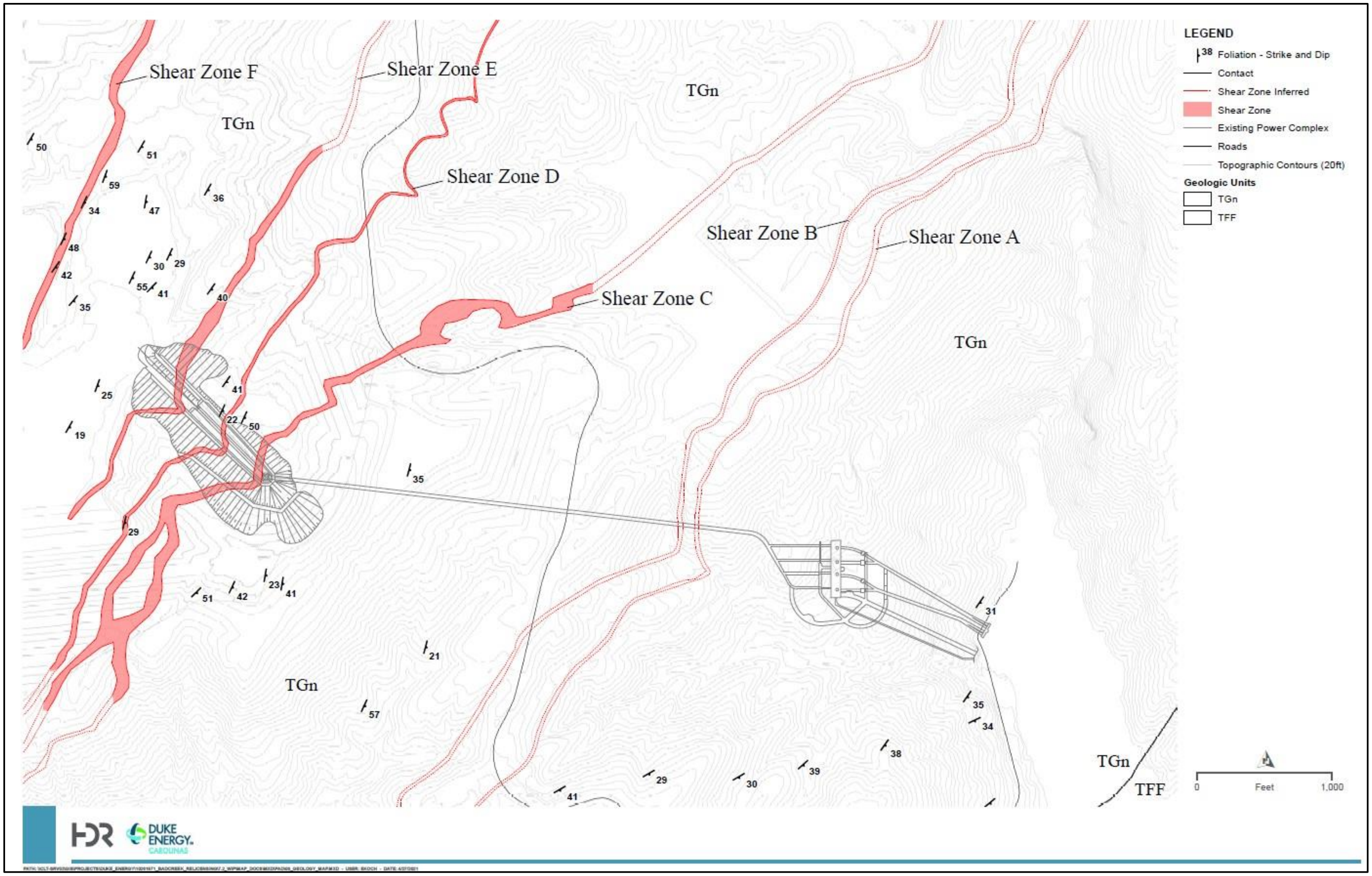


Figure 6.2-4. Geologic Map showing Shear Zones Mapped in the Bad Creek Reservoir and in the Underground Excavations for the Bad Creek Project and their Surface Projections

The zones consist of hard sheared rock with layers of weathered sheared rock. A schematic cross-section of the existing Bad Creek subsurface shear zones is shown on Figure 6.2-5. The shear zones are mineralized with chlorite, epidote, calcite, and quartz in various combinations. Originally white feldspars have been discolored to a pink or light orange-pink color within and adjacent to the shear zones. Along some of the shear planes, breccia is present with thicknesses of less than 1 inch to about 12 inches. The breccia consists of granitic gneiss, coarse quartz/feldspar (pegmatites), and vein quartz fragments in a matrix of fine-grained chlorite and epidote. Several of the shear zones have associated weathered zones up to 12 inches thick. Within the weathered zone there are up to two inches of gouge-breccia composed of granitic gneiss, coarse quartz/feldspar, and vein quartz fragments in a clay matrix. The hard-sheared rock exhibits tight, complex isoclinal folding with sheared-out limbs and a secondary axial planar foliation defined by biotite. This relationship indicates the major shearing is related to the second fold event, although some of the shear zones may have been reactivated from the first fold event. The brittle deformation along the shear zones is a later event overprinting the initial shear zone development.

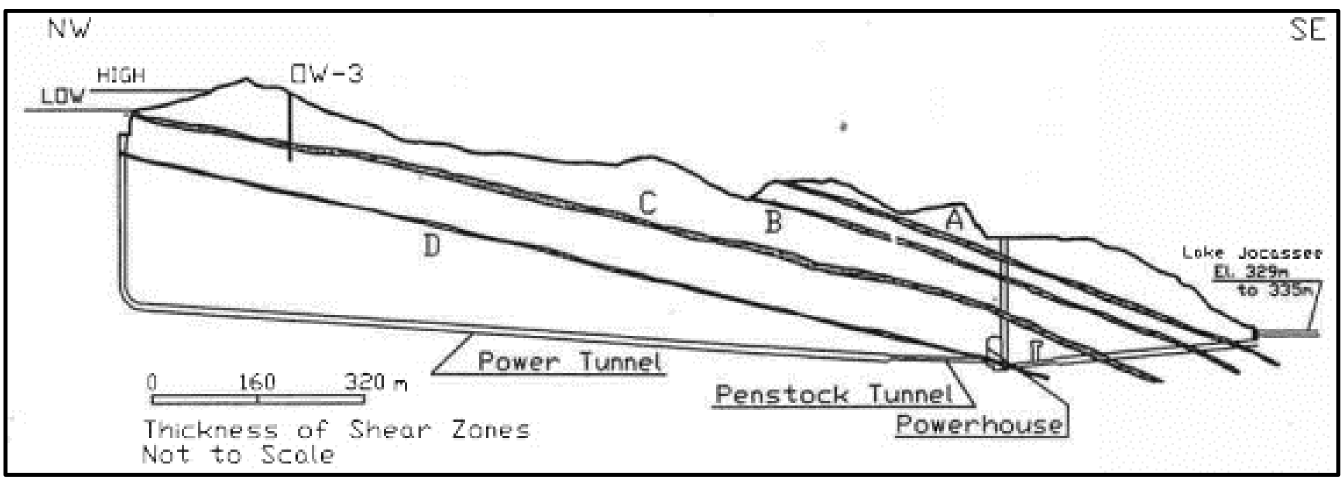


Figure 6.2-5. Cross-section of Existing Bad Creek Underground from the Upper Inlet/Outlet to the Inlet/Outlet Structure on Lake Jocassee showing location of Shear Zones A, B, C, and D (Talwani et al. 1999)

6.2.1.5.2 Joint Sets

There are three dominant joint sets in the Bad Creek Reservoir area: 1) N77E; 82 NW, 2) N42E; 74NW (strike joints), and 3) N47W; 88SW (dip joints). The predominant joint set varies between N70W and N70E with steep north and south dips in the underground works. Another set strikes N60E with moderate to steep northwest dips, and a weakly developed set oriented N45W with steep southwest dips is present. All joint sets have some degree of mineralization, but the northeast and particularly the east-west set (N77E in the reservoir area) contain a greater percentage of mineralized joints. The dominant mineral fillings are quartz, chlorite, epidote, biotite, and calcite in various combinations. Iron oxide and manganese staining is present along weathered joint surfaces. Spacing within the joint sets varies from less than 1 inch to greater than 50 ft.

In the underground portion of the Bad Creek Project, the dominant measured joint set is oriented N70E to N70W (east-west) with dips >50° north and south. Other sets are oriented N60E; 60NW, N65E; 30SE (foliation joints), and N45W; 70-90 SW or NE. The joints are tight at depth with similar mineral fillings as noted in the reservoir area. Near the ground surface some joints are open and weathering has resulted in blocky conditions at the main access tunnel portal and the first 200 ft into the tunnel is supported by steel sets and a concrete lining.

6.2.1.5.3 Faults Zones

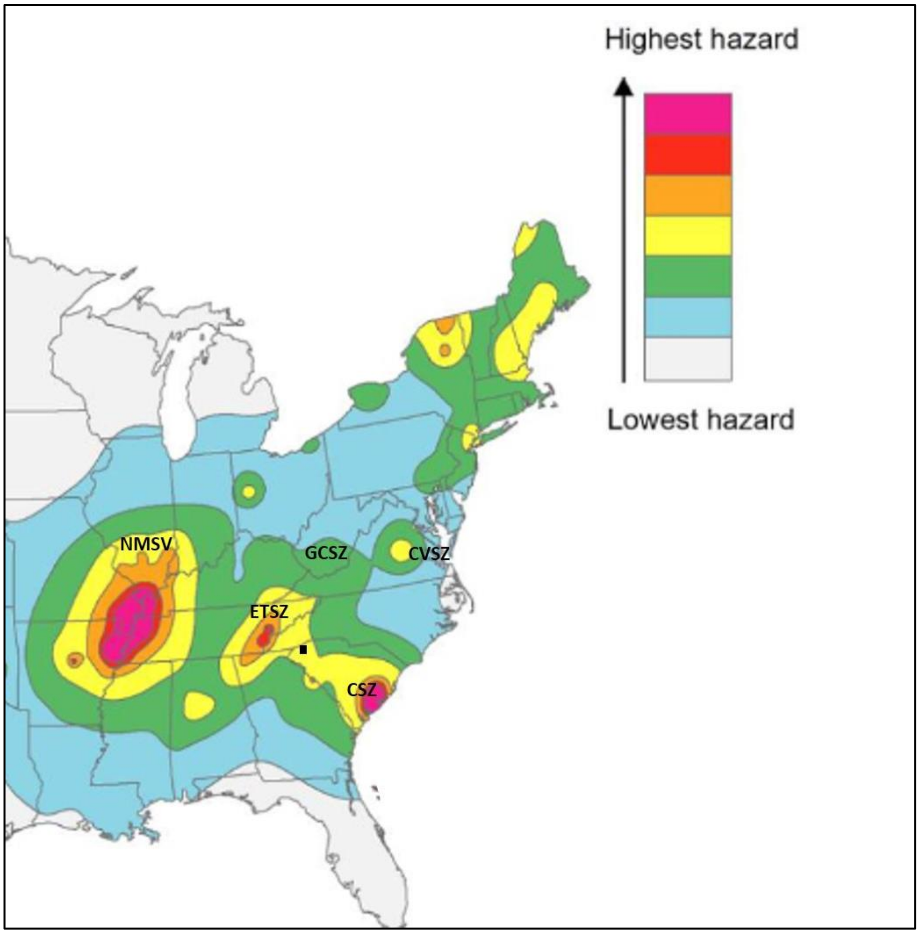
South Carolina is traversed by several northeast trending fault systems that parallel the dominant strike of the Appalachian Mountains. These include the Brevard Fault Zone, the Pax Mountain Fault System, the King’s Mountain Shear Zone, the Pageland Fault, and others. These faults are not believed to have been active for at least the last 300 million years.

Clendenin and Garihan (2007a) mapped two northwest-trending oblique-slip faults northeast and southeast of the existing underground works; however, mapping efforts for the Project did not identify these two faults and they were not field-verified. No northwest-trending faults were mapped in the existing Bad Creek Project underground works or in the area including the dam and dike foundations, the intake structure excavation, or the upper reservoir (Duke Power Company 1991; Schaeffer 1987, Shaeffer 2016).

6.2.1.6 Regional and Local Seismicity

6.2.1.6.1 Seismic Zones and Events

The East Tennessee Seismic Zone (ETSZ) is the closest seismic zone to the Bad Creek Project and is one of the most active seismic zones in eastern North America (Bollinger et al. 1991). It is located primarily in the Valley and Ridge province of Tennessee with a portion in the Valley and Ridge and Blue Ridge provinces of western North Carolina (Figure 6.2-6). The zone is about 300 kilometers (km) long and 50 km wide. Earthquakes in the ETSZ occur at depths of to 5 to 25 km within Precambrian crystalline basement rocks beneath the thrust sheets of Paleozoic sedimentary rocks of the Valley and Ridge (Bollinger et al. 1976, 1991). The structures likely responsible for seismicity in the ETSZ are reactivated Precambrian to Cambrian normal faults formed during the rifting (extension) event that created the Iapetus Ocean. These faults are located beneath the later accreted Appalachian thrust sheets (similar to the Giles County Seismic Zone in Virginia; Wheeler 1995). Despite its relatively high rate of activity, the largest known earthquake in the ETSZ is M_w 4.7[12] (1973 Alcoa-Marysville earthquake; Bollinger et al. 1991).



Note: GCSZ = Giles County Seismic Zone; ETSZ = East Tennessee Seismic Zone; CVSZ = Central Virginia Seismic Zone; CSZ = Charleston Seismic Zone; NMSZ = New Madrid Seismic Zone. Project location indicated by black square (source: USGS)

Figure 6.2-6. Relative Seismic Hazard in the Southeastern U. S. with Identified Seismic Zones (modified from USGS 2018)

[12] M_w = Moment Magnitude.

The Central Virginia Earthquake of August 23, 2011 (M_w 5.7 - 5.8) was the largest earthquake in the central and eastern United States since the 1886 Charleston, South Carolina earthquake (estimated M_w 6.8 - 7.0). The earthquake occurred on a north or northeast-striking plane with reverse faulting within a previously recognized seismic zone, the Central Virginia Seismic Zone (CVSZ). The CVSZ is located in the Appalachian Piedmont Province between Richmond and Charlottesville, Virginia (see Figure 6.2-6). The zone has an elliptical area, with a north-south dimension of 100 km and an east-west dimension of 120 km as defined by historical earthquake activity (Bollinger and Sibol 1985; Coruh et al. 1988). The depth of the earthquakes ranges from near surface to 12 km, placing them above the Appalachian detachment (Chapman 2015) in contrast to the ETSZ, where earthquakes occur below the detachment. The CVSZ has produced small and moderate earthquakes since at least the 18th century. The previous largest historical shock from the CVSZ occurred in 1875.

Per the recent EPRI (2012) Central and Eastern United States seismic source characterization, the Bad Creek Project is located in the Paleozoic extended crust zone (Figure 6.2-7). On August 9, 2020, a 5.1-M_w magnitude earthquake occurred with an epicenter about 2.5 miles southeast of Sparta, just south of the Virginia-North Carolina border (Figure 6.2-8). The earthquake caused damage to over 500 buildings and other infrastructure (Hill 2020). Surface ruptures were attributed to a south southwest-dipping reverse fault (Little River fault) and were for ~2.5 km along the northwest trend (Hill 2020). The Little River Fault produced a maximum vertical displacement of 25.2 cm, with similar vertical displacements along much of the fault trace (Hill 2020). The hanging wall was to the south (northeast side up; reverse fault) as shown by the initial USGS focal mechanisms (USGS 2020a). There is no recorded historical seismicity in and around Sparta, but Hill (2020) speculated the Little River Fault may be associated with the Giles County seismic zone, which is centered in Virginia about 100 km to the north (see Figure 6.2-6). The depth of the main shock, 4.1 km (USGS 2020b), suggests it occurred above the master decollement (depths of 5 to 12 km) and is not related to the Giles County or East Tennessee Seismic Zones where the earthquakes typically occur below the decollement in the Paleozoic extended crust. The estimated magnitude of the Skyland 1916 earthquake is M_w 5.1 (Figure 6.2-8), similar to the Sparta earthquake.

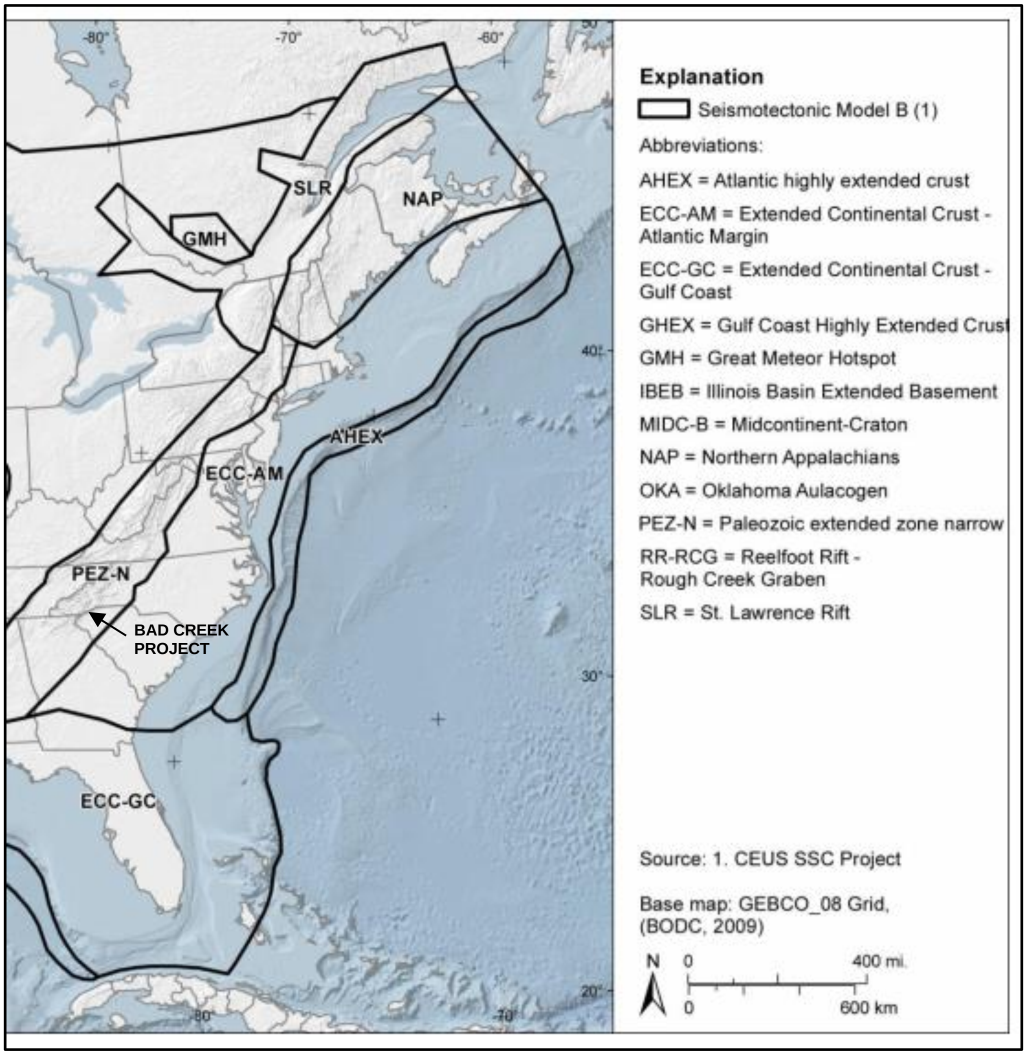


Figure 6.2-7. Central and Eastern United States Seismotectonic Zones and Location of the Bad Creek Project (EPRI 2012)

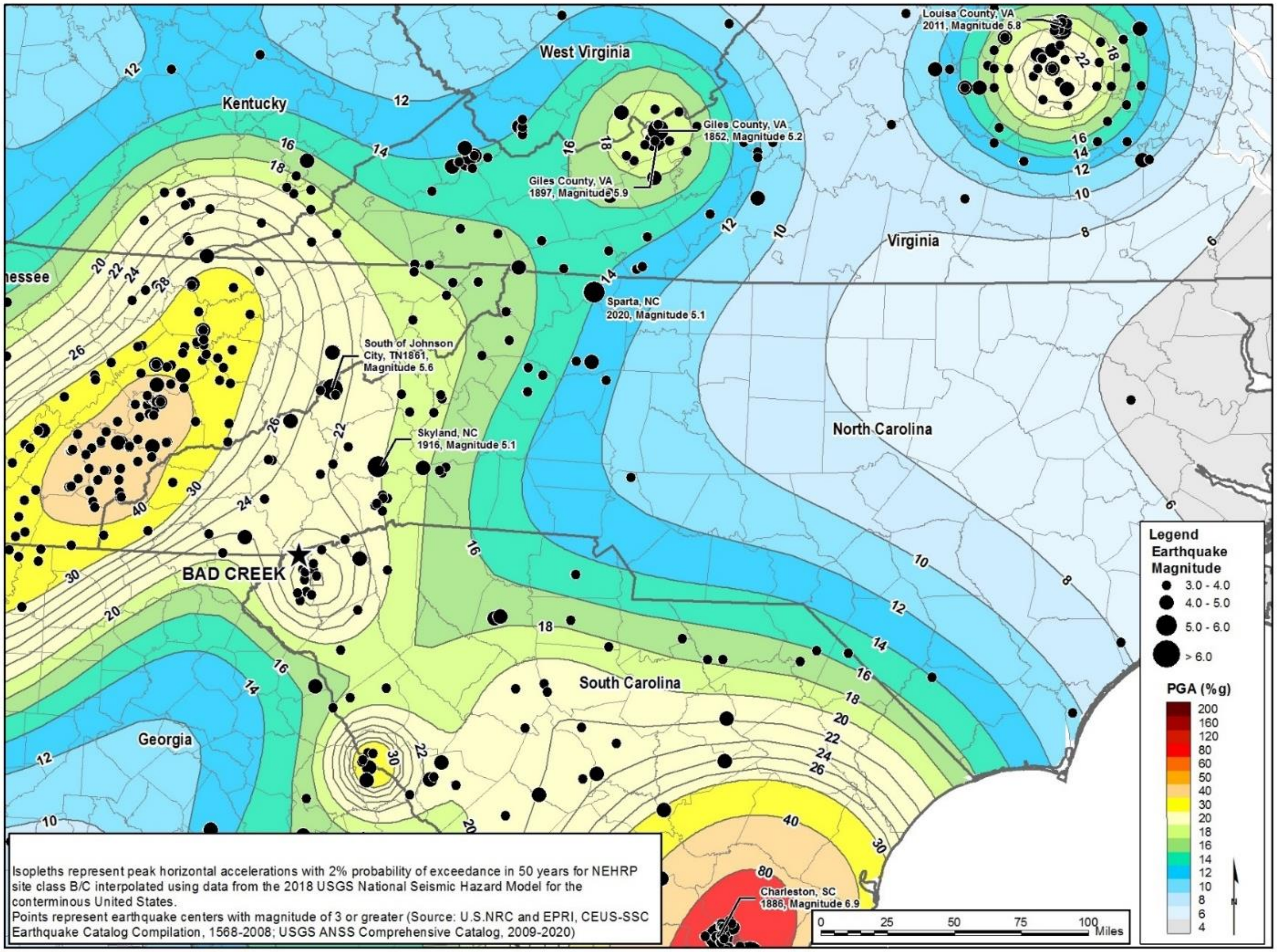


Figure 6.2-8. Peak Ground Acceleration (PGA) and Historic Earthquake Centers near the Bad Creek Project

6.2.1.6.2 Previous Seismicity at the Site

Prior to the filling of Lake Keowee in 1968, historical seismic activity had not been documented in the vicinity of the Bad Creek Project. Because seismic activity appeared to have increased after impoundment of the KT Project (as evidenced by several seismic events associated with Lake Keowee in 1978 and other recorded events), the potential of reservoir-induced seismicity was studied by Duke Power Company (Schaeffer 1991). Both Lake Keowee and later Lake Jocassee were associated with reservoir-induced seismicity (sometimes referred to as reservoir-triggered seismicity). Most of the events have been small, with the largest having a local Magnitude (M_L) of 3.8. Activity at Lake Jocassee has decreased significantly since first filling in 1976, while activity at Lake Keowee has also decreased (Schaeffer 2000). During the study of reservoir-induced seismicity, seismic activity was closely recorded by stations of the seismic network operated by Duke Power Company, as well as the South Carolina Seismic Network. Only a minor increase in seismicity was reportedly related to initial filling of the Bad Creek upper reservoir – from about 5 events per month to about 10 per month. However, no correlation could be made with the observed increase with Bad Creek Reservoir filling and operation of the plant (up to 160 ft of potential change in the reservoir level). Of the minor earthquakes in the area, none were located under or in close proximity to the Bad Creek Reservoir. Seismic activity clearly related to Lakes Keowee and Jocassee decreased to near-background levels by 2000 (Schaeffer 2000).

6.2.1.6.3 Seismic Hazards

Earthquakes with $M_w \geq 3$ and contours of Peak Ground Acceleration (PGA) for V_{s30}[13] equals 760 meters/second (m/s) with 2 percent probability of exceedance in 50 years (2,475-year return period) from the 2018 National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS 2018) are shown in Figure 6.2-8. The PGA at the Bad Creek Project is 0.24g for V_{s30} of 760 m/s (Site Class B/C[14] Boundary; USGS 2018, 2014a) and 0.21g for V_{s30} of 2,000 m/s (Site Class A[4]). Overall, the Project vicinity is considered to have low to moderate seismic risk, with no known Quaternary/active faults (USGS 2014a, 2014b, 2018).

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[13] V_{s30} is the shear wave velocity of the upper 30 m of earth materials.
[14] Site Class A = Hard Rock (V_s > 1,524 m/s); Class B = Rock (762 m/s < $V_s \leq$ 1,524 m/s); Class C = Very Dense Soil and Soft Rock (366 m/s < $V_s \leq$ 762 m/s).

6.2.1.7 Geologic Hazards

6.2.1.7.1 Landslides

Work activities in the area of the west abutment of the Main Dam began in Spring 1986. Following the construction of a temporary construction road and initial stripping of slope, tension cracks indicative of slide movement were noted. Movement progressed over time and in July 1986, an exploration program was undertaken which included soil borings, installation of crack monitors, shear tubes, and inclinometers. The investigation determined the entire area was an old colluvial landslide bound by two drainage features. An area of wet and organic material at the toe of the slope was removed and replaced with random rock fill, which became a permanent feature, which was extended and enlarged until ultimately about 350,000 cubic yards of material had been placed. This area is currently monitored by three inclinometers which show some continued movement. The west abutment above the buttress continues to move as indicated by the inclinometers. Any landslide type of failure of the slope above the buttress would represent a maintenance concern with necessary remedial activity but would not impact Main Dam stability.

There was a previous landslide above the inlet/outlet structure; the slide material was removed during construction of the existing plant and a retaining wall was installed on the slope which stabilized part of the original landslide above the retaining wall and below the present control room/switchyard complex. There are four inclinometers on the retaining wall above the old landslide area to monitor potential slope movement at the inlet/outlet works.

6.2.1.7.2 Sinkholes

Bedrock in the Project vicinity is metamorphic gneiss, schist, or graywacke-schist. Solution prone carbonate rocks of sedimentary origin do not exist; therefore, sinkhole development is not considered a significant concern.

6.2.1.7.3 Liquefaction

Liquefaction occurs when loose, saturated, granular, and non-plastic soil is exposed to cyclic motion (e.g., earthquake) sufficient to increase soil pore water pressure and thus significantly reduce shear strength such the soil flows or settles significantly. Since the earth and rockfill embankments at the Project do not consist of or overlie loose sandy soils, liquefaction due to seismic shaking is not considered a significant concern.

6.2.1.8 Summary of Geologic Characteristics

Geologic characteristics of the bedrock, based on the geological and geotechnical studies performed during the design of the existing Bad Creek Project underground structures as well as geologic mapping and studies performed during their construction, are presented in Table 6.2-1.

Table 6.2-1. Summary of Geologic Characteristics

Geologic Characteristic	Relation to Project Vicinity
High seismic risk/active faulting within Project vicinity	The Project vicinity is considered to have low to moderate seismic risk. There are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018).
Active landslides in Project Boundary	There is an old landslide at the inlet/outlet of the existing Bad Creek Project on Lake Jocassee. The slide material was removed during construction of the existing plant and a retaining wall was installed on the slope stabilized part of the original landslide above the retaining wall and below the present control room/switchyard complex. Jocassee is oriented such that landslides/rockslides are a potential issue during any excavation in this area.
Deep chemical weathering profile	Total soil thickness and the depth of bedrock weathering at the intake in the existing Bad Creek Reservoir and at the inlet/outlet structure in Lake Jocassee varies from several ft to greater than 60 ft based on exploratory and construction boreholes.
Highly permeable rock	Not present in the TGn. The majority of water encountered in the underground excavations, past the initial ~200 ft of main access and tailrace tunnels from their portals on Lake Jocassee, is associated with the foliation parallel shear zones and with some of the high-angle fault zones (Schaeffer 2016,1987; Duke Power Company 1991).
Soluble rock material (e.g., karst)	Not present in the TGn.
Low strength, vibration-sensitive, friable, highly abrasive, slaking, or unlithified rock material	Weathered rock associated with shear zones and biotite schist and biotite-hornblende schist will have lower shear strengths than the unweathered TGn.
Highly faulted, folded, or fractured rock material	The majority of faults/fractures in the TGn have secondary mineralization have healed faults/fractures. The shear zones mapped in the reservoir and in the existing Bad Creek Project underground structures have weathered sheared rock and later brittle faulting associated with them.
Thinly laminated, structurally deformed, fine-grained rock masses	Phyllonitic material present along some of the foliation-parallel shear zones in the underground excavations and thinly foliated biotite-hornblende schist layers.

Geologic Characteristic	Relation to Project Vicinity
Rock mass in-situ stress field	High in-situ stresses resulted in rock burst and stress-related issues in the larger underground opening including the powerhouse during their excavation. The Powerhouse was oriented based on the orientation of the maximum horizontal stress orientation and consideration of the rock mass discontinuities (shear zones, high-angle minor faults, and joints).

6.2.1.9 Mineral Resources

South Carolina's leading mineral commodities include cement, crushed stone, construction sand and gravel, industrial sand and gravel, kaolin, and vermiculite. In Oconee County, resources include crushed stone-granite, marble, talc, and mica (Maybin et al. 1997) as well as gold and silver; however, there are no active mines or mining sites near the Project.

6.2.2 Soils (18 CFR §5.6(d)(3)(ii)(B))

While the type of underlying bedrock (parent material) typically dictates which soils are predominant in an area, climate, relief, the presence of organisms, and passage of time are also important soil formation factors. In the vicinity of the Project, the landscape influences soil formation through its effects on erosion, moisture, temperature and plant cover, and differences in slope and aspect. For example, soils with gentle slopes are stable and will develop mature profiles as a result of chemical weathering. On side slopes, soils may be thinner and can develop from materials from higher elevations.

Soils of the Project vicinity are considered upland soils, which are typically well drained sandy loam with some clay loam. In general, soils surrounding Lake Jocassee and Bad Creek are consistent because of the similar geologic conditions and topography in the reservoir area. Soils are typically sandy loam derived in place from metamorphic bedrock. Although the soils are typically sandy loam at the surface, these units often include a sandy clay, clay or clay loam subsoil. Several soil types include a significant percentage of gravelly or cobbly soil. They are typically underlain by saprolite or weathered rock at depths ranging from 10 to greater than 60 inches. In some locations, weathered or unweathered bedrock may be present below the surface soils at depths as shallow as 1 to 2 ft. Depths to weathered or unweathered crystalline bedrock are several tens of feet or more.

Soils in the Project Boundary are provided in Table 6.2-2 (site area only) and Table 6.2-3 (transmission line corridor only). An aerial view of the soils within the Project Boundary is included on Figure 6.2-9 and soils within the Transmission Line corridor are shown on Figure 6.2-10.

Table 6.2-2. Soils in the Project Boundary (Excluding Transmission Line Corridor)

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
AsF	Ashe sandy loam, 25 to 50 percent slopes	23.1	2.3
HaE	Halewood fine sandy loam, 15 to 25 percent slopes	52.7	5.1
HaF	Halewood fine sandy loam, 25 to 45 percent slopes	533.6	52.0
HcC2	Hayesville and Cecil fine sandy loams, 6 to 10 percent slopes, eroded	8.2	0.8
HcD2	Hayesville and Cecil fine sandy loams, 10 to 15 percent slopes, eroded	9.9	1.0
HcE	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes	26.9	2.6
Mv	Riverview-Chewacla complex, 0 to 2 percent slopes, frequently flooded	18.3	1.8

Note: Values do not sum to 100 due to 34.4 percent water.

Table 6.2-3. Soils in the Project Boundary (Transmission Line Corridor)

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
HaE	Halewood fine sandy loam, 15 to 25 percent slopes	9.7	3.2
HaF	Halewood fine sandy loam, 25 to 45 percent slopes	165.6	54.6
HcB	Hayesville and Cecil fine sandy loams, 2 to 6 percent slopes	1.1	0.4
HcD2	Hayesville and Cecil fine sandy loams, 10 to 15 percent slopes, eroded	3.8	1.3
HcF	Hayesville and Cecil fine sandy loams, 25 to 45 percent slopes	63.5	20.9

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
HcF2	Hayesville and Cecil fine sandy loams, 25 to 45 percent slopes, eroded	5.3	1.8
HcE	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes	7.7	2.5
HcE2	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes, eroded	5.5	1.8
HhF	Hayesville, Cecil, and Halewood sandy loams, shallow, 25 to 60 percent slopes	24.3	8.0
HsE2	Hiwassee sandy loam, 15 to 25 percent slopes, eroded	0.4	0.1
MfE	Madison fine sandy loam, high, 15 to 25 percent slopes	0.6	0.2
TcF	Talladega and Chandler loams, 25 to 60 percent slopes	7.9	2.6

Note: Values do not sum to 100 due to 2.6 percent water

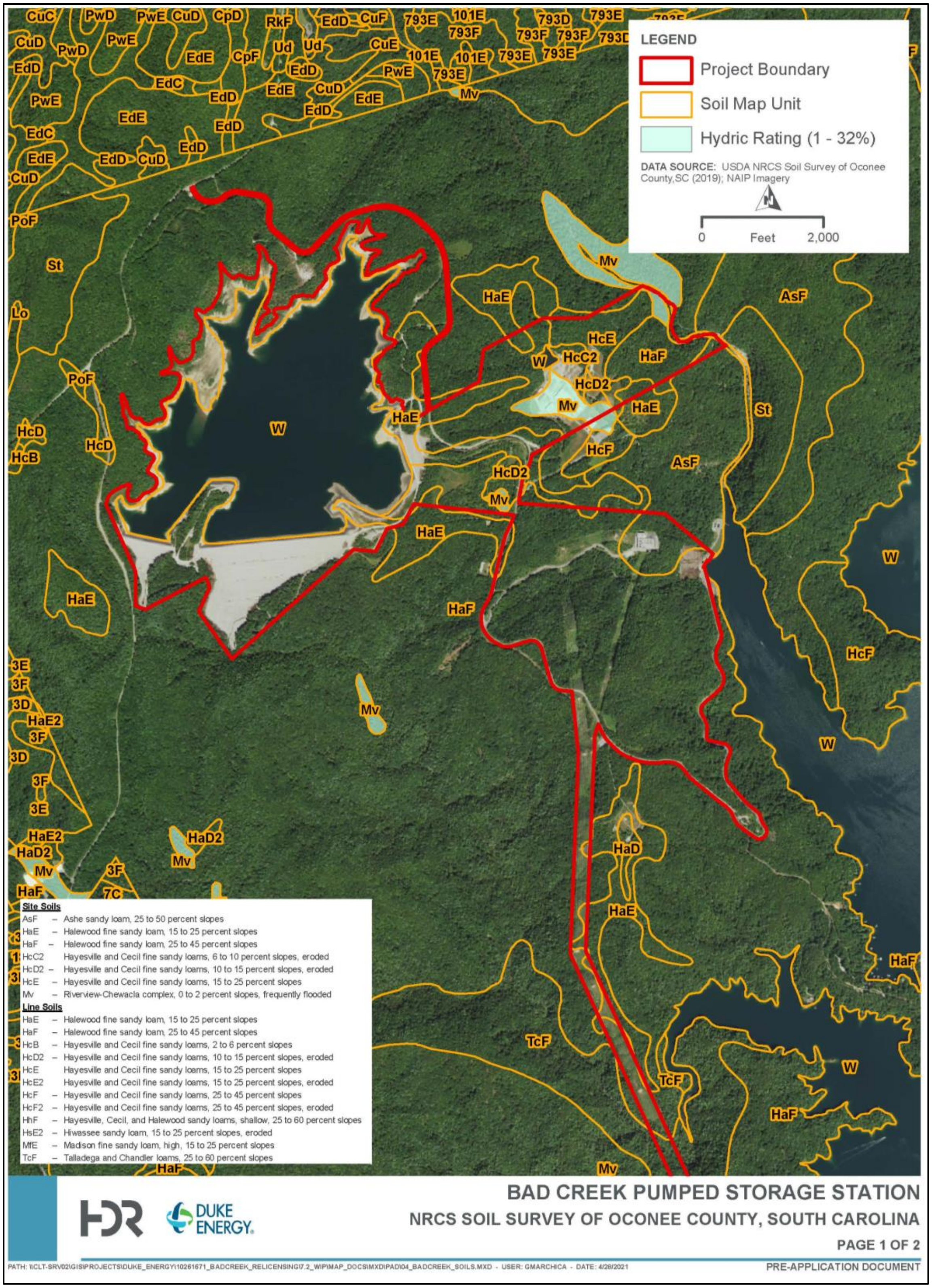

Figure 6.2-9. Soils in the Project Boundary (Site)

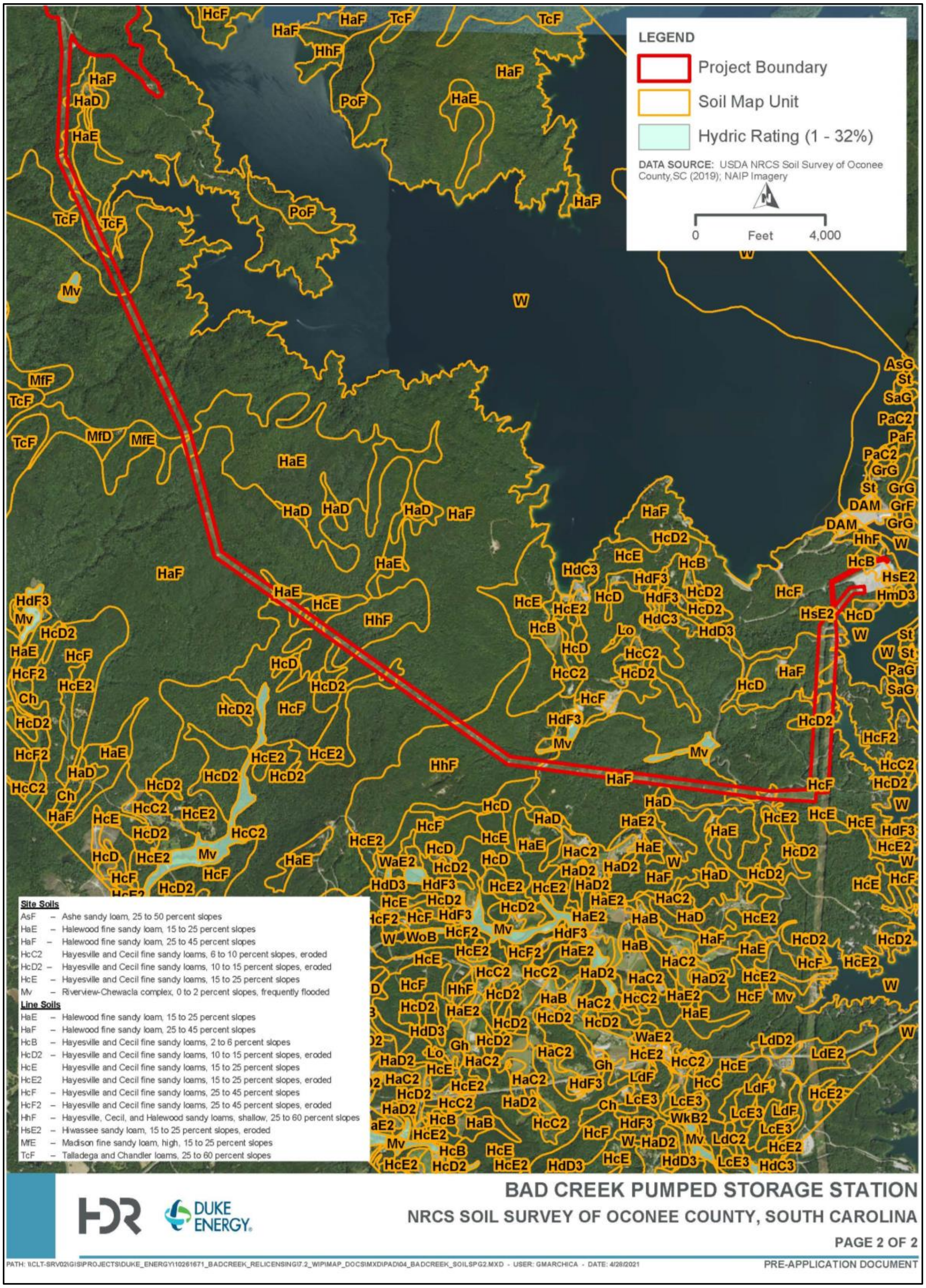

Figure 6.2-10. Soils in the Project Boundary (Transmission Line Corridor)

6.2.3 Reservoir Shoreline and Stream Banks (18 CFR §5.6(d)(3)(ii)(C))

6.2.3.1 Bad Creek Reservoir Shoreline

The Bad Creek Reservoir was designed to withstand extreme surface water fluctuation associated with daily and weekly pumping and generating cycles and is subject to inspection as part of Duke Energy's Owner's Dam Safety Program. The reservoir is not open to public use.

6.2.3.2 Lake Jocassee Shoreline

The Bad Creek Project Boundary does not include any portion of the Lake Jocassee shoreline except for the small (approximately 1,500 ft total length) engineered portion of shoreline associated with the discharge structure; however, because of the pump-back operation between Lake Jocassee and Bad Creek Reservoir and natural resources that have the potential to be affected by this relationship, the shoreline condition of Lake Jocassee is considered here.

To assess general characteristics of shoreline erosion on lakes Jocassee and Keowee, a Shoreline Erosion Study was carried out by Duke Energy (Baird 2013) to meet the requirements for the KT Project relicensing. The purpose of the erosion study was to determine the effects of KT Project operations, natural waves, and recreation-induced waves on erosion within the KT Project boundary and to quantify erosion along the shorelines of Lake Jocassee (and Lake Keowee), with the following specific objectives: (1) characterize the overall erosion along the shorelines of each reservoir; (2) identify Project-induced erosion sites; (3) quantify the level of erosion occurring at those sites; and (4) collect adequate data on the project effect to evaluate the potential needs or opportunities for protection, mitigation and enhancement measures and monitoring in those sites.

The Baird (2013) study results indicated the primary sources of erosion include physical weathering (e.g., freeze-thaw), wave action from wind and recreational boating, concentrated runoff, operation of the reservoir (cyclic raising and lowering); and non-project development along the shoreline (i.e., new and former land development). Most erosion on the KT Project reservoirs was determined to be from wave action associated with wind and boat wakes, while water level fluctuations due to the project operations had minor effects on erosion.

To assess the relative magnitude of waves from wind versus recreational boating, wind data (from 1986 to 2009) and wave data were used to determine direction of prevailing winds, direction of impact on shorelines, and seasonal wind direction frequency/wind speed. A numerical model was used to estimate the percentage of erosion from boat wakes. A comparative evaluation of these indicated approximately 25 to 45 percent of the erosion noted was attributed to boat wakes in Lake Jocassee and the remainder was attributable to wind waves. To assess the effect existing project operations have on erosion, five representative sites were examined featuring eroding shorelines in soils and soft bedrock (see Baird 2013). Based on shoreline profile measurements through comparisons of sequences of orthophotos, Baird and Orbis 2013 indicated shoreline erosion is caused primarily by wind and boat waves and the extent of erosion at each site reflected the magnitude of waves from these sources and the relative resistances of the local substrate. KT Project operations did affect the elevations where wave-induced erosion occurs, but current KT Project operations do not appear to contribute appreciably to the overall rate of shoreline erosion. However, if the Normal Maximum Elevation (i.e., full pond; 1,110 ft msl) is raised, this could reduce erosion rates as the amount of time the reservoir would be drawn down would be reduced, thereby exposing less of the lower bank slopes, which would subsequently not be exposed to waves. In general, wind and wave-caused erosion is expected to continue in areas with erodible soils where bedrock has not been exposed but may occur at lower rates if pool elevations are raised (Baird 2013).

In previous shoreline studies at Lake Jocassee, scarp height (thickness of soil visible above the water line), recession of banks, and percentage of shoreline protection around the reservoir were documented in previous studies (Orbis 2012) and are provided in Table 6.2-4. Overall, on Lake Jocassee, 25 percent of the 92 miles of shoreline was classified as eroding in naturally occurring soils, 45 percent was previously eroded with exposed bedrock or protected shoreline (i.e., not eroding), and 30 percent was classified as not eroding and not showing signs of past erosion.

Table 6.2-4. Scarp Characteristics for Lake Jocassee Shoreline and Erosion Classifications

Shoreline Erosion Classification	Scarp Characteristics	Lake Jocassee (% of shoreline)	Lake Keowee (% of shoreline)
Active low/mod/high	<1 ft to >3 ft scarp; unprotected with soil overburden	25	65
Passive low/mod/high	<1 ft to >3 ft scarp; bedrock or protected	45	2
Active none	No eroded scarp; unprotected with soil overburden	26	13
Passive none	No eroded scarp; bedrock or protected	4	20

Source: Based on Orbis, Inc. (2012, 2010a,b)

Note: None = no visual evidence of shoreline erosion; low – less than 1-ft vertical scarp; moderate = between 1 ft and 3 ft vertical scarp; high – above 3-ft vertical scarp; active = naturally occurring soils; passive = exposed bedrock or protected shoreline

Overall, the study showed approximately 75 percent of the Lake Jocassee shoreline is either (a) bedrock or (b) shows no signs of erosion (Orbis 2012).

Additionally, Duke Energy is responsible for managing activities within the reservoir boundaries of Lakes Jocassee and Keowee in a manner promoting safe public use and maintains environmental safeguards. For safety reasons, Duke Energy does not allow any access to Bad Creek Reservoir. Duke Energy maintains a Shoreline Management Plan (SMP) for Lakes Jocassee and Keowee (Duke Energy 2014c) classifying the respective shorelines and denotes where environmentally important habitat exists, where existing facilities and uses occur, and where future/existing construction activities may be considered.

As part of the SMP, which is described further in Section 6.8.7, Duke Energy maintains Shoreline Management Guidelines, which, when used in combination with the SMP shoreline classifications, guide responsible reservoir use (i.e., private piers, slips, marina, shoreline stabilization efforts).

6.2.3.3 Whitewater River Stream Bank

There is a 0.4-mile-long portion of the Whitewater River’s descending right bank adjacent to the Project Boundary. The river in this reach is slightly meandering with boulder/cobble/gravel/sand substrate, shoals, some exposed bedrock, and well vegetated banks (heavily forested on both sides of the river). This portion of the river is immediately upstream of the steeper white-water/rapids reach of the river that empties into Whitewater Cove approximately half a mile downstream. Project activities are not anticipated to impact this short reach of the Whitewater River or its shoreline.

6.2.4 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

The shear zones mapped in the reservoir and in the existing Bad Creek Project underground structures have weathered sheared rock and later brittle faulting associated with them. Weathered rock associated with shear zones and biotite schist and biotite-hornblende schist will have lower shear strengths than the unweathered surrounding rock. The majority of faults/fractures in the TGn have secondary mineralization with healed faults/fractures. High in-situ stresses resulted in rock burst and stress-related issues in the larger underground opening including the powerhouse during their excavation; however, during construction, the existing powerhouse was oriented based on the orientation of the maximum horizontal stress orientation and consideration of the rock mass discontinuities (shear zones, high-angle minor faults, and joints) to mitigate these stresses. However, the Project vicinity is considered to have low to moderate seismic risk and there are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018), therefore, no further PM&E measures are proposed at this time.

There is active slope movement in the Project and evidence of previous mass wasting events; however, these areas are routinely monitored and no further PM&E measures are proposed at this time. Wave energy from wind and boat wakes causes erosion at Lake Jocassee, however, because Bad Creek Reservoir is not open to the public, erosion is not monitored. Shoreline erosion at Lake Jocassee has been measured at approximately three inches per year with minimal effects on vegetation (Duke Energy 2014d). Continued operation at Bad Creek is unlikely to affect or increase shoreline erosion rates at Lake Jocassee; however, Lake Jocassee has an SMP in place to limit/prevent/mitigate potential erosion.

6.2.5 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

6.2.5.1 Geology

The proposed Bad Creek II Complex may affect, and be affected by, existing subsurface features, surface features, and/or soil movement. Conditions may impact the safety of Project structures during construction and with continued operation include underlying geology, slope movement (i.e., landslides), and seismic activity.

A previously identified landslide exists at the proposed location of the intake/outlet works for the Bad Creek II Complex powerhouse on Lake Jocassee (see Section 6.2.1.7.1). The slide material will be removed during construction and a retaining wall installed on the slope for stabilization of the landslide materials uphill of the wall.

The shear zones mapped in Bad Creek Reservoir and in the existing Project underground structures have weathered sheared rock and later brittle faulting associated with them. Later brittle faults are present and are mineralized/healed with various combinations of greenschist facies minerals. Most of the water encountered in the underground excavations for the existing Project (past the initial ~200 feet of the main access and tailrace tunnels from their respective openings at Lake Jocassee) is associated with the existing shear zones parallel to the bedrock foliation. Similar conditions are anticipated in the Bad Creek II Complex underground excavations. High in-situ stresses resulted in rock burst and stress-related issues in the larger underground openings in the existing underground excavations; this will likely occur in the underground excavations for the Bad Creek II Complex. Mitigation measures developed for existing underground excavations will be utilized in the excavation and construction of the proposed powerhouse and associated tunnels and shafts.

As mentioned in previous sections, the Project vicinity is considered to have low to moderate seismic risk and there are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018).

As part of the ongoing Bad Creek II Feasibility Design by HDR in coordination with Duke Energy, a geotechnical field exploration program was carried out from February through June of

2021. The Bad Creek II Complex geotechnical investigation was conducted to support the feasibility design of the Bad Creek II tunnel and appurtenant structures including the proposed upper and lower intake/outlet, the gate shafts, and vertical shafts. Subsurface drilling, geologic mapping, and surface geophysical investigations were carried out. Findings of the geotechnical investigation and geologic assessment will be presented in a final report (expected to be complete by early 2023) and will inform any necessary measures that may be required regarding geologic stability at the Project.

6.2.5.2 Shorelines and Stream Banks

The addition of a second discharge would add to the overall outflow through the conduits leading to the west side of Whitewater River cove. This increase in discharge could result in increased bank erosion on the opposite side of Whitewater Cove (i.e., east bank). A preliminary three-dimensional computational flow dynamics (CFD) model, as further described below, was developed by HDR for Duke Energy to evaluate the potential operational impacts of the Bad Creek II Complex during turbine mode (including shoreline erosion potential) within the Whitewater River cove (also referred to as Whitewater River arm) of Lake Jocassee.

The CFD modeling framework included a calibration phase focused on replicating the existing dominant flow and velocity patterns predicted by a previously developed physical model (Larsen and White 1986), followed by a second phase which focused on evaluating the velocity and flow pattern impacts of the proposed second inlet/outlet structure at two Lake Jocassee elevations – 1,110 ft and 1,080 ft msl. Existing topographic/bathymetric data was used to develop the model to include the geometry of the proposed structure. Monitoring points for velocities and water surface elevations were placed within the model to gather point data in the reservoir. The proposed Bad Creek II Complex powerhouse inlet/outlet structure configuration was then added to the CFD model, assuming full generation at both inlet/outlet structures (a combined 39,560 cfs was used for model runs) to determine impacts on flow velocity along the east bank of Lake Jocassee in the Whitewater River cove. The CFD model results were verified against the physical model (Larsen and White 1986) results.

Under Normal Minimum Elevation, flow patterns were similar to the full reservoir configuration, with increased velocities throughout, as expected. Lower elevations in Lake Jocassee increased the effect of the concentrated flow from the inlet/outlet structures and surface velocities have the potential to exceed 5 feet per second (fps), while flow along the east bank generally peaked at approximately 3.5 fps along the tunnel centerlines.

The CFD model was used to estimate velocities of water discharge against the east bank of Lake Jocassee for erosion potential. The peak velocities for the Bad Creek II Complex inlet/outlet configuration along the east bank did not exceed the modeled velocities seen in the Bad Creek configuration at Lake Jocassee (1,110 ft msl). The Bad Creek II Complex inlet/outlet configuration predicted minor increases to peak velocities along the east bank when compared to the Bad Creek modeled velocities. The location of the peak velocities was closer to the Bad Creek II Complex inlet/outlet structure and similar in magnitude to the physical model simulation results. The results of this preliminary study indicate the additional turbine flows resulting from Bad Creek II (in combination with existing Bad Creek) do not appear to significantly increase the potential for erosion along the east bank of the Whitewater River cove of Lake Jocassee, assuming the geology is consistent along the bank. The modeled velocities were approximately equivalent to the physical model study, which are representative of the existing conditions. Bank erosion on the east bank of the Whitewater River cove of Lake Jocassee has not been an operational issue over the life of Bad Creek and velocities are within the same general range from the Bad Creek II Complex configuration. The geology is favorable on the west facing slope and no design requirements are anticipated to mitigate erosion potential.

6.3 Water Resources (18 CFR §5.6(d)(3)(iii))

This section describes water resources associated with the Project (i.e., within the Project Boundary and vicinity). Topics include existing and proposed uses of Project waters, water quality standards, and existing water quality data.

6.3.1 Drainage Area (18 CFR §5.6(d)(3)(iii)(A))

The Project, Project facilities, and the western portion of Lake Jocassee are situated in the Whitewater River watershed (HUC 030601010104), which has an area of approximately 80 mi^2. The Project transmission line corridor extends through a small portion of the Upper Little River-Lake Keowee watershed (HUC 030601010302) and terminates at the Jocassee station in the Cane Creek-Lake Keowee watershed (HUC 030601010201) (see Figure 6.1-2). These watersheds are located within the northwestern portion of the Seneca sub-basin (HUC 03060101) (1,028 mi^2), which is part of the larger Savannah River Basin (10,577 mi^2).

Bad Creek Reservoir has a drainage area of 1.5 mi^2 and receives drainage from two small streams, Bad Creek and West Bad Creek; these small streams were once tributaries of Howard Creek and are now partially to mostly submerged. Howard Creek flows from the northwest and through the southern border of the Project Boundary with a drainage area of approximately 4.3 mi^2 at its downstream confluence with Limber Pole Creek.

6.3.1.1 Bad Creek Reservoir Storage

Based on the Original License data (circa 1974), the reservoir consists of a 318-acre reservoir with a total storage capacity of 33,323 acre-ft, of which 30,229 acre-ft is usable storage. Usable storage is considered the volume of water between minimum reservoir 2,150 ft msl and full pond 2,310 ft msl. Updated reservoir curves and as-built data were developed in 1991 and 1992; however a more recent and comprehensive light detection and ranging (LiDAR) survey was carried out in 2018 with the primary objectives of updating usable storage and total storage for the Bad Creek Reservoir (Theorem 2018). Based on the 2018 high-resolution LiDAR data, the usable storage volume is 31,808 acre-ft, an increase of 1,579 acre-ft compared to the original licensing volume. Table 6.3-1 summarizes the historical Project reservoir surface areas and volumetric information.

Table 6.3-1. Usable Storage Summary (Theorem 2018)

Data Description	Water Surface Area at 2,150 ft msl (acre)	Water Surface Area at 2,310 ft msl (acre)	Usable Storage: Cumulative Volume between 2,150 and 2,310 ft msl (acre-ft)
1974 Bad Creek Licensing Data	49.5	318	30,229
1991 Bad Creek Internal Data Memorandum	N/A	359	31,392
1991 Bad Creek Internal Volume Curve Data	69.5	359	31,338
1991 Bad Creek Internal Efficiency Data	N/A	359	30,932
1992 Bad Creek Licensing As-Built Data	N/A	367	31,400
2018 Bad Creek LiDAR Data	80.3	363	31,808

Additionally, in 2020, HDR prepared upper reservoir area-volume curves for both the total and usable volumes as shown on Figure 6.3-1 and Figure 6.3-2.

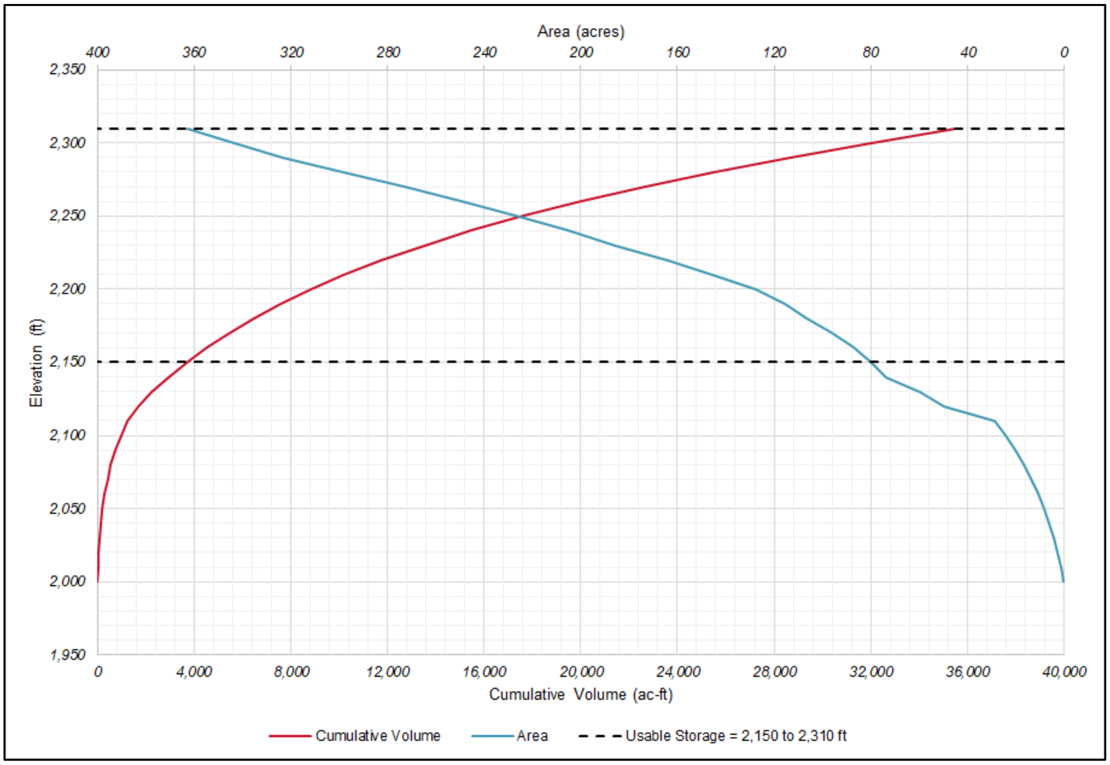

Figure 6.3-1. Bad Creek Upper Reservoir, Total Area-Volume Curves

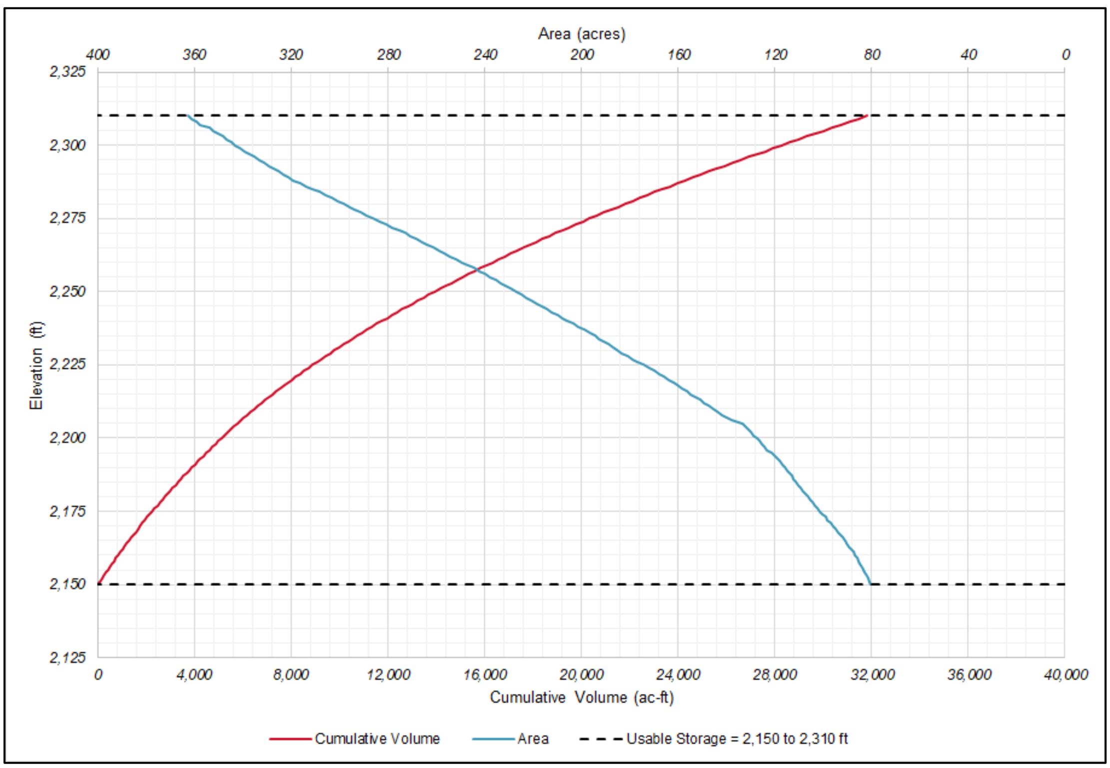

Figure 6.3-2. Bad Creek Upper Reservoir, Usable Area-Volume Curves

6.3.2 Flows (18 CFR §5.6(d)(3)(iii)(B))

The Bad Creek Project exchanges water between an upper and lower reservoir and has no significant contributing inflows; therefore, this section is not applicable.

