TVA/WR/WQ--90/14

DE91 005454

Tennessee Valley Authority
River Basin Operations
Water Resources

WATER RESOURCES REVIEW: OCOEE RESERVOIRS--1990

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August 1990

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EXECUTIVE SUMMARY

TVA is preparing a series of reports to make technical information on individual TVA reservoirs readily accessible. These reports provide a summary of (1) reservoir purpose and operation; (2) physical characteristics of the reservoir and watershed; (3) water quality conditions; (4) aquatic biological conditions; and (5) designated, actual and potential uses of the reservoir and impairments of those uses. This reservoir status report addresses the three Ocoee Reservoirs in Polk County, Tennessee.

TVA purchased Ocoee Reservoirs Nos. 1 and 2 in 1939 and impounded Ocoee Reservoir No. 3 in 1942 for the sole purpose of hydropower generation. Today, the Ocoee Reservoirs provide slightly over two percent of the total hydropower capacity of the TVA system.

The Ocoee Reservoirs have been seriously impacted by erosion, mining, and mineral processing activities in the Copper Basin. Revegetation of the denuded areas of the Copper Basin is expected to exert a positive influence on the water quality and aquatic biology of the Ocoee reservoirs. Cooperation of various private industries and government agencies in the revegetation effort has reduced the barren area to about 10,200 acres--one-third of the original problem area. However, Ocoee No. 3 Reservoir has already lost most of its storage capacity to sediments accumulated from erosion in the Copper Basin, and a large delta has formed in Ocoee No. 1 Reservoir at the inflow. High concentrations of suspended sediments and metals (especially zinc) have severely limited the biological productivity of the Ocoee Reservoirs, although a limited sport fishery appears to be developing in Ocoee No. 1 Reservoir.

The principal uses of the Ocoee reservoirs are for hydropower production and recreation, including swimming and boating in Ocoee No. 1 Reservoir, and whitewater rafting in the tailwater of Ocoee No. 2. Other potential uses of the reservoirs are either not presently in demand or have been precluded by poor water quality and aquatic biological conditions.

Several agencies routinely monitor water quality and aquatic biological conditions at various locations within the Ocoee reservoirs, but more detailed information on certain problems and concerns is needed for optimum management of the reservoirs.

WATER RESOURCES REVIEW:
OCOEE RESERVOIRS--1990

PURPOSE AND OPERATION OF THE OCOEE DAMS AND RESERVOIRS

The Ocoee projects are a series of three hydropower facilities on the Ocoee River in Polk County, Tennessee (figure 1). Ocoee Dams Nos. 1 and 3 impound small reservoirs, while Ocoee Dam No. 2 simply diverts the river flow into a flume. Ocoee No. 3, the most upstream dam, impounds a 7-mile reach of the Ocoee River downstream from the town of Copperhill, Tennessee. During normal operation for power production, releases from Ocoee No. 3 Dam by-pass the natural streambed and travel through a 2.5-mile tunnel to Ocoee No. 3 Powerhouse. The water released through the powerhouse re-enters the natural stream channel and flows down to Ocoee No. 2 Dam--a rock-filled timber crib dam that diverts the river to a wooden flume. After flowing nearly 5 miles through the wooden flume, the water passes through Ocoee No. 2 Powerhouse and once again re-enters the natural stream channel. Ocoee No. 1 Dam, located about 8 miles downstream from Ocoee No. 2 Powerhouse, impounds Ocoee No. 1 Reservoir, also known as "Parksville Lake." Water released through Ocoee No. 1 Dam joins the Hiwassee River about 12 miles downstream, near Benton, Tennessee.

TVA purchased Ocoee Nos. 1 and 2 from Tennessee Electric Power Company in 1939, and constructed Ocoee No. 3 Dam in 1942 for the sole purpose of hydropower generation. Ocoee No. 3 powerhouse has one hydropower unit with a generating capacity of 28,800 kW. Ocoee No. 2 powerhouse, which has 2 hydropower units, has a total generating capacity of 21,000 kW. Ocoee No. 1 dam has 5 hydropower units with a total generating capacity of 18,000 kW. Collectively, the Ocoee projects make up slightly over two percent of the total hydropower capacity of the TVA system.

The Ocoee projects are operated to meet power system demands as economically as possible. Because hydropower generation is the most economical, versatile and dependable power source in the TVA system, it is used to provide peaking power quickly for those times when daily power demands are the highest. Hydropower generation is also scheduled for high demand times of the week (generally during the 5-day workweek) and high demand times of the year (June through August, and December through February).

Pool elevations of Ocoee No. 3 Reservoir normally do not vary significantly over the course of the year except during sediment sluicing operations. TVA conducts sediment sluicing operations at Ocoee No. 3 Dam on an "as needed" basis (usually about once a year) to flush the buildup of sediments from in front of the intake of the tunnel that leads to the Ocoee No. 3 powerhouse. These sluicing operations, which are usually conducted in early winter, involve a major drawdown in the elevation of Ocoee No. 3 Reservoir, followed by pulsing of flows from the upstream Blue Ridge Dam in order to mobilize as much sediment as possible and

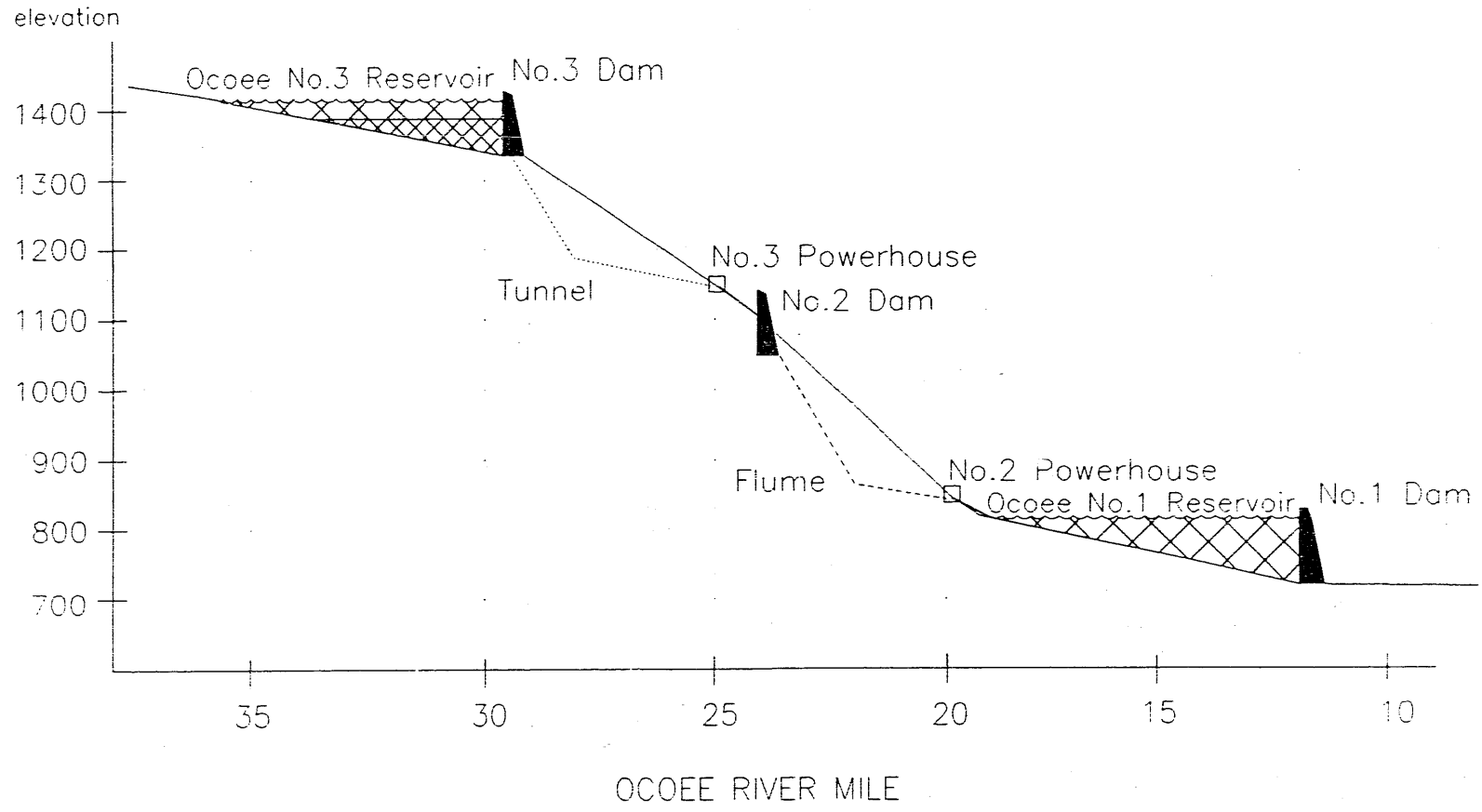


Figure 1. Schematic of the Ocoee Reservoirs System

flush it downstream. After the sediment sluicing operation is completed, the pool elevation of Ocoee No. 3 is returned to normal.

Ocoee No. 2 Reservoir is riverine in nature, and the dam merely diverts flow to the flume without impounding a large pool. For 106 days per year, TVA releases water from Ocoee No. 2 to the usually dry riverbed to provide whitewater recreation opportunities. Including maintenance days, TVA releases water through Ocoee No. 2 Dam for a total of 116 days per year.

Pool elevations of Ocoee No. 1 Reservoir are varied seasonally: an elevation of 828.5 ft is normally maintained May to October, then the elevation is dropped to 821 ft in January and February (figure 2). This operation provides limited incidental flood control benefits.

TVA coordinates releases from Ocoee No. 1 Dam with releases from Apalachia Dam (on the Hiwassee River near the North Carolina border) to provide a combined daily average release from the two plants equal to or greater than 600 cfs. This flow enhances the capacity of the Hiwassee River to assimilate wastewater discharges.

