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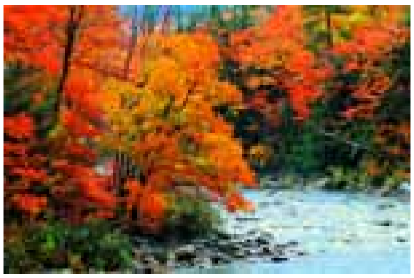

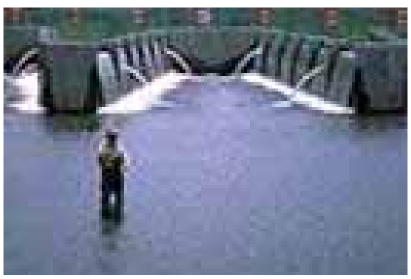

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Tennessee Valley Authority Reservoir Operations Study

Record of Decision

May 2004

Lead Agency: Tennessee Valley Authority

In cooperation with U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service.

TVA

Billing Code 8120-08 (U)

TENNESSEE VALLEY AUTHORITY

Final Programmatic Environmental Impact Statement–Tennessee Valley Authority Reservoir Operations Study

AGENCY: Tennessee Valley Authority (TVA)

ACTION: Issuance of Record of Decision

SUMMARY: This notice is provided in accordance with the Council on Environmental Quality's regulations (40 Code of Federal Regulation [CFR] Parts 1500 to 1508) and TVA's procedures implementing the National Environmental Policy Act (NEPA). TVA has decided to adopt the Preferred Alternative identified in its Final Programmatic Environmental Impact Statement–Tennessee Valley Authority Reservoir Operations Study. The Final Environmental Impact Statement (FEIS) was made available to the public on February 19, 2004. A Notice of Availability of the FEIS was published in the Federal Register on February 27, 2004. The TVA Board of Directors decided to adopt the Preferred Alternative at its May 19, 2004, public meeting. In adopting the Preferred Alternative, TVA has decided to change the policy that guides the operations of the Tennessee River and reservoir system. Consistent with the operating priorities established by the TVA Act, the change will establish a balance of reservoir system operating objectives to produce a mix of benefits that is more responsive to the values expressed by the public during the Reservoir Operations Study (ROS). This includes enhancing recreational opportunities while avoiding unacceptable effects on flood risk, water quality, and TVA electric power system costs.

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SUPPLEMENTAL INFORMATION: TVA is a multipurpose federal corporation with a mandate to foster the social and economic well-being of the residents of the Tennessee Valley region through the wise use, conservation, and development of its natural resources. In carrying out this mission, TVA conducts a range of programs and activities, including operating the Nation's largest public power system, serving almost nine million people in parts of seven southeastern states, and operating a system of dams and reservoirs with associated facilities—its water control system.

As directed by the TVA Act, TVA manages the Tennessee River and reservoir system as an integrated water control system primarily for the purposes of navigation, flood control, and power production. Consistent with those purposes, TVA operates the system to improve water quality and water supply, and provide recreational opportunities, and a wide range of other public benefits. The water control system has hydroelectric generators and provides the cooling water supply for TVA's coal-fired and nuclear power plants and water supply for other industries located adjacent to the reservoirs. TVA's power system and its management of the integrated water control system are central components of the economic well-being of the Tennessee Valley region.

TVA also manages 11,000 miles of public shoreline to maintain the integrity of the reservoir system. TVA has custody of and manages 293,000 acres of land in the Valley, most of which is along the shorelines of TVA reservoirs. Development and management of these lands and activities are influenced by reservoir levels and river flows.

TVA's reservoir operations policy guides the day-to-day management of the reservoir system. The reservoir operations policy sets the balance of trade-offs among competing uses of the water in the system. It determines the storage and flow of water in the reservoir system in response to rainfall and runoff. It affects the rise and fall of reservoir levels, when changes in reservoir levels occur, and the amount of water flowing through the reservoir system at different times of the year. Because TVA must respond to widely varying conditions in the operation of its reservoir system that are largely beyond TVA's control, its operations policy is basically a guideline and is implemented in a flexible manner.

TVA conducted the ROS to determine whether changes in how it operates the reservoir system would produce greater overall public value for the people of the Tennessee Valley. TVA initiated the study in response to recommendations by public groups, individuals, and other entities while at the same time recognizing that the needs and values of the region and its people change over time. The scope of the study included 35 projects in the Tennessee River and Cumberland River watersheds. The study included a long-range planning horizon to the year 2030. The study area included most of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia.

On February 25, 2002, TVA published a notice in the Federal Register announcing that it would prepare a programmatic EIS on its reservoir operations policy and inviting comments on its scope and contents. TVA, the U.S. Army Corps of Engineers (USACE), and the U.S. Fish and Wildlife Service (Service) cooperated to prepare the EIS. TVA also established two groups—a 17-member Interagency Team and a 13-member Public Review Group (IAT/PRG)—to ensure that agencies and members of the public were actively and continuously involved throughout the study.

During scoping, TVA received over 6,000 individual comments, about 4,200 form letters and petitions signed by more than 5,400 members of the public. In addition, 3,600 residents in the TVA Power Service Area commented as part of a random telephone survey conducted by an independent research firm. TVA staff used this input to identify a broad range of issues and values to be addressed in the ROS. Overall, the public placed a high value on recreation, a healthy environment, production of electricity, and flood control.

Based on issues and values identified during the scoping process, TVA staff along with input from members of the IAT/PRG developed a set of objectives that TVA used to define, evaluate, and compare a range of eight policy alternatives in the DEIS. The eight alternatives were examined in detail through a combination of data collection, statistical analysis, computer modeling, and qualitative assessment. As part of the analysis process, TVA worked with national experts from various disciplines. TVA staff developed advanced technologies for modeling water quality impacts and new analytical tools for modeling flood risk on an unprecedented scale—encompassing 35 dams and reservoirs and 99 years of hydrologic data.

The Notice of Availability of the DEIS was published in the Federal Register on July 3, 2003. During the comment period on the DEIS, TVA received input from almost 7,000 individuals, including form letters and petitions with over 4,500 signatures. Volume II, Appendix F of the FEIS contains responses to the over 3,200 separate comments TVA received during the DEIS review process. Most individuals expressed support for those alternatives in the DEIS that increased reservoir and tailwater recreation opportunities. However, state and federal agencies were concerned about the adverse water quality effects associated with most of the alternatives, particularly those enhancing recreation opportunities. Generally, the agencies preferred that TVA retain its existing operations policy (the No Action Alternative or Base Case). The

Environmental Protection Agency (EPA) suggested the development of a hybrid or blended alternative that would avoid or reduce the environmental impacts associated with the identified action alternatives.

The Department of the Interior, other agencies, and some members of the public strongly encouraged TVA to employ an adaptive management approach to implementing whatever changes might result from ROS. Adaptive management involves monitoring and modifying system operations as appropriate to respond to future conditions, such as changes in water quality. TVA currently practices adaptive management through the flexibility built into its operations policy and extensive monitoring of the reservoir system. TVA will continue to use such adaptive management practices as it implements the Preferred Alternative.

As suggested by EPA, TVA developed an alternative that blends elements of the action alternatives supported by the public while avoiding or reducing associated adverse environmental impacts. Specifically, TVA used a series of simulations to combine and adjust elements of alternatives included in the DEIS that supported increased recreation opportunities, navigation, and other system benefits. Adjustments were made to avoid or reduce adverse impacts to other objectives including flood risk, water quality, power costs, aquatic resources, wetlands, migratory waterfowl and shorebirds, and shoreline erosion. The end result of the blending process is TVA's Preferred Alternative.

The FEIS was released to the public on February 19, 2004, with a request for comment on the Preferred Alternative. The Notice of Availability of the FEIS with 45 days for the public to comment was published in the Federal Register on February 27, 2004.

Comments on the Final EIS

Although not required, TVA provided a 45-day comment period on the FEIS and the Preferred Alternative. To facilitate the review process, TVA distributed approximately 1,200 copies of the FEIS and posted a copy on the official agency internet web site, where comments could be made. In addition, TVA accepted comments by surface or electronic mail, telephone, and facsimile. TVA staff met with and briefed over 1,100 interested stakeholders. Approximately 50 scheduled briefings were conducted for federal, state, and local officials, TVA power distributors, reservoir user groups, and Valley media. TVA continued to meet with its cooperating agencies and with members of the IAT/PRG to brief them on the FEIS and the Preferred Alternative and to receive their input.

During the FEIS review process, TVA received comments from almost 2,000 individuals, 4 federal agencies, and 10 state agencies. The comments included over 500 form letters and petitions signed by more than 800 individuals. Most of the comments were similar to those TVA received on the DEIS, except for those comments specifically on the Preferred Alternative. In general, the public and agencies supported the Preferred Alternative and viewed it as a substantial improvement over the Base Case. However, about 800 individuals expressed concerns regarding the delayed fill component on the upper mainstem projects, especially Watts Bar and Fort Loudoun/Tellico, and the potential adverse recreation and economic impact this could have on marina operators on these reservoirs. Concerns were also expressed about the lack of changes in the operations of Tims Ford and Kentucky Reservoirs.

The delayed fill component of the Preferred Alternative was included to enhance flood risk protection at locations on the mainstem reservoirs, including Chattanooga. Although there is some uncertainty in this regard, TVA expects the delayed fill to have minimal effects on the recreation opportunities (dock accessibility) on the upper

mainstem reservoirs and fish spawning. Impacts to fish spawning would be minimized because much of the prime nesting habitat would be covered during the first week of April when half the summer pool is filled and before spawning begins. Additionally, starting on April 8, a slow fill into the remainder of the shallows may benefit the growth and survival of both fry and young-of-year fish. TVA's analysis of median reservoir levels projected under the Preferred Alternative indicate that boat ramps, commercial marinas, and most private docks will be functional from April 15 through the period of slowed fill. Assuming average rainfall and runoff, water levels would be within the summer operating zone by the first week of May. More importantly, TVA's adaptive management approach to implementing the Preferred Alternative will enable the agency to determine if unacceptable or unexpected adverse impacts result on these reservoirs and to adjust operations appropriately. No changes were made on Tims Ford and Kentucky reservoirs to avoid unacceptable impacts on flood risk, wetlands, and wildfowl. None of the comments on the FEIS identified material weaknesses in TVA's analyses.

Alternatives Considered

TVA considered eight reservoir operations policy alternatives in the DEIS: **Base Case** (the No Action Alternative), **Reservoir Recreation A**, **Reservoir Recreation B**, **Tailwater Recreation**, **Tailwater Habitat**, **Summer Hydropower**, **Equalized Summer/Winter Flood Risk**, and **Commercial Navigation**. A ninth alternative, the Preferred Alternative was addressed in the FEIS. Each policy alternative establishes a balance of reservoir system operating objectives. Except for the Base Case, each alternative would change, to various degrees, reservoir levels and flow releases and their seasonal timing to produce a different mix of benefits. Under all of the alternatives, including the Preferred Alternative, TVA would continue to use water stored in the

reservoirs to preserve the reliability of the TVA power system during Power System Alerts or other critical power system situations.

As required by NEPA, TVA used the **Base Case Alternative** to document the existing reservoir operations policy and to serve as a baseline against which the action alternatives are compared. Under the Base Case, TVA would continue to operate its integrated water control system in accordance with the existing balance of operating objectives, reservoir levels and water release guidelines, and project commitments and constraints.

The Base Case also involves a number of other actions that would occur regardless of changes in the reservoir operations policy. These actions include: existing water-use patterns, taking into account increasing water supply demand in the future (through 2030), modernization and automation of TVA's hydro plants, operation of Browns Ferry Nuclear Plant Unit 1 and continued operation and uprate of Units 2 and 3, and operation of the Tennessee−Tombigbee Waterway at full capacity.

TVA considered three alternatives (**Reservoir Recreation A, Reservoir Recreation B, and Tailwater Recreation**) designed primarily to shift the balance of operating objectives to enhance recreation opportunities while maintaining other system benefits. These alternatives would extend summer pools and limit water releases between June 1 and Labor Day, provide higher winter pools, and modify winter operating ranges of mainstem reservoirs to allow a one-foot fluctuation. Under the Tailwater Recreation Alternative, an increase in tailwater flows at five additional projects would have priority over reservoir levels to support tailwater-related recreation activities.

The **Tailwater Habitat Alternative** was designed primarily to improve conditions in tailwater aquatic habitats. Under this alternative, TVA would release water to try to mimic natural variations in runoff through the year. Tailwater habitat would also be

improved by decreasing the rate of river fluctuations associated with rapid changes in the number of turbines operated.

Two alternatives (**Summer Hydropower and Equalized Summer/Winter Flood Risk**) were designed to increase summer hydropower production and reduce summer flood risk, respectively. These alternatives would generally reduce summer pool levels and increase winter pool levels, establish weekly average water releases during summer, and modify winter operating ranges of mainstem reservoirs to allow a one-foot fluctuation.

The **Commercial Navigation** alternative was designed to increase the reliability and reduce the cost of commercial navigation by increasing the depth of the main channel in order to accommodate heavier barges. This alternative would raise the winter flood guides on mainstem reservoirs by two feet, modify their winter operating range to allow a one-foot fluctuation, and increase minimum flows at several key projects with major navigation locks.

The **Preferred Alternative** was designed to provide increased recreation opportunities while avoiding or reducing adverse impacts on other operating objectives and resource areas. Under the Preferred Alternative, TVA will no longer target specific summer pool elevations. Instead, TVA intends to manage the *flow* of water through the system to meet operating objectives. TVA will use weekly average system flow requirements to limit the drawdown of 10 tributary reservoirs (Blue Ridge, Chatuge, Cherokee, Douglas, Fontana, Nottely, Hiwassee, Norris, South Holston, and Watauga) June 1 through Labor Day to increase recreation opportunities. For four mainstem reservoirs (Chickamauga, Guntersville, Wheeler, and Pickwick), summer operating zones will be maintained through Labor Day. For Watts Bar Reservoir, the summer operating zone will be maintained through November 1. Great Falls Reservoir will be filled on a schedule to achieve summer pool elevation by Memorial Day.

Weekly average system minimum flow requirements from June 1 through Labor Day, measured at Chickamauga Dam, will be determined by the volume of water in storage at the 10 tributary reservoirs compared to the total storage available. A system minimum operating guide (MOG), which is a seasonal system storage guide curve as opposed to the project storage guide curve under existing operations, will be used to define the combined storage volume for those 10 tributary reservoirs. If the volume of water in storage is above the system MOG, the weekly average system minimum flow requirement will be increased each week from 14,000 cfs the first week of June to 25,000 cfs the last week of July. Beginning August 1 and continuing through Labor Day, the weekly average flow requirement will be 29,000 cfs. If the volume of water in storage is below the system MOG curve, only 13,000 cfs weekly average minimum flows will be released from Chickamauga Dam between June 1 and July 31, and only 25,000 cfs weekly average minimum flows will be released from August 1 through Labor Day.

TVA has established reservoir balancing guides for each tributary storage reservoir to ensure that water releases for downstream system needs will be withdrawn more equitably from tributary reservoirs. The balancing guide is a seasonal reservoir pool elevation that defines the relative drawdown at each tributary reservoir when water must be released to meet downstream flow requirements. Under this operating principle, water would be drawn from each tributary reservoir so that the elevation of each reservoir is similar relative to its position between the flood guide and the balancing guide. Balancing pool elevations will be accomplished to the extent practicable, depending on hydrology and power system economic and reliability considerations. To reduce impacts to power cost, TVA will ensure minimal hydropower capacity at each tributary reservoir by generating up to a volume of water equivalent of 17 hours of use per week at best turbine efficiency from July 1 through Labor Day.

Based on the results of the flood risk analysis, TVA has decided to raise winter flood guides and winter operating ranges on Blue Ridge, Boone, Chatuge, Cherokee, Douglas, Fontana, Hiwassee, Norris, Nottely, South Holston, and Watauga. Additionally to better protect against the risk of flooding for all main river projects (with the most benefits realized at Chattanooga), TVA will slow the filling of the three upper mainstem projects (Fort Loudoun/Tellico, Watts Bar, and Chickamauga) to reach the summer operating zone by early May. In addition, minimum winter pool elevation would be raised by 0.5 feet at Wheeler to better ensure minimum navigable channel depth.

Based on input from affected stakeholders, TVA will formally schedule water releases to increase tailwater recreational opportunities below Apalachia, Norris, Ocoee #1, South Holston, and Watauga/Wilbur. With variation in the amounts of flow and days of release, water releases will be provided from Apalachia, May 1 through October 31; from Norris, May 1 through October 31; from Ocoee #1 on Tuesdays and Wednesdays from June 1 through August 31; from South Holston April 1 through October 31; and from Watauga for recreation flows below Wilbur Memorial Day through October 31. This will allow people recreating on these tailwaters and recreation service providers to better plan their activities. The specified flows with the Preferred Alternative will be met depending on the volume of water in the upstream reservoirs. TVA will provide continuous minimum flows in the area between the Apalachia Dam and downstream powerhouse from June 1 through November 1 to enhance aquatic habitat. TVA will also provide continuous minimum flows up to 25,000 cfs at Kentucky, as needed, to maintain a minimum tailwater elevation of 301 for navigation.

Basis for Decision

The TVA Board has decided to adopt the Preferred Alternative. This alternative will establish a balance of reservoir system operating objectives that is more responsive

to values expressed by the public during the ROS while remaining consistent with the operating priorities established by the TVA Act. It also reduces or avoids the unacceptable environmental impacts associated with most of the other action alternatives.

The Preferred Alternative will provide greater value for reservoir and tailwater recreation users, increase revenue for recreation service providers, enhance the scenic beauty of the reservoirs, and result in some benefits to commercial navigation and aquatic habitat. It will provide more equitable pool levels among tributary reservoirs. It avoids and reduces impacts to the primary system operating objectives of flood control, navigation, and power generation associated with the other action alternatives.

Based on computer simulations, the Preferred Alternative is not expected to increase flood damage associated with flood events up to a 500-year magnitude at any critical location within the Tennessee Valley, including Chattanooga. Rather, with the slowed filling of the three upper mainstem reservoirs, flood risk protection should be increased for locations on all of TVA's mainstem reservoirs, including Chattanooga. The Preferred Alternative will increase the minimum depth of the Tennessee River navigation channel at two important locations and will maintain power system reliability while lessening impacts on the delivered cost of power compared to other alternatives. Additionally, the Preferred Alternative will lessen impacts on reservoir water quality, as well as shoreline erosion and its associated adverse effects on cultural resources and some shoreline habitats compared to Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative. To the extent practicable, impacts on wetlands, water quality, and aquatic resources will be mitigated thereby reducing the potential for long-term cumulative impacts. TVA will maintain tailwater minimum flows and dissolved oxygen (DO) targets

established by the Lake Improvement Plan to help reduce the risk of adverse water quality impacts.

Responding to flood control, wetland, and wildlife concerns expressed by USACE, the Service, state agencies, and some members of the public, no changes in seasonal water levels on Kentucky Reservoir and Tims Ford were included in the Preferred Alternative. Current operating conditions will be retained for these reservoirs.

In strictly economic terms, the overall public value of the Preferred Alternative will be similar to the Base Case, which represents TVA's current operations policy. Revenues from recreation of approximately $9 million and shipper savings of approximately $2.5 million will be largely offset by the increase in power costs of approximately $14 million annually. Additionally, the Preferred Alternative is expected to reduce flood damages along mainstem reservoirs, including such locations as Chattanooga and South Pittsburg, Tennessee, and Decatur, Alabama (e.g., for the last two major flood events in early May 1984 and 2003, flood damages would have been reduced in the Chattanooga area by a total of $12 million to $15 million, respectively). Further, TVA will make a capital investment of about $17 million over three years to address DO issues with an annual operation and maintenance cost of about $800,000. TVA will also spend over $500,000 annually in monitoring mosquito breeding habitat, shoreline erosion, water quality, aquatic resource, threatened and endangered species, and changes in certain wetland types; and based on monitoring results, could provide additional funding to address resource improvement opportunities.

TVA closely coordinated the formulation of the Preferred Alternative with USACE and the Service. USACE concurs that the Preferred Alternative addresses its primary concerns with flood control, water quality, and environmental conditions on the lower Tennessee, Cumberland, Ohio, and Mississippi Rivers and satisfies their concerns about Section 404 and navigation on the Tennessee River. USACE and TVA cooperated to

conduct additional analyses for high-flow periods and increased navigation problems during low-flow periods for areas downstream from Kentucky Reservoir along the lower Ohio and Mississippi River. Both agencies concluded that the Preferred Alternative will not adversely impact the risk of flooding during high-flow periods and that under the Preferred Alternative there are potential benefits to navigation on the lower river during extreme low water periods. As a result of these analyses, USACE recommended a more rigorous management of flood control storage at Kentucky and Barkley reservoirs and that TVA closely adhere to the reservoir guide curves at these reservoirs to ensure their continued effective operation over a wide range of flow conditions. TVA is committed to continuing the close cooperative relationship with USACE in managing low-flow and emergency situations that may arise on the lower Ohio and Mississippi rivers.

The Service agreed with TVA's determination that implementation of the Preferred Alternative will not jeopardize the continued existence of any listed threatened and endangered species. The Service issued a Biological Opinion which identified two reasonable and prudent measures, with terms and conditions that TVA must take to minimize the impacts of incidental take of the snail darter (a fish) and pink mucket (a mussel) that might otherwise result from the Preferred Alternative. As requested by the Service, TVA has entered into discussion with the Service over possible effects to endangered and threatened species associated with those components of TVA's reservoir operations that are not being changed through implementation of the Preferred Alternative.

In cooperation with the State Historic Preservation Officers (SHPO) of Alabama, Georgia, Mississippi, North Carolina, Tennessee, and Virginia, and the Eastern Band of Cherokee Indians, TVA developed a Programmatic Agreement that addresses the identification and protection or mitigation of historic resources that could be affected by

adoption of the Preferred Alternative. Kentucky SHPO concurs with TVA's opinion that there will be no effect on historic properties in Kentucky under the Preferred Alternative. This fulfills TVA's responsibilities under the National Historic Preservation Act.

Environmentally Preferable Alternative

In general, the extent of potential environmental effects of the reservoir operations policy alternatives is related to the amount and timing of water held in storage and flow through the system. TVA has concluded that the Commercial Navigation Alternative, with its minor changes in water availability limited primarily to mainstem reservoirs, has slightly better environmental consequences than the Base Case and Preferred Alternative and is the environmentally preferable alternative. The Commercial Navigation Alternative would not have any adverse effects on protected species and would result in slightly beneficial effects for critical habitats of some protected species. It would provide beneficial effects on greenhouse gas emissions, aquatic resources, summer water temperature, mainstem water levels, and increased stability of wetland habitats. However, the Commercial Navigation Alternative would result in slightly adverse impacts on wetland plant communities, terrestrial ecology (use of mud flats and some bottomland hardwood wetlands), recreation spending, and private site access. It also would incrementally increase flood risk at key locations and would do little to enhance recreation opportunities.

Impacts of the Base Case and Preferred Alternative, with the added mitigation measures, would be basically the same as those for the Commercial Navigation Alternative except for flood risk as noted above. The Preferred Alternative was formulated purposefully to reduce or avoid the adverse impacts associated with all of the other action alternatives, especially the substantially adverse impacts related to flood

damages, water quality, power costs, aquatic resources, wetlands, and migratory waterfowl and shorebirds.

The Commercial Navigation Alternative was not selected as TVA's preferred alternative primarily because it would increase flood risk and would produce little or no changes in recreation opportunities and other system benefits except for reduced cost for waterborne transportation. As such, it is not as responsive to expressed public values as TVA's Preferred Alternative.

Potential Mitigation Measures

All identified practicable means to mitigate potential environmental impacts associated with this decision will be implemented. Primarily, TVA has chosen to do this in the way the Preferred Alternative was formulated, as discussed above. However, TVA was unable to avoid all potential impacts. In particular, implementation of the Preferred Alternative could result in slightly adverse to adverse impacts on certain wetland types and locations, water quality and aquatic resources in some reservoirs, and other resource areas. In some cases, the extent of the impacts may vary from year to year—depending on the reservoir, annual rainfall and runoff conditions, and other factors. TVA will use a mix of monitoring and adaptive response as a component of its programmatic approach to mitigating these impacts.

TVA will continue its existing monitoring activities under its Reservoir Release Improvement and Vital Signs Reservoir Ecological Health Monitoring Programs to look for water quality and ecological changes. Additional DO and temperature sampling will be conducted at selected tailwater locations as determined by Vital Signs monitoring. A Wetlands Monitoring Program will be established to determine whether shifts of wetland plant communities occur as a result of extended water levels. TVA commits to conducting wetland monitoring activities on a 3- to 5-year basis for 15 years to establish

effects. If substantial shifts of wetland plant communities occur, TVA will take appropriate action to mitigate adverse effects.

TVA also will extend the existing Vector Monitoring Program to identify any increase in the number of days that reservoir mosquito breeding habitat exists due to the extended time the mainstem reservoirs are held up. If the number of days of reservoir mosquito breeding habitat increases, TVA will extend the duration of reservoir level fluctuations on Chickamauga, Guntersville, Pickwick, and Wheeler for mosquito control. If extending the duration of the fluctuations does not offset the increase in reservoir mosquitoes, TVA will investigate other mitigation methods.

Based on results of DO monitoring, TVA will upgrade aeration equipment and operations at appropriate locations as necessary to continue to meet the DO target levels established by the 1991 Lake Improvement Plan. This could include increased oxygenation, upgrading existing equipment, or installing additional equipment. Such measures will be initiated and completed within 1 year after implementation at Watts Bar and within 3 years at other locations where established targets are not being met. The estimated cost of these changes is $17 million over three years with an annual operation and maintenance cost of $800,000. TVA will share information about the enhanced aeration efforts with interested agencies and will continue monitoring to determine whether efforts are successful. If DO targets cannot be maintained, TVA will investigate additional mitigation approaches with interested agencies. TVA will also spend over $500,000 annually on other measures to reduce or avoid potential environmental and cultural resource impacts associated with the Preferred Alternative.

TVA will continue monitoring sensitive cultural resource sites along the reservoir shoreline to determine if the rate of shoreline erosion increases, affecting those sites. If the rate of erosion increases and affects those sites, TVA will increase its stabilization efforts to protect sensitive cultural resources. Further, TVA will ensure that the

measures identified in its programmatic agreement with State Historic Preservation Officers for the states of Alabama, Georgia, Mississippi, North Carolina, Tennessee and Virginia, and the Eastern Band of Cherokee Indians will be implemented in accordance with the stipulations of that agreement.

TVA will implement the reasonable and prudent measures, including the terms and conditions, identified in the Service's Biological Opinion to minimize the impacts of incidental take of the snail darter and pink mucket. Relative to the population of the endangered green pitcher plant on Chatuge Reservoir that could be affected by changes in reservoir levels, TVA will work with the Service, the landowner, and other interested agencies to conduct a hydrologic study to determine what effects, if any, implementation of the Preferred Alternative will have on the plants and their habitat. The study and results will be completed within 1 year after implementation. TVA will monitor on an annual basis the status of green pitcher plant populations around Chatuge Reservoir and share data with interested agencies. If results of the study and monitoring indicate that changes resulting from implementation of the Preferred Alternative are likely to adversely affect the green pitcher plant, TVA will take appropriate action to avoid or mitigate those adverse effects.

Additionally, the results of the ROS indicate that there is a need for TVA and state and other federal agencies to work together in a more cooperative manner to develop a Drought Management Plan for the Tennessee River system and to determine habitat requirements and opportunities for potential enhancements for shorebirds and important sports fish. TVA will work with state and other federal agencies to develop a Drought Management Plan within a reasonable period of time. This plan will be implemented during extreme drought conditions when TVA must suspend normal reservoir operating guidelines. Efforts to determine habitat requirements and potential enhancements for shorebirds and important sports fish will include better identification of

information gaps, cataloguing federal and state programs that address these habitats and species, sharing data with other interested agencies, and investigating actions that could be taken to enhance these habitats and species.

Implementation of Policy Guidelines

TVA will begin implementing the described changes to TVA's reservoir operations policy on the date of release of this Record of Decision. TVA will use these guidelines to make determinations of changes in pool levels and flows through the system during normal operations. Operations of the reservoir system during a power supply alert will depend on the level of alert. Water stored in the reservoir system will be released as needed to preserve the integrity and stability of the TVA Power System.

Kathryn J. Jackson
Executive Vice President
River System Operations & Environment

May 19, 2004
Date

Chapter 1

Introduction

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1.1 Introduction

The Tennessee Valley Authority (TVA) is a multipurpose federal corporation responsible for managing a range of programs in the Tennessee River Valley (the Valley) for the use, conservation, and development of the water resources related to the Tennessee River. In carrying out this mission, TVA operates a system of dams and reservoirs with associated facilities—its water control system (Figure 1.1-01). As directed by the TVA Act, TVA uses this system to manage the water resources of the Tennessee River for the purposes of navigation, flood control, power production and, consistent with those purposes, for a wide range of other public benefits.