6.3.3 Flow Duration Curves (18 CFR §5.6(d)(3)(iii)(C))

Water from the Bad Creek Reservoir is exchanged directly with Lake Jocassee. Due to the small drainage area (1.5 mi^2), inflows are insignificant and have no effect on the operation of the Project; therefore there are no flow duration curves and the Project does not have a licensed operating guide curve. The Project is operated on a daily cycle to meet system demands, normally in generation mode during periods of high energy demand and in pumping mode (to refill the reservoir) during periods of lower energy demand (HDR 2014a).

Figure 6.3-3 shows the daily midnight reading from 2001 through 2020 and the 30-day moving average using the daily midnight reading (night-time operations typically indicate periods of no generation). The average reservoir elevation for 2020 was approximately 2,276.9 ft msl. This figure shows a change in the daily midnight reservoir elevation occurred during 2010 (daily reservoir elevation decreases); this elevation trend is reflective of changes in system power dispatch requirements and the evolving utilization of the Bad Creek pump-turbines.

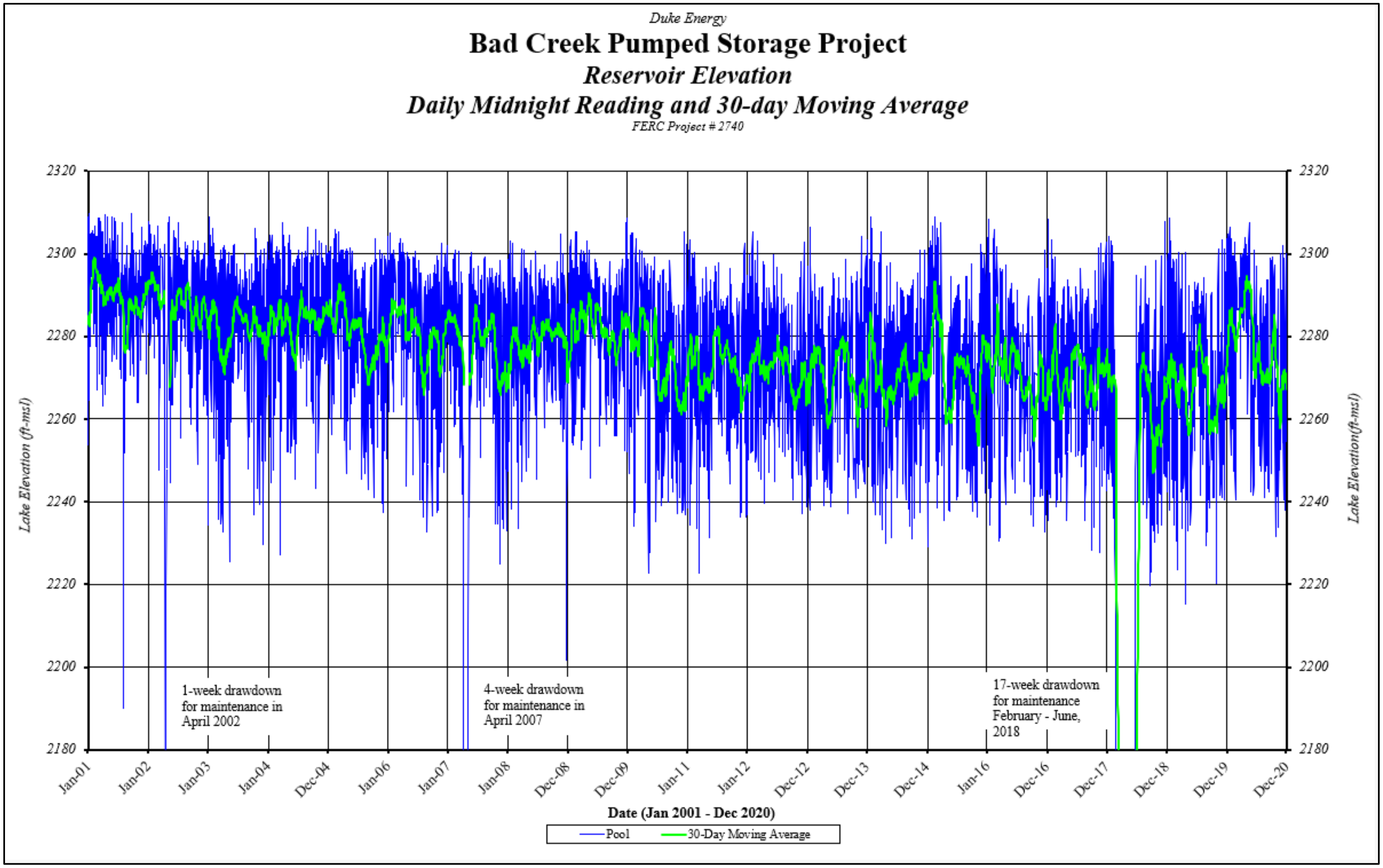

Figure 6.3-3. Bad Creek Upper Reservoir Daily Midnight Reading and 30-Day Moving Average

There are existing flow duration curves for Lake Jocassee (which releases water directly into Lake Keowee) and Lake Keowee, which releases water downstream of Keowee Dam into the Seneca River. Historical flow data and flow duration curves for water releases from Lake Jocassee are included in Exhibit B of the KT final relicensing application (Duke Energy 2014a). The Lake Jocassee water surface elevation exceedance curve and daily water surface elevations from 1975 - 2020 are shown on Figure 6.3-4 and Figure 6.3-5, respectively.

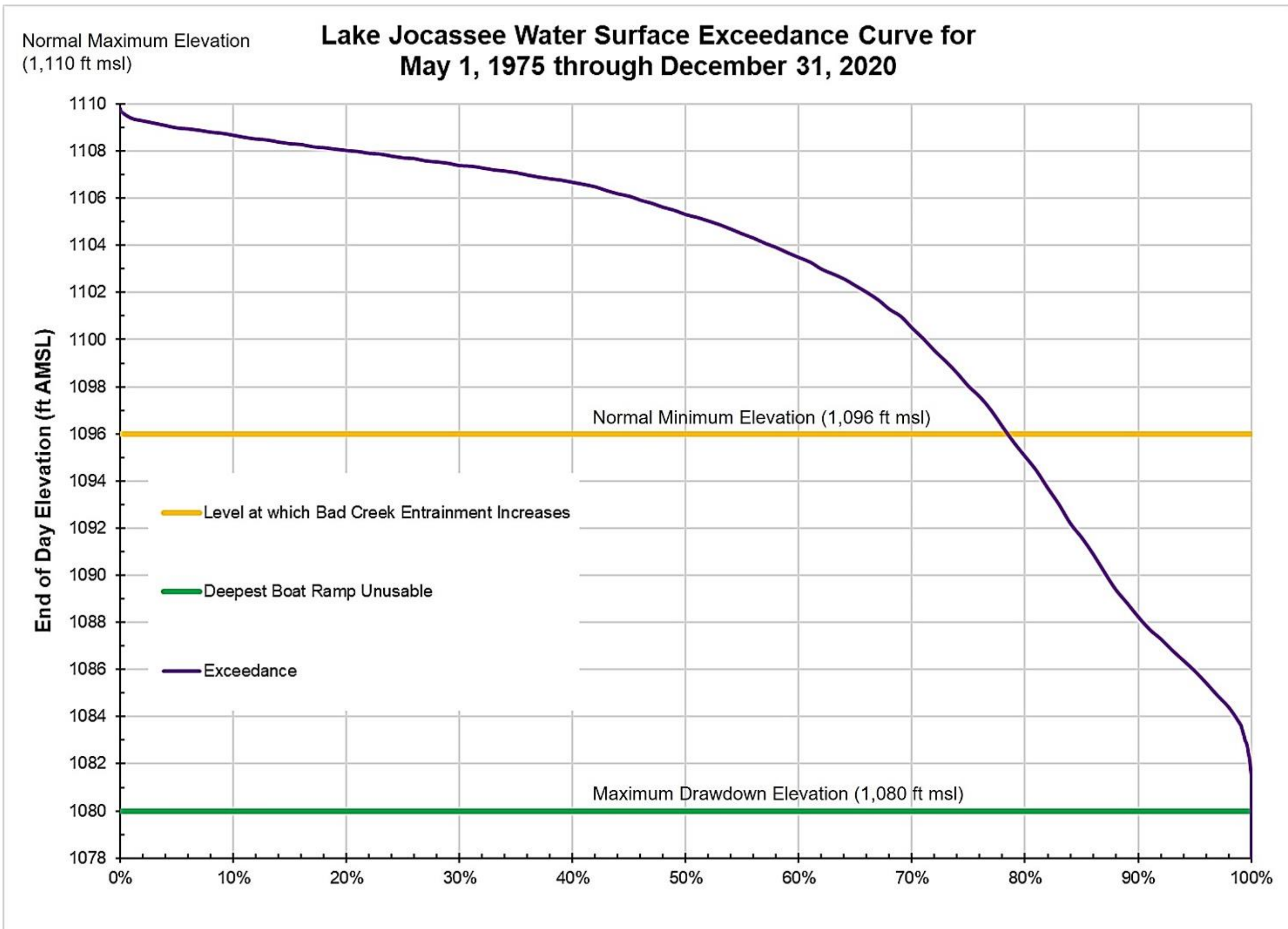

Figure 6.3-4. Lake Jocassee Water Surface Exceedance Curve (May 1, 1975 - December 31, 2020)

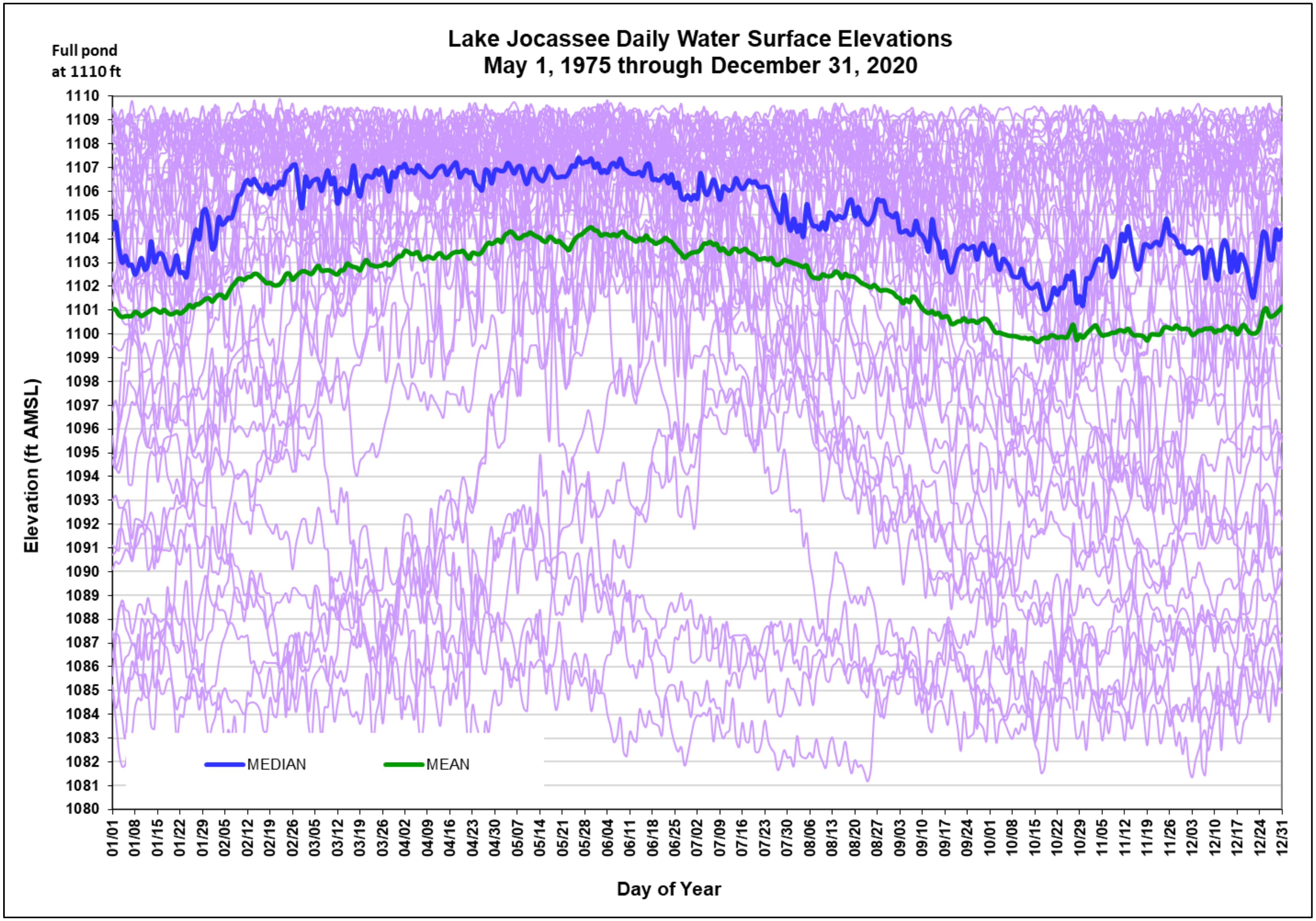

Figure 6.3-5. Lake Jocassee Daily Water Surface Elevations (May 1, 1975-December 31, 2020)

6.3.4 Existing and Proposed Uses of Project Waters (18 CFR §5.6(d)(3)(iii)(D))

Existing waters of the Bad Creek Reservoir are used only for Project operations. There are no other existing or proposed uses for Project waters.

6.3.5 Existing Instream Flow Uses (18 CFR §5.6(d)(3)(iii)(E))

Downstream of the Bad Creek and KT Projects, the USACE operates three large reservoirs (Hartwell Lake, Richard B. Russel Lake, and J. Strom Thurmond Lake). These reservoirs provide flood control, fish and wildlife habitat, water supply, recreation, water quality, and power generation. There are also several other downstream facilities (previously listed in Section 6.1).

On October 1, 1968, Duke Energy entered into an agreement with the USACE and SEPA regarding water releases from the KT Project with the sole purpose to ensure the upstream projects were operated such that the downstream facilities received sufficient flows to meet their power-generating requirements. The 1968 Operating Agreement did not recognize the Bad Creek Project (which was not yet licensed) or the USACE's Richard B. Russell Project.

Duke Energy, USACE, and SEPA executed an NOA on October 17, 2014, which replaced the 1968 operating agreement associated with the KT Project's Original License. The NOA (USACE 2014) was developed to ensure the percentages of remaining usable water storage in the Duke Energy and USACE systems remain in balance when low inflow conditions develop and as these conditions become more severe. Details of the Low Inflow Protocol are included in the NOA (USACE 2014) and Low Inflow Protocol triggers developed during the KT Project relicensing are provided in HDR (2014b).

Under the NOA, declining remaining usable water storage in the downstream USACE reservoir system triggers Duke Energy to release water from the Keowee Development so both systems remain in balance until the Duke Energy system (i.e., Lakes Jocassee, Lake Keowee, and Bad Creek Reservoir) reaches 12 percent remaining usable water storage. At that point, while downstream water flow releases from the Keowee Development associated with hydroelectric generation would cease (excluding releases that may be required by the FERC, for Oconee

Nuclear Station operations or situations covered by the Maintenance and Emergency Protocol), approximately 650 acre-ft of water per week would continue flowing downstream due to leakage and seepage, consistent with existing operations. Therefore, water continues flowing into Hartwell Lake even during the most severe droughts. Further, at the point of ceasing hydroelectric generation releases, without sufficient inflow, the remaining usable water storage combined in the three Duke Energy reservoirs would continue to decline below 12 percent due to reservoir water withdrawals, surface evaporation, leakage, and seepage. Thus, as the USACE system continues to decline below 12 percent remaining usable water storage, the Duke Energy system remaining usable water storage would also continue to decline. The NOA also included operational effects of access to additional water storage in Lake Keowee not previously available due to the operational limitations of Oconee Nuclear Station. The USACE completed an Environmental Assessment of the potential effects of the NOA and issued a Finding of No Significant Impact prior to executing the NOA (USACE 2014).

As part of the relicensing process for the KT Project, Duke Energy conducted a detailed Water Supply Study (WSS) (HDR 2014b). The assessment compiled information about water withdrawals and returns within the Savannah River Basin (greater than or equal to 100,000 gallons per day). Table 6.3-2 provides an aggregate summary by watershed of projected net withdrawals in future years. Net withdrawal is defined as the difference between the amount of water withdrawn within a particular reservoir's watershed and the amount of water returned within a particular reservoir's watershed. It is possible to have a negative net withdrawal of water within a particular watershed if the amount of water returned is greater than withdrawn. Results indicate overall net water withdrawal for the entire basin is expected to increase over time (see Table 6.3-2).

Table 6.3-2. Existing and Projected Annual Average Net Withdrawal Rates by Watershed in the Savannah River Basin

Reservoir	Base[1]	2016	2026	2036	2046	2056	2066
Bad Creek	0	0	0	0	0	0	0
Jocassee	5	5	5	5	5	5	5
Keowee	64	74	88	112	126	139	155
Hartwell	24	38	45	59	64	69	74
Russell	-4	-4	4	3	2	10	9
Thurmond	18	19	30	33	35	49	53
Subtotal	**107**	**132**	**173**	**211**	**232**	**272**	**296**
Woodlawn	-2	-3	-4	-7	0	-4	-8
Stevens Creek	12	12	13	13	24	24	25
North Augusta	25	37	55	63	73	85	99
Augusta Canal Diversion	0	0	0	0	0	0	0
Augusta Canal Diversion Return	84	84	85	85	84	83	82
Augusta	-19	-20	-12	-14	-17	-19	-23
Girard	33	79	77	74	71	67	64
Millhaven	3	4	4	4	13	14	14
Clyo	7	7	7	16	25	24	24
Below Clyo	-8	-10	2	7	10	22	20
Total	**243**	**325**	**399**	**452**	**516**	**569**	**592**

Source: HDR 2014b
[1]Base year rates were based on the most recent available years for which withdrawals and returns were recorded. The most recent year for a given water user ranged between 2007 and 2010.

6.3.6 Federally Approved Water Quality Standards (18 CFR §5.6(d)(3)(iii)(F))

Bad Creek Reservoir is used only for Project operations; it is not designated for any other uses and therefore has no applicable state or federal water quality standards. While there are no state or federal water quality standards applicable to the waters of the Bad Creek Reservoir, Lake Jocassee is included in the highest water quality classification (i.e., excellent rating) as designated by SCDHEC and preservation of existing conditions is recommended, with most tributaries within the watershed fully supporting their designated use. Lake Jocassee is one of only a few reservoirs in South Carolina that possesses the necessary aquatic habitat (water temperatures and DO) to support both a warmwater and a coldwater (salmonid [trout]) fishery year-round (USACE 2014). The South Carolina state-mandated DO average daily water quality standard is a minimum of 5.0 milligrams per liter (mg/L) for non-trout waters and not less than 6.0 mg/L for trout waters. Because TPGT waters (i.e., Lake Jocassee) are considered a type of trout water, they are subject to the same water quality standards as natural trout waters, therefore, the DO minimum for Lake Jocassee is 6.0 mg/L or above. DO measured in the forebay and tailwater areas of Lake Jocassee routinely has concentrations exceeding that threshold. As stated above, SCDHEC has consistently identified Lake Jocassee (as well as downstream Lake Keowee) among the cleanest South Carolina reservoirs based on data from 1980-1981, 1985-1986, and 1989-1990 studies (USACE 2014). Recent data continue to indicate Lake Jocassee (main lake and downstream of the weir), the Toxaway Arm, and the Whitewater Arm fully support aquatic life and recreational designated uses (USACE 2014 [Appendix C]).

A summary of water quality standards for South Carolina applicable to Project waters is included in Table 6.3-3.

Table 6.3-3.South Carolina Numeric State Water Quality Standards Applicable to Project Waters

Parameter	South Carolina Water Quality Standard
Temperature (applies to heated effluents only)	Not to exceed 2.8°C (5°F) above natural temperatures up to 32.2°C (90°F) Trout Waters: Not to vary from levels existing under natural conditions, unless determined some other temperature shall protect the classified uses

Parameter	South Carolina Water Quality Standard
Dissolved Oxygen	Daily average not less than 5.0 mg/L Instantaneous low of 4.0 mg/L Trout Waters: Not less than 6.0 mg/L
pH	Between 6.0 and 8.5 Trout Waters: between 6.0 and 8.0
Turbidity	FW Except for lakes: Not to exceed 50 NTUs provided existing uses are maintained. FW Lakes Only: Not to exceed 25 NTUs provided existing uses are maintained. Trout Waters: Not to exceed 10 NTUs or 10% above natural conditions, provided existing uses are maintained.
Phosphorus	Blue Ridge - Shall not exceed 0.02 mg/L. Piedmont - Shall not exceed 0.06 mg/L.
Nitrogen	Blue Ridge - Shall not exceed 0.35 mg/L. Piedmont - Shall not exceed 1.5 mg/L.
Chlorophyll a	Blue Ridge - Shall not exceed 10 µg/L. Piedmont - Shall not exceed 40 µg/L.

2012b. R. 61 - 68 Water Classifications and Standards. Columbia, SC. URL: https://live-sc-dhec.pantheonsite.io/sites/default/files/media/document/R.61-68.pdf (Accessed March 2021)

6.3.7 Existing Water Quality Data (18 CFR §5.6(d)(3)(iii)(G))

6.3.7.1 Bad Creek Reservoir

Water quality has not historically been monitored in Bad Creek Reservoir as it is not subject to state classification designation or the associated standards.

6.3.7.2 Lake Jocassee

Duke Energy has monitored water quality conditions in Lake Jocassee in some capacity since its formation (1974). Duke Energy water quality sampling generally consisted of monthly, quarterly, or annual in situ temperature, DO, conductivity and pH at several locations in the lake. Nutrients, chlorophyll a, and primary anions and cations as well as various metals have been sampled at least semi-annually over the years (USACE 2014). The chemical composition of the water in Lake Jocassee reflects the chemical composition and weathering sequence of the surrounding parent rock material. Not only does the ionic composition mimic the consistency of the solutes from the chemical weathering of the parent rock material, but the very low concentrations also reflect the extremely slow rates of chemical weathering of the underlying rock formations. The ionic strength, i.e. low conductivity, was found to be similar to other systems draining the Blue Ridge escarpment (USGS 1982). A table of mean chemical composition of Lake Jocassee is included in Table 6.3-4. Other key water quality parameters (i.e., DO and temperature) are discussed in the following section.

Table 6.3-4. Mean Chemical Composition of Lake Jocassee (USACE 2014)

Parameter	Concentration (mg/L)
Sodium	1.39
Calcium	1.2
Potassium	0.67
Magnesium	0.41
Bicarbonate	5.06
Chloride	1.16
Sulfate	1.92
Total Dissolved Solids	10.4
Total Suspended Solids	0.84
Inorganic Solids	0.60
Conductivity (units)	17

6.3.7.2.1 Effects of Bad Creek Construction on Lake Jocassee Water Quality

During construction of Bad Creek, monitoring of Lake Jocassee took place over three periods to determine the impact of construction and operation on Lake Jocassee water quality: pre-construction (baseline), construction (construction impacts), and operational (Project impacts). The pre-construction data indicated that Lake Jocassee is a somewhat acidic, oligotrophic reservoir with very low dissolved solids and nutrients. Because of the lakes’ geomorphological characteristics, there is little mixing between the upper and lower levels of the water column; therefore, thermal stratification may persist for up to four years without turn-over (Duke Power Company 1995a). Because stratification patterns in the reservoir can affect the water quality regime, Duke Energy conducted physical and analytical modeling and based on those results, constructed an energy dissipating weir 550 meters (m) (1,804 ft) downstream of the Project discharge. The weir, built out of nearly half a million cubic yards of rock excavated during Project construction, extends to within 12 m of full pond elevation of Lake Jocassee and was installed both to help minimize the effects of Bad Creek operations on the natural stratification of Lake Jocassee and to dissipate the energy of the discharging water.

The construction and operational phases of monitoring indicated water quality impacts were temporary and spatially confined to the Whitewater River cove. As construction activities ceased, impact parameters (i.e., turbidity and phosphorous) quickly returned to pre-Project levels (Duke Power Company 1995a). Temperature and DO data during operational monitoring results (over the first three years of Bad Creek operation) indicated no changes in temperature or DO profiles in Lake Jocassee due to the operations at Bad Creek with the exception of increased thermal and chemical mixing upstream of the submerged weir (which was predicted during the initial [pre-construction] modeling effort). Overall, operational monitoring indicated the weir successfully restricts Bad Creek impacts to an isolated area of the Whitewater River cove upstream of the submerged rock weir.

6.3.7.2.2 Water Quality Monitoring

As a condition of the Original License for the Bad Creek Project, and as described in Section 1.6, Duke Energy entered into an MOU with the SCDNR for the long-term management and maintenance of high-quality fishery resources in Lake Keowee, Lake Jocassee, and their tributary streams. The MOU and first 10-Year Work Plan were approved pursuant to Article #32(b)(1) of the Original License for the Bad Creek Project on May 1, 1997. Through this MOU, SCDNR and Duke Energy personnel work cooperatively, and include third parties as necessary, to design and implement data collection and other activities to develop and enhance management strategies for fish in these areas. Activities included in the 10-Year Work Plans are focused on fisheries surveys and inventories, water quality and aquatic habitat evaluations, fish stocking, recreation, and shoreline impacts.

Duke Energy’s trout habitat monitoring program addresses two different license articles for the Bad Creek Project. License Article #32(b)(2) covers Lake Jocassee pelagic trout habitat and License Article #34 covers Lake Jocassee water quality. Both articles required Duke Energy to conduct a water quality and trout habitat monitoring program for a 5-year period (i.e., 1995 – 1999).[15] The first 5-year summary report (Foris n.d.), which also included historic data from 1973, concluded operations at the Bad Creek Project had minimal impact on pelagic trout habitat in Lake Jocassee, because the weir likely restricted vertical mixing in the main body of the reservoir. More recent data (from 10-Year Work Plan results as well as studies conducted for the KT Project relicensing) confirm Bad Creek operations have minimal to no impact on trout habitat in Lake Jocassee.[16] More detail on trout habitat is provided in Section 6.4 (Fish and Aquatic Resources). Duke Energy continues to monitor temperature and DO in the Jocassee tailrace (since 2000).

Generally, DO concentrations in Lake Jocassee are a function of the degree of the previous winter mixing – colder winter temperatures result in deeper mixing within the reservoir, which results in higher DO concentrations the following year (USACE 2014). A comparison of temperature and DO distribution between full pond and drawdown conditions indicated low water years exhibited deeper, stronger thermoclines. Multiple droughts over the reservoir's history have resulted in maximum drawdowns up to 29 ft (USACE 2014); however, the overall thermal structure of the reservoir maintained average DO concentrations throughout the water column and were not impacted by the drawdown events (i.e., reduced water elevation), indicating even under extreme drought conditions, DO remains above threshold levels (i.e., 6.0 mg/L).

Although Lake Jocassee water quality meets (and exceeds) state standards, SCDHEC's Water Quality Certification (CWA Section 401) requires Duke Energy to monitor DO, therefore, this parameter (as well as temperature) is still routinely monitored in the Keowee Hydro Station and Jocassee Pumped Storage Station tailwaters. In 2008, Duke Energy installed water quality monitors (temperature, DO, conductivity, and water level) in the tailraces of both Jocassee and Keowee hydroelectric stations. These monitors were equipped with Hach LDO® oxygen sensors and were serviced at regular intervals. Recent data (over the last 13 years) collected with the

[15] The pelagic trout habitat monitoring program in Lake Jocassee began in 1973 to coincide with operations at the Jocassee Pumped Storage Station.

[16] Under the existing monitoring program, if trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations; however this situation has yet to arise based on monitoring. This condition has never been triggered during the Original License term.

temperature and DO monitors revealed a similar yearly cycle of meteorologically controlled temperatures. The only differences between the Jocassee Pumped Storage Station and the Keowee Hydro Station tailrace temperature data resulted from different withdrawal depths (i.e., Lake Jocassee releases cooler water from deeper in the lake than the surface water withdrawal at the Keowee Hydro Station). (Though it should be noted that Lake Keowee is also subject to impacts of operation of the Oconee Nuclear Station.)

DO concentrations in the tailraces reflect the oxygen concentrations at the withdrawal depths with Lake Jocassee exhibiting less variability than Keowee water releases. The more consistent DO values in the Jocassee tailrace were the result of high exchange rates of similar water in the tailrace during the Jocassee generating and pumping cycle. Whereas the Keowee Hydro Station released water at infrequent intervals, greater temperature and DO variability was observed due to the differences between the released water and the water remaining in the tailrace for longer periods. The DO concentrations in the water released from both Jocassee Pumped Storage Station and Keowee Hydro Station were all well above and continue to remain above state water quality standards.

An example of typical DO and temperature in the forebay and tailrace of Lake Jocassee is included below. A study by Reservoir Environmental Management, Inc. (REMI) (2013) was carried out for the KT Project relicensing effort. Temperature and DO data were collected in the forebay and tailwaters of Jocassee in 2012 and were compared against historic water quality. Study results show tailwaters for 2012 consistently meet state water quality standards and the monthly historical temperature and DO profile data that have been collected in the forebay of Lake Jocassee since the reservoir was impounded in 1974 suggests state DO standards at the Jocassee tailwaters have likely been continually met since initial impoundment of the reservoir (REMI 2013). Example DO and temperature conditions measured at Lake Jocassee during this study (i.e., 2012) are shown in Table 6.3-5.

Table 6.3-5. Hourly and Daily Temperature and DO from 2012 Study (REMI 2013)

Location	Jocassee Tailwater						Jocassee Forebay					
Hourly Average												
Parameter	**Dissolved Oxygen (mg/L)**			**Temperature (C)**			**Dissolved Oxygen (mg/L)**			**Temperature (C)**		
Month	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*
Jan	8.83	9.06	9.33	11.0	12.0	14.3	--	--	--	--	--	--
Feb	9.11	9.69	10.05	10.5	11.3	13.7	9.17	9.62	9.95	10.5	11.0	13.3
March	9.09	9.82	10.23	11.0	14.0	18.9	9.21	9.64	9.97	11.9	14.0	17.1
April	8.86	9.46	9.97	14.3	17.2	22.2	8.92	9.34	9.62	14.1	16.7	18.5
May	8.31	8.95	9.63	17.0	20.5	24.3	8.5	8.94	9.27	18.5	20.7	23.8
June	7.73	8.37	8.89	21.4	23.7	27.3	6.56	8.32	8.95	20.2	22.0	24.2
July	7.17	7.75	8.30	24.7	26.5	29.2	5.82	7.70	8.23	24.0	26.6	28.9
Aug	6.80	7.37	8.44	26.6	27.5	29.7	6.61	7.47	7.91	26.4	27.3	29.4
Sept	6.55	7.41	7.72	24.5	26.3	28.5	6.91	7.45	7.85	24.4	26.1	28.2
Oct	7.29	7.74	8.35	19.3	22.6	25.7	7.17	7.73	8.35	19.3	22.4	25.5
Daily Average												
Parameter	**Dissolved Oxygen (mg/L)**			**Temperature (C)**			**Dissolved Oxygen (mg/L)**			**Temperature (C)**		
Month	*Min*	*Mean*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*
Jan	8.92	9.06	9.22	11.1	12.0	13.7	--	--	--	--	--	--
Feb	9.15	9.69	9.92	10.6	11.3	12.7	9.46	9.63	9.82	10.6	11.0	11.7
March	9.57	9.82	10.03	11.3	14.0	16.9	9.52	9.63	9.78	13.0	14.0	15.5
April	9.08	8.63	9.79	15.4	17.2	19.6	9.18	9.35	9.50	15.0	16.6	17.3
May	8.61	8.95	9.39	18.1	20.1	22.9	8.68	8.94	9.12	19.5	20.8	22.7
June	8.04	8.37	8.67	22.1	23.7	25.4	7.35	8.31	8.77	20.7	22.8	25.6
July	7.43	7.75	8.09	25.4	26.5	27.9	7.15	7.70	8.03	25.4	26.6	27.9
Aug	7.21	7.37	7.64	26.9	27.5	29.1	7.06	7.47	7.65	26.9	27.3	28.0
Sept	7.23	7.41	7.58	25.0	26.9	29.1	7.25	7.45	7.60	24.6	26.1	27.2
Oct	7.45	7.75	8.24	19.5	22.6	24.8	7.45	7.73	8.24	19.5	22.4	24.4

Levels of pH in the waters of Lake Jocassee coincide with a gain or loss of oxygen, giving strong evidence for biological processes dominating the oxygen and carbon dioxide concentrations throughout the water column. Levels also depend on level of mixing in the reservoir and are more pronounced during summer (stratification) than winter (mixing) (Duke Energy 2011). Total phosphorus, nitrate-nitrogen, and chlorophyll-a measurements have also been collected by Duke Energy since the time of impoundment. Phosphorus levels have generally been below the SC state water standards for waters of the Blue Ridge (0.02 mg/L) and are far below standards for Piedmont reservoirs (0.06 mg/L) (Duke Energy 2011), while chlorophyll-a concentrations average 2 to 3 micrograms/liter, which is well below the 10 microgram/liter reference standard for the Blue Ridge and Piedmont (40 microgram/liter) reservoirs.

Turbidity in Lake Jocassee is considered low and is consistently below the state standard for trout waters of 10 nephelometric turbidity units (NTU) (Duke Energy 2014d). Turbidity in Lake Jocassee was high in the newly impounded reservoir but soon decreased (1979-1980) as shown on Figure 6.3-6. With the construction and initial operation of Bad Creek Project, turbidity increased again in the late 1980s and gradually decreased back to pre-construction levels after construction activity ceased (Duke Energy 2011).

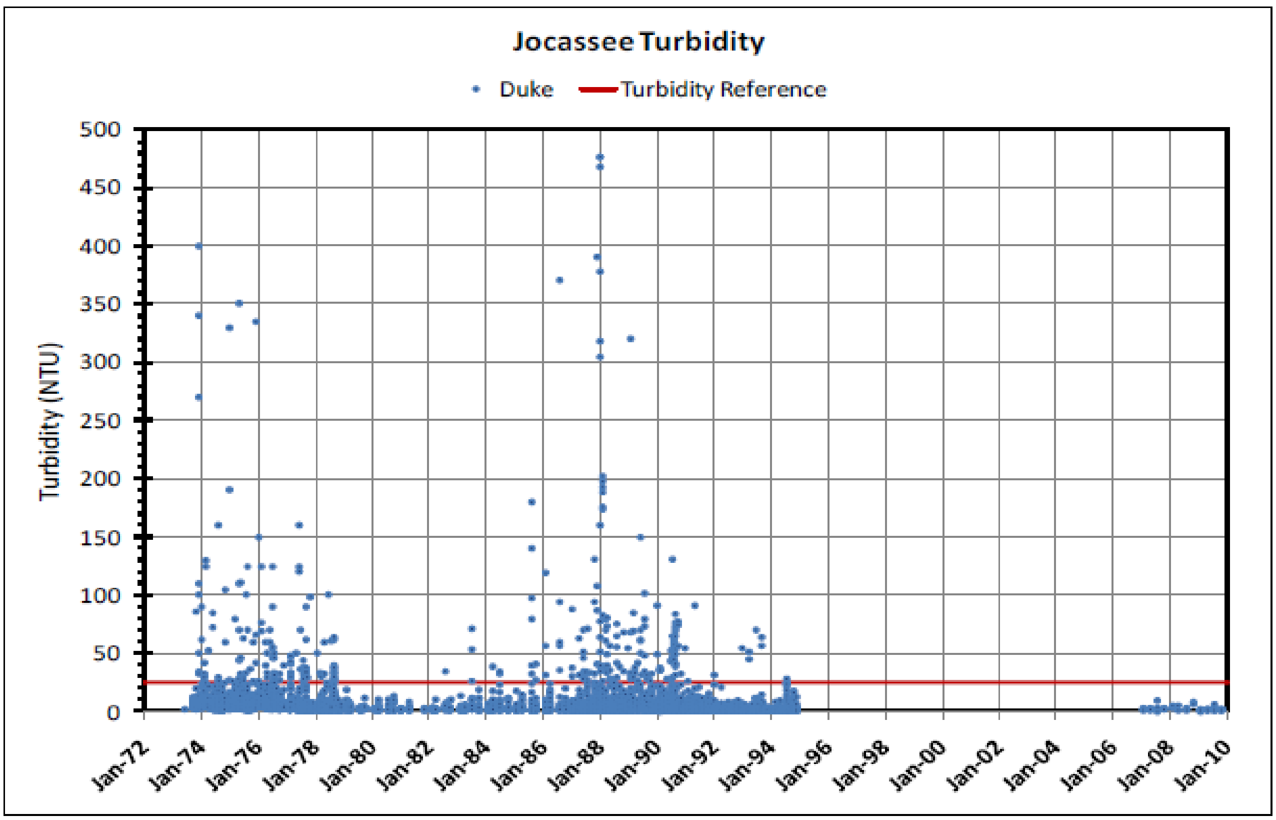

Figure 6.3-6. Lake Jocassee Turbidity (Source: Duke Energy 2011)

Finally, in the Environmental Assessment report developed as part of the KT Project relicensing effort in 2014, FERC specifically did not recommend continued water quality monitoring for the following reasons: (1) existing water quality in the reservoirs and tailwaters (i.e., Lake Jocassee and Lake Keowee) is meeting or exceeding levels consistent with state water quality standards, and is consistent with levels supporting designated uses, and no issues have been raised concerning pH and total dissolved gas; (2) water quality modeling results indicate under the proposed [KT] Project operation, suitable DO levels and water temperatures would exist for the propagation of aquatic life in the Keowee Development water releases; (3) there are no proposed changes in KT Project operation that would alter water quality from existing conditions in the Jocassee Development tailwaters; and (4) the fishery at the KT Project is considered high quality.

6.3.8 Gradient for Downstream Reaches Directly Affected by the Project (18 CFR §5.6(d)(3)(iii)(H))

The only downstream reach directly affected by the Project is Lake Jocassee, which is not included in the Project license. This section is, therefore, not applicable for the Bad Creek Project.

6.3.9 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

There are no known potential adverse effects to existing uses of Project waters or water quality in the upper or lower reservoirs due to the continued operation of the Project, therefore, no additional PM&E measures beyond the existing monitoring and measures required by the Work Plans established under the MOU and those required by KT Project Relicensing Agreement are proposed at this time. Duke Energy expects to further consult with SCDHEC and relicensing stakeholders through the ILP regarding final PM&E measures directed at operation of the existing Project to be included in the final licensing proposal.

6.3.10 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

6.3.10.1 Impact on Water Exchange Between the Upper and Lower Reservoirs

Operation of the proposed Bad Creek II Complex, which will add pumping and generating capacity to the Project, has the potential to impact water surface elevations of Lake Jocassee. The impact of existing operation of the Bad Creek Project on Lake Jocassee water levels is minimal. Operational data at Bad Creek over the past 15 years indicate an average daily change in the upper reservoir level of approximately 10 ft. The maximum increase over any one-day time period was 60 ft and the maximum decrease was 58 ft. The largest water surface elevation change at Lake Jocassee (as a direct result of operations at Bad Creek) occurs when it is at Normal Minimum Elevation. Using fill (i.e., pump back) vs. generation scenarios at the Project, the effect Bad Creek operations has on Lake Jocassee water levels was determined (Table 6.3-6). The maximum daily change in water level at the Project (60 ft increase and 58 ft decrease in the upper reservoir) resulted in a corresponding 2.4 feet in water level change at Jocassee. The average water level change at Bad Creek Reservoir (under both filling and pumping scenarios) resulted in approximately half a foot of water level change at Lake Jocassee.

Table 6.3-6. Daily Elevation Changes in Lake Jocassee from Operations at Bad Creek (past 15 years)

Scenario	Start Elevation		End Elevation	
	Bad Creek	Jocassee	Bad Creek	Jocassee
Fill 1	Max-60'	Min	Max	-2.4
Fill 2	Max-10'	Min	Max	-0.52
Gen 1	Max	Min	Max-58'	2.4
Gen 2	Max	Min	Max-10'	0.5

Additionally, previous analyses have shown if the entire Bad Creek Reservoir active storage volume (31,808 acre-ft or 160 ft of drawdown) was released, the impact on Lake Jocassee (at 1,110 ft msl) would only result in an approximate 4-ft increase in water level.

Prior to the ongoing upgrade of the units at the existing Project, this maximum drawdown would take 29 hours and after the upgrade, it will take 23 hours with all four units running. The combined Bad Creek and Bad Creek II Complex would reduce the time for maximum drawdown from 23 hours to 11 hours, with a subsequent decrease in pumping refill time from 26 hours to 13 hours.

6.3.10.2 Impacts to Project Streams

Construction of the Bad Creek II Complex would impact existing streams and waterbodies, including wetlands. Overburden (i.e., soil and rock) material from the construction activities are proposed to be deposited in several spoil locations throughout the site. Siting for spoil locations alternatives is ongoing by Duke Energy; however, due to the amount of material required for construction, existing topography, and prevalence of headwater streams and seeps located throughout the site, it is unlikely there would be an alternative identified that will result in zero impacts to steams and downstream waters. As described in Section 5.6.3.3, placement of excavated rock removed from the underground excavations to the downstream slope of the existing submerged weir in Lake Jocassee, as was done for the construction of the existing Project, would significantly reduce the amount of material to be placed at upland disposal sites, thereby reducing impacts to existing streams and wetlands. Upland disposal resulting in impacts to streams or wetlands, as well as placement of rock spoils at the submerged weir, will require an individual permit from the USACE as well as water quality certification from SCDHEC under the authorities of Sections 404 and 401 of the CWA. If development of the Bad Creek II Complex is pursued by Duke Energy, Duke Energy expects to initiate this parallel regulatory process in conjunction with the relicensing process.

Operations of the Bad Creek II Complex are not likely to affect existing streams or tributaries, as there would be no changes to the local watersheds or modification of uplands.

6.3.10.3 Spoil Locations

According to preliminary studies and estimates for proposed material removed from underground excavations, approximately 4 million cubic yards of spoil material for the Project infrastructure will need to be deposited into on-site spoil locations or along the submerged weir in Lake Jocassee. Potential spoil location alternatives and estimated impacts to water resources are included on Figure 6.3-7. Compiled natural resources reports in Appendix E provide more details on locations and aquatic resources that will potentially be impacted. The location of each sited spoil area location alternative and surface waters are shown on Figure 6.3-7. The estimated total length of the aquatic resources potentially impacted for each spoil area location alternative is provided in Table 6.3-7 and estimated impacts to water resources by potential structure locations are provided in Table 6.3-8.

Table 6.3-7. Estimated Impacts to Water Resources by Potential Spoil Location

Spoil Area Location Alternative	Spoil Area Capacity (Million Cubic Yards)	Impacted Streams (ID Numbers[1])	Total Estimated Stream Impact Length (linear feet)
A*+	1.3	0	0
B*	1.3	19 P, 20 P, 21 P	1,865
C	0.7	17 P	286
D	1.3	13I, 14 P	996
E	0.16	0	0
F*	0.25	0	0
G*	1.1	4 I, 4a P	1,484
H	1.5	0	0
I*	1.1	0	0

[1]Corresponds to stream ID numbers provided in the Bad Creek NRA (Appendix E)
*Duke Energy Preferred Spoil Area
PPerennial
IIntermittent
NIsolated Wetlands created by Duke Energy, not expected to be federally regulated or require mitigation
+ Spoil Area A includes spoil placement along the existing submerged weir in Lake Jocassee

Table 6.3-8. Estimated Impacts to Water Resources by Potential Structure Locations

Proposed Structure	Impacted Streams (ID Numbers[1])	Total Estimated Stream Impact Length (linear feet)
525 kV Switchyard	6 P, 7 P	425
Transformer Yard	0	0

[1]Corresponds to stream ID numbers provided in the Bad Creek NRA (Appendix E)
PPerennial
NIsolated Wetlands created by Duke Energy, not expected to be federally regulated or require mitigation

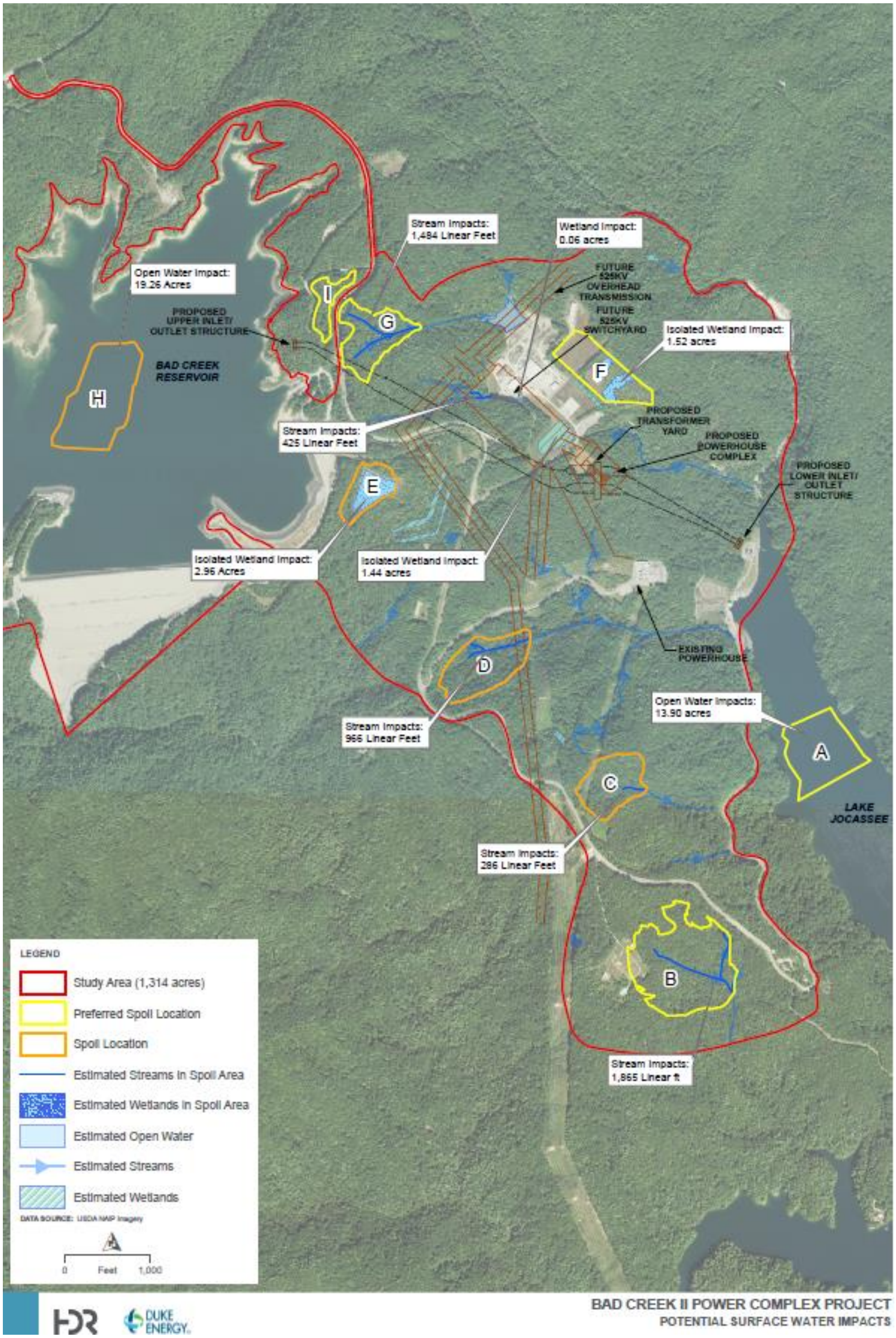

Figure 6.3-7. Potential Spoil Locations Relative to Surface Waters

6.3.10.4 Construction and Operation Impacts to Lake Jocassee

Long-term impacts to the water quality of Lake Jocassee are not expected as a result of the operation of the proposed Bad Creek II Complex. The primary (temporary) impact to surface water quality (Lake Jocassee) during construction would be increased suspended sediment loads due to overland runoff and stream bank activities associated with the construction activities. These activities could lead to elevated turbidity levels, decreased DO levels, and degradation of aquatic habitat in Lake Jocassee; however, effects would occur in a localized area and would likely affect only the Whitewater River arm of Lake Jocassee. Temporary impacts during construction activities would occur in the Whitewater River cove due to construction of the new lower reservoir inlet/outlet structure and expansion of the submerged weir by placement of rock materials excavated during tunneling activities. Similar to the impacts of the construction of the existing Project, temporarily elevated turbidity would be anticipated in the Whitewater River arm of Lake Jocassee. Previous studies during original weir construction indicated while turbidity did increase during the construction phase, turbidity levels returned to normal following construction (refer to Figure 6.3-6). Best management practices, as required by water quality permit(s) issued by SCDHEC, would be implemented. Turbidity will be monitored during the expansion of the weir and general project construction. As noted in Section 6.3.6, waters of Lake Jocassee, including the Whitewater River cove, are classified as TPGT, for which turbidity standards are not to exceed 10 NTU or 10 percent above natural conditions. Duke Energy expects to consult with SCDHEC through the relicensing and 404/401 permit process regarding turbidity standards and associated monitoring and protection measures for construction of the Bad Creek II Complex, if the Project expansion is proposed by Duke Energy.

Operation of the Bad Creek II Complex has the potential to impact waters of Lake Jocassee. It was concluded in early modeling studies (prior to operation of the existing Project) the only substantial impact to Lake Jocassee related to Bad Creek Project operations was vertical mixing of the reservoir. This impact is reduced through the presence of the submerged weir. Similar to the inlet/outlet structure for the Bad Creek Project, the inlet/outlet structure for the Bad Creek II Complex would be upstream of the submerged rock weir; therefore, vertical mixing is expected to be limited to this isolated area of Whitewater River cove. Based on initial CFD modeling of the area to support the evaluation of the second inlet/outlet structure's effects within the

Whitewater River arm of Lake Jocassee upstream of the weir (see Section 6.2.5.2), results indicated velocities produced by full generation from both powerhouses (i.e., existing and proposed) are similar to velocities experienced in the Whitewater River cove since operations began in 1991. While Duke Energy does not presently expect significantly increased vertical mixing in the reservoir following expansion of the submerged weir and commencement of operation of the new powerhouse, Duke Energy expects this issue to be further evaluated through additional or ongoing studies related to the Bad Creek II Complex.

Excess sediment deposition and accumulation has the potential to alter water quality and bottom substrate that provides important littoral habitat to aquatic species; therefore, Best Management Practices (BMPs) would be put in place during construction and a comprehensive Erosion and Sedimentation Control Plan would be implemented during all phases of construction to reduce impacts to the extent possible. A Water Quality Monitoring Plan would also be developed by Duke Energy in consultation with agencies, including monitoring locations, methods, and reporting criteria for major parameters such as DO, temperature, pH, specific conductance, and turbidity for Project construction (pre-, during, and post-construction) and operation.

6.3.10.5 Site and Road Impacts

Traffic on access roads during construction and during construction and continued Project operation can also increase sediment runoff, therefore, BMPs (e.g., vegetation or matting) would be installed near haul roads and access roads. Additionally, spill prevention, control, and safety management plans would be in place to prevent vehicle fluids from entering the watersheds if spilled.

6.4 Fish and Aquatic Resources (18 CFR §5.6(d)(3)(iv))

6.4.1 Aquatic Habitat (18 CFR §5.6(d)(3)(iv)(A))

Bad Creek Reservoir is used only for Project operations; it is not designated for any other uses and therefore has no applicable state or federal water quality standards (see Sections 6.3.4 and 6.3.6). Due to the water level fluctuations, no public access (including fishing) is permitted for Bad Creek Reservoir (Section 5.4.1). Because there are no regulatory designations, water sampling is not performed in the upper reservoir, and no aquatic habitat or aquatic biota information is available for Bad Creek Reservoir. Because operation of the existing Project and/or construction and operation of the Bad Creek II Complex has the potential to impact aquatic habitat in Lake Jocassee, information is provided below for Lake Jocassee and described in greater detail (for trout habitat) in Section 6.4.2.5. Essential fish habitat is discussed in Section 6.4.4.

6.4.1.1 Lake Jocassee Littoral Habitat

The littoral fish habitat in Lake Jocassee resembles many undeveloped mountain lakes in North Carolina, comprising rocky outcrops (77 percent of the littoral zone), sand (8 percent), emergent vegetation or stream confluences (7 percent), residentially developed piers and riprap (4 percent), clay (3 percent), and cobble (1 percent) (Duke Energy 2014d). Much of the littoral zone exhibits steep slopes, with areas of significant woody debris (large stumps). Standing timber in deeper areas of Lake Jocassee (at depths greater than 100 ft) may provide trout habitat during the summer and fall months if not excluded by water quality characteristics related to seasonal stratification (Barwick et al. 2004). Limited aquatic vegetation growth is likely due to a steep littoral zone, insufficient substrate, and frequent water level fluctuations preventing plant establishment.

Duke Energy used the CHEOPS™ operations model to simulate hourly water levels in Lake Jocassee under four alternative scenarios compared to baseline conditions as related to KT Project operations, using hydrology from the years 1939 to 2011 (Duke Energy 2014d). Twelve metrics were defined to assess the effects on spawning conditions for black bass, sunfish, Blueback Herring, and Threadfin Shad. Under the most severe hydrologic conditions modeled, hourly model outputs indicate KT Project operations should support reservoir target levels for at least 20 consecutive days, at least 99 percent of the time, and 100 percent of the time for 15 or fewer consecutive days for the black bass spawning period. Given the littoral spawning species hatch and disperse from nests within 5 days of hatching, the 20-consecutive-day period of uninterrupted spawning should enhance an already healthy fish community for shallow water species. The stable reservoir conditions may also benefit pelagic species such as Threadfin Shad or Blueback Herring by expanding habitat.

Fish species spawning in the littoral zone are primarily sunfish and black bass, which are highly adaptable spawners and maintain robust populations in Lake Jocassee (Duke Energy 2014d).

Life history characteristics fostering successful reproduction for these species include spawning over a range of water depths, the relatively short duration required for eggs to hatch and for larvae to become mobile, and high fecundity (see Section 6.4.5.1).

6.4.1.2 Lake Jocassee Pelagic Habitat

Lake Jocassee is classified as an oligotrophic waterbody exhibiting low productivity, low nutrient concentrations, and high clarity. Generally, DO concentrations remain relatively high due to the low productivity (slow consumption of oxygen due to limited biological activity and benthic decomposition rates) (Dobson and Frid 2009). It is a dimictic lake experiencing seasonal thermal stratification (summer) and mixing (winter), however as stated in Section 6.3.7.2.1., the lake's geomorphological characteristics can sometimes result in minor mixing between the upper and lower levels of the water column, allowing for thermal stratification to persist for up to four years without turn-over (Duke Power Company 1995a). Seasonal stratification can lead to a "temperature-oxygen squeeze" for some coldwater species, limiting the habitat available due to hypoxic hypolimnetic waters and a warm epilimnion (Coutant 1985) (refer to Figure 6.4-3).

6.4.2 Environmental Studies and Agreements under the Work Plans

As stated in Section 1.6, Duke Energy filed a revised Exhibit S within one year of the prior FERC license issuance to address fish and wildlife PM&E measures. Environmental studies under the revised Exhibit S required by the FERC license included an assessment of Project effects on fish entrainment and associated mortality; coldwater fish (trout) habitat in Lake Jocassee; and a detailed mitigation plan with proposed fish and wildlife PM&E measures to be implemented by Duke Energy to mitigate impacts associated with Bad Creek Project operations on Lake Jocassee and nearby stream fisheries. Duke Energy and the SCDNR developed the MOU in 1996 to establish a framework to help maintain the high-quality fisheries of lakes Jocassee and Keowee (Duke Power and SCDNR 1996).

The Bad Creek Fishery Resources Work Plan consists of three, successive 10-Year Work Plans (i.e., 1996 – 2005; 2006 – 2016[17]; and 2017 – 2027). The activities and agreements in the 10-Year Work Plans include:

1) agreement on minimizing fish entrainment via the Project;
2) electrofishing of littoral fish populations;
3) water quality monitoring for trout habitat;
4) hydroacoustic monitoring of small pelagic fish;
5) cost sharing for trout stocking; and
6) cost sharing for fisheries research and enhancements.

While most of the activities and agreements under the scope of work include both lakes Jocassee and Keowee, only descriptions relative to Lake Jocassee are included herein.

6.4.2.1 Current 10-Year Work Plan (2017-2027)

The current 10-Year Work Plan (2017-2027; SCDNR and Duke Energy 2016) continues many of the management activities implemented in prior work plans. Duke Energy and SCDNR continue to cooperatively monitor the fishery in lakes Jocassee and Keowee while annually reviewing the results of the monitoring studies. Many of the studies and activities conducted at Lake Jocassee under the MOU are relevant to assessing potential environmental impacts associated with existing and continued operation of the Project. The current 10-Year Work Plan is composed of the same main components as the six listed above, with the exception of water quality monitoring for trout habitat (no. 3), which was completed under the 2006-2015 work plan (see Section 6.4.2.4). However, trout habitat monitoring in Lake Jocassee was adopted as a requirement of the KT Project Relicensing Agreement.