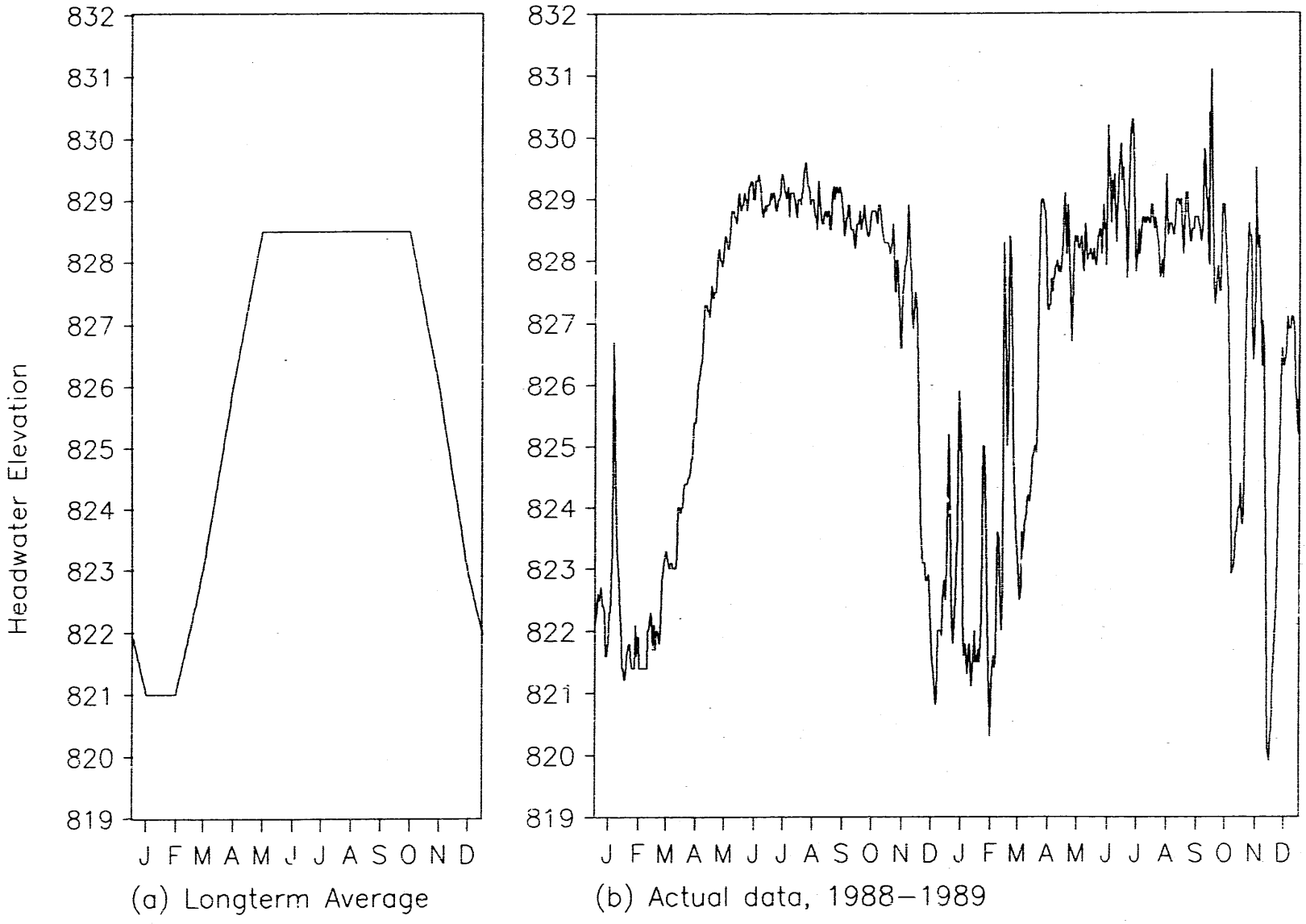


Figure 2. Seasonal Pool Elevations of Ocoee No. 1 Reservoir
(Note: Reservoir elevations for operational records use Tennessee Electric Power Co. convention, equal to the U.S.C. and G.S. 1936 Supplementary Adjustment minus 6.89 feet.)

DESCRIPTION OF THE OCOEE RESERVOIRS AND SURROUNDING AREA

Watershed Characteristics

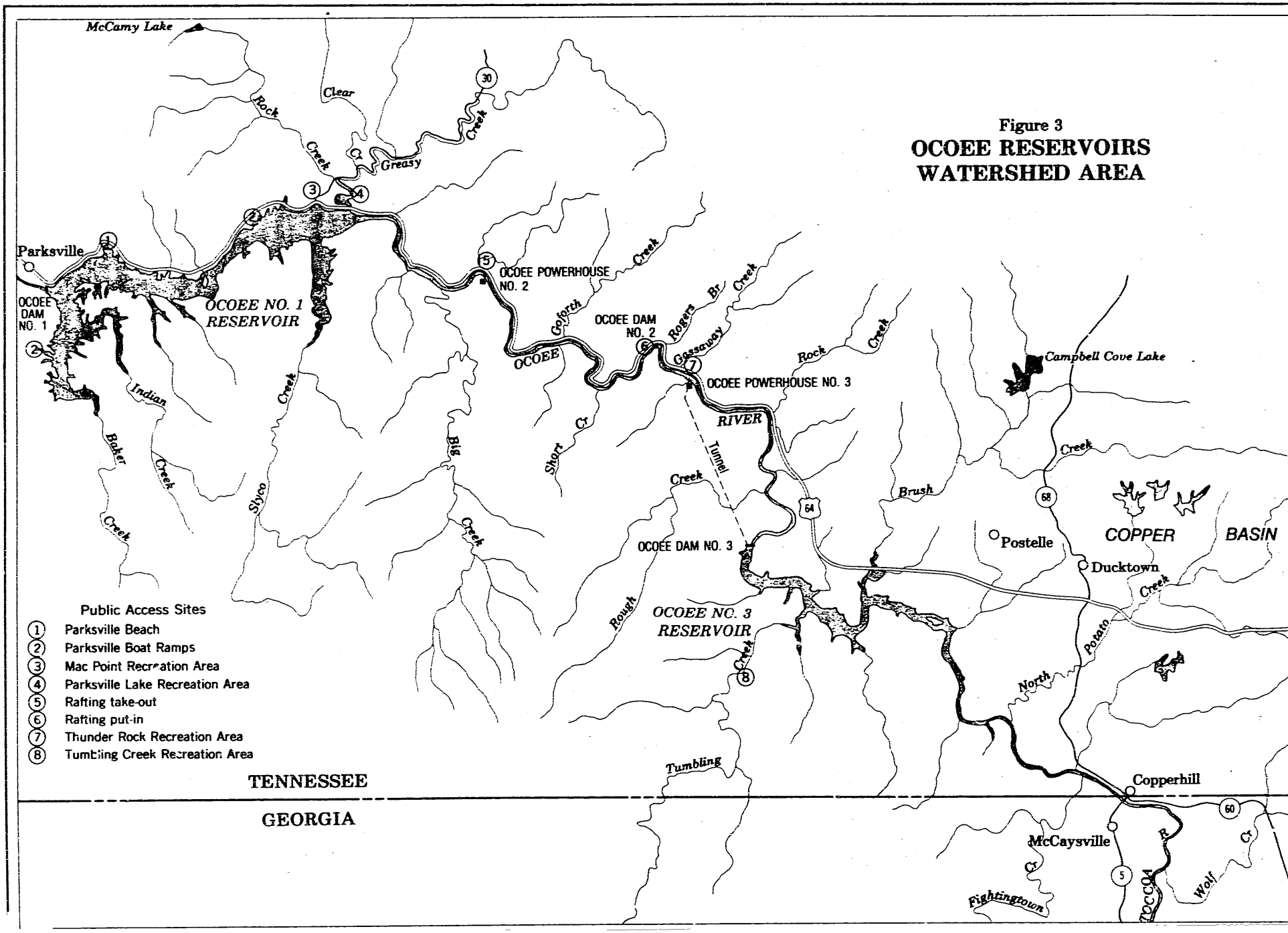
The three Ocoee projects lie entirely within Polk County, Tennessee. The population of Polk County was estimated at 13,700 in 1987. The county is oriented toward manufacturing and has limited managerial and professional opportunities. About 2,100 Polk County residents travel out of the county to work. County unemployment figures have been in double digits since 1980.

The water quality and aquatic biology of the Ocoee Reservoirs are strongly shaped by the natural characteristics of, and human activity in, the contributing watershed (figure 3). The total drainage area upstream from Ocoee No. 1 Dam is 595 square miles. Flows from the uppermost 232 square miles of the drainage area are regulated by TVA's Blue Ridge Dam in Fannin County, Georgia. The majority of the watershed is mountainous, forested land within Chattahoochee National Forest in Georgia and Cherokee National Forest in Tennessee. However, where the Ocoee River enters Tennessee from Georgia, it receives drainage from a barren area known as the Copper Basin. The water quality of drainage from this relatively small portion of the total watershed has been--and will likely continue to be--the primary factor controlling the characteristics and uses of the Ocoee Reservoirs.

The watershed of the Ocoee Reservoirs is underlain by metamorphic siltstones that contribute little buffering capacity to the water. The Copper Basin, immediately upstream from the Ocoee projects, is the site of significant ore deposits in the form of chalcopyrite (copper-iron sulfides), sphalerite (zinc sulfides), magnetite (iron oxides), pyrrhotite (ferrous sulfides) and pyrite (iron disulfides) (TDHE, 1985). Copper mining and smelting have been a major influence on water quality in the area since copper ore was discovered in the Copper Basin in 1843. Until 1904, an open-air roasting process was employed for smelting. The enormous fuel demand for this process lead to clearcutting of the thousands of acres of forest within hauling distance of the mines; dense wood smoke with a high SO_2 content killed the remaining vegetation in the area. In 1901, the Tennessee Copper Company installed a blast furnace to take the place of open-air ore roasting, and stacks disseminated the SO_2-laden furnace gases over an even wider area. Spurred by complaints from local citizens and a lawsuit entered by the State of Georgia, a process was developed in 1907 to reclaim the SO_2 for production of sulfuric acid. By the early 1930s, sulfuric acid had become the principal product of the operation.

Figure 3

OCOEE RESERVOIRS WATERSHED AREA



By the time the acid rain from the SO_2 emissions began to be controlled, erosion damage to the lands in the Copper Basin was severe. On thousands of acres, the top soil was completely washed away, leaving only a rocky cover of slate fragments. The remaining soils were extremely acidic, with pH values as low as 3.5. For years, unchecked erosion continued to expand the barren area by undercutting grass cover. Ultimately, about 50 square miles (32,000 acres) of land were disturbed, with severe erosion of the topsoil and subsoil on 23,000 acres.

The first extensive cooperative attempts to reclaim the barren area began in the 1930s as a cooperative effort by the Civilian Conservation Corps, the Tennessee Valley Authority, and the Tennessee Copper Company. In the years that followed, Tennessee Copper Company and its successors, with the assistance of various universities, and federal and local agencies, continued the revegetation efforts, but substandard soil conditions limited the success of the early reclamation efforts. Since 1984, TVA and Tennessee Chemical Company have treated 1,855 acres and prepared a master treatment plan for revegetation of the remaining 1,211 acres of denuded lands and 9,546 acres of partially vegetated lands (Muncy, 1986). The remaining problem area in need of treatment is only about one-third of the original 32,000 acres.

Shoreline Characteristics

Ocoee No. 3 Reservoir has 24 miles of shoreline: four miles are owned privately, two are owned by TVA, and 18 are held by the U.S. Forest Service (Cherokee National Forest). None of the privately owned shoreline has been developed, and no significant increase in development around Ocoee No. 3 Reservoir is anticipated.

Ocoee No. 1 Reservoir has 47 miles of shoreline: 43 miles are held by the U.S. Forest Service and four miles are privately owned. Although some private homes and cabins already exist on the Forest Service lands, the Forest Service no longer grants special use permits, so no additional private dwellings can be built on these lands. All of the privately owned shoreline has been developed; consequently, no significant increase in development around Ocoee No. 1 is anticipated.

Reservoir Characteristics

Physical Characteristics

The Ocoee Reservoirs are among the smallest, in terms of surface area and volume, in the TVA system. Ocoee No. 3 Reservoir is less than 50 feet deep at the dam and has a mean depth of only six feet at normal maximum pool (table 1). Ocoee No. 2 Reservoir is riverine in nature and has no storage capacity. Its depth depends on the rate of discharge from

Table 1. Physical Characteristics of the Ocoee Reservoir Projects

	Ocoee Project		
	No. 1	No. 2	No. 3
Location			
Dam	ORM 11.9	ORM 24.2	ORM 29.2
Powerhouse	ORM 11.9	ORM 19.7	ORM 25.0
Pool elevations (msl)			
Normal maximum	838[a]	N/A	1435
Normal minimum	818[a]	N/A	1413
Reservoir volume (ac-ft)[b]			
Normal maximum pool	83,300	N/A	4,180
Normal minimum pool	52,270	N/A	551
Reservoir area (ac)			
Normal maximum pool	1,890[c]	N/A	480[d]
Normal minimum pool	1,315[c]	N/A	39[d]
Mean depth (ft)[b]			
Normal maximum pool	45.1	N/A	6.0
Normal minimum pool	40.7	N/A	1.0
Shoreline (miles at normal maximum pool)	47	N/A	24
Average unregulated flow (cfs)	1,410	1,270	1,170
Useful controlled storage[b] (ac-ft)	31,030	0	3,629
Average retention time at maximum pool (days)	30	N/A	<2
Length of backwater (miles at normal maximum pool)	7.5	N/A	7

a. Elevations based on U.S. Coastal and Geodetic Survey 1936 Supplementary Adjustment. To obtain Tennessee Electric Power Company data used for Ocoee No. 1 operations, subtract 6.89 ft.

b. as of 1982
c. as of 1978
d. as of 1969

Ocoee No. 3 Dam and the rate of release to the flume; the maximum depth at Ocoee No. 2 Dam is about 20 feet. Ocoee No. 1 Reservoir has a mean depth of 45 feet, and is about 100 feet deep at the dam.