TVA RESERVOIR SYSTEM OPERATING OBJECTIVES

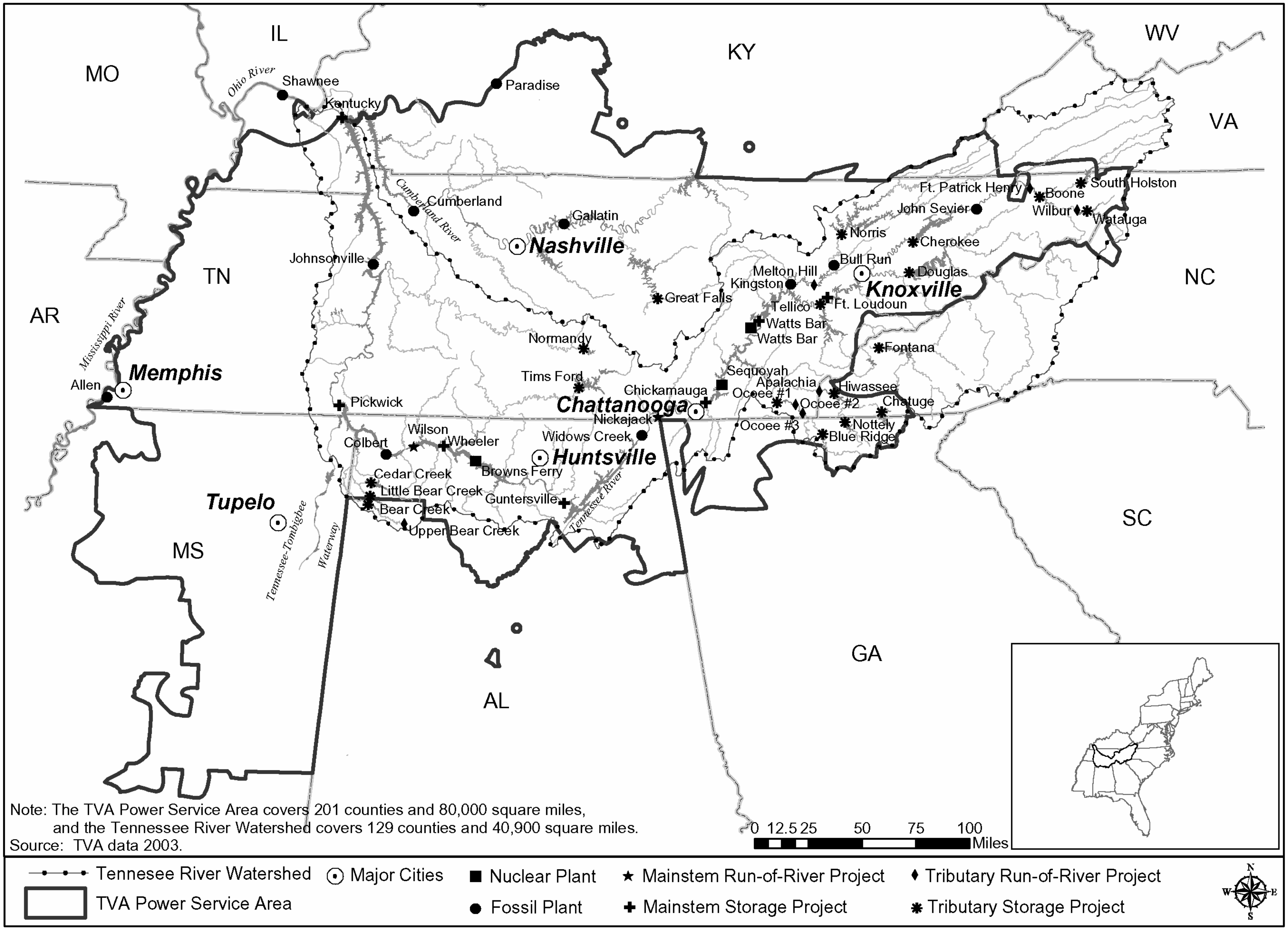
- Navigation
- Flood control
- Power production
- Water supply
- Water quality
- Recreation
- Other objectives

TVA generates and distributes electric power to customers within its Power Service Area. The water control system has hydroelectric generators and provides the cooling water supply for TVA's coal-fired and nuclear power plants located adjacent to TVA reservoirs. TVA's power system and its management of water resources are central components of sustainable economic development in the Valley and TVA Power Service Area.

TVA also has custody of and manages approximately 293,000 acres of land in the Valley, most of which is along the shorelines of TVA reservoirs. TVA has established policies for the development of reservoir shorelines and adjacent TVA lands (see Section 1.8). Development and management of these lands and activities are influenced by reservoir levels and river flows.

TVA's reservoir operations policy guides the day-to-day operation of its water control system. The reservoir operations policy sets the balance of trade-offs among competing uses of the water in the system.

TVA has periodically evaluated the reservoir operations policy to respond to the values expressed by the public. The last examination of the policy culminated in the issuance of TVA's Lake Improvement Plan in December 1990 (the Tennessee River and Reservoir System Operation and Planning Review). TVA now is completing a comprehensive study of its reservoir operations policy, the Reservoir Operations Study (ROS), to determine whether changes in the policy could produce greater overall public value. With considerable involvement and advice from the public and interested federal and state agencies, TVA staff analyzed and reviewed a wide range of policy alternatives for its water control system. Staff is recommending appropriate changes in the reservoir operations policy to the TVA Board of Directors (the Board). A decision by the Board to change the reservoir operations policy would affect the operation of TVA's water control system and would modify the present balance among the various operating objectives.



Note: The TVA Power Service Area covers 201 counties and 80,000 square miles, and the Tennessee River Watershed covers 129 counties and 40,900 square miles.
Source: TVA data 2003.

Figure 1.1-01 Tennessee River Watershed and TVA Power Service Area

TVA prepared this Final Programmatic Environmental Impact Statement (FEIS) in accordance with the Council on Environmental Quality (CEQ) regulations and TVA's own procedures for implementing the National Environmental Policy Act (NEPA). The U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS) were cooperating agencies in the preparation of this EIS. As the lead agency in this effort, TVA was primarily responsible for ensuring opportunities for stakeholder participation, EIS content, and compliance with all aspects of NEPA and other applicable statutes and implementing regulations.

According to the CEQ, a programmatic EIS is appropriate when a decision involves a policy or program, or a series of related actions by an agency over a broad geographic area. This programmatic EIS summarizes the results of the ROS, the public involvement process, the development and evaluation of policy alternatives, and the potential impacts of those alterations on the natural and human environment. The ROS is integrated into this FEIS and is not a separate report. Distribution of the Draft EIS (DEIS) afforded the public, governmental agencies, and non-governmental organizations opportunity for review and comment prior to TVA staff making a recommendation to the Board.

1.2 Purpose and Need

The specific purpose of the ROS is to enable TVA to review and evaluate its reservoir operations policy to determine whether changes in the policy would produce greater public value. TVA's reservoir operations policy affects how much reservoir levels rise and fall, when changes in reservoir levels occur, and the amount of water flowing through the reservoir system at different times of the year.

Changes in TVA's reservoir operations policy would modify the present balance among the various operating objectives for the system in response to changing public values. The final result of the ROS is a set of recommendations developed by TVA staff in this FEIS and a subsequent decision by the Board, possibly establishing a new reservoir operations policy. Implementing a new reservoir operations policy would involve changing the existing reservoir system operating guidelines. The Board's decision will be documented in a Record of Decision. In addition, because TVA receives no appropriations (money) from Congress, changes to operations that require additional capital or operating expenditures would need to be funded by either TVA or others.

1.3 Scope of the ROS

TVA owns or operates 49 dams and reservoirs (called projects) within the Tennessee River and Cumberland River watersheds. The scope of the ROS included evaluating the operations of 35 of these projects—projects for which TVA schedules water releases and reservoir levels in accordance with its reservoir operations policy (Figure 1.1-01). The projects not included in the ROS are one pumped storage project and several small water retention dams that are essentially self-regulating. These projects have little impact on the operation of TVA's water control system.

In addition, physical removal of or major structural modifications to TVA dams and power plants is not included in the scope of this EIS.

The geographic area potentially affected by changes in the reservoir operations policy includes the Tennessee River watershed and the larger TVA Power Service Area (Figure 1.1-01). This area covers almost all of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia. The Tennessee River watershed includes 129 counties and encompasses 40,900 square miles; TVA's Power Service Area comprises 201 counties and covers approximately 80,000 square miles. Analyses of some resource areas (e.g., navigation) included parts of the Ohio and Mississippi River systems that are outside the Valley. Other resource evaluations (e.g., air quality) included areas outside the TVA Power Service Area to ensure a comprehensive analysis.

KEY TERMS

The System—The TVA water control system (also referred to as the reservoir system) is a series of interconnected dams and reservoirs on the Tennessee River and its tributaries. Many of the dams include hydropower generation facilities and locks for navigation.

Operation of the System—TVA controls water storage in each reservoir and the flow of water from one reservoir to another, in response to changing rainfall and runoff.

Reservoir Operations Policy—This policy balances the benefits of operating objectives and is implemented through a set of operating guidelines for all reservoirs in the system.

Operating Objectives—These objectives include navigation, flood control, power production, recreation, water supply, water quality, and other benefits.

Operating Guidelines—Operation of the system is governed by a set of operating guidelines that include guide curves, minimum flow requirements, water release requirements, and other requirements to meet system operating objectives.

Policy Alternative—A reservoir operations policy alternative is a set of operational changes that would adjust the present balance among the various operating objectives for the system. A policy alternative may emphasize several operating objectives at the same time.

As is typical of water resource planning and management studies of this type, the ROS and this EIS used a long-range planning horizon (to the year 2030).

1.4 Decisions To Be Made

The Board will decide whether TVA's reservoir operations policy will be changed and the nature of the change, based on the recommendations of TVA staff. In addition to staff recommendations, the Board will consider this FEIS, public comments, and other factors. The Board will make a decision following the Notice of Availability of this FEIS and after public comments on the FEIS are considered. The final decision will be documented in a Record of Decision and made available to the public. Decisions made by other federal agencies would be appropriately documented by the respective agency.

1.5 History of Policy Changes

TVA has periodically made changes and adjustments to its reservoir operations policy in order to achieve greater overall value for the public. Past policy changes reflected factors such as the public's changing needs and concerns, requests from citizens and regional groups,

environmental quality issues, changes in the power industry, and TVA's own mission and planning needs. The reservoir operations policy also reflects a growing experience and understanding of the challenges and limitations imposed by annual variations in rainfall and runoff, especially during droughts and floods.

- **1970s—Improved Reservoir System Benefits.** In the early 1970s, TVA began looking for ways to improve long-term power supply, water quality in tailwaters, aquatic habitat, and recreational opportunities without sacrificing navigation, flood control, and power production. A multiple-reservoir study completed in 1971 found that TVA could meet some of these objectives by raising minimum winter water levels at nine tributary reservoirs.

- **1980s—Reservoir Resource Reevaluation Program.** TVA began its Reservoir Resource Reevaluation Program in the early 1980s, bringing together a team of TVA specialists to review its operations and evaluate suggested changes. This was the beginning of a more formal evaluation process that involved public input. Although the program did not create broad policy changes for TVA reservoir operations, it provided a forum for external groups (e.g., state organizations and reservoir user groups) to voice their concerns and to understand the impacts of requested changes on individual reservoirs, as well as the entire TVA system.

- **1980s—Reservoir Release Improvement Evaluations.** The low availability of water during the extended drought of the 1980s affected water quantity and quality in river segments below dams. In response, TVA experimented with minimum flows to improve aquatic habitat, water quality, and waste assimilation (the process by which a river accepts wastewater). TVA developed methods to provide higher minimum flows, including turbine pulsing, reregulation weirs, and continuous releases through small turbines. TVA also began the process of evaluating and implementing methods to increase dissolved oxygen (DO) concentrations in the water released from the dams.

- **1990s—Lake Improvement Plan.** By the late 1980s, there was growing recognition that benefits beyond the operating objectives of navigation, flood control, and power production had become increasingly important to residents of the Valley. In response to public input through the NEPA process, TVA completed the Tennessee River and Reservoir System Operation and Planning Review EIS, also known as the Lake Improvement Plan (TVA 1990). In 1991, the Board approved changes to the reservoir operations policy. These changes included extending summer reservoir levels on 10 tributary reservoirs to August 1 in order to increase recreational opportunities. Consistent with the Reservoir Release Improvement (RRI) evaluations, TVA also increased minimum flow requirements for many of its mainstem and tributary projects, and began a program to increase DO concentrations in the releases from 16 TVA dams.

TVA continued to receive requests for changes to reservoir levels and other operations during implementation of the Lake Improvement Plan. As more and more users requested studies for their particular reservoir or tailwater, TVA decided that a piecemeal approach raised questions of fairness in how each reservoir would be treated. A comprehensive review was needed to examine the effects of changes in the reservoir operations policy on system performance (in terms of benefits produced) and on system-wide costs.

In March 1997, TVA established a 4-year moratorium on making any new changes in reservoir operations. This action was taken to allow the agency time to deal with the uncertainty of deregulation of electric utilities and to develop the analytical tools and methodologies for evaluating and explaining the benefits ascribed to reservoir operations changes, particularly in the area of flood risk in the Tennessee River watershed. In July 1998, an internal TVA task force report recommended that TVA continue its moratorium and, in the next 2 to 4 years, begin a system-wide evaluation of policies that would affect reservoir levels. The task force also noted the complexities involved in carrying out such a study and identified several areas requiring further attention, including a proactive communication plan with the public and better evaluation methodologies for costs and benefits. This EIS fully addresses those recommendations.

1.6 Scoping Process

NEPA regulations require an early and open process for deciding what should be discussed in the EIS document—known as the scope of the evaluation. The scoping process involves requesting and using comments from the public and interested agencies to help identify the issues and alternatives that should be addressed in the EIS, and the temporal and geographic coverage of the study.

Consistent with NEPA requirements, the ROS process and this EIS were designed to be responsive to the values, comments, and input of the public and other governmental and non-governmental organizations. The objectives of the ROS and this EIS included, but were not limited to:

- Identifying public issues, concerns, and values regarding the reservoir system;
- Using public input to shape reservoir operations policy alternatives;
- Identifying key objectives and options for formulating and evaluating reservoir operations policy alternatives;
- Identifying the social, economic, and environmental factors to be considered in formulating policy alternatives;
- Developing and analyzing policy alternatives;
- Explaining the potential environmental and socioeconomic effects of the policy alternatives to the year 2030; and,
- Providing opportunities for the public to actively participate in this process.

In July 2002, TVA issued a report entitled Reservoir Operations Study Environmental Impact Statement Scoping Document, which is summarized in the following sections.

1.6.1 Public Involvement

At the beginning of the NEPA process, citizens were asked to help TVA define the scope of the planned evaluation. Scoping began in January 2002, when TVA mailed letters describing the ROS to more than 60,000 stakeholders across the Tennessee River Valley and Power Service Area, including representatives of agencies and Indian tribes that might be affected or interested. On February 25, 2002, TVA published a Notice of Intent in the Federal Register that described the agency's plans to prepare a programmatic EIS and invited interested parties to comment on its scope.

TVA also established two groups—an Interagency Team (IAT) and a 13-member Public Review Group (PRG) —to ensure that other agencies and members of the public were actively and continuously involved throughout the study. The IAT included representatives from 11 federal agencies and six Valley states. Members of the PRG represented reservoir user groups, white–water interests, local governments, local utilities and utility districts, industry, river advocates, fishery interest groups, academia, and other special interests. Several meetings were held with members of the joint IAT/PRG groups during the scoping process. Additional meetings with the joint IAT/PRG groups were held throughout the course of the study and preparation of this EIS.

TVA reviewed input from technical experts and management staff, and from groups such as the Regional Resource Stewardship Council and individuals of the IAT/PRG. TVA then held 21 community workshops between March 21 and April 18 that were attended by more than 1,300 people (Table 1.6-01). During each workshop, TVA staff distributed informational brochures and other materials, and answered questions about the ROS, the EIS process, and related environmental and operational issues.

TVA also sought feedback by mail, e-mail, fax, telephone, and computer polling. The agency received more than 6,000 individual comments, approximately 4,200 form letters, and petitions signed by more than 5,400 people. In addition, 3,600 residents in the Power Service Area answered a random telephone survey conducted by an independent research firm. The latter survey was designed to sample a representative cross section of the populace served by TVA.

1.6.2 Results of the Scoping Process

The scoping process identified a broad range of issues and values to be addressed and alternatives to be evaluated in the ROS. Overall, the public placed a high value on recreation, a healthy environment, production of electricity, flood control, and water supply. People were also concerned with a number of other topics. After all public feedback was evaluated, TVA identified 11 major issues for evaluation (Table 1.6-02). Other issues typically addressed in NEPA reviews were also incorporated into the analysis of each policy alternative (for example, air quality, climate, groundwater resources, and other resource topics).

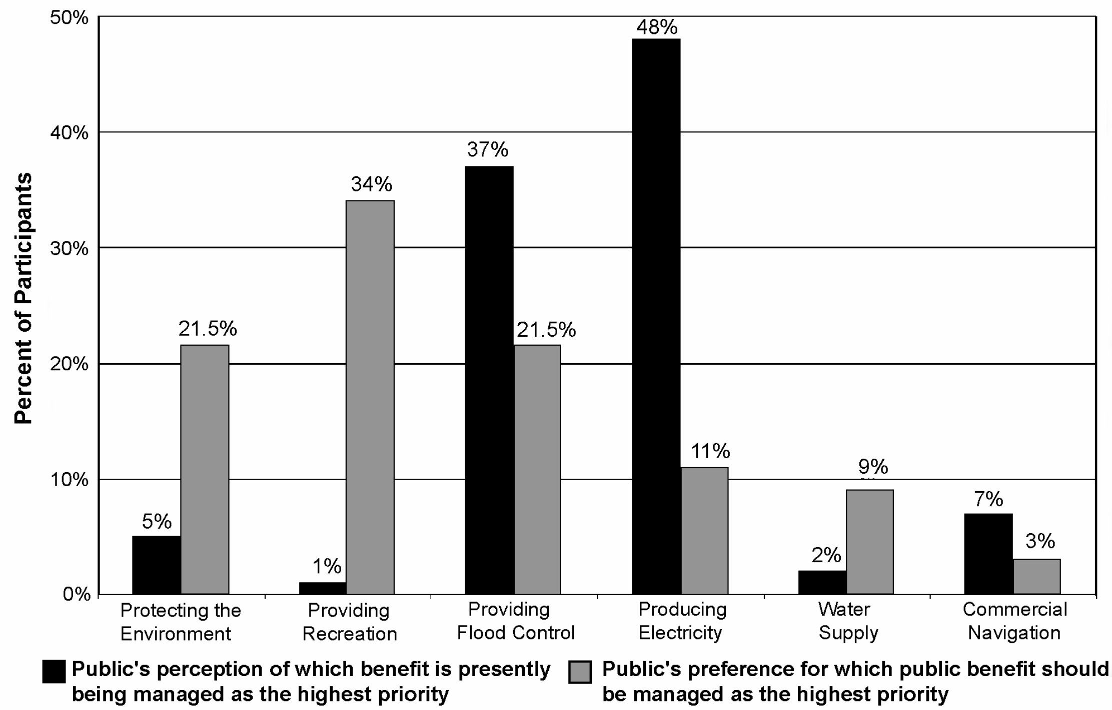
Table 1.6-01 Community Workshops Held during the Scoping Process

Date	Location	Participants Registered
Thursday, March 21, 2002	Catoosa/Walker County, Georgia	61
	Tupelo, Mississippi	13
Saturday, March 23, 2002	Murphy, North Carolina	74
	Guntersville, Alabama	45
Tuesday, April 2, 2002	Decatur, Alabama	100
	Starkville, Mississippi	7
Thursday, April 4, 2002	Paris, Tennessee	47
	Nashville, Tennessee	45
Saturday, April 6, 2002	Morristown, Tennessee	108
	Muscle Shoals, Alabama	36
Tuesday, April 9, 2002	Knoxville/Loudon County, Tennessee	28
	Chattanooga, Tennessee	96
Thursday, April 11, 2002	Blountville, Tennessee	128
	Gilbertsville, Kentucky	225
Saturday, April 13, 2002	Norris, Tennessee	28
	Savannah, Tennessee	22
Tuesday, April 16, 2002	Blairsville, Georgia	272
	Bowling Green, Kentucky	14
Thursday, April 18, 2002	Bryson City, North Carolina	57
	Memphis, Tennessee	9
	Tullahoma, Tennessee	37

Table 1.6-02 Public Feedback Provided during the Scoping Process

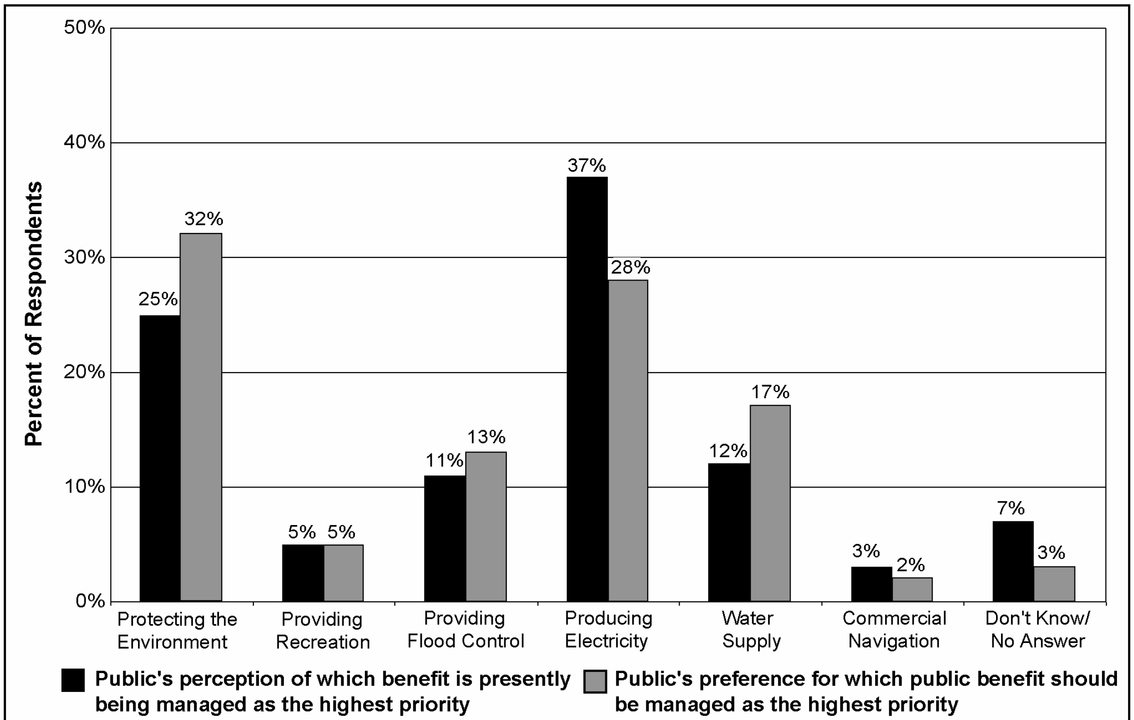
Major Issues	Concerns Expressed by the Public
Reservoir and downstream water quality	Dissolved oxygen concentrations, temperature, ammonia levels, wetted area (the area of river bottom covered by water), velocity, algae, and waste assimilation capacity
Environmental resources	Aquatic resources, erosion and sedimentation, visual resources, cultural resources, federally and state-listed species, wetlands, and ecologically significant areas
Reservoir pool levels	Reservoir pool elevations and the annual timing of fill and drawdown, and their effects on reservoir recreation, property values, and aesthetics
Recreation flows	TVA's ability to schedule releases for tailwater recreation, including fishing, rafting, canoeing, and kayaking
Economic development	Recreation, property values, navigation, power supply, and water supply
Water supply	Reservoir and downstream intakes and potential inter-basin transfers
Navigation	Impacts on channel depth, speed of currents, and water levels
Flood risk on regulated waterways	Available reservoir space for storing floodwaters, how fast space can be recovered after a flood, and costs related to property damage and jobs lost or disrupted
Power reliability	Availability of cooling water at coal-fired and nuclear plants, fuel delivery by barges for coal-fired plants, and restrictions on hydropower production during critical power demands
Cost of power	Hydropower production, including total megawatt hours, seasonal availability, and value during high-cost periods
Capital costs	Changes to reservoir operations, including modifications and upgrades to, as well as additions to and removal of, various structures and equipment

When asked to respond to the keypad question "Which of TVA's public benefits should be managed as the highest priority?" workshop participants said providing recreation (34 percent), protecting the environment (21.5 percent), and providing flood control (21.5 percent) should be the top three priorities (Figure 1.6-01). The results of the same question asked in the telephone survey are illustrated in Figure 1.6-02. Unlike the results from the workshops, the telephone survey participants said protecting the environment (32 percent), producing electricity (28 percent), and water supply (17 percent) should be the top three priorities.



Source: TVA data 2002.

Figure 1.6-01 Community Workshop Keypad Results--Comparison of the Public's Perceptions of and Preferences for TVA Management Priorities



Source: TVA data 2002.

Figure 1.6-02 Telephone Survey Results--Comparison of the Public's Perceptions of and Preferences for TVA Management Priorities

Many of those commenting, including the 5,400 individuals who signed petitions, expressed the desire for TVA to increase recreational opportunities in a variety of ways, such as:

- Holding reservoir water levels stable;
- Delaying the date at which summer reservoir water levels are lowered;
- Filling reservoirs earlier to improve fish spawning and subsequent fishing opportunities; and,
- Increasing the amount of water released from some dams for wade fishing, boat fishing, and recreational boating.

Nearly 4,000 of those commenting requested that TVA change its reservoir operations policy to protect the diversity of aquatic life and, specifically, to protect endangered, threatened, and other at-risk species. Less than 1 percent of those submitting comments expressed support for TVA to continue its existing reservoir operations policy.

OBJECTIVES IDENTIFIED DURING SCOPING FOR THE ROS EIS

- Supplying low-cost, reliable electricity
- Increasing revenue from recreation
- Reducing flood risk and flood-related damages
- Lowering the cost of transporting materials on the commercial waterway
- Providing enough water for municipal, agricultural, and industrial purposes
- Improving recreation on reservoirs and tailwaters
- Improving water quality in reservoirs and tailwaters
- Improving aquatic habitat in reservoirs and tailwaters
- Minimizing erosion of reservoir shoreline and tailwater riverbanks
- Increasing protection for threatened and endangered species
- Protecting and improving wetlands and other ecologically significant areas
- Protecting and improving the scenic beauty of the reservoirs

Objectives

To define and evaluate policy alternatives, TVA established a set of objectives that incorporates the issues that were identified by the public and interested parties during the scoping phase (Table 1.6-03). TVA also considered other objectives, such as reducing the cost of treating water for municipal and assimilation-capacity uses, maintaining existing dam safety margins, and improving air quality.

Preliminary Alternatives

On the basis of the objectives identified during scoping, 65 possible changes to the reservoir operations policy were identified and proposed. TVA technical experts worked with individuals in the IAT/PRG to refine this list into a set of operations options—specific changes to reservoir operations that could be considered in formulating alternative reservoir operations policies (Table 1.6-04). Various combinations of these options were then evaluated to develop specific policy alternatives. Chapter 3 further describes the process TVA used to develop, screen, and select a range of policy alternatives for detailed evaluation.

Table 1.6-03 Description of Objectives Identified during the Scoping Process

Objective	Summary Definition[1]
Supplying low-cost, reliable electricity	Supplying low cost, reliable electricity from the TVA system involves efficiently managing the water within the TVA reservoir system to release water as necessary to assure adequate cooling water for TVA's coal-fired and nuclear power plants that provide the majority of TVA's generation. This water management lessens the need to reduce generation at these plants during the summer and fall to maintain water quality. Reservoir releases for cooling water and other purposes are dispatched through hydropower units when it is most valuable, reducing reliance on higher cost fuels during high demand periods. Also, although hydropower provides only 10 to 15 percent of TVA's annual energy generation, the operational flexibility afforded by the hydropower units to adjust the system generation to changes in demand is critical to maintaining the stability of the power system at a low cost. Reservoir operations that enhance the ability to meet these factors result in lower cost of electricity and increased system reliability.
Increasing revenue from recreation and tourism	Reservoir levels and river flows affect the level of use and desirability for recreational uses. Managing the reservoir system for longer periods at levels more suitable and desirable for recreation—especially during high-use periods—can increase recreational use and the expenditures of users, increasing recreation and tourism revenues within the Valley economy.
Reducing flood risk and flood-related damages	Flood risk and flood-related damages within the Valley are closely related to the amount of flood storage space available within the TVA reservoir system—which is controlled by reservoir levels—especially during winter. The timing and rate of filling the mainstem reservoirs in spring can also be of particular importance. Reservoir operations that increase the available flood storage throughout the year and maintain more flood storage space through spring decrease flood risk and flood-related damage.
Lowering the cost of transporting materials on the commercial waterway	Reservoir levels and flows within the commercial waterway of the TVA system influence the depths and velocities in the navigation channel, which influence the navigability, size of barges that can used, barge travel times, and a number of factors that influence shipper costs. Reservoir operations that improve the suitability of the commercial waterway result in reduced shipper costs.
Providing enough water for municipal, agricultural, and industrial purposes	The TVA reservoir system provides the source of water for a variety of municipal, agricultural, and industrial uses. Reservoir levels and flows are important components affecting the availability of sufficient water supplies. Water levels in reservoirs and flow rates can affect conditions at the intake structures, the cost of pumping water, and other factors that affect the use of water. Reservoir operations that ensure adequate flow and reduce pumping costs result in a greater reliable supply of water.
Improving recreation on reservoirs and tailwaters	Reservoir levels and river flows affect the level of use, desirability, and quality of experience for recreational uses. Managing the reservoir system to provide longer periods at reservoir levels more suitable and desirable for recreation, especially during high-use periods, and providing flows to support greater and more desirable conditions for water-based recreation improve the quality and diversity of recreation opportunities.