[17] Several activities conducted under the first two 10-year work plans were identified as PM&E measures under the KT Project (FERC No. 2503) and are now included in the KT Project Relicensing Agreement and the New License issued by FERC in 2016. As a result, the original 2006 – 2015 Work Plan was extended by one year to cover 2016.

6.4.2.2 Bad Creek Pumped Storage Station Entrainment Study

Duke Energy completed a 3-year fish entrainment study at Bad Creek during the first three years of Project operations (1991-1993) (Barwick et al. 1994). A fish entrainment study plan was developed in cooperation with the SCDNR and the USFWS.

The study goals were: (1) to estimate the number and mortality of fish entrained from Lake Jocassee during the pumping mode of operation and (2) evaluate the impact of entrainment on fishery resources in Lake Jocassee.

6.4.2.2.1 Project Operations under Entrainment Sampling

The existing Project uses excess electricity to pump water from Lake Jocassee into Bad Creek Reservoir for later use in generation to meet system demands (Barwick et al. 1994). During pumping, water can be withdrawn from Lake Jocassee through four bays in the inlet/outlet structure at a depth of 50-80 feet (when the reservoir is at full pond). Pumping with Units 1 or 2 withdraws water through Bays 1 and 2 and pumping with Units 3 or 4 withdraws water through Bays 3 and 4. Pumped storage operations can result in weekly water level fluctuations of 98-131 feet in Bad Creek Reservoir. The total annual hours of pumping during the 3-year entrainment study (for all units combined) were 2,789 hours (1991), 4,385 hours (1992), and 7,070 hours (1993).

6.4.2.2.2 Entrainment Sampling Methods

To estimate entrainment during pumping at the Project, fixed hydroacoustic techniques and full-recovery netting were used from January 1991 through December 1993[18] (Barwick et al. 1994). Hydroacoustic monitoring was conducted to estimate the density of fish, or entrainment rate, through the facility. Full-recovery netting was performed to assess the accuracy of hydroacoustic estimates and species composition of fish entrained.

For hydroacoustic monitoring, one transducer was mounted above each bay at 8.0 m below full pond elevation of Lake Jocassee (Barwick et al. 1994). For details on hydroacoustic system models, transducers, and installed depths and locations, see Barwick et al. (1994). All

[18] Due to high rates of entrainment noted during the last three months of 1993 and its apparent correlation to low water levels, hydroacoustic monitoring of entrainment continued through January 1994 but was not quantified.

hydroacoustic entrainment data were expressed as mean number of fish entrained per hour per month per bay.

Full-recovery samples were at least 2.5 hours in duration; sample specimens were identified to lowest practical taxonomic level, enumerated, and measured for total length. Early in the study, because daytime entrainment was low and netting during the day provided little meaningful data beyond that collected at night, daytime netting was discontinued (in March 1992).

Mortality was assumed to be 100 percent for all fish entrained during pumping operations. A summary of multiple empirical entrainment studies summarized by Electric Power Research Institute (EPRI) demonstrates that some survival occurs through hydroelectric power facilitates (EPRI 1997), and therefore an assumption of 100 percent mortality is highly conservative. Duke Energy personnel observations of fish in Bad Creek Reservoir support this conclusion.

Regression analyses were used to determine the relationship between numbers of fish caught in the nets (except when large numbers of turbine-struck fish were caught or one of the nets failed) and numbers of fish estimated via hydroacoustics to have been entrained (Barwick et al. 1994). No attempt was made to estimate entrainment at the Project during the generation mode (versus pumping) of operation because the probability of the return of a significant number of viable fish to Lake Jocassee from Bad Creek Reservoir was expected to be low.

6.4.2.2.3 Entrainment Study Results

Total annual entrainment in 1991 was estimated at 51,146 fish or 18.3 fish per hour based on 2,789 hours of pumping operations at Bad Creek (Table 6.4-1) (Barwick et al. 1994). In 1992, an estimated 22,183 fish or 5.1 fish per hour were entrained during 4,385 hours of pumping operations (Table 6.4-1) (Barwick et al. 1994). Entrainment was generally highest during spring and early summer in 1991, and greatest in summer and early fall in 1992. Five species comprised greater than 90 percent of fish entrained during the study: Threadfin Shad (*Dorosoma petenense*), Blueback Herring (*Alosa aestivalis*), Bluegill (*Lepomis macrochirus*), White Bullhead (*Ameiurus catus*), and Redbreast Sunfish (*Lepomis auritus*). All other taxa represented two percent or less of the total estimated entrainment. Generally, most of the fish entrained were small or intermediate in length with few fish longer than 300 millimeters.

Table 6.4-1. 1991-1993 Bad Creek Project Entrainment Study Results

Year	Estimated Entrainment Rate (fish/hour)	Hours of Pumping	Total Estimated Fish Entrained	Dominant Species (Relative Abundance)
1991	18.3	2,789	51,146	Threadfin Shad (36.0%) Blueback herring (23.8%) Bluegill (20.6%) White Catfish (10.5%) Redbreast Sunfish (3.5%) *Total: 94.4%*
1992	5.1	4,385	22,183	Blueback herring (57.5%) Threadfin Shad (13.7%) Bluegill (13.4%) White Catfish (9.8%) Redbreast Sunfish (2.5%) *Total: 96.9%*
1993	45.0	7,070	317,998	Threadfin Shad (87.7%) Blueback Herring (9.1%) *Total: 96.9%*

Annual fish entrainment estimated for 1993 was considerably higher than the previous two years (Barwick et al. 1994). An estimated 317,998 fish (45.0 fish per hour) were entrained during 7,070 hours of pumping operations (Table 6.4-1). Entrainment was highest during fall and early winter. Eighteen taxa were entrained in 1993, with total numbers dominated by Threadfin Shad (87.7 percent) followed by Blueback herring (9.1 percent). All other fish species represented less than two percent of the total estimated entrainment. Most of the entrained fish were small or intermediate in length.

A complication of the study arose when a significant number of fish were entrained a second time (re-entrainment) after being pumped from Lake Jocassee into Bad Creek Reservoir, then returned to Lake Jocassee during generation and entrained again during subsequent pumping (Barwick et al. 1994). After consultation with the SCDNR, modifications to the sampling plan were made to reduce the statistical errors introduced by re-entrainment; however, re-entrainment was not eliminated completely, and additional studies were conducted in 1993 in an attempt to better understand re-entrainment (Barwick et al. 1994). Based on these (unpublished) studies, entrainment results were thought to be overestimated (conservative) for years 1992 and 1993. Due to limited hours of pumping in 1991 (i.e., least chance of re-entrainment), the annual entrainment losses were thought to be the most accurate estimate of entrainment rates (Barwick et al. 1994).

Project operations and resulting turbulence and water velocities near the intakes impacted entrainment during the study. An excerpt from Barwick et al. (1994) provides additional details on the relationship between operation and entrainment:

> Fish entrainment [at the Project] was highest on Bay 1, with entrainment on Bays 2, 3, and 4 being considerably lower and similar. Even though two-unit (simultaneous pumping with Units 1 and 2 or Units 3 and 4) and four-unit (simultaneous pumping with all units) pumping resulted in higher intake velocities and moved a much larger volume of water than one-unit pumping, the number of fish entrained per hour was at times higher during one-unit pumping than during two-unit or four-unit pumping. In 1993, entrainment rates during one-unit pumping were generally more than twice that noted for two-unit and four-unit pumping. Preliminary velocity measurements near the discharge indicated that flow patterns may be responsible for the reduced rate of entrainment during two- and four-unit operation (J. C. Knight, Duke Power Company, personal communication). During one-unit operation laminar flows were noted. However, during two-unit operation (no measurements of velocity were made during 4-unit operation) considerable turbulence was noted some distance from the discharge structure. This turbulence may act as a behavioral barrier that prevented fish from moving into the immediate vicinity of the discharge structure. If this were true, this turbulence may keep fish far enough away from the discharge structure to result in reduced entrainment during two-unit and four-unit pumping.

6.4.2.2.4 Summary of Entrainment Study

The rate of entrainment at Bad Creek was generally low (five fish/hour) during most of the study (October 1991-August 1993) (Barwick et al. 1994). Overall, an estimated 391,327 fish were entrained at the Bad Creek Project during 14,244 hours of pumping from 1991 to 1993. A total of 300,406 of these fish were Threadfin Shad and most were entrained in late 1993 in response to low water levels in Lake Jocassee (14 ft below full pond elevation). Blueback Herring, White Catfish, Redbreast Sunfish, and Bluegill were the only other taxa entrained in significant numbers.

Results of entrainment studies indicated: (1) entrainment had no statistical impact on the abundance of prey and sportfish taxa in Lake Jocassee; (2) entrainment had no statistical impact on the effort and harvest of fish by anglers fishing Lake Jocassee; and (3) entrainment had no predicted long-term impact on the prey fish population in Lake Jocassee during normal operating conditions observed in 1991-1993 (Barwick et al. 1994). Results of risk assessment studies predicted low probability of impact by entrainment on Threadfin Shad during normal operations of the Bad Creek Project; however, a major die-off may occur if there is an extended drawdown period in Lake Jocassee (which congregates fish in the upper reservoir and increases vulnerability to entrainment during generation) or low water temperatures due to a colder than average winter. It is important to note the significance of re-entrainment on the overall number of fish entrained at the Bad Creek Project may have had a profound impact on the overall number of fish estimated to be entrained at the Project, however, it could not be determined to what extent.

As previously noted, the Project license was amended in 2018 to authorize pump-turbine unit upgrades and rehabilitation. As described in FERC's amendment order, the new pump-turbine runners pass water at a higher flow rate between the upper and lower reservoirs but do not change the volume of water transferred between the reservoirs or reservoir level (FERC 2018). Replacement of the pump-turbine runners for the four existing units was expected to increase the Project's Maximum Hydraulic Capacity by approximately 14.7 percent. In the amendment order, FERC agreed with Duke Energy's assessment that the proposed increase in pumping capacity would not significantly increase the number of fish entrained at the Bad Creek Project (consultation was also conducted with resource agencies; no objection was received).

6.4.2.3 Electrofishing of Littoral Fish Population

Duke Energy has monitored spring littoral fish populations in Lake Jocassee via boat-mounted electrofishing since 1996 (SCDNR and Duke Energy 1996) and continues every three years (i.e., 2017, 2020, 2023, and 2026) under the current 10-Year Work Plan (SCDNR and Duke Energy 2016). The electrofishing surveys document fish species by number and weight at 20 representative (300-m long) shoreline sampling locations, consisting of 10 in the upper portions of Lake Jocassee (i.e., Toxaway and Whitewater arms) and 10 in the lower portion (i.e., main body) (Figure 6.4-1) (Duke Energy 2014d).

Similar to many reservoir fisheries in the southeastern U.S., warmwater species, particularly centrarchids (sunfish and bass), dominated samples numerically (comprising 72 to 91 percent of fish collected in the lower portion reservoir and 78 to 94 percent of fish collected in the upper portion of the reservoir) (Table 6.4-2) (Duke Energy 2014d, 2016a, 2021a). Coldwater species (such as Rainbow Trout [*Oncorhynchus mykiss*] and Brown Trout [*Salmo trutta*]) were infrequently collected. A review of biomass in kilograms (kg) shows standing stock was consistently higher in the upper portions of Lake Jocassee than the lower portion of the reservoir

(Table 6.4-3), which is consistent with typical limnological patterns in response to upstream nutrient inputs in reservoir systems (Green et al. 2015).

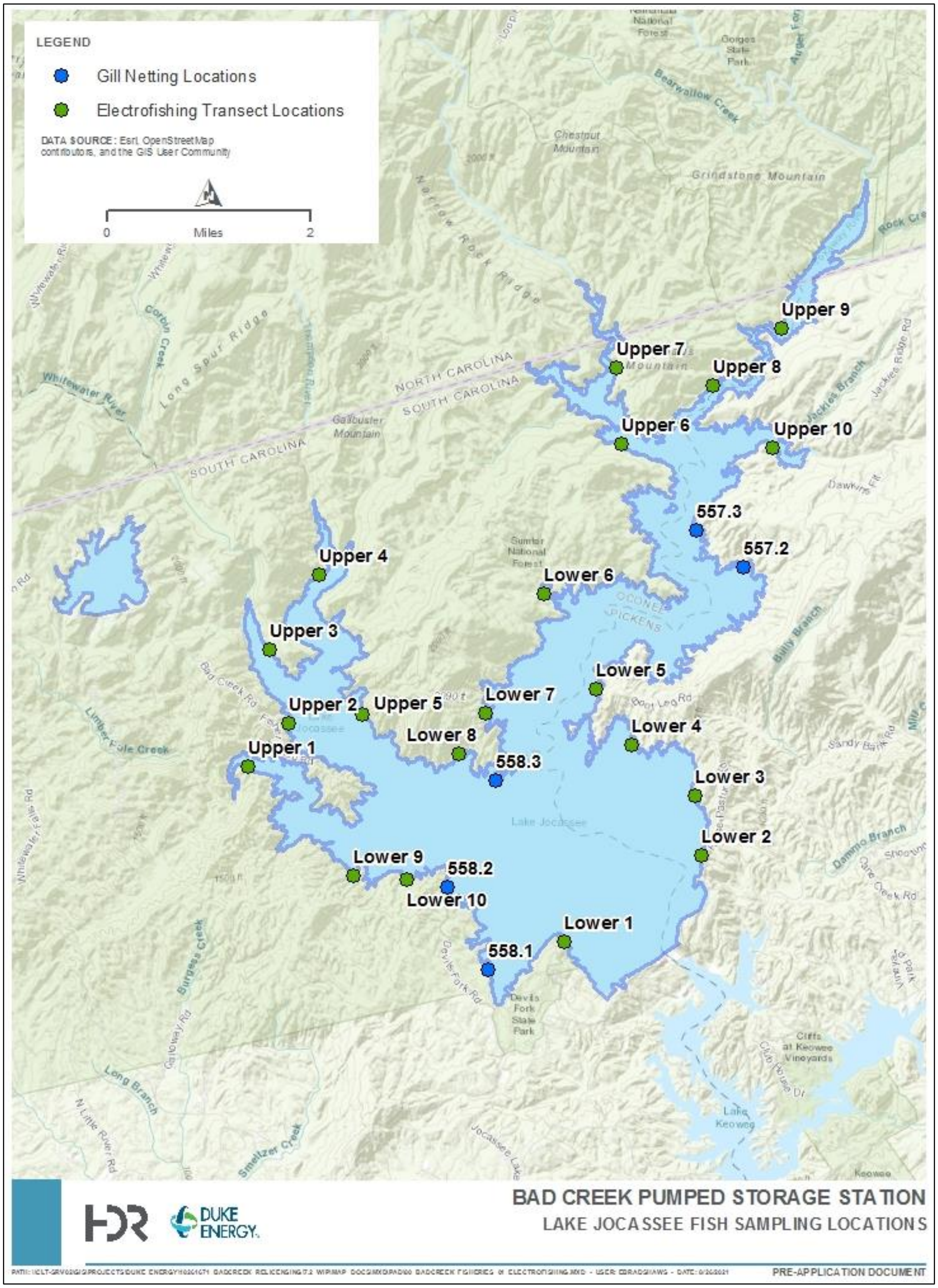

Figure 6.4-1. Lake Jocassee Fish Sampling Locations

Table 6.4-2. Number of Fish Collected during Spring Electrofishing in Lake Jocassee

Common Name	Species Name	Lower Lake Jocassee									Upper Lake Jocassee								
		1996	1999	2002	2005	2008	2011	2014	2017	2020	1996	1999	2002	2005	2008	2011	2014	2017	2020
Alabama Bass	*Micropterus henshalli*	--	--	2	4	4	--	5	1	21	1	--	--	1	1	2	1	3	14
Bartram's Bass	*Micropterus* sp. cf. *cataractae*	55	63	77	38	23	56	77	12	4	60	81	96	50	87	87	115	24	12
Black Crappie	*Pomoxis nigromaculatus*	--	--	--	--	--	--	--	--	--	2	--	1	--	--	--	--	--	--
Blackbanded Darter	*Percina nigrofasciata*	--	--	--	--	1	1	--	--	--	--	--	--	--	--	2	1	--	--
Blueback Herring	*Alosa aestivalis*	6	77	44	171	81	31	45	--	354	414	9	17	178	71	23	168	--	559
Bluegill	*Lepomis macrochirus*	133	67	246	270	370	221	251	44	34	62	81	288	330	702	273	244	68	41
Brassy Jumprock	*Moxostoma* spp.	--	--	--	--	--	--	--	--	--	--	1	--	1	--	4	--	--	--
Brown Trout	*Salmo trutta*	--	2	2	--	--	--	--	--	2	1	--	--	--	--	--	--	--	--
Common Carp	*Cyprinus carpio*	17	8	11	1	--	--	3	--	--	12	9	5	1	1	--	--	--	--
Flat Bullhead	*Ameiurus platycephalus*	1	--	--	--	3	1	12	1	--	4	4	4	4	4	8	10	2	1
Golden Shiner	*Notemigonus crysoleucas*	2	--	--	--	1	--	--	--	--	--	--	--	--	1	1	--	--	--
Green Sunfish	*Lepomis cyanellus*	31	12	42	26	42	58	47	19	14	14	18	12	29	53	134	37	18	17
Hybrid Black Bass	*Micropterus* spp.	--	--	--	--	6	1	--	--	3	--	--	--	--	1	--	6	--	1
Hybrid Sunfish	*Lepomis* spp.	--	--	9	4	6	3	5	3	--	--	1	5	10	3	5	4	4	--
Largemouth Bass	*Micropterus salmoides*	9	12	13	5	8	9	2	6	9	31	37	45	38	58	41	34	43	34
Notchlip Redhorse	*Moxostoma collapsum*	--	--	--	--	--	--	--	--	--	2	1	--	--	--	--	--	--	--
Rainbow Trout	*Oncorhynchus mykiss*	1	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--
Redbreast Sunfish	*Lepomis auritus*	264	167	391	259	415	239	500	79	92	118	221	212	242	354	357	251	115	80
Redear Sunfish	*Lepomis microlophus*	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--
Smallmouth Bass	*Micropterus dolomieu*	--	2	24	--	4	3	7	8	--	1	--	1	1	1	5	2	2	--
Snail Bullhead	*Ameiurus brunneus*	4	2	1	12	6	13	2	14	34	--	--	1	4	4	3	1	14	7
Striped Jumprock	*Moxostoma rupiscartes*	--	--	--	--	--	1	--	--	--	--	--	--	1	--	--	--	--	--
Threadfin Shad	*Dorosoma petenense*	--	--	98	--	--	--	--	--	--	--	649	101	--	--	--	--	--	--
Walleye	*Sander vitreus*	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	5	2	9	6	12	11	1	1	1	4	1	3	8	13	17	3	2	1
Whitefin Shiner	*Cyprinella nivea*	27	1	11	1	253	65	31	29	9	19	31	45	46	75	16	16	14	15

Common Name	Species Name	Lower Lake Jocassee									Upper Lake Jocassee								
		1996	1999	2002	2005	2008	2011	2014	2017	2020	1996	1999	2002	2005	2008	2011	2014	2017	2020
Yellow Perch	*Perca flavescens*	--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	2	--	--
	Total	**555**	**415**	**980**	**797**	**1,235**	**714**	**989**	**216**	**577**	**745**	**1,145**	**836**	**944**	**1,429**	**978**	**893**	**306**	**768**

-- No fish collected
Note: 2017 and 2020 data are preliminary
Source: Duke Energy 2014d, 2016a, 2021a

Table 6.4-3. Weight (kg) of Fish Collected during Spring Electrofishing in Lake Jocassee

Common Name	Species Name	Lower Lake Jocassee									Upper Lake Jocassee								
		1996	1999	2002	2005	2008	2011	2014	2017	2020	1996	1999	2002	2005	2008	2011	2014	2017	2020
Alabama Bass	*Micropterus henshalli*	--	--	<0.1	0.4	1.1	<0.1	2.8	0.1	2.6	<0.1	--	--	<0.1	0.4	<0.1	0.2	0.1	3.5
Bartram's Bass	*Micropterus* sp. cf. *cataractae*	5.5	8.5	7.2	7.4	2.3	6.2	12.4	2.7	1.1	6.6	10.4	9.5	7.0	11.9	10.0	13.4	3.9	2.2
Black Crappie	*Pomoxis nigromaculatus*	--	--	--	--	--	--	--	--	--	0.6	--	1.2	--	--	--	--	--	--
Blackbanded Darter	*Percina nigrofasciata*	--	--	--	--	<0.1	<0.1	--	--	--	--	--	--	--	--	<0.1	<0.1	--	--
Blueback Herring	*Alosa aestivalis*	0.2	1.2	0.2	2.4	1.1	0.2	0.3	--	2.4	10.3	0.1	0.3	2.1	0.7	0.2	1.2	--	3.3
Bluegill	*Lepomis macrochirus*	2.3	2.6	3.2	5.6	2.8	3.0	4.3	0.8	1.1	1.1	1.8	2.1	3.8	2.8	3.2	3.4	1.7	0.8
Brassy Jumprock	*Moxostoma* spp.	--	--	--	--	--	--	--	--	--	--	0.2	--	0.7	--	1.3	--	--	--
Brown Trout	*Salmo trutta*	--	0.2	0.2	--	--	--	--	--	0.2	0.1	--	--	--	--	--	--	--	--
Common Carp	*Cyprinus carpio*	20.9	18.5	14.3	1.4	--	--	5.5	--	--	17.3	13.7	6.2	1.7	1.1	--	--	4.9	--
Flat Bullhead	*Ameiurus platycephalus*	<0.1	--	--	--	0.2	0.1	1.2	--	--	1.1	0.4	0.2	0.2	0.2	0.6	0.8	0.1	0.1
Golden Shiner	*Notemigonus crysoleucas*	<0.1	--	--	--	<0.1	--	--	--	--	--	--	--	--	<0.1	<0.1	--	--	--
Green Sunfish	*Lepomis cyanellus*	0.6	0.4	0.5	0.7	0.5	0.7	0.9	0.2	0.3	0.5	0.4	0.5	0.7	0.6	2.7	2.2	0.2	0.4
Hybrid Black Bass	*Micropterus* spp.	--	--	--	--	1.4	0.1	--	--	1.2	--	--	--	--	0.2	--	0.9	--	0.4
Hybrid Sunfish	*Lepomis* spp.	--	--	0.2	0.1	0.1	0.1	0.2	0.3	--	--	0.1	0.2	0.3	0.1	0.2	0.1	0.2	--
Largemouth Bass	*Micropterus salmoides*	7.1	10.5	8.4	2.9	3.8	3.1	0.9	8.0	8.5	17.2	10.1	17.0	15.9	19.9	6.1	18.6	9.8	17.5
Notchlip Redhorse	*Moxostoma collapsum*	--	--	--	--	--	--	--	--	--	1.5	1.2	--	--	--	--	--	--	--
Rainbow Trout	*Oncorhynchus mykiss*	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Redbreast Sunfish	*Lepomis auritus*	6.3	5.4	5.7	6.6	4.6	4.7	10.3	1.6	1.9	5.0	6.4	4.1	6.4	4.9	5.4	6.5	2.5	2.6
Redear Sunfish	*Lepomis microlophus*	--	--	--	--	--	<0.1	<0.1	--	--	--	--	--	--	--	--	--	--	--

Common Name	Species Name	Lower Lake Jocassee									Upper Lake Jocassee								
		1996	1999	2002	2005	2008	2011	2014	2017	2020	1996	1999	2002	2005	2008	2011	2014	2017	2020
Smallmouth Bass	*Micropterus dolomieu*	--	1.6	1.2	--	0.4	0.5	1.3	0.7	--	<0.1	--	<0.1	0.7	1.1	1.4	0.1	1.5	--
Snail Bullhead	*Ameiurus brunneus*	0.2	0.1	<0.1	0.6	0.2	0.7	0.1	0.7	1.0	--	--	0.1	0.1	0.2	0.2	0.1	0.8	0.4
Striped Jumprock	*Moxostoma rupiscartes*	--	--	--	--	--	<0.1	--	--	--	--	--	--	0.1	--	--	--	--	--
Threadfin Shad	*Dorosoma petenense*	--	--	0.3	--	--	--	--	--	--	--	1.8	0.3	--	--	--	--	--	--
Walleye	*Sander vitreus*	--	--	--	--	--	--	--	--	--	--	1.5	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	0.1	0.1	0.1	0.2	0.1	0.1	<0.1	<0.1	--	0.1	<0.1	<0.1	0.1	0.1	0.4	0.1	--	--
Whitefin Shiner	*Cyprinella nivea*	0.1	<0.1	0.1	0.1	0.4	0.2	0.1	0.1	--	0.1	0.1	0.2	0.1	0.3	0.1	0.1	--	--
Yellow Perch	*Perca flavescens*	--	--	--	--	--	--	--	--	--	<0.1	--	--	<0.1	--	--	<0.1	--	--
	Total	**43.4**	**49.1**	**41.7**	**28.4**	**18.9**	**19.9**	**40.3**	**15.0**	**20.5**	**61.4**	**48.2**	**41.8**	**40.0**	**44.5**	**31.8**	**47.8**	**25.7**	**31.29**

-- No fish collected
Note: 2017 and 2020 data are preliminary
Source: Duke Energy 2014d, 2016a, 2021a

6.4.2.4 Gill Net Studies

As part of the 1996-2005 Work Plan, gill netting was performed at five locations annually by SCDNR and funded by Duke Energy (Figure 6.4-1) (SCDNR and Duke Energy 1996). The purpose of these studies was to contribute data to the longest-running database on the Jocassee fishery. Gill netting was first implemented in 1975, prior to the development of creel survey or hydroacoustic techniques. Gill netting data also provided information on trout densities, species and strain performance, year class strength, growth, and survival among other population health characteristics. These data were used to inform stocking and management decisions, such as creel and size limits.

From 1999 to 2012, numbers and biomass of Brown Trout averaged 87 fish and 115.6 kg per 40 gill-net sets (Table 6.4-4 and Table 6.4-5) (Rodriguez 2013). Fewer Rainbow Trout were collected (average of 7 fish and 3.7 kg per 40 gill-net sets); however, this species may not be sampled efficiently with gill nets. Numbers and biomass of total black basses averaged 110 fish and 84.1 kg per 40 gill-net sets, the majority of which consisted of Bartram's Bass (*Micropterus* sp., 87 percent of black bass numbers and 77 percent of black bass biomass). The remainder of black basses were comprised of Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass. Numbers and biomass of White Catfish averaged 40 fish and 10.7 kg per 40 gill-net sets.

Table 6.4-4. Number of Fish Collected in Gill Net Sampling on Lake Jocassee, 1999-2012

Year	Brown Trout	Bullhead Catfish	Largemouth Bass	Rainbow Trout	Bartram's Bass	Smallmouth Bass	White Bass	White Catfish
1999	74	24	9	1	107	14	1	57
2000	124	6	5	3	111	3	2	20
2001	126	14	7	3	86	3	0	14
2002	139	17	5	0	85	5	0	17
2003	107	4	3	36	59	8	0	25
2004	80	2	4	4	64	2	0	9
2005	83	13	1	1	102	8	1	58
2006	49	28	2	5	127	8	1	3
2007	51	18	8	22	118	18	4	11

Year	Brown Trout	Bullhead Catfish	Largemouth Bass	Rainbow Trout	Bartram's Bass	Smallmouth Bass	White Bass	White Catfish
2008	85	7	13	6	120	7	0	23
2009	116	39	9	4	125	15	1	93
2010	53	33	8	3	76	9	0	60
2011	69	61	4	4	91	9	1	100
2012	68	38	6	2	63	8	0	66
Mean	**87**	**22**	**6**	**7**	**95**	**8**	**1**	**40**

Source: Rodriguez 2013

Table 6.4-5. Biomass (kg) of Fish Collected in Gill Net Sampling on Lake Jocassee, 1999-2012

Year	Brown Trout	Bullhead Catfish	Largemouth Bass	Rainbow Trout	Bartram's Bass	Smallmouth Bass	White Bass	White Catfish
1999	114.2	3.3	14.3	0.2	68.1	24.4	1.1	8.4
2000	172.6	0.6	8.6	0.8	69.8	5	2.9	3.8
2001	194.7	1.9	10.6	2.3	54.1	7.6	0	10.7
2002	167.8	1.3	8.1	0	53.4	4.9	0	6.6
2003	132.6	0.3	4.7	12.8	50.6	8.9	0	6.8
2004	89.4	0.1	6.9	1.9	42.3	2.6	0	4.6
2005	111.6	0.6	0.6	0.2	63.9	9	0.7	8.8
2006	80.9	3.8	5.1	4.2	85.3	8.7	1.6	1.1
2007	67.9	2.5	11	17.3	90.7	21.2	5.1	5.9
2008	113.1	2.5	30.4	2.7	86.4	5.7	0	20.7
2009	126.6	3.2	15.8	2.9	78.3	15.6	1	20.9
2010	60.9	2.6	11.4	2.4	53.3	8.4	0	12.7
2011	89.7	5.9	4.7	2	58.3	8.4	0.5	22.2
2012	95.7	3.3	10	1.9	39.9	10.1	0	17.1
Mean	**115.6**	**2.3**	**10.2**	**3.7**	**63.9**	**10**	**0.9**	**10.7**

Source: Rodriguez 2013

6.4.2.5 Lake Jocassee Trout Habitat

Lake Jocassee is one of only a few reservoirs in South Carolina containing a combination of water temperatures and DO levels supporting both a warmwater and a coldwater (trout) fishery year-round (USACE 2014). Soon after the creation of Lake Jocassee in the early 1970's, South Carolina state fishery biologists introduced Rainbow and Brown trout into the reservoir to diversify the fishery of the waterbody. Annual stockings of these species have continued and are an important part of the state's management goals of creating and maintaining a productive coldwater sport fishery. The success of the fishery is dependent on adequate availability of suitable pelagic habitat, as defined by specific thermal and DO criteria.

Vertical profile surveys of temperature and DO have been conducted in Lake Jocassee since 1973. Water quality data were collected at multiple locations starting at the water surface (0.3 m) and proceeding downward at 2-m intervals to the reservoir bottom (Foris 2008). Locations were selected to assure adequate characterization of the spatial aspects of pelagic trout habitat throughout the reservoir, including up-lake, mid-lake, and down-lake sampling locations (Figure 6.4-2). Profile data allow evaluation of the vertical and horizontal distribution of trout habitat conditions, as measured by thickness/depth (m) and volume (m^3), throughout the year and prediction of late-summer (i.e., September) trout habitat thickness in the main body of the reservoir using an empirical model developed by Duke Energy (Foris 1991). Pelagic trout habitat is defined as water with temperatures ≤ 20.0 degrees Celsius (°C) and DO concentrations ≥ 5.0 (mg/L) (Oliver et. al. 1978).

The temporal and spatial distribution of trout habitat over the 1973-2015 period were consistent with typical temperature and DO regimes observed in Lake Jocassee (Duke Energy 2014d; Duke Energy 2016a). Seasonally, more habitat was available during the winter cooling period when temperatures were well below 20°C, and DO concentrations generally exceeded 5.0 mg/L. As the seasons progressed and air temperatures increased, habitat availability gradually declined both horizontally and vertically within the reservoir due to warming of the upper water layers and depletion of DO in the middle and lower portions of the water column (Figure 6.4-3). Habitat was consistently at a minimum in late summer (September) just prior to fall cooling, coinciding with the height of thermal stratification in the reservoir. In most years, September pelagic trout habitat was restricted to the main body of the reservoir where water depths exceeded 70 m.

Specifically for the most recent 10-Year Work Plan (2006-2015), measured trout habitat thickness ranged from 17 to 73 m as shown on Figure 6.4-4, which indicated sufficient habitat availability in Lake Jocassee to support a robust trout population. Since trout habitat thickness was never predicted to be less than 10 m, additional monitoring under the current 10-Year Work Plan (2017-2027) was not required. However, continued monitoring of trout habitat thickness is performed under the KT Project Relicensing Agreement, which requires a model prediction and verification by temperature and DO survey at the deepest location in Lake Jocassee (station 558.0) in February and September, annually. If trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations.

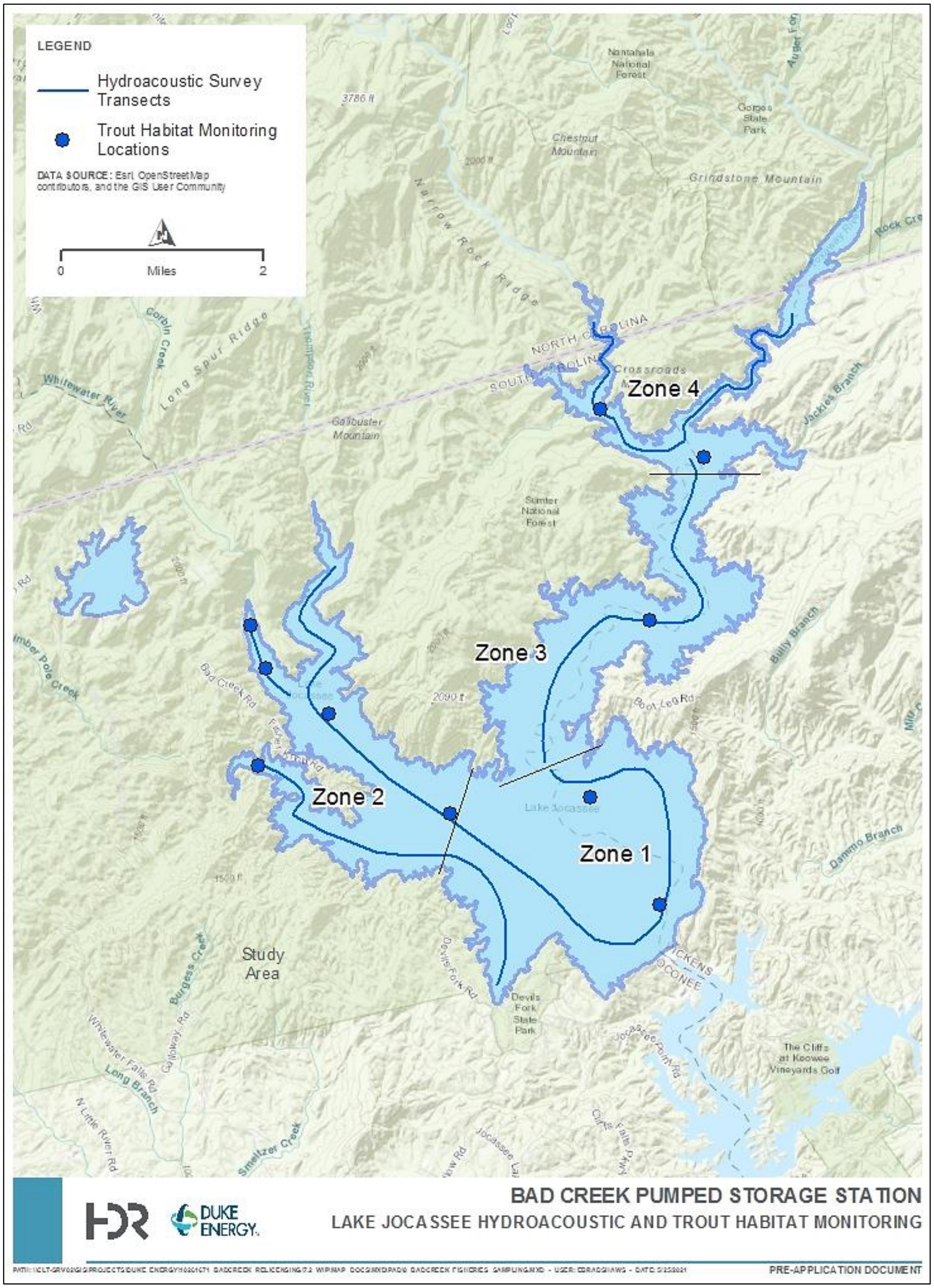

Figure 6.4-2. Hydroacoustic Survey Transects and Trout Habitat Monitoring Locations

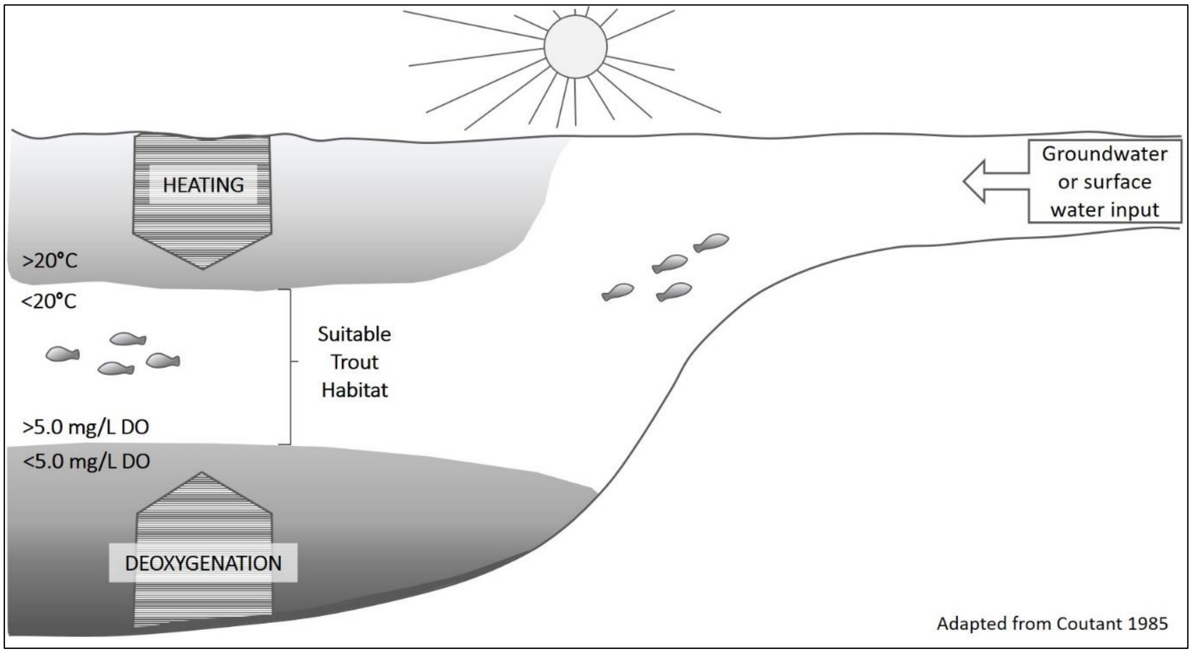

Figure 6.4-3. Schematic Depicting Example of Trout Habitat Thickness in the Water Column Depending on Thermal and Dissolved Oxygen Dynamics

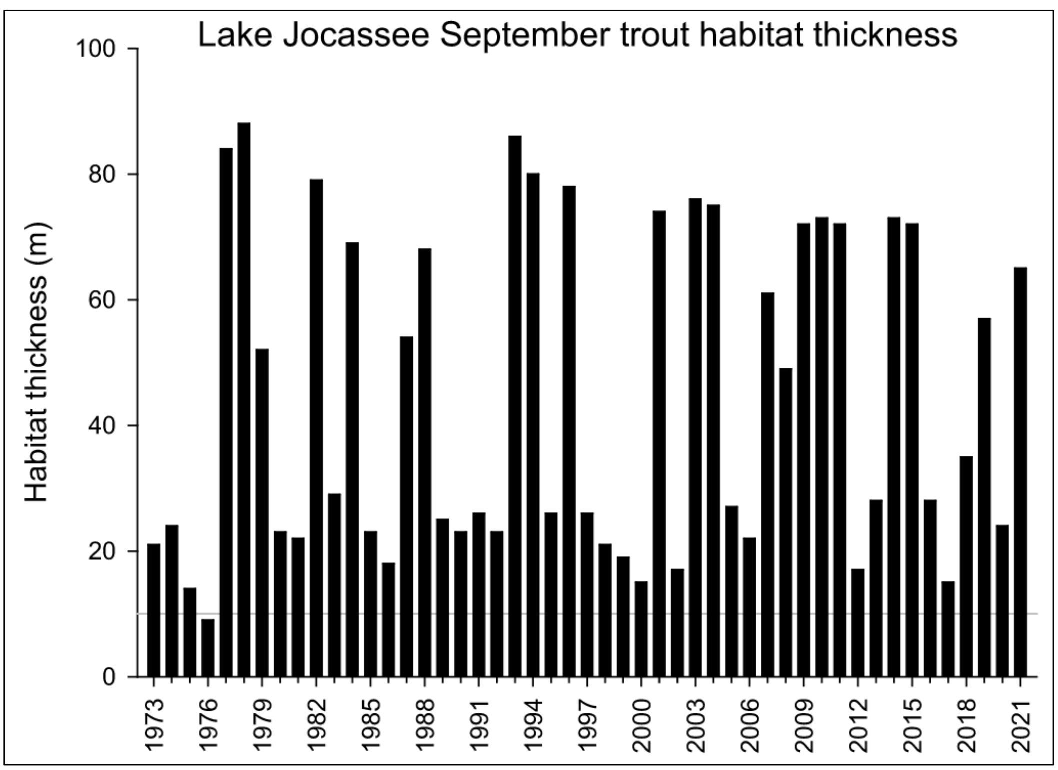

Figure 6.4-4. Measured Trout Habitat Thickness 1973-2015 (Source: Duke Energy 2021b)

6.4.2.6 Hydroacoustic Monitoring of Small Pelagic Fish

Hydroacoustic monitoring of fish populations by Duke Energy to assess pelagic prey fish (i.e., Threadfin Shad and Blueback Herring) abundance and distribution began in 1997 (SCDNR and Duke Energy 1996). Sampling was performed in four zones of the reservoir (Figure 6.4-2) in the spring and fall (biannually) from 1997 to 2015, and annually in the fall during the current Work Plan. Hydroacoustic sampling is completed using multiplexing, side-scan, and down-looking transducers (Duke Energy 2014d). Complementary to hydroacoustic sampling, purse seine sampling was also conducted in conjunction with the fall hydroacoustic sampling from 1997 to 2012 in order to characterize species composition of the pelagic forage fish community.

The upper Toxaway River arm of Lake Jocassee (i.e., Zone 4) had the highest forage fish densities during the most recent 10-year Work Plan period; however, the pelagic forage fish populations exhibited a wide degree of variability both spatially and temporally (Figure 6.4-5). While species composition has generally varied since 1997, the Threadfin Shad population has declined substantially from 2009 to 2014 (Table 6.4-6) (Duke Energy 2014d, 2021c). Although purse seine sampling was discontinued shortly after, population estimates for Threadfin Shad in 2015 suggest the population is rebounding. Variations in Threadfin Shad populations may be related to cold winter conditions which can result in die-offs of this sensitive species (Rhode et al. 2009) or could be the result of fluctuating chlorophyll-a and zooplankton levels which can have a large impact on the Threadfin Shad population as a planktivore subsisting in oligotrophic waters. Threadfin Shad are an ideal species as a forage fish for sought-after sportfish species due to their early age of maturity (within the first year) and high fecundity; this life history strategy also allows for persistent populations despite sensitivity to naturally occurring environmental conditions, such as seasonally cool ambient temperatures (Higginbotham 2010).

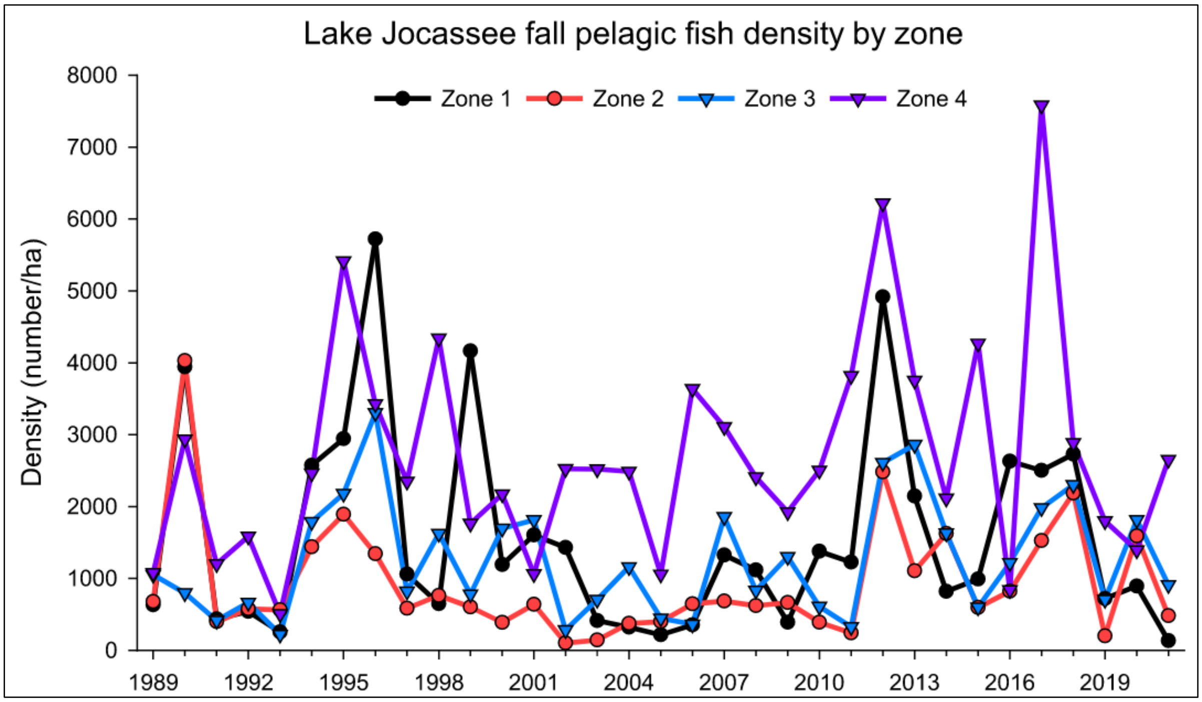

Figure 6.4-5. Lake Jocassee Fall Forage Fish Density (fish/hectare) by Zone during Mobile Hydroacoustic Surveys 1989-2021 (Source: Duke Energy 2021b)

Table 6.4-6. Estimated Lakewide Number of Forage Fish and Relative Abundance in Lake Jocassee, Fall 1997 through 2020[1]

Year	Lakewide Fall Estimate of Forage Fish (millions)			Relative Abundance (%) in Purse Seine Samples		
	Blueback Herring	Threadfin Shad	Total	Blueback Herring	Threadfin Shad	Total
1997	3.96	0.00	3.96	99.9	0.1	100
1998	4.12	1.39	5.51	74.7	25.3	100
1999	5.95	1.02	6.97	85.3	14.7	100
2000	1.16	3.17	4.33	26.8	73.2	100
2001	3.03	1.42	4.45	68.2	31.8	100
2002	1.73	1.62	3.35	51.5	48.5	100
2003	2.16	0.68	2.84	76.0	24.0	100
2004	2.50	0.79	3.29	76.1	23.9	100
2005	1.14	0.51	1.65	69.1	30.9	100
2006	2.68	0.60	3.28	81.8	18.2	100
2007	3.68	1.72	5.40	68.1	31.9	100

Year	Lakewide Fall Estimate of Forage Fish (millions)			Relative Abundance (%) in Purse Seine Samples		
	Blueback Herring	Threadfin Shad	Total	Blueback Herring	Threadfin Shad	Total
2008	1.64	2.18	3.82	42.9	57.1	100
2009	3.08	0.30	3.38	91.2	8.8	100
2010	3.65	0.22	3.87	94.4	5.6	100
2011	3.84	0.12	3.96	96.9	3.1	100
2012	13.07	0.01	13.08	99.9	0.1	100
2013	7.81	0.52	8.33	93.8	6.2	100
2014	4.80	0.04	4.84	99.2	0.8	100
2015	3.43	1.45	4.88	70.2	29.8	100
2016	--	--	5.38	--	--	--
2017	--	--	10.59	--	--	--
2018	--	--	8.91	--	--	--
2019	--	--	2.78	--	--	--
2020	--	--	4.85	--	--	--
Mean	**3.86**	**0.94**	**4.80**	**77.2**	**22.8**	**100**

[1]Species composition data is unavailable after 2015 due to discontinuation of purse seine sampling
Source: Duke Energy 2014d and Duke Energy 2021c

6.4.2.7 Cost-share for Fishery Enhancements and Studies

The Bad Creek MOU lists a number of activities eligible for cost-sharing, including fisheries research, water quality studies, trout habitat studies, stream surveys, creel surveys, fish and habitat management, development of bank and stream-side access, and stream protection and enhancement. Over the last Work Plan period (2005-2016), funding was provided by Duke Energy for activities implemented by the SCDNR including the following:

- Annual trout stocking: 2006-2015 (Table 6.4-8)
- Triennial creel surveys (Figure 6.4-7)
    - Lake Jocassee: 2006, 2009, 2012, and 2015
    - Lake Keowee: 2008, 2011, and 2014

- Bioenergetics study: 2012 (Taylor and Bulak 2011)
- Redeye bass study: 2014 (Leitner and Kanczuzewski 2015)
- Eastern Brook Trout restoration efforts: 2015

Table 6.4-7. Annual Funding for Trout Stocking and Creel Surveys, 2006-2015

Year	Trout Stocking	Fish Monitoring, Research, and Restoration	Total
2006	$80,000	$110,000	$190,000
2007	$80,000	$135,000	$215,000
2008	$88,200	$127,746	$215,946
2009	--	--	$238,104[1]
2010	$95,030	$143,992	$239,022
2011	$95,030	$143,992	$239,022
2012	$81,829	$160,046	$241,875
2013	$75,900	$166,000	$241,900
2014	$78,891	$168,109	$247,000
2015	$80,054	$170,630	$250,684
Total	$754,934	$1,325,515	$2,318,553

[1]Itemization not provided by SCDNR

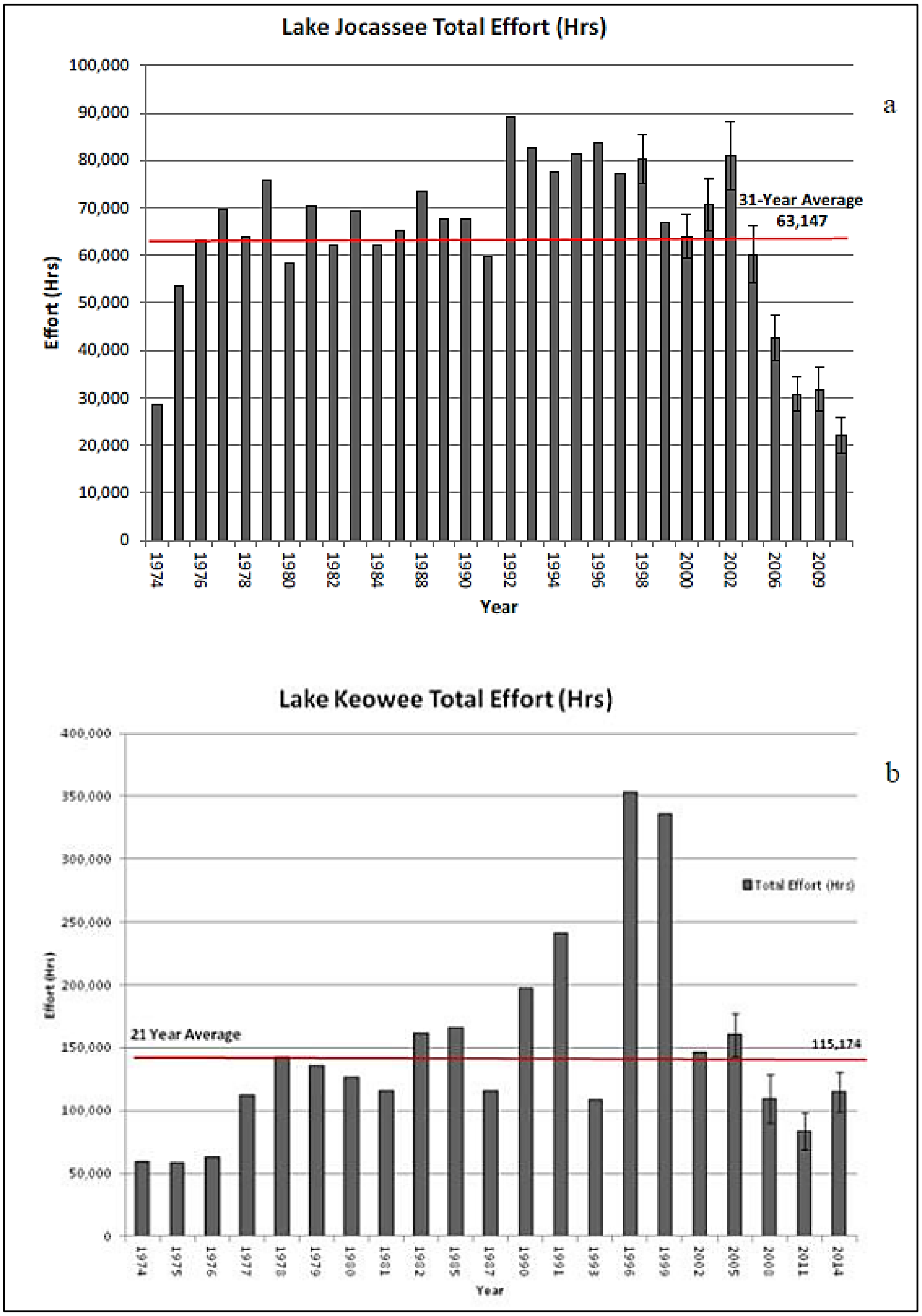

Figure 6.4-6. Recreational fishing effort on Lake Jocassee (a) and Lake Keowee (b) from 1974 – 2014 (with 95% Confidence Intervals for estimates from 2005 to 2014)

6.4.3 Other Environmental Studies

6.4.3.1 2021 Bad Creek Desktop Entrainment Study

Given the historical entrainment report developed by Barwick et al. (1994), baseline entrainment information is available for the Project. An updated desktop entrainment study was performed by Kleinschmidt Associates for Duke Energy in support of this PAD and to evaluate potential impacts of the proposed Project expansion (i.e., Bad Creek II Complex). Specifically, this study considered the potential for entrainment of Lake Jocassee fishes through the Project under the proposed action (i.e., operation of two powerhouses at the Project). A summary of this study follows, and the full report is included as Appendix F.

6.4.3.1.1 Methods

The entrainment risk analysis comprised two primary components: a Monte-Carlo simulation model to estimate the number of fish entrained and estimated mortality, and a vulnerability assessment of species subject to entrainment. Target species selected for this analysis were based on a previous empirical entrainment study conducted at the Project from 1991 to 1993 (see Section 6.4.2.2) (Table 6.4-8). Relative abundance of entrained species (proportions) was applied to entrainment rates measured in fish per million cubic feet (Mft^3).

Table 6.4-8. Monthly Sum of Entrainment at the Bad Creek Project from 1991 to 1993

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Black Crappie				18	73							4
Blackbanded Darter					134	9		5				
Blueback Herring	2,086	2,093	1,267	2,885	1,753	5,837	5,955	1,854	7,836	7,736	9,170	5,466
Bluegill	8		30	116	2,537	796	6,626	1,388	3,941	2,399	68	80
Brown Trout	5			56	149	41						14
Channel Catfish			1		60	9		5				
Common Carp					277	54			11			
Flat Bullhead					55			98				
Golden Shiner			2	18	153	9		2				

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Green Sunfish								3	111	181		
Hybrid Sunfish									37			
Largemouth Bass					37	17	97	5	97	410		
Quillback					18							
Rainbow Trout	27					6						
Redbreast Sunfish				18	220	15	1,392	547	611	480	1	16
Redear Sunfish					18							
Redeye Bass							14	2	48	62		
Spottail Shiner					18							
Striped Jumprock												14
Threadfin Shad	3,033	4,072	5,290	8,656	2,302	1,588	3,485	425	2,4365	4,1867	71,009	134,314
Warmouth				124	311	63	419	4	49	113		
White Bass					2	16			113		1	
White Catfish	3		6	207	2,961	196	2,723	1,765	1,679	1,339	68	2
Whitefin Shiner					20				49			
Yellow Perch	140	64	54	177	385			55	75		1	7
Yellowfin Shiner					18							

Entrainment Simulations

Using the open-source software package Stryke (validated by the USFWS Turbine Blade Strike Model), entrainment was simulated for the relative frequency and magnitude of mortality events for the Project and Bad Creek II Complex. Fish simulated to route through the Project were assumed to experience 100 percent mortality through the powerhouse(s). Seasonal entrainment rates incorporating hourly entrainment data from the historical study were evaluated by probability distributions through the Stryke package.

Monthly entrainment rates were described with either a Pareto, Weibull Max, or Generalized Extreme Value distribution. Bad Creek, under the proposed action of adding the additional twin powerhouse, is intended to be operated (pumped) up to 6 hours per day on weekdays and 2 hours per day on weekends. To simplify, the simulation is for pumping 6 hours per day, 30 days per month, which produced a more conservative estimate.

For every month, Stryke simulated daily entrainment events (fish/Mft^3) for 30 model-days. Then expanded that to a daily entrainment estimate (fish) by multiplying the entrainment rate by the total amount of water pumped (Mft^3) during a six-hour period. Stryke simulates a daily entrainment event as a function of species and season; after iterating through each scenario and species combination, it then summarizes results and fits daily survival rates to a beta distribution to estimate median survival and 95 percent credible interval for the scenario.

Swim Speed Analysis

Swimming speed information was compiled for target and, where necessary, surrogate species. Swimming speed was compared to the estimated intake velocities at the intake structure. It was assumed that intake velocities would be similar at the proposed Bad Creek II Complex intake.

Entrainment Vulnerability Assessment

The entrainment vulnerability assessment was based on a traits-based assessment (Cada and Schweizer 2012) and productivity and susceptibility assessment (Patrick et al. 2009) approach, as well as a quantitative approach to assessing fish population sustainability. Specifically, fish population growth rates were used for each species to evaluate a population's ability to "make up for" turbine passage losses with compensatory mechanisms. If these compensatory mechanisms are not enough to overcome losses, the fish population is vulnerable to entrainment stressors. Both the traits-based assessment and productivity and susceptibility assessment methods use a set of traits and combined them into a qualitative categorization of vulnerability. Quantitative estimates of the combined impact of these population traits are available in the literature for many species in the form of population growth rates or doubling rates for depleted populations. By using these estimates directly, subjective selection of traits to include and subjective methodology for weighting the importance of each individual traits can be avoided. Rather, the traits have been incorporated into well-established population modeling techniques and the overall estimate has been objectively and quantitatively derived.

Population growth for a harvested (or in this case, potentially entrained) population of fish can be described on annual increments using the Schaeffer Model:

$$N_{t+1} = N_t + r\left(1 - \frac{N_t}{K}\right)N_t - E_t,$$

where

N_t = population size in year t;
K = carrying capacity of population;
E_t = entrainment losses in year t; and
r = discrete population growth rate

If it is assumed the population is depleted relative to the carrying capacity, then this equation simplifies to:

$$N_{t+1} \approx N_t(1 + r) - E_t.$$

If entrainment loss as the fraction of the population lost (PL; E_t = PL x N_t,) is reparametrized, then:

$$N_{t+1} \approx N_t(1 + r - PL).$$

Thus, if the entrainment loss rate (PL) is greater than the discrete population growth rate (r), the local population may decline over time.

The discrete population growth rate (r) for each species of concern was derived from information on FishBase (Froese and Pauly 2021), from model-derived resilience factors for the exact or in some cases, a surrogate species. The following growth rates were obtained from FishBase:

1) "K", which is presumed to be the intrinsic population growth rate for depleted populations. The intrinsic growth rate (K) is related to the discrete growth rate as follows:

$$\exp(K) = (1 + r).$$

K is not reported for all species; when not reported for a species of concern, surrogate species were identified that were primarily based upon taxonomic linkages.

2) "Population doubling time," which is reported as a categorical range for all species (i.e., three presumed ranges for low resilient, moderate resilient, and high resilient species)[19]. The population doubling time (D) is related to the discrete population growth rate as follows:

$$(1 + r) = \exp\left(\frac{\ln(2)}{D}\right)$$

Both, K and population doubling time were estimated for (1+r) and the most conservative result from each range of values (the lower discrete population growth rate) was used as an estimate for species vulnerability.