When TVA purchased the Ocoee No. 1 facility in 1939, the reservoir had already lost 16 percent of its original volume due to the buildup of sediment eroding from the denuded Copper Basin. TVA completed Ocoee No. 3 Dam in 1942 and for the next 30 years Ocoee No. 3 Reservoir accumulated most of the sediment coming from the Copper Basin. Consequently, sedimentation rates in Ocoee No. 1 Reservoir temporarily decreased (figure 4). However, by 1976, Ocoee No. 3 Reservoir had lost 80 percent of its original volume to sediment. Now that Ocoee No. 3 Reservoir is no longer an efficient sediment trap, the sedimentation rate in Ocoee No. 1 Reservoir appears to be increasing again. Although erosion rates in the Copper Basin are declining as a result of revegetation activities, sediments already in the two upstream Ocoee projects will continue to redistribute down to Ocoee No. 1 Reservoir for many years to come. Data from TVA's most recent survey of sediment buildup in Ocoee No. 1 Reservoir are to be available in 1990.

Hydrologic Characteristics

Total inflows to Ocoee No. 3 vary from a low of 667 cfs in December to a high of 1276 cfs in April (long-term monthly averages) (figure 5). On an annual basis, about 56 percent of the total inflow to Ocoee No. 3 consists of discharges from Blue Ridge Dam, while about 44 percent enters locally via small tributaries downstream from Blue Ridge Dam. On a monthly basis, the percentage of local inflow varies from a high of 71 percent in March to a low of 23 percent in September. Like inflows, long-term average releases from Ocoee No. 3 vary seasonally from a low of 667 cfs in December to a high of 1276 cfs in April.

Because Ocoee No. 2 has no storage volume, flows through this riverine reach are equal to whatever is released from Ocoee No. 3 Dam plus inflow from the 20 mi^2 local drainage area between Ocoee Dams Nos. 2 and 3.

Total inflows to Ocoee No. 1 vary from a low of 870 cfs in December to a high of 1656 cfs in April (long-term monthly averages) (figure 6). On an annual basis, about 81 percent of the total inflow to Ocoee No. 1 comes through Ocoee No. 3, while about 19 percent enters the system locally via small tributaries between Ocoee No. 3 and Ocoee No. 1 dams. On a monthly basis, the percentage of local inflow varies from a high of 26 percent in February to a low of 11 percent in April. During the summer and fall months, most of the total inflow to Ocoee No. 1 Reservoir originates as outflow from Blue Ridge Dam. During the winter and spring, however, the largest portion of the total inflow originates as local inflow between Blue Ridge Dam and Ocoee No. 3 Dam (i.e., from the area that includes the Copper Basin). Long-term average releases from Ocoee No. 1 vary seasonally from a low of 970 cfs in December to a high of 1556 cfs in April.

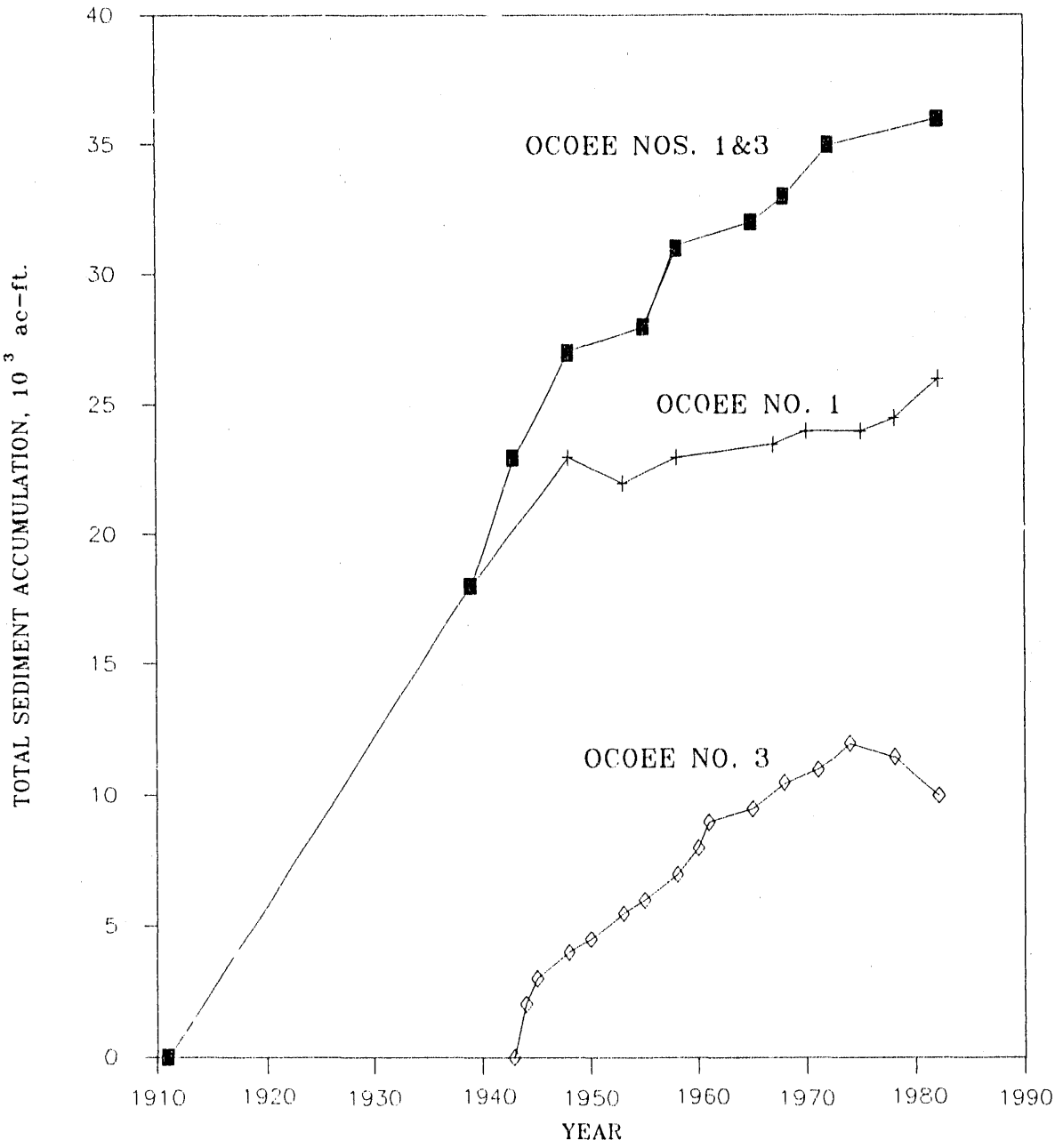


FIGURE 4. History of sedimentation in the Ocoee Reservoirs

OCOEE NO. 3

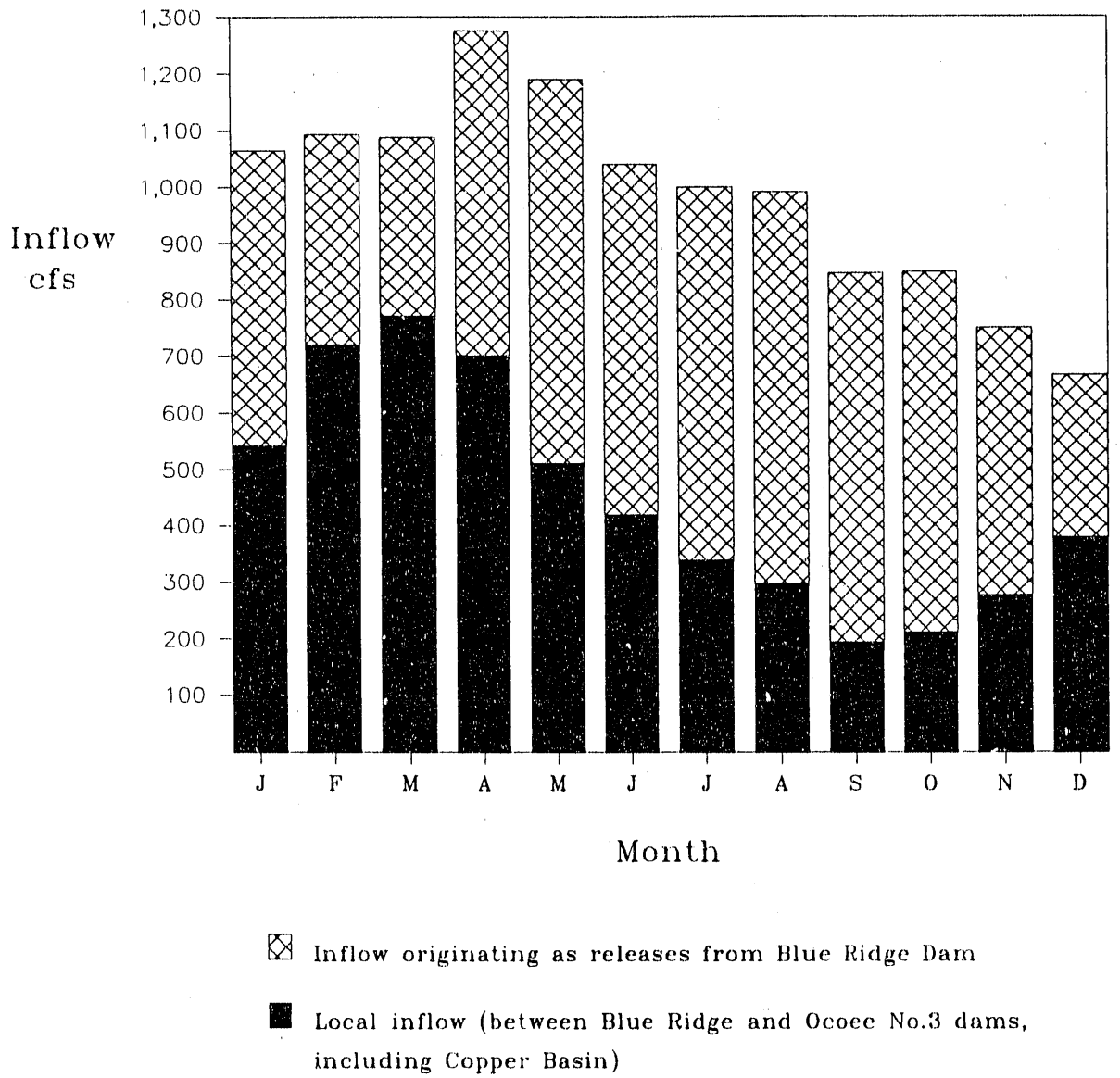


Figure 5. Long-Term Average Monthly Inflows to Ocoee No.3 and Percentage of Total Inflow of Local Origin