Table 1.6-03 Description of Objectives Identified during the Scoping Process (continued)

Objective	Summary Definition[1]
Improving water quality in reservoirs and tailwaters	Water quality throughout the TVA system is strongly affected by reservoir system operations. Indicators of water quality include temperature, dissolved oxygen levels, and the occurrence of water quality constituents. Changes in system operation affect flows in tailwaters and the length of time that water stays in the reservoirs, affecting the probability and occurrence of unsuitable water quality conditions and overall system water quality. Management of the reservoir levels and dam releases can either improve or degrade these conditions.
Improving aquatic habitat in reservoirs and tailwaters	A variety of factors, including water quality, temperature, reservoir levels, flows, and hydraulic-habitat conditions in tailwaters, determine the quantity, quality, and diversity of aquatic habitat within the TVA reservoir system. Other important factors include the timing of changes in reservoir levels, flows during critical spawning or migration periods, severity of low oxygen conditions, and the abundance of aquatic plants. Reservoir operations that improve water quality, improve tailwater flow-habitat conditions (e.g., increased minimum flows, reduced daily flow fluctuation), or lead to improved spawning and rearing conditions result in improved aquatic habitat and an enhancement of aquatic resources.
Minimizing erosion of reservoir shoreline and tailwater riverbanks	The length of time that reservoir or tailwater shorelines are exposed to wave action or sustained high flow affect the rate of shoreline erosion. A number of resource areas are affected by shoreline erosion, including visual and cultural resources, wetlands and shoreline habitats, and water quality. Reservoir operations that reduce shoreline erosion positively affect shoreline conditions and a number of other related resource areas.
Increasing protection for threatened and endangered species	Most threatened and endangered species in the TVA system occur in aquatic habitats along the stream sections least modified by construction of the TVA reservoir system. Reservoir operations that improve water quality conditions result in greater protection for these species.
Protecting and improving wetlands and other ecologically significant areas	Wetlands and other ecologically significant areas along the TVA reservoir system are dependent on how often and for how long they are inundated or saturated. Over time, changes in the timing and duration of surface water and soil saturation can affect the location, types, and functions of wetlands. In addition, a number of important or ecologically significant areas depend on certain reservoir levels (e.g., reservoir levels at waterfowl management areas) to maintain their operational integrity.
Protecting and improving the scenic beauty of the reservoirs	The scenic beauty of the TVA reservoirs can be affected by reservoir levels, especially during the fall foliage viewing period. Lower reservoir levels expose reservoir bottoms and a "shoreline ring." In general, reservoir operations that maintain higher levels and reduce the exposure and visibility of the shoreline serve to protect and improve the scenic beauty.

[1] See Chapter 2 for more detailed descriptions of the relationships between reservoir operations and operating objectives.

Table 1.6-04 Operating Options Developed during the Scoping Process

Options for Mainstem Reservoirs	Raise or lower winter and/or summer pool elevations
	Fill reservoirs to summer levels earlier
	Delay summer drawdown until later in the year
Options for Tributary Reservoirs	Raise or lower maximum and/or minimum summer pool elevations
	Raise winter pool elevations
	Fill reservoirs to summer levels earlier
	Delay unrestricted drawdown until later in the year
	Replace unrestricted drawdown with a restricted (stepped) drawdown
	Provide tailwater flows to support fishing and boating
	Modify the rate of flood-storage recovery by slowing drawdown
Options for All Reservoirs	Increase minimum flows to improve water quality and biodiversity

1.7 DEIS Public Review Process

The DEIS on TVA's ROS was distributed in July 2003. Approximately 1,530 copies of the DEIS were sent to affected tribal governments, agencies, organizations, and members of the public. The Notice of Availability of the DEIS was published in the Federal Register on July 3, 2003. The comment period closed on September 4, 2003, but TVA continued to accept comments through mid-October from tribes and persons informing the agency that their comments would be late.

Comments were provided by members of the public, organizations, and interested agencies at 12 interactive workshops held around the Tennessee Valley region after the DEIS was released. Approximately 1,700 individuals registered at the workshops (Table 1.7-01). During these workshops, comments could be made in writing using comment cards, given to court reporters, or entered on computer terminals through an interactive software program that was specially designed to assist the public in providing comments. TVA also posted a copy of the DEIS on its official agency internet web site, and comments could be made through this web site. In addition, TVA accepted comments through surface or electronic mail, by phone, and by facsimile.

While the ROS proceeded, TVA continued to meet with its cooperating agencies and with members of the IAT/PRG to receive their input on the DEIS. TVA conducted special briefings with resource agency staffs, including the U.S. Environmental Protection Agency (USEPA), to apprise them of ROS analyses and progress. These briefings provided interested agencies multiple opportunities to help direct and influence the scope and substance of the study, the EIS process, and associated analyses. TVA also held briefings with about 200 community leaders and representatives of interest groups to share information and to receive their input on the DEIS (see Appendix F, Table F1-02).

Including form letters and petitions, TVA received a total of 2,320 sets of comments on the DEIS (Appendix F, Table F1-03). These sets of comments included input from almost 7,000 individuals, 7 federal agencies, 14 state agencies, one tribal government, 8 county and local government agencies, and 42 other organizations. TVA has carefully reviewed and responded to all of the comments on the DEIS (see Appendix F).

Table 1.7-01 DEIS Community Workshops

Date	Location	Attendance
July 21, 2003	Murfreesboro, TN	30
July 22, 2003	Knoxville, TN	58
July 24, 2003	Bristol, TN	299
July 28, 2003	Morristown, TN	479
July 29, 2003	Murphy, NC	53
July 31, 2003	Blairsville, GA	407
August 5, 2003	Chattanooga, TN	53
August 7, 2003	Decatur, AL	106
August 12, 2003	Gilbertsville, KY	105
August 14, 2003	Pickwick, TN	70
August 19, 2003	Muscle Shoals, TN	54
August 21, 2003	Columbus, MS	10
Total workshop attendance		**1,724**

1.8 Statutory Overview

A number of federal statutes and executive orders are relevant to the formulation and evaluation of reservoir operations policy alternatives. Compliance with applicable regulations may affect the environmental consequences of an alternative or measures needed during its implementation.

Chapter 4, Description of Affected Environment, describes the regulatory setting for each resource; Chapter 5, Environmental Consequences of the Alternatives, discusses applicable laws and their relevance to this analysis. Specific analyses and EIS sections or content that are required by these statutes are included in this EIS (for example, a prime farmland report and analysis of threatened and endangered species).

The key authorities that relate to this EIS are summarized in the following sections.

1.8.1 Tennessee Valley Authority Act

The TVA Act charges TVA to promote the social and economic welfare of the citizens of the region through wise use and conservation of the area's natural resources (*United States ex rel. TVA v. Welch, 327 U.S. 546 [1946]*). Two sections of the TVA Act are especially important to TVA's management of the Tennessee River system. Section 9a authorizes the Board to regulate the river system—primarily for the purposes of navigation and flood control and, when consistent with these purposes, to provide and operate facilities for the generation of electric energy. Section 26a requires TVA approval before any obstruction affecting navigation, flood control, or public lands can be constructed, operated, or maintained along or in the Tennessee River system. Under the authority of the TVA Act, TVA manages the Tennessee River system to advance the economic and social well being of the citizens of the Tennessee Valley region.

1.8.2 National Environmental Policy Act

NEPA established a process by which federal agencies must study the effects of their actions. Whenever a federal agency proposes an action, grants a permit, or agrees to fund or authorize an action that could affect the natural or human environment, the agency must consider the potential adverse and beneficial effects of the action. NEPA requires that an EIS be prepared for major federal actions. This process must include public involvement and analysis of a reasonable range of alternatives. TVA prepared this FEIS to comply with the requirements of NEPA.

1.8.3 Protection of Water Quality

The Clean Water Act (CWA) was passed in 1972 to protect the Nation's water quality. The CWA is the primary law for regulating discharges of pollutants into the waters of the United States by enforcing water quality standards that are defined in Section 301 of the Act. Two categories of pollutants enter streams, rivers, and lakes or reservoirs: nonpoint sources (runoff from the landscape) and point sources (direct discharge via a pipe or ditch into the water). Section 402, the National Pollutant Discharge Elimination System (NPDES) Program, regulates point source discharges; states have been mandated to grant and enforce permits under this program. When stream segments are listed under Section 303(d) as impaired by a pollutant(s), a total maximum daily load (TMDL) must be developed for pollutant(s) for the listed stream segment. This TMDL determines the load of the pollutant(s) that a waterbody can receive without compromising its biological and chemical integrity. Both nonpoint and point sources are targeted for reductions under a TMDL. Many streams in the Tennessee River watershed are listed on the Section 303(d) lists for parameters such as flow alterations; low DO; sediment accumulation; contamination with polychlorinated biphenyls (PCBs), other organic compounds or metals, and pathogens (bacteria or microorganisms); high fecal coliform; and poor biological health. TMDLs for these listed waters are in various stages of development.

Certain actions that affect waters of the United States are coordinated with the applicable state to receive approval under Section 401, water quality certification. This certification is received by showing that the project or discharge will not adversely affect the water quality of the

receiving stream, as defined by its designated uses. The designated use is determined by the primary uses of the water, such as recreation, water supply, and aquatic life.

1.8.4 Protection of Wetlands and Floodplains

Disturbance of many wetlands or any other waters of the United States by the discharge of any dredge or fill material requires a permit from the USACE under Section 404 of the CWA. Under Executive Order 11990—Protection of Wetlands, federal agencies are required to avoid construction in wetlands to the extent practicable and to mitigate potential impacts as appropriate. State programs for protection of wetlands also exist. For example, the Tennessee Aquatic Resource Alteration Permit Program controls alteration of streams and wetlands for actions within the state of Tennessee.

Under Executive Order 11988—Floodplain Management, federal agency actions must, to the extent practicable, avoid siting in floodplain zones in order to reduce the risk of flood loss; minimize impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values of floodplains. The Federal Emergency Management Agency (FEMA) has identified where floodplains occur, and many local governments have adopted regulations to control the development of these defined floodplains.

1.8.5 Flood Control Act of 1944

The Flood Control Act of 1944 generally exempts TVA from USACE regulations governing the operation of federal dams, except when there is danger of flooding on the lower Ohio and Mississippi Rivers. In such a situation, USACE can direct TVA how to release water from the Tennessee River system into the Ohio River system.

1.8.6 Protection of Air Quality

Under the Clean Air Act (CAA), proposed new air pollutant sources must be permitted and must demonstrate that they will not violate the National Ambient Air Quality Standards (NAAQS). State Implementation Plans (SIPs) are developed by each state; these plans outline how the state will protect air quality. SIPs are based on the NAAQS, which are set by the USEPA for pollutants such as sulfur and nitrogen-based air emissions, with margins of safety to protect human health and welfare. Sources of air emissions are controlled based on the size of the emission, its location, and the type of pollutant. For new sources, best available control technology must be used to control emissions, and offsets (reducing emissions from existing sources) are required in some areas.

1.8.7 Protection of Threatened and Endangered Species

Under the Endangered Species Act (ESA), federal agencies must ensure that their actions will not jeopardize the existence of species federally listed as threatened or endangered, or affect the critical habitat of those species. Under provisions of Section 7(a)(2) of the ESA, a federal agency that permits, licenses, funds, or otherwise authorizes activities must consult with the

USFWS as appropriate, to ensure that its actions will not jeopardize the continued existence of any listed species. In addition, Section 9 makes it unlawful to take or harm any listed species. The states within the Tennessee Valley also have programs that protect state-listed threatened and endangered species.

1.8.8 Protection of Cultural Resources

The National Historic Preservation Act (NHPA) and Archaeological Resource Protection Act were enacted to protect cultural and archaeological resources. Before disturbing any cultural or archaeological resources with historical significance, the State Historic Preservation Office must be consulted. In some circumstances, the Federal Advisory Council on Historic Preservation must also be consulted. The Valley states have additional requirements for protection of excavation of the remains of Native Americans on lands under state or local control. Some of these lands border TVA managed reservoirs, and TVA actively works with the states to protect these resources.

1.8.9 Protection of Farmland

Under the Farmland Protection and Policy Act (FPPA), federal agencies are required to identify and consider the potential adverse effects of a proposed action on prime farmland. The FPPA ensures, to the maximum extent practicable, that federal programs are administered in a manner that is compatible with state and local government and private programs to protect farmland. In addition, the State of Tennessee has enacted the Agricultural District and Farmland Preservation Act, which provides limited protection of farmlands that have been specially designated under the Act.

1.8.10 Environmental Justice

Executive Order 12898—Environmental Justice requires some federal agencies to identify and address the adverse human health or environmental effects of federal programs, policies, and activities that may be disproportionately greater for minority and low-income populations. Federal agencies must ensure that federal programs or activities do not directly or indirectly result in disparate impacts on minorities or low-income populations. Federal agencies must provide opportunities for input into the NEPA process by affected communities and must evaluate the potentially significant and adverse environmental effects of proposed actions on minority and low-income communities during preparation of environmental documents. TVA is not subject to this executive order but evaluates environmental justice impacts as a matter of policy.

1.8.11 Homeland Security Act

The primary mission of the Homeland Security Act is to prevent terrorist attacks in the United States, reduce the vulnerability of the United States to terrorism, and minimize damage and assist with recovery if attacks do occur. All federal, state, and local agencies, including TVA,

must follow this Act by ensuring that any public service is protected, emergency plans are developed, and communities are protected from potential terrorist attacks.

1.8.12 Other Regulations and Executive Orders

Other statutes and executive orders may be relevant, depending on the type of specific projects or operating changes that occur as a consequence of this EIS, including:

- Executive Order 13112—Invasive Species;
- Section 10 of the River and Harbors Act;
- Migratory Bird Treaty Act;
- Executive Order 13186—Responsibilities of Federal Agencies to Protect Migratory Birds;
- The Safe Drinking Water Act and Tennessee drinking water regulations;
- The Toxic Substances Control Act;
- The Federal Insecticide, Fungicide, and Rodenticide Act;
- The Resource Conservation and Recovery Act and other solid waste disposal regulations; and,
- The Comprehensive Environmental Response, Compensation, and Liability Act.

1.9 Relationship with Other NEPA Reviews

This EIS builds on other EISs and NEPA reviews. The following completed environmental reviews are relevant to this EIS because they may affect or be affected by related TVA policies, or were included in and used as a basis for the analyses presented herein:

- **Tennessee River and Reservoir System Operation and Planning Review Final Environmental Impact Statement.** Published in December 1990, this EIS was the basis for TVA's present reservoir operations policy. The Lake Improvement Plan is the starting point for the evaluation of the reservoir operations policy, and this ROS EIS relies on relevant information from that document.
- **Shoreline Management Initiative Final Environmental Impact Statement.** In November 1998, TVA issued a final EIS on its policy regulating permitting activities and allowable residential uses for TVA-owned lands and easement properties along 11,000 miles of shoreland in the Tennessee River system. Many of these shorelands are included in the scope of the ROS EIS. The SMI established a management and environmental planning and review process, including individual reservoir Land Management Plans (LMPs) and procedures for implementing the Section 26a permitting program that affect and are affected by the reservoir operations policy. The SMI is the source of some of the basic land use and shoreline development projections used in this ROS EIS, and some of the management

measures resulting from the SMI are relevant to the conclusions about environmental consequences.

- **Energy Vision 2020 Final Environmental Impact Statement.** In December 1995, TVA completed an Integrated Resource Plan identifying and selecting a long-range strategy that would enable TVA to meet the additional electricity needs of its customers from 1996 to 2020. TVA prepared an EIS on the portfolio of energy resource options (including hydropower) that best met TVA's evaluation criteria regarding costs, rates, environmental impacts, debt, and economic development. The plan was designed to aid TVA and its customers in addressing the uncertainty that the electric utility industry would face in a deregulated environment. The power analyses presented in this document are consistent with the analysis in the Energy Vision 2020 EIS.
- **Final Supplemental Environmental Impact Statement for Browns Ferry Nuclear Plant Operating License Renewal, Athens, Alabama.** In March 2002, TVA prepared a Final Supplemental EIS for renewing the operating licenses and extending operation of all three units at its Browns Ferry Nuclear Plant located in Limestone County, Alabama. The Final Supplemental EIS tiered from the 1972 Final EIS and included refurbishment and restart of Unit 1, with extended operation of all three units as its preferred alternative, which was subsequently adopted by TVA. These actions are considered in this ROS EIS as part of the Base Case and all of the policy alternatives.
- **Environmental Assessments for Hydro Modernization Projects.** Various Environmental Assessments (EAs) have been prepared during the implementation of individual elements of TVA's Hydro Modernization (HMOD) projects. EAs have been completed for modernization and rehabilitation of the following TVA hydropower plants: Douglas (March 1995), Cherokee (July 1995), Raccoon Mountain (July 1999), Fort Loudoun (February 2000), Hiwassee (February 2001), Chatuge (April 2001), Watts Bar (December 2001), Apalachia (February 2002), and Boone (October 2002). HMOD projects that were designed and funded, implemented, or completed on or before October 2001 are considered in this ROS EIS as part of the Base Case (see Appendix A, Table A-09); the projects yet to be designed or implemented as of October 2001 are considered in the cumulative impacts analysis.
- **Environmental Assessments and Environmental Impact Statements for Land Management Plans.** Environmental Assessments and EISs were completed for LMPs at the following TVA reservoirs: Melton Hill, Boone, Tellico, Tims Ford, Guntersville, Cherokee, Bear Creek, Norris, and Pickwick. These LMPs were developed in a manner consistent with the implementation of TVA's land management policy as established in the SMI.
- **Final Chickamauga Dam Navigation Lock Project Environmental Impact Statement.** In May 1996, this EIS evaluated the proposed construction of a new 110– by 600–foot navigation lock at Chickamauga Dam. The Final EIS addressed the economic, social, and environmental impacts of various alternative plans and the proposed plan. The USACE prepared a final supplement to the EIS in February 2002. In fiscal

year 2003, Congress authorized construction of a 110– by 600–foot replacement lock.

- **Final and Supplemental Environmental Impact Statements, Lower Cumberland and Tennessee Rivers Kentucky Lock Addition Project.** These Final EISs evaluated the potential impact of constructing a 110– by 1,200–foot navigation lock at the Kentucky Dam.

1.10 EIS Overview

Volume I of this FEIS consists of 10 chapters (Figure 1.10-01) as outlined below. Volume II includes eight appendices, with more detail on technical analyses and supporting data.

- **Chapter 1—**describes the purpose and need for the ROS EIS, scope of the ROS, decision to be made, history of policy changes, reservoir operations policy scoping process, public review and agency consultation requirements, relationship to other NEPA reviews, and EIS overview.
- **Chapter 2**—provides a background and water control system overview, a description of how the water control system is operated to achieve public benefits, and the existing water control system operations.
- **Chapter 3—**includes a description of the process of developing, evaluating, and winnowing the list of reservoir operations policy alternatives; a summary of analyses of policy alternatives; and a summary of the environmental consequences of the policy alternatives considered. It also identifies TVA's Preferred Alternative.
- **Chapter 4—**discusses the affected environment of the reservoir system.
- **Chapter 5—**identifies the environmental consequences of each policy alternative.
- **Chapter 6—**addresses the cumulative impacts of alternatives identified in this EIS, in consideration of other major actions in the region of influence.
- **Chapter 7—**describes a range of potential mitigation measures to offset potential adverse impacts of the Preferred Alternative.
- **Chapters 8–10—**contain a list of preparers, an FEIS distribution list, and supporting information (including an index, a glossary, and the literature cited).
- **Appendix A—**contains tables describing the characteristics of the water control system and its individual projects.
- **Appendix B—**contains detailed descriptions of the Base Case, the preliminary operations policy alternatives, and the Preferred Alternative.
- **Appendix C—**contains information on models used to analyze the alternatives: reservoir level, water availability, and hydropower modeling; energy cost modeling; water quality modeling; flood flow modeling; the hedonic valuation model; and the economic model. Appendix C also contains elevation and flow results from the

Weekly Scheduling Model for key reservoirs and probability plots of the Preferred Alternative.

- **Appendix D—**contains additional information on water quality, groundwater resources, aquatic resources, wetlands, terrestrial ecology, threatened and endangered species, cultural resources, recreation, inter-basin transfers, and social and economic resources.
- **Appendix E—**contains the Prime Farmland Technical Report.
- **Appendix F—**contains the responses to comments on the DEIS.
- **Appendix G—**contains the results of consultations required under Section 7 of the ESA.
- **Appendix H—**contains the results of consultations required under Section 106 of the NHPA.

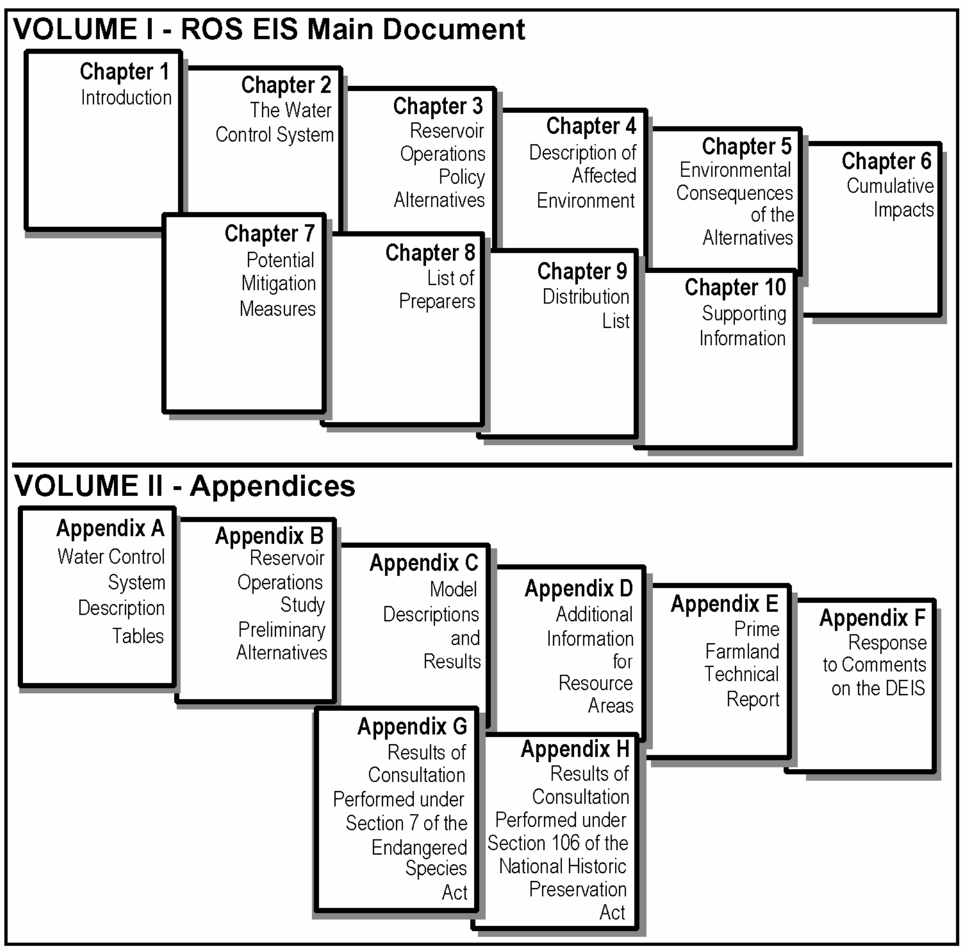


Figure 1.10-01 Contents of the ROS EIS

Chapter 2

The Water Control System

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2.1 Background and Water Control System Overview

This chapter describes the seasonal patterns of rainfall and runoff in the Tennessee Valley watershed and the specific components of the TVA water control system.

2.1.1 Rainfall and Runoff

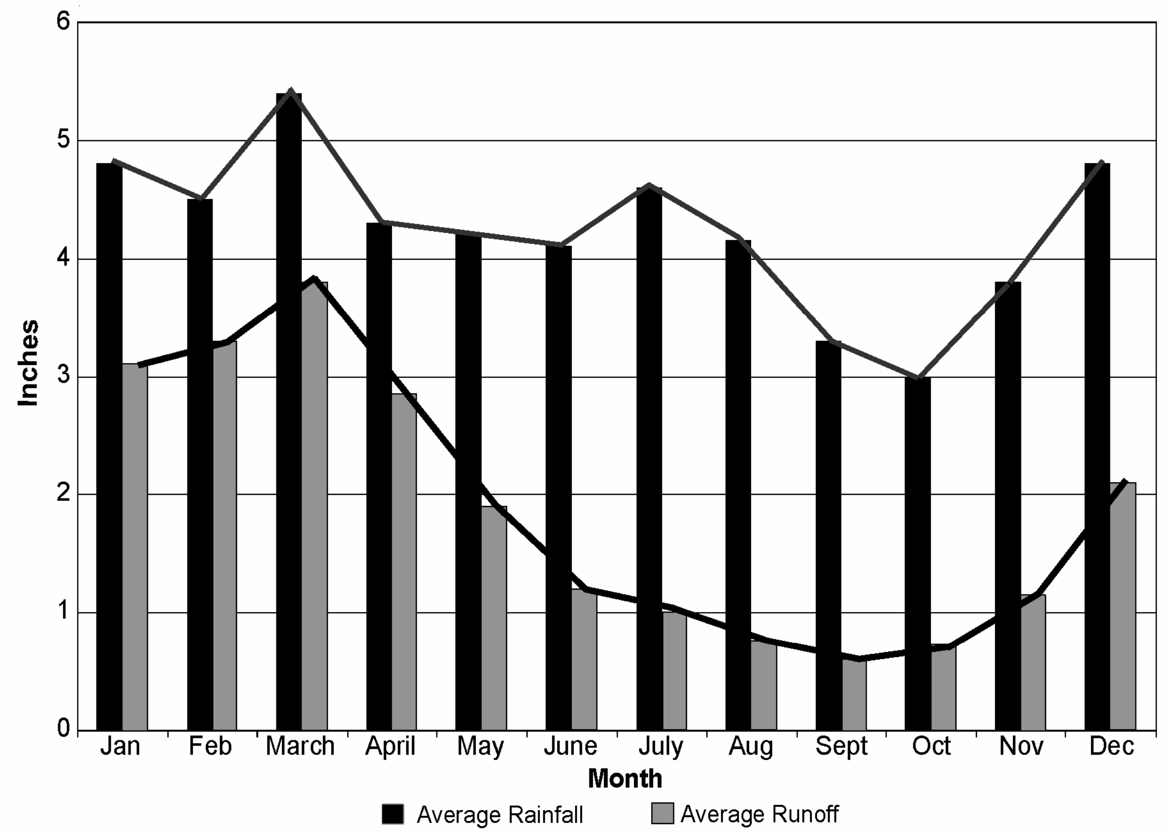
Rainfall, runoff, and topography in the Tennessee Valley watershed strongly influenced the original location, design, and operating characteristics of TVA reservoirs and the water control system. The locations and storage volumes of reservoirs reflect the variation in rainfall and runoff in the region. Rainfall and runoff continue to control when and where water flows into the reservoirs; and runoff exerts a strong influence on the annual, seasonal, and weekly patterns of reservoir operations.

Mean total annual rainfall is 52 inches per year throughout the TVA system, but rainfall varies considerably from year to year and at different locations in the system. During the past 100 years, mean annual rainfall has varied between a low of 36 inches in 1985 and a high of 65 inches in 1973. Rainfall is greatest in certain mountainous regions of the watershed—where rainfall totals over 90 inches per year. In contrast, mean annual rainfall in some portions of the Valley is as low as 40 inches. Although the months with the highest or lowest rainfall may differ each year, rainfall is typically highest from December through March and lowest from September through November (Figure 2.1-01).

More important to reservoir operations than rainfall is the seasonal variation in runoff. Runoff is rainfall that flows into streams and reservoirs. About 40 percent of rainfall in the drainage area of the Tennessee River system becomes runoff; the remainder evaporates, is used by plants, or drains into the soil and becomes part of the groundwater.

Although average rainfall varies somewhat, runoff patterns vary considerably more through the seasons due to changes in ground conditions, plant growth and cover, and storm and rainfall patterns (Figure 2.1-01). During late spring, summer, and fall, soils are generally drier, and dense ground cover helps to intercept and reduce rapid runoff from rainfall. In winter, as plants turn dormant and the ground becomes wetter, runoff increases. As shown in Figure 2.1-01, the greatest total runoff occurs from January through March, which is the major flood season in the Tennessee Valley. Storms tend to be larger during this period, and winter storms can cover the entire Valley for several days—sometimes with one storm followed by another storm 3 to 5 days later.

In contrast, runoff in summer and fall is much lower than in winter and spring. Summer storms generally affect only a portion of the basin. Although the total runoff in a summer storm is a fraction of that for a winter storm, flooding is still a concern—especially on a local scale—because reservoir levels are usually higher and less flood storage space is available.



Note: Rainfall amounts are monthly averages for the whole TVA Region. Runoff is rainfall that flows into streams and reservoirs.
Source: TVA data 2003.

Figure 2.1-01 Monthly Average Rainfall and Runoff (1903 to 2001)

Substantial variation in the annual amount of rainfall affects the degree to which objectives of the water control system can be achieved. For example, lack of rainfall and severe droughts in the 1980s and 1990s limited the amount of water in the system, which in turn reduced hydropower production, caused water quality problems, and reduced recreational use of reservoirs. During such low rainfall periods, achieving reservoir system objectives is difficult because of lower reservoir levels. At other times, excessive amounts of rainfall can rapidly exhaust flood storage space and necessitate frequent spills through sluiceways and spillways.

2.1.2 Structure of the Water Control System

The water control system is composed of dams and reservoirs, tailwaters, navigation locks, and hydropower generation facilities, as described in the following sections.