Entrainment Risk

Risk categories were assigned with consideration of quantitative measures estimating the number of fish entrained and the expected number of mortalities, and a quantitative index expressing the relative vulnerability of those species impacted. The proportion of the fish population in Lake Jocassee lost to entrainment was based on annual baseline population estimates derived from purse seine sampling (2013 to 2015) and camera pelagic surveys (1989 to 2020).

The combined annual population size estimates are skewed with more variance apparent for higher estimates. On the log-scale, there appears to be an approximate 20-year population cycle within Lake Jocassee (Table 6.4-6). The median population estimate over the past 20 years (2001-2020) was estimated to capture an expected population size for a random future year. Estimated PL for each species was the annual estimated entrainment mortality divided by this population size estimate.

[19] FishBase defines resilience as "the capacity of a system to tolerate impacts without irreversible changes in its outputs or structure. In species or populations, often understood as the capacity to withstand exploitation." (Froese and Pauly 2021). FishBase reports resiliency as very low, low medium, or high. Resiliency ranges for species analyzed within this report were sourced directly from FishBase.

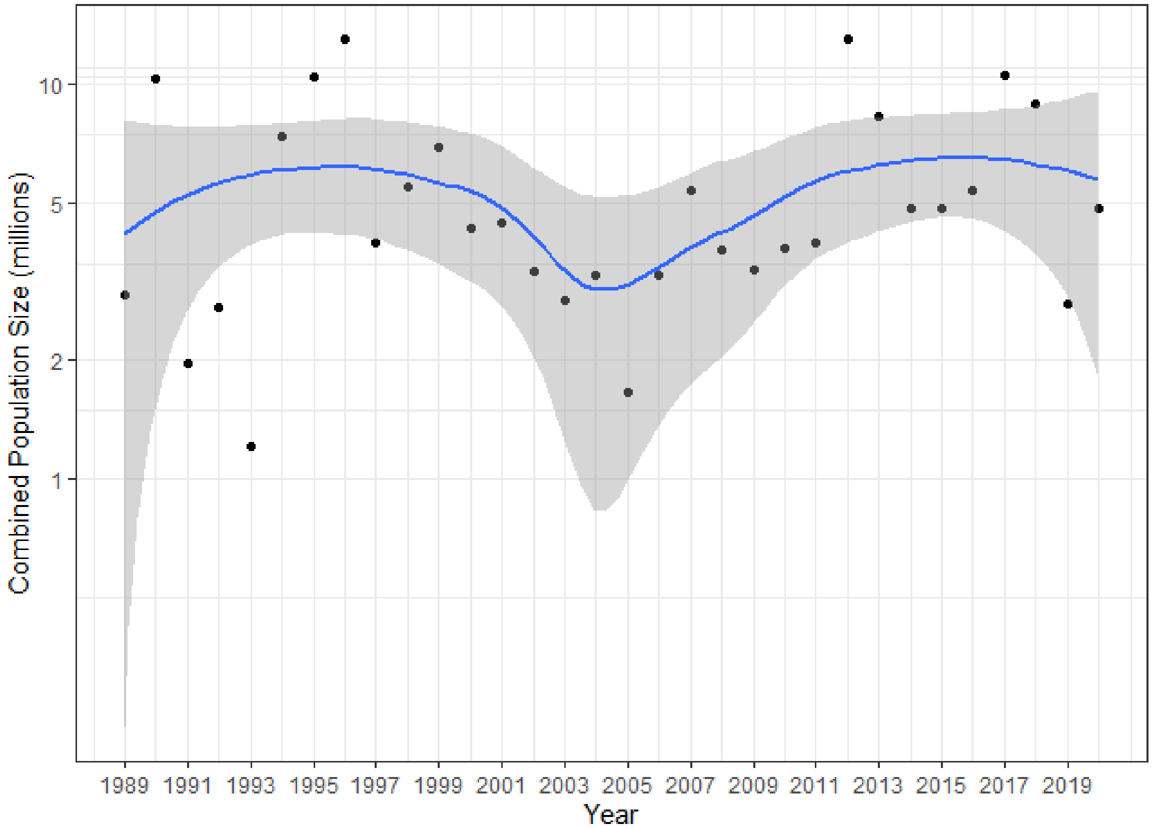

Figure 6.4-7. Estimated Local Population Size (Combined Species) 1989-2020, with Local Regression Smoother Trend Estimate Overlaid

A tabular form of (1+r-PL) is reported for each facility and flow scenario. Values of (1+r-PL) of exactly one would indicate steady population, >1 indicates population growth, and <1 would indicate the population is being impacted by entrainment.

6.4.3.1.2 Results

Entrainment Impact

The Project (with the proposed Bad Creek II Complex) had the largest impact on Blueback Herring and Threadfin Shad, with large entrainment events expected to occur during cold weather months (November through January) (Table 6.4-9). Entrainment was most diverse in May, with 14 species entrained. Important coldwater sportfish (Brown Trout and Rainbow Trout) are anticipated to be impacted, with up to 117 Brown Trout expected to be entrained in May. The median of the annual sum of entrainment for each iteration was used for estimating risk to fish populations.

Table 6.4-9. Median Monthly Entrainment Estimates by Species

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Black Crappie				9	56							
Blackbanded Darter					107	4		1				
Blueback Herring	5,189	2,056	1,038	1,770	1,520	4,922	3,272	1,040	1,356	1,151	1,361	678
Bluegill	13		23	80	2,095	644	3,349	743	708	358	7	9
Brown Trout	7			36	117	32						1
Channel Catfish					49	4		1				
Common Carp					232	43			1			
Flat Bullhead					45			54				
Golden Shiner				9	118	3						
Green Sunfish									18	24		
Hybrid Sunfish									4			
Largemouth Bass					30	11	53	1	14	61		
Quillback					13							
Rainbow Trout	57					2						
Redbreast Sunfish				9	175	10	711	309	101	71		1
Redear Sunfish					12							
Redeye Bass							4		5	6		
Spottail Shiner					13							
Striped Jumprock												1
Threadfin Shad	6,456	4,008	3,932	5,591	1,899	1,323	1,805	232	4,144	6,558	8,910	15,933
Warmouth				80	258	49	218	1	5	14		
White Bass					1	11			17.5			
White Catfish	3		2	136	2443	159	1465	895	274	196	8	
Whitefin Shiner					13				5			
Yellow Perch	300	62	39	117	307			29	10			

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowfin Shiner					12							

Swim Speed Analysis

The water velocity at the current intake structure was measured at 5.8 fps and given that the cross-sectional area of the intake and pumping capacity will stay the same, it was assumed that intake velocities would be similar at the new intake. Of the 26 species entrained at Bad Creek, 19 have mean burst swim speeds below 5.8 fps (Table 6.4-10). Burst speed was estimated as double the sustained swim speed (Bell 1991). Surprisingly, Threadfin Shad have a burst speed of 22.7 fps and sustained swim speed of 11.3 fps, which suggests they would not be entrained at Bad Creek. However, Threadfin Shad had the largest entrainment loss. Considering the largest entrainment events happen during cold weather months, water temperature may be a driver.

Table 6.4-10. Swim Speed Analysis of Those Species Impacted at Bad Creek.

Species	Surrogate Species	Mean Length (ft)	Sustained Swim Speed (fps)	Mean Burst Speed (fps)*
Black crappie	White Crappie	0.558	1.2	2.4
Blackbanded darter	Rio Grande Darter	0.118	1.3	2.6
Blueback herring	--	0.719	11.6	23.3
Bluegill	--	0.164	1.3	2.7
Brown trout	--	0.502	3.6	7.1
Channel catfish	--	0.748	2.6	5.3
Common carp	--	0.535	2.6	5.1
Flat bullhead	Ictaluridae	0.741	2.6	5.2
Golden shiner	Cyprinidae	0.358	2.8	5.7
Green sunfish	Lepomis	0.266	2.2	4.4
Hybrid sunfish	Lepomis	0.266	2.2	4.4
Largemouth bass	--	0.420	1.2	2.5
Quillback	Catostomidae	0.581	4.1	8.2
Rainbow trout	--	0.381	1.3	2.7
Redbreast sunfish	--	0.157	1.2	2.3

Species	Surrogate Species	Mean Length (ft)	Sustained Swim Speed (fps)	Mean Burst Speed (fps)*
Redear sunfish	Bluegill	0.164	1.3	2.7
Redeye bass	Largemouth Bass	0.420	1.2	2.5
Spottail shiner	--	0.167	0.7	1.4
Striped jumprock	Catostomidae	0.581	4.1	8.2
Threadfin shad	Clupeidae	1.076	11.3	22.7
Warmouth	Lepomis	0.266	2.2	4.4
White bass	Morone	1.322	10.5	21.0
White catfish	Ictaluridae	0.741	2.6	5.2
Whitefin shiner	Cyprinella	0.174	2.2	4.4
Yellow perch	--	0.338	1.1	2.2
Yellowfin shiner	Notropis	0.138	1.7	3.4

*Mean swim speed in red denotes those less than 5.8 fps.

Entrainment Vulnerability Assessment

Blueback Herring and Threadfin Shad are considered moderately vulnerable species with population doubling times from 1.4 to 4.4 years (Table 6.4-11). The intrinsic growth rate estimated for Blueback Herring indicates that this species is moderately vulnerable, with a discrete annual increase of about 20 percent per year. The intrinsic growth rate was not available for Threadfin Shad, but surrogate alosines (genus *Alosa*) have estimated discrete annual increases of approximately 15-35 percent per year.

Table 6.4-11. Population Growth Rates Used for Vulnerability Assessment

	Parameters from FishBase				Derived discrete growth rate (r) (percent)			
	Intrinsic Population Growth Rate (K) (percent)		Categorical population doubling time (D) (years)		Species-specific		Categorical	
Species	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Blueback Herring	0.18	0.18	1.4	4.4	1.20	1.20	1.17	1.64
Threadfin Shad[1]	--	--	1.4	4.4	--	--	1.17	1.64
American Shad*	0.14	0.14	--	--	1.15	1.15	--	--

	Parameters from FishBase				Derived discrete growth rate (r) (percent)			
Alewife*	0.2	0.2	--	--	1.22	1.22	--	--
Blueback Shad*	0.18	0.18	--	--	1.20	1.20	--	--
Hickory Shad*	0.3	0.3	--	--	1.35	1.35	--	--

[1] Intrinsic rate was not available in FishBase for Threadfin Shad but was available for the four North American Freshwater alosines listed here. * = Surrogate fish species

Entrainment Risk

The losses to Blueback Herring (with and without the proposed Bad Creek II Complex) are relatively small compared to the population numbers, and the risk estimate is low (i.e., discrete population annual growth is estimated to be 16 to 19 percent after accounting for entrainment) (Table 6.4-12). Threadfin Shad is more heavily impacted, with approximately 12 percent of the estimated population lost each year to entrainment; however, the population is sustainable with estimated discrete annual increases in population of three percent (based on American Shad population growth estimates) to 23 percent (based on Hickory Shad population growth estimates). The low end of this range (3 percent) corresponds to a population doubling rate of more than 20 years.

Table 6.4-12. Bad Creek Entrainment Risk

Species	Categorical discrete growth rate (min)	Species-specific discrete growth rate (min)	Estimated Population 2001-2020 (millions)	Annual Entrainment Loss Estimate (millions)	Proportion of Annual Population Lost to Entrainment (PL)	Annual population multiplier including entrainment (categorical)	Annual population multiplier including entrainment (species-specific)
Blueback Herring	1.17	1.20	3.7	0.026	0.0070	1.16	1.19
Threadfin Shad[1]	1.17	1.15	0.52	0.063	0.12	1.05	1.03
American Shad*	--	1.15	--	--	--	--	1.03
Alewife*	--	1.22	--	--	--	--	1.10
Blueback Shad*	--	1.20	--	--	--	--	1.08
Hickory shad*	--	1.35	--	--	--	--	1.23

[1] Intrinsic rate was not available in FishBase for Threadfin Shad but was available for the four North American Freshwater alosines listed here. * = Surrogate fish species

6.4.3.1.3 Discussion

The estimated rates of entrainment mortality at the Project are not expected to affect the sustainability of Lake Jocassee populations. The species with the largest impact, Blueback Herring and Threadfin Shad, have relatively high fecundity, meaning that population-level compensatory mechanisms would likely offset the entrainment losses in terms of effects on these fish populations. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals (Sale et al. 1989).

Using a risk assessment framework allows us to objectively evaluate risks to fish populations from entrainment by combining two components: an estimate of entrainment loss, and an estimate of population vulnerability to that expected loss, for each species impacted. The risk estimate used was the expected population increase in each year after accounting for the entrainment losses. The population increases were based on minimum discrete population growth rates for each species sourced from FishBase.

No expected risk to Blueback Herring was found because the estimated entrainment rate of 0.7 percent per year is substantially below the expected recovery rate of the species. There is moderate potential risk to Threadfin Shad, with entrainment losses predicted to be approximately 12 percent of the median population estimate for the past 20 years. Threadfin Shad is considered to be a moderately vulnerable species with moderate population recovery, and this category of fish is expected to have discrete population growth rates of 17 to 64 percent per year. Although no species-specific growth rates were found for Threadfin Shad, the estimated rates for the surrogate alosines were 15 to 35 percent per year. The expected entrainment rate of 12 percent for Threadfin Shad is close to the expected annual increase for the slowest recovery surrogate (American Shad), indicating that entrainment mortality may keep the population from substantial increase. However, it is not expected to reduce the population, unless it is combined with other impacts.

6.4.3.2 Howard Creek Monitoring

Construction of Bad Creek Reservoir and associated roads from 1982 to 1991 resulted in impacts to Howard Creek due to sediment runoff, and as a condition of the Original License, annual fishery assessments were conducted (Duke Energy 2016b). Results from the initial recovery program suggested Howard Creek had returned to pre-construction condition by 1995. Commencing in 1997, additional fishery sampling of Howard Creek was implemented to assess whether the recovered state would persist. Sampling was performed at three locations on Howard Creek, including two sites downstream of the Project and one upstream as a reference location.

The last year of sampling occurred in 2015. All three survey locations maintained a consistent level of species diversity over the 19-year monitoring study. Generally, species diversity was higher at the downstream location (N=11 species) as compared to the upstream location (N=2 species); this is likely due to species immigration from the reservoir as well as a natural barrier (bedrock slide) found between H1 and H6 that hinders fish migration. All three species of trout known to the region (Rainbow Trout, Brown Trout, and Brook Trout) were collected in Howard Creek, but only Rainbow Trout were collected in significant numbers. The condition of Rainbow Trout was similar between the locations over time and was considered healthy. Other common species present in Howard Creek included Bluehead Chub (*Nocomis leptocephalus*), Yellowfin Shiner (*Notropis lutipinnis*), Blackbanded Darter (*Percina nigrofasciata*), Blacknose Dace, and Northern Hog Sucker (*Hypentelium nigricans*).

The results of the Howard Creek monitoring study suggest this tributary to Lake Jocassee has maintained a recovered condition from 1995 to at least 2015 (the last survey period); in the absence of any other known impacts, it is likely Howard Creek currently supports fish populations similar to those found in other southern Appalachian streams.

6.4.4 Essential Fish Habitat (18 CFR §5.6(d)(3)(iv)(B))

The National Oceanic and Atmospheric Administration (NOAA) Inland Essential Fish Habitat Mapper was reviewed for Lake Jocassee and Bad Creek Reservoir. Neither waterbody contains Essential Fish Habitat requiring consultation with NOAA.

6.4.5 Temporal and Spatial Distribution of Fish Communities (18 CFR §5.6(d)(3)(iv)(C))

Several taxa identified in fish community studies performed on Lake Jocassee may be considered migratory or exhibit localized migratory behavior. Blueback Herring, while typically anadromous, also have self-sustaining landlocked populations present in Lake Jocassee, while others (such as Rainbow and Brown trout) are stocked (additionally, none of these species are indigenous to this river basin). Other species, such as Rainbow Trout, Brown Trout, and Walleye (*Sander vitreus)*, may conduct smaller, seasonal migrations from the lake into streams for spawning, but these migrations are not necessarily required for the species to complete their life cycle**.**

6.4.5.1 Species Life History Characteristics

The life history strategies of fish species (such as, but not limited to the timing and habitat requirements of spawning, hatching, recruitment, dispersal, feeding, etc.) determines the behavior and movements over the life of a fish. This section details the life history characteristics of several of the most common species or species of interest in Lake Jocassee.

6.4.5.1.1 Largemouth Bass (Micropterus salmoides)

Largemouth Bass have been stocked extensively throughout the United States and the world, muddying their native range (Rohde et al. 2009). They are widely distributed throughout South Carolina, occupying a variety of habitats. Preferred habitat includes warm, calm, and clear waters, such as slow streams, farm ponds, lakes, and reservoirs. Some Largemouth Bass will primarily occupy the littoral zone, while others will prefer open water habitat, and yet others may move between littoral and open water habitats regularly (Matthias et al. 2014). Some studies have found Largemouth Bass to move toward warm water during the cooler months, however this may also depend on prey availability (Davis and Lock 1997).

Spawning in South Carolina occurs in March and April with nests generally constructed (by males) in sand or gravel at the base of logs, stumps, or emergent vegetation in the littoral zone (Rohde et al. 2009). Females lay an average of 4,000 eggs per pound of body weight (Davis and Lock 1997). Males will care for the nest and eggs until hatching (2 to 4 days) and will guard the fry until dispersal which may be up to two weeks. Adult Largemouth Bass diet primarily consists of fish; however, they are a gape-limited opportunistic predator and will also consume crayfish, insects, frogs, mice, birds and other animals (Rhode et al. 2009).

6.4.5.1.2 Bartram's Bass (Micropterus sp. cf. cataractae)

Redeye Bass (*Micropterus coosae*) were originally thought to range from the Mobile River drainage eastward to the Apalachicola and upper Savannah River drainages. However, recent research through genetic analyses suggests this species actually comprises several endemic variants (Freeman et al. 2015). In the Savannah River drainage, the species present is now thought to be undescribed species informally called the Bartram's Bass (*Micropterus* sp. cf. *cataractae*).

Bartram's Bass is found in cool, medium-to-high gradient streams typically above the fall line (Judson 2018). It is suspected this species is restricted to streams further upstream due to competition with the Alabama Bass, though these two species have been shown to hybridize.

Bartram's Bass spawns from May to June (Judson 2018). Water velocity appears to be the strongest microhabitat variable selected by nesting Bartram's Bass in the upper Savannah River-approximately 85 percent of nests surveyed were found in velocities less than 0.10 meters per second. Nests were consistently found near the shore, downstream of major flow influences, in pockets of slower water velocity. Approximately 90 percent of nests were found in water less than a meter deep. Nesting Bartram's Bass sites contain silt, gravel, and cobble; however substrate characteristics are likely not necessarily selected for, but are what is available in accordance with the velocity of the nesting area.

Although literature is not available regarding the Bartram's Bass feeding habits, it is likely comparable to Redeye Bass, which feeds on terrestrial insects, crayfish, small fishes, salamanders, and aquatic insects (Rohde et al. 2009).

6.4.5.1.3 Smallmouth Bass (Micropterus dolomieu)

Smallmouth Bass have been widely distributed beyond their native range, including throughout the Piedmont and Blue Ridge of South Carolina, including Lake Jocassee (Rohde et al. 2009). This species found in cool and clear streams with rock and gravel substrate and moderate current, although they are also present in lakes, reservoirs, and pools of large rivers.

Spawning in the southeast occurs in April or early May with nests constructed in coarse gravel near the shoreline (Rohde et al. 2009). Multiple females may spawn in the nest of one male, and males guard the nest until fry disperse. Smallmouth Bass are voracious predators that consume aquatic insects, crustaceans, and other fishes. Highly regarded as gamefish with strong fighting ability, the South Carolina state record for Smallmouth Bass (4.28 kg) was caught in Lake Jocassee in 2001.

6.4.5.1.4 Bluegill (Lepomis macrochirus)

Bluegill are widely distributed throughout South Carolina, partly the result of intrastate introductions (Rohde et al. 2009). They are tolerant of a wide range of conditions and can be found in most of the habitats available in South Carolina. Natural habitat consists of pools of creeks and rivers, swamps, oxbows, ponds, and vegetated shorelines of impoundments, but they have often been found in man-made lakes and ponds. They rarely move far from cover such as weed beds, fallen timber, pilings, etc. (Higginbotham 2004).

Spawning occurs from May through August, typically with a peak in June (Rohde et al. 2009). Bluegill are social (colony) nesters; males will fan out 50 or more circular nests in areas 1 to 5 ft deep (Higginbotham 2004). Females produce between 10,000 and 60,000 eggs per spawn and spawn multiple times per year. Bluegill are opportunistic carnivores that prey on adult and larval insects, crayfish, mollusks, and other fishes.

6.4.5.1.5 Redbreast Sunfish (Lepomis auritus)

Redbreast Sunfish are abundant in upstream reaches of reservoirs and along rocky points or riprap-reinforced shorelines over sandy substrates (Rohde et al. 2009). Habitat also commonly consists of pools and backwaters of streams and rivers with low to moderate gradients typically associated with woody debris, stumps, and undercut banks. Redbreast Sunfish are almost always absent from stagnant and heavily vegetated waters. Redbreast Sunfish abundance has been observed to decline with decreasing water velocity and increasing depth and cover in smaller streams.

Spawning in South Carolina occurs from late May through the end of July when water temperatures range from 20°C to 31°C (Rohde et al. 2009). Nests consist of large, saucer-shaped depressions in coarse sand or gravel in shallow water; beaver ponds often provide spawning and nursery habitat. Nests can be solitary, in small aggregations, or in dense colonies of 80 nests or more. Redbreast Sunfish are opportunistic predators feeding on small fishes, mollusks, insects, crayfish, and other arthropods.

6.4.5.1.6 Rainbow Trout (Oncorhynchus mykiss)

Rainbow Trout are native to western North American and have been widely introduced to cold waters throughout the world (Rohde et al. 2009). In South Carolina, SCDNR has repeatedly introduced Rainbow Trout into watersheds of the upper Blue Ridge region (Rohde et al. 2009). Rainbow Trout are typically found in creeks, rivers, lakes, and reservoirs.

Populations in the Mid-Atlantic and southeastern U.S. are often non-reproducing and replenished via stocking (Rohde et al. 1994). Spawning of wild populations typically occurs from late winter to early spring. Adults migrate upstream from lakes or pools to spawning grounds in shallow and swift streams with gravel and sand substrate (Rohde et al. 1994, 2009). Populations already inhabiting small streams do not migrate; there are no anadromous populations in South Carolina. Females construct redds (nests) in gravel substrate into which eggs fall and are covered by displaced gravel from subsequent activities of the spawners. Juvenile Rainbow Trout consume a variety of aquatic insects while adults prey on terrestrial insects, crayfish, and fishes. The South Carolina state record for Rainbow Trout (5.14 kg) was caught in Lake Jocassee in 1993 (Rohde et al. 2009).

6.4.5.1.7 Brown Trout (Salmo trutta)

Brown Trout are native to Europe and western Asia, and like Rainbow Trout have been widely introduced throughout the world including numerous introductions by SCDNR (Rohde et al. 2009). In South Carolina, Brown Trout may be found in small creeks, rivers, and reservoirs under a wide range of conditions, as they are more tolerant of warmer waters than other trout species; however, they are known to thrive where water temperatures do not exceed 21°C (Rohde et al 1994, 2009).

Spawning typically occurs in the fall and early winter when Brown Trout migrate into gravelly headwater streams where females construct redds (Rohde et al. 2009). There are no anadromous populations in South Carolina. Growth occurs faster in southern waters and maturity can be reached by the end of the first year. Brown Trout are adaptive predators; their diet consists primarily of bottom-dwelling aquatic insects and amphipods and occasionally terrestrial insects. Larger individuals consume crayfish, fishes, salamanders, and frogs (Rohde et al. 1994, 2009). The South Carolina state record for Brown Trout (7.99 kg) was caught in Lake Jocassee in 1987 (Rohde et al. 2009).

6.4.5.1.8 Blueback Herring (Alosa aestivalis)

In South Carolina, Blueback Herring are present in major coastal rivers as a traditionally diadromous species, however there are several landlocked populations in impoundments in the Piedmont and Blue Ridge regions (Rohde et al. 2009; SCDNR 2015). Blueback Herring found in Lake Jocassee are likely the result of an inadvertent introduction from a population originating from (and indigenous to) the Cooper River (Prince and Barwick 1981).

Landlocked populations typically reside in open-water habitats and then move closer to shorelines to spawn (Rohde et al. 2009). Blueback Herring are prolific spawners, as females can spawn up to 250,000 eggs (SCDNR 2015). This species feeds primarily on zooplankton but will also consume small fish (Prince and Barwick 1981).

6.4.5.1.9 Threadfin Shad (Dorosoma petenense)

Threadfin Shad occur throughout South Carolina, primarily in larger rivers and reservoirs, where they have been introduced as forage fish (Rohde et al. 2009). Threadfin Shad are often associated with swiftly moving water and are tolerant of brackish water.

Spawning typically occurs from April to July, from first light to sunrise, and occurs near the shoreline over aquatic plants and other submerged objects (Rohde et al. 2009). Eggs are adhesive and demersal. Threadfin Shad occur in large schools in midwater and feed on phyto- and zooplankton. Threadfin Shad are sensitive to low water temperatures which can result in massive die-offs; however, Threadfin Shad populations are known to dominate the forage-fish communities of reservoirs that do not experience severely cold winters (such as lakes at higher latitudes) or receive thermal effluents.

6.4.5.2 Mussels and Benthic Macroinvertebrates Communities

6.4.5.2.1 Mussels

Duke Energy collected mussel shells during major drawdowns in Lake Jocassee in 2007 (Duke Energy 2014d). Three mussel species were documented: paper pondshell (*Utterbackia imbecillis),* eastern floater (*Pyganodon cataracta*), and the Florida pondhorn (*Uniomerus carolinanus).* The paper pondshell appears to be restricted to the upper reaches of the lake. The Florida pondhorn was noted only in the lower regions of the lake and the eastern floater was found only at the confluence of the Toxaway River. Based on the total number of shells found, the paper pondshell (150 shells) was the most abundant mussel in Lake Jocassee, followed distantly by the Florida pondhorn (6 shells) and eastern floater (1 shell).

Although not reported in the 2007 drawdown study, Asian clam (*Corbicula fluminea*) was identified in macroinvertebrate sampling conducted in downstream Lake Keowee (see Section 6.4.5.2.2). This species is highly invasive, and therefore it is likely it is also established in Lake Jocassee.

6.4.5.2.2 Benthic Macroinvertebrates

No other benthic macroinvertebrate information is available for Lake Jocassee. Therefore, presented here are the results of a benthic macroinvertebrate study conducted on downstream Lake Keowee, which characterized littoral benthic macroinvertebrates from 1989 through 1993 (Duke Power Company 1995b).

Benthic macroinvertebrates were sampled quarterly (February, May, August, and November) in the littoral zone at four locations in 1989 (Duke Power Company 1995b). In 1990, frequency of sampling was reduced to three times annually (March, July, and November) at three sites. From 1991 to 1993, two locations were sampled three times per year.

Overall benthic standing crops increased during the sampling time period as compared to estimated standing crops in 1974-1977 (Duke Power Company 1995b). This may be attributable to changes in the community composition due to the introduction of Asian clam and increases in oligochaete densities, which may be a function of increased sediment and nutrient loading from shoreline development. Oligochaete populations stabilized by 1991. Few glassworms (*Chaoborus* sp.) were observed during this time period, which may be due to predation by Blueback Herring, which are known to feed on glassworms and were inadvertently introduced to

Lakes Keowee and Jocassee in the early-mid 1970s through Threadfin Shad stocking (Fuller et al. 2021).

Chironomid densities during the sampling period were generally within ranges of those historically described (Duke Power Company 1995b). Relative abundance had declined due to high densities of Asian clam and oligochaetes; however a higher number of taxa were identified indicating higher diversity.

6.4.5.3 Aquatic Invasive Species

Many non-native species can coexist with native species and may be beneficial; they typically do not reproduce rapidly or develop large populations (SCDNR 2008). Aquatic invasive species, on the other hand, are non-indigenous species having the potential to adversely affect ecological health or economic activity.

At least 11 non-native (or non-indigenous) fishes have been identified in Lake Jocassee: Blueback Herring, Brown Trout, Channel Catfish (*Ictalurus punctatus*), Common Carp (*Cyprinus carpio*), Green Sunfish (*Lepomis cyanellus*), Rainbow Trout, Smallmouth Bass, Alabama Bass, Threadfin Shad, Walleye, and White Bass (*Morone chrysops*). Many of these species were introduced intentionally to support the sport fishery. Asian clams, mentioned in Section 6.4.5.2, are also likely to be found in Lake Jocassee. Only three of these species are included in South Carolina’s Aquatic Invasive Management Plan (SCDNR 2008); species profiles are provided below.

6.4.5.3.1 Asian clam (Corbicula fluminea)

The Asian clam was first reported in South Carolina in the late 1960s or early 1970s (SCDNR 2008). It spread through human activities such as bait bucket dumping, aquaria releases, or intentional releases by people who bought the clams at food markets. They can also spread by passive movement of larvae in water currents. Ecological impacts of the Asian clam include altering of benthic substrates and increased competition with native species for food and habitat resources. The Asian clam has likely caused the decline and/or extirpation of several native freshwater mussel species throughout North America.

6.4.5.3.2 Green Sunfish (Lepomis cyanellus)

Green Sunfish are native to the central and eastern United States west of the Appalachian Mountains and east of the Continental Divide, from the Great Lakes region south to the Gulf Coast states (SCDNR 2008). Green Sunfish is one of the most tolerant sunfishes with regard to temperature extremes, turbidity, and disturbed habitat, and therefore can out-compete and/or suppress native fish in these types of habitats (Rohde et al. 2009; Rohde et al. 1994).

6.4.5.3.3 Alabama Bass (Micropterus henshalli)

Alabama Bass are native to the Mobile River Basin and were likely illegally introduced to South Carolina by anglers (Benson 2021; USGS 2015). They are prolific and can competitively displace Largemouth Bass populations in upstate Piedmont and mountain lakes. They also hybridize with Bartram's Bass, previously thought to be Redeye Bass (see Section 6.4.5.1.2) (Barwick et al. 2006).

6.4.6 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Existing and historic major PM&E measures in place at the Project are primarily focused on fisheries, water quality, and recreation, and are established by the following:

- Bad Creek Project License Exhibit S (Environmental Study Plans)
- Duke Energy and SCDNR MOU and 10-Year Work Plans
- KT Project Relicensing Agreement

Duke Energy proposes to consult with agencies and other stakeholders through the relicensing process to develop an updated MOU and 10-Year Work Plan, which could be integrated into a new Comprehensive Relicensing Agreement for the Bad Creek Project (if one is pursued by Duke Energy and relicensing stakeholders in parallel with the ILP), to determine and guide PM&E measures to be implemented through the New License term.

6.4.6.1 Littoral Fish Spawning and Reproduction

Continued Project operations are not expected to cause substantial fluctuations in water surface elevations at Lake Jocassee. As discussed in Section 6.3.10.1, the impact of operation of the existing Bad Creek Project on Lake Jocassee water levels is minimal. In accordance with the KT Project Relicensing Agreement, Duke Energy minimizes fluctuations of the Lake Jocassee water surface elevation as a protective measure for water quality, aquatic biota, and aquatic habitat. Lake levels in Lake Jocassee during the April 1 to May 15 spawning period are kept stable to the maximum extent practical to ensure water level fluctuations do not adversely affect spawning success of black bass (see Section 8.5.4 of the KT Project Relicensing Agreement). Duke Energy will maintain reservoir levels consistent with the general reservoir elevation trends observed during the stabilization periods in 1996-1999, 2003-2007, and 2010. Consistent with the KT Project Relicensing Agreement, if water levels decline below the reservoir level trends observed during the years listed, Duke Energy will consult with SCDNR on options for reservoir stability for the remainder of the current period.

Duke Energy has monitored the littoral fish community in Lake Jocassee since 1974. Electrofishing is used to assess the status of littoral fish populations, including important sportfish such as Largemouth Bass, Alabama Bass, and Smallmouth Bass; other sunfishes; and other important prey species, such as sunfish, cyprinids, clupeids, and others. In accordance with the current 10-Year Work Plan (FERC 2017), Duke Energy continues electrofishing of littoral fish populations every three years with the goals to:

1) determine species composition and detect changes in species communities, newly introduced species, etc.;
2) obtain catch-per-unit effort data to detect increasing or decreasing population trends; and
3) evaluate the relative condition of Largemouth Bass and Alabama Bass.

6.4.6.2 Fish Entrainment

Interpreting the long-term effect of entrainment on fish populations is challenging and must consider many factors such as station operation, reservoir water levels, changes in stock size or harvest levels, increased production and survival among some species, and production foregone.

6.4.6.2.1 Direct Mortality due to Fish Entrainment

Entrainment of fish at Bad Creek during pumping and generation has the potential to cause injury or mortality to fish as they pass through the turbines. Injury or mortality could result from turbine blade strike, contact with stationary parts such as wicket gates, and/or the effects of pressure changes. The potential for fish to become entrained or impinged at a hydroelectric facility is dependent on a variety of factors such as fish life history, size, and swimming ability; water quality; operating regimes; inflow; and intake/turbine configurations (Cada et al. 1997). A gradient of fish entrainment potential exists both temporally and spatially at intake structures. Smaller-sized fish may be more abundant during certain portions of the year, thus increasing their potential for entrainment. In addition, diurnal and seasonal movements of both small and large fish may bring them in close proximity to intake structures. Physical and operational characteristics of a given project, including trash rack bar spacing, intake velocities, intake depth, stratification, and intake proximity to feeding and rearing habitats also affect the potential for a fish to become entrained.

The entrainment studies conducted in the 1990s and 2021 did not assess mortality of fish passing through the facilities; alternatively, the studies conservatively assumed 100 percent mortality of entrained fish. More recent methods of desktop entrainment assessments, based on empirical studies, apply the EPRI (1997) Turbine Entrainment and Survival Database in combination with the USFWS Turbine Blade Strike Analysis model (which is based on Franke et al. [1997]). Methods presented by Franke et al. (1997) are routinely used as desktop analyses in lieu of field studies to assess mortality resulting from fish entrainment at hydropower plants, and is widely accepted by industry, agencies, and FERC. The USFWS Turbine Blade Strike Analysis incorporates the Franke et al. (1997) equations into a Monte Carlo simulation that probabilistically models blade strikes and non-turbine route fish mortality. These desktop methods show mortality to rarely, if ever, be 100 percent. Therefore, the entrainment estimates provided by the Barwick et al. (1994) and risk assessment by Kleinschmidt (2021) are likely to conservatively overestimate entrainment mortality and risk to fish populations at the Project and Bad Creek II Complex.

Despite the conservative (i.e., maximum) estimate of entrainment mortality at Bad Creek, results of the entrainment studies (summarized in Sections 6.4.2.2 and 6.4.3.1) indicated entrainment had neither a statistical impact on the abundance of prey and sportfish taxa in Lake Jocassee, nor an impact on the effort and harvest of fish by anglers. Entrainment was also predicted to have no long-term impact on the prey fish population.

6.4.6.2.2 Operational Guidelines

In addition to entrainment estimates, the Barwick et al. (1994) study identified operational periods associated with entrainment rates at the Bad Creek Project during pump-back operations. Results from this evaluation were used to establish operational guidelines and a communications protocol between Duke Energy and SCDNR to minimize entrainment impacts.

As part of those operational guidelines, Duke Energy agreed to operate its facilities to minimize, to the extent practicable, the length of time during which the Lake Jocassee pool elevation is below 1,099 ft msl (SCDNR and Duke Energy 2016) (Table 6.4-13).[20] Lake Jocassee normal full pond elevation is 1,110 ft msl, therefore, 1,099 ft msl is equivalent to an 11-ft drawdown[21]. In accordance with the current 10-Year Work Plan, if Lake Jocassee pool elevation falls below 1,099 ft msl, Duke Energy will implement operational changes at the Bad Creek Project based on hydro unit availability and other operational considerations to minimize fish entrainment (FERC 2017). These protocols include turning lights off near the inlet/outlet structure so as not to attract fish to the area and implementing a unit startup and shutdown sequence that minimizes fish entrainment.[22]

If the Lake Jocassee pool elevation falls below 1,099 ft msl and is projected to remain below this level for 30 consecutive days, Duke Energy will notify the SCDNR and will provide subsequent notification when the pool elevation rises above 1,099 ft msl for seven consecutive days (SCDNR and Duke Energy 2016).[23] However, if the pool level is projected to remain below 1,099 ft MSL for 60 consecutive days, Duke Energy will initiate consultation with the SCDNR and the USFWS to determine if additional measures to minimize impacts are appropriate.

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[20] Site-specific studies have indicated that fish entrainment can increase when Lake Jocassee pool elevations drop below 1,096 ft msl. Setting the threshold at 1,099 ft msl provides a 3-ft buffer to allow time for Duke Energy to notify and consult with SCDNR.

[21] The Lake Jocassee Maximum Drawdown Elevation as specified in the Keowee-Toxaway Project Relicensing Agreement and the New License issued by FERC in 2016 is 1,080 ft msl, allowing a maximum 30-ft drawdown.

[22] The pumping protocol includes starting up Unit 4 first, followed by Units 2, 3, and 1 sequentially. Unit order is reversed during the shutdown sequence.

[23] No additional notifications to the SCDNR are necessary unless the Lake Jocassee pool elevation drops below 1,099 ft msl after Duke Energy previously notified the SCDNR that the lake rose above 1,099 ft msl for seven consecutive days.

Table 6.4-13. Lake Jocassee Water Surface Elevations Driving Operational Scenarios at the Bad Creek Project

Elevation Description	Water Surface Elevation (ft msl)
Normal Maximum Elevation (i.e., full pond)	1,110.0
Water surface elevation threshold for implementation of protective operational measures to minimize fish entrainment	1,099.0[1]
Lowest water surface elevation for hydropower operations (i.e., Maximum Drawdown Elevation)	1,080.0
Water surface elevation below which fish entrainment becomes elevated at the Bad Creek Project (i.e., Normal Minimum Elevation)	1,096.0

[1]If water surface elevation is expected to remain at or below 1,099.0 ft msl for more than 30 consecutive days, SCDNR will be notified.

Over the last 10-Year Work Plan period (2006-2015), Lake Jocassee experienced 16 low water-level events due to drought. Extended droughts caused long-term events of low water levels in 2007-2009 and 2011-2013 (events lasting 673 days and 638 days, respectively) (Duke Energy 2016a). Additionally, shorter low water-level events occurred over the 10-year period ranging from 1 to 191 days. There was a total of seven low water-level events longer than 30 days and five low water-level events longer than 60 days. Duke Energy consulted with SCDNR as required and based on those efforts, no additional measures were determined necessary or implemented to minimize fish entrainment over the 10-year period.

Duke Energy proposes to continue the measures described above through the New License term.

6.4.6.2.3 Pelagic Prey Fish Monitoring

Threadfin Shad and Blueback Herring comprise the primary prey for trout and bass, and understanding their relative abundance is important to assessing the overall quality of the fisheries in Lake Jocassee. The hydroacoustic and purse seine studies are critical to understanding operational impacts to pelagic prey species associated with entrainment mortality. Therefore, in addition to the operational measures described above, these studies will be continued through the current 10-Year Work Plan (FERC 2017).

6.4.6.3 Pelagic Trout Habitat

The major factor influencing the wide range in Lake Jocassee habitat availability, as determined by water quality monitoring data coupled with various statistical assessments of these data, is the magnitude and depth of winter mixing and reoxygenation of the water column. In those years with complete (top-to-bottom) water column mixing and reoxygenation throughout the reservoir, oxygen supplies for aerobic metabolism in the middle and bottom depths are plentiful, resulting in September DO concentrations in the main body greater than 5.0 mg/L extending to the lake bottom. In contrast, in those winters where mixing and reoxygenation of the water column were limited to the upper 30 to 50 m of the water column, aerobic consumption during the stratified period resulted in rapid depletion of the limited oxygen supplies below these depths, culminating in the 5.0 mg/L DO isopleth being located higher in the water column. The existing submerged weir restricts mixing for the benefit of trout habitat. Continued operation of the Project is not expected to have a measurable incremental effect on trout habitat in Lake Jocassee.

The empirical model has accurately predicted late summer habitat thickness since 1989 (Figure 6.4-8). Predicted and measured late-summer habitat thickness was consistently greater than five meters, therefore, additional monitoring requirements and modifications to hydropower operations at the Bad Creek Project and Jocassee Pumped Storage Station were not required and this component was not carried through to the current (2017-2027) 10-Year Work Plan. However, under the KT Project Relicensing Agreement, model prediction and verification by temperature and DO surveys at the deepest location in Lake Jocassee (station 558.0) is performed biannually (February and September). If trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations.

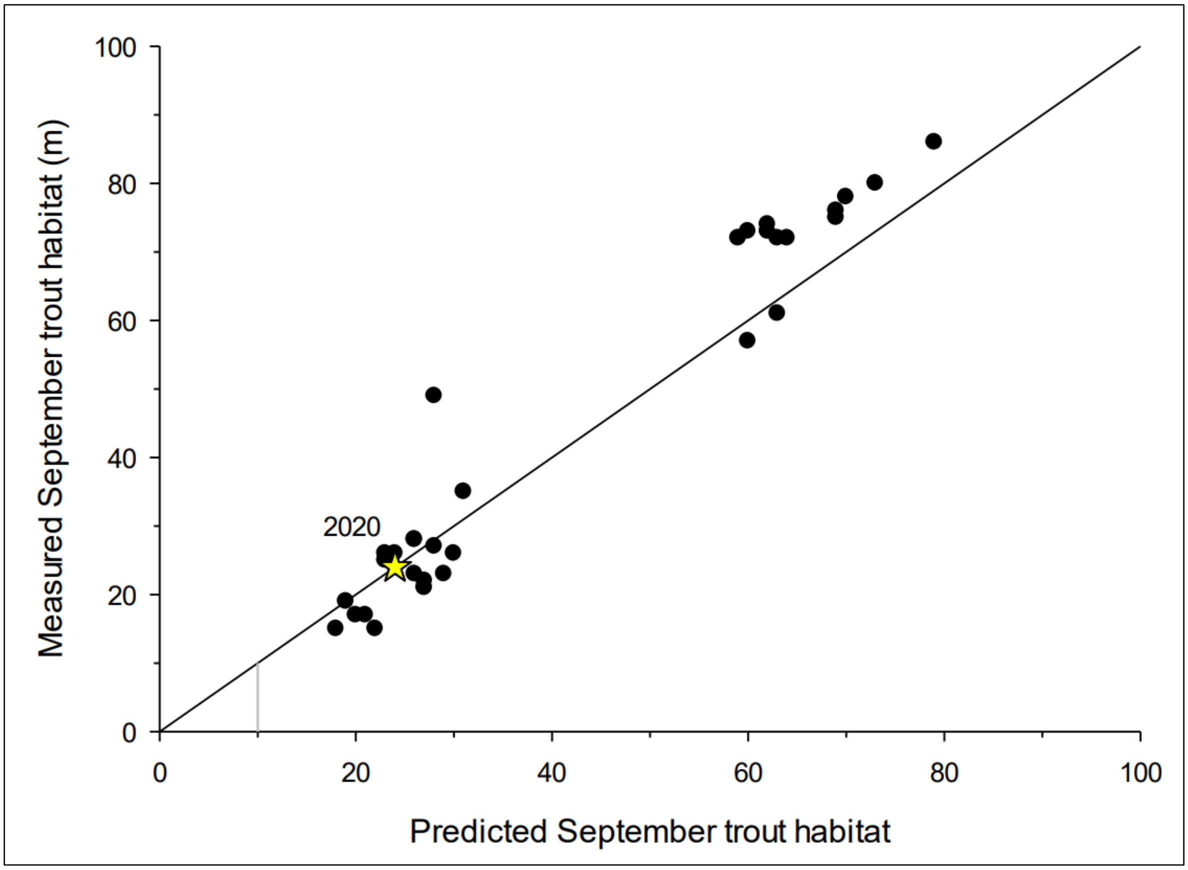


Figure 6.4-8. Measured versus Modeled Predicted Trout Habitat Thickness during the Work Plan Period 2006-2015 (source: Duke Energy 2020b)

6.4.6.4 Fisheries Enhancements

6.4.6.4.1 Cost Share for Trout Stocking

Lake Jocassee is recognized as a regional trout fishery, and maintaining this fishery is an important shared interest of SCDNR and Duke Energy. Under the current 10-Year Work Plan (2017-2027), the Licensee will provide $80,000 (in 2017 dollars) per year to the SCDNR toward the growing and stocking of trout in Lake Jocassee and its tributaries. This funding will continue through 2027 and will be adjusted annually based on the Consumer Price Index. This will assist in ensuring trout are available for maintaining the quality sport fishery in Lake Jocassee. Duke Energy proposes to consult with agencies and stakeholders through the relicensing process to determine appropriate PM&E for trout for the New License term.

6.4.6.4.2 Cost Share for Fisheries Research and Enhancements

The Bad Creek MOU lists a number of activities eligible for cost-sharing, including fisheries research, water quality studies, trout habitat studies, stream surveys, creel surveys, fish and habitat management, development of bank and stream-side access, and stream protection and enhancement. The MOU has provided funding for several other fisheries studies conducted over the past 25 years, including seasonal trout habitat use, the strength of the forage base, and an evaluation of predator (trout)/prey balance (bio-energetics); these studies are used to inform stocking rates, stream assessment, and Brook Trout restoration. These studies have contributed to the body of science needed to improve the management of aquatic resources in Lake Jocassee.

Study/management activity funding requests are submitted by the SCDNR to Duke Energy for review and concurrence. In previous work plan periods, SCDNR has elected to conduct sportfish creel surveys on lakes Jocassee and Keowee every three years. In previous work plans, SCDNR has elected to conduct sportfish creel surveys on lakes Jocassee and Keowee. Creel surveys provide unique information to describe the fishery from an angler perspective, including estimates of fishing effort, harvest and success. These data provide information useful in tracking angling trends, developing fishing regulations, and measuring angler satisfaction. SCDNR will continue creel surveys on a six-year interval rather than the three-year interval as conducted previously. Funding for four creel surveys, two per lake, would not exceed $390,000 total over the 2017-2027 period of this work plan. Other potential studies that may be carried out under the existing Work Plan include:

- Redeye Bass studies
- Additional trout stream restoration
- Black bass exploitation studies
- Jocassee trout survival/mortality/exploitation studies
- Habitat protection/access improvement/erosion control.

Duke Energy provided a one-time payment of $120,000 in 2017 to support Bad Creek MOU research and monitoring activities by SCDNR. Duke Energy also provided further funding of $90,000 in 2019 and will provide another $90,000 in 2025. Under the KT Project Relicensing Agreement, Duke Energy provided $100,000 to SCDNR to support tributary stream restoration efforts.

Duke Energy expects to consult with agencies and other stakeholders regarding the need for additional PM&E measures focused on fisheries research and enhancements in the New Project License through the ILP.

6.4.7 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

6.4.7.1 Fish Entrainment

Based on Lake Jocassee water surface elevation data from the 2006 – 2015 10-Year Work Plan period, there were 16 low-water events (i.e., pond elevations below 1,099 ft msl) occurring during severe and/or extended drought conditions. Details on these events are provided in Table 6.4-14.

Table 6.4-14. Number of Consecutive Days Lake Jocassee Pond Elevation was below 1,099 ft msl during 2006-2015

Event Start Date	Event End Date	Event Duration (Days)
8/1/2006	2/7/2007	191
2/17/2007	2/28/2007	12
6/30/2007	6/30/2007	1
7/8/2007	5/10/2009	673
5/14/2009	5/15/2009	2
5/21/2009	5/23/2009	3
7/25/2009	9/28/2009	66
10/5/2009	10/21/2009	17
10/23/2009	10/23/2009	1
9/27/2010	9/29/2010	3
10/2/2010	12/27/2010	87
1/13/2011	3/8/2011	55
8/2/2011	8/4/2011	3
8/6/2011	5/4/2013	638
9/30/2014	10/23/2014	24
10/25/2014	12/7/2014	44

Source: Keowee-Toxaway Fishery Resources Work Plan

Of the 16 low-water events occurring during this 10-year period, 7 lasted longer than 30 consecutive days, and 5 events lasted longer than 60 consecutive days. Duke Energy consulted with the resource agencies, as required by the Work Plan, and determined no additional measures were necessary to minimize fish entrainment at the Bad Creek Project.

The 2014 NOA recognizes additional reservoir storage capacity added by Duke Energy and the USACE since 1968, revises the minimum operating levels for Lake Jocassee and Lake Keowee, incorporates the USACE Drought Plan operating protocols, and incorporates Duke Energy's Low Inflow Protocol which provides rules regarding operations during droughts, including Normal Minimum Elevations and water use conservation for existing and future water intake owners located on KT Project reservoirs. In summary, the NOA results in higher pond levels in Lake Jocassee, particularly during severe droughts, which will help minimize the potential for environmental impacts (e.g., entrainment) associated with the existing Bad Creek Project and a potential future Bad Creek II Complex.

Like the existing Project, entrainment of fish at the Bad Creek II Complex during pumping has the potential to cause injury or mortality to fish as they pass through the water conveyance system and turbines. It is understood fish transferred to Bad Creek reservoir via pumping entrainment are lost to the Lake Jocassee fishery since complete mortality has been assumed. Previous studies demonstrate that the overall numbers of fish entrained at the Project are primarily a function of fish density in the water column and the amount (volume) of water transferred. Although the proposed action will increase the rate at which water is pumped, the total volume of water passed during a pumpback cycle is expected to remain about the same. Therefore, it is unlikely that the proposed increase in pumping capacity will significantly increase the numbers of entrained fish during pumping at the Project.

In regard to Lake Jocassee fishery impacts, the estimated rates of entrainment mortality at the Project, with operation of Bad Creek II Complex, are not expected to affect the sustainability of Lake Jocassee fish populations. This includes assuming 100% mortality for those fish entrained during pumping operations and lost to the fishery. The species that experience the largest impact- Blueback Herring and Threadfin Shad- have relatively high fecundity, meaning that population-level compensatory mechanisms would likely offset the entrainment losses in terms of effects on these fish populations. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals (Sale et al. 1989). Based on the risk assessment framework, there is no expected risk to Blueback Herring and moderate risk to Threadfin Shad. However, operation of the Bad Creek II Complex in addition to the existing Project is not expected to reduce the Threadfin Shad population on a long-term basis. As stated above, there are existing operational measures in place to minimize entrainment and forage fish populations are currently monitored regularly in order to evaluate effects to the Lake Jocassee fish community.

To minimize risk of entrainment to the fish community at the maximum extent practicable, it is likely Bad Creek II Complex operations will fall under the same guidelines as the existing Project during low water events (i.e., turning off lights during pump-back operations, unit sequencing during startup and shutdown, and notifications/consultation with the resource agencies) if pond elevations fall below 1,099 ft msl. These operational protocols may continue to evolve as additional information is gathered.

6.4.7.2 Pelagic Trout Habitat

The proposed inlet/outlet structure for the Bad Creek II Complex is located in the Whitewater River cove of Lake Jocassee upstream of the existing Bad Creek Project inlet/outlet structure. As discussed in Sections 5.4.5 and 6.3.10.4, and depicted on Figure 5.4-12, the submerged weir reduces vertical mixing in Lake Jocassee that could otherwise occur due to operation of the existing Bad Creek Powerhouse. The underwater weir would be expanded during construction of the Bad Creek II Complex through the placement of excavated rock materials from underground excavations (see Section 5.6.3.3). Similar to the inlet/outlet structure for the Bad Creek Project, the inlet/outlet structure for the Bad Creek II Complex would be upstream of the submerged rock weir; therefore, vertical mixing would be expected to be limited to this isolated area of Whitewater River cove. While Duke Energy does not presently expect significantly increased vertical mixing in the reservoir following expansion of the submerged weir and commencement of operation of the new powerhouse, Duke Energy expects this issue to be further evaluated through additional or ongoing studies (including the CFD model) related to the Bad Creek II Complex. Additionally, the added exchange of water between Bad Creek Reservoir and Lake Jocassee may warrant an annual trout habitat monitoring program through the next Work Plan period during and following construction of the Bad Creek II Complex.

6.4.7.3 Fish Community and Enhancements

No effects on the population, abundance, or distribution of forage fish are anticipated as a result of the proposed Bad Creek II Complex operations; however, annual sampling and monitoring conducted as part of the current 10-Year Work Plan will likely continue in future years and any changes in forage fish populations or diversity would be identified under those activities. The data collected as part of these studies would allow effective on-going monitoring of forage populations which are the primary food of trout and other predatory sportfish in Lake Jocassee and Lake Keowee.

No effects on the littoral fish populations or changes in suitable habitat are anticipated as a result of the proposed Bad Creek II Complex operations; however, annual electrofishing conducted as part of the current 10-Year Work Plan would likely need to continue in future years to provide data (1) to determine species composition and to detect changes, (2) to obtain catch-per-unit effort data to detect increasing or decreasing population trends, and (3) to evaluate the relative condition of largemouth and spotted bass.

No impacts to the cost sharing program for trout stocking are anticipated as a result of the proposed Bad Creek II Complex; however, it is likely the addition of a second powerhouse would provide additional justification for continuation of some level of cost sharing for trout stocking in future years.

6.5 Wildlife and Botanical Resources (18 CFR §5.6(d)(3)(v))

The Project Boundary and vicinity includes several natural community types and a wide variety of terrestrial habitats and wildlife, including potential for the presence of protected plant and animal species.

The Project is located partially within the Blue Ridge Level III ecoregion and the Piedmont Level III ecoregion, and further refined within the Level IV Southern Crystalline Ridges and Mountains ecoregion and the Level IV Southern Inner Piedmont ecoregion (Griffith et al. 2002). The Blue Ridge ecoregion is considered a transitional area between the mountainous ecoregions of the Appalachians to the northwest and the rolling hills of the Piedmont to the southeast. The

Piedmont ecoregion is a transitional area between the mostly mountainous ecoregions of the Appalachians/Blue Ridge and the relatively flat coastal plain to the southeast. The Southern Crystalline Ridges and Mountains ecoregion is characterized by crystalline rock types of gneiss and schist and soils tend to be well-drained, acidic, and loamy. This ecoregion is mostly forested with chestnut oak dominating on most slopes and ridges (Griffith et al. 2002). The Southern Inner Piedmont ecoregion is characterized by rolling to hilly terrain with gneiss and schist bedrock covered with clayey and micaceous saprolite. This ecoregion is generally forested with oak-pine, oak-hickory, and loblolly-shortleaf pine forest throughout (Griffith et al. 2002).

6.5.1 Terrestrial Habitats (18 CFR §5.6(d)(3)(v)(A))

Terrestrial habitats within the Blue Ridge ecoregion portion of the Project Boundary may include the following classified habitats:

- Appalachian Oak and Oak-Pine Forest
- Low Elevation Basic Mesic Forest
- Low Elevation Acidic Mesic Forest
- High-elevation Forest
- Riverbanks, Streambanks, and Alder Zones
- Moist or Wet Types Due to Unique Landform
- Vertical or Horizontal Rock Outcrop

Terrestrial habitats within the Piedmont ecoregion portion of the Project Boundary may include the following classified habitats:

- Oak-Hickory Forest
- River Bottoms
- Piedmont Small Stream Forest
- Cove Forest
- Grassland and Early Successional Habitats (SCDNR 2005b)

Terrestrial habitat descriptions and associated wildlife and plant species potentially located within the Project Boundary are provided in Table 6.5-1.

