4.4 Water Quality

4.4.1 Introduction

Resource Issues
▶ Residence time
▶ Algal growth
▶ Thermal stratification
▶ Dissolved oxygen depletion
▶ Anoxic products

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.

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.

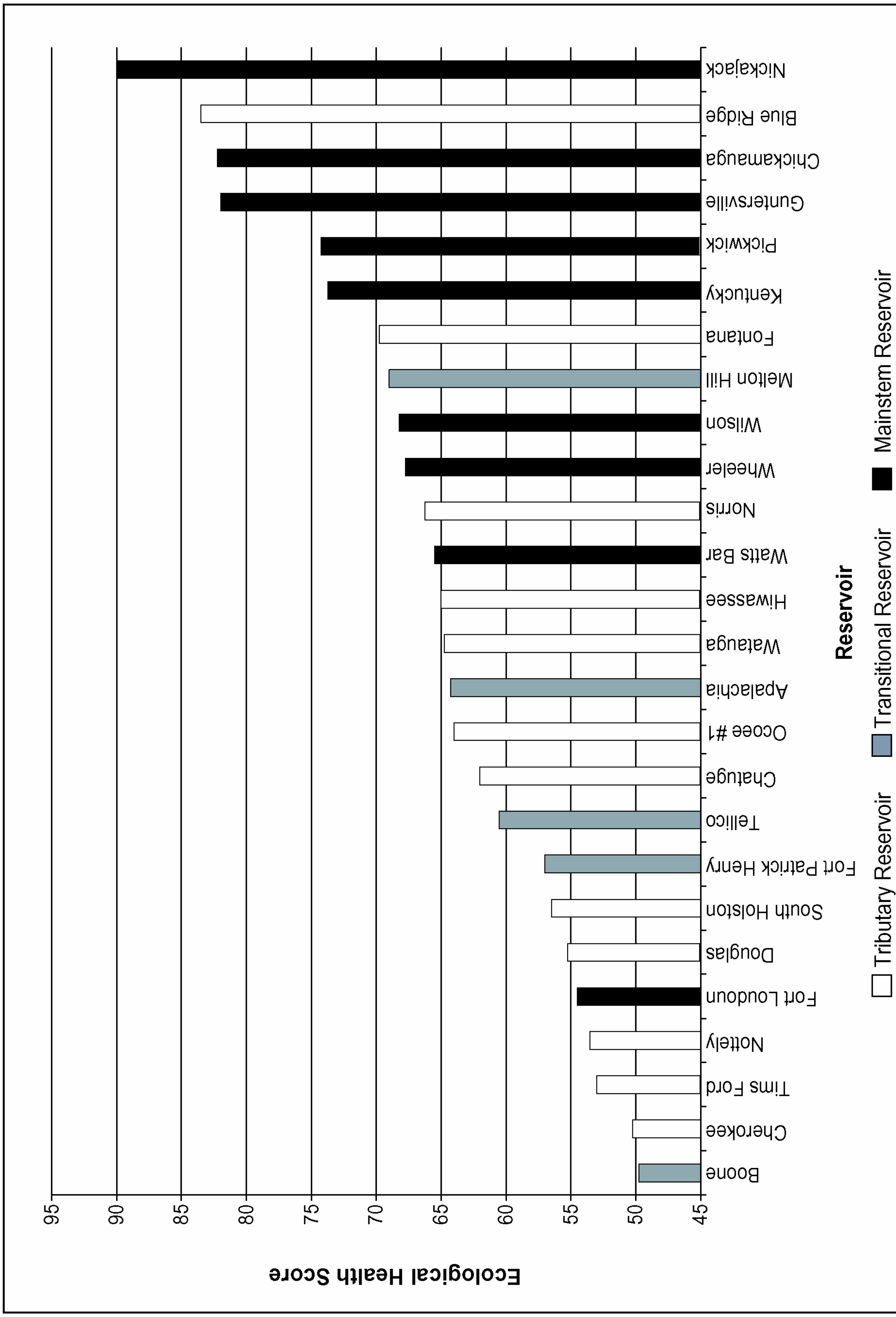
Scoring Ranges for All Reservoirs		
Poor	**Fair**	**Good**
<59	59-72	>72

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.