Dams and Reservoirs (Projects)

The 35 projects that comprise the water control system evaluated in the ROS include nine mainstem reservoirs and 26 tributary reservoirs (Table 2.1-01). Mainstem projects are those on the Tennessee River from Fort Loudoun Reservoir to Kentucky Reservoir (Figure 1.1-01).

Each TVA project typically falls into one of four general categories that are closely related to its characteristics (e.g., location and size), primary function (e.g., navigation, storage for flood control, or power generation), and operation. These categories include mainstem storage projects, mainstem run-of-river projects, tributary storage projects, and tributary run-of-river projects, as described below and listed in Table 2.1-01.

RESERVOIR CLASSIFICATION TERMS

Mainstem Projects—TVA mainstem projects are located on the Tennessee River as opposed to tributary streams and smaller rivers that feed into it.

Tributary Projects—TVA tributary projects are located on the smaller rivers and streams that feed into the mainstem.

Storage Projects—Storage projects have volume available for retaining floodwaters. These projects are operated on an annual fill and drawdown cycle. They are operated with higher pool levels during the summer recreation period and lower pool levels during the winter flood period.

Run-of-River Projects—Run-of-river projects have limited storage volume and generally release the same amount of water that flows into the reservoir on an hourly, daily, or weekly basis; therefore, these projects are operated based on streamflow, with limited seasonal change in storage.

- **Mainstem Storage Projects.** Projects located on the mainstem of the Tennessee River, the lowest part of the TVA water control system (Figure 1.1-01), are managed for navigation, flood control, power production, recreation, and other uses. Seven mainstem storage projects and their associated locks comprise the majority of the 800-mile Tennessee River commercial navigation channel. Their pool elevations (or reservoir levels) and flow releases are essential to maintaining a viable commercial waterway. Mainstem storage projects are operated on a seasonal basis for flood control. Mainstem project pool elevations typically fluctuate from approximately 2 to 6 feet on an annual basis—much less than tributary projects.

- **Mainstem Run-of-River Projects.** The two mainstem run-of-river projects serve the same general functions as the mainstem storage projects. Because they have limited storage volume, these projects generally release water on an inflow-equals-outflow basis (reflecting operations of the larger upstream projects). Run-of-river projects provide navigation, hydropower production, recreation, and a range of other benefits.

Table 2.1-01 Characteristics of TVA Reservoirs

Project and Location	Operating Mode	Length of Reservoir (miles)[1]	Navigation Facilities	Flood Storage (1,000 acre-feet)[5]	Turbine Units and Generating Capacity (MW)[7]
Mainstem Projects					
Kentucky, KY	Storage	184.3	2 Locks, canal[2]	4,008	5 (223)
Pickwick, TN	Storage	52.7	2 Locks, canal[3]	493 [6]	6 (240)
Wilson, AL	Run-of-river	15.5	2 Locks	0	21 (675)
Wheeler, AL	Storage	74.1	2 Locks	349	11 (412)
Guntersville, AL	Storage	75.7	2 Locks	162	4 (135)
Nickajack, TN	Run-of-river	46.3	Lock	0	4 (104)
Chickamauga, TN	Storage	58.9	Lock	345	4 (160)
Watts Bar, TN	Storage	95.5*	Lock	379	5 (192)
Fort Loudoun, TN	Storage	60.8*	Lock	111	4 (155)
Total mainstem		**663.8**	**14 Locks**	**5,847**	**64 (2,296)**
Tributary Projects					
Norris, TN	Storage	129.0	-	1,473	2 (131)
Melton Hill, TN	Run-of-river	44.0	Lock	0	2 (72)
Douglas, TN	Storage	43.1	–	1,251	4 (156)
South Holston, TN	Storage	23.7	–	290	1 (39)
Boone, TN	Storage	32.7*	–	92	3 (92)
Fort Patrick Henry, TN	Run-of-river	10.4	–	0	2 (59)
Cherokee, TN	Storage	54.0	–	1,012	4 (160)
Watauga, TN	Storage	16.3	–	223	2 (58)
Wilbur, TN	Run-of-river	1.8	–	0	4 (11)
Fontana, NC	Storage	29.0	–	580	3 (294)
Tellico, TN	Storage	33.2	Canal[4]	120	0 [8]
Chatuge, NC	Storage	13.0	–	93	1 (11)
Nottely, GA	Storage	20.2	–	100	1 (15)
Hiwassee, NC	Storage	22.2	–	270	2 (176)
Apalachia, NC	Run-of-river	9.8	–	0	2 (100)

Table 2.1-01 Characteristics of TVA Reservoirs (continued)

Project and Locations	Operating Mode	Length of Reservoir (miles)[1]	Navigation Facilities	Flood Storage (1,000 acre-feet)[5]	Turbine Units and Generating Capacity (MW)[7]
Tributary Projects (continued)					
Blue Ridge, GA	Storage	11.0	–	69	1 (22)
Ocoee #1, TN	Storage	7.5	–	0	5 (19)
Ocoee #2, TN	Run-of-river	–	–	0	2 (23)
Ocoee #3, TN	Run-of-river	7.0	–	0	1 (29)
Tims Ford, TN	Storage	34.2	–	220	1 (45)
Normandy, TN	Storage	17.0	–	48	0[8]
Great Falls, TN	Storage	22.0	–	0	2 (34)
Upper Bear Creek, AL	Run-of-river	14.0	–	0	0[8]
Bear Creek, AL	Storage	12.0	–	37	0[8]
Little Bear Creek, AL	Storage	6.0	–	25	0[8]
Cedar Creek, AL	Storage	9.0	–	76	0[8]
Total tributary		**622.1**	**1 Lock**	**5,979**	**45 (1,546)**
Total projects		**1,285.9**	**15 Locks**	**11,826**	**109 (3,842)**

Notes:

[1] Full summer pool. *Fort Loudoun—49.9 miles on the Tennessee River, 6.5 miles on the French Broad River and 4.4 miles on the Holston River; Watts Bar—72.4 miles on the Tennessee River and 23.1 miles on the Clinch River; Norris—73 miles on the Clinch River and 56 miles on the Powell River; Boone—17.4 miles on the South Fork Holston River and 15.3 miles on the Watauga River.

[2] Includes new main lock chamber (110 feet wide and 1,200 feet long) and the Barkley Canal.

[3] Tennessee–Tombigbee Waterway; Bay Springs Reservoir is connected to Pickwick Reservoir by a navigation canal.

[4] River diversion through a canal increases energy generation at Fort Loudoun.

[5] Numbers reflect allocated flood storage. The observed flood storage varies, depending on rainfall and runoff.

[6] Includes additional storage volume from Bay Springs Reservoir.

[7] Actual megawatt generating capacity at any time depends on several factors, including operating head, turbine capability, generator cooling, water temperature, and power factor. Generating capacities include rehabilitation and modernization of turbine units already performed, as well as those in the design, construction, or authorization phase.

[8] Project design does not include power generation capacity.

- **Tributary Storage Projects.** Eighteen tributary storage projects are located on the tributaries of the Tennessee River and one, Great Falls Reservoir, is located on a tributary of the Cumberland River (Figure 1.1-01). These projects store water to provide flood control, recreational benefits, and water supply. They release water over time to generate power and support downstream flows for navigation and power generation lower in the system—at downstream tributary and mainstem projects. Historically, water in tributary projects was held in storage and released to maximize hydropower production during summer. Presently, water is released not only to generate hydropower but also to provide minimum flows (water releases necessary to help maintain downstream water quality and protect aquatic habitat) and to maintain summer pool elevations longer into the summer. Reservoir levels for tributary storage projects fluctuate considerably on a seasonal basis; levels can fluctuate up to 90 feet.

- **Tributary Run-of-River Projects.** The seven tributary run-of-river projects are operated as part of the tributary project group. Because they are located between much larger reservoirs (Figure 1.1-01) and have limited storage volume, tributary run-of-river projects generally release water on an inflow-equals-outflow basis, reflecting operations of the larger upstream projects. Daily fluctuations in pool elevations are common but limited to a few feet. Although tributary run-of river projects are operated for similar objectives as tributary storage projects, they are generally operated as pass-through projects and provide little storage for flood reduction or minimum flows.

Tailwaters

Tailwater is a widely used term that generally refers to the portion of a river below a dam that extends downstream to the upper portion of the next reservoir pool in the system. The term tailwater can also refer to the upper portion of a reservoir pool immediately below an upstream dam with river-like characteristics, but which is also influenced at times by the elevation of the downstream pool. In these tailwater areas, the water is nearly always moving but the rate of flow, temperature, and other water quality characteristics are controlled or at least strongly affected by releases from the upstream dam.

In this EIS, several resource areas define or identify various lengths of tailwaters. These differences reflect the many types of tailwater characteristics and uses that occur in the study area and demonstrate that there is no single, well-defined definition of tailwater or, in many cases, a clearly defined transition point between a tailwater and the downstream reservoir pool. Section 4.1 provides further information on waterbody types in the TVA reservoir system.

Navigation Locks

The TVA reservoir system also includes 15 navigation locks located at 10 dams. Operated by the USACE, the locks provide an 800-mile commercial navigation channel from the mouth of the Tennessee River at Paducah, Kentucky; upstream past Knoxville, Tennessee; and into parts of

the Hiwassee, Clinch, and Little Tennessee Rivers. TVA operates the reservoir system to maintain a minimum 11-foot depth in the navigation channel along this navigable waterway.

Hydropower Generation Facilities

Hydropower generation facilities are incorporated into 29 of the project dams. Although these facilities initially provided base load power (operating almost continuously), they now generate electricity primarily during periods of peak power demand. Fossil and nuclear power generation facilities with much greater generation capacities have been added to the TVA power system to provide base load power. Operation of the reservoir system has changed over time to meet peak power demands, improve overall power system reliability, and to ensure that an adequate supply of cooling water is made available to the coal and nuclear power plants. Depending on annual runoff, the hydropower facilities provide from 10 to 15 percent of TVA’s average power requirements.

TVA is in the midst of an Hydro Automation Program, which will automate the control of TVA's hydro generating units. When completed in 2004, the Hydro Automation Program will greatly improve TVA's flexibility to control its conventional hydro generating units (turbines). This flexibility will enable TVA to reduce overall operating expenses and to increase operating efficiencies. TVA will be able to produce the maximum amount of power with the available minimum amount of water and to provide rapid, automatic, real-time dispatching of the generating units.

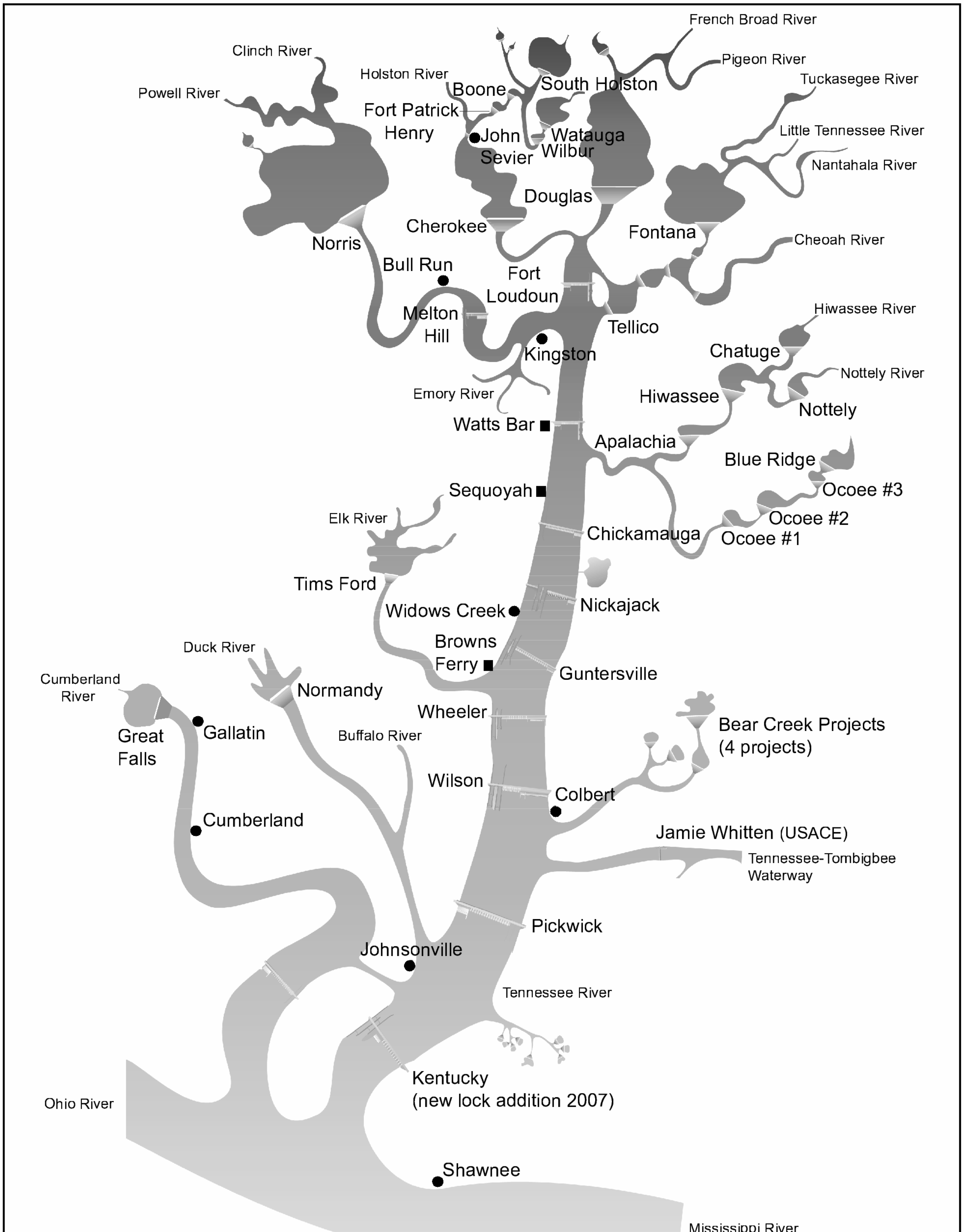
In addition, TVA began to rehabilitate and upgrade its aging hydropower generation facilities in 1991. Eventually, as many as 92 hydro turbine units at 26 plant sites (including Raccoon Mountain Pumped Storage Project) may be rehabilitated and modernized. The goal of TVA's HMOD projects is to provide for a safer and more reliable hydropower system, improved operational efficiency, and increases in system capacity at an acceptable economical cost and return to TVA. HMOD projects that were designed and funded, implemented, or completed on or before October 2001 are considered in this EIS as part of the Base Case (see Appendix A, Table A-09). The projects yet to be designed or implemented as of October 2001 are considered in the cumulative impacts analysis.

2.2 Water Control System

This section describes how the water control system is operated to optimize public benefits while observing physical, operational, and other constraints.

2.2.1 Flows through the Water Control System

Figure 2.2-01 depicts a schematic of the water control system. Water stored in the tributary reservoirs is released downstream to the larger Tennessee River mainstem projects (shown on the center of the schematic) and eventually flows into the Ohio River. Water is released from the projects to provide flows to maintain minimum navigational depth, reestablish flood storage volume in the reservoirs, generate power as it passes through the system, supply cooling water to the coal and nuclear power plants, and maintain water quality and aquatic habitat.



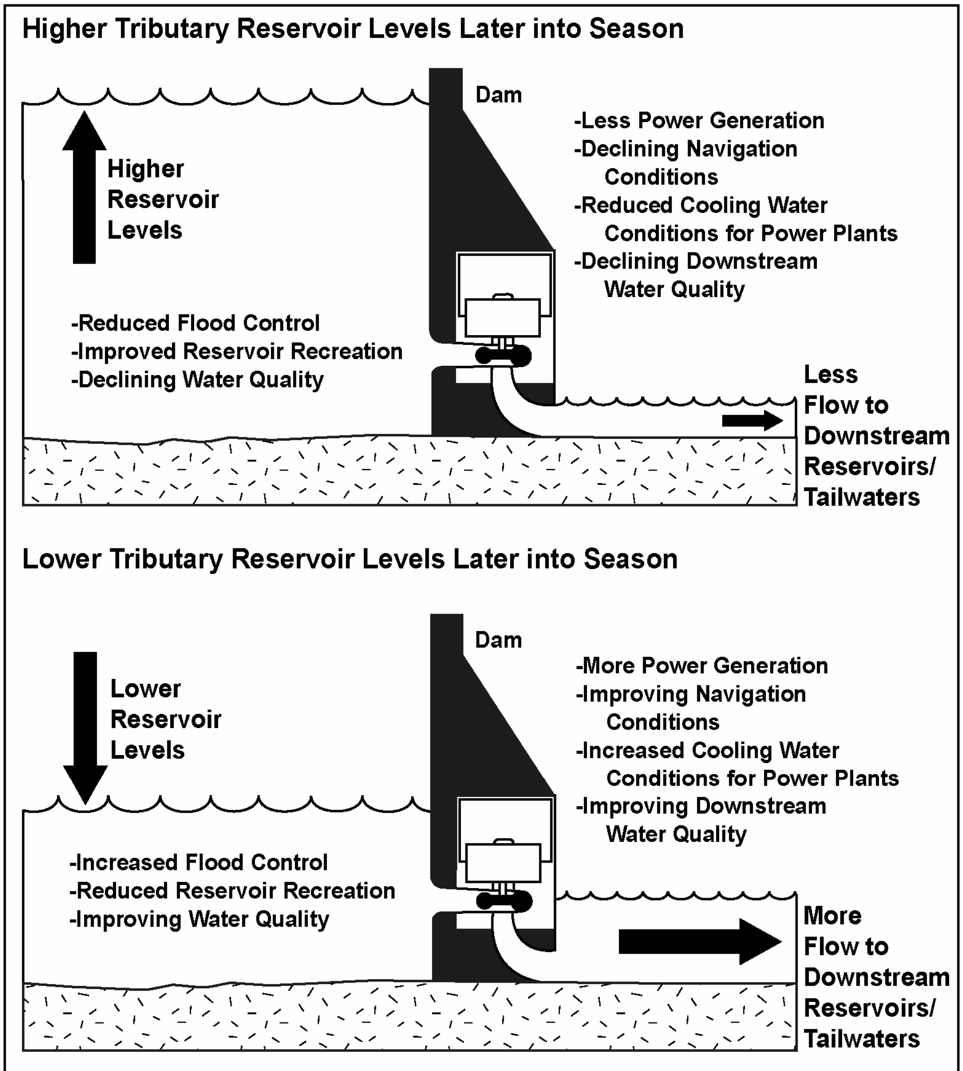
Note: The scope of the ROS EIS includes the 35 projects and power facilities shown here. (Paradise and Allen Fossil plants are outside the bounds of this schematic. See Figure 1.1-02 for their locations. The other 14 TVA projects not labeled on this figure are outside the scope of this study.)
Source: TVA data 2003.

Figure 2.2-01 Schematic Diagram of the TVA Water Control System

Throughout the year, TVA manages the distribution of flows through the system in response to changing rainfall and runoff levels and other operating factors. Higher reservoir levels during some months of the year increase recreational opportunities and other benefits. During other months of the year, lower reservoir levels (especially at storage projects) provide flood storage volume during high-runoff periods.

2.2.2 Balancing Operating Objectives

The TVA reservoir system is not operated to maximize a single benefit to the exclusion of others. The system is operated to achieve a number of objectives and to provide multiple public benefits. Some operating objectives are complementary; others require trade-offs, especially in periods of limited water (Figure 2.2 -02).



Source: TVA data 2003.

Figure 2.2-02 Achieving a Balance of Reservoir System Operating Objectives (Summer/Fall)

During the late summer and fall drawdown period, water released to increase winter flood storage also supports navigation, power production, water quality, and tailwater recreation, creating complementary benefits.

A clear example of a trade-off during operation of the reservoir system is the lower reservoir levels needed for flood control and the higher reservoir levels desired for recreation. To manage flood risk, TVA lowers reservoir levels before the high runoff period, thus providing storage volume. Lowering reservoir levels affects the amount of water surface available for reservoir recreational activities and detracts from the recreational experience. In certain seasons, there is an unavoidable trade-off between flood control and reservoir recreational opportunities. Just as the trade-offs affect the benefits created, they often involve different beneficiaries.

2.2.3 Reservoir Operations Policy

TVA's reservoir operations policy establishes a balance of operating objectives. It guides system-wide decisions about how much water is stored in specific reservoirs, how the water is released, and the timing of those releases. The policy helps TVA in managing its reservoir system to fulfill its statutorily prescribed operating objectives (navigation, flood control, and power production) and to provide other benefits to the region—such as recreational opportunities and improved water quality.

The reservoir operations policy is composed of guidelines that describe how the reservoirs should be operated given the rainfall and runoff and the operating objectives. To be effective over the wide range of rainfall and runoff patterns within the 40,000-square-mile watershed, these guidelines must be flexible. This flexibility also allows the water control system to provide multiple uses of the water.

Reservoir operating guidelines establish pool level parameters for daily operations. One of the most important factors that determines where the actual pool levels are relative to these guidelines is the year-to-year variation in rainfall and runoff. Reservoir operations may temporarily deviate from normal operating guidelines to meet critical power system situations and meet other reservoir system needs to the extent practicable. Temporary deviations above and below these guidelines occur frequently due to floods and droughts.

Elements of TVA's reservoir operations policy include:

- **Reservoir Operating Guidelines—**control the amount of water in each reservoir, the reservoir pool elevations, and the flow of water from one reservoir to another; these guidelines are implemented through guide curves for each reservoir.
- **Water Release Guidelines—**control the release of water needed for reservoir system and project minimum flows, including flows for special operations.
- **Other Guidelines and Operational Constraints—**include procedures and limitations set for hydropower generation, response to drought conditions, scheduled maintenance

for power generation facilities, power system alerts, dam safety, security threats, and environmental emergencies (e.g., spills).

The manner in which these guidelines are implemented under the present reservoir operations policy is described in the following section and in Section 2.3, Existing Water Control System Operations.

Reservoir Operating Guidelines

Reservoir operating guidelines are implemented as planned operating ranges of reservoir levels throughout the year. TVA represents these guidelines in graphs called guide curves, which show the planned reservoir levels for navigation, flood control, recreation, and other operating objectives. Guide curves also depict the volume of water available to TVA for hydropower generation and other beneficial uses.

> **RESERVOIR GUIDE CURVES**
>
> Guide curves are line graphs showing the planned reservoir levels throughout the year. They also depict the storage allocated for flood control, operating zones and, in some reservoirs, the volume of water available for discretionary uses.
>
> (See Figures 2.2-03 and 2.2-04.)

Guide curves for mainstem and tributary reservoirs have different characteristics. Mainstem guide curves typically allow for a much smaller range of reservoir elevation change. Tributary guide curves include a larger change in reservoir elevations over the annual cycle and usually include a discretionary operating zone (the area between the flood guide and Minimum Operations Guide [MOG]). Because guide curves specify certain periods for raising or lowering the reservoirs, they substantially affect seasonal releases in project tailwaters. Each project has its own guide curve.

These project-specific guide curves are based on original project allocations and subsequent modifications, many years of historical flows, flood season conditions, and experience with project and reservoir system operations. Reservoir operations per the guide curves maintain project storage volume available for flood control within the watershed at any given time of year, as well as the amount of stored water needed to meet other purposes such as year-round navigation, power generation, reservoir recreation, water quality, waste assimilation, and other environmental resource considerations.

TVA operating guidelines must be flexible enough to respond to unusual or extreme circumstances in the system that are beyond TVA's control. The most important of these is variation in rainfall and runoff, at times resulting in low inflow conditions

> **RESERVOIR OPERATING PERIODS**
>
> **Winter Flood Control Period—**Reservoir elevations are held at lower levels during periods of higher runoff to provide more flood storage.
>
> **Fill Period—**During the spring period of diminishing runoff, reservoirs are filled at a rate designed to maintain flood storage and reach summer pool elevations.
>
> **Recreation/Summer Pool Period—**Reservoir levels are maintained at or above minimum operations guide levels to the extent possible during this time of lower flood risk. Drawdown rates are restricted during this period in tributary reservoirs.
>
> **Drawdown Period—**Reservoirs are drawn down to or below winter flood guide levels (for tributary reservoirs) or within operating zone levels (for mainstem reservoirs) in anticipation of higher runoff; this is the unrestricted drawdown period.
>
> (See Figures 2.2-03 and 2.2-04.)

(droughts) or high inflow conditions (floods) that substantially increase the difficulty in meeting the multiple needs of the system. Other extreme circumstances include extreme temperatures and sudden loss of generating units, requiring a quick response that may be available only from TVA's hydropower electric units.

Tributary Reservoir Guide Curves

Figure 2.2-03 shows a generic guide curve for a tributary storage reservoir. Because tributary reservoirs provide a significant portion of the system's flood storage, their reservoir pool may vary substantially over the annual cycle.

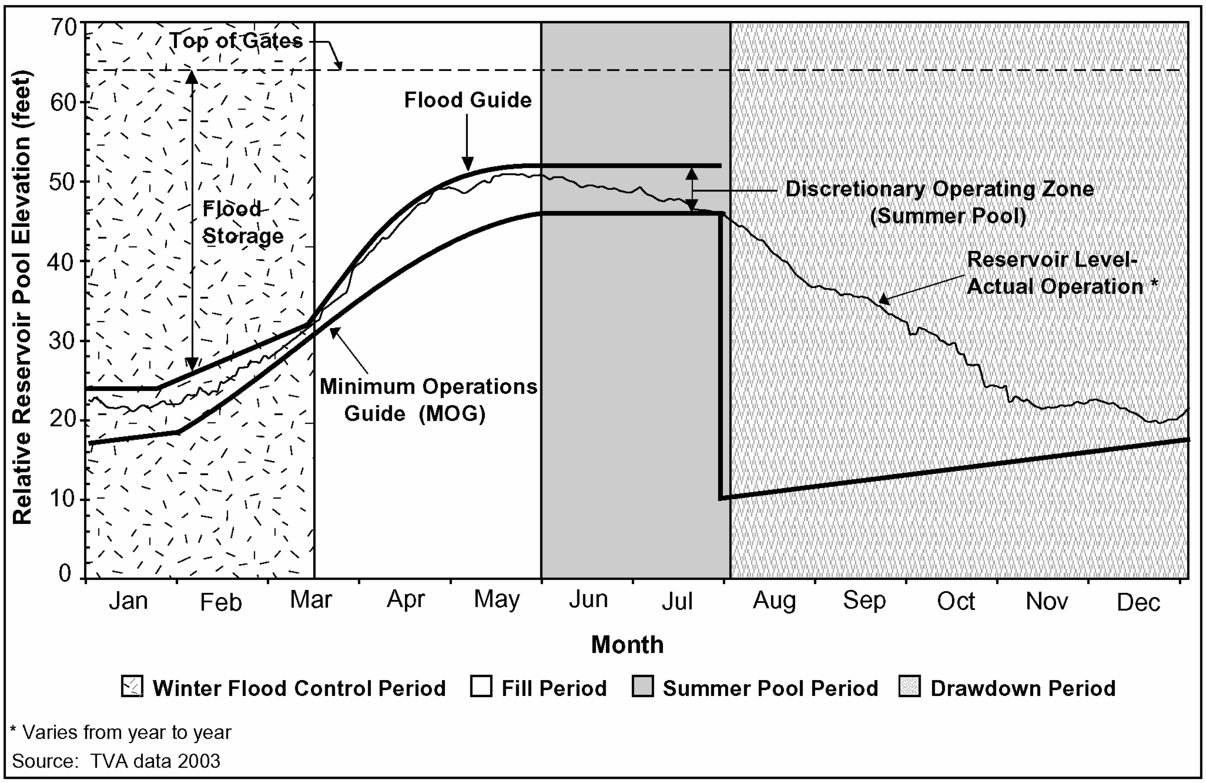


Figure 2.2-03 Generic Tributary Reservoir Guide Curve

To achieve multiple reservoir system elevations, the guide curve must include operational flexibility. Managing the tributary reservoir levels within a discretionary operating zone creates this flexibility. The lower limit of this zone is the MOG. When a reservoir is at or below its MOG, only minimum flows are released.