Table 6.5-1. Predominant Terrestrial Habitats and Associated Wildlife and Plant Species Potentially Located within the Project Boundary

Habitat Classification	Description and Ecological Setting	Associated Species
Blue Ridge Ecoregion		
Appalachian Oak and Oak-Pine Forest	Oak and oak-pine forests compose the predominant vegetation type throughout the Blue Ridge Ecoregion. Vegetation composition and structure is highly variable, depending primarily on exposure and	PLANTS: Oak species including scarlet, black, white, and chestnut; pines

Habitat Classification	Description and Ecological Setting	Associated Species
	position on slope and, secondarily, on soil moisture. Ridgetops and exposed upper slopes support an open canopy forest of oak species such as scarlet (*Quercus coccinea*), black (*Q. velutina*) and chestnut oak, (*Q. prinus*) and/or mixed pines and oaks. The understory is open, and groundcover is sparse; blueberry (*Vaccinium* spp.) is a characteristic groundcover. Upper portions of hill slopes and exposed nose slopes typically support a canopy dominated by chestnut oak with numerous hardwood co-dominants, and a shrub layer dominated on some sites by dense stands of mountain laurel (*Kalmia latifolia*). More mesic lower slopes, particularly north-facing slopes at intermediate and low elevations and sites along small streams and ravines, support diverse hardwood species, typically including white oak (*Q. alba*), tulip poplar (*Liriodendron tulipifera*), Fraser magnolia (*Magnolia fraseri*), and red maple (*Acer rubrum*). Diverse shrub and herbaceous species are also present, along with widely spaced clumps of mountain laurel.	including white (*Pinus strobus*) and loblolly (*Pinus taeda*); tulip poplar; Fraser magnolia; red maple; blueberry; mountain laurel
Low Elevation Basic Mesic Forest	Low elevation mesic forest occupies relatively sheltered, well-drained sites on concave landforms and lower slopes. It is a rare type within the ecoregion, occurring only on sites exhibiting unusually deep soils. Tulip poplar typically dominates the overstory, and Carolina silverbell (*Halesia carolina*) is characteristic in the mid-story or understory. The shrub layer is typically sparse or absent. Herb species richness and cover are highest and characteristic ground flora species include bloodroot (*Sanguinaria canadensis*), foamflower (*Tiarella* spp.), Carolina silverbell, partridge berry (*Mitchella repens*), cane (*Arundinaria* spp.) and ginseng (*Panax ginseng*). Mixed mesophytic forests are recognized generally as habitats within the Southern Appalachians that support high densities and/or provide optimal habitat for many species of breeding birds and have high salamander species diversity.	PLANTS: Tulip poplar, bloodroot, foamflower, Carolina silverbell, partridge berry, cane, ginseng
Low Elevation Acidic Mesic Forest	Low elevation acidic mesic forest occurs on well-drained, relatively sheltered sites in stream bottoms, along ravines of small streams or on hill slopes. The type is more prevalent on north facing slopes or lower positions on other slopes. Eastern hemlock (*Tsuga canadensis*) is characteristic, occurring either as the dominant overstory or understory tree; rhododendron (*Rhododendron* spp.) dominates the shrub layer, occurring in thickets or solitary clumps. Tulip poplar, white pine, hickories (*Carya* spp.), sweet birch (*Betula lenta*), beech (*Fagus grandifolia*), and basswood (*Tilia americana*) are common associates. White pine becomes much more dominant along with hemlock in the Ellicott Rock /Chattooga River Basin in the western portion of the Blue Ridge. The type provides key habitat for wildlife species associated with riparian habitats.	PLANTS: Eastern hemlock, rhododendron, white pine, hickory species, sweet birch, beech, basswood
High-elevation Forest	In South Carolina, this type is limited to the highest peaks. Occurring at scattered sites at over 900 m elevation, South Carolina represents the southern limit of this habitat. Several canopy trees, other plant species, and a few priority wildlife species, are also at their southern range limits. Canopies consist of red maple, chestnut oak, northern red oak (*Q. rubra*), black oak, hickory and yellow poplar. Herbaceous species diversity is high, but less than in mesic hardwood/bloodroot or cove forests. High-elevation forest is distinguished from other forests by the lack of calciphilic species and the dominance of red maple and chestnut oak. On steep to very steep upper to middle slopes with northerly aspects, vegetation is dominated by northern red oak with or without lesser amounts of chestnut oak and red maple. Great laurel (*Rhododendron maximum*) forms a dense continuous subcanopy and on	PLANTS: Red maple, chestnut oak, northern red oak, black oak, hickory species, tulip poplar, rhododendron, great laurel

Habitat Classification	Description and Ecological Setting	Associated Species
	more exposed sites small-leaf rhododendron (*Rhododendron minus*) becomes more dominant.	
Riverbanks, Streambanks, and Alder Zones	This habitat type forms the riparian vegetation zone along streams and rivers, typically along streams wide enough to prevent canopy closure, at scattered locations with a suitable substrate of seasonally flooded rocky or alluvial soils. It exhibits variation in size and persistence. At the base of the escarpment, this habitat also occupies broad floodplains, where it grades into the floodplain forest types of the upper Piedmont. Alder (*Alnus* spp.) is a characteristic species occuring in relative abundance along with mixed canopy species. Common shrubs are yellow root (*Xanthorhiza simplicissima*), Virginia willow (*Itea virginica*), azalea (*Rhododendron* spp.) and occasionally black willow (*Salix nigra*) and sweet pepperbush (*Clethra alnifolia*).	PLANTS: Alder species, yellow root, Virginia willow, azalea species, black willow, sweet pepperbush
Moist or Wet Types Due to Unique Landform	Highly variable landforms within the Southern Blue Ridge Ecoregion include numerous wet places increasing local and regional habitat diversity. Open seeps of variable size occur on granitic cliffs and domes. Spray cliffs occur in spray and splash zones at the edges and bases of waterfalls. Upland bogs form in poorly drained wet seepage areas at heads of small streams, which are nearly always saturated. Upland bogs are characterized by Sphagnum (*Sphagnum* spp.) and many bog species such as orchids (*Orchidaceae*) and sedges (*Carex* spp.). Vegetation in upland bogs is apparently fire controlled. Without burning, succession leads to a wetland community dominated by woody vegetation.	PLANTS: Sphagnum species, orchid species, sedge species
Vertical or Horizontal Rock Outcrop	Rock outcrops of widely varying sizes and slopes occur throughout the region. Slopes range from nearly horizontal to nearly vertical. The more extensive and exposed outcrops have their own characteristic vegetation and habitat features. Vegetation ranges from none, (bare rock) to a mosaic of herbaceous plant, shrub and tree-dominated communities. Successional trees, such as eastern red cedar (*Juniperus virginiana*) and Virginia pine (*Pinus virginiana*) are common on these sites. Crevices and ledges can only provide habitats for larger plants once sufficient soil has built up. Vegetation communities are relatively unstable. A cliff or dome may also have areas of wet seepage zones.	PLANTS: Eastern red cedar, Virginia pine
Piedmont Ecoregion		
Oak-hickory Forest	Occurring throughout South Carolina but most characteristic of rolling uplands in the Piedmont, oak-hickory forest is a widely distributed community varying from site to site. Occurring in highly fragmented stands, later successional stages tend to be made up of a diverse assemblage of hardwoods, primarily oaks and hickories, as co-dominants in combination with pines. Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species. Vegetation mostly consists of early- to mid-successional managed stands of pine and pine-hardwood forest. The understory in pure pine stands is often open, but in mixed or older stands, it is dominated by the hardwoods characteristic of the site. Common pine species of the piedmont include shortleaf (*Pinus echinata*) and loblolly, with the former better adapted to dry, fine textured upland soils and loblolly achieving maximum growth on deep soils with good moisture and drainage.	PLANTS: Oak species, hickory species, pine species
River Bottoms	River bottoms or "bottomland forests" consist of hardwood-dominated woodlands with moist soils usually associated with major river floodplains. Characteristic trees include sweetgum, loblolly pine, water oak (*Q. nigra*), willow oak (*Q. phellos*), laurel oak (*Q. laurifolia*),	PLANTS: Sweetgum (*Liquidambar styraciflua*), loblolly pine, oak species, American Holly (*Ilex*

Habitat Classification	Description and Ecological Setting	Associated Species
	cherrybark oak (*Q. pagoda*) and American holly. A subtype dominated by bald cypress and water tupelo occurs on lower elevation sites but is not as prevalent as in the broader floodplains of the Coastal Plain. Compared to the Coastal Plain, the floodplains of major rivers in the Piedmont are confined by topography to relatively narrow corridors.	*opaca*), bald cypress (*Taxodium distichium),* water tupelo (*Nyssa aquatica*)
Piedmont Small Stream Forest	Piedmont small stream forests are distinguished from forest communities on larger floodplains because of differences between the scales of the ecosystems. In smaller floodplains, the levees, sloughs, and ridges are largely absent or poorly developed. Flooding regime is also more variable between small watersheds than larger ones. Soils are various alluvial types seasonally or intermittently flooded. The forest has an open to dense understory or shrub layer and a sparse to dense herb layer. The canopy has a mixture of bottomland and mesophytic trees including river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), sweetgum, tulip poplar, American elm (Ulmus americana), hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*) and red maple.	PLANTS: River birch, sycamore, sweetgum, tulip tree, American elm, hackberry, green ash, red maple
Cove Forest	Cove forests are botanically diverse, well-developed hardwood forests occurring on scattered rich and generally small sites (less than 200 acres). Usually, these forests occur on protected bluffs in association with small stream forests or river bottoms. No single species tends to dominate. Shrub species are usually numerous and the herbaceous flora is fairly rich, with many spring ephemerals. Canopy and understory is composed of hardwoods including beech), tulip poplar, black gum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), white oak, northern red oak, black oak, sweetgum, red maple, southern sugar maple (*A. saccharum*), basswood, ironwood (*Carpinus caroliniana),* flowering dogwood (*Cornus florida*), American holly, witch-hazel (*Hamamelis virginiana*) and hop-hornbeam (*Ostrya virginiana*).	PLANTS: Beech, tulip tree, black gum, sourwood, oak species,sweetgum, maple species, basswood, ironwood, flowering dogwood, American Holly, witch-hazel, hop-hornbeam
Grassland and Early Successional Habitats	A variety of open habitats occupies a considerable portion of upland sites in the Piedmont, including agricultural land, recently abandoned farmland, recently cleared land and a matrix of managed open pine forest and grassland. Golf courses, urban yards and open spaces are also included in this habitat type. The vegetation on most sites is oak-hickory forest, although many sites are maintained in early successional stages.	PLANTS: Oak species, hickory species, Grass species, early successional species

Sources: SCDNR 2005a and SCDNR 2005b

6.5.1.1 Natural Communities

6.5.1.1.1 Transmission Line Corridor

On June 8 – 10, 2021, HDR biologists surveyed the approximately 9.25-mile-long, 400-ft wide transmission line corridor extending between the existing Project and the Jocassee Powerhouse Switchyard for existing natural communities. According to the Natural Communities of South Carolina Initial Classification and Description (Nelson 1986), four natural communities were identified: Cove Forest, Chestnut Oak Forest, High Elevation Seep, and Mesic Mixed Hardwood Forests. These natural communities were observed within the 50-foot buffer on either side of the

Bad Creek to Jocassee transmission line corridor and within the unmaintained areas of the right-of-way.

Chestnut Oak Forest

Chestnut Oak Forest is predominantly present within the northern portion of the Project with higher mountains and ridges. Plant species observed within these communities include Virginia pine (*Pinus virginiana*), shortleaf pine (*Pinus echinate*), white pine (*Pinus strobus*), chestnut oak (*Quercus prinus*), black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), sourwood (*Oxydendrum arboreum*), black cherry (*Prunus serotina*), Piedmont rhododendron (*Rhododendron minus*), mountain laurel (*Kalmia latifolia*), doghobble (*Leuothoe fontanesiana*), sassafras (*Sassafras* albidum) and huckleberry (*Vaccinium stamineum*).

Cove Forests

Cove Forests were observed in ravines and steep slopes adjacent to stream channels in forested areas outside of the maintained right-of-way for the Bad Creek to Jocassee transmission line. Plant species observed within this community included American basswood (*Tilia heterophylla*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*), silver maple (*Acer saccharinum*), birch (*Betula lenta*), rhododendron, mountain laurel, spicebush (*Lindera benzoin*), flowering dogwood (*Cornus florida*), galax (*Galax* spp.), maiden hair fern (*Adiantum* sp.) and woodferns (*Dryopteris* sp.)

High Elevation Seeps

High Elevation Seep communities were observed throughout the transmission line corridor and were mostly associated with ephemeral or intermittent streams down gradient. Plant species identified within these areas are umbrella leaf (*Diphylleia cymosa*), beaksedge (*Rhynchospora capitellata*), mountain laurel, jewelweed (*Impatiens capensis*), and sphagnum.

Maintained Bad Creek-to-Jocassee transmission line right-of-way areas are comprised of early successional woody, herbaceous, and vine species including red maple, hickories, black cherry, black locust (*Robinia pseudoacacia*), mutilfora rose (*Rosa multiflora*), sawtooth blackberry (*Rubus argutus*), horseweed (*Conyza canadensis*), goldenrods (*Solidago* sp.), New York ironweed (*Vernonia noveboracensis*), curly dock (*Rumex crispus*), dogfennel (*Eupatorium* *capillifolium*), pokeberry (*Phytolacca* sp.), bushy bluestem (*Andropogon glomeratus*), broomsedge (*Andropogon virginicus*), fescue (*Fescue* sp.), Johnson grass (*Sorghum halepense*), Japanese stiltgrass (*Microstegium vimineum*), deer-tongue grass (*Dichanthelium clandestinum*), white clover (*Trifolium repens*),morning glory (*Ipomoea* sp.) greenbrier (*Smilax rotundifolia*), devil's walking stick (*Aralia spinosa*), Japanese honeysuckle (*Lonicera japonica*), muscadine grape (*Vitis rotundifolia*), bracken fern (*Pteridium aquilinum*), and nettled chain fern (*Woodwardia areolata*).

Mesic Mixed Hardwood Forests

Mesic Mixed Hardwood Forests were dominant in areas of less steep terrain, where the canopy was comprised of hardwood species such as red maple, eastern red cedar (*Juniperus virginiana*), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), ironwood (C*arpinus caroliniana*), and pignut hickory (*Carya glabra*).

6.5.1.1.2 Area of Influence Excluding Transmission Line Corridor

On September 1 – 3, 2021, HDR biologists conducted a survey of the balance of the area of influence – an area of 1,314 acres—for existing natural communities. According to the Natural Communities of South Carolina Initial Classification and Description (Nelson 1986) and the Nature Served community classification system (Nature Serve 2013), five ecological groups and community types were identified within the area of influence: 1) Shortleaf Pine-Oak Forest and Woodland, 2) Rhododendron Forest, 3) Montane Oak- Hickory Forest 4) Acidic Cove Forests, and 5) Floodplain Forest. Open maintained areas and existing right-of-way areas were also documented.

Shortleaf Pine-Oak Forest and Woodland

This habitat type is characterized by shortleaf pine (*Pinus echinate)* and oak-dominated forested areas on exposed ridges and sideslopes (Simon 2015). Dominant tree canopy cover observed included white oak (*Quercus alba*), scarlet oak (*Quercus coccinea*), northern red oak (*Quercus rubra*), chestnut oak (*Quercus montana*), mockernut hickory (*Carya tomentosa*), tulip poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), eastern hemlock (*Tsuga canadensis*), Virginia pine (*Pinus virginiana*), and sourwood (*Oxydendrum arboreum*). Saplings and shrubs consisted of similar canopy species as well as American holly

(*Ilex opac*a), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*), mountain laurel (*Kalmia latifolia)*, rhododendron (*Rhododendron maximum*), cucumber magnolia (*Magnolia acuminata*), witch-hazel (*Hamamelis* spp.), bear oak (*Quercus ilicifolia*), and sassafras (*Sassafras albium*). Herbaceous and vine species consisted of rattlesnake weed (*Hieracium venosum*), spotted wintergreen (*Chimaphila maculate*), Christmas fern (*Polystichum acrostichoides* and muscadine grape (*Vitis rotundifolia*).

Mixed Oak/Rhododendron Forest

This habitat type is characterized by rhododendron-dominated thickets found on mountains and in the upper Piedmont, with sparse herbaceous cover. Dominant species observed for this habitat type included northern red oak, shortleaf pine, mountain laurel, rhododendron, deerberry (*Vaccinium stamineum*), white pine, sourwood, red maple (*Acer rubrum*), and black gum (*Nyssa sylvatica*).

Montane Oak-Hickory Forest (Cove and Slope)

This habitat type is characterized by a mix of hardwood tree species on lower elevations within mountains and upland slopes between rivers and headwater tributaries. Dominant tree species observed for this habitat type included northern red oak, chestnut oak (pignut hickory (*Carya glabra*), white pine, red maple tulip poplar, mountain laurel, sourwood, black gum, magnolia, and high bush blueberry.

Acidic Cove Forest

This habitat type is characterized by hemlock and mixed hardwood-conifer forests, typically dominated by an evergreen understory occurring in narrow coves (ravines) and extending to adjacent protected, north-facing slopes (Simon 2015). Dominant tree species observed for this habitat type consisted of red maple, sweetgum (*Liquidambar styraciflua*), black gum, eastern hemlock, rhododendron, tulip poplar, sourwood, chestnut oak, sweet birch (*Betula lenta*), and white ash (*Fraxinus americana*). Shrubs consist of mountain doghobble (*Leucothoe fontanesiana*), deerberry, witch hazel, elderberry (*Sambucus nigra*), magnolia, spicebush (*Lindera benzoin*), and pawpaw (*Asimina triloba*). The herbaceous and vine layer is dominated by Galax (*Galax urceolata*), black cohosh (*Actaea racemosa*), black cohosh (*Actaea racemosa*), jewelweed (*Impatiens capensis*), Indian cucumber (*Medeola virginiana*), violets (*Viola* spp.), Christmas fern, wood ferns (*Dryopteris* spp.), and Virginia creeper (*Parthenocissus quinquefolia*).

Floodplain Forest

This habitat type is found in regularly or seasonally flooded areas adjacent to river systems with a diverse herbaceous cover. Dominant trees consisted of white oak, sweetgum, red maple, eastern hemlock, sourwood, red oak, and yellow birch (*Betula alleghaniensis*). The shrub and vine layer consists of pawpaw, alders (*Alnus* spp.), and muscadine. The herbaceous layer consists of black cohosh, Indian cucumber, wild ginger (*Asarum* spp.), running cedar (*Diphasiastrum digitatum)*, partridge berry (*Mitchella repens*), wood fern, Christmas fern, jewelweed (*Impatiens capensis*), and nettled chain fern (*Woodwardia areolata*).

Maintained Right-of-Way and Fields

Maintained ROW areas and fields are comprised of early successional woody, herbaceous, and vine species including red maple, hickories, black cherry, black locust (*Robinia pseudoacacia*), mutilfora rose (*Rosa multiflora*), sawtooth blackberry (*Rubus argutus*), goldenrods (*Solidago* spp.), curly dock (*Rumex crispus*), dogfennel (*Eupatorium capillifolium*), pokeberry (*Phytolacca* spp.), rabbit tobacco (*Pseudognaphalium obtusifolium*), asters (*Aster* spp.), beggars tick (*Bidens* spp.), bushy bluestem (*Andropogon glomeratus*), broomsedge (*Andropogon virginicus*), foxtails (*Seteria* spp.) boneset, fescue (*Fescue* spp.), crabgrass (*Digitaria* spp.), Johnson grass (*Sorghum halepense*), Japanese stiltgrass, deer-tongue grass, white clover (*Trifolium repens*), morning glory (*Ipomoea* spp.) greenbrier (*Smilax rotundifolia*), ragweeds (*Ambrosia* spp.), Japanese honeysuckle (*Lonicera japonica*), and muscadine grape.

6.5.2 Terrestrial Wildlife Resources (18 CFR §5.6(d)(3)(v)(B))

Terrestrial communities in the Project vicinity are comprised of mature forested habitats with areas of early successional habitats that may also support a diverse number of wildlife species. Representative mammal, bird, reptile, and amphibian species commonly occurring in these habitats are listed below. Note individual species and/or evidence of species observed during HDR's field surveys are indicated with an asterisk (*). Information on species typically using these habitats in the Piedmont ecoregion was obtained from relevant literature, mainly the Biodiversity of the Southeastern United States, Upland Terrestrial Communities (Martin et al.

1993). Mammal species commonly occurring in the Appalachian Oak Forest Region include eastern cottontail (*Sylvilagus floridanus*), North American beaver *(Castor canadensis),* black bear (*Ursus americanus*)*, coyote (*Canis latrans*), gray squirrel (*Sciurus carolinensis*)*, white-tailed deer (*Odocoileus virginianus*)*, raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), red fox (*Vulpes vulpes*), least weasel (*Mustela nivalis*). and various vole, rat, and mice species. Bird species commonly using these habitats include yellow-billed cuckoo (*Coccyzus americanus*), black-billed cuckoo (*Coccyzus erythropthalmus*) wild turkey (*Meleagris gallapava*), American crow (*Corvus brachyrhynchos*), northern cardinal (*Cardinalis cardinalis*), field sparrow (*Spizella pusilla*), prairie warbler, eastern towhee (*Pipilo erythrophthalmus*), wood thrush, ovenbird (*Seiurus aurocapillus*), red-eyed vireo (*Vireo olivaceous*), chickadees (*Parus sp*), and woodpeckers (Family Picadae). Predatory birds may include American kestrel (*Falco sparverius*), barred owl (*Strix varia*), peregrine falcon (*Falco peregrinus*), red-shouldered hawk (*Buteo lineatus),* red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), owl species, and turkey vulture (*Cathartes aura*).

Reptile species using these terrestrial communities include the northern scarlet snake (*Cemophoroa coccinea copei*), timber rattlesnake (*Crotalus horridus*), copperhead (*Agkistrodon conttortrix*), eastern ratsnake (*Pantherophis obsoletus*), common five-line skink (*Plestiodon fasciatus*), amphibians include tree toads (*Bufo* spp.), spadefoot (*Scaphiopus holbrooki*), and frog species (*Hyla* spp., *Rana* spp., and *Pseudacris* spp.). The dominant salamander community are the dusky salamanders (*Desmognathus* spp.).

The South Carolina Heritage Trust (SCHT) online mapper (SCHT 2021) identified Global and State Conservation status species and species of concern that may occur within the Project Boundary and over 170 species of birds were observed at bird population hotspots in the Project vicinity, identified from the eBird volunteer birding database (eBird 2021).

Species that are considered important because of their commercial, recreational, or cultural value include large game such as white-tailed deer, black bear, wild turkey, as well as small game animals such as possums, raccoons, and foxes, which are considered recreationally valuable for hunting (NCWRC 2022). The Eastern Band of Cherokee Indians consider hickory tree species culturally significant. Hickory tree wood is used to craft equipment for a popular Cherokee sport called Cherokee Stickball. Hickory trees are also used to create traditional Cherokee style meals using hickory ash which is used to cook hominy, and hickory nut soup (Knuchi) (NCWF 2022).

6.5.2.1 Bat Surveys

On behalf of Duke Energy, in support of this PAD and evaluation of potential impacts of constructing the Bad Creek II Complex, ERM conducted field surveys in 2021 to assess the presence/likely absence of bat species and their potential habitats within the Project vicinity (ERM 2021). Habitat surveys, acoustic surveys, and mist net surveys were carried out to determine the presence and identification of bat species. Details of the methods, analyses, and findings of the surveys are included in the ERM Bad Survey Report (ERM 2021).

Habitat surveys were performed to identify potential roost trees for federally endangered Indiana bat (*Myotis sodalist*) and federally threatened northern long-eared bat, particularly near water resources and forested edges that receive direct solar exposure. Cliffs and talus slopes were visually assessed for cracks and crevices which serve as preferred roosts for eastern small-footed bats (*Myotis leibii*).

Four acoustic survey site locations with two detectors were placed in preferred habitats including two adjacent to the shoreline of the reservoir, one along the service road extending from the existing transmission line right-of-way, and one along the shoreline of Lake Jocassee. The acoustic analysis suggested the presence of 12 bat species within the Project. The tri-color bat (*Perimyotis subflavus*) and big brown bat (*Eptesicus fucus*) made up more than 70 percent of the total 6,000 call files to identify species. Manual vetting of the calls confirmed high confidence of five species and medium confidence of an additional four species. Indiana bat and northern-long-eared (*Myotis septentrionalis*) bat were determined not likely to be present.

Four mist surveys were conducted including two sites in July 2021 and two sites in October 2021. Each site deployed multiple net sets and sites were surveyed for two nights for a total of 26 net nights. Two sites were located within road corridors adjacent to the reservoir, one site was located on the service road extending from the existing transmission line right-of-way, and one site was located south of the reservoir dam at the intersection of a field and road corridor. A total of 14 bats, representing four different species including big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), and eastern small-footed bat were captured during the surveys.

The results of the 2021 bat survey indicated a diversity of bat species present within the Project vicinity. Habitat surveys indicated abundant suitable habitat for Indiana bat and northern long-eared bat but results from the presence/absence survey revealed that these species are not likely to be on-site. Of the 14 bats captured, four of them were eastern small-footed bats; the eastern small-footed bat is considered a species in need of management in the State of South Carolina, which is the equivalent to state-threatened status. Abundant rocky roosting habitat for eastern small-footed bat was found within the area of influence, although none could be confirmed to be occupied. Results of the acoustic survey suggest high confidence in the presence of little brown bat and tri-colored bat, which are both currently designated as At-Risk Species and are under review for future listing with the USFWS.

6.5.2.2 Invasive Species

Invasive species are non-native plant, animal, or fungal species causing or are likely to cause economic or ecological harm or harm to human health. Numerous invasive species have been introduced to South Carolina which can cause, or are presently causing, the extirpation of native species, alterations to natural ecological communities, impacts to agricultural production, adverse impacts to threatened and endangered species, and direct harm to people.

Disturbed areas within the area of influence, especially adjacent to existing structures, have been encroached on by invasive species including princess tree (*Catalpa bignonioides*), Japanese stiltgrass, mimosa tree (*Albizia julibrissin*), Japanese honeysuckle, and sawtooth oak. In addition, sounds and visual signs of invasive feral hogs (*Sus scrofa*) such as unrooted plants and hoof prints were identified during field surveys.

While not a complete list of all invasive species in South Carolina, Table 6.5-2 provides invasive species of concern in South Carolina (NRCS 2011; Defenders of Wildlife 2021; USDA 2021a; and USDA 2021b). Species observed in the field during other surveys performed by HDR for the Bad Creek to Jocassee transmission line corridor are indicated with an asterisk (*).

Table 6.5-2. Invasive Species of Concern in South Carolina

Common Name	Scientific Name	Life Form	General Habitat
Animals			
Ambrosia beetle	*Xylosandrus crassiusculus*	Insect	Terrestrial
Asian Clam[1]	*Corbicula fluminea*	Animal	Aquatic
Asian Longhorn Beetle	*Anoplophora glabripennis*	Animal	Terrestrial
Emerald Ash Borer	*Agrilus planipennis*	Animal	Terrestrial
European Cherry Fruit Fly	*Rhagoletis cerasi L.*	Insect	Terrestrial
Feral Hog	*Sus scrofa*	Animal	Terrestrial
Flathead catfish	*Pylodictus olivaris*	Animal	Aquatic
Gypsymoth	*Lymantria dispar*	Animal	Terrestrial
Hemlock Wooly Adelgid	*Adelges tsugae*	Animal	Terrestrial
Imported Fire Ant	*Solenopsis invicta*	Insect	Terrestrial
Spotted Lanternfly	*Lycorma delicatula*	Animal	Terrestrial
Plants			
Alligator Weed	*Alternanthera philoxeroides*	Plant	Aquatic
Autumn Olive, Russian Olive, Thorny Olive	*Elaeagnus umbellata, E. angustifolia, E. pungens*	Plant	Terrestrial
Bamboo	*Phyllostachys aurea*	Plant	Terrestrial
Beach Vitex	*Vitex rotundifolia*	Plant	Terrestrial
Bull Thistle*	*Cirsium vulgare*	Plant	Terrestrial
Chinaberry Tree	*Melia azedarach*	Plant	Terrestrial
Chinese Parasol Tree	*Firmiana simplex*	Plant	Terrestrial
Chinese Silvergrass	*Miscanthus sinensis*	Plant	Terrestrial
Chinese Tallow Tree, Popcorn Tree	*Sapium or Triadica sebiferum*	Plant	Terrestrial
Chinese/Japanese Privet	*Ligustrum sinense L. japonicum*	Plant	Terrestrial
Common Salvinia	*Salvinia minima*	Plant	Aquatic
Coontail	*Myriophyllum heterophyllum*	Plant	Aquatic
Crested Floating Heart	*Nymphoides cristata*	Plant	Aquatic
English Ivy	*Hedera helix*	Plant	Terrestrial
Giant Reed	*Arundo donax*	Plant	Terrestrial
Giant Salvinia	*Salvinia molesta*	Plant	Aquatic

Common Name	Scientific Name	Life Form	General Habitat
Golden Bamboo	*Phyllostachys aurea*	Plant	Terrestrial
Hydrilla	*Hydrilla verticallata*	Plant	Aquatic
Japanese Climbing Fern	*Lygodium japonicum*	Plant	Terrestrial
Japanese Honeysuckle*	*Lonicera japonica*	Plant	Terrestrial
Japanese Knotweed*	*Polygonum cuspidatum*	Plant	Terrestrial
Japanese Stilt-Grass*	*Microstegium vimineum*	Plant	Terrestrial
Johnson Grass*	*Sorghum halepense*	Plant	Terrestrial
Kudzu	*Pueraria montana*	Plant	Terrestrial
Mimosa*	*Albizia julibrissin*	Plant	Terrestrial
Multiflora Rose*	*Rosa multiflora*	Plant	Terrestrial
Musk Thistle, Nodding Thistle, Plumeless Thistle	*Carduus nutans*	Plant	Terrestrial
Oriental Bittersweet	*Celastrus orbiculatus*	Plant	Terrestrial
Parrot Feather	*Myriophyllum aquaticum*	Plant	Aquatic
Periwinkle (Bigleaf and Common)	*Vinca major, Vinca minor*	Plant	Terrestrial
Phragmites	*Phragmites australis*	Plant	Aquatic
Princess Tree/Royal Paulownia*	*Paulownia tomentosa*	Plant	Terrestrial
Sericea/Chinese Lespedeza*	*Lespedeza cuneata*	Plant	Terrestrial
Showy Rattlebox	*Crotalaria spectabilis*	Plant	Terrestrial
Shrub/Shrubby Lespedeza*	*Lespedeza bicolor*	Plant	Terrestrial
Tree-Of-Heaven*	*Ailanthus altissima*	Plant	Terrestrial
Trifoliate Orange	*Poncirus cuspidatum*	Plant	Terrestrial
Vasey’s grass, Dallis grass	*Paspalum urvillei, P. dilatatum*	Plant	Terrestrial
Water Hyacinth	*Eichhornia crassipes*	Plant	Aquatic
Water Lettuce	*Pistia stratiotes*	Plant	Aquatic
Water Primrose	*Ludwigia hexapetala*	Plant	Aquatic
Weeping Lovegrass	*Eragrostis curvula*	Plant	Terrestrial
Wisteria -Chinese Wisteria/Japanese Wisteria	*Wisteria sinensis. W. floribunda*	Plant	Terrestrial

Common Name	Scientific Name	Life Form	General Habitat
Fungus			
Chestnut blight	*Cryphonectria parasitica*	Fungus	Terrestrial
Dutch elm disease	*Ophiostoma ulmi, Ophiostoma himal-ulmi*	Fungus	Terrestrial

6.5.3 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Continued Project operations are not anticipated to affect wildlife and botanical resources of the Project vicinity. Protection of upland habitat around Lake Jocassee is provided by the requirements and agreements of the KT Project Relicensing Agreement and license. As described above, operation of the Project does not significantly impact Lake Jocassee water levels. Project operations are not likely to affect vegetation dispersal in the Project Boundary.

The SMP for the KT Project includes conditions for native vegetation plantings allowing the use of plantings to supplement existing native vegetation for protection and enhancement of important habitat areas. Continued implementation of the SMP will provide protection for vegetation communities at Lake Jocassee.

Vegetation on faces of dams at the Project is maintained in accordance with the FERC-approved Dam Safety Surveillance and Monitoring Plan while vegetation maintenance of access areas is conducted on an as-needed basis. Vegetation along the transmission line corridor is maintained on a regular basis.

6.5.4 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

Construction of the proposed Bad Creek II Complex would impact existing plant and wildlife communities. The primary impacts would be direct habitat loss from tree clearing required within the limits of disturbance, as well as associated access roads. Loss of forested communities will permanently impact native plant communities and will affect wildlife communities by displacement, habitat fragmentation and interrupting migration corridors. Habitat loss would likely disperse mobile wildlife into surrounding areas in an attempt to find new food sources and shelter. Impacted areas will, however, be concentrated in the vicinity of existing Project structures and spoil (excavated soil) disposal areas sited to reduce impacts. Because construction of the Bad Creek II Complex would not require construction of any new dams or reservoirs, the scale of impact and disturbance is significantly reduced compared to development of a new ("greenfield") energy storage and generation project of this size.

Duke Energy expects to consult with agencies and other stakeholders through the ILP to determine appropriate PM&E measures (e.g., seasonal restrictions for vegetation clearing, revegetation plans) for plant and wildlife resources during and following construction of the Bad Creek II Complex, if this Project expansion is pursued by Duke Energy.

Land clearing and soil disturbance could potentially enable the introduction or facilitate the spread of invasive plant and insect species. Similarly, construction or operation of the water supply intake and supporting infrastructure could potentially enable the introduction or facilitate the spread of invasive aquatic species. Project construction and operation also have the potential to affect (positively or negatively) the spread of invasive species. As such, Duke Energy expects consultation with stakeholders through the ILP to determine appropriate protection, mitigation, or enhancement measures for construction and operation of the Bad Creek II Complex to reduce the potential for the Project to contribute to the spread of invasive species.

6.6 Wetlands, Riparian, and Littoral Habitat (18 CFR §5.6(d)(3)(vi))

Wetlands are generally defined as those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. The USACE and SCDHEC have jurisdiction over wetlands in South Carolina.

Riparian habitats are areas supporting vegetation found along waterways such as lakes, reservoirs, rivers, and streams. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequency of flooding, ability to provide important ecosystem functions, and unique assemblage of plant and animal communities (Mitsch and Gosselink 2000). Riparian habitat in the area of influence is dominated by hardwood forest. Small areas of open field or cleared areas are present along parts of building areas, roads, and electric transmission line corridors in the vicinity of the Project.

The littoral zone, in the context of a large river system, is the habitat between about a half-meter of depth and the depth of light penetration. The littoral width varies based on the geomorphology and rate of sedimentation of the stretch of river (Wetzel 1983).

Extensive desktop studies and field-based studies were performed to identify environmental resources pertaining to wetlands and waterbodies, protected species, and protected species habitat. Overview summaries are provided in this section of the PAD while detailed data reports are provided in Appendix E. Protected species habitat descriptions are included for animal species in the Section 5.6 of Appendix E, which also describes habitat requirements (i.e. wetland vs. stream vs. terrestrial), and a protected species habitat map is also included in Appendix E. Wetland plant species habitats are described in this section as well as Appendix E. Terrestrial non-protected wildlife is discussed in Section 5.4 of Appendix E. There are no aquatic species that are currently federally listed that would occupy littoral zones and wetlands; however, bald eagles could be present in riparian areas.

6.6.1 Wetlands and Waterbodies Acreage

Federal wetland data maintained by the USFWS (National Wetlands Inventory [NWI] Mapper [USFWS 2019a]) were reviewed to identify any federally mapped wetlands in the Project Boundary. Wetlands and surface waterbody classifications are based on the NWI classification hierarchy (Cowardin et al. 1979). A map of NWI wetland habitats (from the desktop study) existing in the Project Boundary is presented on Figure 6.6-1. Please see Appendix E for detailed field-estimated locations and acreages of wetlands in the Project Area. While acreages of littoral and riparian zone habitat were not directly measured in the field, they were estimated for the main site as provided on Figure 6.6-2.

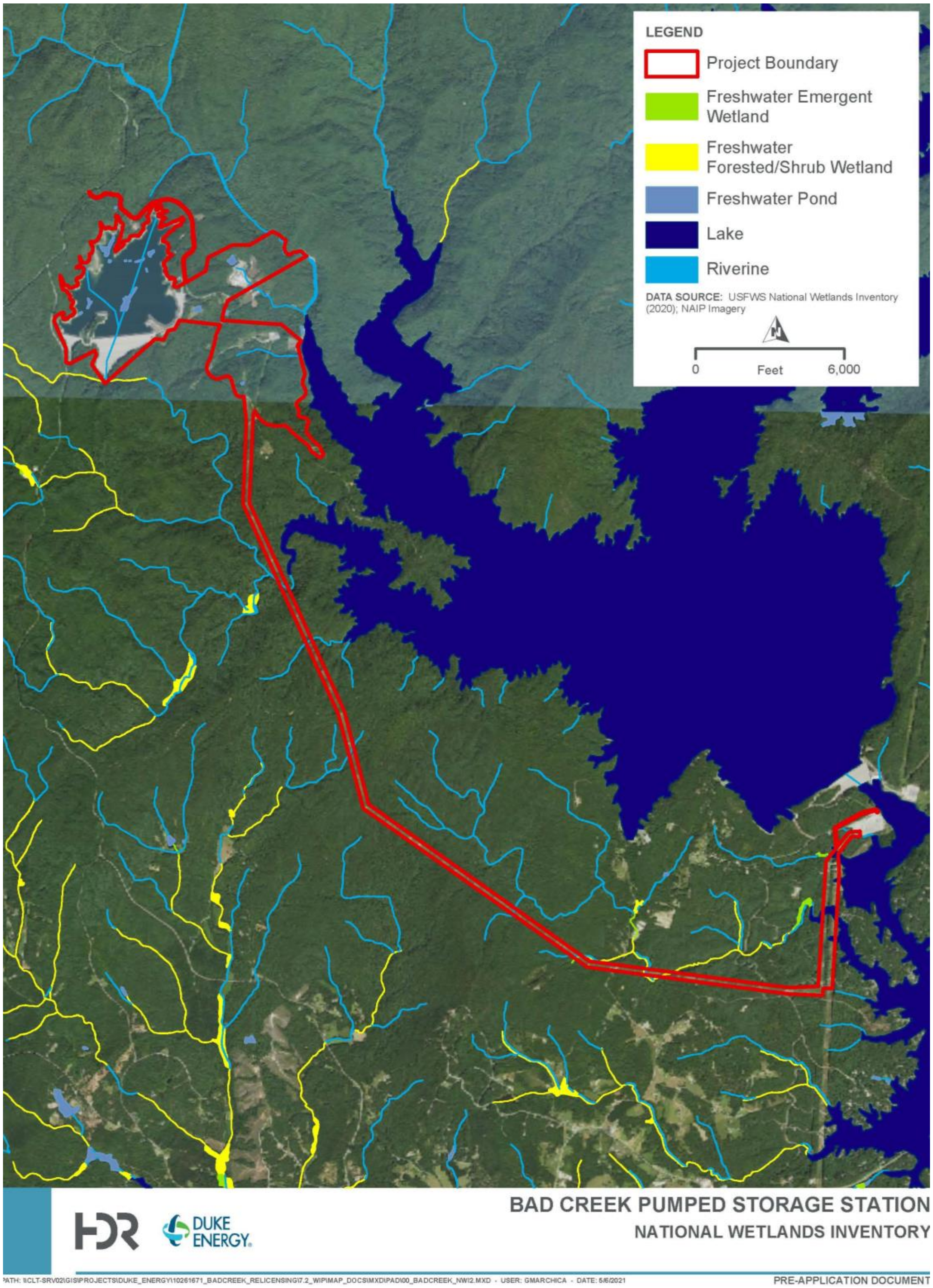
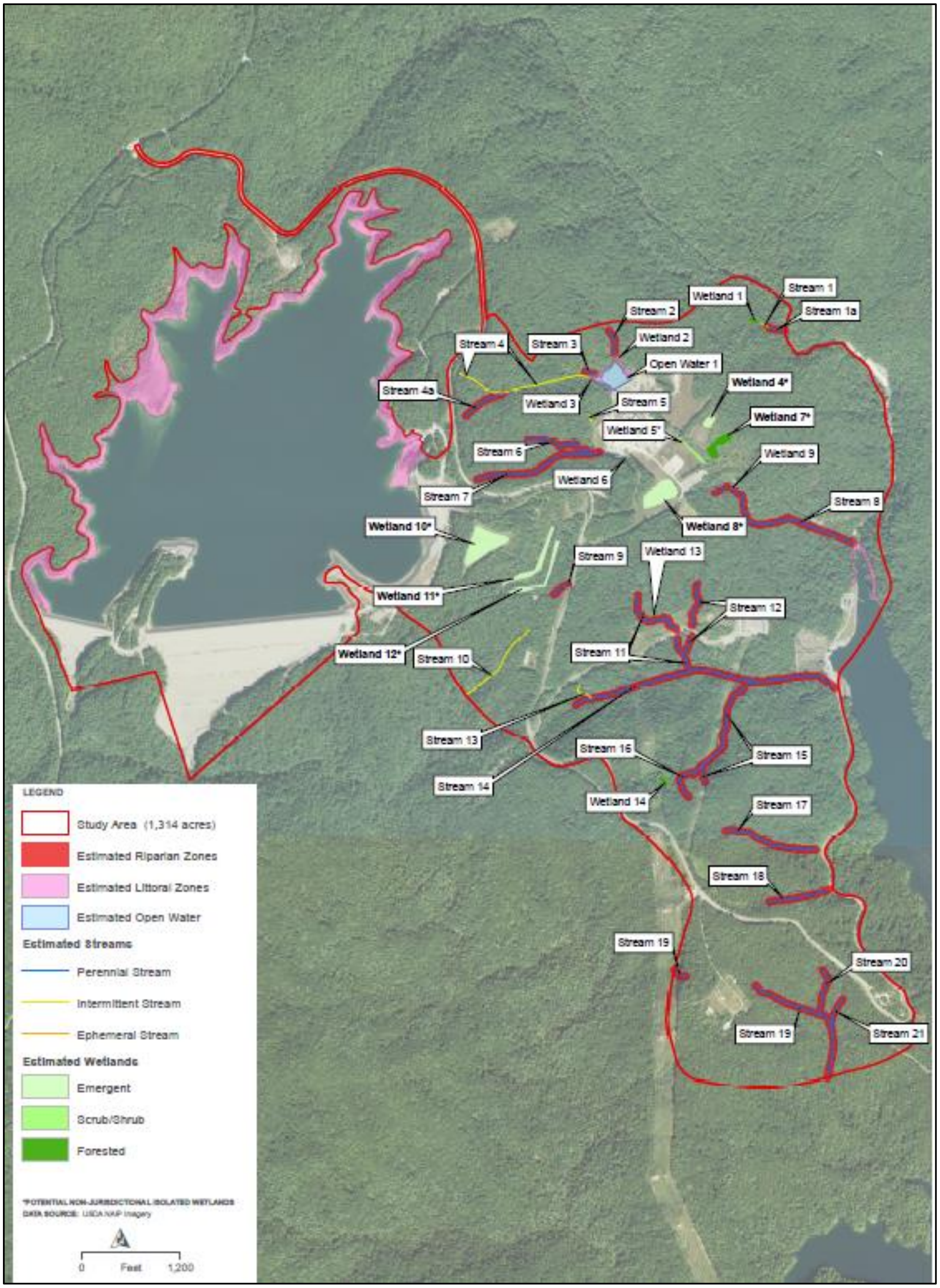


Figure 6.6-1. Bad Creek Project Boundary National Wetlands Inventory



Note: See Appendix E for details

Figure 6.6-2. Estimated Riparian and Littoral Zones from Desktop Analysis and Wetlands from Field Assessment

On June 8-10, 2021, HDR biologists surveyed the Bad Creek-to-Jocassee transmission line corridor for wetlands and jurisdictional waters of the U.S. regulated under Section 404 of the CWA. This 436-acre area consists of a maintained utility line right-of-way (approximately 9.25 miles long, and 400-feet wide) with two transmission lines (a 100-kV line [Eastatoe Line] and a 525-kV line [Whitewater Line]), and a 50-foot buffer.

On September 1-3, 2021, HDR biologists surveyed the balance of the area of influence including Bad Creek Reservoir and dams, inlet/outlet structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, driveways, parking lots, maintenance buildings, open areas, access roads, and undisturbed forested areas for wetlands and jurisdictional waters of the U.S.

The wetlands and waterbodies assessments were conducted according to the methodologies and guidance described in the U.S. Army Corps of Engineers (USACE) 1987 Wetland Delineation Manual (USACE 1987), the 2012 USACE Eastern Mountains and Piedmont Regional Supplement (Version 2.0) (USACE 2012), and the North Carolina Division of Water Quality (NCDWQ) Methodology for Identification of Intermittent and Perennial Streams and Their Origins (Version 4.11) (NCDWQ 2010).

Accessible jurisdictional waters of the U.S. were delineated and mapped using a Trimble® Geo7X Global Positioning System (GPS) unit capable of sub-meter accuracy. GPS points were post-processed utilizing Trimble® GPS Pathfinder Office software. Due to the extremely challenging and potentially dangerous field conditions within the area of influence, and particularly the transmission line corridor (i.e., rugged terrain with precipitous drops in elevation), some potentially jurisdictional features were not field-delineated (flagged in the field); instead, these features were field-documented (i.e., photographs, GPS points, and field notes) and delineated via desktop methods.

The on-site reconnaissance activities of the transmission line corridor identified 47 jurisdictional streams, 17 jurisdictional wetlands, and 1 open water within the 436-acre area covered by this survey. The field survey of the balance of the area of influence estimated 23 potentially jurisdictional streams, 7 potentially jurisdictional wetlands, and 7 potentially non-jurisdictional isolated wetlands, and one potentially jurisdictional open water. The following subsections include the summarized results of these surveys, and the full reports are included in Appendix E.

6.6.1.1 Transmission Line Corridor

The on-site reconnaissance activities of the transmission line corridor identified 47 jurisdictional streams, 17 jurisdictional wetlands, and 1 open water within the 436-acre area covered by this survey. A summary of jurisdictional water of the U.S is provided in Table 6.6-1 (Streams) and Table 6.6-2 (Wetlands). Refer to Appendix E for complete descriptions, maps, and photographs of streams and wetlands.

Table 6.6-1. Summary of Delineated Jurisdictional Waters of the U.S. within the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Delineation Field/Desktop
Stream 1 Tributary to Lake Jocassee	35.007605/ -82.999465	R5UB	No	Non section-10, non-wetland	4	292	Field
Stream 2 Tributary to Lake Jocassee	35.007471/ -83.000856	R5UB	No	Non section-10, non-wetland	N/A	105	Field
Stream 3 Tributary to Lake Jocassee	35.007427/ -83.00065	R5UB	No	Non section-10, non-wetland	6	518	Field
Stream 4 Tributary to Lake Jocassee	35.005426/ -83.001804	R5UB	No	Non section-10, non-wetland	2	118	Field
Stream 5 Tributary to Lake Jocassee	35.005456/ -83.001424	R5UB	No	Non section-10, non-wetland	6	492	Field
Stream 6 Tributary to Lake Jocassee	35.004004/ -83.000687	R4SB3	No	Non section-10, non-wetland	2	77	Desktop
Stream 7 Tributary to Howard Creek	34.998808/ -83.000566	R4SB3	No	Non section-10, non-wetland	1	305	Field
Stream 8 Tributary to Howard Creek	34.996033/ -83.000017	R4SB3	No	Non section-10, non-wetland	1	363	Field
Stream 9 Tributary to Howard Creek	34.995722/ -83.000043	R5UB	No	Non section-10, non-wetland	2	406	Field
Stream 10 Howard Creek	34.979904/ -82.995071	R3RB1	No	Non section-10, non-wetland	30	744	Desktop
Stream 11 Bad Creek	34.973516/ -82.991385	R3RB1	No	Non section-10, non-wetland	N/A	388	Desktop
Stream 12 Tributary to Bad Creek	34.969395/ -82.989084	R4SB3	No	Non section-10, non-wetland	2	426	Desktop

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Delineation Field/Desktop
Stream 13 Tributary to Bad Creek	34.967167/ -82.987982	R5UB	No	Non section-10, non-wetland	5	950	Desktop
Stream 14 Tributary to Burgess Creek	34.963408/ -82.986504	R5UB	No	Non section-10, non-wetland	2	638	Field
Stream 15 Tributary to Burgess Creek	34.961486/ -82.985501	R5UB	No	Non section-10, non-wetland	4	555	Desktop
Stream 16 Tributary to Burgess Creek	34.960094/ -82.985267	R4SB3	No	Non section-10, non-wetland	2	364	Desktop
Stream 17 Tributary to Burgess Creek	34.959568/ -82.985056	R5UB	No	Non section-10, non-wetland	2	410	Desktop
Stream 18* Tributary to McKinneys Creek	34.956222/ -82.983014	N/A	No	Non section-10, non-wetland	N/A	116	Desktop
Stream 19 Tributary to McKinneys Creek	34.954374/ -82.98097	R4SB3	No	Non section-10, non-wetland	1	135	Desktop
Stream 20 Tributary to Smeltzer Creek	34.950466/ -82.974798	R4SB3	No	Non section-10, non-wetland	1	232	Desktop
Stream 21 Tributary to Smeltzer Creek	34.950178/ -82.974556	R5UB	No	Non section-10, non-wetland	2	266	Desktop
Stream 22 Tributary to Smeltzer Creek	34.950232/ -82.974548	R4SB3	No	Non section-10, non-wetland	1	93	Desktop
Stream 23 Tributary to McKinneys Creek	34.947858/ -82.969656	R4SB3	No	Non section-10, non-wetland	5	198	Field
Stream 24 Tributary to McKinneys Creek	34.947375/ -82.969274	R4SB3	No	Non section-10, non-wetland	4	400	Field
Stream 25 Tributary to McKinneys Creek	34.946827/ -82.967671	R5UB1	No	Non section-10, non-wetland	4	228	Field
Stream 26 Tributary to McKinneys Creek	34.94593/ -82.96611	R4SB3	No	Non section-10, non-wetland	3	218	Field
Stream 27 Tributary to McKinneys Creek	34.944548/ -82.963566	R4SB3	No	Non section-10, non-wetland	2	181	Desktop
Stream 28 Tributary to McKinneys Creek	34.944078/ -82.963383	R5UB1	No	Non section-10, non-wetland	8	393	Desktop
Stream 29	34.943604/	R4SB4	No	Non section-10,	5	53	Field

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Delineation Field/Desktop
Tributary to McKinneys Creek	-82.961675			non-wetland			
Stream 30 Tributary to McKinneys Creek	34.943499/ -82.961551	R4SB4	No	Non section-10, non-wetland	5	78	Desktop
Stream 31 Tributary to McKinneys Creek	34.942654/ -82.960143	R4SB3	No	Non section-10, non-wetland	4	121	Field
Stream 32 Tributary to McKinneys Creek	34.942443/ -82.959684	R4SB3	No	Non section-10, non-wetland	3	92	Field/Desktop
Stream 33 Tributary to McKinneys Creek	34.939394/ -82.954482	R4SB3	No	Non section-10, non-wetland	3	193	Field
Stream 34 Tributary to McKinneys Creek	34.939177/ -82.954722	R5UB	No	Non section-10, non-wetland	20	923	Field/Desktop
Stream 35 Tributary to McKinneys Creek	34.938624/ -82.952141	R4SB4	No	Non section-10, non-wetland	3	143	Desktop
Stream 36 Tributary to McKinneys Creek	34.937162/ -82.945579	R4SB3	No	Non section-10, non-wetland	1	131	Desktop
Stream 37 McKinneys Creek	34.937468/ -82.943401	R3RB1	No	Non section-10, non-wetland	35	1667	Desktop
Stream 38 Tributary to McKinneys Creek	34.936968/ -82.934986	R4SB4	No	Non section-10, non-wetland	5	126	Desktop
Stream 39 Tributary to McKinneys Creek	34.936725/ -82.934224	R5UB	No	Non section-10, non-wetland	5	337	Field/Desktop
Stream 40 Tributary to McKinneys Creek	34.936397/ -82.932557	R4SB3	No	Non section-10, non-wetland	4	502	Field/Desktop
Stream 41 Tributary to McKinneys Creek	34.935929/ -82.928646	R4SB3	No	Non section-10, non-wetland	2	474	Field/Desktop
Stream 42 Tributary to Keowee River	34.935294/ -82.923879	R5UB	No	Non section-10, non-wetland	5	474	Field
Stream 43 Tributary to McKinneys Creek	34.937773/ -82.921347	R4SB3	No	Non section-10, non-wetland	4	294	Field
Stream 44 Tributary to McKinneys Creek	34.941303/ -82.921558	R5UB	No	Non section-10, non-wetland	4	502	Field
Stream 45 Tributary to McKinneys Creek	34.943124/ -82.921786	R4SB3	No	Non section-10, non-wetland	4	75	Field
Stream 46	34.947967/	R4SB3	No	Non section-10,	0	176	Field

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Delineation Field/Desktop
Tributary to Keowee River	-82.920913			non-wetland			
Stream 47 Tributary to Keowee River	34.953631/ -82.917938	R5UB1	No	Non section-10, non-wetland	4	43	Field
					Total:	**16,015 feet**	

[1] R3RB = Riverine, upper perennial, rocky shore, bedrock
R4SB3 = Riverine, intermittent, streambed, cobble-gravel
R4SB4 = Riverine, intermittent, streambed, sand
R5UB = Riverine, unknown perennial, unconsolidated bottom
R5UB1 = Riverine, unknown perennial, unconsolidated bottom, cobble-gravel
*N/A = Information Not Available

6.6.1.1.1 Relatively Permanent Waters with Seasonal Flow

Streams 1 – 5, 9, Stream 10 (Howard Creek), Stream 11 (Bad Creek), Streams 13 – 15, 17, 21, 25, 28, 34, Stream 37 (McKinneys Creek), Streams 39, 41, 42, 44, and 47 were identified as Relatively Permanent Waters (RPWs) that exhibit perennial surface water flow to Traditional Navigable Waters (TNWs). According to the Cowardin Classification hierarchical structure (Cowardin et al. 1979), Streams 10, 11, and 37 were identified as riverine upper perennial feature with rock bottom, and a bedrock bottom (R3RB1). Streams 1 – 5, 9, 13 – 15, 17, 21, 25, 28, 34, 39, 41, 42, 44, and 47 were identified as unknown perennial features with unconsolidated bottoms (R5UB). Streams 25, 28, and 47 were identified as unknown perennial features with unconsolidated bottoms, and a cobble-gravel bottom (R5UB1). OHWM indicators observed during the assessment included a well-defined natural line impressed on the bank, shelving, absence of vegetation, disturbed and/or washed away leaf litter, sediment deposition, the presence of wrack lines, sediment sorting, and scour.

6.6.1.1.2 Relatively Permanent Waters with Seasonal Flow

Streams 6 – 8, 12, 16, 19, 20, 22 – 24, 26, 27, 29, 30, 31 – 33, 35, 36, 38, 40, 41, 43, 45, and 46 were identified as RPWs that exhibit continuous seasonal surface flow to TNWs. According to the Cowardin Classification hierarchical structure (Cowardin et al. 1979), Streams 6, 7, 8, 16, 12, 19, 20, 22 – 24, 26, 27, 31 – 33, 36, 40, 41, 43, 45, and 46 were identified as intermittent features with cobble-gravel streambeds (R4SB3). Streams 29, 30, 35, and 38 were identified as intermittent features sandy bottom streambeds (R4SB4). OHWM indicators observed during the assessment include a well-defined natural line impressed on the bank, disturbed or washed away leaf litter, absence of vegetation, sediment deposition, and scour.

Table 6.6-2. Summary of Delineated Jurisdictional Wetlands of the U.S. within the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	Type of Jurisdiction	Estimated Amount of Aquatic Resource in Review Area (acres)	Delineation Field/Desktop
Wetland 1	35.002006/ -83.000426	PFO1A	Non section 10, wetland	0.21	Field
Wetland 2	34.964528/ -82.986422	PEM1B	Non section 10, wetland	0.20	Field
Wetland 3	34.946697/ -82.968198	PEM1B	Non section 10, wetland	0.09	Field/Desktop
Wetland 4	34.946288/ -82.967052	PEM1B	Non section 10, wetland	0.09	Desktop
Wetland 5	34.946105/ -82.966438	PEM1B	Non section 10, wetland	0.04	Desktop
Wetland 6	34.939473/ -82.954447	PSS1B	Non section 10, wetland	0.03	Field
Wetland 7	34.938974/ -82.953543	PEM1B	Non section 10, wetland	0.08	Field/Desktop
Wetland 8	34.938626/ -82.952386	PEM1B	Non section 10, wetland	0.08	Field
Wetland 9	34.937447/ -82.947585	PEM1B	Non section 10, wetland	0.94	Desktop
Wetland 10	34.93611/ -82.932187	PEM1A	Non section 10, wetland	0.10	Desktop
Wetland 11	34.935799/ -82.928469	PEM1B	Non section 10, wetland	0.05	Desktop
Wetland 12	34.935572/ -82.924748	PEM1B	Non section 10, wetland	0.09	Field
Wetland 13	34.935551/ -82.922075	PEM1B	Non section 10, wetland	0.51	Desktop
Wetland 14	34.937813/ -82.921394	PEM1A	Non section 10, wetland	0.02	Field
Wetland 15	34.941097/ -82.921763	PSS1B	Non section 10, wetland	0.04	Field
Wetland 16	34.941877/ -82.921115	PSS1B	Non section 10, wetland	0.07	Field
Wetland 17	34.953551/ -82.917925	PFO1B	Non section 10, wetland	0.03	Field
			Total:	**2.67 acres**	

[1] PEM1A = Palustrine, emergent, persistent, temporarily flooded.
PEM1B = Palustrine, emergent, persistent, saturated.
PFO1A = Palustrine, forested, broad-leaved deciduous, temporarily flooded.
PFO1B = Palustrine, forested, broad-leaved deciduous, saturated.
PSS1B = Palustrine, scrub-shrub, broad-leaved deciduous, saturated.

6.6.1.1.3 Wetlands

Emergent Wetland

Wetlands 2 through 5, and 7 through 14 were identified as palustrine, emergent, persistent wetlands (PEM1) (Cowardin et al. 1979). Herbaceous species are dominant and consist of soft rush (*Juncus effusus*), shallow sedge (*Carex lurida*), cattail (*Typha angustifolia*) and woolgrass (*Scirpus cyperinus*). Primary and secondary wetland hydrology indicators observed during the assessment include high water table, saturation, oxidized rhizospheres on living roots, water-stained leaves, and drainage patterns. Hydric soil indicators include a depleted matrix within the upper 12 inches of the soil profile, prominent redox concentrations and indicators consistent with hydric soils.

Forested Wetland

Wetlands 1 and 17 were identified as palustrine, forested, broad-leaved deciduous (PFO1) wetlands according to the Cowardin (et al. 1979) hierarchical structure. Wetland 1 was identified as a temporarily flooded wetland (PFO1A). These wetlands exhibit sparsely vegetated concave surfaces. Tree species are dominant and consist of black willow (*Salix nigra*), red maple (*Acer rubrum*), persimmon (*Diospyros virginiana*), black tupelo (*Nyssa sylvatica*), and green ash (*Fraxinus pennsylvanica*). Primary and secondary wetland hydrology indicators include surface water, high water table, saturation, sediment deposits, water-stained leaves, the presence of oxidized rhizospheres on living roots, and geomorphic position. Hydric soil indicators include a depleted matrix within the upper 12 inches of the soil profile and distinct redox concentration starting at 4 inches of the soil profile.

Scrub/Shrub Wetland

Wetlands 6, 15, and 16 were identified as palustrine, scrub-shrub, deciduous, saturated wetlands (PSS1B) (Cowardin et al. 1979).

Primary and secondary wetland hydrology indicators observed during the assessment include high water tables, drainage patterns, water-stained leaves, and geomorphic position. Hydric soil indicators include a depleted matrix below the surface, and a gleyed matrix within the upper 12 inches of the soil profile. Scrub-shrub vegetation was dominant and consisted of black tupelo and American hophornbeam (*Ostrya virginiana*).

Open Waters

Open waters consisted of one freshwater impoundment, Lake Keowee (Open Water 1), and was identified as palustrine, unconsolidated bottom, permanently flooded, diked/impounded (PUBHh) features according to the Cowardin hierarchical structure (Cowardin et al. 1979).

Table 6.6-3. Summary of Open Waters of the U.S. within the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	Type of Jurisdiction	Estimated Amount of Aquatic Resource in Review Area (acres)
Open Water 1 Lake Keowee	34.951090/ -82.920118	PUBHh	Non section-10, non-wetland	2.3

[1] PUBHh = Palustrine, unconsolidated bottom, permanently flooded, diked/impounded

6.6.1.2 Area of Influence Excluding Transmission Line Corridor

The field survey of this area estimated 23 potentially jurisdictional streams, 7 potentially jurisdictional wetlands, and 7 potentially non-jurisdictional isolated wetlands, and one potentially jurisdictional open water. A summary of jurisdictional water of the U.S is provided in Table 6.6-4 (Streams) and Table 6.6-5 (Wetlands). Refer to Appendix E for complete descriptions, maps, and photographs of streams and wetlands.

Table 6.6-4. Summary of Delineated Jurisdictional Waters of the U.S. within the Area of Influence, Excluding the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Field/ Desktop Method	SCDHEC Water Classification
Stream 1 Tributary of Whitewater River	35.017309/ -82.996716	R6	No	Non section-10, non-wetland	3	107	Field	ORW
Stream 1a Tributary of Whitewater River	35.017154/ -82.996251	R5UB1	No	Non section-10, non-wetland	3	204	Field	ORW
Stream 2 Tributary of Whitewater River	35.016612/ -83.002729	R5UB1	No	Non section-10, non-wetland	8	314	Field	ORW

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Field/ Desktop Method	SCDHEC Water Classification
Stream 3 Tributary of Whitewater River	35.015567/ -83.003704	R5UB1	No	Non section-10, non-wetland	6	134	Field	ORW
Stream 4 Tributary of Whitewater River	35.010507/ -83.006335	R4SB3	No	Non section-10, non-wetland	3	1705	Field	ORW
Stream 4a Tributary of Whitewater River	35.014573/ -83.007978	R5UB1	No	Non section-10, non-wetland	3	542	Field	ORW
Stream 5 Tributary of Whitewater River	35.014023/ -83.003695	R4SB3	No	Non section-10, non-wetland	4	115	Field	ORW
Stream 6 Tributary of Whitewater River	35.013187/ -83.004582	R5UB1	No	Non section-10, non-wetland	3	1031	Field	ORW
Stream 7 Tributary of Whitewater River	35.012733/ -83.005029	R5UB1	No	Non section-10, non-wetland	4	1556	Field	ORW
Stream 8 Tributary of Whitewater River	35.010744/ -82.996315	R5UB1	No	Non section-10, non-wetland	4	2065	Field	ORW
Stream 9 Tributary of Whitewater River	35.008408/ -83.004716	R5UB	No	Non section-10, non-wetland	4	217	Field	ORW
Stream 10 Tributary of Whitewater River	35.005939/ -82.007026	R4SB3	No	Non section-10, non-wetland	2	1144	Field	ORW
Stream 11 Tributary of Lake Jocassee	35.006202/ -82.999718	N/A	No	Non section-10, non-wetland	N/A	1250	Field	TPGT
Stream 12 Tributary of Lake Jocassee	35.007454/ -82.999402	N/A	No	Non section-10, non-wetland	N/A	833	Field	TPGT

Feature Name	Latitude/ Longitude	Cowardin Class[1]	§303 (d) (Y/N)	Type of Jurisdiction	Stream Width (ft)	Estimated Amount of Aquatic Resource in Review Area (ft)	Field/ Desktop Method	SCDHEC Water Classification
Stream 13 Tributary of Lake Jocassee	35.004870/ -83.003711	R4SB3	No	Non section-10, non-wetland	2	621	Field	TPGT
Stream 14 Tributary of Lake Jocassee	35.005732/ -82.998758	R3RB1	No	Non section-10, non-wetland	4	3277	Desktop	TPGT
Stream 15 Tributary of Lake Jocassee	35.004001/ -82.997931	R5UB1	No	Non section-10, non-wetland	2	2196	Desktop	TPGT
Stream 16 Tributary of Lake Jocassee	35.002184/ -82.999679	R5UB	No	Non section-10, non-wetland	3	621	Desktop / Field	TPGT
Stream 17 Tributary of Lake Jocassee	34.999955/ -82.996057	R5UB1	No	Non section-10, non-wetland	2	1151	Field	TPGT
Stream 18 Tributary of Lake Jocassee	34.954374/ -82.98097	N/A	No	Non section-10, non-wetland	N/A	747	Desktop	TPGT
Stream 19 Devil's Fork	34.994273/ -82.993806	R5UB1	No	Non section-10, non-wetland	2	1891	Field	TPGT
Stream 20 Tributary of Devil's Fork Creek	34.995032/ -82.993812	R5UB1	No	Non section-10, non-wetland	2	577	Desktop / Field	TPGT
Stream 21 Tributary of Devil's Fork Creek	34.994306/ -82.993386	N/A	No	Non section-10, non-wetland	N/A	362	Desktop	TPGT
Total:						**22,660 feet**		

[1]R3RB1 = Riverine, upper perennial, rocky shore, bedrock
R4SB3 = Riverine, intermittent, streambed, cobble-gravel
R5UB = Riverine, unknown perennial, unconsolidated bottom
R5UB1 = Riverine, unknown perennial, unconsolidated bottom, cobble-gravel
R6 = Ephemeral
*N/A = Information Not Available due delineation conducted via desktop.