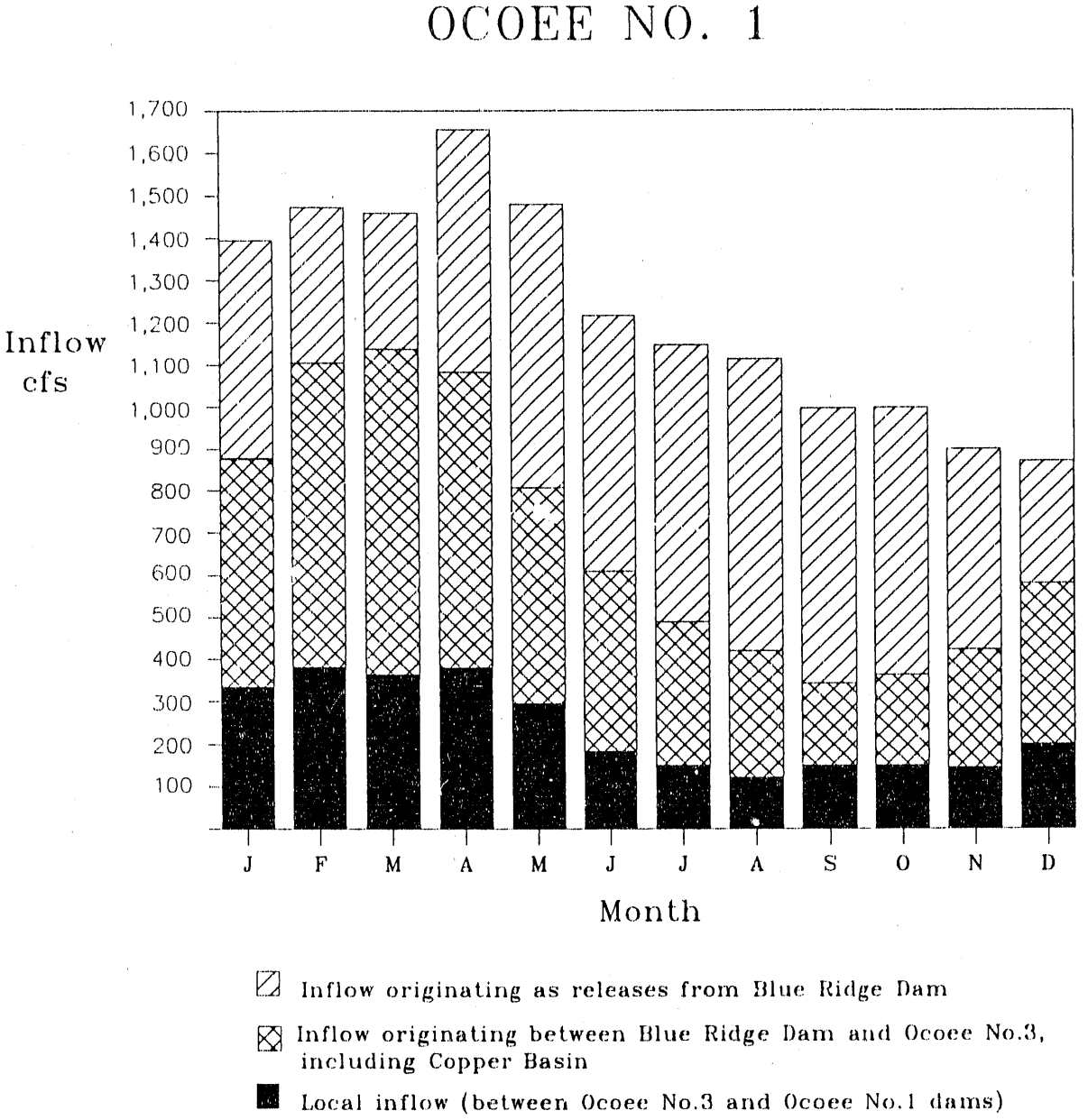


Figure 6. Long Term Average Monthly Inflows to Ocoee No.1 and Typical Origin of Flows

Assuming normal maximum pool volume and average unregulated flows, the theoretical hydraulic retention time of Ocoee No. 3 Reservoir is less than two days, while the retention time of Ocoee No. 1 Reservoir is on the order of a month. During periods of high flow (such as during winter and spring storms), the retention time of Ocoee No. 1 Reservoir may decrease to a week or less.

WATER QUALITY CONDITIONS

Physical and Chemical Characteristics

Temperature and Dissolved Oxygen Patterns

Ocoee No. 1 is a warm monomictic impoundment; that is, it exhibits stable thermal stratification during the summer and the entire water column mixes throughout the winter (figure 7). Conductivity profiles of the water column often show a weak chemocline as well, but the reservoir is not meromictic (i.e., with a permanently stagnant bottom layer that does not participate in seasonal mixing) as was once thought. Aerial photographs of Ocoee No. 1 Reservoir often show a distinct boundary, perpendicular to the direction of flow, between relatively turbid and clear water. This demarcation occurs consistently at about ORM 15.8 and probably indicates a plunge point where the cross-sectional area of the channel widens, velocity decreases, and the turbid inflows form a density current that flows under the standing water in the pool.

Although Ocoee No. 1 Reservoir exhibits strong thermal stratification, depletion of dissolved oxygen (DO) in the hypolimnion over the course of the summer is not severe. Dissolved oxygen concentrations less than 5 mg/l usually occur only directly over the sediments. Dissolved iron and manganese concentrations in the hypolimnion do not increase markedly through the summer. Hypolimnetic DO depletion in the embayments tends to occur earlier in the season and to a slightly greater extent than in the main channel. Dissolved oxygen concentrations as low as 3.0 mg/l have been observed over the sediments in the embayments. BOD_5 concentrations in Ocoee No. 1 Reservoir, as measured during an intensive survey by TVA in 1982-83, were invariably low and usually less than 1.0 mg/l (table 2).

There are no recent temperature and DO profiles in the forebay of Ocoee No. 3 Reservoir; however, no significant stable stratification would be anticipated given the relatively shallow depth of the water and the short retention time. There are no recent measurements of BOD_5 in Ocoee No. 3.

Nutrients

There are no recent data on nutrient concentrations upstream from the Tennessee Department of Health and Environment (TDHE) quarterly monitoring site at Ocoee River mile 19.6. Nutrient concentrations at mile 19.6 and within the main body of Ocoee No. 1 Reservoir are low to moderate (table 3). Dissolved phosphorus concentrations are generally less than the analytical detection limit. Ratios of total nitrogen to total phosphorus suggest that phytoplankton growth, if it were to become limited by nutrient concentrations at all, would likely be more strongly limited by nitrogen than by phosphorus.

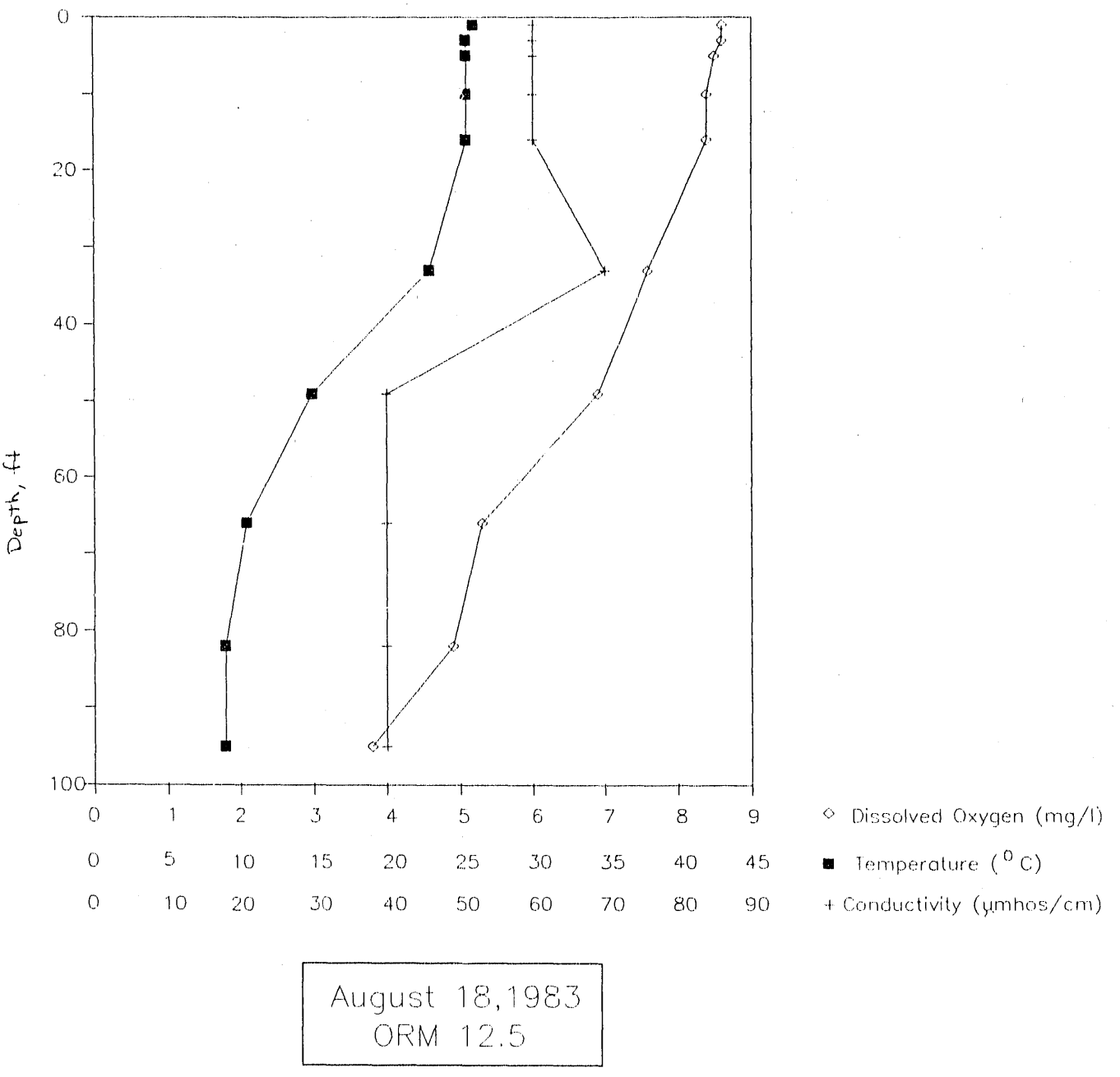


Figure 7. Typical Late Summer Thermal and Chemical Stratification in Ocoee No.1 Reservoir Forebay

Table 2. Summary of Recent Chemical Water Quality Data for the Ocoee River

Parameter		Ocoee River mile					
		35.2[a] (TDHE, 1981)	25[b] (TDHE, 1981)	19.6[c] (TDHE, 1984-89)	15.5[d] (TVA, 1982-83)	14.0[e] (TVA, 1982-83)	12.5[f] (TVA, 1982-83)
pH (s.u.)	Mean	7.0	6.3	6.5	6.9	6.7	6.8
	Range	-	-	5.8-7.8	6.3-8.0	5.7-7.5	5.6-9.3
	Number of samples	1	1	21	78	115	131
Alkalinity (mg/l)	Mean	12	14	7	7	7	7
	Range	-	-	-	1-12	1-10	1-11
	Number of samples	1	1	1	24	15	27
Hardness (mg/l)	Mean	81	24	53.6	25	26	27
	Range	-	-	21-109	15-42	15-38	18-43
	Number of samples	1	1	21	13	12	13
Acidity (mg/l)	Mean	7	2	3	7	7	9
	Range	-	-	-	3-12	2-11	3-15
	Number of samples	1	1	1	24	15	27
Sulfate (mg/l)	Mean	77	40	N/C	26	26	27
	Range	-	-	-	17-35	16-34	20-34
	Number of samples	1	1	-	16	15	16
Dissolved solids (mg/l)	Mean	157	95	N/C	58	60	62
	Range	-	-	-	30-80	40-70	50-70
	Number of samples	1	1	-	16	15	16
Conductivity (µmhos/cm)	Mean	N/C	N/C	156	95	93	91
	Range	-	-	64-296	60-149	40-152	40-135
	Number of samples	-	-	21	78	122	139