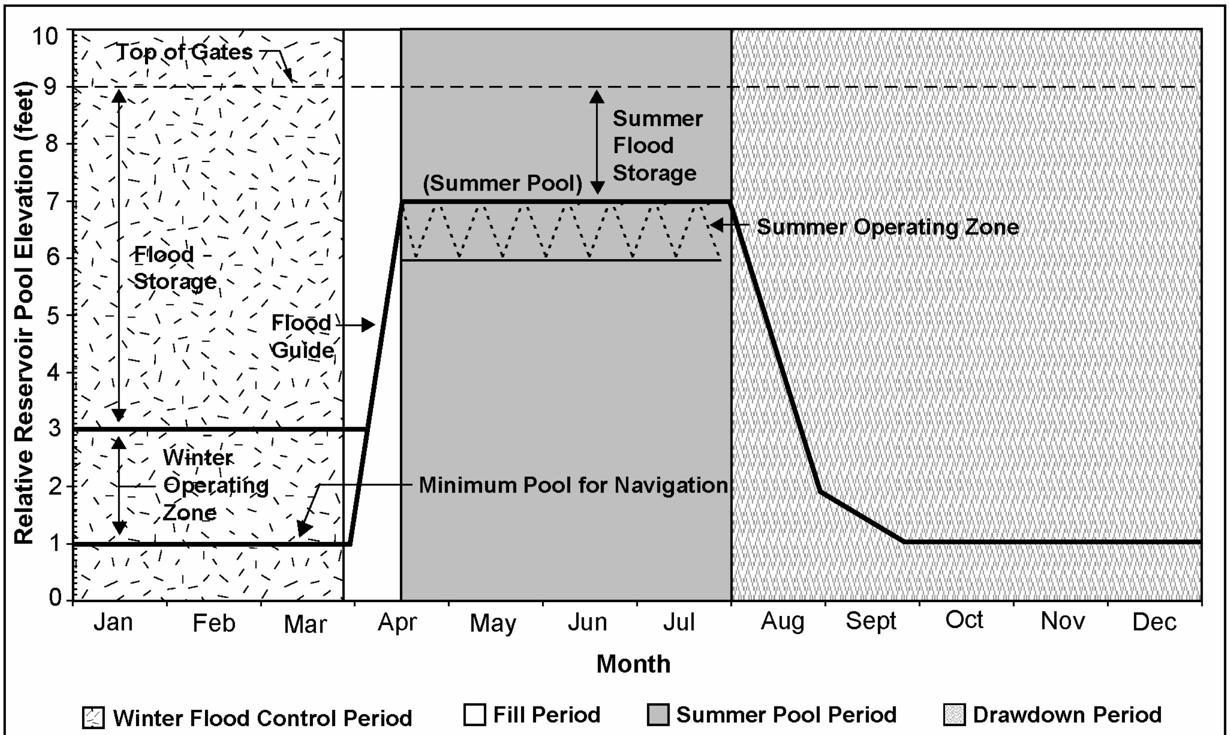
The upper limit of the discretionary operating zone is the flood guide. Reservoir levels generally are not allowed to exceed this limit because the flood guide controls the minimum amount of flood storage available in a reservoir. By limiting reservoir elevations to a level equal to or lower than the flood guide, TVA is assured that flood storage necessary to minimize flood risk is

available for use. Occasionally, temporary fills to higher levels occur when high flows are regulated, and lower levels may occur for power generation emergencies.

Under typical conditions, the water level in a tributary storage reservoir fluctuates within its discretionary operating zone. The reservoir can be drawn down to generate hydropower and to meet downstream water requirements, such as providing cooling water for nuclear and coal power plants, process water for industry, or flow for navigation.

Mainstem Reservoir Guide Curves

The generic guide curve for a mainstem reservoir (Figure 2.2-04) shows that the schedules for drawdown and fill are somewhat similar to those for a tributary reservoir, but the drawdown is generally much smaller than for a tributary reservoir because of the difference in reservoir characteristics. All mainstem projects have a seasonal fluctuation zone, which is followed to the extent practicable (Appendix A, Table A–02).



Source: TVA data 2003.

Figure 2.2-04 Generic Mainstem Reservoir Guide Curve

- **January–March.** Reservoir elevations are lowest from January to March, the period of highest runoff and flood risk, as shown in Figure 2.2-04. Pools are maintained within a 1- to 2-foot winter operating zone to the extent possible, except when regulating high flows. The bottom of this winter regulating zone is the lowest elevation to which the reservoir is drawn while still meeting minimum navigation depth requirements.

- **April.** From late March through the middle of April, reservoir elevations are raised to the summer pool level as runoff and system demands allow.

- **Mid-April through Late Summer.** Reservoirs are maintained at summer operating levels until seasonal drawdown begins. Normal operation includes a band of reservoir fluctuations, called the summer operating zone. Fluctuations of reservoir levels in this zone are used for power generation; and for mosquito control operations at Chickamauga, Guntersville, Wheeler, and Pickwick Reservoirs.

  Occasionally, temporary fills to higher levels occur when high flows are regulated, and lower levels may occur for power generation emergencies.

RESERVOIR POOL LEVELS AND OPERATING ZONES

Top of Gates—Top of Gates represents the maximum controlled elevation at a project; typically, the top of a spillway gate in a closed position or crest elevation of an uncontrolled outlet structure.

Flood Guide*—This seasonal elevation guide depicts the amount of storage allocated in a reservoir for flood reduction.

Flood Storage—Flood storage is the volume of runoff that can be stored in a reservoir to reduce downstream flooding.

Minimum Operations Guide (MOG)*—This seasonal guideline for reservoir elevation for some tributary projects depicts the elevation below which only minimum flows are usually released, except during emergencies.

Minimum Flow—A minimum flow is a release from one or more dams to meet downstream water needs (e.g., navigation, water supply, aquatic habitat, and waste assimilation). A minimum flow does not represent the lowest flow rate that TVA can pass from a dam or dams.

Discretionary Operating Zone*—This range of reservoir elevations between the MOG and the flood guide enables flexible operation of the system to achieve multiple benefits.

Summer Pool*—The range between the flood guide and the MOG during June and July. Full summer pool is the targeted reservoir elevation to be achieved by the beginning of the summer recreation season, and is also the summer flood guide. Minimum summer pool is the level for tributary storage projects equal to the MOG for June and July.

Restricted Drawdown*—This allowable lowering of tributary storage pool levels from June 1 to July 31 is limited to maintaining at least minimum summer pools, if possible.

Unrestricted Drawdown*—Reservoir pool elevations are lowered in late summer (usually August 1) to meet the January 1 flood guide. The release rate depends on the economical use of hydropower and design considerations, and is not restricted to maintaining minimum reservoir levels.

Summer Operating Zone—**This zone allows for fluctuations in reservoir levels for power production, flood control, and mosquito control.

Winter Operating Zone—**This zone includes fluctuations in reservoir levels between the winter flood guide and the minimum pool for navigation.

* Applies only to some tributary reservoirs.

** Applies only to mainstem reservoirs.

(See Figures 2.2-03 and 2.2-04.)

- **Fall Drawdown.** Reservoir elevations are lowered to the winter operating level beginning at various dates through summer and fall (Appendix A, Table A–08).

Water Release Guidelines

TVA manages the rate of flow and water levels through the system by selective releases from the dams. These releases affect water quality conditions in the tailwaters and reservoirs, water supply to the lower reservoirs, and the temperature of cooling water for coal and nuclear power plants located on mainstem reservoirs. TVA also manages flows in the tailwaters to maintain water quality and aquatic habitat. At times, TVA releases water to provide flows for special operations, as described in a following section.

To meet flow needs in the tailwaters and flow-through needs in the downstream reservoirs, TVA has adopted two broadly defined reservoir release policy elements: project minimum flows and system minimum flows. A minimum flow is a release from one or more dams to meet down-stream water needs (e.g., navigation, water supply, aquatic habitat, and waste assimilation); a minimum flow does not represent the lowest flow rate that TVA can pass from a dam or dams.

Project Minimum Flows

Project minimum flows are flows released at a specific reservoir (Appendix A, Table A–03). TVA implements project minimum flows to achieve specific operating objectives, including water supply and water quality improvements, and benefits for aquatic habitat and fisheries. Project minimum flows are provided below seven mainstem (these are also the system minimum flows discussed below) and 20 tributary reservoirs in a variety of ways, including instantaneous flows (continuous via small turbine operation or sluice outlet setting), pulsing flows (use of a generating unit at various hourly intervals), and daily average releases.

Minimum flows at 10 tributary projects were developed on the basis of techniques used by the USFWS to enhance aquatic life in streams in other regions of the country (see discussion of the Lake Improvement Plan in Chapter 1). These minimum flows are intended to afford greater protection for aquatic life from environmental stresses than would occur under average dry conditions.

System Minimum Flows

System minimum flows are indicators of total flow to meet requirements for navigation, water supply, cooling water for coal and nuclear plants, water quality, and aquatic habitat. System minimum flows are measured at the Chickamauga, Kentucky, and Pickwick Dams and other locations (Appendix A, Table A–03). These flows include a bi-weekly average minimum flow in summer and a daily average minimum flow in winter. If the total of the project minimum flows discussed above plus any natural runoff from the watershed is insufficient to meet these system minimum flows, additional water must be released from upstream reservoirs to supply the difference.

TVA uses a number of guidelines for system minimum flows as described in Section 2.3, Existing Water Control System Operations. These system minimum flows include:

- **Flows for Navigation—**to maintain minimum channel depths in the Tennessee River navigation channel.
- **Flows for Water Quality—**to minimize the water residence time (the amount of time it takes for water to pass through the reservoir) in mainstem reservoirs, thereby limiting periods of low DO in mainstem dam releases and reducing water quality degradation.
- **Flows for Cooling Water—**to meet the water temperature requirements of the cooling system discharges for TVA's nuclear and coal power plants.

Flows for Special Operations

Flows for special operations occur when reservoir levels are held steady or release schedules are modified to accommodate specific requests. In 2002, TVA responded to over 200 requests to support special events and activities across the Valley. Special operations have included boat parades, regattas, rowing competitions, and fishing tournaments throughout the Valley. Special operations have been scheduled to assist clean-ups, aid in stocking trout, free stranded barges, dilute runoff from fire-fighting, and recover drowning victims. They have also been used to support surveys of endangered plants, help control mosquito populations, and conduct fisheries research. Special operations may also be scheduled to facilitate boat ramp and pier construction, installation of water intake pipes, and shoreline stabilization projects.

Other Guidelines and Operational Constraints

Ramping Rates

Reservoir releases are normally made through a project's hydropower turbines, and these releases determine the rate of flow and depth in the project tailwater. The number of turbines in use and their size control the rate of flow. Project design features (e.g., the types and sizes of turbines) and the rate at which turbines are turned on and off—or ramped up or down—also govern the rate of flow. For purposes of this EIS, ramping rates refer to how many hydro turbine units are simultaneously brought online or taken offline at a hydropower plant. The term ramping rate can also indicate an increase or decrease in generation by an individual hydro turbine unit.

Restrictions are placed on ramping rates for environmental or safety concerns, or to limit upstream generation to balance a downstream project's storage volume. Existing ramping restrictions for TVA dams are outlined in Appendix A, Table A–04.

Response to Drought Conditions

Based on the 100 years of water flow data compiled by TVA, severe system-wide drought conditions are rare. When drought conditions occur, it becomes more difficult to meet competing demands for the use of water.

The system operating guidelines for the larger tributary storage projects include some measures that respond to drought conditions. For example, releasing only minimum flows when reservoirs are below their MOGs helps conserve water while still protecting aquatic life. When drought conditions persist for an extended period of time, operating decisions must be made based on the best available information. For example, during the hot, dry summer of 1999, operations at Normandy Reservoir were adjusted to enhance municipal water supply and Tims Ford Reservoir was operated to alleviate problems with inadequate water depth at the intake for a downstream public utility.

Scheduled Maintenance Periods for Hydropower Generation Facilities and Power Plants

TVA must plan and conduct periodic shutdowns of its hydropower facilities for maintenance activities. Special operations for this purpose usually require restrictions on reservoir levels or releases. These restrictions sometimes extend to upstream hydropower plants, because their flows can affect the special operations or maintenance outages at downstream projects. When hydropower units are out of service, they are unavailable for reservoir releases; therefore, such shutdowns are scheduled in consideration of projected release schedules.

TVA also schedules and performs periodic maintenance on its nuclear and fossil power plants. Scheduling of these outages may influence the timing of reservoir level changes or downstream flows.

Critical Power System Situations

During critical power system situations, including but not limited to Power System Alerts or implementation of the Emergency Load Curtailment Plan (ELCP), reservoir operations may temporarily deviate from normal system operating guidelines to meet power system needs. In such situations, water stored in the reservoirs may be used to the extent practicable to preserve the reliability of the TVA power system. Power system alerts are issued when situations such as an unexpected shutdown of a large generating unit, extreme temperatures, or an interchange curtailment (which limits TVA's ability to import power due to overloads on the bulk transmission grid) would reduce power supply reserves below TVA/North American Electric Reliability Council requirements.

The ELCP was developed to provide arrangements and contingency plans to meet power system emergencies. Emergency situations involving a sudden loss in power generation do not always allow a sequential implementation of the steps contained in the power system alert and ELCP processes. Further, issuance of a power system alert or ELCP does not necessarily mean that MOGs are no longer followed. The specific type of power emergency determines the type of operational responses required.

Dam Safety

TVA follows federal regulatory guidelines to ensure that operation of its reservoir system does not jeopardize the structural integrity of the dams. Dams and adjacent features, such as embankments and shoreline structures, are designed to be stable under a set of operating conditions, both normal and unusual, that might occur during the life of the structure. Drawdown limits for dam safety (Appendix A, Table A–07) ensure that the structures and systems are not exposed to conditions that are outside those design or safety limits. Relative to the reservoir operations policy, the pertinent limits include a maximum allowable reservoir elevation and a maximum rate of reservoir drawdown. The maximum allowable reservoir elevation is an unusual condition that would occur during a major flood. Reservoir drawdown occurs as a part of normal operations, and TVA must limit the rate of drawdown to maintain structural stability.

2.3 Existing Water Control System Operations

The previous section described the reservoir guide curves and other operational guidelines that are used to manage day-to-day operation of the water control system. The guide curves and guidelines were developed to achieve, to the extent possible, public benefits from the operating objectives established for the water control system. The following sections discuss how the system is operated to meet these objectives.

The operating objectives include:

- Navigation
- Flood control
- Power production
- Water supply
- Water quality
- Recreation
- Other objectives

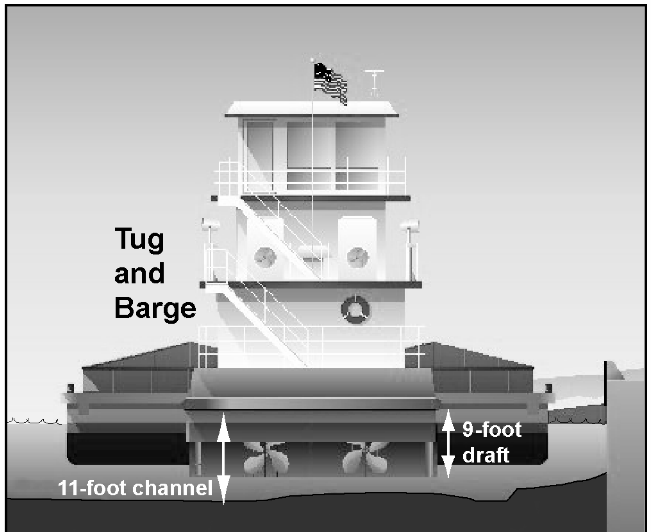
2.3.1 Operations for Navigation

Navigation is one of TVA's primary objectives. The Tennessee River is a key element of regional commerce because it provides a waterborne transportation route for movement of bulk commodities and materials into and out of the region. Commodities transported by barge include coal, aggregates, grains, and chemicals. Because most bulk commodities are needed on a year-round basis, maintaining navigation on the reservoir system is an important operating objective. This objective is met by maintaining adequate river depths, rate of flow, and controlling flood flows during times of high runoff.

Maintaining Adequate River Depths for Navigation

The existing reservoir operations policy prescribes that the reservoir system be operated to provide a minimum depth of 11 feet in the navigation channel within the reservoirs on the

mainstem between Paducah, Kentucky (where the Tennessee River joins the Ohio River), and Knoxville, Tennessee. The 11-foot channel allows for passage of commercial barges with a 9-foot draft (the depth below the water surface that a towboat and barge extend when fully loaded). The additional 2 feet of channel depth allow for such operational factors as squat, trim, and wave action (factors that affect the draft of the boat), as well as sufficient channel width for safe navigation (Figure 2.3-01).



Note: A minimum channel depth of 11 feet allows standard commercial barge traffic to move through the system with a 2-foot overdraft (extra space between bottom of boat and river bottom).
Source: TVA data 2003.

Figure 2.3-01 Illustration of Minimum Channel Depth for Navigation

During normal flow conditions, operation of the reservoir system for flood control and power generation provides adequate water flow through the system to maintain minimum channel depths, making these operating objectives complementary uses of the water. To maintain adequate river depths for navigation, TVA must:

- Hold pool levels at all nine mainstem reservoirs high enough to provide an 11-foot depth at the shallowest points along the channel; and,
- Release enough water to create a depth of flow sufficient to provide an 11-foot channel at Kentucky and Pickwick tailwaters.

At times during summer and fall, when runoff is lowest, flows may be insufficient to maintain an 11-foot depth for the entire navigation channel. The channel depth at shoals, sandbars, and other shallows may cease to meet the 11-foot minimum and may impede navigation operations. During these periods, barge operators may reduce barge loads (and the draft needed for passage) or cease operations altogether. In response to low flows and shallow navigation channels, TVA may release water from storage in the tributary reservoirs to increase flows in the mainstem reservoirs and tailwaters in order to maintain the 11-foot minimum channel depth for navigation.

Controlling Flood Flows for Navigation

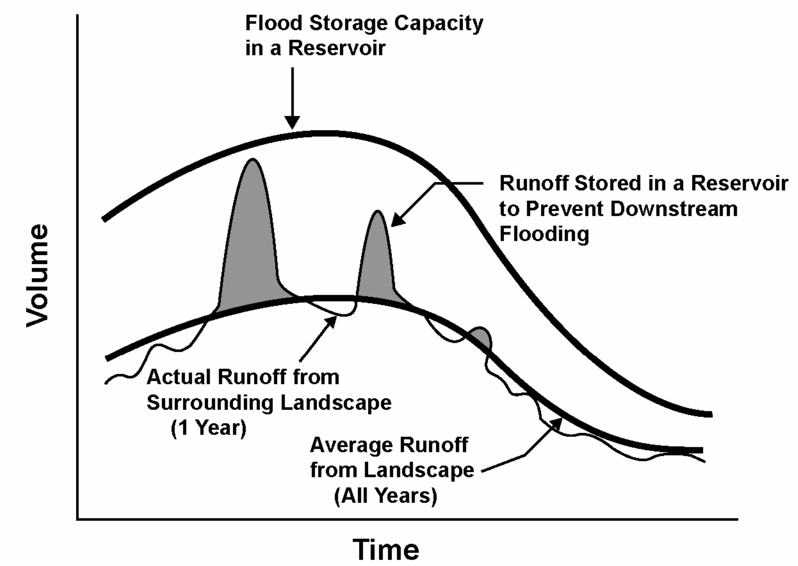
During periods of high flow (during and after major storms and high runoff), flow velocity and turbulence in the navigation channel, especially at the entrance and exit of locks and in shoal areas, may become dangerous to barge operations. For safety in these circumstances, navigation is suspended and barge movement is stopped until flows are reduced to a safe level and navigation can be resumed. When the reservoir system stores flood flows, disruption of navigation from dangerous high flows is minimized. To the extent that navigational operations

are not interrupted by insufficient water depths or high river flows, the reliability and cost effectiveness of river transportation are achieved by operation of the reservoir system.

2.3.2 Operations for Flood Control

Reducing flood damage at critical locations is the second primary objective of the reservoir system. The greatest potential for flood damage is in and around Chattanooga, which is located just upstream from the point where the Tennessee River passes through the Cumberland Mountains. This mountain pass constricts higher river flows, backing water up onto adjacent floodplains.

During periods of high flow, flood risk can be significantly reduced by storing runoff in both tributary and mainstem storage reservoirs (Figure 2.3-02).



Note: On average, there is more storage capacity than is needed. However, the full capacity is needed during high runoff years.
Source: TVA data 2003.

Figure 2.3-02 Storage of Increased Runoff to Prevent Flooding

To reduce the risk of flooding, TVA implements the following actions:

- A portion of each reservoir's storage volume is set aside specifically for floodwater storage (Table 2.1-01). This storage is reserved so that it is available when increased runoff occurs.

- During a flood event, the reservoir operations policy permits storage reservoirs to rise above their flood guides, storing the excess runoff and reducing downstream flood crests that may otherwise inundate flood-prone areas.

- After the peak flow of the storm has passed, the stored floodwaters are released at a controlled rate to recover flood storage. This controlled release protects against downstream flooding and reclaims the reservoir's flood storage volume in preparation for the next storm.

Each reservoir's flood guide curve reflects the amount of storage reserved for flood control and how it varies by season of the year. These allocations were determined in the original project design, and some have been modified based on subsequent analysis of rainfall and runoff characteristics of the drainage basin and the physical limitations of the reservoir system. As noted in the discussion of reservoir guide curves (Section 2.2, Water Control System), the amount of flood storage for most tributary storage reservoirs is greatest in winter and early spring. As runoff volumes decline in late spring or summer, reservoir levels are allowed to increase, thus reducing flood storage volume (Figures 2.2-03 and 2.2-04).

Water releases during flood control operations may differ from normal releases. Most often, water is released through the hydro turbines. The flood control reservoir operations policy prescribes the amount of water to be released and the method of its release to reestablish flood storage. This drawdown is usually accomplished by operating the hydro turbines at maximum capacity until the necessary quantity of water has been discharged from the reservoirs. At other times, additional water must be released through sluiceways or spillways to lower the reservoir levels more quickly and regain the storage space needed for future storms.

Although the general flood protection procedure is the same for all storms, which reservoirs are filled and the timing of the store-and-release operation varies from storm to storm depending on where and how much rainfall occurs, and how much flood storage is allocated. System operations in response to an isolated thunderstorm might involve store and release at a single reservoir. In contrast, flood control operations for a major storm that spans the majority of the Tennessee Valley would necessitate the integrated operation of all the reservoirs in the system and may require coordination with the USACE on the lower Ohio and Mississippi Rivers.

2.3.3 Operations for Power Production

A third primary objective of the TVA water control system is the production of power for energy users in the TVA Power Service Area (Figure 1.1-02). TVA's power system includes 3,842 megawatts (MW) of conventional hydropower generating capacity, 1,645 MW of pumped storage capacity, and over 25,000 MW of fossil and nuclear generation facilities.

Most of TVA's fossil and nuclear generation plants are located along the reservoir system. Thus, the reservoir system is used directly to generate electrical energy (hydropower) and supports energy generation by providing cooling water to coal and nuclear plants, and transport of coal to its power plants. TVA operates all of its power plants together to meet regional power demands at the lowest possible cost to consumers.

Hydropower Generation

Energy generation from TVA's hydropower facilities is an important component of TVA's power supply system. Hydropower facilities provide reliable, low-cost energy. In the TVA system, these facilities primarily provide peaking power (power needed during periods of highest energy demand). The TVA Power Service Area typically has one period of high demand in summer and a second high-demand period in winter; the summer peak period is longer than the winter peak period. In an average year, more than 55 percent of the annual hydropower generation occurs during these two peak periods.

Hydropower is generally produced whenever reservoir releases are made, regardless of the purpose of the release. When a reservoir is within its discretionary operating zone (Section 2.2, Water Control System), additional water may be released for the sole purpose of generating hydropower. Releases are scheduled so that hydropower turbines are operated to maximize their value to the power supply system—by operating during the peak demand hours of each day and typically more on weekdays than on weekends.

The primary limit on generation of hydropower within the reservoir system is the availability of water, which may be constrained by low rainfall or other system operating priorities. For example, when TVA maintains higher summer pool levels by restricting drawdown, less water is available for hydropower generation.

Under normal streamflow conditions, releases from upstream reservoirs are scheduled to avoid releasing more flow into the mainstem reservoirs than TVA's hydropower units can use. During high-flow periods, excess water must be discharged through spillways or sluiceways, but using this option means losing the opportunity to use the water to generate electricity and diminishing the potential energy value of the water.

Coal and Nuclear Power Generation

Operation of the reservoir system also provides cooling water for TVA's coal and nuclear power plants. TVA coal and nuclear plants provide 80 percent of the energy needed for the TVA Power Service Area and depend on reservoir operations. Because their availability is essential to TVA's ability to provide reliable, affordable electricity, support of coal and nuclear plant operations by the reservoir system is an important operating objective.

The coal and nuclear plants require large quantities of cooling water to operate. Return of the cooling water to the reservoir system is regulated (by permit) and includes limitations on the increase in reservoir water temperatures that can result from the power plant discharge. These limitations are established to maintain water quality and protect aquatic life. System minimum flows in the Tennessee River are governed in part by the cooling water needs of these plants.

If cooling water discharges from any of TVA's power plants are predicted to exceed permit limits, power plant operations must be curtailed or river flows must be modified. The options available to TVA include reducing generation output (referred to as derating a power plant),

which reduces the amount of discharged heat; or, at some facilities, switching to more expensive backup cooling systems (cooling towers). Both options increase TVA's cost of power generation. TVA may also modify reservoir releases to provide more flow or create steady flow. When possible, TVA selects the option that minimizes power costs.

Reductions in coal and nuclear power generation (derates) typically occur during summer months. When flows in the reservoir system are reduced, reservoir water temperatures increase—providing less power plant cooling capacity. If the river flow is too low to provide adequate cooling water, flows may be supplemented by releases from tributary storage reservoirs. Historically, modification of some plant operations for some portion of the summer period has been necessary to maintain thermal limit compliance.

Any reduction in energy output from the coal and nuclear plants typically must be replaced by obtaining the electricity from other generating sources. Because generation output reductions due to thermal limits generally occur on hot summer days when the demands on TVA's generating resources are the greatest and when all of TVA's plants are already operating, replacement energy often must be obtained from non-TVA energy resources at higher costs. Although replacement energy may be available from outside sources, overloading can occur on the bulk transmission grid, resulting in insufficient transmission capacity to bring it into TVA's Power Service Area. Recently, circumstances have occurred when energy was available only from other sources and the costs of the available energy were very high compared to TVA's power system costs.

2.3.4 Operations for Water Supply

The TVA reservoir system supports a variety of instream and offstream water uses, including power production (cooling water for coal and nuclear power plants), industrial production, public supply, and irrigation. Water is withdrawn at over 700 points along the Tennessee River and its tributaries to benefit approximately 4 million citizens. According to the U.S. Geological Survey, about 12 billion gallons of water are withdrawn from the river system each day (Hutson et al. 2003). TVA's reservoir operations provide the reservoir levels and system flows necessary to support water supply withdrawals and allow pumping mechanisms to function properly.

Water in the TVA system is some of the most intensively used in the United States as measured by water use per area or population (Hutson et al. 2003). At the same time, the basin has one of the lowest rates of consumptive use. Basin-wide consumptive use is presently about 5 percent of the water withdrawn; 95 percent of the water withdrawn is returned to surface water or groundwater for reuse. Increase in consumptive uses through 2030 is not expected to exceed 14 percent of the total water withdrawn (Hutson et al. 2003).

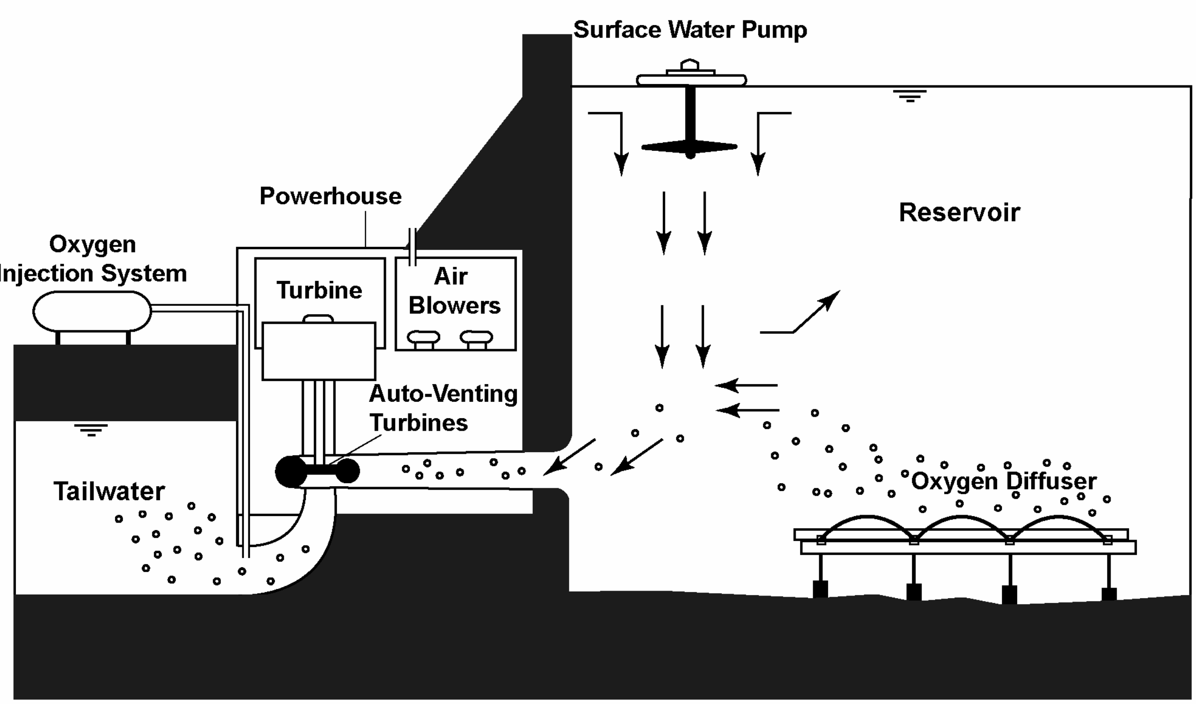
2.3.5 Operations for Water Quality

The public value placed on water quality has increased in recent years; TVA reservoir operations presently support a variety of water quality functions. These functions—previously outlined in Section 2.2.5, Water Release Guidelines, and more fully explained in the Water

Quality sections in Chapters 4 and 5—include maintaining water quality in project reservoirs and tailwaters, increasing the aeration of reservoir releases, diluting municipal and industrial waste, and ensuring adequate supplies of cooling waters for coal and nuclear power plants.

Reservoir operations and releases affect the concentration of DO in the water. Dissolved oxygen is an important water quality parameter, because insufficient DO concentration can be detrimental to the health and integrity of aquatic biota in reservoirs and tailwaters. As water is stored in reservoirs, physical and biological processes often depress the concentration of DO in the deeper waters of the reservoir. Depletion of DO concentrations is generally greater when the rate of water flow through a reservoir is less (water is held for longer periods). Higher DO concentrations accompany higher rates of flow through a reservoir. Because most hydropower turbines withdraw water from the deeper waters of the reservoir, the operation of hydropower facilities contributes to downstream DO problems, particularly below tributary dams. From June through November, hydropower releases from deeper reservoirs may contain little or no DO. This lower concentration of DO stresses aquatic life in tailwaters, cool-water species in reservoirs, and limits the water's capacity for assimilating waste.