6.6.1.2.1 Relatively Permanent Waters with Seasonal Flow

Twelve streams exhibit perennial surface water flow to TNWs. According to the Cowardin Classification hierarchical structure (Cowardin et al. 1979). Stream 14 was identified as a riverine upper perennial feature with rock bottom, and a bedrock bottom (R3RB1). Streams 9 and 16 were identified as unknown perennial features with unconsolidated bottoms (R5UB). Streams 1a, 2, 3, 4a, 6, 7, 8, 15, 17, 19 (Devil’s Fork), and 20 were identified as unknown perennial features with unconsolidated bottoms, and a cobble-gravel bottom (R5UB1). OHWM indicators observed during the assessment included a well-defined natural line impressed on the bank, shelving, absence of vegetation, disturbed and/or washed away leaf litter, sediment deposition, the presence of wrack lines, sediment sorting, and scour.

6.6.1.2.2 Relatively Permanent Waters with Seasonal Flow

Streams 4, 5, 10, and 13 were identified as RPWs that exhibit continuous seasonal surface flow to TNWs. According to the Cowardin Classification hierarchical structure (Cowardin et al. 1979), Streams 4, 5, 10, and 13 were identified as having intermittent features with cobble-gravel streambeds (R4SB3). Stream 1 was identified as having ephemeral features (R6). OHWM indicators observed during the assessment include a well-defined natural line impressed on the bank, disturbed or washed away leaf litter, absence of vegetation, sediment deposition, and scour.

Table 6.6-5. Summary of Delineated Jurisdictional Wetlands of the U.S. within the Area of Influence, Excluding the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	Type of Jurisdiction	Estimated Amount of Aquatic Resource in Review Area (acres)	Delineation Field/Desktop
Wetland 1	35.017444/ -82.997152	PFO1A	Non section 10, wetland	0.19	Field/ Desktop
Wetland 2	35.016034/ -83.002669	PFO1A	Non section 10, wetland	0.16	Field/ Desktop
Wetland 3	35.015447/ -83.003539	PFO1B	Non section 10, wetland	0.14	Field/ Desktop
Wetland 4*	35.014031/ -82.998895	PEM1A	Non section 10, wetland	0.37	Field/ Desktop
Wetland 5*	35.013029/ -82.999567	PSS1B	Non section 10, wetland	0.40	Field/ Desktop
Wetland 6	35.012820/ -83.002279	N/A	Non section 10, wetland	0.59	Desktop
Wetland 7*	35.013291/ --82.998458	PFO1A	Non section 10, wetland	1.17	Field/ Desktop
Wetland 8*	35.011612/ -83.000774	PEM1B	Non section 10, wetland	2.08	Field/ Desktop
Wetland 9	35.01188/ -82.997959	PFO1B	Non section 10, wetland	0.11	Field/ Desktop
Wetland 10*	35.009826/ -83.007907	PEM1B	Non section 10, wetland	3.00	Field/ Desktop
Wetland 11*	35.009272/ -83.005815	PEM1B	Non section 10, wetland	1.22	Field/ Desktop
Wetland 12*	35.008874/ -83.005572	PEM1B	Non section 10, wetland	1.04	Field/ Desktop
Wetland 13	35.00748/ -83.00088	N/A	Non section 10, wetland	0.10	Desktop
Wetland 14	35.002013/ .83.000405	N/A	Non section 10, wetland	0.22	Desktop
			Total:	**10.79 acres**	

[1] PEM1A = Palustrine, emergent, persistent, temporarily flooded.
PEM1B = Palustrine, emergent, persistent, saturated.
PFO1A = Palustrine, forested, broad-leaved deciduous, temporarily flooded.
PFO1B = Palustrine, forested, broad-leaved deciduous, saturated.
PSS1B = Palustrine, scrub-shrub, broad-leaved deciduous, saturated.
*Potentially non-jurisdictional isolated wetland

6.6.1.2.1 Wetlands

Isolated Wetlands

Wetlands 4, 5, 7, 8, 10, 11, and 12 were identified as isolated wetlands that do not appear to have a significant nexus to a TNW or are abutting a RPW. These wetlands were likely formed by impervious spoil. Wetlands 4, 8, and 10-12 were identified as palustrine, emergent, persistent wetlands (PEM1) (Cowardin et al. 1979). Herbaceous species are dominant and consist of arrow-leaved tearthumb (*Polygonum sagittata*), (soft rush (*Juncus effusus*), shallow sedge (*Carex lurida*), cattail (*Typha angustifolia*), Japanese stiltgrass (*Microstegium vimineum*), and woolgrass (*Scirpus cyperinus*). Primary and secondary wetland hydrology indicators observed during the assessment included high water table, saturation, oxidized rhizospheres on living roots, water-stained leaves, and drainage patterns typical of this wetland.

Wetland 5 was identified as palustrine, scrub-shrub, deciduous, saturated wetlands (PSS1B) (Cowardin et al. 1979). Tree species (primarily saplings) consist of black willows, black locust, sawtooth oak, while the herbaceous layer is dominated by Japanese stilt grass, wool grass, and beggar's tick (*Bidens* spp.).

Primary and secondary wetland hydrology indicators observed during the assessment include high water tables, saturation, stunted vegetation, drainage patterns, water-stained leaves, and geomorphic position typical of this wetland. Scrub-shrub vegetation was dominant and consisted of blackberry (*Rubus* spp.), woolgrass (*Scirpus cyperinus*), blueberry (Vaccinium spp.), boneset (*Eupatorium perfoliatum*), soft rush (*Juncus effusus*), and lizard's tail (*Saururus cernuus*).

Forested Wetland

Wetlands 1-3, and 9 were identified as palustrine, forested, broad-leaved deciduous (PFO1) wetlands according to the Cowardin (et al. 1979) hierarchical structure. Wetland 1 was identified as a temporarily flooded wetland (PFO1A) and 2-3 and 7 are considered saturated. These wetlands exhibit concave surfaces. Tree species are dominant and consist of sawtooth oak *(Quercus acutissima),* basswood *(Tilia americana*), black willow, (*Salix nigra*), green ash (*Fraxinus pennsylvanica*), honey locust (*Gleditsia tricanthos*), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), black tupelo (*Nyssa sylvatica*), and green ash (*Fraxinus pennsylvanica*). The herbaceous and shrub layer is dominated by wood fern (*Thelypteris kunthii*), deer-tongue (*Dicanthelium clandestinum*), and witch-hazel (*Hamamelis* spp.). Primary and secondary wetland hydrology indicators include surface water, high water table, saturation, water-stained leaves, aquatic vegetation, and geomorphic position typical of this of wetland.

Open Waters

The fire protection pond located at the junction of Stream 2 and Stream 3 was identified as an open water and was classified as palustrine, unconsolidated bottom, permanently flooded, diked/impounded (PUBHh) features according to the Cowardin hierarchical structure (Cowardin et al. 1979).

Table 6.6-6. Summary of Open Waters of the U.S. within the Area of Influence, Excluding the Transmission Line Corridor

Feature Name	Latitude/ Longitude	Cowardin Class[1]	Type of Jurisdiction	Estimated Amount of Aquatic Resource in Review Area (acres)
Open Water 1 Fire Protection Pond	35.012387 -83.01685	PUBHh	Non section-10, non-wetland	1.70

[1] PUBHh = Palustrine, unconsolidated bottom, permanently flooded, diked/impounded
Open waters were delineated from desktop and are approximate acreages.

6.6.1.3 Flood Hazards

Based on a review of the Federal Emergency Management Agency's (FEMA) National Flood Hazard Layer data (2019a), the Project does not fall within a Special Flood Hazard Area (SFHA); SFHA are classified by FEMA as high flood risk (AE) zones and are subject to inundation by the 1-percent-annual-chance flood event being equaled or exceeded in any given year (i.e., 100-year flood). Approximately 0.13 acre of the Project Boundary is mapped as Zone AE (easternmost portion of Project Boundary). The 1-percent annual chance flood is also referred to as the base flood or 100-year flood (FEMA 2019b). Additionally, approximately 5.9 acres of Zone AE is mapped along McKinneys Creek (Stream 37) along the powerline right-of-way in the southern portion of the Project Boundary. Approximately 2.3 acres of Zone AE associated with Lake Keowee (Keowee River) is mapped near the Jocassee Station in the southern portion of the Project Boundary; however, no Regulatory Floodway areas occur within the area of influence (FEMA Map Numbers 45073C0020C, 45073C0040D, 45073C0100D, 45073C0105D, 45073C0115D, 45073C0120D, and 45073C0110D). Figure 6.6-3 shows the FEMA Flood Zones within the Project Boundary.

Zones AE extends into the area of influence along Whitewater River; however, no Regulatory Floodway areas occur where Bad Creek II facilities are proposed (FEMA Map Numbers 45073C0020C, 45073C0040D, 45073C0100D, and 4507C0105D). Impacts to jurisdictional features, development, or improvements to existing uses within the SFHA may require FEMA compliance.

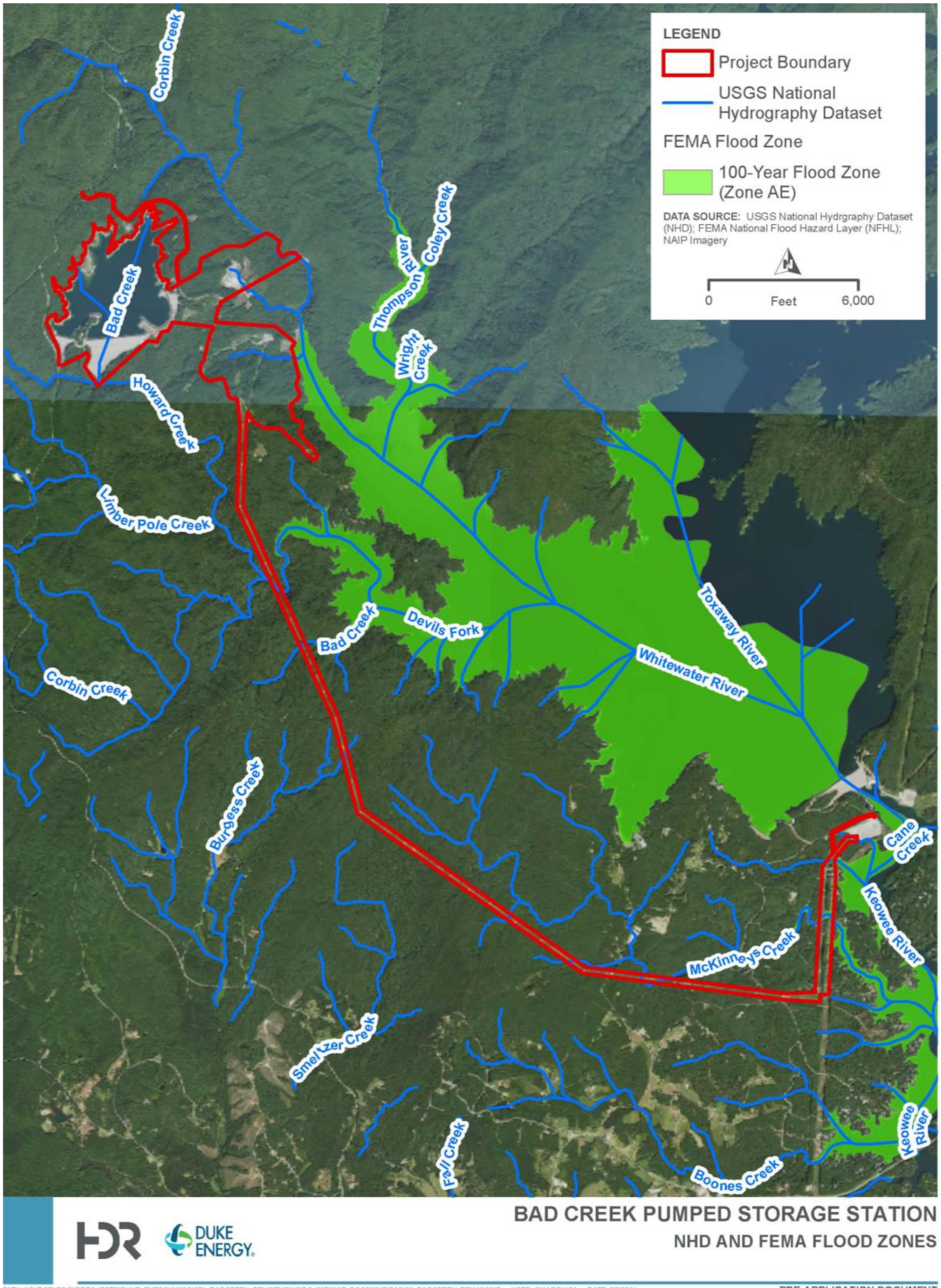


Figure 6.6-3. FEMA Flood Zones and NHD

6.6.2 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Continued operations at the Project are not anticipated to impact existing wetland, riparian, and littoral habitat.

During the New License term, exchanges of water between Bad Creek Reservoir and Lake Jocassee are not expected to differ from existing conditions. In both reservoirs, daily changes in reservoir levels will continue to result in frequent inundation and drying of the soils along the reservoir perimeter and will have some influence on vegetation growing within the affected area. However, these effects are generally limited to a narrow band around the reservoirs and are consistent with current operations. As such, daily changes in reservoir elevations under continued Bad Creek Project operations with have minimal effects on vegetation at Lake Jocassee or Bad Creek.

6.6.3 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

Lake Jocassee is classified as state navigable waters (SCDHEC 2019a; 2019b). Activities occurring below or above the OHWM are regulated under the South Carolina State Regulation 19-450 Permits of Construction in Navigable Waters, and a permit is required by SCDHEC for any filling or construction or alteration in, on, or over navigable waters, or in, or on the bed under navigable waters, or in, or for any activity significantly affecting the flow of any navigable water.

A separate Construction in State Navigable Waters Permit would not be required for activities that require another SCDHEC permit for certification including but not limited to 401 Water Quality Certifications, water supply permits, and National Pollutant Discharge Elimination System stormwater permits. A public notice to a newspaper of local and statewide circulation and as well as notification letters informing owners or residents of property adjoining the area of the proposed activities may be required. The applicant shall provide SCDHEC with an affidavit of publication from the newspaper within fifteen (15) days of publication.

Construction of the proposed Bad Creek II Complex infrastructure and spoil areas will result in unavoidable temporary and permanent impacts to wetlands and surface waterbodies. Impacts may include dredging, fill, clearing, and de-watering. CWA Section 404/401 permits and coordination from environmental regulatory agencies will be required to authorize impacts to surface waters. Permit applications require compensatory mitigation and detailed best management practices to protect downstream water quality. Floodplain development permits will be required from the local floodplain administrator for proposed activities within classified Special Flood Hazard Areas.

Because construction of the Bad Creek II Complex would not require construction of any new dams or reservoirs, the scale of impact and disturbance of impacts to wetlands and surface water bodies is small compared to development of a greenfield energy storage and generation project of this size. However, according to the preliminary studies and estimates for proposed material removed from underground excavations, approximately 4 million cubic yards of spoil material for the Bad Creek II Complex infrastructure will need to be deposited into on-site spoil locations or along the submerged weir in Lake Jocassee. Potential spoil locations and estimated impacts to water resources are included in Table 6.6-7. Proposed Bad Creek II Complex above-ground structure estimated impacts to water resources are included in Table 6.6-8 (see Appendix E).

Table 6.6-7. Estimated Impacts to Water Resources by Potential Spoil Location

Spoil Area ID	Spoil Area Capacity (Million Cubic Yards)	Impacted Streams	Estimated Stream Impact Length (linear feet)	Estimated Wetlands Impacted	Wetland Impact Areas (acres)	Open Waters Impacted	Open Water Impact Amounts (acres)
A*+	1.3	0	0	0	0	Lake Jocassee	13.90
B*	1.3	19 P, 20 P, 21 P	1,865	0	0	0	0
C	0.7	17 P	286	0	0	0	0
D	1.3	13I, 14 P	996	0	0	0	0
E	0.16	0	0	10N	2.96	0	0
F*	0.25	0	0	4 N, 7N	1.52	0	0
G*	1.1	4 I, 4a P	1,484	0	0	0	0
H	1.5	0	0	0	0	Bad Creek Reservoir	19.26

Spoil Area ID	Spoil Area Capacity (Million Cubic Yards)	Impacted Streams	Estimated Stream Impact Length (linear feet)	Estimated Wetlands Impacted	Wetland Impact Areas (acres)	Open Waters Impacted	Open Water Impact Amounts (acres)
I*	1.1	0	0	0	0	0	0

*Duke Energy Preferred Spoil Area
[P]Perennial
[I]Intermittent
[N]Isolated Wetlands created by Duke Energy, would not be federally regulated or require mitigation
[+] Spoil Area A includes spoil placement along the existing submerged weir in Lake Jocassee

Table 6.6-8. Estimated Impacts to Water Resources by Potential Aboveground Structure Locations

Proposed Structure	Impacted Streams	Estimated Stream Impact Length (linear feet)	Estimated Wetlands Impacted	Wetland Impact Areas (acres)	Open Waters Impacted	Open Water Impact Amounts (acres)
525 kV Switchyard	6 [P], 7 [P]	425	6 [N], 8 [N]	1.50	0	0
Transformer Yard	0	0	0	0	0	0

[P]Perennial
[N]Isolated Wetlands created by Duke Energy, would not be federally regulated or require mitigation

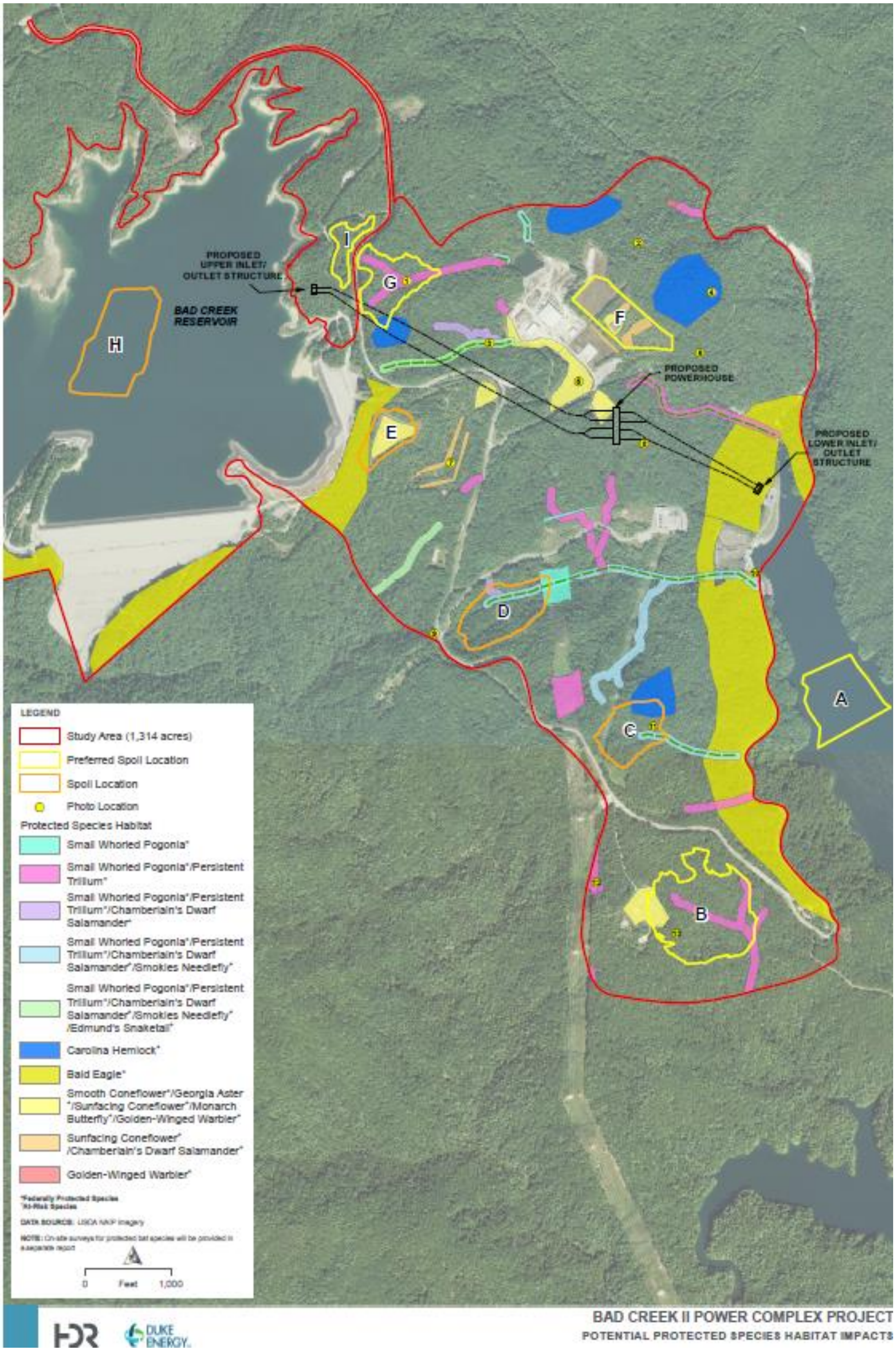


Figure 6.6-4. Proposed Spoil Locations Relative to Protected Habitat

6.7 Rare, Threatened, and Endangered Species (18 CFR §5.6(d)(3)(vii))

As part of the information-gathering process conducted to support the development of this PAD, HDR utilized the USFWS Information for Planning and Consultation (IPaC) database (USFWS 2021a), USFWS South Carolina List of At-Risk, Candidate, Endangered, and Threatened Species for Oconee County (USFWS 2021b), and the SCDNR Natural Heritage Program for Threatened and Endangered Species consultation report (SCNHP 2020) to evaluate the potential occurrence of Rare, Threatened, and Endangered (RTE) species within the Project Boundary.

Field investigations were carried out during summer 2021 to survey for federally protected species habitat and species of concern. These surveys (Appendix E) covered (1) a 436-acre area consisting of the maintained Bad Creek to Jocassee transmission line right-of-way (approximately 9.25 miles long and 400-feet wide) with two transmission lines (the 100-kV line [Eastatoe Line] and 525-kV line [Whitewater Line]), and a 50-foot unmaintained buffer and (2) a 1,314-acre area consisting of all existing Bad Creek Project facilities, maintained right-of-way areas, and undisturbed forested areas, including areas that could be impacted by construction of the Bad Creek II Complex. Additional field surveys were performed to assess the presence/absence of bat species and their potential habitats within the Project vicinity (Appendix G).

6.7.1 Federally Listed Threatened, Endangered, and Candidate Species (18 CFR §5.6(d)(3)(vii)(A))

6.7.1.1 Endangered Species Act

The purpose of the Endangered Species Act (ESA) is to “protect and recover imperiled species and the ecosystems upon which they depend” (USFWS 2013). HDR reviewed the list of federally protected species for Oconee County from the USFWS website, updated on May 3, 2021 (USFWS 2021b). In addition, HDR consulted the USFWS IPaC database and the SCDNR Natural Heritage Program database for records of threatened and endangered species documented in the Project vicinity. The IPaC Resources List summarizes the species and trust resources under the USFWS’s jurisdiction known or expected to be at or near the area of influence. The query revealed no proposed threatened or endangered species, critical habitat or proposed critical habitat have been identified within the area of influence. The SCDNR consultation database also summarizes the records of species of concern associated with or near the area of influence.

Based on this review, a total of six threatened, endangered, or candidate species have the potential to occur in Oconee County Table 6.7-1. A summary of the desktop review is provided below.

Table 6.7-1. Federally Protected Species Potentially Occurring within the Project Boundary

Species	Federal Designation[1]	Preferred Habitat	Survey Window	Habitat Present in Project Boundary
Birds				
Bald Eagle (*Haliaeetus leucocephalus*)	BGEPA	Nests at tops of large, mature trees near large rivers, lakes, and marshes containing small animals, fish, and carrion.	Year round	Potential habitat located in large trees surrounding the Bad Creek Reservoir and Lake Jocassee. Bald eagles have been observed within the Project Boundary and there is an active nest on Lake Jocassee.
Mammals				
Indiana bat (*Myotis sodalis*)	E	Indiana bats hibernate in tight clusters on the ceilings and sides of caves and mines. Summer habitat includes small to medium river and stream corridors with well-developed riparian buffers and forested areas within 1 to 3 miles of small to medium rivers and streams.	Year round	Potential suitable habitat is abundant; however, recent presence/absence surveys indicated habitat is unoccupied.
Northern long-eared bat (*Myotis septentrionalis*)	T	Hibernates in caves and mines during winter, roosts under bark, in cavities or crevices in trees and snags during summer.	Year round	Potential suitable habitat is abundant; however, recent presence/absence surveys indicated habitat is unoccupied.
Plants				
Persistent trillium (*Trillium persistens*)	E	Deciduous or conifer-deciduous forests of ravines or gorges under canopies dominated by hemlock, white pine, beech, black oak, and chestnut oak.	Early March – Mid April	Forested areas adjacent to existing right-of-way and unmaintained low forested valleys.
Small whorled pogonia (*Isotria medeoloides*)	T	Older hardwood stands of beech, birch, maple, oak, and hickory, sometimes softwoods like hemlock, with an open understory; acidic soils with a thick layer of dead leaves, often on slopes or near small streams.	Mid May – Early July	Forested areas adjacent to existing right-of-way and unmaintained low forested valleys.
Smooth coneflower (*Echinacea laevigata*)	E	This species is typically found in meadows, open woodlands, the ecotonal	Late May-October	Existing maintained right-of-way

Species	Federal Designation[1]	Preferred Habitat	Survey Window	Habitat Present in Project Boundary
		regions between meadows and woodlands, cedar barrens, dry limestone bluffs, clear cuts, and roadside and utility rights-of-way.		

Source: USFWS 2021b

The following subsections include a summary of habitat descriptions and the presence/absence of habitat within the area of influence that are federally protected under the provisions of Section 7 and Section 9 of the ESA of 1973.

6.7.1.1.1 Bald Eagle (Haliaeetus leucocephalus) [Federally Protected under BGEPA]

As part of the desktop analysis, species protected under the Bald and Golden Eagle Protection Act (BGEPA) were reviewed for potential presence within the area of influence (USFWS 1978). The BGEPA prohibits the "taking" of bald eagles, parts, nests, or eggs without a permit from the U.S. Department of the Interior.

The USFWS Recommended Survey Window for Bald Eagle is October 1 – May 15. Bald eagles occur throughout much of the continental U.S. and Canada. The species frequently builds their nests in dominant live pines near large bodies of open water and may congregate around fish processing plants, dumps, and below dams where fish congregate. Nests typically measure 6 to 8 feet deep and 6 feet in diameter and are cone shaped. Bald eagles are opportunistic feeders and consume a variety of prey, which may be self-caught, scavenged, or robbed from other bird species. The threat to this species is attributed to disturbance and destruction of foraging and nesting habitat by urban and residential development (USFWS 1978).

Potential habitat for the bald eagle exists in large trees around Bad Creek Reservoir and Lake Jocassee. This species utilizes super canopy trees isolated from human disturbance for perching or roosting, and large bodies of water for foraging. One historical nest (N825-Y2019) has been documented approximately 5.5 miles northeast of the Project on Lake Jocassee.

Biological Opinions have been developed for the bald eagle for areas in the west (Oregon, California), midwest (Wyoming, Idaho), and southeast (Florida, Alabama), but none have been written for this species for activities occurring in South Carolina (USFWS 2022).

6.7.1.1.1 Indiana Bat (Myotis sodalis) [Federally Endangered]

The USFWS Recommended Survey Window for Indiana Bat is May 15 to August 15. Indiana bats hibernate during winter in caves or, occasionally, in abandoned mines. For hibernation, they require cool, humid caves with stable temperatures, under 50° F but above freezing. After hibernation, Indiana bats migrate to their summer habitat in wooded areas where they usually roost within live trees and/or snags with exfoliating bark, cracks, crevices, and/or hollows, greater than or equal to 5 inches in diameter. During summer, males roost alone or in small groups, while females roost in larger groups of up to 100 bats or more. Indiana bats forage in or along the edges of forested areas and eat a variety of flying insects found along rivers or lakes and in uplands (USFWS 2019b; ERM 2021).

One small cave/den was identified in the area of influence that could be utilized as winter hibernacula, and large trees and snags with suitable cavities or crevices for summer roosting habitat and suitable foraging habitat occur in the area of influence. The USFWS County List states the Indiana bat as “Not a South Carolina resident.” In 2021, habitat surveys in the area of influence were performed by ERM to identify potential roost trees for the Indiana bat (see Section 6.5.2.1 and Appendix F), particularly near water resources and forested edges that receive direct solar exposure. Habitat for the Indiana bat was found to be abundant near the Project. Therefore, acoustic surveys and mist surveys were conducted within the identified suitable habitat, however these surveys determined that the Indiana bat was not likely to be present (ERM 2021).

Coordination with the USFWS prior to any tree clearing activities would be conducted. No critical habitat for the Indiana bat is designated in the State of South Carolina. Biological Opinions developed for the Indiana bat have been completed in Arkansas, Indiana, Kentucky, Michigan, Missouri, New York, Ohio, Illinois, Tennessee, and West Virginia. No Biological Opinions appear to have been developed for projects in South Carolina, including Oconee County (USFWS 2022).

6.7.1.1.2 Northern long-eared bat (Myotis septentrionalis) [Federally Threatened]

The USFWS Recommended Survey Window for Northern long-eared bat is year-round; however, winter surveys are not as successful. Northern long-eared bats spend winter hibernating in caves and mines called hibernacula. They use areas in various sized caves or mines with constant temperatures, high humidity, and no air currents. Within hibernacula, surveyors find them hibernating most often in small crevices or cracks, often with only the nose and ears visible. During the summer, northern long-eared bats roost in trees smaller than those used by the Indiana bat and measuring three inches in diameter at breast height, in cavities or in crevices of both live trees and snags (dead trees). Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices. Rarely this bat has also been found roosting in structures such as barns and sheds (USFWS 2015).

Forested uplands and riparian area provide potential roosting and foraging habitat for the northern long-eared bat. USFWS and SCDNR typically recommend any tree clearing activities should be conducted during the inactive season (November 15th through March 31st) to avoid negative impacts to this species.

Multiple biological opinions have been developed for the northern long-eared bat in Alabama, Arkansas, Illinois, Indiana, Kentucky, Main, Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Tennessee, Virginia, and West Virginia. No Biological Opinions appear to have been developed for projects in South Carolina, including Oconee County (USFWS 2022). No official status reports exist for the northern long-eared bat; however, the general status of this species, the associated listing, fact sheets, range maps, and other important information are available on the USFWS website (USFWS 2017a). A recovery plan has not yet been developed for the northern long-eared bat. No critical habitat has been defined for the northern long-eared bat.

One small cave/den was identified in the Project Boundary that could be utilized as winter hibernacula, and large trees with peeling bark and snags with suitable cavities or crevices suitable for summer roosting habitat and potential foraging habitat occur in the Project Boundary. It is recommended that tree clearing activities are not conducted during the summer months to avoid impacts to roosting sites for the species. As presented in Section 6.5.2.1, habitat surveys in the vicinity of the Project were also performed by ERM to identify potential roost trees for the northern long-eared bat, particularly near water resources and forested edges that receive direct solar exposure. Habitat for the northern long-eared bat was found to be abundant near the Project. Therefore, acoustic surveys and mist surveys were conducted within the identified suitable habitat, however these surveys determined that the northern long-eared bat was not likely to be present (ERM 2021).

Coordination with the USFWS prior to any tree clearing activities would be conducted.

6.7.1.1.3 Persistent trillium (Trillium persistens) [Federally Endangered]

The USFWS Optimal Survey Window for persistent trillium is March through mid-April. Known populations of persistent trillium occur in the Tallulah Gorge in a single drainage straddling the Georgia/western South Carolina border. It occurs in organic soils in mixed deciduous-pine woodlands, along stream flats and at edges of Rhododendron thickets. The species prefers gorges and steep ravines, but some populations have also been found on slopes less than 45 degrees (USDA 2021c).

Data from SCDNR do not indicate known occurrences of persistent trillium within a 2-mile radius of the Project Boundary. No biological opinions have been developed for persistent trillium State of South Carolina or elsewhere (USFWS 2021c). Several status reports exist for persistent trillium and a recovery plan was developed in 1984. No critical habitat has been defined for persistent trillium.

Potential habitat for persistent trillium is present within the forested areas of the area of influence, specifically adjacent to streams within deep ravines under full mature tree canopies yet with plenty filter light and rich soils. Plants from the trillium genus were identified within the area of influence; coordination with USFWS including a survey for persistent trillium during the recommended optimal window would be conducted.

6.7.1.1.4 Small whorled pogonia (Isotria medeoloides) [Federally Threatened]

The USFWS Optimal Survey Window for small whorled pogonia is mid-May through early July. Small whorled pogonia is an orchid occurring in young as well as maturing (second to third successional growth) mixed-deciduous or mixed-deciduous/coniferous forests. The species does not appear to exhibit strong affinities for a particular aspect, soil type, or underlying geologic substrate. Sometimes it grows in stands of softwoods with a thick layer of dead leaves, often on slopes near small streams. The species may also be found on dry, rocky, wooded slopes; moist slopes; ravines lacking stream channels; or slope bases near braided channels of vernal streams. The orchid, often limited by shade, requires small light gaps or canopy breaks, and typically grows under canopies that are relatively open or near features like logging roads or streams creating long-persisting breaks in the forest canopy (USFWS 2019c).

Multiple biological opinions have been developed for small-whorled pogonia in Virginia and West Virginia, but none in the State of South Carolina (USFWS 2022). No species status reports exist for small whorled pogonia (USFWS 2016a). A recovery plan was developed in 1992. No critical habitat has been defined for the small whorled pogonia.

No plants from this species were identified during the field survey. In addition, the USFWS IPaC report, and the SCDNR Natural Heritage Program (NHP) report did not indicate records for the species within a 2.0-mile of radius of the area of influence. However, potential habitat is present within the area of influence for the small-whorled pogonia and therefore coordination with USFWS would be conducted.

6.7.1.1.5 Smooth coneflower (Echinacea laevigata) [Federally Endangered]

The USFWS Optimal Survey Window for smooth coneflower is Late May – October. Smooth coneflower, a perennial herb, is typically found in meadows, open woodlands, the ecotonal regions between meadows and woodlands, cedar barrens, dry limestone bluffs, clear cuts, and roadside and utility rights-of-way. In South Carolina, the species normally grows in magnesium- and calcium-rich soils associated with diabase and marble parent material, and typically occurs in Iredell, Misenheimer, and Picture soil series. It grows best where there is abundant sunlight, little competition in the herbaceous layer, and periodic disturbances (e.g., regular fire regime, well-timed mowing, and careful clearing) preventing encroachment of shade-producing woody shrubs and trees. On sites where woody succession is held in check, it is characterized by several species with prairie affinities (USFWS 2017b). Data from SCDNR indicate one occurrence of smooth coneflower within the Project Boundary and one known occurrence within two miles of the Project Boundary.

No biological opinions or species status reports have been developed for smooth coneflower (USFWS 2021d). A recovery plan was developed in 1995. No critical habitat has been defined for smooth coneflower.

Potential habitat for smooth coneflower was identified within the maintained right-of-way, specifically within the open and regularly maintained portions of the transmission line corridor; however, a survey for the species during the optimal survey window did not reveal the presence of any plants from this species within this area. The SCDNR NHP query report indicates a population for smooth coneflower occurs both within the area of influence, and within a 2-mile radius of the area of influence. HDR coordinated with the SCDNR regarding the population indicated on the NHP report and the agency indicated the population has been extirpated by the filling of Lake Jocassee in the 1970's. Although the types of soils generally associated with the species (Iredell, Misenheimer, and Picture soil series) are not found within the area of influence, additional surveys would be conducted within the boundaries of the final limits of disturbance for the proposed transmission line (as plant surveys are typically valid for 5 years). If this species is identified in the finalized limits of disturbance, coordination of USFWS concerning potential take of the smooth coneflower would be conducted.

6.7.1.2 Migratory Bird Treaty Act of 1918 (MBTA)

The Migratory Bird Treaty Act of 1918 (MBTA) prohibits the take of migratory birds unless authorized under the terms of a valid federal permit issued by the USFWS (USFWS 2020). As part of the analysis conducted, species protected under the MBTA were reviewed for potential presence within the proposed Project vicinity using the USFWS IPaC database. Based on the IPaC review, eleven species of migratory birds have the probability of presence within the area of influence; (1) bald eagle (*Haliaeetus leucocephalus*), (2) bobolink *(Dolichonyx oryzivorus*), (3) Canada warbler (*Cardellina canadensis*), (4) cerulean warbler (Dendroica cerulea), (5) eastern Whip-poor-will (*Antrostomus vociferus*), (6) golden-winged warbler (*Vermivora chrysoptera*), (7) Kentucky warbler (*Oporornis formosus*), (8) prairie warbler (*Dendroica discolor*), (9) red-headed woodpecker (*Melanerpes erythrocephalus*), (10) wood thrush (*Hylocichla mustelina*), and (11) yellow-bellied Sapsucker (*Sphyrapicus varius*). Numerous other avian species are known to inhabit or migrate through the proposed Project vicinity.

6.7.1.3 At Risk Species

The Southeast Region of the USFWS in conjunction with states, federal agencies and other partners has begun evaluating over 400 animal and plant species for potential listing under the

ESA. These species are commonly known as "At-Risk species" and are defined as those that are: (1) Proposed for listing under the ESA by the USFWS; (2) Candidates for listing under the ESA; or (3) Petitioned by a third party for listing under the ESA. The USFWS's South Carolina At-Risk Species List for Oconee County and/or in the Project vicinity identifies 10 species potentially residing near the Bad Creek Project Table 6.7-2.

HDR conducted on-site surveys for At-Risk plant and animal species including an on-site survey for At-Risk terrestrial plants. The survey, however, was conducted outside the optimal survey window for Georgia aster and sun-facing coneflower. The following subsections include a summary of habitat descriptions and the presence/absence of habitat within the area of influence for the At-Risk species provided in Table 6.7-2.

Table 6.7-2. South Carolina List of At-Risk Species – Oconee County

Species	Preferred Habitat	Survey Window	Habitat Present in Area of Influence
Amphibian			
Chamberlain's dwarf salamander (*Eurycea chamberlain*)	Under leaf litter and small debris in wet areas, particularly seepages near small streams, and other wetland types	Spring and Fall	Yes
Birds			
Golden-winged warbler (*Vermivora chrysoptera*)	Shrubby, tangled thickets and other early successional habitats during breeding. Mature forest habitats after breeding.	April-July (nesting surveys)	Yes
Insect			
Edmund's snaketail (*Ophiogomphus Edmundo*)	Larvae are found in medium- to large-sized, clear streams and rivers with moderately fast currents but spend most of their adult lives in the treetops, only returning to the water to breed. During the breeding stage, males are typically found perched on rocks in riffles or rapids as they patrol their territories.	Year round	Yes
Monarch butterfly (*Danaus plexippus*)	Monarchs are typically found in open grass areas during the breeding season. Adults use a wide variety of flowering plants throughout migration and breeding.	August-December	Yes
Smokies needlefly (*Megaleuctra williamsae*)	Restricted to high elevation springs and seeps in relatively undisturbed forested areas. Nymphs sprawl in accumulations of decaying leaves and other debris covered with a thin film of flowing water.	April-June	Yes
Mammal			
Little brown bat (*Myotis lucifugus*)	The little brown bat lives along streams and lakes. It forms nursery colonies in buildings. In the winter it hibernates in caves and mines.	Year round	Yes
Tri-colored bat (*Perimyotis subflavus*)	Forested landscapes, often in open woods. They can also be found over water and adjacent to water edges.	Year round	Yes
Plants			

Species	Preferred Habitat	Survey Window	Habitat Present in Area of Influence
Carolina hemlock (*Tsuga caroliniana*)	Rocky slopes, ridgelines and gorges in the Southern Blue Ridge mountains.	Year round	Yes
Georgia aster (*Symphyotrichum georgianum*)	Woodlands or piedmont prairies dominated by native plants, with acidic soils varying from sand to heavy clay	Early October-mid November	Yes
Sun-facing coneflower (*Rudbeckia heliopsidis*)	Moist to wet sites and acidic soils such as those found in pine-oak woodlands, peaty seeps in meadows, and sandy alluvium along streams. Occurs in full sun to partial shade.	July - October	Yes

6.7.1.3.1 Chamberlain's dwarf salamander (Eurycea chamberlain)

USFWS Optimal Survey Window: Spring/Fall

Habitat Description: Chamberlain's dwarf salamander is typically found in wet areas, particularly seepages near small streams, and other wetland type areas. This species is typically found under leaf litter and small debris; however, has been observed with leaf or pine straw litter along the edge of seep streams, or small debris piles in the terrestrial uplands adjacent to seepage wetlands (USFWS 2016b).

Potential habitat for the Chamberlain's dwarf salamander is present within the area of influence. Coordination with USFWS would be conducted regarding potential negative impacts to the Chamberlain's dwarf salamander and opportunities to implement conservation measures to protect the species.

6.7.1.3.2 Golden-winged warbler (Vermivora chrysoptera)

USFWS Optimal Survey Window: April-July (nesting surveys)

Habitat Description: Golden-winged warbler uses wet shrubby, tangled thickets and other early successional habitats during breeding. Females select a nest site, which is typically on the ground in a grassy opening or along the shaded edge of a field near a forest border. The nest is typically well concealed by overhead grasses and leafy material. Golden-winged warblers move into mature forests immediately after fledging. This means mosaics of shrubby, open areas (for nesting) and mature forest habitats (which offer cover for fledglings from predators like hawks) are important landscape features (Cornell 2019).

Potential habitat for the golden-winged warbler is present within the area of influence (emergent and scrub/shrub wetland areas surrounded by forested communities). Given these habitats are particularly important for the conservation of the species, coordination with the USFWS would be conducted regarding potential negative impacts to the golden-winged warbler and opportunities to implement conservation measures to protect the species.

6.7.1.3.3 Edmund's snaketail (Ophiogomphus Edmundo)

USFWS Optimal Survey Window: Year round

Habitat Description:

Habitat Description: Edmund's snaketail larvae are found in medium- to large-sized, clear streams and rivers with moderately fast currents but spend most of their adult lives in the treetops, only returning to the water to breed. During the breeding stage, males are typically found perched on rocks in riffles or rapids as they patrol their territories. Mating takes place while perched; once fertilized, females deposit their eggs in the water near the same riffles guarded by the male and return to the treetops. This species is restricted to the southern Blue Ridge of North Carolina, Tennessee, South Carolina, and Georgia (USFWS 2019c and GDNR 2021).

Potential habitat for the species is present within the area of influence. Specifically, in or surrounding treetops near Howard Creek, McKinneys Creek and Bad Creek. Coordination with the USFWS would be conducted regarding potential negative impacts to the Edmund's snaketail and opportunities to implement conservation measures to protect the species.

6.7.1.3.4 Monarch butterfly (Danaus plexippus)

USFWS Optimal Survey Window: August-December

Habitat Description: The monarch butterfly is a large butterfly that lives in a variety of habitats throughout North America and various additional locations across the globe. They need milkweed (*Asclepias* spp.) for breeding.

In North America the eastern population (east of the Rocky Mountains) migrate north to the United States and Canada in March from the mature oyamel fir forests in the mountains of central Mexico. The fall migration back to overwintering sites in Mexico is from August to November. Monarchs are typically found in open grass areas during the breeding season. Adults use a wide variety of flowering plants throughout migration and breeding. Important nectar sources during the spring migration typically include *Coreopsi*s spp., *Viburnum* spp., *Phlox* spp., and early blooming milkweeds. Important nectar sources during fall migration include goldenrods (*Solidago* spp.), asters (*Symphyotrichum* spp. and *Eurybia* spp.), gayfeathers (*Liatris* spp.), and coneflowers (*Echinacea* spp.) (USFWS 2019e).

Monarch butterflies were not identified during the on-site survey; however, the site investigation was not conducted during the recommended survey window. Nonetheless, potential habitat for the monarch butterfly was identified within the area of influence for migrating and breeding adults. The maintained right-of-way offers a variety of flowing plants for nectar, including plants from the milkweed genus (*Asclepias* spp.), as well as nighttime roosting trees such as willows and pines are present within the forested areas of the area of influence. Certain vegetation management practices, such as mowing outside the species breeding and migration windows, may alleviate any potential effects to this species from proposed actions. According to the Monarch Joint Venture, the recommended vegetation management time window for the Project's region is November 1st through April 1st (Monarch Joint Venture 2021).

On December 15, 2020, the USFWS announced its findings after a thorough assessment of the monarch butterfly's status that adding the monarch butterfly to the list of threatened and endangered species is warranted but precluded by work on higher-priority listing actions. With this decision, the monarch becomes a candidate for listing under the ESA, and its status will be reviewed each year until it is no longer a candidate. Duke Energy is an active partner in the Monarch Candidate Conservation Agreement with Assurances program.

6.7.1.3.5 Smokies needlefly (Megaleuctra williamsae)

USFWS Optimal Survey Window: April-June

Habitat Description: These slender, brown to black stoneflies ranging from 4 to 15 millimeters (0.2 to 0.6 inches) in length are restricted to high elevation springs and seeps in relatively undisturbed forested areas and water temperatures below 25°C. Nymphs sprawl in accumulations of decaying leaves and other debris covered with a thin film of flowing water (USFWS 2019f).

Potential habitat is present for the Smokies needlefly in the higher elevation seeps and steams found within the area of influence.

6.7.1.3.6 Little brown bat (Myotis lucifugus)

USFWS Optimal Survey Window: Year round

Little brown bats use buildings, caves, trees, rocks, and wood piles as roost sites; however, their habitat use changes over the course of the year and varies based on sex and reproductive status.

During the summer little brown bats commonly roost in human-made structures but have also been found in the summer under tree bark, in rock crevices, and in tree hollows. Preferring old growth forest over younger stands, as the larger trees offer more crevices, and the reduced understory vegetation of the mature growth forests makes prey easier to find and capture. During winter little brown bats hibernate in humid caves and mines with constant temperatures. They may migrate hundreds of miles to get from their summer habitats to hibernacula (WDR 2017).

Potential summer habitant is present within the forested areas of the area of influence. The results of the 2021 ERM bat acoustic field survey found that within the bats recorded with *Myotis* genus (less than 5 percent of all calls), the little brown bat was the most commonly recorded. It is recommended that tree clearing activities are not conducted during the summer months to avoid impacts to roosting sites for the species (ERM 2021). Coordination with the USFWS would be conducted prior to any tree clearing activities.

6.7.1.3.7 Tricolored bat (Perimyotis subflavus)

USFWS Optimal Survey Window: Year round

Tricolored bats are associated with forested landscapes, often in open woods. They can also be found over water and adjacent to water edges. They hibernate in caves, mines, and tunnels in the same sites as large populations of other bats, such as little brown bats. In the summer, tricolored bats generally roost separately, often in trees (MDNR 2021). In South Carolina, sparse vegetation and early successional stands were found to be the best predictor of foraging habitat use by tricolored bats (USFWS 2019g).

Potential summer habitat is present within the forested areas of the area of influence. The tricolored bat was the most commonly recorded species during the 2021 ERM bat acoustic field survey. It is recommended tree clearing activities are not conducted during the summer months to avoid impacts to roosting sites for the species (ERM 2021). Coordination with the USFWS would be conducted prior to any tree clearing activities.

6.7.1.3.8 Carolina hemlock (Tsuga caroliniana)

USFWS Optimal Survey Window: Year round

Carolina hemlocks occur in a variety of landscapes ranging from xeric ridgelines to gorges in the Southern Blue Ridge Mountains. These occurrences are mostly on cliffs, rocky slopes and ridges, less commonly on gentle slopes and flat areas in valleys. Soils are usually nutrient-poor and rocky. Carolina hemlocks are very shade tolerant and are often associated with the following species: eastern hemlock (*Tsuga canadensis*), chestnut oak (*Quercus prinus*), northern red oak (*Quercus rubra*), Virginia pine (*Pinus virginiana*) and others (USFWS 2019h).

Potential habitat for Carolina hemlock is found in the northern portion of the area of influence along the forested ridges and gorges. The USFWS recommends avoiding logging and clearing on mountain slopes and in high-elevation habitats. Coordination with the USFWS is recommended regarding potential negative impacts to the Carolina hemlock and opportunities to implement conservation measures to protect the species.

6.7.1.3.9 Georgia aster (Symphyotrichum georgianum)

USFWS Optimal Survey Window: Early October-mid November

Georgia aster lives in woodlands or piedmont prairies dominated by native plants, with acidic soils varying from sand to heavy clay. The primary controlling factor appears to be the availability of light. The plant tends to compete well for resources until it begins to get shaded out by woody plants. Since the plant prefers open areas, disturbance (fire, native grazers, etc.) is a part of this plant’s habitat requirements. The historic sources of disturbance have been virtually eliminated from its range, except where road, railroad, and utility rights-of-way maintenance are mimicking the missing natural disturbances (USFWS 2014).

Potential habitat for the species is present within the maintained portions of the right-of-way. An additional field survey within the species optimal surveying window and coordination with the USFWS regarding potential negative impacts to the Georgia aster, and opportunities to implement conservation measures to protect the species would be conducted.

6.7.1.3.10 Sun-facing coneflower (Rudbeckia heliopsidis)

USFWS Optimal Survey Window: July-October

Sun-facing coneflower prefers moist to wet sites such as acidic swales in pine-oak woodlands, peaty seeps in meadows, and sandy alluvium along streams. It occurs in full sun to partial shade. The species can also be found in upland oak-hickory or oak -pine-hickory or open pine-mixed hardwoods. It grows in seeps, bogs, sandy wet clear crop areas or in places with many boulders. The seeps where it is found are acid with grasses, sedges, and herbs (USFWS 2017c).

Potential habitat for the species is present within the maintained portions of the right-of-way near adjacent to streams and wetlands. The USFWS recommends right-of-way management appropriate for the species such as thinning of the overstory. An additional survey within the species optimal surveying window and coordination with the USFWS regarding potential negative impacts to the sun-facing coneflower, and opportunities to implement conservation measures to protect the species would be conducted.

6.7.2 State-listed Threatened, Endangered, and Candidate Species (18 CFR §5.6(d)(3)(vii)(A))

Additional species are protected in South Carolina by the Nongame and Endangered Species Conservation Act (Code 1976§50-15-10 to 90) and tracked as sensitive by SCDNR under the South Carolina State Wildlife Action Plan (SWAP). Species with SWAP priorities of High, Highest or Moderate are designated as having conservation priority under the SWAP. SWAP species are those species of greatest conservation need not traditionally covered under any federal funded programs. Species are listed in the SWAP because they are rare or designated as at-risk due to knowledge deficiencies; species common in South Carolina but listed rare or declining elsewhere; or species that serve as indicators of detrimental environmental conditions. SCDNR recommends appropriate measures be taken to minimize or avoid impacts to the aforementioned species of concern.

A list of state protected species that may occur within Project vicinity based on HDR's review of data from SCDNR is provided in Table 6.7-3.

Table 6.7-3. State Listed Threatened or Endangered Species in Oconee County, SC

Common Name	Scientific Name	Federal Protection Status	State Protection Status[1]	G Rank[2]	S Rank[3]	SWAP Priority[4]
Bald eagle	*Haliaeetus leucocephalus*	Bald & Golden Eagle Protection Act	ST: State Threatened	G5	S3B, S3N	High
Eastern small-footed bat	*Myotis leibii*	N/A	ST: State Threatened	G4	S1	Highest
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	NA	SE: State Endangered	G3G4	S2	Highest

[1]Endangered - Any species or subspecies of wildlife whose prospects of survival or recruitment within the State are in jeopardy or are likely within the foreseeable future to become so."
Threatened - "A species that is likely to become endangered and in need of management."
[2] Global Conservation Status: G Rank – G1=critically imperiled; G2=imperiled; G3; vulnerable; G4=apparently secure; G5=secure
[3] SCDNR State Ranking – S1=critically imperiled; S2=imperiled; S3; vulnerable; S4=apparently secure; S5=secure
[4] SWAP Priority: those species of greatest conservation need not traditionally covered under any federal funded programs. Species with priorities of High, Highest, or Moderate are designated as having conservation priority under the SWAP.

During the 2021 field survey completed by ERM, potential roost habitat (rock crevices, along cliffs, talus slopes, or riprap) for the eastern small-footed bat was found to be abundant, but after searches none could be confirmed to be occupied. Large numbers of additional potential roost crevices were noted that were inaccessible from the ground. Additionally, during the acoustic survey performed by ERM, eastern small-footed bats made up the majority of calls recorded. Emergence surveys were conducted within two representative habitat areas for the eastern small-footed bat, and no eastern small-footed bats were observed or detected leaving rock roosts. During the mist netting surveys, four eastern small-footed bats were captured and detected, and abundant roosting habitat was found within the Project vicinity (ERM 2021). Coordination with the USFWS would be conducted prior to any ground disturbing or tree clearing activities.

6.7.3 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Wildlife habitats and species in the vicinity of the Project are reflective of current Project operations. Duke Energy does not expect operation of the Project over the term of the New License to affect habitat for RTE species. As noted above, suitable foraging and potential roosting habitat for bats, including the species listed above, is likely common in the area of influence, which supports a range of upland, riparian, wetland, and open water habitats. The upland forested habitats used by these species are not affected by normal Project operations.

Field surveys performed in support of development of this PAD also identified potential habitats for five federally threatened and endangered species within the area of influence: northern long-eared bat, Indiana bat, persistent trillium, small whorled pogonia, and smooth coneflower. As a conservation measure for federally protected bat species, it is recommended tree clearing activities be conducted during the bats inactive season (November 15th through March 31st for northern long-eared bat) to avoid negative impacts to the species.

According to the USFWS list of At-Risk species for South Carolina, and the SCDNR consultation report, 10 At-Risk species occur in Oconee County and/or in the Project vicinity. Results from the field assessments indicate potential habitats for the Chamberlain's dwarf salamander, golden-winged warbler, Edmund's snaketail, monarch butterfly, Smokies needlefly, little brown bat, tri-colored bat, Carolina hemlock, Georgia aster, and sun-facing coneflower are present within the area of influence.

No environmental PM&E measures are presently proposed by Duke Energy. Duke Energy will consult with resource agencies and other stakeholders through the relicensing process regarding potential Project effects on RTE species and reasonable additional measures for the continued protection of species or potential habitat.

6.7.4 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

Through this licensing process, Duke Energy expects to consult with agencies to identify (1) species of concern and (2) proper methods and procedures for survey of the Project Boundary as necessary and required to determine presence or absence of protected species. Based on the results of RTE surveys, Duke Energy anticipates further consultation with agencies to determine appropriate PM&E measures for the protection of RTE species, if applicable, and to ensure viable measures will be included in the licensing proposal if Duke Energy pursues development of the Bad Creek II Complex.

In addition, coordination with the USFWS concerning potential Project impacts to these species is proposed by Duke Energy. Recommendations include a survey for persistent trillium during the recommended optimal window, and follow up surveys including bat species, once limits of disturbance for construction of the proposed Bad Creek II Complex are determined and the surveys can be conducted appropriately proximate to the commencement of land-disturbing activities.

6.8 Recreation and Land Use (18 CFR §5.6(d)(3)(viii))

6.8.1 Existing Recreation Facilities and Opportunities (18 CFR §5.6(d)(3)(viii)(A))

The Project is located in a remote area in the Blue Ridge Mountains in South Carolina, just south of the North Carolina state border. Lake Jocassee, which serves as the Project's lower reservoir but is not included within the Project Boundary, provides nearby recreational opportunities for visitors. Lake Jocassee is surrounded by a series of steep-sided gorges with minimal residential development along the shoreline; the only developed public access is via Devils Fork State Park (Table 6.8-2). As a result, the lands surrounding Lake Jocassee provide for a predominately natural setting. Lake Jocassee provides opportunities for boating (i.e., motor, sailing, canoeing, kayaking, paddle boarding, etc.), fishing, swimming, and scuba diving. The surrounding area also offers visitors opportunities for hiking, camping, hunting, whitewater rafting, and viewing wildlife and waterfalls.

There are no recreation facilities within the existing Project Boundary. There is one recreational facility or area associated with the Project: the Foothills Trail, a 77-mile trail linking Oconee and Table Rock State Parks completed in 1981. The Foothills Trail is managed by the Foothills Trail Conservancy (previously the Foothills Trail Conference). The Foothills Trails Conservancy, with which Duke Energy is considered a partnering organization, is a non-profit 501(c)(3) membership organization composed of government agencies, recreational outfitters, and non-governmental organizations.

6.8.1.1 FERC-Approved Recreation Facilities at the Project

There are no FERC-approved Recreation Facilities within the Project Boundary, and there is no public access to Bad Creek Reservoir due to potential large fluctuations in water levels on a daily basis. The reservoir is fenced to prohibit public access due to public safety concerns.

An approximately 43-mile segment of the Foothills Trail and two access points to Lake Jocassee were developed by Duke Energy under the terms of the Original License. Prior to the construction of the Project, the first portion of the Foothills Trail was built linking Table Rock State Park to Oconee State Park. During the original licensing of the Project, Duke Energy agreed to build and maintain the central section of the Foothills Trail as mitigation for the loss of land and water resources then providing limited dispersed outdoor recreation opportunities in the upper reservoir area and in response to stakeholder demand for a trail in this area. Duke Energy constructed an approximately 43-mile trail[24] with approximately 3 miles of spur trails from Pinnacle Mountain (Table Rock State Park) west to the Whitewater River (Nantahala National Forest), following the northern shoreline of Lake Jocassee (Duke Energy 1981), helping to create the now 77-mile-long trail completed in 1981 (Foothills Trail 2021). All facilities were constructed in accordance with Appalachian Trail Conference design standards. While this 43-mile trail segment (including 10 trailhead access points and 8 interpretive signs) is located on non-Project lands[25], it is maintained by Duke Energy and private contractors with coordination and assistance from the Foothills Trails Conservancy. The Foothills Trails Conservancy is responsible for major and minor maintenance for the rest of the Foothills Trail.