Table 2 (Continued)

Parameter		Ocoee River mile					
		35.2[a] (TDHE, 1981)	25[b] (TDHE, 1981)	19.6[c] (TDHE, 1984-89)	15.5[d] (TVA, 1982-83)	14.0[e] (TVA, 1982-83)	12.5[f] (TVA, 1982-83)
Suspended solids (mg/l)	Mean	43	1	14	17	6	5
	Range	-	-	1-148	<1-62	<1-26	<1-28
	Number of samples	1	1	21	16	15	16
Turbidity (NTU or FTU)[g]	Mean	18 NTU	3.4 NTU	N/C	30.2 FTU	17.8 FTU	14.9 FTU
	Range	-	-	-	2.9-90	<1.3-6.5	1-70
	Number of samples	1	1	-	16	15	16
BOD_5 (mg/l)	Mean	N/C	N/C	N/C	<1.0	<1.0	<1.0
	Range	-	-	-	<1.0-1.0	<1.0	<1-0
	Number of samples	-	-	-	16	15	16

a. Ocoee No. 3 Reservoir at Rogers Bridge
b. Ocoee River at Ocoee No. 3 Powerhouse
c. Ocoee River downstream from Ocoee No. 2 Powerhouse
d. Ocoee No. 1, upper reservoir
e. Ocoee No. 1, midreservoir
f. Ocoee No. 1, forebay
g. Formazin turbidity units (FTU) approximately equivalent to nephelometric turbidity units (NTU).

Table 3. Summary of Recent Nutrient Concentrations Data for the Ocoee River

Parameter		Ocoee River mile 19.6 (TDHE, 1984-89)	15.5[a] (TVA, 1982-83)	12.5[a] (TVA, 1982-83)
NH_3-N (mg/l)	Mean	0.11	0.04	0.04
	Range	<0.01-0.62	0.01-0.11	0.01-0.10
	Number of samples	21	5	5
NO_2+NO_3-N (mg/l)	Mean	0.23	0.09	0.09
	Range	<0.01-2.15	0.06-0.11	0.03-0.13
	Number of samples	21	5	5
Organic N (mg/l)	Mean	0.18[b]	0.06	0.05
	Range	*	0.01-0.13	0.03-0.07
	Number of samples	21	5	5
Total N (mg/l)	Mean	0.52[b]	0.18	0.18
	Range	*	0.10-0.29	0.07-0.29
	Number of samples	21	5	5
Dissolved P (mg/l)	Mean	N/C	<0.01	<0.01
	Range	-	<0.01-0.01	<0.01
	Number of samples	-	4	4
Total P (mg/l)	Mean	0.07	0.05	0.02
	Range	<0.01-0.62	0.02-0.09	<0.01-0.05
Number of samples		21	5	5

a. Epilimnetic samples only.

b. Calculated from other parameters.

Alkalinity, Acidity, Hardness, and pH

The waters of the Ocoee River upstream from the influence of the Copper Basin are naturally soft, poorly buffered, and somewhat acidic. Sampling in Ocoee No. 3 Reservoir during the 1960s and 1970s typically showed pH values around 6, total alkalinity less than 10 mg/l, and hardness values that ranged from less than 25 mg/l to greater than 150 mg/l. There has been no routine monitoring of these parameters in Ocoee No. 3 Reservoir for over 10 years.

The pH and alkalinity values seen in Ocoee No. 1 Reservoir are similar to the values found in Blue Ridge Reservoir, upstream from the influence of the Copper Basin. An intensive survey by TVA in 1982-83 found pH values less than 6.0 only in the hypolimnetic water directly over the sediments and only on one occasion (table 2). Generally speaking, significant elevations of pH in the surface waters attributable to photosynthesis are not observed in this reservoir.

Acidity values in Ocoee No. 1 Reservoir generally equal or slightly exceed alkalinity values, and sulfate concentrations are significantly elevated over background (table 2). Sulfate concentrations in the Ocoee Reservoirs are also unusual in that they are higher than the total carbonate plus bicarbonate concentration (Cox, 1986).

The U.S. Forest Service collects pH data weekly at Parksville Beach and Mac Point Recreation Area in conjunction with fecal coliform sampling. pH values less than the water quality criterion of 6.0 are the norm, but because the acidity and alkalinity of the water are low, these low pH values are unlikely to cause eye irritation in swimmers.

Turbidity and Suspended Solids

There are no recent data on turbidity and suspended solids for Ocoee Reservoirs Nos. 2 and 3. While the suspended solids load to these reservoirs may have decreased in recent years because of reduced erosion in the Copper Basin, the rate at which sediments continue to accumulate in Ocoee No. 3 Reservoir indicates that the load is still excessive.

The TDHE, in its quarterly monitoring at Ocoee River mile 19.6 (downstream from Ocoee No. 2 Powerhouse), has occasionally observed suspended solids concentrations of greater than 100 mg/l, but the average over the last 5 years of sampling has been about 14 mg/l (table 2).

The most recent information on turbidity and suspended solids in Ocoee No. 1 Reservoir was collected by TVA in 1982-83 (table 2). The first set of samples, collected less than two weeks after a sediment sluicing operation at Ocoee No. 3 Dam, showed turbidity values averaging 50 FTU and suspended solids varying from less than 20 to greater than

50 mg/l. The highest values were noted deep in the water column, verifying the density currents noted in aerial photographs of the reservoir. Turbidity and suspended solids concentrations were higher in the main body of the reservoir than in the embayments. Subsequent samples showed steadily decreasing turbidity and suspended solids throughout the spring. Samples taken at tributary inflows to the reservoir after storm events did not show excessive sediment loads. During the summer, water clarity in Ocoee No. 1 Reservoir is often exceptionally good: weekly Secchi depth measurements made by TVA during the drought in 1986 were usually greater than 3 meters and occasionally greater than 5 meters.

Metals

Concentrations of iron, copper, zinc, lead and manganese in the Ocoee Reservoirs are significantly elevated over background levels in the Toccoa (Ocoee) River upstream from the Copper Basin (table 4). In terms of potential toxicity to the aquatic biota, dissolved metals concentrations are of greater significance than total metals concentrations. However, nearly all the metals data available for the Ocoee Reservoirs are for total (particulate plus dissolved) concentrations rather than dissolved concentrations. Total concentrations of metals in Ocoee No. 1 Reservoir tend to be highest during times of high suspended solids concentrations, but the variables are not strongly correlated. The only recent data on dissolved metals concentrations are from single grab samples collected by TDHE in 1981 (table 5). Those data indicate that most of the iron and aluminum is suspended, while most of the copper, zinc, and manganese is dissolved.

Toxics

The primary toxics-related concern in the Ocoee Reservoirs is high concentrations of metals. In addition, the softness of Ocoee River waters enhances the toxicity of some of these metals. Based on the U.S. Environmental Protection Agency's hardness-dependent ambient water quality criteria, concentrations of copper, lead, and zinc in the Ocoee Reservoirs are probably sufficiently high to cause chronic toxicity to aquatic organisms.

Recent bioassays with juvenile fathead minnows, juvenile bluegills, and common shiners have not shown acute toxicity in the Ocoee River downstream from the Copper Basin; however, chronic effects on fish have not been adequately examined. Neither acute nor chronic effects on phytoplankton, which form the base of the aquatic food web, have been investigated.

Spills of acid and other chemicals, either at the Tennessee Chemical Company plant complex, or following truck accidents or train derailments in the area, have occurred several times in the past few years. Whitewater rafting on the Ocoee downstream from Ocoee No. 2 Dam

Table 4. Summary of Recent Metals Concentrations Data for the Ocoee River

Parameter	Ocoee No. 3 Reservoir (ORM 35.2) Mean	Range	Number of samples	Ocoee River downstream from Ocoee No. 2 Powerhouse (ORM 19.6) Mean	Range	Number of samples	Ocoee No. 1 Reservoir forebay (ORM 12.5) Mean	Range	Number of samples
Aluminum (µg/l)[a]	2000	-	1	N/C[b]	-	-	306	<50-1500	19
Cadmium (µg/l)	N/C	-	-	2.0[c]	<0.2-5.0	21	0.3	0.2-0.6[d]	19
Chromium (µg/l)	N/C	-	-	8	<1-14	21	N/C	-	-
Copper (µg/l)	81[c]	-	1	41[c]	<5-361	21	20[c]	<5-80	19
Iron (µg/l)	N/C	-	-	N/C	-	-	58	<30-100	12
Lead (µg/l)	<10	-	1	23[d]	<1-171[c]	21	19[c]	<1-82	19
Manganese (µg/l)	290	-	1	N/C	-	-	102	10-190	19
Mercury (µg/l)	N/C	-	-	0.2[d]	<0.2-0.4[c]	21	<0.2	<0.2	3
Nickel (µg/l)	<10	-	1	16	<1-20	21	N/C	-	-
Selenium (µg/l)[a]	2	-	1	N/C	-	-	1.2	<1.0-2.0	13
Zinc (µg/l)	242[c]	-	1	154[c]	51-574	21	78[c]	20-185	19
Hardness (mg/l)	81	-	1	54	21-109	21	27	18-43	13

a. No numerical criteria available.
b. N/C = not collected.
c. Exceeds EPA chronic and acute criteria.
d. Exceeds EPA chronic criterion.

Table 5. Relative Distribution of Total and Dissolved Metals in Ocoee River Waters (TDHE, 1985)

Metal (µg/l)	Ocoee River mile			
	35.2	25	19.6	16
Aluminum				
total	2000	490	610	50
dissolved	20	70	170	50
Copper				
total	81	18	23	25
dissolved	29	27[a]	31[a]	30[a]
Iron				
total	7000	800	1000	210
dissolved	220	240	100	60
Lead				
total	<10	<10	<10	<10
dissolved	<10	20[a]	<10	<10
Manganese				
total	290	180	156	43
dissolved	240	210[a]	136	10
Nickel				
total	N/C	<10	50	<10
dissolved	N/C	<10	<10	<10
Zinc				
total	242	78	91	43
dissolved	150	95[a]	50	41

a. Dissolved concentration exceeding total concentration questionable; however, data are shown as reported by laboratory.

has been interrupted or closed on several of these occasions. A spill of N,N-dimethylaniline in September 1985 was reported to have caused a number of rafters to experience burning and itching eyes and skin.

Bacteriological Water Quality

The U.S. Forest Service monitors fecal coliform concentrations of the waters at Parksville Beach and Mac Point Recreation Area (both on Ocoee No. 1 Reservoir) at least once per week during the recreation season. Fecal coliform concentrations greater than 200 per 100 ml are noted occasionally, and in those instances the USFS closes the beaches and conducts approximately daily monitoring until levels decline to less than 200 per 100 ml.