Starting in the 1980s, under the Reservoir Release Improvement (RRI) Program, TVA developed methods to increase oxygen in the water below hydropower dams. These methods included auto-venting turbines, surface water pumps, oxygen injection systems, aerating weirs, and blowers (Figure 2.3-03). In 1991, under the Lake Improvement Plan, TVA adopted efforts to increase DO concentrations in the releases from 16 dams using these techniques (Appendix A, Table A–05) and to provide project minimum flows.



Source: TVA data 2003.

Figure 2.3-03 Aeration Methods to Increase Oxygen in Water below Hydropower Projects

A direct relationship exists between storage of water in the tributary reservoirs later into the summer and an increasing frequency of late summer water quality problems, especially DO. Increasing flow through the reservoirs in late summer, as is now accomplished by the late-summer/fall drawdown and system minimum flows, reduces DO problems. Higher DO concentrations often occur when water from the tributaries is moved through the reservoir system in late summer and early fall to meet certain other reservoir system operating priorities, such as hydropower production and system minimum flows for navigation and coal plant cooling water.

2.3.6 Operations for Recreation

Recreation on the reservoirs and tailwaters of TVA's system has grown in importance over the last 30 years. Reservoir operations presently include a variety of measures that provide recreational opportunities for residents and for visitors. Operations for recreation can be broadly divided into those for reservoir recreation and those for tailwater recreation.

Reservoir Recreation

TVA's present guidelines for reservoir levels were developed in part to improve recreational opportunities on tributary reservoirs during spring, summer, and fall. Beginning in mid-March, the 10 tributary reservoirs that are subject to substantial drawdown—Norris, Cherokee, South Holston, Watauga, Douglas, Fontana, Blue Ridge, Hiwassee, Nottely, and Chatuge—are filled to reach the target June 1 summer pool levels for recreation. The reservoirs are filled as quickly as possible, as long as reservoir levels do not exceed flood guide levels. Further, if low rainfall prevents reservoirs from filling at the desired rate, releases are limited to only those necessary for minimum flows.

Based on TVA's most recent evaluation in the Lake Improvement Plan, reservoir levels are maintained within the discretionary operating zone as much as practicable from June 1 to August 1. The rate of drawdown from June 1 to August 1, known as the period of restricted drawdown, is adjusted as necessary in an effort to generate hydropower while keeping reservoir levels above the MOG for recreation. If reservoir levels fall to the MOG due to low rainfall or high power demand, water levels are maintained as high as possible for recreation by restricting any further releases to minimum flows. On August 1, TVA begins the period of unrestricted drawdown on these reservoirs and is no longer restricted to maintaining minimum reservoir levels. Mainstem reservoirs fill earlier and drop only a few feet from summer pool to winter flood season levels.

Tailwater Recreation

There are 21 tailwaters on the reservoir system that may support recreational activities. In some tailwater reaches of the river, fishing, boating, and white-water activities (rafting and kayaking) are important. Providing recreational benefits may require managing reservoir releases for flows in tailwaters. Flows in the tailwaters should be sufficient to maintain fisheries and aquatic communities, and to support water-based recreation. Project minimum flow guidelines have been established at 20 tributary dams in the system; many of these have tailwaters that support recreational use. In addition, releases to meet system minimum flows

support recreational use at various levels, depending on the specific conditions, access, accrual of flow from other tributaries, and a variety of other factors.

2.3.7 Operations for Other Objectives

TVA operates the reservoir system to achieve the primary operating objectives described earlier, but the system produces other important benefits in the watershed and Power Service Area. The following secondary benefits are generally available when they do not conflict with the reservoir system's primary objectives.

Mosquito Control

During late spring and summer, TVA fluctuates water levels every week on four mainstem reservoirs (Chickamauga, Guntersville, Wheeler, and Pickwick) by 1 foot, flow permitting. This temporary change in reservoir level disrupts mosquito habitat, reducing the number of mosquito larvae during the height of the mosquito breeding season.

Fish Spawning

In spring (generally the period of late-April to mid-May), the reservoir system is operated so that water levels in tributary reservoirs are relatively stable for a 2-week period when the water temperature at a 5-foot depth reaches 65 °Fahrenheit. At this water temperature, peak spawning occurs for several popular sport fish species (mainly largemouth bass and black crappie). If reservoir levels are reduced during the peak spawning period, fish nests and eggs may be stranded above the water line or fish may abandon nests if water becomes too shallow. Stabilizing reservoir levels aids fish spawning success for these species, ultimately improving recreational angling. During the peak spawning period, it is most beneficial to avoid more than a 1-foot-per-week change (either lowering or rising) in pool levels. Rising water levels affect fish spawning success less than falling levels.

The period to maintain constant tributary reservoirs levels for fish spawning coincides with the period for filling reservoirs to reach their target summer elevations, resulting in conflict. In addition, if the water level in a particular reservoir or group of reservoirs rises during this period due to heavy rains, it is often necessary to lower pool levels in order to recover flood storage volume.

2.3.8 System Monitoring and Decision Support

TVA's reservoir operations policy provides the framework for overall operation of the system. Day-to-day decisions on actual release schedules are based on existing and forecasted weather conditions, immediate and projected needs for river flows, and special operation requirements. To ensure the efficient operation of its complex reservoir system, TVA uses a variety of data collection, computerized reporting, and decision support systems.

TVA, in cooperation with the USGS and USACE, maintains a computerized hydrologic data network (rainfall and streamflow gauges) throughout the Tennessee Valley; these measurements are reported and used in real time, generally about every 2 hours. Forecasting of weather and scheduling of water releases are supported by an array of computerized data collection and decision support tools, allowing TVA to examine several operational options before making decisions.

TVA's operations are closely coordinated with those of other agencies, especially the Nashville District of the USACE, which operates projects in the Cumberland River Basin that can interact with TVA's operations and affect downstream conditions. During periods of flooding on the lower Ohio and Mississippi Rivers, releases from Kentucky Dam are coordinated with the USACE Great Lakes and Ohio River Division, to aid in reducing flooding on those rivers. The same is true during extreme low-flow periods, when minimum river depths for commercial navigation are not available. The interconnected Tennessee and Cumberland Rivers constitute only 6 percent of the total Mississippi River watershed area above Memphis. During low-flow periods, however, discharges from the storage dams on these rivers contribute up to 40 percent of the total flow.

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4.4 Water Quality

4.4.1 Introduction

TVA reservoirs affect the quality of Valley waters by changing the thermal characteristics, residence times (length of time water spends in a reservoir), oxygen consumption and re-aeration, particle settling, algal growth, and cycling of nutrients and other substances (Churchill and Nicholas 1967, TVA 1978). This section describes water quality conditions that are affected by existing reservoir operations or that may be affected by an alternative operations policy. It also summarizes existing water quality in the potentially affected reservoirs and tailwaters.

Resource Issues

- Residence time
- Algal growth
- Thermal stratification
- Dissolved oxygen depletion
- Anoxic products

The regulation of the Tennessee River and tributaries through the TVA system of dams and reservoirs controls the rate of water movement through the reservoir system. The timing of reservoir releases changes the residence time of water in the reservoir and the pattern of downstream flows. Residence time influences several water quality constituents directly and many more indirectly. Temperature, dissolved oxygen (DO), and the production of algae are affected directly by residence time. The timing and degree of thermal stratification (the separation or layering of colder and warmer waters within the reservoirs) is also directly related to residence time. DO concentrations in reservoirs are related to thermal stratification, oxygen demand (biological, chemical, and sediment), and the timing and depth of water releases. Residence time and the availability of nutrients and light affect the dynamics of algal growth. In turn, algae play a critical role in the DO balance of the system. In the context of reservoir operations, residence time, thermal stratification, DO depletion, and algal growth are key water quality processes. They reflect overall water quality conditions, eutrophication, and the ability of the reservoir to assimilate waste.

Other water quality conditions are also important to the reservoir system. Very low DO concentrations (referred to as anoxic conditions) can mobilize or dissolve metals, sulfides, and ammonia contained in bottom sediments. Nutrient loadings (nitrogen and phosphorus) from the watershed play an important role in the growth of algae in the reservoirs. These parameters and processes are assessed qualitatively in Section 5.4 based on a quantitative analysis of the potential impacts on temperature, DO, and algae.

Erosion, sedimentation, and turbidity are affected by impoundments and project operations, such as release flows and drawdowns. Reservoir releases can increase downstream erosion and sedimentation, which can affect algae (discussed in this section) and other aquatic life (see Section 4.7, Aquatic Resources). Erosion is discussed in Section 4.16, Shoreline Erosion. Other water quality issues are largely unaffected by reservoir operations. Examples include bacterial contamination and contamination of sediments by polychlorinated biphenyls (PCBs).

4.4.2 Regulatory Programs and TVA Management Activities

Regulations and implementing programs at several levels of government monitor and manage the water quality in the Valley. State and federal programs authorized by the Clean Water Act (CWA) include the National Pollutant Discharge Elimination System (NPDES) and total maximum daily loads (TMDLs). The relationship of these programs to water quality in the Valley and to reservoir operations is described in the following sections. TVA activities include the Reservoir Release Improvement (RRI) Program, Vital Signs Monitoring Program, and Shoreline Treatment Program.

State and Federal Water Quality Programs

The federal CWA is the basis for many of the state and federal programs that address water quality issues. Wastewater permits are issued by the states under the NPDES program. States have established water quality criteria based on preserving specified designated uses of stream segments. Designated uses include uses such as water supply, power production, contact recreation, aquatic life, and waste assimilation. In cases where the water quality criteria are not met for a designated use, the stream segment is designated as water-quality limited. Water-quality limited stream segments are identified in the state's Section 303(d) list. The 303(d) list is updated every 2 years. For water-quality limited stream segments, the state must establish a TMDL for the pollutant(s) causing the stream segment to violate the water quality criteria and not meet its designated use. The objective of the TMDL is to inventory all sources of the pollutant and allocate loadings such that the stream segment meets its designated use.

The majority of reservoirs and tailwaters in the Valley meet both state and federal water quality criteria and guidelines. However, many segments of the system are listed as water-quality impaired under Section 303(d) of the CWA. The state-designated impaired TVA reservoirs and tailwaters within the scope of this EIS are presented in Appendix D1, Table D1-01. The primary causes for the listing of these reservoirs and tailwaters include flow alteration; low DO concentrations; thermal modification; sediment accumulation; contamination with PCBs, other organic compounds, or metals; and pathogen (bacteria, microorganisms) contamination. Of these causes, only flow alteration, temperature, DO, and sediment accumulation are influenced substantially by reservoir operations.

Reservoir operations have the potential to change flow, DO, and temperature. Changes in these conditions can potentially cause exceedances of the water quality criteria, affecting NPDES discharge permits or TMDL allocations of pollutant loads. For example, if minimum flows or DO concentrations were decreased, or if temperature were increased, the capacity to assimilate (dilute, break down, or absorb) waste would be reduced. If the changes are large, water quality criteria may be exceeded; designated stream uses may not be met; and existing and future dischargers may be limited, prohibited, or required to reduce existing pollutant loads.

The development and implementation of TMDL plans in the Tennessee River watershed may improve water quality in certain impaired segments by reducing inputs of pollutants. On the other hand, increased population growth will likely increase development pressure in the watershed, resulting in increases in nutrient and sediment loading to the TVA system. The net impact of these potential changes on water quality constituents likely to be affected by the alternatives under consideration was assumed for purposes of this assessment to be offsetting.

Reservoir Release Improvement Program

In 1991, TVA undertook a 5-year program to address tailwater oxygen concentrations and minimum flow requirements downstream of 20 TVA dams (Higgins and Brock 1999). TVA now uses auto-venting turbines, surface water pumps, oxygen-injection systems, aerating weirs, and air compressors and blowers to increase DO concentrations to target levels (TVA 1990). Turbine pulsing, weirs, and small hydropower units are used to maintain minimum flows when hydro turbines are not operating.

The RRI Program, completed in 1996, has increased DO concentrations to target levels in 300 miles of tailwaters below TVA dams and has improved minimum flows in 180 miles of tailwaters. The number and diversity of fish and insects have increased in those sections of river, resulting in a substantial growth in tailwater fishing. DO improvements have been made in the tailwaters below Apalachia, Blue Ridge, Boone, Chatuge, Cherokee, Douglas, Fontana, Fort Loudoun, Fort Patrick Henry, Hiwassee, Norris, Nottely, South Holston, Tims Ford, Watauga, and Watts Bar Reservoirs. TVA has made the commitment that the alternatives being considered would not reverse any of the improvements that have been made under this program (TVA 2002b) to ensure that DO targets and minimum flow described in the Lake Improvement Plan are maintained.

Vital Signs Monitoring Program

TVA initiated a reservoir monitoring program in 1990 to provide information on the ecological health or integrity of major reservoirs in the Valley (TVA 2002a). TVA monitors ecological conditions at 69 sites on 31 reservoirs. Each site is monitored every other year unless a substantial change in the ecological health score occurs during a 2-year cycle. If that occurs, the site is monitored the next year to confirm that the change was not temporary. Roughly half the sites are sampled each year on an alternating basis.

Five ecological indicators (chlorophyll-a, DO, sediment quality, benthic macroinvertebrates, and fish assemblage) are monitored at up to four locations in each reservoir. To complete the ecological health scoring process, the 20 to 100 percent scoring range is divided into categories representing good, fair, and poor ecological health conditions relative to what is expected given the hydrogeomorphology of the reservoir.

In general, ecological health scores for tributary reservoirs are lower than for mainstem reservoirs (Figure 4.4-01). Dissolved oxygen is the ecological health indicator mostly responsible for this difference between mainstem and tributary reservoirs because of its effects on chemical and biological conditions. Most mainstem reservoirs rarely receive poor ratings for DO, which means that DO concentrations <2.0 milligrams per liter (mg/L) occur either infrequently or for only short durations. On the other hand, DO concentrations <2.0 mg/L occur at most tributary reservoirs each summer and fall and, as a result, they received poor ratings. Transitional reservoirs, a designation used in the impacts assessment in Section 5.4, function somewhat differently than both mainstem and tributary reservoirs. The ecological health scores of transitional reservoirs are distributed throughout the poor to fair range.

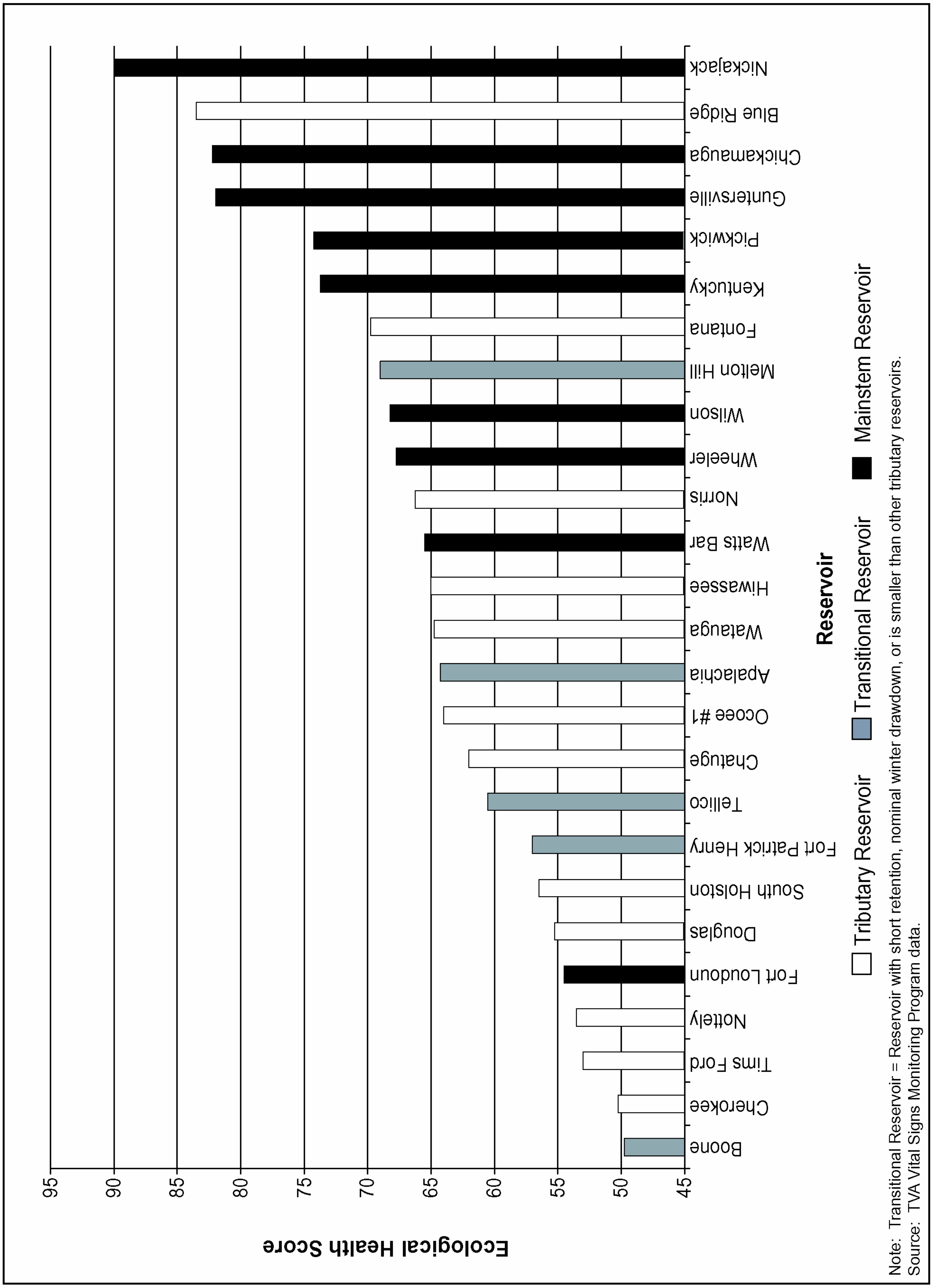
Scoring Ranges for All Reservoirs		
Poor	**Fair**	**Good**
<59	59-72	>72

The primary causes of low DO concentrations in tributary reservoirs are long residence time, depth, and nutrient loading (nutrients help algae grow). Shorter residence times in the mainstem reservoirs help prevent low DO concentrations by moving water through the reservoirs before decomposition consumes oxygen and allows for more mixing, more aeration, and lower algal growth (algal cells consume oxygen when they sink deeper than light can penetrate). However, Vital Signs monitoring data indicate lower DO concentrations in mainstem reservoirs during spring and summer periods of low flow, when the residence times are longer. Table 4.4-01 shows the ecological health indicators for affected reservoirs during the most recent monitoring cycle (2000 or 2001).

Shoreline Management Initiative

The SMI was designed to improve resource management and to refine existing permitting processes for activities on and near the shorelines of waters in the TVA system. The resultant plan established a policy to protect TVA-owned or controlled shoreland as well as private shoreland and aquatic resources, while allowing adjacent residents reasonable access to the water.

Through the Shoreline Treatment Program, TVA treats critical erosion sites (TVA 1998). This aspect of the SMI is discussed in Section 4.16, Shoreline Erosion.



Note: Transitional Reservoir = Reservoir with short retention, nominal winter drawdown, or is smaller than other tributary reservoirs.
Source: TVA Vital Signs Monitoring Program data.

Figure 4.4-01 Average Reservoir Ecological Health Score 1994 to 2001

Table 4.4-01 Ecological Health Indicators for TVA Reservoirs in the ROS (2000 and 2001)

Reservoir	Dissolved Oxygen[1]	Chlorophyll-a[2]	Year
Apalachia	Fair	Poor	2000
Bear Creek	Poor	Poor	2001
Beech	Poor	Poor	2000
Blue Ridge	Good	Good	2001
Boone	Poor	Fair	2001
Cedar Creek	Poor	Good	2001
Chatuge	Fair	Good	2001
Cherokee	Poor	Poor	2000
Chickamauga	Fair	Fair	2001
Douglas	Poor	Fair	2001
Fontana	Fair	Good	2000
Fort Loudoun	Poor	Poor	2001
Fort Patrick Henry	Good	Poor	2001
Guntersville	Good	Fair	2000
Hiwassee	Poor	Fair	2000
Kentucky	Good	Poor	2001
Little Bear Creek	Poor	Good	2001
Melton Hill	Fair	Good	2000
Nickajack	Good	Good	2001
Normandy	Poor	Poor	2000
Norris	Poor	Good	2001
Nottely	Good	Fair	2001
Parksville	Good	Good	2001
Pickwick	Good	Poor	2000
South Holston	Poor	Good	2000
Tellico	Poor	Good	2001
Tims Ford	Fair	Good	2000
Watauga	Poor	Poor	2000
Watts Bar	Poor	Poor	2000
Wheeler	Poor	Poor	2001
Wilson	Poor	Poor	2000

[1] A good rating indicates that water can support fish and aquatic life.

[2] A good rating indicates low to moderate algal growth.

Source: TVA 2002a.

Watershed Water Quality Improvement

In 1992, TVA began its watershed water quality Improvement effort to protect and improve water quality throughout the Tennessee Valley. TVA builds partnerships with community residents, businesses, and government agencies to promote watershed protection. It works with its partners to clearly define cause and sources of existing problems and to develop local capability to address and correct those problems. TVA's Watershed Teams are responsible for carrying out these efforts.

TVA evaluates water quality conditions in the 611 hydrologic units comprising the Tennessee Valley and uses this information to target locations where improvements are needed or where current conditions are likely to decline without intervention. Presently, TVA and partners are working at 47 targeted locations to control pollution sources that would otherwise affect streams and reservoirs.

4.4.3 Existing Conditions

Important reservoir processes that are potentially affected by reservoir operations include residence time, thermal stratification, DO depletion, algal growth, and sediment transport and anoxic products. The following sections examine these processes with respect to existing conditions, potential impacts from changes in reservoir operations, and the differences among the tributary and mainstem reservoirs.

Residence Time

By their name and function, reservoirs are constructed to retain flowing water. One of the primary mechanisms by which reservoirs and reservoir operations affect water quality is the residence time. Residence time is used to characterize the amount of time that is available for physical, chemical, and biological processes to occur within a reservoir. For example, a residence time of 300 days would suggest a reservoir with sufficient time for thermal stratification, algal growth, reduced DO, and a variety of related biological and chemical processes to show an effect. In contrast, a residence time of 10 days would suggest substantial water movement and little time for these processes to make a substantial change in water quality. Table 4.4-02 gives the average annual residence time and other physical characteristics in TVA reservoirs.

Thermal Stratification

Temperature is important because of its effect on aquatic life and reservoir mixing (Churchill and Nicholas 1967 and TVA 1978). The maximum summer temperature of a reservoir and the amount of cold water available influence the type of fish community that can exist, as well as the species and distribution of other biota. Temperature affects physical properties, such as DO, and influences the chemical and biological reactions that take place in aquatic systems (Wetzel 2001).

Table 4.4-02 Physical Characteristics of Selected TVA Reservoirs

Reservoir	River Basin	Drainage Area (sq km)	Mean Annual Flow (m^3/s)	Full Pool		Mean Depth (m)[1]	Residence Time (days)[1]
				Area (ha)	Volume (10^6 m^3)		
Mainstem Reservoirs							
Fort Loudoun	Tennessee	24,730	463	5,909	448	7.6	10
Watts Bar	Tennessee	44,830	778	15,783	1,246	7.9	17
Chickamauga	Tennessee	53,850	962	14,326	775	5.4	8
Nickajack	Tennessee	56,640	998	4,197	297	7.1	3
Guntersville	Tennessee	63,330	1,172	27,479	1,256	4.6	12
Wheeler	Tennessee	76,640	1,432	27,143	1,295	4.8	9
Wilson	Tennessee	79,640	1,489	6,273	782	12.5	6
Pickwick	Tennessee	85,000	1,573	17,443	1,140	6.5	8
Kentucky	Tennessee	104,120	1,754	64,873	3,502	5.4	19
Tributary Reservoirs							
Watauga	Watauga	1,210	20	2,602	702	27.0	325
Wilbur	Watauga	1,220	21	29	1	3.0	0
South Holston	Holston	1,820	27	3,068	811	26.4	262
Boone	Holston	4,770	70	1,744	233	13.4	30
Fort Patrick Henry	Holston	4,930	73	353	33	9.4	5
Cherokee	Holston	8,880	127	12,262	1,827	14.9	92
Douglas	French Broad	11,760	190	12,303	1,737	14.1	49
Fontana	Little Tennessee	4,070	112	4,306	1,752	40.7	124
Tellico	Little Tennessee	6,800	169	6,678	511	7.7	31
Norris	Clinch	7,540	115	13,841	2,517	18.2	169
Melton Hill	Clinch	8,660	137	2,303	148	6.4	11
Blue Ridge	Toccoa/Ocoee	600	17	1,331	238	17.9	117
Ocoee #1	Toccoa/Ocoee	1,540	39	765	105	13.7	28
Ocoee #2	Toccoa/Ocoee	1,330	36	0	0	0.0	0
Ocoee #3	Toccoa/Ocoee	1,270	32	194	4	1.8	1
Nottely	Hiwassee	550	11	1,692	210	12.4	134
Chatuge	Hiwassee	490	12	2,853	288	10.1	199
Hiwassee	Hiwassee	2,510	60	2,465	521	21.1	67
Apalachia	Hiwassee	2,640	60	445	71	16.0	13
Normandy	Duck	510	10	1,307	144	11.0	141
Tims Ford	Elk	1,370	27	4,836	654	13.5	240
Upper Bear Creek	Bear Creek	280	6	749	46	6.2	75
Bear Creek	Bear Creek	600	13	279	12	4.2	9
Little Bear Creek	Bear Creek	160	3	631	56	8.9	158
Cedar Creek	Bear Creek	460	9	1,700	116	6.8	113

[1] Mean depth and residence time are based on average, rather than full pool area and volume.

Source: TVA data.

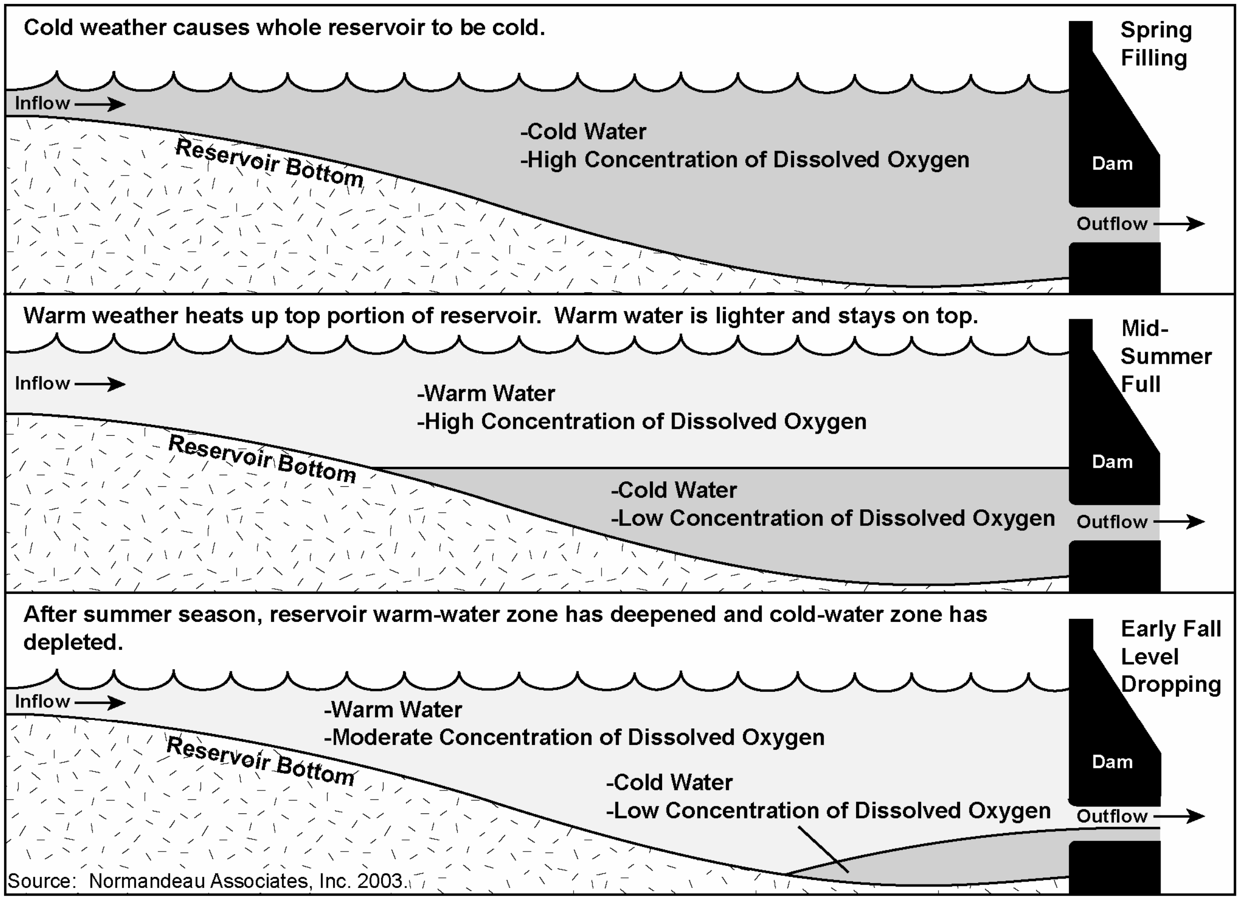


Figure 4.4-02 Reservoir Characteristics during Summer Pool Elevation from Spring to Early Fall

Water temperature in TVA reservoirs varies depending on the season and the amount and temperature of water entering each reservoir. During cooler weather, temperatures are uniform from the surface to the bottom. As the days get longer and hotter, the temperature of the surface water rises. Since warm water is less dense than cold water, it floats on top of the cooler water. This density difference inhibits mixing, resulting in thermal stratification which separates water into horizontal layers by temperature (Figure 4.4-02).