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[24] While the original Exhibit R states 31 miles of trail were to be constructed, and the updated Exhibit R identifies approximately 38 miles, modern documents and the easement for the trail corridor identify 43 miles of main trail and 3 miles of spur trail. The spur trails are managed by Duke Energy.

[25] Duke Energy holds a 200-ft wide (100-ft from center line) lease for the main portion of the trail, 4 spur trails, and Sassafras Mountain, Chimney Top Gap, and Laurel Valley Access Areas.

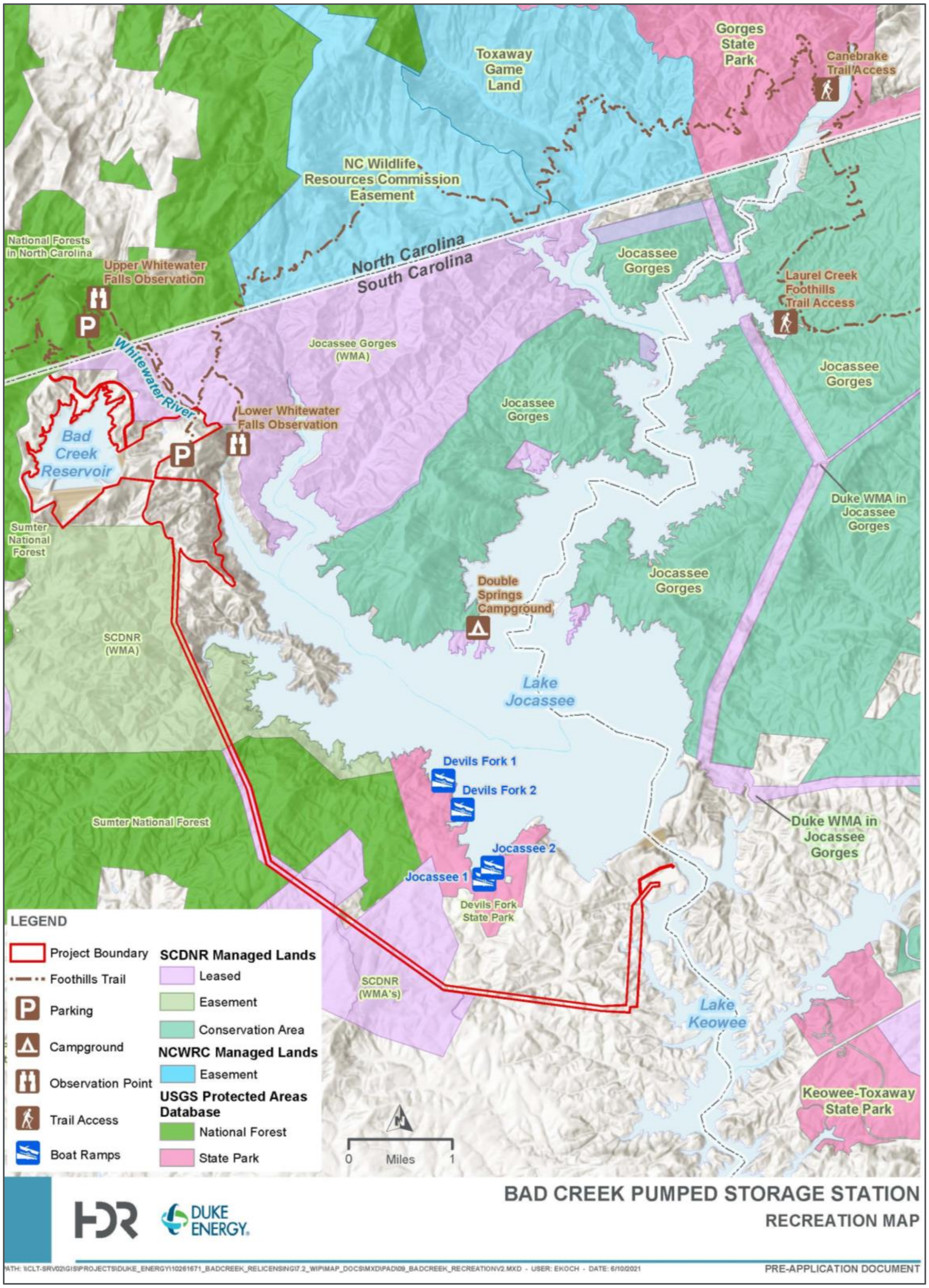

Figure 6.8-1. Recreational Facilities and Opportunities

In the vicinity of the Project but on non-Project lands, the Foothills Trail includes a hiking path to the Upper Whitewater Falls Observation and one spur off the trail, to the Lower Whitewater Falls. From the parking area just east of the Project facilities to the Upper Whitewater Falls is a 2-mile strenuous trail ending at the Upper Whitewater Overlook. The hike takes visitors along Whitewater River and Corbin Creek Falls. The Lower Whitewater Falls is an almost 2-mile moderate spur off the trail to a viewing platform of a 200-ft tiered waterfall (Foothills Trail 2021).

The Canebrake Trail Access and Laurel Creek Foothills Trail Access (both access points off the Foothills Trail and located on non-Project lands) are Project-related facilities maintained by Duke Energy under the Original License. Both provide access to/from Lake Jocassee via trail or boat. Neither site has developed parking or recreation facilities and there is no vehicular access. The trail at Laurel Creek includes bridges, wooden steps, and trail markings. The KT Recreation Study in support of the relicensing found that the Laurel Creek trail was the most-used primitive trail access on Lake Jocassee, with recreational opportunities including picnicking, swimming, camping and hiking. Canebrake Trail Access was moderately used with no formal facilities; activities include boating and hiking (Duke Energy 2014b).

Project access areas offering vehicular parking include Sassafras Mountain Access Area, Chimneytop Gap Access Area, Laurel Valley Access Area (referenced as Rocky Bottom in the 1980 Bad Creek Exhibit R), and the Lower Whitewater Falls Access Area. These parking areas provide gravel parking, interpretive signage, and trailheads.

Figure 5.8-1 denotes existing recreation facilities in the vicinity of the Project Boundary.

6.8.1.2 Non-Project Recreation Facilities and Opportunities

The Project is surrounded by public non-Project recreation facilities and opportunities including the Whitewater River, Lake Jocassee, Jocassee Gorges, Devils Fork State Park, Keowee-Toxaway State Park, Toxaway Game Land, and Sumter National Forest, which all provide a wide range of recreational activities. The majority of the surrounding land is managed by SCDNR as either owned, leased, or conserved areas as shown on Figure 6.8-1[26].

The Whitewater River flows from its headwaters in North Carolina into Lake Jocassee at the Whitewater Cove. The "Base of Upper Falls to Lake Jocassee" is a 3-mile whitewater segment adjacent to the Project Boundary that attracts whitewater enthusiasts. American Whitewater rates the difficulty of this whitewater segment between II-V+ with an average gradient of 440 ft per mile. Within the 3 miles there are only two short stretches usable for rafting while the rest is unsafe for rafting or flatwater use (American Whitewater 2019). The Whitewater River also provides desirable trout fishing, although anglers must hike the Foothills Trails to reach the deep pools and runs. The river is managed and stocked by the SCDNR as a wild-trout stream, and wild and stocked rainbow and brown trout are abundant (On the Fly South n.d.).

Jocassee Gorges is largely managed by the SCDNR and is approximately 43,000 acres of forested hills and mountainous terrain with numerous streams and waterfalls. This vast landscape was protected in part by the SCDNR, Duke Energy, and the Richard King Mellon Foundation (assisted by the Conservation Fund). Duke Energy previously owned all of the Jocassee Gorges tract and has since retained only the land required for current and future Project operations (i.e., these lands are now under conservation easement to the SCDNR[27]).

Jocassee Gorges natural area offers recreational opportunities for hunting, fishing, bird watching, hiking and camping. Within the Jocassee Gorges, there are populations of black bears, white-tailed deer, wild turkeys, raccoons and feral hogs which attract hunters to the area. Anglers are drawn to the trout streams and reservoirs for trout, largemouth and smallmouth bass, and sunfish (Jocassee Gorges n.d.).

Devils Fork State Park is the only developed public access on Lake Jocassee and is operated by SCDRT. Development of the park is a result of the Original KT License, fulfilling Duke Energy's obligation to provide recreation opportunities. Devils Fork encompasses 622 acres and

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[26] SCDNR "owned" land indicates that they own the property(s). "Leased" land typically falls within the WMA program and indicates SCDNR leases it from another property owner. "Conservation easements" are properties that SCDNR holds and can be on owned, leased or neither. The management terms can vary on conservation easements.

[27] Duke Energy's land conservation efforts in the 1990's resulted in selling approximately 47,000 acres to state/federal agencies for permanent protection (the land was later divided up into Gorges State Park, Nantahala National Forest, Toxaway Game Land, Jocassee Gorges, and Sumter National Forest).

includes two hiking/walking trails (the Oconee Bell Trail and the Bear Cove Trail), along with public lake access. A second access to Lake Jocassee is the Double Springs Campground (also a fulfillment of a license requirement under the KT Project), which has 25 boat-in primitive tent pads, two primitive restrooms, and one composting toilet (Duke Energy 2021d)[28]. See Table 6.8-1 below for a complete list of recreation facilities on Lake Jocassee at Devils Fork State Park covered under the KT Project License.

Table 6.8-1. Recreation Facilities at Lake Jocassee – Devils Fork State Park and Double Springs Campground (Source: Duke Energy 2021d)

• North Remote Boat Launch Area (Double Springs): Two one-lane boat ramps; courtesy dock; vault toilet; 5 vehicle parking spaces (including 1 ADA); 29 vehicle with trailer parking spaces
• South Remote Boat Launch Area (Roundhouse Point): Two one-lane boat ramps; courtesy dock; vault toilet; 35 vehicle spaces (including 1 ADA); 8 vehicle with trailer spaces; 2 picnic tables
• Lakeside Campground Area: 59 RV campsites; 25 tent campsites; 2 bathhouses; dump station; picnic tables; 50 vehicle with trailer parking spaces
• Day Use Area: Three one-lane boat ramps; courtesy dock; 125 vehicle with trailer spaces (including 4 ADA); 191 vehicle spaces (including 7 ADA)
• Villa Area: 20 rental villas; two one-lane boat ramps; courtesy dock; 21 vehicle with trailer parking spaces
• Double Springs Campground: 25 boat-in primitive tent pads; 2 primitive restrooms; 1 composting toilet
• Non-Motorized Access Area: Diver access point; 56 vehicle parking spaces (including 2 ADA); 2 vehicle with trailer parking spaces; vault toilet

Note: ADA = Americans with Disabilities Act; RV = recreational vehicle

The Bootleg Access Area is an 18-acre site located on the east side of Lake Jocassee. This site is leased to the SCDNR and managed in conjunction with the Jim Timmerman Natural Resources Area. Two other undeveloped sites owned by Duke Energy and reserved for future potential recreation needs on Lake Jocassee include the Handpole Ridge Access Area, which is a 5-acre site on the Horsepasture River section of Lake Jocassee, and the Grindstone Access Area, which is a 5-acre site on the Toxaway River section of Lake Jocassee. No facility development is currently planned for either of these areas.

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[28] Note that these amenities were included in the 2021 KT Project RMP under "proposed enhancements", however, they have since been completed.

Keowee-Toxaway State Park consists of 1,000 acres donated by Duke Energy in 1970 to the South Carolina State Parks. The State Park provides a half-mile trail to Lake Keowee where anglers can enjoy freshwater fishing for bass, bream, crappie and catfish. Other hiking opportunities include Raven Rock Hiking trail which is a little over four miles and Natural Bridge Nature Trail, a half-mile loop. There is also a canoe/kayak access for non-motorized boat access to Lake Keowee. Swimming is also permitted. Several geocaches are located throughout the park (SC Parks 2021). In 2018, new amenities were constructed including camping facilities, fishing pier, picnic shelters, restrooms, and an event center.

Toxaway Game Land is about three miles northwest of the Project just over the South Carolina border in Transylvania County, North Carolina. It is managed by the North Carolina Wildlife Resources Commission and provides public hunting opportunities and camp sites (NCWRC n.d.).

Sumter National Forest borders the Project to the west and is part of the Andrew Pickens Ranger District. This district encompasses over 80,000 acres providing recreational opportunities such as hiking, canoeing/kayaking/whitewater, horseback riding, autumn leaf viewing, fishing and hunting (USFS n.d.).

6.8.2 Specially Designated Recreation Areas in the Vicinity of the Project (18 CFR §5.6(d)(3)(viii)(F))

6.8.2.1 Wild, Scenic, and Recreation Rivers

There are no Wild, Scenic, and Recreational designated waterways within the Project Boundary or the Project Vicinity. Waters within the Project Boundary or the Project Vicinity are not protected under the SC Scenic Rivers Program administered by the SCDNR.

6.8.2.2 Nationwide Rivers Inventory

There are no Nationwide Rivers Inventory designated waterways within the Project Boundary or the Project Vicinity.

6.8.2.3 Scenic Byways

There are no scenic byways within the Project Boundary. West of the Project in Sumter National Forest is the Oscar Wigington Scenic Byway, a two-lane road with overlooks, easy access to waterfalls, and hiking trails. Wigington Overlook provides a view of Lake Jocassee and the surrounding Blue Ridge Mountains (SCDPRT 2021).

6.8.2.4 National Trails System and Wilderness Areas

Other than the previously discussed Foothills Trail, there are no National Recreation Trails or Wilderness Areas within or adjacent to the Project Boundary or Project Vicinity. The Foothills Trail is not under study for inclusion.

6.8.2.1 Regionally or Nationally Important Recreation Areas

There are no regionally or nationally important recreation areas, other than the opportunities discussed in Section 6.8.

6.8.3 Current Project Recreation Use Levels (18 CFR §5.6(d)(3)(viii)(B))

As previously discussed, there is no public recreation use in the Project Boundary due to the large fluctuations in water levels on a daily basis resulting in public safety concerns.

6.8.3.1 2013 Recreation Use and Needs Study

In support of the KT Project relicensing, Duke Energy developed and conducted the 2013 Recreation Use and Needs (RUN) Study (Duke Energy 2014d) to assess existing recreational uses and the need for additional recreation facilities and boating use at Lake Jocassee (and Lake Keowee). This study included facility inventories and condition assessments, spot counts, trail and traffic counters, aerial photography, recreation site use records, various types of visitor surveys and interviews, and telephone interviews with land and facility managers.

Recreational use at facilities in the Project Vicinity was evaluated during the RUN Study for the Laurel Fork Falls Boat-In Access Area and Canebreak Boat-In Access Area. Both sites were evaluated with trail counters and were ranked second and third most popular for access (although far behind Devils Fork, which is the only developed access on Lake Jocassee).

Lake Jocassee's recreational use was measured and based on the mix of boating types observed in 2007 and 2012, Duke Energy estimated boating capacity of the reservoir to be between 944 (2012) to 1025 (2007) boats at a time. The top five reported recreational activities on Lake Jocassee are shown in Table 6.8-2.

Table 6.8-2. 2013 Top 5 Access Area User Count and Percentages on Lake Jocassee

Activity	Access Area Users	
	Count	Percent Use
Day Fishing from Boat	72	45
Swim/Sunbathe from Boat	66	41
Camping (Tent or Vehicle)	13	8
Wildlife Viewing	12	7
Motor/Power Boating	11	7

The results of the 2013 RUN Study found 98 percent of respondents were "satisfied" or "very satisfied" with the number of facilities at Lake Jocassee and more than half confirmed their visitor needs were met. For those whose visitor needs were not met, the most common response was to keep the water level high.

Duke Energy previously estimated recreation use at Lake Jocassee to increase by approximately 53 percent from 2012 to 2050. The number of water-based recreation days is expected to increase by up to 70 percent by 2050, while land-based recreation is projected to increase by 30 to 35 percent.

6.8.4 Recreation Needs Identified in Management Plans (18 CFR §5.6(d)(3)(viii)(D))

The 2019 State Comprehensive Outdoor Recreation Plan (SCORP) is South Carolina's five-year recreation plan serving as a guide for federal, state, and local government and private sector entities involved with recreation planning or development. The SCORP also considers current residents and out of state visitors, provides an inventory of recreational amenities, analyzes future demand, and develops a program to address needs or issues arising during the development of the SCORP (SCDPRT 2019).

The 2019 SCORP estimates South Carolina has nearly 1.7 million acres of public recreational land and over half is managed by federal agencies. Local governments account for approximately 40,000 acres of recreation access (or 3%). The most common type of facilities in South Carolina are baseball/softball fields, playgrounds, tennis courts, picnic shelters and basketball courts, while the least common are water parks, skate parks, and archery ranges. South Carolina has almost 4,000 miles of trails and established greenways/blueways, managed by a variety of stakeholders (federal, state, local, private, not-for-profit). Hiking and walking trails are the most common type of trail available and mountain biking and all-terrain vehicle single use trails are the least common.

As part of the research of the 2019 SCORP, two online surveys were distributed and nearly all (98%) respondents indicated they had visited a local or state park or recreation area in the past year. The most popular outdoor activity was hiking (70%), followed by walking (67%) and camping (59%). The most popular water-related activity was canoeing/kayaking (37%). Respondents rated the outdoor recreation facilities as very good (50%).

The 2019 SCORP concluded maintaining existing facilities and demand for new facilities should be the top two priorities of the state. The 2019 goals of the SCORP are to:

1) Improve access to public recreation areas
2) Promote stewardship of resources
3) Ensure sustainable economic benefits, and
4) Adapt to changes in recreation demand

6.8.5 Non-Recreational Land Use and Management (18 CFR §5.6(d)(3)(viii)(I))

Duke Energy is not aware of non-recreational land use and management of lands owned or under easement within the Project Boundary.

6.8.6 Existing Shoreline Buffer Zones (18 CFR §5.6(d)(3)(viii)(C))

There are currently no dedicated shoreline buffer zones within the Project Boundary.

6.8.7 Licensee's Shoreline Permitting Policies (18 CFR §5.6(d)(3)(viii)(E))

There is no public access to the Bad Creek Reservoir shoreline, and thus discussion of shoreline permitting policies is not relevant. Duke Energy has such policies for its other licensed projects, and they can be accessed via the Duke Energy website [https://www.duke-energy.com/Community/Lakes/Services]. Under the KT Project License, Lake Jocassee has an SMP, which was originally approved by FERC on February 4, 2013 and is managed by Duke Energy to protect and enhance the scenic, recreational, and other environmental values of the KT Project. Non-Project use as defined by the SMP includes private docks, shoreline stabilization and public recreational access, but does not allow for marina facilities[29]. The SMP is a comprehensive management tool for managing requests for shoreline development activities within the existing FERC Project Boundary in a manner consistent with KT Project purposes. The SMP includes shoreline classification maps, lake use restrictions for each classification, and management guidelines for construction, stabilization, excavation, and vegetation management (Duke Energy 2014c).

The Lake Jocassee shoreline adjacent to the area of influence is classified Public Infrastructure, Project Operations, and Environmental. The Environmental shoreline classification area is located at the confluence with Whitewater River and is protected to provide spawning, rearing, and nursery habitat for fish and habitat for amphibians, reptiles, and birds. No vegetation removal, construction, excavation, or shoreline stabilization is permitted within the Environmental shoreline classification area.

Due to fluctuating water levels and public safety concerns, there is no recreational access to Bad Creek Reservoir. An SMP has not been developed and would not be required or appropriate for the upper reservoir.

[29] No marina facilities, except those multi-slip facilities associated with license-required KT Project Access Areas (e.g., Devils Fork State Park) are allowed on Lake Jocassee.

6.8.8 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Duke Energy has played a role in the protection of a significant amount of public recreational land in the vicinity of the Bad Creek Project. Duke Energy has donated lands for public recreational use and maintains and plans to continue to honor, under the New License term, its commitments to recreation in the vicinity of the Bad Creek Project.

There are no recreation opportunities immediately within the Bad Creek Project Boundary. The majority of the recreation in the vicinity of the Project consists of water-based activities on Lake Jocassee and use of the Foothills Trail. A segment of the Foothills Trail and two popular undeveloped access areas were developed as a requirement of the Original License. Duke Energy expects to continue to maintain these amenities as non-Project facilities in the New License term.

For the benefit of natural, cultural, and recreation resources, Duke Energy proposes to continue to operate the Project in the existing mode and with the existing protections for restrictions on land and shoreline development in the vicinity of the Project Boundary. Duke Energy anticipates development of an updated Recreation Management Plan (RMP) for the Project with or following the FLA, as needed to address existing and proposed facilities and arrangements. Duke Energy will consult with interested stakeholders throughout the ILP regarding necessary recreational facility maintenance or potential new enhancement measures. Any such measures would be developed in consultation with appropriate resource agencies and other relicensing stakeholders.

6.8.9 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

There are no public recreational facilities or opportunities within the Project Boundary. With the exception of the parking area just east of the Project facilities, which would be closed throughout construction (approximately five years), impacts to recreation due to construction of the Bad Creek II Complex would be limited to water-based recreation in the Whitewater River arm of Lake Jocassee.

The proposed Bad Creek II Complex would have an inlet/outlet structure on the west bank of the Whitewater River cove of Lake Jocassee upstream from the existing Bad Creek Project inlet/outlet structure. During construction activities (assumed to last approximately five years), recreational activities would be prohibited in this area (Whitewater River cove) to protect the public. Recreation across the majority of Lake Jocassee, including the boat ramps and access areas identified in Table 6.8-1, would not be impacted by construction of the Bad Creek II Complex.

Closure of the parking area during construction would result in a short-term adverse impact to recreational opportunities for the public in this portion of Lake Jocassee. Other parking areas do, however, provide Foothills Trail access, and trail access to the Upper and Lower Whitewater Falls would not be impacted by construction.

Operation of the Bad Creek II Complex, alone or in combination with operation of the existing Project powerhouse, has the potential to impact surface water velocities in the Whitewater River cove of Lake Jocassee, particularly during periods of generation. As previously discussed, a three-dimensional CFD model has been developed for Duke Energy to support the evaluation of the second inlet/outlet structure's effects within the Whitewater River cove. This study is applicable to the potential for increased bank erosion on the east side of the cove as well as effects on recreation (i.e., boaters) near the discharge area. Once Bad Creek II Complex operations begin, CFD modeling of this area indicates surface velocities may exceed 5 fps in some areas near the discharge under Normal Minimum Elevation conditions as a result of the combined operations of the two projects. Flat-water paddlers have paddling speeds and abilities dependent on many factors, including paddling technique, paddler strength and endurance, weather conditions, hull design, and load (Dowd 1983; Hutchinson 2002). Generally speaking, an average kayaker of moderate experience and moderate strength, paddling in calm conditions, in a standard flatwater kayak (approximately 15 ft in length) with light gear (e.g., water bottle, sunscreen, paddle jacket) can sustain a speed of approximately 5 fps for long stretches of time. Beginner kayakers average slightly slower speeds of approximately 3.4 to 4.2 fps. It is possible that surface currents and resulting eddies could match, or exceed, the ability of a paddler if the conditions were sustained over a long distance. However, for this specific impact, the location and extent of the current would occur in a localized area; therefore, it is likely even beginner paddlers could increase their speed to overcome surface currents and change course. For example, a paddler trying to access the upper portion of the Whitewater River cove could hug the east bank where velocities are lower.

The proposed Bad Creek II Complex is not expected to have long-term adverse impacts on recreation uses or facilities. Short-term impacts due to construction activities may require mitigation in the form of additional boating and/or land-based (i.e., trails, overlooks, etc.) amenities. Duke Energy expects to consult with agencies and other relicensing stakeholders through the ILP to identify additional measures for the additional protection and enhancement of recreation opportunities in the vicinity of the Project Boundary, if development of the Bad Creek II Complex is pursued by Duke Energy.

6.9 Aesthetic Resources (18 CFR §5.6(d)(3)(ix))

The Project is situated within the Blue Ridge Mountains in the Upstate of South Carolina. The existing landscape and scenic attributes in the vicinity are dominated by rolling hills, forests, stream corridors, steep slopes, waterfalls, rock outcrops, and mountain ridges. The areas surrounding the Project reservoir are primarily undeveloped forested land. Although there is some development around Lake Jocassee, the shoreline is also mostly forested with a mixture of pines and hardwoods and there are numerous waterfalls where tributaries flow into the reservoir. Surrounding protected lands include the Sumter National Forest and the Jocassee Gorges and the area overall is aesthetically appealing.

There are numerous opportunities to enjoy nature and scenery in the immediate vicinity of the Project such as hiking, camping, fishing, hunting, scenic and wildlife viewing, and boating (flatwater and whitewater). The aesthetic conditions within the vicinity of the Project have been a priority of Duke Energy since the 1970's and this commitment continues today. Duke Energy has played a large role in contributing to the protection of large amounts of nearby public recreational lands to enhance the aesthetics of the area (see Section 6.8).

Visual elements associated with the Project include the upper reservoir, the main dam, the west dam, the east dike, the equipment building, access roads, lower reservoir inlet/outlet structure and powerhouse portal area (Whitewater River arm of Lake Jocassee), transformer yard and switchyard (adjacent to equipment building), and the 100 kV transmission line extending from the Bad Creek transformer yard to a grid intertie station at the Jocassee Station.

Except for the lower reservoir inlet/outlet structure and powerhouse portal, major elements of the Bad Creek facility are only visible from the Bad Creek access road and are not visible from any state highway or from other areas of Lake Jocassee (via boat).

During a 2013 RUN Study at the KT Project (Duke Energy 2014d), one third of the people surveyed stated nothing detracts from the aesthetic quality of the Lake Jocassee. Almost half of Lake Jocassee respondents listed low-water levels as the main detraction to aesthetic resources, while in a 2007 RUN Study only 36 percent of respondents listed low-water levels as a detraction. No respondents listed “development” as detracting from scenic and aesthetic qualities of the area.

As a result of the Original License for the KT Project, the Jocassee SMP now has provisions limiting the ability of adjoining property owners to eliminate vegetated shoreline along Lake Jocassee with the intention to provide a more natural looking shoreline buffer. Additionally, following the relicensing of the KT Project, new Normal Minimum Elevations were set to be higher such that the frequency and magnitude of exposed shorelines would be reduced, improving the visual appearance for visitors.

6.9.1 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Since major elements of the Project are not visible to the public except from the access road and Whitewater River arm of Lake Jocassee, Duke Energy expects there to be no temporary or permanent impacts on aesthetic resources from the continuing operation of the Project, therefore, there are no PM&E measures proposed. There is no need to reduce visual impacts due to the continued operation of the Project.

6.9.2 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

The construction of the Bad Creek II Complex will include a new powerhouse and associated structures as well as the new inlet/outlet structure to the Lake Jocassee. Similar to the existing inlet/outlet structure, the new inlet/outlet structure will be viewable via boat (from the Whitewater River cove). With the construction of the proposed Project expansion, the visual landscape will be altered both during and after construction; however, the impact of this is considered minor as the facility is not readily viewed from public access areas. See Figure 6.9-1 for a digital rendering of the Project post-construction.

Short-term aesthetic impacts will occur during construction of the Bad Creek II Complex, due to land clearing and grading activities; creation of new upland spoil areas; temporary, localized turbidity impacts in the Whitewater River cove; construction traffic; temporary construction facilities; and the continued presence of heavy construction equipment. Common mitigation techniques can be applied to reduce impacts to visual resources during and after construction including minimization of disturbance (e.g., limit clearing trees and vegetation to the extent possible), lighting control, strategic placement of facility appurtenances, and reduction of visual contrast caused by new rights-of-way, access roads, laydown areas, and staging areas. Duke Energy expects the best management practices and PM&E measures required to address the requirements of the FERC license and Section 404/401 permit will also benefit aesthetic resources. Duke Energy expects to further consult with relicensing stakeholders to determine whether additional PM&E measures are needed for the protection of aesthetic resources.

Figure 6.9-1. Preliminary Rendering of the Bad Creek Existing Project and Proposed Bad Creek II Complex, following Completion of Construction

6.10 Cultural Resources (18 CFR §5.6(d)(3)(x)

6.10.1 Regulatory Background

In considering a New License for the Project, FERC has the lead responsibility for compliance with applicable federal laws, regulations, and policies pertaining to historic properties, including the National Historic Preservation Act of 1966 (NHPA), as amended[30]. Section 106 of the NHPA (Section 106)[31] requires federal agencies to consider the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment.

The Section 106 process (defined at 36 CFR Part 800) is intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of consultation with agency officials, State Historic Preservation Officers (SHPO), federally recognized Indian Tribes, and other parties with a potential interest in an undertaking's effects on historic properties. The goals of the Section 106 process are to:

- Identify historic properties that may be affected (directly and/or indirectly) by an undertaking;
- Assess the effects of an undertaking on historic properties; and
- Seek ways to avoid, minimize, or mitigate adverse effects on historic properties through consultation.

Historic properties are defined in 36 CFR Part 800 as any pre-contact or historic period district, site, building, structure, or individual object listed in or eligible for inclusion in the National Register of Historic Places (NRHP). This term includes artifacts, records, and remains related to and located within historic properties, as well as properties of traditional religious and cultural importance (often referred to as traditional cultural properties) meeting the NRHP criteria.

The Secretary of the Interior has established the criteria for evaluating properties for inclusion in the National Register (36 CFR Part 60). In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The

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[30] 54 USC §300101 et seq.

[31] 54 USC §306108

quality of significance is present in historic properties that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

- Are associated with events that have made a significant contribution to the broad patterns of our history; or
- Are associated with the lives of persons significant in our history; or
- 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 values, or that represent a significant or distinguishable entity whose components may lack individual distinction; or
- Have yielded or may be likely to yield information important in prehistory or history.

Generally, a cultural resource must be 50 years old or older to be considered for NRHP eligibility, although more recent resources may possess exceptional historical significance and be considered.

6.10.2 Background Information

The cultural resources information related to the Project was retrieved from the ArchSite online cultural resources database maintained by the South Carolina Department of Archives and SCDAH and the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, as well as from reports of previous cultural resources investigations maintained by Brockington and Associates, Inc.

The earliest known Native American presence within the Project vicinity dates to the Paleoindian period from 10,000 to 7900 Before Common Era (BCE). During this period, it is believed the hunter gatherer population was small and nomadic. Paleoindian tool forms were lanceolate (and usually fluted) projectile points, flake knives, and scrapers.

The Archaic period (c. 8000 to 1000 BCE) is generally divided into three smaller periods: Early, Middle and Late Archaic. During the Early Archaic period (until 1000 BCE), populations of hunter gatherers in the Project vicinity became larger due to the transition from hunting large game to hunting smaller game and gathering wild foods, however the population was still relatively small and seasonal. The Early Archaic period is marked by a change in lithic technology. Notched and stemmed projectile points, such as Kirk Corner-Notched, Taylor Side-Notched, and Palmer Corner-Notched define sites occupied during this period. The Middle

Archaic (c. 6000 to 3000 BCE) was still a period of small mobile settlements with populations that practiced the seasonal rounds, but there was a wider range of tools used including Stanly, Morrow Mountain, and Guilford projectile points. In addition, new tools were introduced, such as atlatl weights, net sinkers, mortars, and nutting stones. It was not until the Late Archaic period (c. 3000 to 700 BCE) that Native Americans became more sedentary. This period is marked by the appearance of large shell midden sites and fiber tempered ceramics in the Savannah River Valley and along the coast. The development of pottery began around 2500 BCE , about the same time as the beginning of plant cultivation. In the Piedmont and the Blue Ridge, inhabitants used soapstone-cooking tools and practiced freshwater shellfish procurement. Pottery use did not occur in the regions above the Fall Line until after 1700 BCE .

The Woodland period, 700 BCE through approximately 1000 Common Era (CE), was marked by the use of ceramics, the greater exploitation of agriculture, and a heightened ceremonialism in the Project vicinity. The Woodland period, also divided into three subperiods, is most widely known for the emergence of the Hopewell phenomenon characterized by the construction of earthen mounds, often containing burials. This was all part of the development of a ceremonial exchange network spanning over half the continent. Artifacts typical of the Early Woodland period (700 to 300 BCE) in the Project vicinity include Dunlap and Swannanoa ceramics and Savannah River Stemmed and Swannanoa Stemmed projectile points. For the Middle Woodland (300 BCE to CE 600), pottery consists of the Pigeon and Cartersville series and projectile points are of the Pigeon Side and Corner Notched types. Small triangular projectile points, such as the Connestee Triangular, and Napier and Connestee Series pottery are diagnostic of the Late Woodland period (CE 600 to 1000) in the region.

The Mississippian period, from CE 1000 to 1600, marked the transition into a heavy reliance on agriculture and the establishment of sedentary populations in major river valleys and fertile bottomlands. The Mississippian period is known for the increase in social and ceremonial complexity. It was a period of hierarchical social rankings and paramount chiefdoms with permanent mound communities within the major river valleys and the fertile bottomlands. The communities were reliant on agriculture with an emphasis on maize, beans, and squash, but continued the hunting and gathering tradition in the vast tracts of surrounding forest. Early Mississippian artifacts (circa CE 900 to 1200) include Etowah series ceramics. The Middle Mississippian period (CE 1200 to 1450) was marked by the construction of large platform mounds, the spread of the Savannah ceramic complex, and a wide array of artifacts such as copper breastplates, conch shell bowls, and shell gorgets. The Late Mississippian period (CE 1540 to 1600) was marked by the Lamar ceramic complex, generally characterized by grit tempered and complicated stamp pottery.

Southeastern Native Americans were first introduced to Europeans by Spanish explorers during the early 1500s. Spanish explorer Hernando de Soto (c. 1540-1542) encountered the "Ocute" chiefdom on the Oconee River in Georgia, the "Cofitachequi" along the Wateree River in South Carolina, and the "Coosa" in the Tennessee and Coosa valleys. While there were inhabitants near the headwaters of the Savannah in and around the Project at the time, there is no record of de Soto visiting the Project vicinity.

Many Cherokee towns, known as the Lower Towns, were located near the Project vicinity. By the 1700s, Keowee was the main town of the Lower Cherokee along the trade route through the Project vicinity. The towns of Sinica, Toxaway, Eastatoe, Tamassee, Jocassy, and Aconnee are the source of the names of many towns or landmarks near the Project today. Permanent European settlement in the Project vicinity did not begin until the late 18th century. In 1730, the British sent an emissary to the Cherokee Nation along the Keowee River to claim land for the King of England and to discuss trade concerns.

While the British provided the main European influence over the Lower Cherokees through the 1700s, the French began to enter the area in the 1730s and 1740s. In order to counter the French influence, the British proposed building forts on Cherokee lands. The Cherokee agreed due to their own problems with the Creek Indians. The Creeks were soon after defeated and driven further south into Georgia. Fort Prince George was constructed near Keowee Town in 1753. The years that followed were marked by tension and skirmishes between the Cherokee and the British. By 1760, the British military had launched a full effort to destroy the Lower Towns of the Cherokee.

Many of the Cherokee Lower Towns were destroyed by South Carolina and Georgia forces in early 1776. White settlement of the Keowee Valley began in the 1780s with the issuance of land grants by the State of South Carolina. The Treaty of Hopewell between the U.S. and Cherokees was signed in 1785 and ended hostilities among the Lower Towns and South Carolina. By 1785, Lower Town Cherokees were beginning to move farther south and east, and the Project vicinity became part of the Ninety-Six District. Due to the growing population, the large districts were soon split up. By the 1790s, the entire Project vicinity was part of the Pendleton District. By the time of the Indian Removal Act of 1838, the Cherokees had abandoned the Lower Towns. The Indian Removal Act of 1838 resulted in the Cherokee people being forcibly moved from their lands east of the Mississippi River via the Trail of Tears to an area in present-day Oklahoma. It is estimated that of the 17,000 Cherokees forced to relocate from North Carolina, between 4,000 and 5,000 died during the journey.

Beginning in 1784–1785 and for several years after, the State of South Carolina issued many land grants for most of the Project vicinity. Many prominent settlers moved into the area to occupy large tracts of land that previously made up the Cherokee Lower Town region. A number of historic houses had their beginnings during this period. One such house was the "Alexander-Hill House," built in 1831 near Roberton's Ford in the community of Old Pickens. The house is currently located in High Falls County Park and is listed in the NRHP. The Jocassee Valley was settled later than the Keowee Valley, in the early 1800s, due to its location farther upstream. Most settlers in the region were relatively poor compared to the plantation owners farther south in the state. Most homes were constructed of logs and grain farming was a common practice.

The 1810s brought growth in the region to a halt as westward expansion boomed. Growth in the Carolinas was at a standstill through the 1830s. The next economic stimulus to the region came by way of the railroad. In the 1840s, the "Blue Ridge Railroad" was built to connect the port of Charleston and the rest of South Carolina with other southern and western states. At the same time, a group of German immigrants had plans to create a colony in the Project vicinity. This new colony, called "Walhalla," was planned and laid out by Charleston's German Colonization Society. By the mid-1850s Walhalla had over 1,000 people within the settlement. When the town was only three years old, it consisted of 65 buildings. The businesses in town included smiths, tailors, shoemakers, carpenters, painters, cabinet makers, a tinsmith, a coppersmith, a mechanic, a druggist and a doctor, four storekeepers, masons, brick-makers, miners, a baker, a butcher, a gardener, a teacher, a preacher, and four beer brewers. There were also two hotels in town. Many farming families lived nearby, as well as a large number of Blue Ridge Railroad Company workers. Laborers working on the railroad, including the nearby Stumphouse Mountain Tunnel located approximately 14 miles southwest of the Project, numbered over 3,000 during peak times. The onset of the American Civil War in 1861 led to financial problems that dissolved the Blue Ridge Railroad Company.

Despite economic and social disruption, the Civil War and Reconstruction periods had less impact in the Project vicinity than in other parts of the state, as there were very few slaves in the Upstate at the time and cotton was not a major crop in years before the war. Cotton became more prevalent in the Keowee Valley in the years after the war, as sharecropping became more common. It was during this Reconstruction period that South Carolina switched from the district systems in favor of the county system. The Pickens District was split into Pickens and Oconee Counties.

Around 1890, there was a dramatic increase in the number of textile mills throughout the state. Most new mills were located in the upper Piedmont where the railroads provided easy access. The upper Piedmont soon became the most industrial portion of the state. By 1905, there were over 37,000 mill workers in the State of South Carolina. By the 1920s, the number of textile workers had reached over 50,000 and approximately 44 percent of all American textiles were produced in the State of South Carolina. While other industries collapsed during the Great Depression of the 1930s, the cotton mills and the textile industry remained viable. The Newry Mill located on the Little River is a prime example of regional textile history. The mill, founded around 1890, remained in operation until 1975.

Timber and agriculture also became important economic activities during the same time as the cotton mills. By the late 1800s, there was a relatively thorough net of railroad lines throughout the lower portion of the Project vicinity. This spurred other economic activities; timber clear-cutting was taken as far up the Blue Ridge as railroad spur lines would allow. Railroads and timbering made possible a number of small communities during this period. Towns like Salem, which consisted of a church, a school, a few stores, and six sawmills, were developed to support timber operations in and around the Project vicinity. With the use of modern fertilizers, agricultural production increased. Sumter National Forest was established in 1936; the Nantahala National Forest had been established in 1920. The Project vicinity remained dominated by rural communities and small farms through the 1950s.

Development of the Jocassee Valley took a path different from the downstream Keowee Valley. Though originally settled in the early 1800s, there was never a large population in the Jocassee

Valley. Most were poor, working as subsistence farmers. The valley remained unchanged until the 1890s when increasing numbers of people began to visit the valley at the foot of the Blue Ridge Mountains to escape the summer heat. By the early 1900s, there were at least three hotels or inns within the valley, most of which only operated from May to October. Atakulla Lodge, A.L. Whitmire Hotel, and Brown's Hotel were the three most popular inns. Visitors often came from distant locations to stay in the Jocassee Valley during the hot summer months. Many guests used the nearby railroad system to get to larger towns, such as Seneca, before making their way to the valley. The resorts and tourism industry continued through the 1950s and 1960s until the land within the Project vicinity was purchased and plans were made for construction of the KT Project.

By the early 1900s, electricity was becoming increasingly more prevalent in larger cities throughout the south, such as Atlanta and Charleston. Southern Power Company, a precursor to Duke Power and later Duke Energy, showed interest in the Keowee River Basin as early as 1916. The plan for a potential hydroelectric plant seemed to have fallen by the wayside until the 1940s and 1950s when Duke Energy began acquiring land in the Keowee and Jocassee Valleys. Duke Power publicized its plans to construct two hydroelectric facilities and additional steam electric facilities in 1965. The Federal Power Commission licensed the KT Project in 1966 and Oconee Nuclear Station was licensed the following year. Construction of the Keowee and Jocassee Dams began soon afterward. Keowee Hydro Station began commercial operation in 1971 and Jocassee Pumped Storage Station began operation in 1973. The Bad Creek facilities associated with the greater KT Project (the upper reservoir and dams, inlet/outlet structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and a 9.25-mile-long transmission corridor extending from the Bad Creek to the Jocassee switchyard) were licensed in 1977 and added to the system.

6.10.3 Area of Potential Effects

The area of potential effect (APE) is defined as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The APE is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking. In the context of the relicensing process, FERC generally defines the APE as follows: "The APE includes all lands within the Project Boundary. The APE also includes any lands outside the Project Boundary where cultural resources may be affected by Project-related activities conducted in accordance with the FERC license."

Because the Project Boundary encompasses all lands necessary for Project purposes, all Project-related operations, potential enhancement measures, and routine maintenance activities associated with the implementation of a license issued by the Commission are expected to take place within the Project Boundary. This includes lands within the full pond elevation of Bad Creek Reservoir, any recreational access areas, and additional lands associated within the powerhouse and dam complex.

While the Project Boundary commonly serves as the APE for relicensings, most infrastructure projects in South Carolina use 300 ft from a project work area as an acceptable limit for visual effects on historic architectural resources. An APE not limited to the Project Boundary may be appropriate due to construction activities that would be associated with the Bad Creek II Complex. The nature of traditional cultural properties will determine the potential for the Project to affect such resources. A preliminary proposed APE is presented in Figure 6.10-1. Note that locations specific to archaeological information is Controlled Unclassified Information (CUI) under Section 106 and have therefore not been included herein. A final APE will be developed in consultation with FERC, SHPO, federally-recognized Tribes, and other stakeholders.

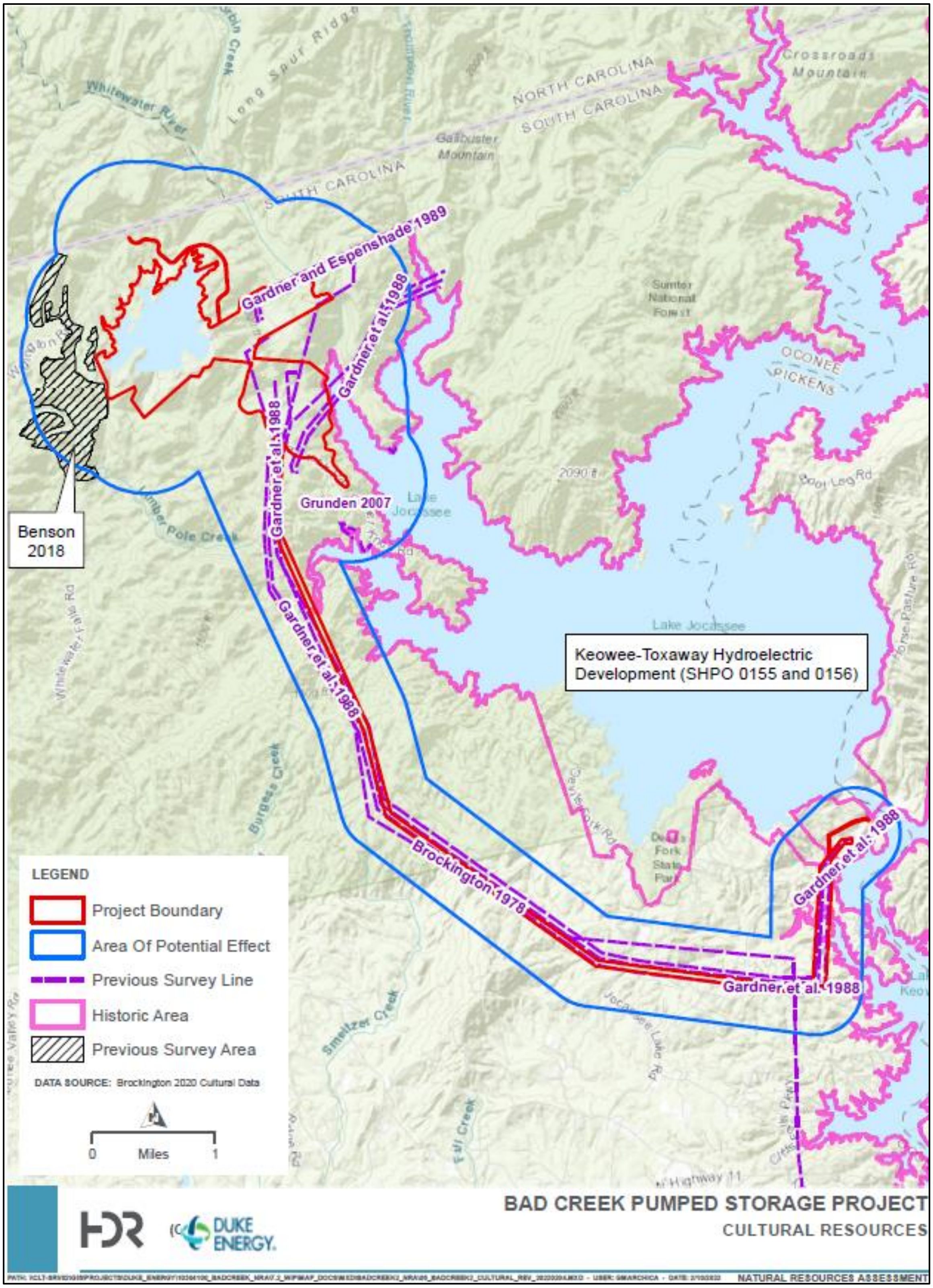

Figure 6.10-1. Proposed Area of Potential Effects

The portions of the Project's footprint that underwent extensive land modification (removal of vegetation, soil, subsoil, and/or bedrock to a depth of 1+ feet) in the past are highly unlikely to contain any archaeological resources or historical architectural resources other than the elements of the Project greater than 50 years of age. Similarly, portions of the Project were subject to an intensive cultural resources survey and found to contain no identified resources and are highly unlikely to contain any additional resources. Figure 6.10-1 displays the locations of previous cultural resources surveys near the Project.

6.10.4 Archaeological Resources (18 CFR §5.6(d)(3)(x)(A))

The Project Boundary contains 10 known archaeological sites (38OC0101-0103, 38OC0241-0244, 38OC0247-0248, and 38OC0250). All these sites reflect Pre-Contact occupations within the APE. Nine sites (38OC0101-0103, 38OC0241-0244, and 38OC0247-0248) are not eligible for the NRHP. One site (38OC250) requires additional investigation to determine if it is eligible for the NRHP. Table 6.10-1 summarizes information concerning these sites as well as 16 sites occurring outside of the Project Boundary.

- Site 38OC101 is a single chipped stone artifact recovered by Brockington (1978). Five shovel tests around the find failed to produce any additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0102 is a diffuse scatter of chipped stone artifacts. Brockington (1978) recovered one quartz biface and several possible quartz flakes from the ground surface; three shovel tests near these finds failed to produce additional artifacts. Gardner et al. (1988) revisited the site and recovered two additional flakes of chipped stone. The site is not eligible for the NRHP.
- Site 38OC0103 is a diffuse scatter of chipped stone artifacts. Brockington (1978) recovered a quartz biface fragment, four possible flakes, and one piece of green stoneware from the surface of the ridge. Gardner et al. (1988) revisited the site and recovered no additional artifacts from the ground surface or from four shovel tests excavated at the reported location of the site. The site is not eligible for the NRHP.

Table 6.10-1. Cultural Resources Within and Near the Project Boundary

Resource #	NRHP Status	Project Effect	Type	Reference
Sites in the Project Boundary				
38OC0101	Not Eligible	No Effect	Pre-Contact lithic scatter	Brockington 1978
38OC0102	Not Eligible	No Effect	Pre-Contact lithic scatter	Brockington 1978; Gardner et al. 1988
38OC0103	Not Eligible	No Effect	Pre-Contact lithic scatter	Brockington 1978; Gardner et al. 1988
38OC0241	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0242	Not Eligible	No Effect	Middle Archaic lithic scatter	Gardner et al. 1988
38OC0243	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0244	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0247	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0248	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0250	**Needs Evaluation**	**Adverse?**	**Mississippian camp**	**Gardner et al. 1988**
0155	**Needs Evaluation**	**No Adverse Effect?**	**Keowee Hydroelectric Development**	**Stallings 2012**
0156	**Needs Evaluation**	**No Adverse Effect?**	**Jocassee Hydroelectric Development**	**Stallings 2012**
Sites in the APE (outside Project Boundary) (see Figure 6.10-1)				
38OC0050	Eligible	No Effect	Cherokee hamlet (submerged)	Stephenson 1972
38OC0052	Not Eligible	No Effect	Woodland camp	Stephenson 1972
38OC0053	Not Eligible	No Effect	Woodland camp	Stephenson 1972
38OC0054	Not Eligible	No Effect	Archaic/Woodland camp	Stephenson 1972
38OC0240	Not Eligible	No Effect	Late Archaic lithic scatter- Post-Contact scatter	Gardner et al. 1988
38OC0245	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0246	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988

Resource #	NRHP Status	Project Effect	Type	Reference
38OC0249	Needs Evaluation	No Effect	Late Archaic/Middle Woodland/Mississippian rock shelters	Gardner et al. 1988
38OC0251	Needs Evaluation	No Effect	Middle Archaic/Late Archaic camp-Post-Contact scatter	Gardner et al. 1988
38OC0252	Not Eligible	No Effect	Pre-Contact lithic scatter	Gardner et al. 1988
38OC0690	Not Eligible	No Effect	Pre-Contact lithic scatter	Benson 2018
38OC0691	Needs Evaluation	No Effect	Pre-Contact lithic scatter	Benson 2018
38OC0692	Not Eligible	No Effect	Pre-Contact lithic scatter	Benson 2018
38OC0693	Not Eligible	No Effect	Pre-Contact lithic scatter	Benson 2018
38OC0694	Not Eligible	No Effect	Pre-Contact lithic scatter	Benson 2018
38OC0695	Not Eligible	No Effect	Pre-Contact lithic scatter	Benson 2018

- Site 38OC0241 is a diffuse scatter of chipped stone artifacts. Gardner et al. (1988) recovered five quartz flakes and one quartz shatter fragment from the ground surface; three shovel tests excavated near these finds failed to produce additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0242 is a Middle Archaic scatter of chipped stone tools. Gardner et al. (1988) recovered two quartz flakes and a quartz biface from the ground surface and a Morrow Mountain projectile point and another quartz flake from one of three shovel tests excavated at the locale. The site is not eligible for the NRHP.
- Site 38OC0243 is a diffuse scatter of chipped stone artifacts. Gardner et al. (1988) recovered 11 quartz flakes from the ground surface; four shovel tests excavated near these finds failed to produce additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0244 is a diffuse scatter of chipped stone artifacts. Gardner et al. (1988) recovered chert and quartz flakes from two areas within the site on opposite sides of the transmission line corridor. Three shovel tests excavated in the transmission line corridor failed to produce additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0247 is a diffuse scatter of chipped stone artifacts. Gardner et al. (1988) recovered three quartz flakes and two rhyolite flakes from the ground surface; two shovel tests excavated near these finds failed to produce additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0248 is a diffuse scatter of chipped stone artifacts. Gardner et al. (1988) recovered 10 quartz flakes, 1 quartz core fragment, and 1 quartz biface from the ground surface; four shovel tests excavated near these finds failed to produce additional artifacts. The site is not eligible for the NRHP.
- Site 38OC0250 produced two quartz flakes, one quartzite flake, and one chert Mississippian triangular projectile point (Gardner et al. 1988). The artifacts all came from 45-65 cm below the ground surface and in association with a possible hearth. This suggests additional buried artifacts and features related to a Mississippian occupation may be present at the site. The site requires additional investigation to determine its NRHP eligibility.

The vast majority of archaeological sites identified in and near the Project APE reflect Pre-Contact Native American occupations. Most are small scatters of lithic artifacts likely representing short-term occupations associated with the acquisition or processing of nearby resources. Several sites located in the flood plains of the nearby streams, including four sites now beneath the waters of Lake Jocassee, represent longer periods of occupation. The only Post-Contact occupation identified near the Project APE may reflect de facto refuse dropped or discarded by someone traveling along the road where the material was found or may be associated with a farmstead that once stood on the opposite side of the river.

6.10.4.1 Historic Architectural Resources

There are two known historical architectural resources located in or immediately adjacent to the Project APE - SHPO Site Number 0155 Keowee Hydroelectric Development and SHPO Site Number 0156 Jocassee Hydroelectric Development. These sites were recommended potentially eligible for the NRHP. An NRHP evaluation of the KT Project, which includes both SHPO Site Numbers 0155 and 0156, was delayed due to the collective age of the facilities (less than 50 years old).

Duke Energy is in the process of completing an Architectural Survey and National Register Evaluation for the Jocassee Pumped Storage Hydro Station. A formal determination of eligibility for the KT Project can proceed in 2022 given the collective construction dates of 1972 (Stallings 2012).

6.10.5 Existing Discovery Measures (18 CFR §5.6(d)(3)(x)(B))

Review of ArchSite and reports of previous cultural resources investigations indicates the corridor between the existing Bad Creek and Jocassee powerhouses has been inventoried through intensive cultural resources survey. These investigations employed surface inspection and subsurface sampling to locate, delineate, and evaluate archaeological sites (Table 6.10-2). A brief summary of the findings of each of these existing surveys is included below.

Table 6.10-2. Previous Cultural Resources Surveys Within the APE

Author(s)	Year	In Project Boundary	Sponsor/Owner	Surveyed
Brockington	1978	Yes	Duke Power Company	Oconee-Bad Creek and Jocassee-Bad Creek Trans Lines
Gardner et al.	1988	Yes	Duke Power Company	Jocassee-Bad Creek-Coley Creek Trans Lines
Gardner and Espenshade	1989	Yes	Duke Power Company	Bad Creek-Jocassee ReRoute Trans Lines
Grunden	2007	No	Duke Power Company	Lake Jocassee Shoreline
Stallings	2012	Yes	Duke Power Company	KT Project
Benson	2018	No	U.S. Forest Service	FY2018 Sumter NF Pine Beetle Salvage Harvest Area

6.10.5.1 Existing Cultural Resources Surveys

- Brockington (1978) examined approximately 13 miles of transmission line corridors between the Oconee Nuclear Station and the Jocassee powerhouse/dam, including areas in the northern and southern portions of the Project Boundary. This survey identified five archaeological sites; three lie within the Project Boundary (38OC0101-38OC103).
- Gardner et al. (1988) examined approximately 12 miles of transmission line corridor between the Jocassee powerhouse, the Bad Creek powerhouse, and the Coley Creek transmission lines, including areas in the northern portion of the Project Boundary and the corridor between the Bad Creek and Jocassee powerhouses within the Project Boundary. This survey identified 15 sites (including two identified by Brockington 1978), 9 of which lie within the Project Boundary (38OC0102, 38OC0103, 38OC0241-38OC0244, 38OC0247, 38OC0248, and 38OC0250).
- Gardner et al. (1989) examined approximately 1.2 miles of rerouted transmission line corridor between the Bad Creek and Jocassee powerhouses, including areas in the northern portion of the Project Boundary. This survey identified no sites.
- Grunden (2007) examined selected portions of the shoreline of Lake Jocassee, including three areas to the east of the Project Boundary and APE. This survey identified no sites within the Project Boundary or APE.

- Stallings (2012) evaluated the NRHP-eligibility of the KT Project to the east and south of the Project Boundary. This survey identified two historic above-ground resources - SHPO Site Number 0155 Keowee Hydroelectric Development and SHPO Site Number 0156 Jocassee Hydroelectric Development. Portions of both of these resources lie within the southern portion of the Project Boundary near the Jocassee powerhouse.
- Benson (2018) examined approximately 2,400 acres of the Sumter National Forest to the west of the Bad Creek Project Boundary. This survey identified six sites, all outside the Project Boundary and APE.

The remaining portions of the Project APE have not been inventoried for historic properties to date. Much of this area has witnessed extensive ground disturbance related to the construction of the Project. Should an inventory be undertaken, efforts should focus on the flatter portions of the terrain (areas with less than 15 percent slope) where people are most likely to have carried out the kinds of activities that generate refuse and debris that can be discovered through archaeological investigations. The areas of higher potential within the unsurveyed portions of the Project APE are shown on Figure 6.10-2.

For architectural resources, the Bad Creek Project was completed in 1991, therefore, it will not be 50 years of age at the time of the FLA and will not require NRHP evaluation until 2041.

6.10.6 Identification of Indian Tribes and Traditional Cultural Properties (18 CFR §5.6(d)(3)(x)(C))

Consultation with Indian tribes with interests in the area will be initiated to determine if traditional cultural properties or other resources important to tribes, per 18 CFR §5.6(d)(3)(xii)(B), such as subsistence use areas or areas affected by use agreements with other parties, exist within or near the Project vicinity. The Project vicinity is within the ancestral homelands of the Cherokee Indians. Numerous late 17th and 18th century Cherokee towns and settlements once existed along the Whitewater, Toxaway, and Keowee rivers. As such, consultation will be initiated with the Eastern Band of the Cherokee Indians in North Carolina, the Cherokee Nation of Oklahoma, and the United Keetoowah Band of Cherokee Indians in Oklahoma. Consultation will also be initiated with the Catawba Indian Nation in South Carolina.

If FERC requests consultation with additional Indian tribes, the Project would extend invitations to consult to those additional tribes.

Based on the environmental justice analysis in Section 6.11, no tribal communities are known to exist in the Project vicinity, and no environmental justice impacts were identified. Thus, no impacts pursuant to 18 CFR §5.6(d)(3)(xii)(A) have been identified. Consultations with Indian tribes with interests in the area will also address the identification of anticipated Project effects on tribal cultural or economic interests.