The TDHE monitors fecal coliform concentrations at Ocoee River mile 19.6 (Caney Creek parking area, rafter take-out) on a quarterly basis. Over the last 5 years, 20 out of 33 samples have had fecal coliform concentrations of <10 per 100 ml; only 3 of the 33 samples have exceeded 200 per 100 ml. The maximum value observed was 1050 per 100 ml, which violated the Tennessee criterion for an instantaneous maximum of 1000 per ml. TVA conducted intensive monitoring for fecal coliforms at Ocoee River mile 19.6 during June 1986, and found the site to be well within Tennessee's water quality criteria.

During the intensive survey of 1982-83, TVA conducted monthly sampling for fecal coliform concentrations at Ocoee Inn Boat Dock, Parksville Beach, Mac Point Recreation Area, Camp Cherokee (Boy Scouts) and Camp Ocoee Swimming Area (YMCA). Fecal coliform concentrations in all samples were low.

Sediment Quality

Sediments from Ocoee Nos. 1 and 3 Reservoirs are relatively coarse, primarily inorganic, and markedly enriched with arsenic, cadmium, copper, lead, and zinc (table 6). Some reservoir sediment samples exhibit even higher concentrations of copper, lead and zinc than are typically found in the soils of the Copper Basin. The degree to which metals in these reservoir sediments contribute to dissolved metals concentrations in the water column has not been clearly established.

In 1985, TVA conducted a mineralogic analysis of sediments that had collected in the upper reaches of Ocoee No. 1 Reservoir near Greasy Creek. The sediments consisted of 67.5 percent quartz sand, 15.4 percent miscellaneous iron-oxide minerals, 14.5 percent mica and 2.6 percent magnetite. The mica particles were of too fine a size to be economically recoverable.

Table 6. Metal Content of Sediments from the Ocoee Reservoirs and Soils from the Copper Basin

Parameters, mg/kg	Ocoee No. 1[a] sediments	Ocoee No. 3 Sediments			Sediments[e] from other TVA tributary reservoirs	Copper Basin[f] soils
		ORM 29.25[b]	ORM 35.2[c]	ORM 29.0, 30.1[d]		
Aluminum	10,000	4,300	N/A	N/A	1,200-21,000	N/A
Antimony	<7	N/A[g]	<7	N/A	<7	N/A
Arsenic	83	21	N/A	N/A	<2-20	N/A
Barium	33	63	N/A	N/A	22-240	N/A
Beryllium	1.3	<0.6	N/A	N/A	<0.5-1.6	N/A
Cadmium	7.7	2.2	2.0	N/A	<0.3-1.3	N/A
Chromium	36	7	N/A	N/A	6-37	N/A
Cobalt	49.0	14	N/A	N/A	2.7-31	N/A
Copper	1,807	39	726	950	5.9-73	426
Iron	109,000	12,000	50,600	10,200	10,000-47,000	50,900
Lead	1,608	4	234	250	5-300	128
Lithium	3	2	N/A	N/A	1.7-12	N/A
Manganese	704	320	382	1,000	96-4,000	431
Mercury	0.71	0.53	0.12	N/A	<0.1-1.1	N/A
Molybdenum	<7	<6	<7	N/A	<7	N/A
Nickel	11	4.6	N/A	N/A	2.3-46	N/A
Selenium	<1	<1	N/A	N/A	0.3-8.0	N/A
Silver	2.6	1.7	N/A	N/A	0.7-2.1	N/A
Strontium	<3.2	<2.9	N/A	N/A	<3.4	N/A
Tin	<66	<58	68	N/A	<70	N/A
Vanadium	<33	<29	<34	N/A	<37	N/A
Zinc	1,827	350	2,038	1,650	21-580	214

a. ORMs 12.0 and 12.5, TVA data collected 1972-77, number of samples = 1 to 6.
b. TVA data collected 1973, number of samples = 1.
c. TVA data collected 1973-1977, number of samples = 5.
d. Composite (EMPE, 1984).
e. Range of values for 15 sites in TVA tributary reservoirs east of Chattanooga, Tennessee.
f. Number of samples = 42 (EMPE, 1984).
g. N/A = not analyzed.

Water Quality of Reservoir Releases

The average DO concentration of hydropower releases from Ocoee No. 3 Reservoir during the period June 1 to October 31 was 6.8 mg/l for the years 1976 through 1986. The Ocoee No. 3 tailwater is classified as a trout stream and the DO of the releases was slightly less than the 6.0 mg/l criterion for trout streams for an average of two weeks per year during this period. Dissolved oxygen concentrations are academic, however, because other water quality factors have precluded a viable fishery in this reach of the Ocoee River.

The average DO concentration of hydropower releases from Ocoee No. 1 Reservoir during the period June 1 to October 31 was 7.3 mg/l for the years 1976 through 1986. Because the power intakes at Ocoee No. 1 withdraw from the epilimnion, the DO of discharges virtually never drop below the 5 mg/l criterion applicable to the tailwater. Hydropower releases from Ocoee No. 1 Reservoir may cause temperature impacts on the tailwater fishery, however, as the releases tend to be too cold for a warmwater fishery and too warm for a coldwater fishery.

Water Quality During Sediment Sluicing Operations

Because sediments accumulating in Ocoee No. 3 Reservoir tend to block the intake of the tunnel to Ocoee No. 3 Powerhouse, continued operation of Ocoee No. 3 for power production has necessitated periodically resuspending and flushing sediment through the sluice gates on the dam. These sediment sluicing operations, which in recent years have been conducted for several days to several weeks each winter, severely degrade water quality in the Ocoee River. Turbidity, suspended solids, iron, copper, manganese and zinc increase as much as a thousandfold over background levels (table 7). The suspended sediment scours the rocks in the channel, and when the operation ends, several inches of new sediments are deposited on the rocks downstream. When the sediment plume reaches Ocoee No. 1 Reservoir, it sometimes mixes with the surface waters and gives the entire reservoir a "muddy" appearance.

Table 7. Water Quality Data for the Ocoee River and Ocoee No. 1 Reservoir During Sluicing Operations at Ocoee No. 3 on November 4, 1980

	Ocoee River mile			
Parameter	29.1	25.0	19.7	16.1 m
Turbidity, JTU	7,400	3,000	2,300	7
Total nonfiltrable residue, mg/l	13,000	3,000	3,000	6
Total cadmium, µg/l	29	14	20	0.2
Dissolved cadmium, µg/l	5	1	2	N/A
Total lead, µg/l	7,400	2,400	2,900	15
Dissolved lead, µg/l	25	15	9	2
Total iron, µg/l	2,100,000	490,000	290,000	830
Dissolved iron, µg/l	7,300	660	230	<50
Total manganese, µg/l	15,000	4,000	2,900	240
Dissolved manganese, µg/l	670	580	300	220
Total copper, µg/l	23,000	6,100	4,800	30
Dissolved copper, µg/l	30	20	20	<10
Total zinc, µg/l	26,000	8,000	6,000	100
Dissolved zinc, µg/l	190	110	90	100
BOD_5, mg/l	68	11	6	1.2
COD, mg/l	180	180	180	210
Sulfate, mg/l	90	55	66	58
Conductivity, µmhos/cm	275	180	180	110
pH, standard units	6.3	7.3	6.2	6.0
Alkalinity, mg/l	92	26	26	7
Dissolved solids, mg/l	170	10	150	90
Temperature, °C	14.0	14.0	16.0	15.0

CONDITIONS OF BIOLOGICAL COMMUNITIES

Phytoplankton and Periphyton

The most recent assessment of phytoplankton in Ocoee No. 1 was conducted by TVA in 1982-83 (Cox, 1986). Total algal abundance, chlorophyll a concentrations, and primary productivity were extremely low (table 8). Based on the rate of primary production, the reservoir would be classified "ultra-oligotrophic." While nutrient concentrations are relatively low, algal production in this reservoir is much less than is found in other TVA reservoirs with similar nutrient concentrations. It is assumed that algal production is limited by toxic concentrations of heavy metals, although this has never been confirmed. Blue-green algae normally dominate the summer phytoplankton of other TVA tributary reservoirs with similar nutrient concentrations, pH and alkalinity, but are notably unsuccessful in Ocoee No. 1. Because blue-green algae are generally more susceptible to copper toxicity than are other algae, the relative paucity of blue-greens in Ocoee No. 1 lends further credence to the hypothesis that primary production is being limited by copper or other heavy metals. Turbidity, hydraulic washout, and low inorganic carbon availability may also be important limiting factors at certain times.

The phytoplankton/periphyton resources of Ocoee Nos. 2 and 3 have not been assessed but are assumed to be minimal, due to turbidity, scour, and high concentrations of heavy metals.

Zooplankton

The most recent assessment of zooplankton in Ocoee No. 1 Reservoir was conducted by TVA in 1972. Populations were so sparce that quantitative sampling was not possible (Brown and Meinert, 1976).

Benthos

The most recent assessment of benthic macroinvertebrates in the Ocoee system was conducted by the TDHE in July, 1981 (TDHE, 1985). Although the Ocoee River upstream from the Copper Basin was described as a lush mountain stream supporting large numbers of sensitive taxa, TDHE concluded that "from mile 37 downstream to Parksville Reservoir, the Ocoee virtually remains a biological desert" (table 9). Unsuitable physical habitat (slick metal hydroxide precipitate on rocks, intermittent flows, excessive scour, extensive areas of sandy/silty substrate) is probably the major factor preventing the establishment of a viable benthic community in the riverine reaches between the Ocoee Reservoirs. The benthic community of Ocoee No. 1 pool has not been investigated, but is presumed to be minimal because of extensive siltation.

Table 8. Phytoplankton Dynamics in Ocoee No. 1 Reservoir Forebay

Date	Chlorophyll a (mg/m^3)	Primary productivity ($mgC/m^2/day$)	Total algal abundance (10^6 cell/liter)	Dominant genera
12-21-82	-not collected-	<1	0.026	Oscillatoria, Cryptomonas, Chlamydomonas
02-25-83	0.7	53.9	0.036	Cryptomonas
04-20-83	1.3	32.5	0.133	Tabellaria, Merismopedia, Dinobryon, Oscillatoria
06-15-83	1.2	67.8	0.074	Tabellaria, Cyclotella
08-18-83	0.2	13.4	0.171	Cyclotella

Table 9. Qualitative Description of the Benthos of the Ocoee River (TDHE, 1985)

Sample site	Habitat description	Fauna description
ORM 39 (control)	•pools and riffles •10% canopy cover (hardwoods) •pool substrate 20% bedrock 45% rubble & gravel 35% sand & debris •riffle substrate 30% bedrock 60% rubble & gravel •attached mosses in riffles	•diverse community with abundant clean water type organisms including Ephemeroptera, Plecoptera, Trichoptera, Chitonomidae, Gastropoda and Coleoptera
ORM 27 (between Ocoee No. 3 dam and Powerhouse)	•riverine •no canopy •sandy, acrid-smelling sediment trapped between boulders •slick red precipitate on boulders	•"impoverished" •very few individuals, primarily Diptera
ORM 19.6 (downstream from Ocoee No. 2 Powerhouse)	•riverine •5% canopy cover (hardwoods) •substrate 70% sand, gravel, & silt •slick red precipitate on boulders	•very few individuals; few Trichoptera and Diptera collected appeared to have drifted in from Caney Creek

Mussels

There are no known mussel populations in these reservoirs.

Mosquitoes

Mosquito production in these reservoirs is minimal and TVA does not conduct vector control activities in the area.

Macrophytes

There are no extensive areas of aquatic macrophytes in these reservoirs and TVA does not conduct macrophyte control activities in the area.