In TVA tributary reservoirs, thermal layering or stratification typically starts between April and July as the sun warms the surface layers. Stratification typically persists into late fall or early winter, when surface waters cool and the reservoir turns over or mixes from top to bottom. Surface waters in some reservoirs may approach or exceed 30°C in late summer. Releases of water from TVA dams are typically through low-level turbine intakes, resulting in cooler tailwater temperatures and a reduction in the volume of cold water in the reservoir as the summer progresses.

The low-level release results in colder tailwater temperatures and earlier fall turnover as the warmer surface waters replace the released water. As the cooler water is depleted, the temperature of the release water in the tailwater may rise, depending on the year, reservoir, or operations. Tailwater temperatures below tributary reservoirs can fluctuate during the summer

stratification period as turbines are cycled on and off, periodically releasing cold reservoir water that is subsequently warmed as it moves downstream. During dry years, stratification is somewhat stronger and persists longer into fall. During wet years, stratification is weaker and breaks down earlier in the season. Late in the season, as air temperatures cool, inflow to the tributary reservoirs is often cooler than surface waters. Under these circumstances, inflows enter the reservoirs at mid-depth, creating an interflow. These relatively short-lived events can give rise to atypical DO and water chemistry profiles.

Shorter days and cooler air temperatures during fall cool the surface, gradually allowing it to mix with more and more of the water column. By late October to November, the mixing is complete, resulting in similar temperatures and DO concentrations from surface to bottom. Figure 4.4-02 shows a generalized figure of reservoir thermal stratification by season.

The mainstem TVA reservoirs do not stratify thermally to the extent of the tributary reservoirs, due to the mixing created by shallower depths, higher flows, and shorter residence times. Slight vertical temperature differences and weak thermal stratification occur, particularly during dry years when the upstream water is held back to fill the tributary reservoirs. The stratification that does occur is typically broken up when flows are increased progressively in June, July, and August.

DO Depletion

The importance of DO in rivers and reservoirs is twofold. First, DO is critical for the survival of aquatic organisms. Second, the amount of DO in the water affects many of the chemical reactions that take place in rivers and reservoirs. DO is added to reservoirs from the atmosphere and from oxygenated inflows. In addition, during daylight hours, algae produce oxygen in the surface waters where there is sufficient light. DO is removed from reservoirs by decaying organic materials, plant and animal respiration, and sediments. Oxygen is also lost when inflowing point sources of pollution (primarily from municipal wastewater and industrial discharges) and non-point sources (primarily from agriculture and stormwater runoff) enter the reservoirs and decay, using up DO in the process.

Once thermal stratification is established in a reservoir, DO in deeper water cannot be replenished from the air or from contact with the oxygen-rich surface water. Over time, DO is reduced as organic material sinks to the bottom and decays, potentially resulting in low DO concentrations in the lower layers. The bottom sediments also use oxygen in the decay of organic matter. As oxygen is depleted, iron, manganese, ammonia, and sulfide can be released from the sediments. The amount of nitrogen, phosphorus, and other nutrients entering the water through soil erosion, sewage treatment plant discharges, polluted runoff, and natural sources affects this process. The more nutrients increase, the more algae grow; the more algae grow, the more decaying organic matter is present and the lower the DO concentrations in the deep portions of the reservoir.

As described above, most TVA tributary reservoirs have water quality issues related to thermal stratification. Thermal stratification begins in May, with stronger stratification occurring as

summer progresses. Most tributary reservoirs are deeper than mainstem reservoirs and have much greater residence times (notable exceptions are Melton Hill, Tellico, Boone, Fort Patrick Henry, and Apalachia, which have short residence times but are not on the mainstem). These characteristics tend to enhance stratification. The deeper sections of the TVA tributary reservoirs have little or no DO during thermal stratification in summer and late fall (Churchill and Nicholas 1967). Several tributary reservoirs exhibit very low DO concentrations during late summer. DO concentrations rise and fall in the tributary reservoirs. The two primary forces that break down thermal stratification and reintroduce oxygen to the deep waters in tributary reservoirs are drawdown and the cooler air temperatures during fall. The withdrawal zone for tributary reservoirs is usually deep, removing water from the mid to lower water strata and thereby removing some of the cooler, more dense water that has low DO concentrations. As drawdown proceeds in late summer and fall, the volume of cooler water with low DO concentrations is reduced (Figure 4.4-02).

DO concentrations in the mainstem reservoirs are generally higher than in the tributary reservoirs. The primary reason is the movement of water through the reservoirs, resulting in greater mixing, aeration, and less opportunity for thermal stratification and biochemical reactions. Nevertheless, reduced DO concentrations can occur in some mainstem reservoirs during hot, dry periods. The turbines that pass much of the outflow from the mainstem reservoirs generally pass some surface water with the deeper water, resulting in higher DO concentrations in the tailwaters when compared to the tailwaters of the tributary reservoirs. Two mainstem reservoirs—Fort Loudoun and Watts Bar—experience reduced DO in deeper layers in dry years, due to thermal stratification and low flows.

The release of water from the lower levels of a reservoir can result in low concentrations of DO in the tailwaters and downstream. This condition decreases aquatic habitat and stresses aquatic life. The implementation of the Lake Improvement Plan has significantly improved the DO downstream of TVA dams. As a result of the TVA commitment to maintain Lake Improvement Plan targets, none of the alternatives under consideration would change target DO concentrations in the tailwaters. Specific details on the effects of tailwater quality on aquatic life are presented in Section 4.7, Aquatic Resources.

Algal Growth

Algal growth in reservoirs is important because of its potential impact on recreation, water supply, and DO. As organic matter from dead and dying algae settles, it decomposes and consumes oxygen in the water column. Sediments in reservoirs with high algal growth accumulate rapidly; these sediments are thick and nutrient-rich. They consume large amounts of oxygen from the overlying waters as they decompose. A total loss of oxygen in the lower layers of reservoirs with high algal growth is common (Cooke et al. 1993).

Algal growth in TVA reservoirs is usually limited by a combination of three factors: nutrients (phosphorus and nitrogen), light, and residence time. In tributary reservoirs, residence time is rarely a limiting factor because most have a large volume relative to their inflow rate, which creates long retention times (100 to >300 days). Longer residence times allow suspended

particles to settle, increasing water clarity. As a result, light availability (which often limits algal growth in mainstem reservoirs) is rarely a problem during summer in tributary reservoirs. Consequently, nutrient availability usually is the limiting factor in tributary reservoirs. Annual rainfall patterns that follow a boom or bust cycle (i.e., heavy rain followed by extended dry periods until the next downpour) enhance algal productivity in tributary reservoirs with long retention times because it tends to replenish nutrients. However, such rainfall patterns sometimes have the opposite effect on mainstem reservoirs because of decreased light availability and decreased retention times due to increased flows.

Although reservoir operations have little influence on nutrient inflows from the watershed, the way nutrients cycle in the reservoirs may change in response to operational changes. In addition, algal growth in the reservoirs may change in response to changes in the timing of water movement through the system. Internal nutrient cycling, residence time of water in impoundments, and the timing of reservoir releases are all processes controlled in part by reservoir operations. Each of these factors influences algal growth in the system.

Sediment Transport and Anoxic Products

Contaminated sediments are a water quality concern in some TVA reservoirs and tailwaters. Contaminants such as mercury, cesium, PCBs, and pesticides are often associated with sediments. Changes in reservoir operations under consideration are unlikely to disturb reservoir sediments and mobilize contaminants.

Other materials found in sediments (e.g., iron, manganese, sulfides, and ammonia) may be formed and mobilized in the lower waters of the reservoir when oxygen concentrations are low. These potential pollutants can adversely affect water supplies, recreation, and aquatic life. Changing reservoir elevations or reservoir residence times could affect the duration or severity of low DO conditions that, in turn, introduce iron, manganese, sulfides, and ammonia into the water column. In the tailwaters, monitoring data indicate that reaeration of water discharged quickly reduces the solubility of these compounds. The exception is manganese, which was found in elevated concentrations below the reaeration facilities at several dams. This could result in black-coating of the substrate. Because the occurrence of these compounds is so closely tied with low DO concentrations, DO is used as a surrogate for these parameters in the impact assessment.

4.4.4 Future Trends

Water quality throughout the Valley has the potential to be influenced by several trends in the future. These trends largely depend on political and economic factors that cannot be predicted with any reliability. Increased population growth will likely increase development pressure in the watershed, resulting in increases in nutrient and sediment loading to the TVA system. This will be balanced, in part, through the development and implementation of TMDL plans in the Tennessee River watershed, which may improve water quality in certain impaired segments by reducing inputs of pollutants. Programs targeting pollutant sources from agriculture and stormwater may result in some improvement in water quality in parts of the watershed. The

number of industrial and municipal sources of pollution governed by permit may increase, but the amount of pollution contributed by each source may decrease as technology for treating wastes improves. In segments that are impaired, TMDLs may dictate a reduction in pollutant loads from all of these sources. The net impact of these potential changes on water quality constituents likely to be affected by the alternatives under consideration was assumed for purposes of this assessment to be minimal. This assumption applies to each of the alternatives under consideration equally. In other words, the potential future changes in water quality described above would occur regardless of which reservoir operations policy alternative is selected.

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4.5 Water Supply

4.5.1 Introduction

Extended dry periods during the last 15 years have heightened public awareness of water as a finite resource and have raised questions concerning the availability of surface water and groundwater resources in the Tennessee River watershed. Increasingly, water is seen as a scarce resource that must be protected and managed. An adequate and dependable water supply is one of the key factors needed for economic growth and regional development.

Resource Issues

- Availability of water supplies
- Changes in water supply delivery (costs)
- Changes in water supply quality (treatment)

Changing the reservoir operations policy can potentially affect three issues related to municipal and industrial water supplies:

- **Availability of Water Supplies.** Will implementation of a new reservoir operations policy change reservoir characteristics such that withdrawals for municipal and industrial uses are constrained?
- **Changes in Water Supply Delivery (Costs).** Will implementation of a new reservoir operations policy change reservoir characteristics in a manner that increases the cost of obtaining supplies, as expressed in pumping costs or costs for new or modified intake structures?
- **Changes in Water Supply Quality (Treatment).** Will implementation of a new reservoir operations policy change reservoir characteristics in a manner that degrades water supply quality and thereby limits water supply through increased treatment requirements?

Another issue indirectly related to the potential effects of policy alternatives on water supplies is the inter-basin transfer (IBT) of water supplies outside the Tennessee River watershed. Because IBTs can reduce water supplies through withdrawals, they can affect municipal, commercial, industrial, and private water supplies. Most requests for IBTs involve relatively small quantities of water. Some future IBTs could be of sufficient size to affect reservoir operations and water supplies. Because they are speculative, these future IBTs were not included in any of the policy alternatives. To better understand the possible impacts of future IBTs, TVA prepared a separate sensitivity analysis of several possible IBTs (see Appendix D9, Inter-Basin Transfers—A Sensitivity Analysis). Ongoing IBTs are included in the discussion of existing conditions for water supply.

The study area for the analysis of water supply is the Tennessee River watershed.

4.5.2 Regulatory Programs and TVA Management Activities

Regulatory and management policies that affect water supply include regulation of withdrawals, maintaining water quality, and drinking water standards.

- **Regulation of Withdrawals.** TVA regulates all structures, including intakes constructed at the shoreline of TVA reservoirs by issuing permits under Section 26a of the TVA Act. If dredging or fill is required, the USACE will become involved in the permitting process. State agencies in some cases also require permits for withdrawals. State agencies regulate return flows (discharges) associated with water withdrawals. Since future withdrawals could potentially affect minimum flows, reservoir levels, aquatic life, and other instream beneficial uses, a case-by-case environmental analysis would be required for new intake structures or expansion of existing ones. Tennessee has also adopted an act that regulates IBTs.

- **Maintaining Water Quality.** The CWA established water quality standards that are monitored and enforced by state agencies or USEPA. After completion of the Lake Improvement Plan (TVA 1990), TVA has provided minimum streamflows to improve water quality and aquatic habitat. TVA has also implemented other forms of water quality improvement, most notably oxygen enhancement of dam release waters at key locations on the system.

- **Drinking Water Standards.** Water withdrawn for municipal use is governed by national water quality standards that are enforced by the USEPA and state agencies. To the extent that river water does not meet these standards, additional water treatment must be applied to meet potable water standards before the water is distributed by municipal water agencies.

4.5.3 Water Supply Availability

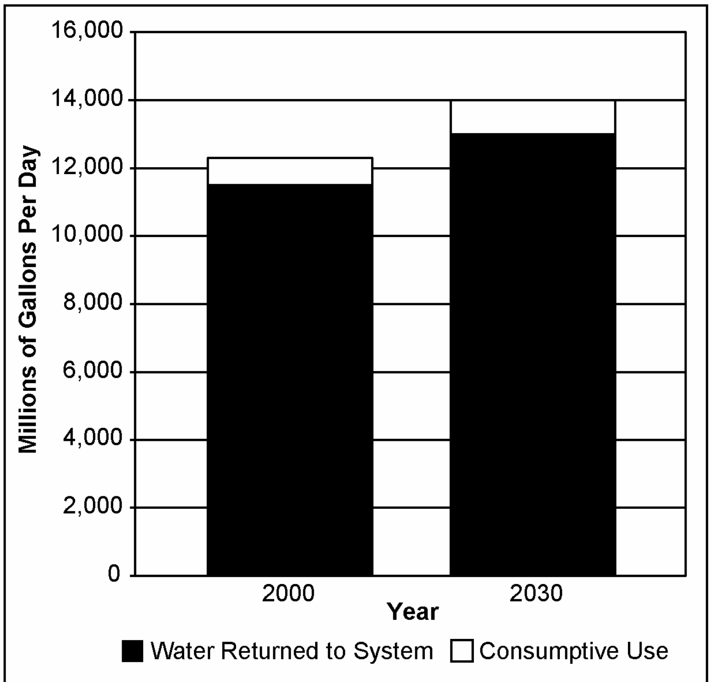
Existing Conditions

Efficient water management and planning require reliable information on existing and future demands relative to the available supplies. TVA and the USGS cooperated in a 2-year study of water supply needs in the region to assist in providing this information (Bohac 2003). The study area included the entire state of Tennessee and those counties in surrounding states that drain to the Tennessee River watershed. The study involved an inventory of existing (year 2000) public and private water supplies and wastewater discharges, a projection of future (year 2030) demands, and comparison of the future demands with the capacity of the available water resources.

In the study, demand for each use was defined in the context of changes in trends in consumption between 2000 and 2030 for reservoirs, tailwaters downstream from reservoirs, unregulated streams, and groundwater. The affected environment for water supply also was

defined in terms of existing IBTs into and out of the Tennessee River watershed to provide a base for determining whether future IBTs would result in environmental consequences.

Figure 4.5-01 shows total water use in the Tennessee River watershed. Ninety-eight percent of this water is derived from surface sources; groundwater is a minor component of most uses and is not used for cooling coal-fired and nuclear power plants (Bohac 2003).

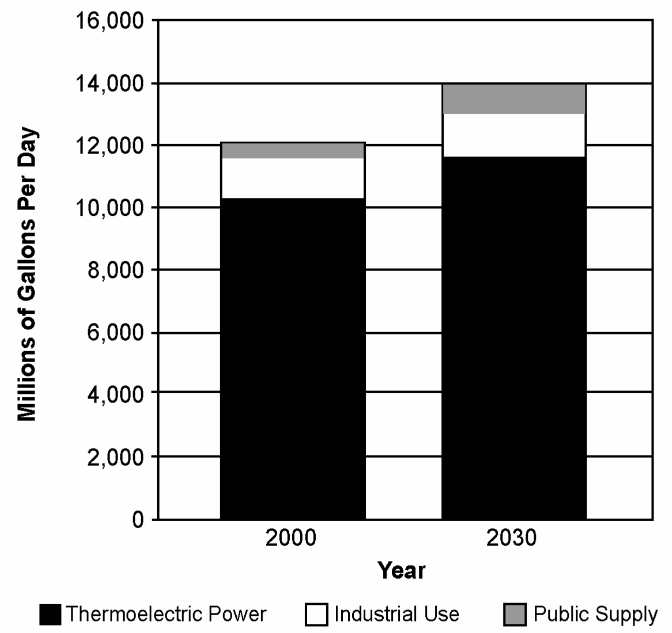


Source: Hutson et al. 2003.

Figure 4.5-01 Water Use in the Tennessee Valley Region for 2000 and 2030

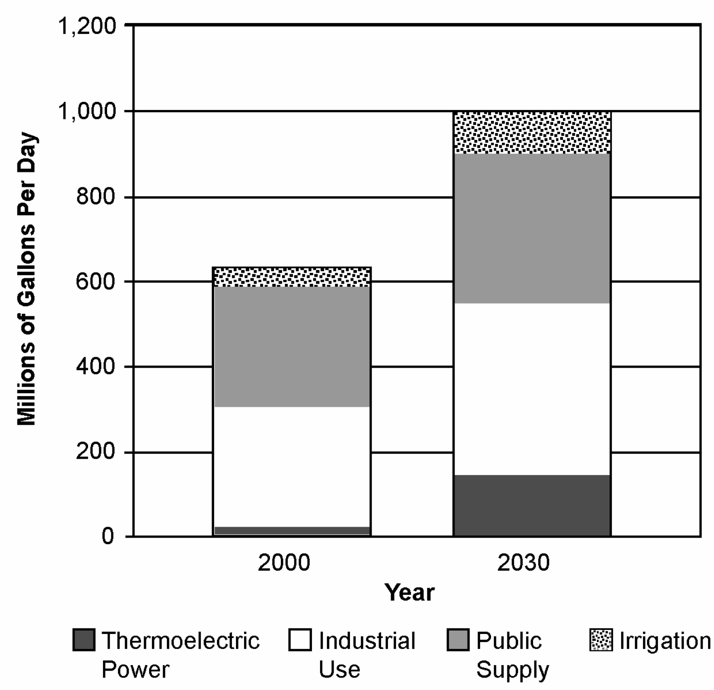
Figure 4.5-02 shows total water use in the Tennessee River watershed by category. Coal-fired and nuclear power generation used approximately 84 percent of the water in 2000; industrial use accounted for 10 percent; and public supply and irrigation accounted for 5 percent and 1 percent, respectively (Hutson et al. 2003, Bohac 2003).

Consumptive use is defined as the difference between withdrawals from and returns back to the river system. It is the water that may be evaporated in power plant and industrial cooling systems, released from plants to the atmosphere as a result of irrigation, consumed by humans or livestock, or otherwise used and not returned to surface water or groundwater (Hutson et al. 2003, Bohac 2003). Figure 4.5-03 shows consumptive use for 2000 and 2030.



Source: TVA data 2003.

Figure 4.5-02 Total Water Use for Thermoelectric Power, Industrial Use, and Public Supply for 2000 and 2030



Source: TVA data 2003.

Figure 4.5-03 Consumptive Water Use for Thermoelectric Power, Industrial Use, Public Supply, and Irrigation for 2000 and 2030

In addition to consumptive use, the USGS study inventoried water diversions—including IBTs. The largest diversion in the TVA system is flow from the Tennessee River to the Tennessee–Tombigbee Waterway, which was approximately 200 million gallons per day (mgd) in 2000. Current IBTs total approximately 5.6 mgd. These transfers are made to meet water supply needs in areas immediately adjacent to the watershed; they consist of suppliers meeting customer demands in existing service areas.

Future Trends

By the year 2030, total water use in the Tennessee River watershed is forecast to increase by 15 percent, from 12,211 to 13,990 mgd (Figure 4.5-01). The percentages of water use by category shown in Figure 4.5-02 are expected to change only slightly by 2030 (Hutson et al. 2003, Bohac 2003).

Consumptive use is expected to increase by 331 mgd (or 51 percent) over the next 30 years, as shown in Figure 4.5-03. This represents approximately 0.5 percent of total average winter river flow and 1.6 percent of average summer river flow (as measured at Kentucky dam). Almost 29 percent of the increase in consumptive use is due to the increase in water use by nuclear and fossil plants; an additional 29 percent of the increase is in the industrial sector, and 34 percent of the increase is due to increased demand in public supply (Hutson et al. 2003, Bohac 2003).

The projected increase in flow to the Tennessee–Tombigbee Waterway by 2030 ranges from 36 to 193 mgd, depending on assumed flows required for barge traffic. The increase could be as much as 600 mgd if traffic through the waterway reaches design capacity. Diversions included other IBTs. For the sensitivity analysis (Appendix D9), it was assumed that IBTs to areas such as Northeast Mississippi; Birmingham, Alabama; and Atlanta, Georgia could reach 461 mgd. Figure 4.5-04 compares the increased flows for the Tennessee–Tombigbee Waterway and existing IBTs to the increase in watershed consumptive use. IBTs to meet water supply requirements in areas adjacent to the watershed are expected to increase to approximately 27 mgd by 2030 (Bohac 2003).

4.5.4 Water Supply Pumping Requirements

Existing Conditions

Over 700 intake structures in the project area provide water to private, industrial, municipal, and commercial users. An estimated 390 million KWH/yr are required to pump water from rivers and reservoirs, with additional energy required to pump water to the point of treatment and use. Because an alternative reservoir operations policy can change the reservoir surface elevations, the amount of energy required to pump water out of the reservoir would vary under the different policy alternatives.

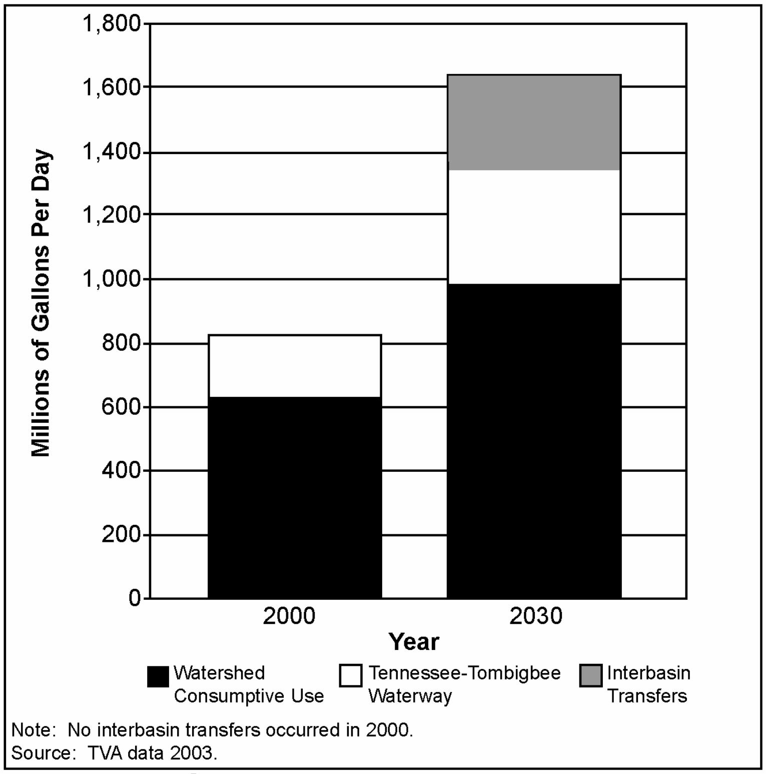


Figure 4.5-04 Consumptive Water Use Plus Water Transfers out of the Tennessee River Watershed

Future Trends

By 2030, approximately 460 million KWH/year will be needed to pump water from rivers and reservoirs assuming current reservoir surface elevations.

4.5.5 Water Supply Quality and Treatment

Existing Conditions

Public Supply

Water quality requirements for public supply systems are driven by water quality regulations. The current USEPA drinking water regulations, which are mirrored in the regulations for the Valley states, were reviewed. Current regulations for public water supply cover four types of contaminants: inorganics; organics; microbial contaminants; and secondary contaminants, which are not related to health.

Interviews were conducted at six major public supply treatment plants. These plants treat about 152 mgd of water, which constitutes 29 percent of the public supply water in the Tennessee River watershed. The locations ranged from Morristown, Tennessee (on Cherokee Reservoir) to Huntsville, Alabama (on Wheeler Reservoir). Plant sizes varied from 1.1 to 44 mgd. The

interviews were used to define the public supply treatment systems that were used to achieve the parameter limits specified in the regulations.

Based on the interviews at the public supply treatment facilities, typical treatment processes for public supplies using water from the Tennessee River watershed included the following unit operations: Chemical coagulant addition and mixing, flocculation, sedimentation, pre-filtration disinfection, filtration, and post-filtration disinfection. The thrust of the treatment process was to remove suspended solids. Since suspended solids include contaminants such as soil, algae, bacteria, and other species—and chemicals that are adsorbed to the particulate matter, suspended solids removal is the key part of any treatment process. Disinfection is important to the operation to kill pathogenic organisms, and chlorine is a commonly used disinfectant.

Natural organic material (NOM) in the water can react with the chlorine used in the treatment process to produce chlorinated organics, collectively called disinfection by-products (DBPs). Because the concentration of DBPs is regulated in the finished drinking water, excessive NOM concentrations must be removed in the flocculation-sedimentation step and the concentrations of DBPs in finished water must not exceed specified limits. The surrogate measure of NOM is typically total organic carbon (TOC), and TOC is usually the regulated parameter.

The six public supply water treatment plants where interviews were conducted reported a range of TOC values from 2 to 5 mg/L. For comparison, samples collected quarterly from Chickamauga Reservoir for the years 1978 through 1986 averaged 2.8 mg/L. The Chickamauga data showed little seasonal variability and little variability with depth, but some variability between years. The minimum value was 1.2 mg/L, and the maximum value was 10 mg/L.

Total organic carbon in reservoirs originates from runoff into streams, wastewater discharges, and algae growth in which inorganic carbon is converted to organic carbon. Reservoirs can be either sources or sinks for TOC. Algae produced in the reservoir can remain suspended or settle to the bottom of the reservoir and accumulate in the reservoir sediments. Various processes (dissolution, diffusion, excretion, and decomposition of the algae) can result in increased TOC concentrations in the reservoir. Reservoir TOC concentrations can be reduced by being adsorbed onto settling particles, by microbial uptake and oxidation to carbon dioxide during respiration, or by degradation by sunlight. Reservoirs can either be net producers or consumers of TOC based on residence time and hydraulic loading.

Algae. Secretions from algae, particularly blue-green algae, are often the source of taste and odor problems at public supply water treatment plants. Several of the public supply treatment plants where interviews were conducted combine granular activated carbon in their filtration process or feed powdered activated carbon before the sedimentation step to remove the objectionable compounds. Other treatment plants add oxidants, such as potassium permanganate, to control taste and odor.

TVA has not conducted any studies to correlate reservoir operational conditions with the production of blue-green algae. Treatment plant operators interviewed also could not give

guidance concerning when and how the blooms occur. There is some anecdotal evidence that stagnant water, during low-flow periods on isolated parts of the reservoirs and rivers feeding the reservoirs, might be the source of blooms. Treatment plant operators who add powdered activated carbon often trigger the start of the feeding season to water temperature.

Iron and Manganese. Drinking water standards for iron and manganese are classified as secondary standards, and are generally not considered to be health related. Iron and manganese in water supplies can cause taste and odor problems and also add color to water, which can stain fixtures and laundry. Iron and manganese, which are trapped in reservoir sediments, can become soluble and enter the water column when the reservoir bottom becomes anoxic (lacking oxygen). Because the soluble iron and manganese come out of the sediments, the high concentrations are confined to the deep reservoir water. Therefore, many public supply intakes, which are located in reservoirs, draw water from multiple levels so that elevated reservoir iron and manganese concentrations can be avoided. Reservoir releases can contain iron and manganese, but the iron and manganese are oxidized in the stream below the dam and may not affect intakes in tailwaters, if they are sufficiently downstream from dams. None of the treatment plants where interviews were conducted specifically treated for iron and manganese. Several plants do add potassium permanganate, which would oxidize iron and manganese if present in the water.

Industry

Interviews were conducted with 11 industries, representing eight standard industrial classification codes and 80 percent of the industrial water taken from the Tennessee River system.

It is estimated that over 80 percent of the water used in industry is used for non-contact cooling and is not treated. For water that is treated, however, the treatment processes of coagulant addition, flocculation, sedimentation, and filtration, which were discussed in relation to public water supply systems, are common to industrial process water treatment and boiler feed systems as well. In cases where high water quality is required, such as for boiler feed, the water is demineralized after filtration.

Thermoelectric Generation

Almost all of the water currently used in thermoelectric generation is used for non-contact once-through cooling and is not treated. However, a small portion of the water is treated to a very high degree for boiler feed and makeup water. Surface water that has been filtered is then subjected to demineralization processes to provide water for the boilers.