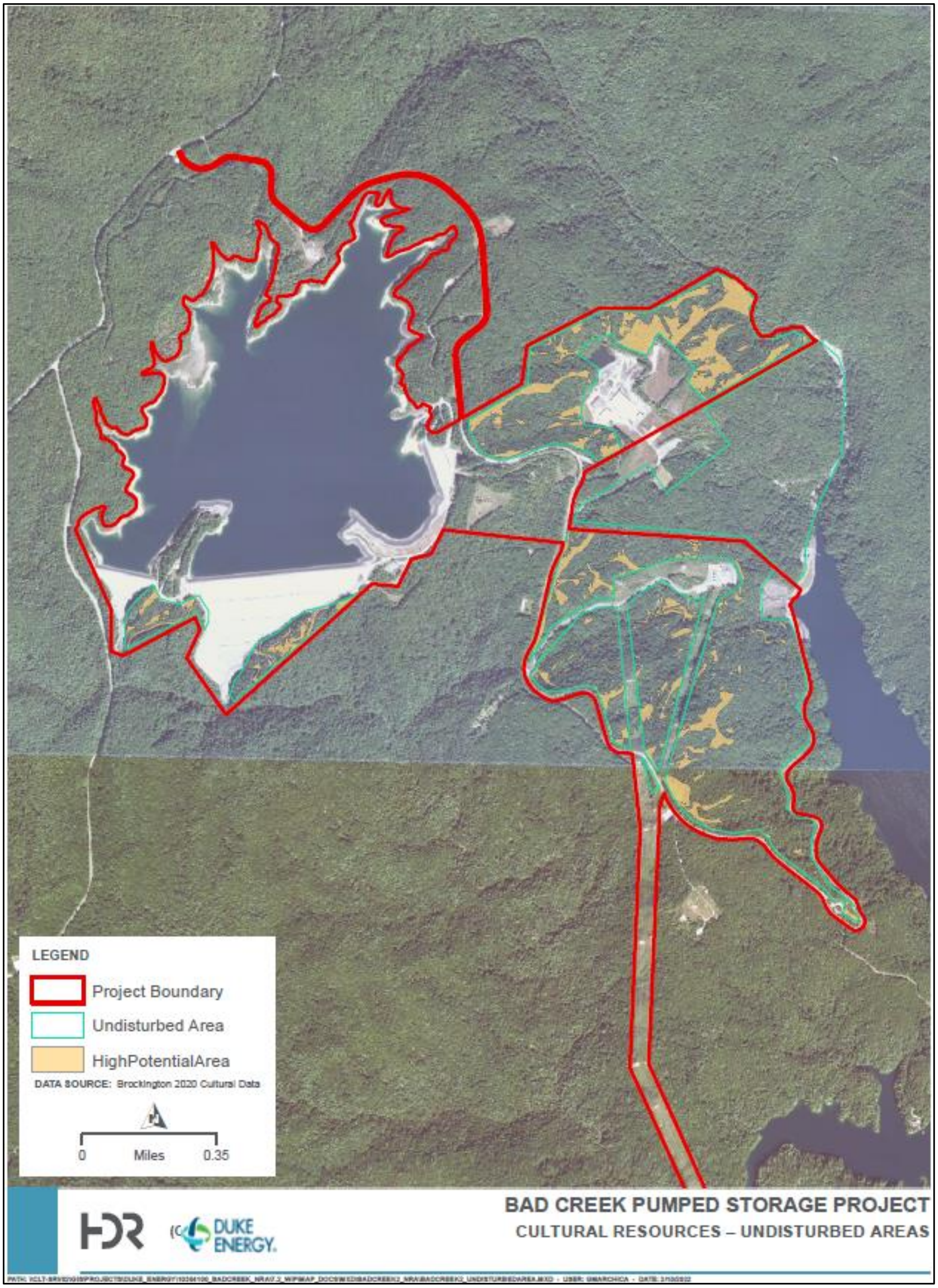

Figure 6.10-2. Higher Potential and Undisturbed Areas within the Project Boundary

6.10.7 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

There are no historic properties within the Project APE and therefore no current opportunities for adverse effects related to the existing operations. However, there are cultural resources (archaeological Site 38OC0250 and SHPO Site Number 0155/0156) requiring a formal determination of NRHP eligibility.

Archaeological Site 38OC0250 lies in the northern portion of the Project Boundary. Should future land disturbing activities be planned for the area of this site, evaluative investigations should be conducted prior to any land disturbance within 50 feet of the site. If the site is determined not eligible for the NRHP, Site 38OC0250 will require no further management consideration and land disturbing activities may occur within the site. Should Site 38OC0250 be determined eligible for the NRHP, planned land disturbing activities should be redesigned to avoid the site. If the site cannot be avoided through redesign, it will result in an adverse effect. Appropriate data recovery investigations should be implemented to recover a sample of the significant information present within the site as mitigation for this adverse effect.

SHPO Site Numbers 0155 (Keowee Hydroelectric Development) and 0156 (Jocassee Hydroelectric Development) lie to the southeast of the Project. Together, these two sites were evaluated together as the potentially eligible KT Project. Continued operation of the Bad Creek Project as a component of the broader KT system will not alter any aspect of the KT Hydroelectric Development that could compromise its potential NRHP eligibility. Should future investigations determine the KT Hydroelectric Development to be not eligible for the NRHP, no further management consideration for this resource will be necessary. Should the KT Project be determined eligible for the NRHP, continued operation of the Bad Creek Project as a component of the broader development will not alter any aspect of the KT Project that could compromise its potential NRHP eligibility and thus will have no adverse effect on the historic property.

6.10.8 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

Construction of the proposed powerhouse complex adjacent to the existing one will result in ground-disturbing activities. As currently planned, these activities will not alter the location or setting of Site 38OC0250. Should redesign of the construction of the proposed powerhouse include the location of Site 38OC0250, evaluative investigations should be conducted prior to any land disturbance within 50 feet of the site. If the site is determined not eligible for the NRHP, Site 38OC0250 will require no further management consideration and land disturbing activities may occur within the site. Should Site 38OC0250 be determined eligible for the NRHP, planned land disturbing activities should be redesigned to avoid the site. If the site cannot be avoided through redesign, it will result in an adverse effect. Appropriate data recovery investigations should be implemented to recover a sample of the significant information present within the site as mitigation for this adverse effect.

Construction of the proposed powerhouse and the facilities necessary for its operation will include peripheral connections with SHPO Site Numbers 0155 and 0156 (KT Project). These facilities are identical to those currently used in the operation of the hydropower-generating facilities of the Project. Further, the addition of the Bad Creek II Complex will not result in operational changes to the KT Project. As such, the new powerhouse will not alter any aspects of the KT Project that could compromise its NRHP eligibility.

If construction activities will occur in areas currently undisturbed and not previously inventoried, an archaeological survey of the footprint of the ground disturbing activities (i.e., limits of disturbance) should be undertaken. If any sites are identified and determined eligible for the NRHP within the proposed powerhouse construction footprint, efforts to avoid the NRHP-eligible site(s) through redesign should be undertaken. If the newly discovered site(s) cannot be avoided, it will result in an adverse effect. Appropriate data recovery investigations should be implemented to recover a sample of the significant information present within the newly discovered site(s) as mitigation for this adverse effect.

In addition, the proposed Bad Creek II Complex may include temporary land disturbance and potential visual effects outside of the current Project Boundary. Similarly, the proposed Bad

Creek II Complex may alter the setting of a traditional cultural property if present within the Project Boundary or nearby.

6.11 Socioeconomic Resources (18 CFR §5.6(d)(3)(xi))

A description of the general land use cover and patterns and figures (Figure 6.1-3) are included in Section 6.1.3.

6.11.1 Population

The Project is located in Oconee County, which was first formed in 1868. The County Seat is Walhalla, while the largest city in Oconee County is Seneca, located approximately 30 miles south of the Project. Oconee County is included in the Seneca, SC Micropolitan Statistical Area, which is also included in the Greenville-Spartanburg-Anderson, SC Combined Statistical Area (SCAC 2021).

Oconee County has a total area of 674 mi^2 with 626 mi^2 of land and 47 mi^2 of water. Large nearby population centers include the City of Greenville, SC, approximately 35 miles to the southwest (population 67,737 in 2019); Asheville, NC (population 91,560 in 2019) approximately 45 miles to the northeast; and Clemson (25,822 student population plus 16,463 permanent residents) 25 miles to the south. There are approximately 119 people per mi^2 and the average annual growth rate between 2000 and 2020 was 18.7 percent. Population trends are shown in Table 6.11-1.

Table 6.11-1. Oconee County Population Estimates (1970-2020)

Year	Population Estimate
2020	78, 607
2019	79,546
2017	77,270
2016	76,407
2010	74,273*
2000	66,215*
1990	57,494*
1980	48,611*
1970	40,728*

*Census Population

6.11.2 Economics and Housing

The primary market sectors in Oconee County are manufacturing; trade, transportation and utilities, and government, together accounting for 65 percent of the employed workforce (Upstate SC Alliance 23013). Economic data for Oconee County show a negative 1.7-percent annual average job growth rate between 2000 and 2010 and an unemployment rate (annual average 2017) of 4.2 percent. There were approximately 25,029 jobs in Oconee County in 2016, where the average annual income per job was $46,655, and per capita personal income was $38,863 (SCAC 2021). Total employment in 2018 was 19,847. There were 31,978 households with an average of 2.40 people per household (average 2015-2019) (USCB 2021a). The median value of owner-occupied housing units was $159,800 and 72.7 percent owned their home.

6.11.3 Demographics

Persons of 65 years of age and older make up 23.6 percent of the county's population, while people under 18 years make up 24.7 percent. The county is equally divided by gender, with 50.8 percent of the total population being female. Per the 2020 census, the racial makeup of the county is 82.3% white, 6.51% black or African American, 5.58% Hispanic or Latino, 0.22% Native American, 0.75% Asian, 0.02% Pacific Islander, and 4.61% from two or more races.

While the operation of Bad Creek does not directly affect the local economy, operations support Lake Jocassee, which does have a positive impact on local economies in the region. The KT workforce directly supporting operation of the KT Project was approximately $5M in 2013 with another 3,800 individuals employed at Oconee Nuclear Station (as of 2013) (Duke Energy 2014d). Recreation visits to the KT Project resulted in approximately $78.6 million in sales in 2012 and approximately a third of that remained in the local economy in the form of employee compensation and tax revenues (Duke Energy 2014d). Additionally, Duke Energy is a large property owner and paid $4.3 million to Pickens County and $27.4 million to Oconee County in local property taxes (in 2013), which benefits the regional economy.

6.11.4 Environmental Justice

In accordance with both Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" and the Council on

Environmental Quality (CEQ) guidance (CEQ 1997), this section identifies the Project vicinity population that is minority and/or low income, also known as environmental justice populations. Minority population percentages that are considered significant for environmental justice purposes will either exceed 50 percent of the general population or be meaningfully greater than the minority population percentage in the general population. Minority populations are defined herein as people who identify themselves as Asian or Pacific Islander, American Indian or Alaskan Native, Black (not of Hispanic origin), or Hispanic, either alone or in combination with other ethnicities. Low-income populations are identified using the annual statistical poverty threshold from the U.S. Census Bureau (USCB) Current Population Reports Series P-60 on Income and Poverty. Those populations with a per capita income at or lower than the current USCB poverty threshold of $13,300 or with a poverty rate at or higher than the official poverty rate for the U.S. of 10.5 percent are considered low income (USCB 2020). The USCB 2010 Oconee County Census Tract (CT) 302 encompasses the existing Project as well as the proposed Bad Creek II Complex.

According to the USCB, 2015-2019 American Community Survey (ACS) 5-year estimates (2019 ACS), the total minority population constitutes 12.2 percent of the total population in Oconee County and 2.4 percent of CT 302 (USCB 2021b). Likewise, no individual minority percentage within CT 302 exceeds those of the county. There was no measurable population of Native Americans (American Indian or Alaskan Native; 0.0 percent), and no tribal communities are known in the Project vicinity (USCB 2022). The poverty rate for all people in Oconee County was 17.5 percent. CT 302 had a poverty rate for all people of 9.0 percent, lower than the county, state, and nation. Similarly, the per capita income of all people in CT 302 ($53,898) is higher than the county ($29,844), state ($29,426), and nation ($34,103).

No identifiable low-income population is present in the Project vicinity. While a small minority population exists, overall, the percentages are well below the county percentages.

6.11.5 Known or Potential Adverse Effects and Proposed PM&E Measures: Existing Operations (18 CFR §5.6(d)(3)(i)(D))

Duke Energy does not anticipate that continued operation of the Project for the term of the New License would have any adverse effects on socioeconomic resources or environmental justice populations.

The Project provides a variety of socioeconomic benefits to the region through the generation of clean, renewable energy, preservation of wildlife habitat, protection of cultural and aesthetic resources, and provision of recreation opportunities.

6.11.6 Known or Potential Adverse Effects and Proposed PM&E Measures: Bad Creek II Complex (18 CFR §5.6(d)(3)(i)(D))

Duke Energy does not anticipate the proposed Bad Creek II Complex would have any adverse effects on socioeconomic resources or environmental justice populations.

Construction and operation of the proposed Project are anticipated to bring economic growth and opportunities to the surrounding communities, including the small minority population in the Project vicinity. Construction and operation of the Project would support local employment and income, and economic output, as well as generate state and local tax revenues.

7 Preliminary Issues, Project Effects, and Potential Studies List (18 CFR §5.6(d)(4))

Based on the resource descriptions and impacts discussions presented in this document, the following provides a brief summary of issues pertaining to the identified resources that may be impacted by continued operation and maintenance of the Project under New License term, preliminary PM&E measures proposed for the New License term, and potential relicensing studies or information gathering requirements associated with the identified resources.

As described in previous sections of this PAD, construction and operation of the Bad Creek II Complex will result in additional potential resource issues and studies that would not be impacted or necessary for relicensing of the existing Bad Creek Project without this expansion. Duke Energy anticipates Project expansion will be one relicensing proposal or alternative evaluated in FERC's forthcoming Scoping Document(s). Additionally, the Proposed and Revised Study Plans to be prepared by Duke Energy will reflect study activities specific to the Bad Creek II Complex, which would not be conducted if the Project expansion were not proposed by Duke Energy.

Major PM&E measures for original Project construction as well as ongoing Project operation are primarily focused on fisheries, water quality, and recreation, and are established by the following:

- Bad Creek Project License Exhibit S (Environmental Study Plans)[32]
- Duke Energy and SCDNR MOU and 10-Year Work Plans
- KT Project Relicensing Agreement

Duke Energy does not propose to modify the KT Project Relicensing Agreement for the Bad Creek Project relicensing but may elect to pursue a separate relicensing agreement for the Project and proposes to continue operating the Project in accordance with the MOU through the New License term. Duke Energy expects to consult with agencies and Project stakeholders through the

[32] License Article #32 (as amended on May 2, 1978, August 15, 1979, and October 2, 1995) required Duke Energy to file a revised Exhibit S within one year of license issuance to address fish and wildlife PM&E measures.

relicensing process to determine if an update to the MOU is needed for the relicensing and develop a next 10-Year Work Plan for the Project.

7.1.1 Geology and Soils

The Bad Creek Project is located immediately northwest of the Brevard zone in the Tugaloo terrane within the Toxaway Dome, and extensive geologic mapping and subsurface investigations were carried out prior to initial construction of the Project. Overall, the Project vicinity is considered to have low to moderate seismic risk. There are no known Quaternary/active faults in the site vicinity. Soils of the Project vicinity are considered upland soils, which are typically well drained sandy loam with some clay loam. In general, soils surrounding Lake Jocassee and Bad Creek are consistent because of the similar geologic conditions and topography in the reservoir area. Soils are typically sandy loam derived in place from metamorphic bedrock. The vicinity is not prone to liquefaction or sinkholes and there are no active mines in the vicinity of the Project. Shoreline erosion of Lake Jocassee is monitored under the SMP for the KT Project.

7.1.1.1 Potential Issues – Existing Project

- Seismic risks: As discussed in Section 6.2, the shear zones mapped in the existing Bad Creek Project footprint have weathered sheared rock and later brittle faulting associated with them. Weathered rock associated with shear zones and biotite schist and biotite-hornblende schist will have lower shear strengths than the unweathered surrounding rock. The majority of faults/fractures in the bedrock have secondary mineralization having healed faults/fractures. High in-situ stresses resulted in rock burst and stress-related issues in the larger underground opening including the powerhouse during their excavation; however, during construction, the existing powerhouse was oriented based on the orientation of the maximum horizontal stress orientation and consideration of the rock mass discontinuities (shear zones, high-angle minor faults, and joints) to mitigate these stresses. The Project vicinity is considered to have low to moderate seismic risk and there are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018).
- Slope instability: There is active slope movement in the Project and evidence of previous mass wasting events; however, these areas are routinely monitored.

- Lower reservoir shoreline erosion: Wave energy from wind and boat wakes cause shoreline erosion at Lake Jocassee. Shoreline erosion at Lake Jocassee has been measured at approximately three inches per year with minimal effects on vegetation (Duke Energy 2014d). Continued operation of Bad Creek is unlikely to increase shoreline erosion rates at Lake Jocassee; however, Lake Jocassee has an SMP in place to limit/prevent/mitigate potential erosion.
- Proposed environmental measures: Existing PM&E measures related to geology and soils for the existing Bad Creek Project are not included in the Project license but are conducted by Duke Energy under Duke Energy's Owner's Dam Safety Program and as required for the continued safe operation of the Project and Project structures. No additional PM&E measures are proposed at this time to address continued operation of the existing Project.

7.1.1.2 Potential Issues – Bad Creek II Complex

The proposed Bad Creek II Complex may affect, and be affected by, existing subsurface features, surface features, and/or soil movement. Conditions that may impact the safety of Project structures during construction and with continued operation include underlying geology, slope movement (i.e., landslides), and seismic activity.

- Seismic risk: The shear zones mapped in the Bad Creek upper reservoir and in the existing Project underground structures have weathered sheared rock and later brittle faulting associated with them. Later brittle faults are present and are mineralized/healed with various combinations of greenschist facies minerals. Most of the water encountered in the underground excavations for the existing Project (past the initial ~200 feet of the main access and tailrace tunnels from their respective openings at Lake Jocassee) is associated with the existing shear zones parallel to the bedrock foliation. Similar conditions are anticipated in the Bad Creek II Complex underground excavations. High in-situ stresses resulted in rock burst and stress-related issues in the larger underground openings in the existing underground excavations; this will likely occur in the underground excavations for the Bad Creek II Complex. Mitigation measures developed for existing underground excavations will be utilized in the excavation and construction of the proposed powerhouse and associated tunnels and shafts.

- Slope instability: A previously identified landslide exists at the proposed location of the inlet/outlet works for the Bad Creek II Complex on Lake Jocassee (see Section 6.2.1.7.1). The slide material will be removed during construction and a retaining wall installed on the slope for stabilization of the landslide materials uphill of the wall.
- Lower reservoir shoreline erosion: The addition of a second discharge would add to the overall outflow through the conduits leading to the west side of the Whitewater River cove. This increase in discharge could result in increased bank erosion on the opposite side of the Whitewater River cove (i.e., east bank).
- Sedimentation and erosion: Construction activities have the potential to generate and contribute significant quantities of sediment-laden runoff to nearby streams. Excess sediment can lead to destruction of fish habitat, degradation of drinking water supplies, road washouts, landslides, and increased flood hazards.
- Proposed environmental measures: PM&E measures for construction and operation of the Bad Creek II Complex related to geology and soils will be evaluated and recommended during the relicensing process. Such measures may include engineering mitigation measures to address geological and geotechnical risks, as well as BMPs initiated prior to and during construction to mitigate erosion and sediment accumulation. Duke Energy expects to develop a comprehensive Erosion and Sedimentation Control (ESC) plan to be implemented for all construction phases of the Bad Creek II Complex. Final BMPs will include numerous measures in the SCDHEC Storm Water Management BMP Field Manual (SCDHEC 2005). Measures such as construction entrances, silt fence, compost filter socks, diversions, fill diversions, rock check dams, stormwater conveyance channels, temporary seeding, and mulching may be utilized to prevent sediment tracking, trap sediment, stabilize disturbed areas, and divert any sediment-containing runoff to temporary sediment basins.
- The potential need for additional PM&E measures for the protection of geology and soil resources will be evaluated during the relicensing process.

7.1.1.3 Proposed Studies

Duke Energy does not propose to conduct a separate relicensing study focused on geology and soils. Duke Energy believes that the ongoing and planned evaluations for the Bad Creek II Complex will be sufficient to inform the relevant geological requirements of the draft and final license applications, including preparation of a preliminary Supporting Design Report for the Bad Creek II Complex. These evaluations include the following:

- A geotechnical field exploration program was carried out from February through June of 2021. The Bad Creek II Complex geotechnical investigation was conducted to support the feasibility design of the Bad Creek II Complex tunnel and appurtenant structures including the proposed upper and lower intake/outlet, the gate shafts, and vertical shafts. Subsurface drilling, geologic mapping, and surface geophysical investigations were carried out. Findings of the geotechnical investigation and geologic assessment will be presented in a final report (expected to be complete by early 2023) and will inform future investigations and necessary measures that may be required regarding geologic stability at the Project, if the Bad Creek II Complex is pursued. These investigations, including characterization of soil type, occurrence, and susceptibility to erosion, will also be used to inform construction measures and methods to reduce soil erosion and sedimentation.
- Duke Energy proposes to evaluate impacts of operation of the expanded Project (i.e., two powerhouses) on velocities of water discharge to the Whitewater River arm of Lake Jocassee through development and use of a three-dimensional CFD model. As described in 6.2.5.2, a preliminary three-dimensional CFD model was developed by HDR for Duke Energy to evaluate the potential operational impacts of the Bad Creek II Complex during turbine mode (including shoreline erosion potential) within the Whitewater River arm of Lake Jocassee. The CFD model was used to estimate velocities of water discharge against the east bank of Lake Jocassee for erosion potential. As part of the ongoing feasibility study for the Bad Creek II Complex, the CFD model is being further developed to reflect the working design of the Bad Creek II Complex. The updated CFD model will be available to analyze a range of potential operating scenarios to evaluate impacts to the Lake Jocassee shoreline and waters of Lake Jocassee. Through the relicensing process, Duke Energy plans to consult with agencies and other Project stakeholders to identify

specific operating scenarios and resources and issues of concern that can be evaluated with this model.

7.1.2 Water Resources

The Project, Project facilities, and the western portion of Lake Jocassee are situated in the Whitewater River watershed (HUC 030601010104), which has an area of approximately 80 mi^2. Bad Creek Reservoir has a drainage area of 1.5 mi^2 and receives drainage from two small streams: Bad Creek and West Bad Creek. Existing waters of the Bad Creek Reservoir are used only for Project operations. There are no other existing or proposed uses for Project waters. The Bad Creek Project exchanges water between an upper and lower reservoir and has no significant contributing inflows. While there are no state or federal water quality standards applicable to the waters of Bad Creek Reservoir, Lake Jocassee is included in the highest water quality classification (i.e., excellent rating) as designated by SCDHEC and preservation of existing conditions is recommended, with most tributaries within the watershed fully supporting their designated use.

7.1.2.1 Potential Issues – Existing Project

There are no known potential adverse effects to existing uses of Project waters or water quality in the upper or lower reservoirs due to the continued operation of the Project.

- Proposed Environmental Measures: Duke Energy plans to further consult with SCDHEC and relicensing stakeholders through the ILP regarding final PM&E measures directed at operation of the existing Project to be included in the final licensing proposal. Based on existing information, Project operations are not expected to adversely affect water quality in Lake Jocassee. Duke Energy plans to continue the Lake Jocassee pelagic trout habitat monitoring program through the New License term.

7.1.2.2 Potential Issues – Bad Creek II Complex

- Lower reservoir water levels: Operation of the proposed Bad Creek II Complex, which will add pumping and generating capacity to the Project, has the potential to impact water surface elevations of Lake Jocassee. The impact of existing operations of the existing Bad Creek Project on Lake Jocassee water levels is minimal. Adding pumping and generating capacity to the Project through the construction of the Bad Creek II Complex would reduce the time for maximum drawdown and refill of the upper reservoir; however, it would not result in additional water level rise in Lake Jocassee.

- Temporary water quality impacts to Lake Jocassee: Disturbance in the Whitewater River cove due to construction of the new lower reservoir inlet/outlet structure and expansion of the submerged weir by placement of rock materials excavated during tunneling activities may affect water quality. Similar to the impacts of the construction of the existing Project, temporarily elevated turbidity would be anticipated in the Whitewater River arm of Lake Jocassee. Previous studies during original weir construction indicated that while turbidity did increase during the construction phase, turbidity levels returned to normal following construction. Best management practices, as required by water quality permit(s) issued by SCDHEC, would be implemented to reduce sedimentation caused by placement of the excavated rock material to enlarge the submerged weir.
- Long-term impacts to the water quality of Lake Jocassee are not expected as a result of the operation of the proposed Bad Creek II Complex. The primary (temporary) impact to surface water quality (Lake Jocassee) during construction would be increased suspended sediment loads due to overland runoff and stream bank activities associated with the construction activities. These activities would lead to temporarily elevated turbidity levels, and potentially temporarily decreased DO levels and degradation of aquatic habitat in Lake Jocassee. These effects would, however, occur in a very localized area and likely affect only the Whitewater River arm of Lake Jocassee. No long-term degradation of water quality and aquatic habitat is expected to result from construction and operation of the Bad Creek II Complex.
- Impacts of upland spoil disposal: Construction of the Bad Creek II Complex would impact existing streams and waterbodies, including wetlands. Overburden (i.e., soil and rock) material from the construction activities are proposed to be deposited in several spoil locations throughout the site. Siting for spoil location alternatives is ongoing by Duke Energy; however, due to the amount of soil material required, existing topography, and prevalence of headwater streams and seeps located throughout the site, it is unlikely there would be a practicable alternative identified that will result in zero impacts to

steams and downstream waters. Estimates for proposed material removed from underground excavations indicate approximately 4 million cubic yards of spoil material for the Project infrastructure will need to be deposited into on-site spoil locations or along the submerged weir in Lake Jocassee. Potential spoil locations and estimated impacts to water resources are documented in Appendix E. As described in Section 5.6.3.3, placement of excavated rock removed from the underground excavations to the downstream slope of the existing submerged weir in Lake Jocassee, as was done for the construction of the existing Project, would significantly reduce the amount of material to be placed at upland disposal sites, thereby reducing impacts to existing streams and wetlands.

- Other surface water impacts: Traffic on access roads during construction and during continued Project operation has the potential to increase sediment runoff, and vehicles and machinery associated with construction can introduce additional environmental risks to the watershed. These impacts can be mitigated through BMPs (e.g., vegetation or matting) installed near haul roads and access roads as well as additional environmental plans to be developed for construction.
- Following completion of construction, operations of the Bad Creek II Complex are not likely to affect existing streams or tributaries, as there would be no changes to the local watersheds or modification of uplands.
- Proposed environmental measures:
    - Duke Energy proposes to develop a Water Quality Monitoring Plan in consultation with agencies, including monitoring locations, methods, and reporting criteria for major parameters such as DO, temperature, pH, specific conductance, and turbidity for Project construction (pre-, during, and post-construction) and operation.
    - As described above for geology and soils, Duke Energy plans to develop a comprehensive ESC Plan to be implemented for all construction phases of the Bad Creek II Complex.

- Duke Energy proposes to develop spill prevention, control, and safety management plans to prevent vehicle spilled fluids from entering the watersheds and harming water quality.
- Upland disposal resulting in impacts to streams or wetlands, as well as placement of rock spoils at the submerged weir as described below, will require an individual permit from the USACE as well as a water quality certification from SCDHEC under the authorities of Sections 404 and 401 of the CWA. Duke Energy expects to initiate this parallel regulatory process in conjunction with the relicensing process, if construction of the Bad Creek II Complex is pursued.
- Duke Energy plans to consult with agencies and other Project stakeholders through the relicensing process to determine additional PM&E measures for the protection of water quality appropriate for construction and operation of the Bad Creek II Complex.

7.1.2.3 Proposed Studies

- Duke Energy proposes to conduct a Water Quality Study for this relicensing to include and address the following:
  - Desktop and literature review of available water quality data collected in the Project Boundary and Lake Jocassee since approximately 1973 and of current designated uses and water quality standards applicable to the Project.
  - (If Bad Creek II Complex is pursued) Potential impacts on surface waters of placement of excavated material in upland disposal areas and at the submerged weir.
  - (If Bad Creek II Complex is pursued) Agency consultation to develop a Water Quality Monitoring Plan (to cover pre-construction, construction, and post-construction), including identification of applicable and appropriate threshold values for water quality parameters and monitoring means and methods.

7.1.3 Fish and Aquatic Resources (Including Related RTE Resources)

7.1.3.1 Potential Issues – Existing Project

- Upper reservoir: Bad Creek Reservoir is used only for Project operations; it is not designated for any other uses and therefore has no applicable state or federal water quality standards. Because of there are no regulatory designations, water sampling is not performed in the upper reservoir. Since Bad Creek Reservoir was a newly created reservoir and has no regulatory designations, no impacts to fish and aquatic resources in the upper reservoir are expected to result from continued operation of the Project.

- Lower reservoir: Operation of the existing Project and/or construction and operation of the Bad Creek II Complex has the potential to impact aquatic habitat in Lake Jocassee.

  - Littoral fish community: The impact of operation of the existing Project on Lake Jocassee water levels is minimal and not expected to cause substantial fluctuations in water surface elevations and therefore, minimal effects to littoral zone fish spawning and reproductive habitat. In accordance with the KT Project Relicensing Agreement, Duke Energy minimizes fluctuations of the Lake Jocassee water surface elevation as a protective measure for water quality, aquatic biota, and aquatic habitat. The KT Project Relicensing Agreement also commits Duke Energy to consultation with SCDNR if water levels decline below the reservoir level trends from 1996-1999, 2003-2007, and 2010 in order to evaluate options for reservoir stability for the remainder of the current period. Duke Energy has monitored the littoral fish community in Lake Jocassee since 1974 and continues electrofishing studies every three years with the goals to 1) determine species composition and detect changes in species communities, introduced species monitoring, etc.; 2) obtain catch-per-unit effort data used to identify increasing or decreasing population trends; and 3) evaluate the relative condition of Largemouth Bass and Alabama Bass.

  - Entrainment: Entrainment of fish at the Project during pumping and generation has the potential to cause injury or mortality to fish as they pass through the water conveyance system and turbines. An empirical entrainment study was conducted after the Project was completed in early 1990s and updated as a desktop study in 2021. Both studies conservatively assumed 100 percent mortality of fish passing through the facility, however it is apparent that some fish survive both pumping and generation operations, given the now-existing fish community in Bad Creek Reservoir (unstudied) and evidence of re-entrainment. Despite the conservative (i.e., maximum) estimate of entrainment mortality at the Project, results of the entrainment studies suggest entrainment has no statistical impact on the abundance of prey and sportfish taxa in Lake Jocassee, nor an impact on the effort and harvest of fish by anglers. Entrainment was also predicted to have no long-term impact on the prey fish population.

    - Based on the historical and recent entrainment studies, clupeids such as Threadfin Shad and Blueback Herring - both important forage species for trout and bass in Lake Jocassee - are the species most at risk of entrainment at the Project.

- Pelagic trout habitat: The major factor influencing the wide range in Lake Jocassee trout habitat availability, as determined by water quality monitoring data coupled with various statistical assessments of these data, is the magnitude and depth of winter mixing and reoxygenation of the water column. Continued operation of the Project is not expected to have a measurable incremental effect on trout habitat in Lake Jocassee. The empirical model has accurately predicted late summer habitat thickness since 1989 and therefore field sampling of temperature and DO profiles was discontinued in 2015.
- Proposed environmental measures: During the New License term, Duke Energy proposes to continue to operate the Project with the PM&E measures for the protection of Lake Jocassee fish and aquatic resources established by the MOU and KT Project Relicensing Agreement. Major measures include:
    - Bad Creek Project operational measures and protocol to reduce entrainment: Previous entrainment studies identified operational guidelines and a communications protocol between Duke Energy and SCDNR to minimize entrainment impacts. As part of those operational guidelines, Duke Energy agreed to operate its facilities to minimize, to the extent practicable, the length of time during which the Lake Jocassee pond elevation

is below 1,099 ft msl; if Lake Jocassee pond elevation falls below 1,099 ft msl, Duke Energy will implement operational changes at the Bad Creek Project based on hydro unit availability and other operational considerations to minimize fish entrainment, such as turning off lights near the inlet/outlet structure and implementing a unit startup and shutdown sequence. If Lake Jocassee is projected to remain below elevation 1,099 ft msl for 30 or 60 days, Duke Energy will notify and/or consult with the agencies to determine if additional measures to minimize impacts are appropriate. Over the last 10-Year Work Plan period (2006-2015), Lake Jocassee experienced 16 low water-level events due to drought and the agencies were consulted. No additional measures were implemented.

- Hydroacoustic monitoring of pelagic prey fish populations: This monitoring for pelagic prey fish (i.e., Threadfin Shad and Blueback Herring) abundance and distribution was performed in the spring and fall (biannually) from 1997 to 2015, and annually in the fall during the current Work Plan to understand and monitor any operational impacts to these species. Hydroacoustic and purse seine studies are proposed to continue through the current 10-Year Work Plan and will be considered for inclusion in the next 10-Year Work Plan, under the terms of the New License.
- Pelagic trout habitat trout habitat thickness is performed under the KT Project Relicensing Agreement, which requires a model prediction and verification by temperature and DO survey at the deepest location in Lake Jocassee (station 558.0) in February and September, annually. If trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations. Because the trout habitat thickness measurements have consistently been validated by the empirical model, no further PM&E measures, beyond the existing measures and requirements of the KT Project License and Relicensing Agreement and the Bad Creek Project Work Plans, are proposed at this time.
- The Bad Creek MOU lists a number of activities eligible for cost-sharing, including fisheries research, water quality studies, trout habitat studies, stream surveys, creel

surveys, fish and habitat management, development of bank and stream-side access, and stream protection and enhancement. Duke Energy provided a one-time payment of $120,000 in 2017 to support Bad Creek MOU research and monitoring activities by SCDNR. Duke Energy also provided further funding of $90,000 in 2019 and will provide another $90,000 in 2025. Under the KT Project Relicensing Agreement, Duke Energy provided $100,000 to SCDNR to support tributary stream restoration efforts.

- Pelagic trout habitat: Lake Jocassee is recognized as a regional trout fishery, and maintaining this fishery is an important shared interest of SCDNR and Duke Energy. Under the current 10-Year Work Plan (2017-2027), the Licensee provides $80,000 (in 2017 dollars) per year to the SCDNR toward the growing and stocking of trout in Lake Jocassee and its tributaries. This funding will continue through 2027 and is adjusted annually based on the Consumer Price Index. This will assist in ensuring trout are available for maintaining the quality sport fishery in Lake Jocassee. Duke Energy proposes to consult with agencies and stakeholders through the relicensing process to determine appropriate PM&E for trout for the term of the New License.
- Since Project impacts to the Lake Jocassee fish community due to entrainment are expected to be low and operational measures and protocols are already in place to minimize entrainment to the extent practicable, no additional PM&E measures, beyond the existing measures and requirements of the KT Project License and Relicensing Agreement and the Bad Creek Project Work Plans, are proposed at this time.
- Duke Energy expects to consult with agencies and other stakeholders regarding the need for additional PM&E measures focused on fisheries research and enhancements in the New License term through the relicensing process.

7.1.3.2 Potential Issues – Bad Creek II Complex

- Entrainment: Like the existing Project, entrainment of fish at the Bad Creek II Complex during pumping and generation has the potential to cause injury or mortality to fish as they pass through the water conveyance system and turbines. The estimated rates of entrainment mortality at the Project, with operation of Bad Creek II Complex, are not expected to affect the sustainability of Lake Jocassee fish populations. The species that experience the largest impact - Blueback Herring and Threadfin Shad - have relatively high fecundity, meaning that population-level compensatory mechanisms would likely offset the entrainment losses in terms of effects on these fish populations. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals (Sale et al. 1989). Based on the risk assessment framework, there is no expected risk to Blueback Herring and a moderate risk to Threadfin Shad. However, operation of the Bad Creek II Complex in addition to the existing Project is not expected to reduce the Threadfin Shad population on a long-term basis. As stated above, there are existing operational measures in place to minimize entrainment and forage fish populations are currently monitored regularly to evaluate effects to the Lake Jocassee fish community.

- Lake Jocassee pelagic trout habitat: The proposed inlet/outlet structure for the Bad Creek II Complex is located in the Whitewater River cove of Lake Jocassee upstream of the existing Bad Creek Project inlet/outlet structure. CFD modeling and subsequent monitoring of temperature and DO over the first three years of Bad Creek operation indicated no changes in temperature or DO profiles in Lake Jocassee due to the operations at Bad Creek with the exception of increased thermal and chemical mixing upstream of the submerged weir (which was predicted during the initial [pre-construction] modeling effort). Overall, operational monitoring indicated the weir successfully restricts Bad Creek impacts to an isolated area of the Whitewater River cove upstream of the submerged rock weir. Given the same volume of water will be generated and pumped between Lake Jocassee and Bad Creek Reservoir as the existing Project, it is not anticipated the addition of a second powerhouse will significantly impact mixing or seasonal stratification in the main body of the reservoir downstream of the weir. However, with the implementation of the Bad Creek II Complex, the added exchange of water between the upper Bad Creek Reservoir and Lake Jocassee warrants an annual trout habitat monitoring program through the next Work Plan period after construction. Monitoring of trout habitat thickness is performed under the KT Project Relicensing

Agreement, which requires a model prediction and verification by temperature and DO survey at the deepest location in Lake Jocassee in February and September, annually.

- No effects on the population, abundance, or distribution of forage fish are anticipated as a result of the proposed Bad Creek II Complex operations; however, annual sampling and monitoring conducted as part of the current 10-Year Work Plan could continue in future years and any changes in forage fish populations or diversity could be identified under those activities. Similarly, no effects on the littoral fish populations or changes in suitable habitat are anticipated as a result of the proposed Bad Creek II Complex operations; however, electrofishing surveys will continue every three years under the current 10-Year Work Plan. The littoral fish community is monitored regularly as part of a current and ongoing program.
- As mentioned in Section 7.1.2.2, streams in the upland areas within the area of influence may be directly impacted by the upland disposal of overburden materials from the construction of Bad Creek II Complex.
- Proposed environmental measures: Duke Energy expects to consult with agencies and other Project stakeholders through the relicensing process to determine additional PM&E measures appropriate for construction and operation of the Bad Creek II Complex.

7.1.3.3 Proposed Studies

- An updated desktop entrainment study has been performed for operation of the existing and expanded Project (i.e., two powerhouse operation) (Kleinschmidt 2021) (Appendix F). Through the relicensing process, Duke Energy proposes to consult with agencies and other Project stakeholders regarding results of this assessment and study updates or modifications required to address impacts of the Bad Creek II Complex.
- Duke Energy does not propose to conduct field surveys targeted at fish and aquatic resources in Lake Jocassee or the upper reservoir as relicensing studies. Several Lake Jocassee studies have recently been conducted or are on-going through the MOU, including an updated entrainment study, littoral zone electrofishing of Lake Jocassee, and hydroacoustic pelagic prey monitoring (previous pelagic trout habitat study finalized in 2015). If the proposed Bad Creek II Complex is pursued, proposed changes to the

underwater weir (see Section 5.6.3.3) have the potential to influence the temperature and DO dynamics in Lake Jocassee. Therefore, recommencing trout habitat monitoring in Lake Jocassee using the validated model would be appropriate if the Bad Creek II Complex is pursued.

- To the best of Duke Energy's knowledge, mussels do not occur in the tributary streams that may be impacted by upland spoil disposal. If the Bad Creek II Complex is pursued, Duke Energy proposes to conduct presence/absence surveys for mussels and other protected aquatic species (if applicable) of potentially impacted streams.

7.1.4 Wildlife and Botanical Resources (Including Related RTE Resources)

7.1.4.1 Potential Issues – Existing Project

- Continued Project operations are not anticipated to affect wildlife and botanical resources of the Project vicinity. Protection of upland habitat around Lake Jocassee is provided by the requirements and agreements of the KT Project Relicensing Agreement and license. As described above, operation of the Project does not significantly impact Lake Jocassee water levels. Project operations are not likely to affect vegetation dispersal in the Project Boundary.
- The SMP for the KT Project includes conditions for native vegetation plantings allowing the use of plantings to supplement existing native vegetation for protection and enhancement of important habitat areas. Continued implementation of the SMP will provide protection for vegetation communities at Lake Jocassee.
- Vegetation on faces of dams at the Project is maintained in accordance with the FERC-approved Dam Safety Surveillance and Monitoring Plan while vegetation maintenance of access areas is conducted on an as-needed basis. Vegetation along the transmission line corridor is maintained on a regular basis.
- Proposed environmental measures: No additional PM&E measures are proposed by Duke Energy at this time. The need for additional PM&E measures for the protection of wildlife and botanical resources will be evaluated through the licensing process.

7.1.4.2 Potential Issues – Bad Creek II Complex

- Construction of the proposed Bad Creek II Complex would impact existing plant and wildlife communities. The primary impacts would be direct habitat loss from tree clearing required within the final limits of disturbance, as well as associated access roads. Loss of forested communities will permanently impact native plant communities and will affect wildlife communities by displacement, habitat fragmentation and interrupting migration corridors.
- Habitat loss would likely disperse mobile wildlife into surrounding areas in an attempt to find new food sources and shelter. Impacted areas will, however, be concentrated in the vicinity of existing Project structures and spoil (excavated soil) disposal areas sited to reduce impacts. Because construction of the Bad Creek II Complex would not require construction of any new dams or reservoirs, the scale of impact and disturbance is small compared to development of a greenfield energy storage and generation project of this size.
- Land clearing and soil disturbance could potentially enable the introduction or facilitate the spread of invasive plant and insect species. Similarly, construction or operation of the water supply intake and supporting infrastructure could potentially enable the introduction or facilitate the spread of invasive aquatic species. Project construction and operation also have the potential to affect (positively or negatively) the spread of invasive species.
- Field surveys conducted in support of this PAD identified potential habitats for five federally threatened and endangered species within the area of influence: northern long-eared bat, Indiana bat, persistent trillium, small whorled pogonia, smooth coneflower, and bald eagle.
- According to the USFWS list of At-Risk species for South Carolina, and the SCDNR consultation report, nine At-Risk species occur in Oconee County and/or in the Project vicinity. Results from field surveys conducted in support of this PAD indicate that potential habitats for all nine At-Risk Species: Chamberlain's dwarf salamander, golden-winged warbler, Edmund's snaketail, monarch butterfly, Smokies needlefly, little brown

bat, tri-colored bat, Carolina hemlock, Georgia aster, and sun-facing coneflower are present within the area of influence.

- The results of the ERM (2021) bat survey indicated a diversity of bat species present within the Project vicinity. Habitat surveys indicated abundant suitable habitat for Indiana bat and northern long-eared bat but results from the presence/absence survey revealed that these species are not likely to be on-site. Of the 14 bats captured, four of them were eastern small-footed bats; the eastern small-footed bat is considered a species in need of management in the State of South Carolina, which is the equivalent to state-threatened status. Abundant rocky roosting habitat for eastern small-footed bat was found within the Project Boundary, although none could be confirmed to be occupied. Results of the acoustic survey suggest high confidence in the presence of little brown bat and tri-colored bat, which are both currently designated as At-Risk Species and are under review for future listing with the USFWS.
- Proposed environmental measures: Duke Energy expects to consult with agencies through the licensing process to determine appropriate PM&E measures for the protection of wildlife and botanical resources before, during, and following construction of the Bad Creek II Complex, including:
    - Measures for seasonal restrictions for vegetation clearing and revegetation plans for plant and wildlife resources.
    - Measures to reduce the potential for the Project to contribute to the spread of invasive species.
    - Coordination with the USFWS concerning potential Project impacts to federally threatened and endangered species, including pre-construction survey for persistent trillium, smooth coneflower, and small whorled pogonia during the recommended optimal window and once limits of disturbance and the construction schedule are established, as well as opportunities to implement conservation measures that will help protect these species.
    - As a conservation measure for federally protected bat species, it is generally recommended that tree clearing activities be conducted during the bats inactive

season (November 15th through March 31st for northern long-eared bat) to avoid negative impacts to the species. A clearing moratorium may also be required contingent on the results of the ongoing bat surveys onsite. If protected bat species (Indiana/northern long-eared bat) are present, the USFWS would likely impose a tree cutting moratorium between April 15 through October 15. Duke Energy expects to consult with USFWS through this relicensing process and other major applicable regulatory processes to determine practicable and appropriate protection measures for construction of the Bad Creek II Complex.

7.1.4.3 Proposed Studies

Based on the studies conducted in support of preliminary evaluation of potential impacts of the Bad Creek II Complex and preparation of this PAD, Duke Energy does not propose to conduct additional broad surveys for wildlife and botanical resources as relicensing studies.

If the Bad Creek II Complex is pursued, and as described in the list of preliminary PM&E measures above, Duke Energy plans to consult with agencies through the relicensing and other applicable regulatory processes to determine specific needs for and timing of focused surveys within the final proposed limits of disturbance.

7.1.5 Wetlands and Riparian Habitat

The USACE and SCDHEC have jurisdiction over wetlands in South Carolina. Surveys of the Bad Creek to Jocassee transmission line corridor and balance of the area of influence were performed for Duke Energy in 2021 for wetlands and jurisdictional waters of the U.S. regulated under Section 404 of the CWA. The on-site reconnaissance activities of the transmission line corridor identified 47 jurisdictional streams, 17 jurisdictional wetlands, and 1 open water within the area covered by this survey. The field survey of the area of influence excluding the transmission line corridor estimated 23 jurisdictional streams, 7 potentially wetlands, and 7 non-jurisdictional isolated wetlands, and one jurisdictional open water.

7.1.5.1 Potential Issues – Existing Project

Continued operations at the Project are not anticipated to impact existing wetland, riparian, and littoral habitat. No additional PM&E measures for wetlands and riparian habitat are proposed.

7.1.5.2 Potential Issues – Bad Creek II Complex

- Surface water and wetland impacts due to spoil disposal: According to the preliminary studies and estimates for proposed material removed from underground excavations, approximately 4 million cubic yards of spoil material for the Project infrastructure will need to be deposited into on-site spoil locations or along the submerged weir in Lake Jocassee. Potential spoil locations and estimated impacts to water resources are included in Section 6.6.3. Proposed structure estimated impacts to water resources are also included in Section 6.6.3.
- Floodplains: The FEMA Map Service Center's National Flood Hazards Layer Geographic Information System (GIS) database identified regulated floodplains located in the area of influence. Coordination with Oconee County's Floodplain Administrator will be required if the proposed Project requires work or placement of fill within the regulated floodplain.
- Proposed environmental measures: Duke Energy does not propose any PM&E measures be included as part of the New License. PM&E measures for the protection of wetland and riparian resources will be determined and implemented through other state and federal permitting processes, including the CWA Section 404 Permit and a 401 Water Quality Certification required for unavoidable impacts to jurisdictional surface waters.
    - Compensatory mitigation will be required for unavoidable impacts to surface waters to ensure that impacts to aquatic resources are avoided or minimized to the greatest extent possible, which is consistent with the current administration's goal of "no net loss of wetlands." Mitigation options may include on-site restoration or purchase credits from an approved in-lieu fee mitigation bank to offset adverse impacts.

7.1.5.3 Proposed Studies

Based on the studies conducted in support of preliminary evaluation of potential impacts of the Bad Creek II Complex and preparation of this PAD, Duke Energy does not propose to conduct an additional broad Wetlands and Riparian Habitat study for the relicensing.

If development of the Bad Creek II Complex is pursued, Duke Energy expects to initiate a parallel regulatory process with USACE and SCDHEC under the authorities of Sections 404 and 401 of the CWA. Pursuit of these permitted actions would require avoidance and minimization of impacts to the maximum extent practicable, as well as mitigation compensation for proposed losses. Part of the process of acquiring authorizations under Sections 404 and 401 with respect to mitigation compensation would involve delineation of waters of the U.S. in the proposed disposal areas; stream and wetland quality assessments (likely based on hydrogeomorphology characteristics and aquatic biota surveys); and alternatives analyses.

7.1.6 Recreation and Land Use

There are no FERC-approved Recreation Facilities within the Project Boundary. There is, however, a 43-mile segment of the Foothills Trail and two access points to Lake Jocassee that are on non-Project lands maintained by Duke Energy under the Original License as Project-related facilities.

7.1.6.1 Potential Issues – Existing Project

- There are no recreation opportunities within the Project Boundary, therefore no impacts are anticipated for the continued operation of the Project. The segment of the Foothills Trail and two undeveloped access areas on non-Project lands that were developed per the Original License will continue to be maintained by Duke Energy in the New License term as a non-Project facility and potentially under a separate agreement with regional stakeholders. The majority of the recreation in the vicinity of the Project consists of water-based activities on Lake Jocassee and use of the Foothills Trail.
- Proposed environmental measures:
  - For the benefit of natural, cultural, and recreation resources, Duke Energy proposes to continue to operate the Project in the existing mode and with the

existing protections for restrictions on land and shoreline development in the vicinity of the Project Boundary.

  - Duke Energy anticipates development of an updated RMP for the Project with or following the FLA, as needed to address existing and proposed facilities and arrangements. Duke Energy will consult with interested stakeholders throughout the relicensing process regarding necessary recreational facility maintenance or potential new enhancement measures. Any such measures would be developed in consultation with appropriate resource agencies and other relicensing stakeholders.

7.1.6.2 Potential Issues – Bad Creek II Complex

- Temporary impacts and restrictions on recreational access during construction:
  - The proposed Bad Creek II Complex would have an inlet/outlet structure on the west bank of the Whitewater River cove of Lake Jocassee upstream from the existing Bad Creek Project inlet/outlet structure. During construction activities (assumed to last approximately five years), recreational activities would be prohibited in this area (Whitewater River cove) to protect the public. Recreation across the majority of Lake Jocassee would not be impacted by construction of the Bad Creek II Complex.
  - Closure of the parking area during construction would result in a short-term adverse impact to recreational opportunities for the public in this portion of Lake Jocassee. Other parking areas do, however, provide Foothills Trail access, and trail access to the Upper and Lower Whitewater Falls would not be impacted by construction. This is considered a temporary impact.
- Recreational public safety: Operation of the Bad Creek II Complex, alone or in combination with operation of the existing Project powerhouse, has the potential to impact surface water velocities in the Whitewater River cove of Lake Jocassee, particularly during periods of generation, which could affect boaters.
- Proposed environmental measures: Short-term impacts due to construction activities may require mitigation in the form of additional boating and/or land-based (i.e., trails,

overlooks, etc.) amenities. Duke Energy expects to consult with agencies and other relicensing participants through the licensing process to identify and propose in the FLA additional PM&E measures for recreation in the Project vicinity.

7.1.6.3 Proposed Studies

- Duke Energy proposes to conduct a RUN Study for the Bad Creek Project. Methods and scope may be adapted from the 2013 RUN Study for the KT Project (Duke Energy 2014d), to include literature search and stakeholder consultation, as well as facility inventories and condition assessments (potentially also including trail management performed by the Foothills Trail Conservancy in relevant areas), spot counts and trail and traffic counters or trail camera observations, aerial photography, recreation site use records, various types of visitor surveys and interviews, and telephone interviews with land and facility managers . The Bad Creek Project RUN Study would focus on the Foothills Trail, Canebreak Trail and Laurel Creek Foothills Trail access points, and parking areas. The RUN Study would inform development of an updated RMP for the New License term and would also support characterization of existing recreational use levels for areas that would be temporarily impacted by Bad Creek II Complex construction.

- If the Bad Creek II Complex is pursued, Duke Energy proposes to conduct a Recreational Public Safety evaluation in consultation with agencies and other Project stakeholders, to evaluate potential public safety risks that may be created or exacerbated by the Bad Creek II Complex during both the construction and operation phases. This study will include but not be limited to identification of areas where access will be temporarily or permanently restricted to the public as well as a boater safety evaluation for the Whitewater River arm of Lake Jocassee. As described in Section 7.1.2.3, if the Bad Creek II Complex is pursued, Duke Energy proposes a desktop relicensing study, to evaluate impacts of operation of the expanded Project (i.e., two powerhouses) on velocities of water discharged to the Whitewater River arm of Lake Jocassee through development and use of a three-dimensional CFD model. The updated CFD model will be available to analyze a range of potential operating scenarios to evaluate impacts to water-based recreation in the Whitewater River arm of Lake Jocassee.

7.1.7 Aesthetic Resources

The Project is located in the Upstate of South Carolina. This area is known for its scenic views of mountains, forested landscapes, and waterfalls. Visual elements associated with the Project include the upper reservoir, the main dam, the west dam, the east dike, the equipment building, access roads, transformer yard and switchyard (adjacent to equipment building), and the 100kV transmission line extending from the Bad Creek transformer yard to a grid intertie station at the Jocassee Station. The Bad Creek facility is not visible from any state highway nor is it visible from Lake Jocassee (via boat). It is only visible from the Bad Creek access road.

7.1.7.1 Potential Issues – Existing Project

Since the Project is not visible from anywhere other than the access road, Duke Energy expects there to be no temporary or permanent impacts on aesthetic resources from the continuing operation of the Project, and no PM&E measures are proposed.

7.1.7.2 Potential Issues – Bad Creek II Complex

- The construction of the Bad Creek II Complex will include a new powerhouse and associated structures as well as two new discharge outlets to the Lake Jocassee. Similar to the existing discharge outlets, the two new discharge outlets will be viewable via boat (from the Whitewater River cove). With the construction of the proposed Project, the visual landscape will be altered both during and after construction; however, the impact of this is considered minor as the facility cannot be viewed by any public areas (i.e., can only be viewed by the Bad Creek Access Road) and visual impacts related to the new discharge outlets will be temporary.
- Short-term aesthetic impacts will occur during construction of the Bad Creek II Complex, due to land clearing and grading activities; creation of new upland spoil areas; temporary, localized turbidity impacts in the Whitewater River cove; construction traffic; temporary construction facilities; and the continued presence of heavy construction equipment.
- Environmental protection measures: Common mitigation techniques can be applied to reduce impacts to visual resources during and after construction include minimization of disturbance (e.g., limit clearing trees and vegetation to the extent possible), lighting

control, strategic placement of facility appurtenances, and reduction of visual contrast caused by new rights-of-way, access roads, laydown areas, staging areas. Duke Energy expects the best management practices and PM&E measures required to address the requirements of the FERC license and Section 404/401 permit will also benefit aesthetic resources. Duke Energy expects to further consult with relicensing stakeholders to determine whether additional PM&E measures are needed for the protection of aesthetic impacts.

7.1.7.3 Proposed Studies

- If development of the Bad Creek II Project is pursued, Duke Energy proposes to conduct an Aesthetic Resources Study to inform the development of the license application, which will describe the aesthetic resources of the proposed Project vicinity, expected impacts on these resources, and any mitigation, enhancement and protection measures proposed. An Aesthetic Resources Study Plan will be carried out to establish the baseline condition of the aesthetic resources near the existing Project and to provide additional information (e.g., including visualizations of the expanded Project) to evaluate impacts of construction and operation of the Bad Creek II Complex on these resources.

7.1.8 Cultural and Tribal Resources

7.1.8.1 Potential Issues – Existing Project

- There are no historic properties within the Project Boundary and therefore no current opportunity for adverse effects related to the existing operations.
- Archaeological Site 38OC0250 lies in the northern portion of the Project Boundary. Should future land disturbing activities be planned for the area of this site, evaluative investigations should be conducted prior to any land disturbance within 50 feet of the site. If the site is determined not eligible for the NRHP, Site 38OC0250 will require no further management consideration and land disturbing activities may occur within the site. Should Site 38OC0250 be determined eligible for the NRHP, planned land disturbing activities should be redesigned to avoid the site. If the site cannot be avoided through redesign, it will suffer an adverse effect. Appropriate data recovery

investigations would be implemented to recover a sample of the significant information present within the site as mitigation for this adverse effect.

- There are two known historical architectural resources located in or immediately adjacent to the Project APE - SHPO Site Number 0155 Keowee Hydroelectric Development and SHPO Site Number 0156 Jocassee Hydroelectric Development. These sites were recommended potentially eligible for the NRHP. A NRHP evaluation of the KT Project, which includes both SHPO Site Numbers 0155 and 0156, has not yet been carried out due to the collective age of the facilities (less than 50 years old). These properties are not expected to be impacted by FERC's issuance of a New License for continued operation of the Bad Creek Project.

7.1.8.2 Potential Issues – Bad Creek II Complex

- Construction of the Bad Creek II Complex will include peripheral connections with SHPO Site Numbers 0155 and 0156 ("Keowee-Toxaway Hydroelectric Development"). These facilities are identical to those currently used in the operation of the hydropower-generating facilities of the Project. Further, the addition of the Bad Creek II Complex will not result in operational changes to the KT Project. As such, the new powerhouse will not alter the any aspects of the KT Project that could compromise its NRHP eligibility.
- Construction of the proposed powerhouse adjacent to the existing Bad Creek Powerhouse will result in ground-disturbing activities, which have the potential to disturb known or potential historic properties. Archaeological sites (38OC249, 38OC251) within the area of influence (see Appendix E – Table 2) are potentially eligible for listing in the NRHP (need evaluation). Any archaeological resource that is listed as eligible should be preserved in place; additional mitigative archaeological investigations would be undertaken at the sites in coordination and consultation with the SHPO and participating Tribes.
- Proposed environmental measures: Duke Energy will continue to pursue, through the relicensing process, identification of NRHP-eligible cultural resources and consideration and implementation of appropriate resource protection, avoidance, or mitigation methods for historic, archaeological, and traditional cultural resources. Potential mitigation for

effects to NHRP-eligible properties may take various forms and expects that FERC may complete Section 106 consultation by entering into a Programmatic Agreement (PA) or Memorandum of Agreement (MOA) with Duke Energy, the Advisory Council, and State and/or Tribal Historic Preservation Officers. The Programmatic Agreement or Memorandum of Agreement would establish mitigation measures such as but not limited to, development of a Historic Properties Management Plan, installment of temporary fencing to protect cultural resources during construction (if present), avoidance of sensitive areas not directly within the footprint of proposed Bad Creek II Complex facilities (as feasible), and monitoring during construction by a qualified archaeologist for construction in areas where cultural resources are likely to be present (if any). Identification of Project impacts and determinations of appropriate mitigation measures to be applied will be developed with input from the SHPO, FERC, interested tribes, and possibly additional interested parties.

7.1.8.3 Proposed Studies

- Duke Energy plans to coordinate with the SCDAH regarding potential issues with respect to cultural resources that may be located within the area of influence of Bad Creek II Complex construction. Duke Energy expects that SHPO will require a cultural resources survey of the APE. A cultural resources survey would likely include an archaeological survey for all non-steep (less than 15 percent slopes) landforms, as well as an architectural survey of any structures on or near the Project that are 40+ years old. Given the landforms within the corridor and their proximity to several creeks, as well as the concentration of previously recorded archaeological sites near the Project on similar landforms, there is an increased probability of archaeological sites across the area of influence.
- Separate from the Bad Creek relicensing process, Duke Energy is in the process of completing an Architectural Survey and National Register Evaluation for the Jocassee Pumped Storage Hydro Station. A formal determination of eligibility for the KT Project can proceed in 2022 given the collective construction dates of 1972.

7.1.9 Socioeconomic Resources

7.1.9.1 Potential Issues – Existing Project

Duke Energy does not anticipate continued operation of the Project for the term of the New License would have any adverse effects on socioeconomic resources or environmental justice populations. No PM&E measures focused on socioeconomic resources are proposed.

7.1.9.2 Potential Issues – Bad Creek II Complex

Duke Energy does not anticipate the proposed Bad Creek II Complex would have any adverse effects on socioeconomic resources or environmental justice populations.

- No identifiable low-income population is present in the Project vicinity. While a small minority population exists, overall, the percentages are well below the Oconee County percentages.

- Construction and operation of the Bad Creek II complex are anticipated to bring economic growth and opportunities to the surrounding communities, including the small minority population in the Project vicinity. Impacts associated with construction of the Bad Creek II Complex are considered temporary and will result in long-term benefits. Operation of the expanded Project would support local employment and income, and economic output, as well as generate state and local tax revenues.

- Proposed environmental measures: No PM&E measures focused on socioeconomic resources are proposed. The need for additional measures will be evaluated through the relicensing process.

7.1.9.3 Proposed Studies

Duke Energy does not propose to conduct a relicensing study focused on socioeconomic resources. Potential issues regarding socioeconomic resources associated with the Bad Creek II Complex will be identified and assessed by Duke Energy and its consultants through the relicensing process.

Data and evaluations, as appropriate, will be presented in the FLA to support FERC's environmental review.

8 Comprehensive Plans (18 CFR §5.6(d)(4)(iii)

Section 10(a)(2) of the Federal Power Act (FPA), 16 U.S.C. section 803(a)(2)(A), requires the Commission to consider the extent to which a project is consistent with federal and state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by a project. Duke Energy has identified 16 comprehensive plans relevant to the Bad Creek Project.

8.1 South Carolina

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8.2 North Carolina

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Appendix A

Appendix A – Distribution List

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Appendix B

Appendix B – Agency Consultation

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Appendix C

Appendix C – Project Boundary Map

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Appendix D

Appendix D – Single-line Diagram

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Appendix E

Appendix E – Natural Resources Assessments

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Appendix F

Appendix F – Desktop Entrainment Analyses

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Appendix G

Appendix G – 2021 Bat Survey Report

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