Fish

Sampling in Ocoee No. 1 Reservoir in the 1950s and in 1970 showed a very poor quality fishery with standing crop averaging 20 kg/hectare. There are no recent cove rotenone data available; however, based on electro-fishing and gill netting data and the increased use of the reservoir by fishermen, it is evident that the fishery of the reservoir is improving. The Tennessee Wildlife Resources Agency now includes Ocoee No. 1 Reservoir in its weekly fishing report. Bluegill, yellow perch, warmouth, green sunfish, gizzard shad, channel catfish, brook silverside, minnow species, largemouth bass, white crappie and black bullhead have been collected by electro-fishing and rainbow trout have been collected in the tributary embayments with gill nets. This represents a definite improvement in the species composition from previous sampling results. Table 10 lists the fish species known to occur in Ocoee No. 1 Reservoir and their relative abundance.

Threatened and Endangered Species

There are three sensitive species known to occur in close proximity to the Ocoee Reservoirs. Ruth's Golden Aster (*Pityopsis ruthii*), a federally listed endangered plant species, is known to occur alongside the Ocoee River near the Ocoee No. 2 Powerhouse. A colony of red-cockaded woodpeckers (*Picoides borealis*), also a federally listed endangered species, occurs on Cherokee National Forest land near the mouth of Baker Creek, Ocoee No. 1 Reservoir. This species, which inhabits old growth yellow pine forests, was formerly more widespread

Table 10. Fishes Known To Occur in Ocoee No. 1 Reservoir

	Common Name	Scientific Name	Abundance[a]
Sport species	green sunfish	Lepomis cyanellus	R
	warmouth	L. gulosus	C
	bluegill	L. macrochirus	C
	longear sunfish	L. megalotis	A
	redear sunfish	L. microlophus	R
	smallmouth bass	Micropterus dolomieui	R
	largemouth bass	M. salmoides	R
	white crappie	Pomoxis annularis	C
	black crappie	P. nigromaculatus	C
	yellow perch	Perca flavescens	R
	rainbow trout	Oncorhynchus mykiss	?
Commercial species	channel catfish	Ictalurus punctatus	C
Other species	gizzard shad	Dorosoma cepedianum	C
	central stoneroller	Campostoma anomalum	R
	common carp	Cyprinus carpio	C
	golden shiner	Notemigonus crysoleucas	R
	striped shiner	Notropis chrysocephalus	C
	white sucker	Catostomus commersoni	C
	northern hogsucker	Hypentelium nigricans	C
	redhorses	Moxostoma spp.	C
	mosquitofish	Gambusia affinis	C
	black bullhead	Ictalurus melas	R
	yellow bullhead	I. natalis	C
	brown bullhead	I. nebulosus	C
	brook silverside	Labidesthes sicculus	R
	bigmouth buffalo	Ictiobus cyprinellus	?
	spotted sucker	Minytrema melanops	?

a. Abundance rating based on historical occurrence (1951 to 1984) in TVA rotenone samples indicated by: R--rare (occurring in less than 10 percent of all samples); C--common (occurring in 10 to 90 percent of all samples); or A--abundant (occurring in more than 90 percent of all samples).

in Tennessee and the Ocoee population is the only extant one known in the state. Specimens of the mountain redbelly dace (Phoxinus oreas) were collected during the early 1970s in Indian Creek (a tributary to Ocoee No. 1 Reservoir) and Maddens Branch (a tributary to the Ocoee River between Ocoee No. 2 Powerhouse and Ocoee No. 1 Reservoir). This fish species, considered by the state of Tennessee to be of "in need of management," prefers small, well-shaded upland streams with undercut banks and pool areas.

Trophic Status

Although nutrient concentrations in Ocoee No. 1 Reservoir are relatively low, conditions in other TVA tributary reservoirs with similar nutrient concentrations suggests that phytoplankton growth in Ocoee No. 1 is not nutrient-limited. Consequently, use of TVA's tributary reservoir trophic state index on Ocoee No. 1 is not strictly appropriate (Placke, 1983). Light penetration during the summer tends to be good, but this is largely a function of the paucity of the phytoplankton. TVA's hypothesis is that primary productivity in this reservoir is limited by toxic concentrations of metals. Based on the barely detectable rates of primary productivity noted during the intensive survey of 1982-83, this reservoir is "ultra-oligotrophic" by most standards, and is certainly one of the least eutrophic in the TVA system. However, anecdotal evidence of decreasing water clarity and increasing fish populations in recent years suggest that Ocoee No. 1 Reservoir may be becoming significantly more productive.

STATUS OF RESERVOIR USES

Designated Use Classifications

The state of Tennessee has classified the waters of the Ocoee Reservoirs for the following uses: fish and aquatic life, recreation, industrial water supply, livestock watering and wildlife, and irrigation. The waters of Ocoee No. 1 Reservoir from the dam at mile 11.9 upstream to mile 17.0 are also classified for use as a domestic water supply.[1]

Each use classification has water quality criteria that are used to judge whether the conditions of each water body are adequate to support the designated use (table 11). In Tennessee's 1988 305(b) report to Congress, Ocoee Reservoirs Nos. 2 and 3 were listed as "not supporting" designated uses. Ocoee No. 1 Reservoir was listed as "not supporting" designated uses on 189 acres and "partially supporting" designated uses on 378 acres.

The Ocoee River from the Ocoee No. 3 powerhouse upstream to Rock Creek is also a designated trout stream. This designation was based on a minimum DO of 6 mg/l and a maximum temperature of 68 F. However, other water quality and flow characteristics prevent this section of the Ocoee from actually sustaining a trout population. Several tributaries to the Ocoee Reservoirs system (Big Creek, East Fork Caney Creek, Clear Creek, Goforth Creek, Rough Creek, both Rock Creeks, and Sylco Creek) are also designated trout streams and do support natural or stocked trout populations. Goforth Creek, Rough Creek, and Sylco Creek are routinely stocked with trout by the Tennessee Wildlife Resources Agency.

Existing and Potential Uses

Evaluation of Use Support

TVA reservoirs often have existing and potential uses that are not specifically recognized in the designated stream use classifications issued by the state regulatory agencies. Uses of TVA reservoirs that may not be not adequately protected under designated use classification systems with their associated water quality criteria include providing fish for human consumption, providing habitat for sensitive threatened or endangered species, hydropower generation, flood control, and various other uses discussed below. Identification of this broad range of potential uses and evaluation of the suitability of the water resource

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1. This use classification for the reach from mile 17.0 upstream to the Tennessee-Georgia state line was deleted in 1982.

Table II. Selected Water Quality Criteria Applicable to the Ocoee River Reservoirs

Parameter	Use Classification[a]					
	DOM	IND	F&AL	REC	IRR	LW&W
Dissolved oxygen (mg/l)	(sufficient to prevent odors of decomposition)	(sufficient to prevent odors of decomposition)	5.0 nontrout waters 6.0 trout streams	(sufficient to prevent odors of decomposition)	(sufficient to prevent odors of decomposition)	(sufficient to prevent odors of decomposition)
pH (standard unit)	6.0–9.0	6.0–9.0	6.5–8.5	6.0–9.0	6.0–9.0	6.0–9.0
Temperature (°C)	30.5 max	30.5 max	30.5 nontrout waters 20 trout streams	30.5 max	NS[b]	NS
Fecal coliforms (No./100 ml)	1000 GM[c] 5000 instantaneous		1,000 GM	200 GM 1000 instantaneous		
Cadmium (µg/l)	10	NS	NS	NS	NS	NS
Chromium (µg/l)	50	NS	NS	NS	NS	NS
Copper (µg/l)	1000	NS	NS (40)	NS	NS	NS
Iron (µg/l)		NS	(1000)			
Lead (µg/l)	50	NS	NS	NS	NS	NS
Manganese (µg/l)			(750)			
Mercury (µg/l)	0.2	NS	NS	NS	NS	NS
Nickel (µg/l)	100	NS	NS	NS	NS	NS
Selenium (µg/l)	10	NS	NS	NS	NS	NS
Zinc (µg/l)	50	NS	NS (90)	NS	NS	NS
Total dissolved solids (mg/l)	500	500	NS	NS	NS	NS

a. DOM = domestic water supply
IND = industrial water supply
F&AL = fish and aquatic life
REC = recreation
IRR = irrigation
LW&W = livestock watering and wildlife

b. Not specified; generally a narrative criterion stating that the parameter must not interfere with that use of the water.

c. GM = geometric mean based on a minimum of 10 samples collected over a period of not more than 30 days.

for each use is an essential first step in managing the resource for the protection and enhancement of all beneficial uses.

For the purpose of this report, a use is considered *impaired* if any physical, chemical or biological characteristic of the water prevents use, diminishes the value of a use, or makes a use inadvisable. For designated uses, there are numerical water quality criteria that permit objective evaluation of whether a body of water is suitable for a particular use. However, the designated uses of TVA reservoirs and the associated water quality criteria vary somewhat from one state to another. Consequently, water quality criteria promulgated by the U.S. Environmental Protection Agency (EPA, 1986) are also cited to provide a broader perspective.

For evaluation of fish flesh contamination, this report uses EPA guidance, Food and Drug Administration (FDA) criteria, and, where available, state policy. The EPA guidance criteria developed pursuant to Section 304(a) of the Clean Water Act are based solely on human health considerations and are generally the most stringent of the criteria available. The EPA criteria have no regulatory impact, but were derived to provide guidance to the states. The FDA criteria, on the other hand, are based on human health considerations, estimation of economic impact on interstate commerce, and analytical detection limits. The FDA criteria have regulatory impact only in the realm of interstate commerce. In practice, the individual states may use the EPA guidance criteria, the FDA criteria, or develop original criteria to advise the public on the consumption of fish from intrastate waters.

In some cases, there are no numerical criteria for evaluating use impairment. Examples of such situations include evaluating the aesthetic quality of the water, assessing interference of mosquitoes or aquatic weeds with recreational use, or protecting the habitat of sensitive threatened or endangered aquatic species. In these instances, evaluation of whether a particular use is impaired based on technical judgment of TVA water resource professionals, coupled with acknowledgment of concerns expressed by the public.

Conditions impacting uses of the Ocoee Reservoirs are summarized in table 12 and discussed, by use, below.

Navigation

The Ocoee dams do not have navigation locks and most of the Ocoee River is not navigable by anything larger than a raft, kayak, or canoe.

Flood Control

The Ocoee Reservoirs are single purpose power projects; however, Ocoee No. 1 Reservoir is operated on a seasonal guide with a 7-foot

Table 12. Impacts on Existing Uses of the Ocoee Reservoirs.