Future Trends

Public Supply

The current DBP rule requires treatment plants that serve more than 10,000 people to remove a specified amount of TOC through coagulation or softening and to meet concentration limits for DBPs (HDR Engineering 2001). The concentration limits are 0.08 mg/L for total trihalomethanes and 0.06 mg/L for haloacetic acids. In 2004, small systems will also be required to achieve the DBP limits. In 2005 or 2006, implementation of Stage 2 of the DBP rule is expected, which will no longer allow the use of averaging samples to meet the DBP limit. Consequently, water treatment plants will need to be modified to meet the limits. Expected changes include elimination of chlorine feed at the front of the treatment plant and the use of alternative disinfectants, such as chlorine dioxide. Coagulation will be enhanced, such as through the use of iron-based coagulants—especially during summer— to remove the required amount of TOC. Additional processes, such as ozone injection or activated carbon addition, might be required for plants to achieve the DBP concentration limits (Foster pers. comm.).

Because of the expected process changes and plant upgrades required for DBP compliance, even at today's levels of TOC, it is likely that almost all public supply water treatment plants using water from the Tennessee River watershed will soon have treatment systems for DBP control. Therefore, changing algae concentration through a modification of reservoir operation would likely change only the degree of treatment required and would not result in the need for any plant to add a new DBP treatment system.

To date, only the larger treatment plants have dealt with the DBP issue, and the impacts to treatment costs brought about by the Stage 2 rules have not been quantified. In addition, no studies have been performed to quantify what factors in the source waters affect the portion of TOC that can give rise to DBP (Volk and Lechevallier 2002). It is therefore not possible to quantify the changes to treatment cost brought about by changes in algae concentration. It is also considered that much of the difficulty in meeting DBP concentration limits under Stage 2 will arise, not from the raw water TOC concentration, but from the amount of time that the treated water spends in the distribution system (Foster pers. comm.). Distribution systems are, of course, unaffected by reservoir operational changes.

New drinking water regulations would be more complex and would generally require a greater degree of treatment, potentially exposing existing smaller systems to violations of standards. Small surface water systems and systems presently supplied by groundwater that are currently exempt from some treatment requirements would be subjected to new treatment standards for the first time. Many systems would be unable to afford the cost of upgrading in order to meet the new regulations. Consequently, many small water systems, particularly those using groundwater, would be consolidated into larger systems primarily supplied by surface water.

Industry

Industrial treatment requirements are driven by process demands, not regulations. If the current industrial mix remains constant, little change in industrial water treatment is expected.

Thermoelectric Generation

Most of the new generating units installed would not be able to use once-through cooling and would be required to use cooling towers. Although surface water can most often be used directly in cooling towers, some chemicals are customarily added to control biological growth and to reduce scaling.

Appendix A

Base Case Water Control System Description Tables

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Table A-01 General Project Characteristics

Project	Year Completed	Length of Reservoir (miles)[2]	Miles of Shoreline	Navigation Facilities	Turbine Units (rated capacity in MW)[6]	Turbine Discharge Capacity[6] (total cfs for all units)	
						Most Efficient Load (MEL)	Maximum Sustainable Load (MSL)
Mainstem Projects							
Kentucky	1944	184.3	2,064.3	2 Locks, canal[3]	5 (223)	–[8]	70,000
Pickwick	1938	52.7	490.6	2 Locks, canal[4]	6 (240)	–[8]	89,000
Wilson	1924[1]	15.5	166.2	2 Locks	21 (675)	–[8]	115,000
Wheeler	1936	74.1	1,027.2	2 Locks	11 (412)	–[8]	120,000
Guntersville	1939	75.7	889.1	2 Locks	4 (135)	–[8]	50,000
Nickajack	1967	46.3	178.7	Lock	4 (104)	–[8]	45,000
Chickamauga	1940	58.9	783.7	Lock	4 (160)	–[8]	45,000
Watts Bar	1942	95.5*	721.7	Lock	5 (192)	–[8]	47,000
Fort Loudoun	1943	60.8*	378.2	Lock	4 (155)	–[8]	32,000
Total Mainstem		**663.8**	**6,699.7**	**14 Locks**	**64 (2,296)**		
Tributary Projects							
Norris	1936	129.0	809.2		2 (131)	6,900	9,100
Melton Hill	1963	44.0	193.4	Lock	2 (72)	17,000	22,000
Douglas	1943	43.1	512.5		4 (156)	19,000	24,600[9]
South Holston	1950	23.7	181.9		1 (39)	2,700	3,300[10]
Boone	1952	32.7*	126.6		3 (92)	10,900	13,200
Fort Patrick Henry	1953	10.4	31.0		2 (59)	6,100	9,000
Cherokee	1941	54.0	394.5		4 (160)	15,700	17,800
Watauga	1948	16.3	104.9		2 (58)	2,700	3,300
Wilbur	1912[1]	1.8	4.8		4 (11)	2,500	2,900
Fontana	1944	29.0	237.8		3 (294)	9,000	11,300
Tellico	1979	33.2	357.0	Canal[5]	0[7]	–	–
Chatuge	1942	13.0	128.0		1 (11)	1,500	1,650
Nottely	1942	20.2	102.1		1 (15)	1,420	1,900
Hiwassee	1940	22.2	164.8		2 (176)	8,100	9,800
Apalachia	1943	9.8	31.5		2 (100)	2,700	2,900
Blue Ridge	1930[1]	11.0	68.1		1 (22)	1,600	1,800
Ocoee #1	1911[1]	7.5	47.0		5 (19)	3,200	3,800

Table A-01 General Project Characteristics (continued)

Project	Year Completed	Length of Reservoir (miles)[2]	Miles of Shoreline	Navigation Facilities	Turbine Units (rated capacity in MW)[6]	Turbine Discharge Capacity[6] (total cfs for all units)	
						Most Efficient Load (MEL)	Maximum Sustainable Load (MSL)
Tributary Projects (continued)							
Ocoee #2	1913[1]	–	–		2 (23)	900	1,050
Ocoee #3	1942	7.0	24.0		1 (29)	1,100	1,500
Tims Ford	1970	34.2	308.7		1 (45)	3,700	4,000
Normandy	1976	17.0	75.1		0[7]	–	–
Great Falls	1916[1]	22.0	120.0		2 (34)	2,700	3,700
Upper Bear Creek	1978	14.0	105.0		0[7]	–	–
Bear	1969	12.0	52.0		0[7]	–	–
Little Bear Creek	1975	6.0	45.0		0[7]	–	–
Cedar Creek	1979	9.0	83.0		0[7]	–	–
Total Tributary		**622.1**	**4,307.9**	**1 Lock**	**45 (1,546)**		
Total Projects		**1,285.9**	**11,007.6**	**15 Locks**	**109 (3,842)**		

Notes:

cfs = Cubic feet per second; MW = Megawatts.

1 Projects acquired from others.
2 Normal summer pool. *Fort Loudoun–49.9 miles on the Tennessee River, 6.5 miles on the French Broad River, and 4.4 miles on the Holston River; Watts Bar–72.4 miles on the Tennessee River and 23.1 miles on the Clinch River; Norris–73 miles on the Clinch River and 56 miles on the Powell River; Boone–17.4 miles on the South Fork Holston River and 15.3 miles on the Watauga River.
3 Includes new main lock chamber (110 feet wide and 1,200 feet long) and the Barkley Canal.
4 Tennessee–Tombigbee Waterway; Bay Springs Reservoir is connected to Pickwick Reservoir by a navigation canal.
5 River diversion through a canal increases energy generation at Fort Loudoun.
6 Actual capacity and turbine flows at any time depend on several factors, including operating head, turbine capability, generator cooling, water temperature, and power factor. Capacities and turbine flows include modernization of turbine units (HMODs) already performed, as well as those in the design, construction, or authorization phase. Turbine discharge assumes availability of all units at maximum discharge.
7 Project design does not include power generation capacity.
8 Mainstem projects can be operated well below MSL values but are predominately operated at MSL values because of higher capacities that can be achieved with acceptable loss of efficiency.
9 Primarily operated at this flow rate during flood control operations or emergency power demands.
10 Limited to a flow rate of 3,000 cfs during non-flooding situations to minimize downstream streambank erosion.

Source: TVA file data.

Table A-02 Reservoir Operating Characteristics

Project	Reserved Flood Storage January 1 to Top of Gates[2] (1,000 acre-feet)	Top of Gates Elevations (feet above mean sea level)	Flood Guide Elevations (feet above mean sea level)			Minimum Targeted Summer Level (feet above mean sea level)	Operating Range of Elevations for Run-of-River Projects[4] (feet above mean sea level)
			Jan 1	Mar 15	Jun 1	Aug 1	
Mainstem Projects							
Kentucky	4,008	375	354	354	359	–	
Pickwick	493[3]	418	408	408	414	–	
Wilson	0	507.88	–	–	–	–	504.5–507.8
Wheeler	349	556.28	550	550	556	–	
Guntersville	162	595.44	593	593	595	–	
Nickajack	0	635	–	–	–	–	632–634
Chickamauga	345	685.44	675	675	682.5	–	
Watts Bar	379	745	735	735	741	–	
Fort Loudoun[1]	111	815	807	807	813	–	
Total Mainstem	**5,847**						
Tributary Projects							
Norris	1,473	1,034	985	1,000	1,020	1,010	
Melton Hill	0	796	–	–	–	–	790–796
Douglas	1,251	1,002	940	958.8	994	990	
South Holston	290	1,742	1,702	1,713	1,729	1,721	
Boone	92	1,385	1,358	1,375	1,382	1,382	
Fort Patrick Henry	0	1,263	–	–	–	–	1,258–1,263
Cherokee	1,012	1,075	1,030	1,042	1,071	1,060	
Watauga	223	1,975	1,940	1,952	1,959	1,949	
Wilbur	0	1,650	–	–	–	–	1,635–1,650
Fontana	580	1,710	1,644	1,644	1,703	1,693	
Tellico[1]	120	815	807	807	813	--	
Chatuge	93	1,928	1,912	1,916	1,926	1,923	
Nottely	100	1,780	1,745	1,755	1,777	1,770	

Table A-02 Reservoir Operating Characteristics (continued)

Project	Reserved Flood Storage January 1 to Top of Gates[2] (1,000 acre-feet)	Top of Gates Elevations (feet above mean sea level)	Flood Guide Elevations (feet above mean sea level)			Minimum Targeted Summer Level (feet above mean sea level)	Operating Range of Elevations for Run-of-River Projects[4] (feet above mean sea level)
			Jan 1	Mar 15	Jun 1	Aug 1	
Tributary Projects (continued)							
Hiwassee	270	1,526.5	1,465	1,482	1,521	1,515	
Apalachia	0	1,280	–	–	–	–	1,272–1,280
Blue Ridge	69	1,691	1,668	1,678	1,687	1,682	
Ocoee #1	0	830.76	820	820	829		
Ocoee #2	0	1115.2	–	–	–	–	Not applicable[6]
Ocoee #3	0	1,435	–	–	–	–	1,428 –1,435
Tims Ford	220	895	873	879	888	–[5]	
Normandy	48	880	864	866.7	875		
Great Falls	0	805.3	–	–	–	–	785–800
Upper Bear Creek	0	797	–	–	–	–	790–797
Bear Creek	37	602	565	572.8	576	–	
Little Bear Creek	25	623	603	615	620	–	
Cedar Creek	76	584	560	574.2	580	–	
Total Tributary	**5,979**						
Total Projects	**11,826**						

Notes:

1 Projects are operated in tandem because of diversion canal to increase power generation at Fort Loudoun.
2 The observed flood storage varies, depending on rainfall and runoff.
3 Includes additional storage volume from Bay Springs Reservoir.
4 The observed range varies, depending on demands on the river system.
5 Tims Ford has no August 1 target level; it does have a minimum elevation requirement of 883 feet above sea level from May 15 through October 15.
6 Does not have a permanent pool.

Source: TVA file data.

Table A-03 Minimum Flows, Techniques, Requirements, and Commitments

Project	Techniques	Minimum Flows (cfs)	Frequency and Duration of Flows	Operating Objective
Mainstem Projects				
Kentucky	Appropriate daily scheduling	18,000	Bi-weekly average: June–August	Water supply, water quality
		15,000	Bi-weekly average: May and September	
		12,000	Daily average: October–April	
		5,000	Year-round instantaneous flows if Paducah, Kentucky, stage on Ohio River is greater than 16 feet (occurs about half the time)	Navigation
		15,000	Continuous when Paducah stage is between 14 and 16 feet (occurs about half the time)	Navigation
		20,000	Continuous when Paducah stage is less than 14 feet (occurs about 2% of time)	Navigation
Pickwick[1]	Appropriate daily scheduling	15,000	Bi-weekly average: June–August	Water supply, water quality
		9,000	Bi-weekly average: May and September	
		8,000	Daily average: October–April	
		16,000	Instantaneous when Kentucky headwater is at 354-foot elevation	Navigation
		8,000	Instantaneous when Kentucky headwater is at 355-foot elevation	Navigation
Wilson	Appropriate daily scheduling	8,000	Instantaneous when Pickwick headwater is at or below 409.5-foot elevation	Navigation
Wheeler and Guntersville	Appropriate daily scheduling (45% Wheeler plus 55% Guntersville flows)	10,000	Daily average: July–September	Operation of downstream nuclear plant
		11,000	Daily average: December–March	
		7,000	Otherwise	
Chickamauga	Appropriate daily scheduling	13,000	Bi-weekly average: June–August	Water supply, water quality
		7,000	Bi-weekly average: May and September	
		3,000	Daily average: October–April	

Table A-03 Minimum Flows, Techniques, Requirements, and Commitments (continued)

Project	Techniques	Minimum Flows (cfs)	Frequency and Duration of Flows	Operating Objective
Mainstem Projects (continued)				
Watts Bar	No more than 15 hours of zero flow for holding pond drainage	1,200	Daily average	Operation of downstream nuclear plant
Douglas and Cherokee flows for Knoxville	Appropriate daily scheduling of Cherokee and Douglas along with local inflow	2,000	Daily average	Water supply, water quality
Norris	Turbine pulsing and reregulation weir	200	Daily average: pulse every 12 hours for 30 minutes	Water supply, water quality
For Bull Run fossil plant	Appropriate daily scheduling	800	Daily average: February–March	Thermal compliance–operation of downstream fossil plant
		1,000	Daily average: April–May	
		1,200	Daily average: June	
		1,500	Daily average: July–September	
		2,000	Daily average: October	
		600	Daily average: November–January	
Melton Hill	Appropriate daily scheduling	400	Daily average	Water supply, water quality
Douglas	Turbine pulsing	585	Daily average: every 4 hours for 30 minutes	Water supply, water quality
Douglas for Knoxville	Appropriate daily scheduling of Cherokee and Douglas along with local inflow	2,000	Daily average	
South Holston	Turbine pulsing and reregulation weir	90	Daily average: pulse every 12 hours for 30 minutes	Water supply, water quality
Boone	Turbine pulsing	400	Daily average	Water supply, water quality

Table A-03 Minimum Flows, Techniques, Requirements, and Commitments (continued)

Project	Techniques	Minimum Flows (cfs)	Frequency and Duration of Flows	Operating Objective
Tributary Projects				
Fort Patrick Henry[2]	Turbine pulsing	800	Average 3-hour discharge–year round	Water supply, water quality
		1,250	Instantaneous: January	Operation of downstream fossil plant
		1,300	Instantaneous: February–March	
		1,500	Instantaneous: April–May	
		1,833	Instantaneous: June–September	
		1,450	Instantaneous: October–November	
		1,350	Instantaneous: December	
Cherokee	Turbine pulsing	325	Daily average: every 6 hours for 30 minutes	Water supply, water quality
Cherokee for Knoxville	Appropriate daily scheduling of Cherokee and Douglas along with local inflow	2,000	Daily average	
Watauga measured from Wilbur[3]	Turbine pulsing	107	Daily average: small unit every 4 hours for 1 hour or large unit every 4 hours for 15 minutes	Water supply, water quality
Fontana measured from Chilhowee[4]	Appropriate daily scheduling	1,000	Daily average: May–October Fontana and Santeetlah plus local inflow	Water supply, water quality
Chatuge	Turbine pulsing and reregulation weir	60	Daily average: every 12 hours for 30 minutes	Water supply, water quality
Nottely	Small hydro unit when large unit is not generating	55	Continuous	Water supply, water quality
Apalachia[5]	Turbine pulsing	200	Daily average: every 4 hours for 30 minutes	Water supply, water quality
	Appropriate daily scheduling of discharges from Apalachia and Ocoee #1	600	Daily average	
Blue Ridge[2]	Small hydro unit when large unit is not generating	115	Continuous	Water supply, water quality

Table A-03 Minimum Flows, Techniques, Requirements, and Commitments (continued)

Project	Techniques	Minimum Flows (cfs)	Frequency and Duration of Flows	Operating Objective
Tributary Projects (continued)				
Ocoee #1	Turbine pulsing	140	Daily average: every 4 hours for 1 hour	Water supply, water quality
	Appropriate daily scheduling of discharges from Apalachia and Ocoee #1	600	Daily average	
Tims Ford	Small hydro unit when large unit is not generating	80	Continuous	Water supply, water quality
For Fayetteville	Appropriate daily scheduling	120	Continuous	
Normandy for Shelbyville	Appropriate daily scheduling	40 155	Continuous	Water supply, water quality
Upper Bear Creek		5	Continuous	Water quality, water supply
Bear Creek for Red Bay		21	Continuous	Water quality, water supply
Little Bear Creek		5	Continuous	Water quality, water supply
Cedar Creek		10	Continuous	

Notes:

cfs = Cubic feet per second.

1 Minimum tailwater below Pickwick is maintained at or above a 355-foot elevation for navigation. Continuous minimum discharge from Pickwick is used to maintain this minimum elevation whenever Kentucky headwater is at or below a 355-foot elevation. These discharges vary as the Kentucky headwater varies between elevations of 354 and 355 feet.

2 Fort Patrick Henry is required to supply a minimum flow for the John Sevier Steam Plant that equals the plant cooling water intake plus a minimum bypass flow for the current time of year. The minimum bypass flow is defined as follows in the National Pollutant Discharge Elimination System permit for John Sevier:

> To the maximum extent practicable (considering only the short and long term availability of water for release from upstream impoundments and alternative sources of generation to meet the public demand for power), not less than 350 cfs nor one-third of the plant cooling water flow, whichever is greater, shall be passed over the dam during the period from June 1 to September 30 at any time the plant is in operation. During the winter months, or during the period of October 1 to May 31, the minimum bypass flow shall be 100 cfs. These are the minimum volumes of cold-water to be provided which will ensure the protection of spawning, development and survival of fish eggs, larvae, and fry and to provide living space for fish consistent with classified uses downstream from the diversion dam.

3 Watauga minimum flow is met at downstream Wilbur.

4 Fontana minimum flow is met at downstream Chilhowee Dam.

5 Apalachia plus Ocoee #1 must meet a combined minimum flow of 600 cfs as the combined daily average.

Source: TVA file data.

Table A-04 Ramping Constraints by Project

Project	Number of Turbine Units	Ramping Rate
Watauga	2	Ramp units up and down a maximum of one unit per hour for downstream safety
Cherokee	4	Ramp units up and down a maximum of two units per hour to minimize downstream bank erosion
Douglas	4	Ramp units up and down a maximum of two units per hour to minimize downstream bank erosion
Apalachia	2	Ramp units up a maximum of one unit per hour for downstream safety
South Holston	1	Maximum turbine flow of 3,000 cubic feet per second (cfs) (below Maximum Sustainable Level [MSL] flows) for hydropower needs required to minimize downstream bank erosion; MSL flows allowed for flood control
Pickwick	6	Turbines limited to a ramp rate of 60 megawatts (MW) per hour when ramping up and a maximum of 40 MW per hour when ramping down for downstream navigation and bank stabilization
Kentucky	5	When Paducah stage is greater than 16 feet–maximum hourly discharge variation of one unit per hour When Paducah stage is less than 16 feet but greater than 14 feet–maximum hourly discharge variation of one unit per hour If Kentucky is not spilling–maximum daily discharge variation of 35,000 cfs per day
Chickamauga	4	From November through April, ramp units up and down a maximum of one unit per hour for Sequoyah Nuclear Plant thermal compliance

Source: TVA file data.

Table A-05 Fishery Types, Dissolved Oxygen Targets, and Type of Aeration Facilities at Reservoir Tailwaters

Project	Fishery Type	DO Target (mg/L)	Type of Aeration Facilities
Mainstem Projects			
Watts Bar		4	Oxygen injection
Fort Loudoun		4	Oxygen injection
Tributary Projects			
Norris	Cold-water	6	Turbine venting
Douglas	Warm-water	4	Turbine venting, surface water pumps, oxygen injection
South Holston	Cold-water	6	Turbine venting, aerating weir
Boone	Cold-water	4	Turbine venting
Fort Patrick Henry[1]	Cold-water	4	Upstream improvements
Cherokee	Warm-water	4	Turbine venting, surface water pumps, oxygen injection
Watauga	Cold-water	6	Turbine venting
Fontana	Cold-water	6	Turbine venting
Chatuge[2]	Warm-water	4	Aerating weir
Nottely	Warm-water	4	Turbine air injection
Hiwassee	Cold-water	6	Turbine venting, oxygen injection
Apalachia[3]	Cold-water	6	Turbine venting
Blue Ridge	Cold-water	6	Oxygen injection
Tims Ford	Cold-water	6	Turbine air injection, oxygen injection

Notes:

mg/L = Milligrams per liter.

[1] The first 4 miles below Fort Patrick Henry are classified as a cold-water fishery; below this point, the tailwater is classified as a warm-water fishery.
[2] Chatuge is classified by state standards as a warm-water fishery but has a trout fishery in its tailwater.
[3] Below the powerhouse.

Source: TVA file data.

Table A-06 Year 2030 Additional Net Water Supply Demand by Project

Project	Additional Net Water Demand (cfs)
Mainstem Projects	
Kentucky	49.91
Pickwick	42.39
Tennessee–Tombigbee Waterway flows	968.80
Wilson	23.99
Wheeler	132.45
Guntersville	17.15
Nickajack	21.70
Chickamauga	31.12
Watts Bar	14.44
Fort Loudoun	16.92
Tellico	1.44
Tributary Projects	
Norris	5.44
Melton Hill	21.99
Douglas	43.22
South Holston	3.79
Boone	-8.62
Fort Patrick Henry	167.60
Cherokee	-133.87
Watauga	23.84
Wilbur	–
Fontana	1.42
Chatuge	3.32
Nottely	0.66
Hiwassee	0.30
Apalachia	0.69
Blue Ridge	16.91
Ocoee #1	-9.02
Ocoee #2	–
Ocoee #3	–
Tims Ford	24.01
Normandy	0.00
Great Falls	–
Upper Bear Creek	0.00
Bear Creek	–
Little Bear Creek	–
Cedar Creek	0.00

Note:

cfs = Cubic feet per second.

Source: TVA file data.

Table A-07 Drawdown Limits for Tributary Reservoirs

Project[1]	Description	Drawdown Limits[2]
Apalachia	Concrete	3 feet per day not to exceed 12 feet per week
Blue Ridge	Hydraulic fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Chatuge	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Cherokee	Concrete and impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Douglas	Concrete and impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Fontana	Concrete	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per day not to exceed 12 feet per week
Great Falls	Concrete	2 feet per day not to exceed 12 feet per week
Hiwassee	Concrete	2 feet per day not to exceed 7 feet per week
Norris	Concrete and earth fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Nottely	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
South Holston	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week
Watauga	Impervious rolled fill	2 feet per day not to exceed 7 feet per week for 28 feet; then 3 feet per week

Notes:

[1] For those reservoirs not shown, the drawdown rate would follow the rate shown for Blue Ridge.
[2] Restrictions are based on dam safety and erosion considerations.

Source: TVA file data.

Table A-08 Fill and Drawdown Dates

Mainstem Project	Operating Mode	Reservoir Fill Target Date	Target Date for Start of Reservoir Drawdown
Kentucky	Storage	May 1	July 5; sloped to December 1
Pickwick	Storage	April 5	July 1; 1-foot fluctuation for mosquito control from mid May to mid-September
Wilson	Run-of-river	Mid-April	December 1
Wheeler	Storage	Mid-April	August 1; 1-foot fluctuation for mosquito control from mid-May to mid-September
Guntersville	Limited drawdown	Mid-April	July 1; with 1-foot drawdown to November 1; 1-foot fluctuation for mosquito control from mid-May to mid-September
Nickajack	Run-of-river	–	–
Chickamauga	Storage	Mid-April	July 1; with 1.5-foot drawdown to mid-August, remainder of winter drawdown begins on October 1; 1-foot fluctuation for mosquito control from mid-May to mid-September
Watts Bar	Storage	Mid-April	August 1; 1-foot drawdown to September 1, then begin remainder of winter drawdown
Fort Loudoun[1]	Storage	Mid-April	November 1
Tributary Project	**Operating Mode**	**Reservoir Fill Target Date**	**Date for Start of Unrestricted Reservoir Drawdown**
Norris	Storage	June 1	August 1
Melton Hill	Run-of-river	–	–
Douglas	Storage	June 1	August 1
South Holston	Storage	June 1	August 1
Boone	Storage	Mid-May	Labor Day (follows guide curve)
Fort Patrick Henry	Run-of-river	–	–
Cherokee	Storage	June 1	August 1
Watauga	Storage	June 1	August 1
Wilbur	Run-of-river	–	–
Fontana	Storage	June 1	August 1
Tellico[1]	Storage	Mid-April	November 1

Table A-08 Fill and Drawdown Dates (continued)

Tributary Project	Operating Mode	Reservoir Fill Target Date	Date for Start of Unrestricted Reservoir Drawdown
Chatuge	Storage	June 1	August 1
Nottely	Storage	June 1	August 1
Hiwassee	Storage	June 1	August 1
Apalachia	Run-of-river	–	–
Blue Ridge	Storage	June 1	August 1
Ocoee #1	Storage	May 1	November 1
Ocoee #2	Run-of-river	–	–
Ocoee #3	Run-of-river	–	–
Tims Ford[2]	Storage	Mid-May	October 15
Normandy	Storage	May 1	November 1; usually falls throughout summer to meet downstream minimum flows
Great Falls	Storage	August 1	October 1
Upper Bear Creek	Run-of-river	–	–
Bear Creek	Storage	Mid-April	November 15
Little Bear Creek	Storage	Mid-April	November 1
Cedar Creek	Storage	Mid-April	November 1

Notes:

1 Tellico, connected by canal to Fort Loudoun, has a pool elevation the same as Fort Loudoun. Because Fort Loudoun is targeted to reach its summer pool level by April 15 and its drawdown does not begin until November 1, Tellico has a flat summer pool.

2 Tims Ford, by design and original project allocation, has always been operated with a minimum summer pool level of 883 feet, which applies until October 15.

Source: TVA file data.

Table A-09 Hydro Modernization Projects To Be Completed by 2014

Power Plant	Status in October 2001[1,2]	Runner Performance Planned	Increased Flow[3]
Phase 2 and Phase 3 Projects			
Douglas (Units 1–4)	Phase 3	High efficiency and capacity	Yes
Guntersville (Units 1–4)	Phase 3	Increased efficiency and capacity	No
Raccoon Mountain (Units 1–4)	Phase 3	High capacity	Yes
Fort Loudoun (Units 3–4)	Phase 3	Increased efficiency and capacity	Mix
Boone (Units 1–3)	Phase 2	High efficiency, low flow	Insignificant
Chatuge (Unit 1)	Phase 2	High capacity	Yes
Apalachia (Units 1–2)	Phase 2	Increased efficiency and capacity	Insignificant
Watts Bar (Units 1–5)	Phase 2	Increased efficiency and capacity	Yes
Phase 1 and Not Started Projects			
Cherokee (Units 1–4)	Phase 1	High efficiency, low flow	Yes
Wheeler (Units 1–8)	Phase 1	High efficiency, low flow	Not expected
Wilson (Units 19–21)	Phase 1	Increased efficiency and capacity	Expected
Fort Loudoun (Units 1–2)	Not started	Increased efficiency and capacity	Mix
Wilson (Units 1–4)	Not started	High efficiency	Yes
Wilson (Units 5–8)	Not started	High efficiency	Yes
Ocoee #3 (Unit 1)	Not started	Increased efficiency and capacity	Yes
Nickajack (Units 3–4)	Not started	Increased efficiency and capacity	Yes
South Holston (Unit 1)	Not started	Increased efficiency and capacity	No
Melton Hill (Units 1–2)	Not started	Increased efficiency and capacity	No
Watauga (Units 1–2)	Not started	Increased efficiency and capacity	Yes
Blue Ridge (Unit 1)	Not started	Increased efficiency and capacity	Yes
Wilbur (Units 1–4)	Not started	Increased efficiency and capacity	Insignificant

Notes:

HMOD = Hydro Modernization.
Phase 1 = No plans developed to date; Phase 2 = Design; Phase 3 = Construction.

[1] HMOD projects that have been completed or are scheduled to start soon include:

Tims Ford (Unit 1)	Wheeler (Units 9–11)
Chickamauga (Units 1–4)	Kentucky (Units 1–5)
Wilson (Units 9–18)	Nottely (Unit 1)
Norris (Units 1–2)	Fontana (Units 1–3)
Fort Patrick Henry (Units 1–2)	Hiwassee (Units 2)
Guntersville (Units 1 and 4)	Douglas (Units 2, 3, and 4)
Douglas (Unit 1)	Guntersville (Unit 3)
Raccoon Mountain (Unit 3)	Fort Loudoun (Unit 4)
Guntersville (Unit 2)	Hiwassee (Unit 1)

[2] HMOD projects that were in Phase 2 (design) and Phase 3 (construction) in October 2001 are included in the Base Case. Projects that were in Phase 1 or not started in October 2001 are addressed in the cumulative effects analysis.

[3] HMOD flows for completed projects and those in Phase 2 (design) and Phase 3 (construction) are included in Table A-01.

Source: TVA file data 2001.

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