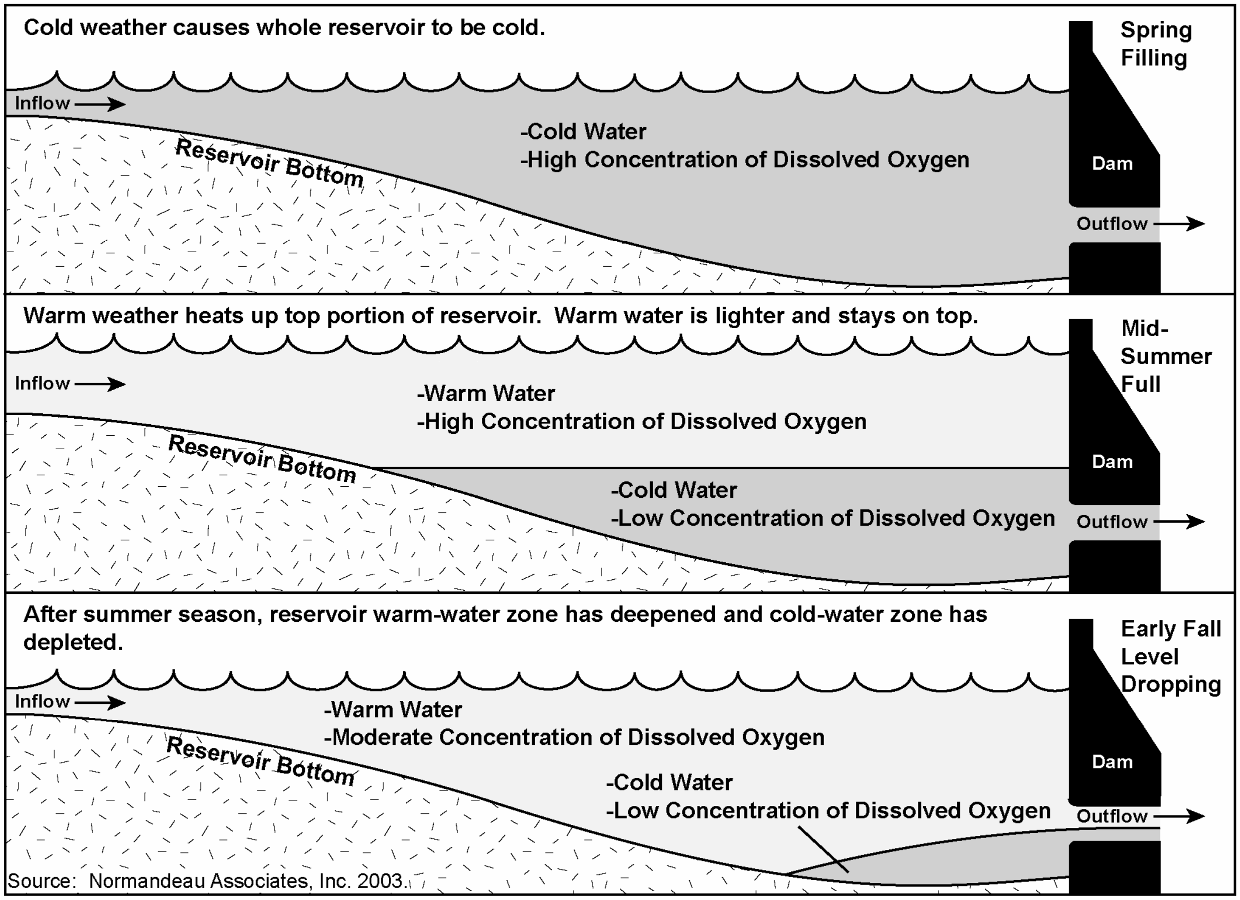


Figure 4.4-02 Reservoir Characteristics during Summer Pool Elevation from Spring to Early Fall

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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