Cause	Uses(s) Impacted	Effects(s)	Frequency	Extent	Severity	Level of documentation[a]
High suspended solids concentration	(1) power production	• loss of storage capacity	continuous	localized	unknown	3
		• excessive equipment wear	infrequent	localized	limits use	3
	(2) support for biological communities	• hydropower potential lost during sluicing	continuous	widespread	limits or precludes use	3
		• limits productivity				
	(3) boating	• mudflats limit boat access	seasonal	localized	limits use	3
	(4) sport fishing	• limits productivity	continuous	widespread	limits or precludes use	3
	(5) aesthetic quality	• water appears muddy	intermittent	widespread	affects quality of use	4
		• mudflats detract from scenic beauty	seasonal	localized	affects quality of use	4
PCBs	(1) sport fishing	• affects advisability of consumption of catch	continuous	unknown	not presently limiting use	2-L
Chemical spills	(1) swimming	• eye and skin irritation	infrequent	widespread	temporarily precludes use	3
	(2) boating	• whitewater rafting halted	infrequent	localized	temporarily precludes use	3
High metals concentrations	(1) support for biological communities	• limits productivity	unknown	widespread	unknown	2-L
	(2) sport fishing	• limits productivity	unknown	widespread	unknown	2-L
Low pH	(1) swimming	• possible eye irritation	essentially continuous	widespread	minimal impact on use	1-A
Elevated fecal coliform (FC) concentrations	(1) swimming	• USFS closes beaches when FC >200/100 ml	infrequent	localized	temporarily precludes use of beaches	1-L

Table 12 (Continued)

Cause	Uses(s) impacted	Effects(s)	Frequency	Extent	Severity	Level of documentation[a]
Temperature	(1) support for biological communities	• Ocoee No. 1 discharges are too warm for coldwater fishery, too cold for warmwater fishery	continuous	localized	minor impact	2-A
Flooding	(1) support for T&E species	• could alter habitat for Ruth's Golden Aster	infrequent	localized	unknown	4

a. 1 = data exceed criteria; 1-A = adequate database; 1-L = limited database;
2 = data exceed recommended levels; 2-A = adequate database; 2-L = limited database;
3 = impairment verified, but no criteria available or criteria inadequate to protect use;
4 = impairment not verified; assessment based on professional judgment.

annual pool elevation drawdown (long-term average) and thus may provide minimal incidental flood control benefits. The excessive sediment deposition occurring in Ocoee No. 1 Reservoir could eventually impact this incidental benefit.

Power Production

The Ocoee Dams and powerhouses provide slightly over two percent of the total hydropower generating capacity of the TVA system. The suspended sediment load of the Ocoee River causes accelerated wear of the turbines used in hydropower production. In addition, there is a loss of hydropower generating potential during sediment sluicing operations at Ocoee No. 3. Loss of reservoir storage volume has the potential to impact power production if inflow has to be passed through the reservoir rather than being held to meet power system needs as economically as possible.

Water Supply

There are no public drinking water supplies drawing from the Ocoee Reservoirs. YMCA Camp Ocoee has used Ocoee No. 1 Reservoir as a potable water supply in past years, but now uses a well. Use of the Ocoee Reservoirs for potable water supply would probably be impaired by excessive concentrations of suspended solids and metals, and possibly by low alkalinity and low pH.

The Tennessee Chemical Company facility withdraws water from two intakes near ORM 37.0, immediately upstream from Ocoee No. 3 Reservoir. Daily use depends on ambient temperature and may be as high as 60 million gallons per day. There are no industrial intakes directly in the Ocoee Reservoirs. Some potential industrial water supply uses could be impaired by excessive concentrations of suspended solids and metals, and possibly by low alkalinity and low pH.

There is no demand on the Ocoee Reservoirs for agricultural water supply. However, water quality is normally adequate for use for livestock watering and irrigation, although this use may be impaired during accidental spills of toxic substances in the Copper Basin or along railroads and highways in the drainage area.

Consumption of Aquatic Life and Wildlife

Because the aquatic life of the Ocoee Reservoirs is very limited, consumption of sport fish or wildlife that feed on aquatic organisms is minimal. Metals concentrations in fish tissue from Ocoee No. 1 Reservoir do not present a health hazard to the average sport fisherman who eats his catch (table 13). Selenium concentrations in catfish composites from Ocoee No. 1 Reservoir are higher than typically found elsewhere in the Tennessee Valley, but neither EPA nor FDA have proposed criteria for

Table 13. Metals and PCB Content of Fish Fillet Composites from Ocoee No. 1 Reservoir and Its Tributaries

	Concentrations (µg/g)								
	TVA 1984				TDHE 1984			TVA 1987	TVA 1988
	Upper reservoir		Lower reservoir		Near Ocoee No. 1 Dam			ORM 12	ORM 12
Parameters	Channel catfish (n=10)[a]	Largemouth bass (n=19)[b]	Channel catfish (n=10)[c]	Largemouth bass (n=10)[c]	Largemouth bass (n=5)	Channel catfish (n=4)	carp (n=3)	Channel catfish (n=5)	Channel catfish (n=5)
Antimony	<2.0	<2.0	<2.0	<2.0	NA[d]	NA	NA	<2.0	<2.0
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.02	0.03
Beryllium	<0.1	<0.1	<0.1	<0.1	NA	NA	NA	<0.02	<0.02
Cadmium	<0.1	<0.1	<0.1	<0.1	<0.02	0.04	0.17	0.01	<0.02
Chromium	<1.0	<1.0	<1.0	<1.0	2.8[e]	0.72	0.27	<0.02	<0.02
Copper	0.7	0.6	0.5	0.7	0.35	0.68	1.0	1.0	<2.0
Lead	<1.0	<1.0	<1.0	<1.0	<0.02	<0.2	0.25	0.04	0.1
Mercury	<0.1	0.3	<0.1	0.11	NA	0.04	0.05	<0.1	<0.1
Nickel	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	<1.0	<1.0
Selenium	0.65	1.3	1.2	3.6	NA	NA	NA	0.83	1.0
Silver	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	<0.2	<0.1
Thallium	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	<1.0	<1.0
Zinc	4.7	5.6	4.3	6.3	NA	NA	NA	6.4	6.0
PCBs	NA	NA	NA	ND[f]	ND	1.3	0	0.9	1.1

a. All specimens collected in main channel.
b. Seven specimens collected in tributary embayment, three in main channel.
c. All specimens collected in tributary embayment.
d. Not analyzed.
e. Value considered questionable; blending process in sample preparation may contribute some chromium contamination.
f. Not detected.

selenium in fish tissue. Although concentrations of PCBs in composites of Ocoee No. 1 Reservoir catfish do not exceed FDA's 2.0 µg/g tolerance for regulating interstate commerce, they do exceed EPA's recommended criterion of 0.0014 µg/g corresponding to an incremental lifetime cancer risk of 1:1,000,000. EPA's recommended criterion is substantially less than TVA's 0.1 µg/g detection limit for PCBs, however. Both selenium and PCB concentrations exceed the trigger level of 1.0 µg/g used in TVA's Valleywide Fish Tissue Screening Study project to recommend resampling the next year at the screening level. TDHE has not issued a consumption advisory on this fishery.

Recreation

Swimming and Wading: Nearly all of the Ocoee River from the upper end of Ocoee No. 3 Reservoir downstream to Ocoee No. 1 Dam is surrounded by Cherokee National Forest, and most of the developed public recreation areas are maintained by the U.S. Forest Service. Ocoee No. 1 Reservoir has developed areas for swimming and other body contact recreation, and the reservoir is estimated to receive nearly 200,000 recreational visits per year (1980 estimate). Two of the recreation areas on Ocoee No. 1 (Mac Point and Parksville Beach) have designated swimming areas. The U.S. Forest Service has occasionally closed these beaches when fecal coliform concentrations exceeded 200 per 100 ml. There are no fecal coliform data for any of the Ocoee Reservoirs collected with the frequency required to determine strict compliance with the Tennessee criteria (i.e., geometric mean of at least 10 samples over 30 days must not exceed 200 per 100 ml, and no individual samples may exceed 1000 per 100 ml). However, based on the data available, bacteriologic water quality of the Ocoee Reservoirs is normally adequate for body contact recreation.

Occasionally, pH values at some recreation sites on Ocoee No. 1 are less than Tennessee's minimum criterion of 6.0 for body contact recreation. Low pH values undoubtedly occur sporadically in Ocoee Nos. 2 and 3 as well. However, because of the low alkalinity of Ocoee Reservoir waters and the transient nature of the low pH excursions, this does not significantly impair use of the Ocoee Reservoirs for swimming or wading.

Recreational use of the whitewater reach downstream from Ocoee No. 2 Dam has occasionally been precluded by accidental spills of hazardous or toxic chemicals in the Copper Basin. A spill of N,N-dimethylaniline in September 1985 apparently caused a number of rafters to experience burning and itching eyes and skin.

Boating: Ocoee No. 1 Reservoir has the only accessible water for flat water boating. The only commercial marina in the area (Ocoee Inn) is located on Ocoee No. 1 Reservoir. Recreational use of Ocoee No. 1 Reservoir may occasionally be impacted by excessive turbidity, and access by boat to some areas of Ocoee No. 1 Reservoir is limited by sediment buildup.

During normal operation for power production, Ocoee No. 2 Dam diverts the Ocoee River from the natural streambed into a wooden flume that leads to the No. 2 Powerhouse. This leaves the natural streambed between the dam and the powerhouse dry except for the small amount of local inflow. The outstanding recreational potential of this section of the Ocoee River was largely overlooked until 1976, when flows had to be diverted from the wooden flume back to the natural streambed to accommodate renovation of the flume. Whitewater enthusiasts were quick to discover the class III and IV rapids generated when the river flows over the 4.5 mile reach with a gradient of 60 feet per mile. The conflict that ensued between the whitewater recreation interests and hydropower interests was resolved in 1983 by a $7.4 million Congressional appropriation to reimburse the TVA power system for the revenue losses incurred by providing recreational releases for 106 days per year. The appropriation is being repaid to the U.S. Treasury through recreation user fees collected by commercial whitewater outfitters.

Whitewater enthusiasts consider the Ocoee to be one of the top ten whitewater spots in the eastern United States. The Ocoee River has about 140,000 recreational visits per year, with 100,000 of those visitors rafting with one of the 24 licensed commercial outfitters. In 1982 and 1989, the Ocoee was the site of the National Slalom Championships and of the Annual Hot Dog Contest hosted by Perception Sports Equipment Company. In 1990, the Ocoee is to be the site of the U.S. Olympic trials for slalom and downriver racers.

The Tennessee Department of Conservation recently completed a study on the recreational carrying capacity (number of whitewater rafters and boaters that can be accommodated) below Ocoee No. 2 Dam (McDonald and Hammitt, 1989). The recreational carrying capacity of the Ocoee has not yet been reached; however, on some days (especially Saturdays in August), actual use approaches the established carrying capacity of 4,000 rafters per day. On such days, crowding of the facilities decreases the reported quality of the recreation experience according to the study. The study recommended that the rafter put-in and take-out facilities be expanded, and that TVA continue to restrict the number of outfitters permitted to operate on the Ocoee River.

Sport Fishing: Traditionally, the sport fishing in Ocoee No. 1 Reservoir has been very poor because of the impacts of sediment and toxic metals from the Copper Basin. In recent years, however, the fishery has shown signs of recovery. The Tennessee Wildlife Resources Agency now includes Ocoee No. 1 Reservoir in its weekly fishing report. In recent years, fishing for bass, trout and catfish has been characterized by Tennessee Wildlife Resources Agency as "good", while fishing for bream has been listed as "excellent." There are no recent creel data for Ocoee No. 1. There are no sport fishing opportunities in Ocoee Nos. 2 or 3.

Aesthetic Quality: The Ocoee Reservoirs are located in a densely wooded, mountainous region of Cherokee National Forest, which provides an aesthetically pleasing backdrop. The U.S. Forest Service has managed

development of private cabins on the shoreline so that they remain relatively unobtrusive. The aesthetic quality of the water is highly variable; at times, the suspended sediment load of the Ocoee River is great enough to make Ocoee No. 1 Reservoir and the upstream riverine reaches appear exceedingly muddy. During the low flows of summer, however, the clarity of the water in Ocoee No. 1 Reservoir is often very good.

Support for Biological Communities

Aquatic Life: The Ocoee River and reservoirs provide very poor aquatic habitat downstream from the Copper Basin. The sediments in the Ocoee Reservoirs are sandy, enriched with metals, and subject to transport whenever flows are high. Consequently, the benthos of these reservoirs is virtually nonexistent. In the riverine reaches from Ocoee No. 3 Dam downstream to the headwaters of Ocoee No. 1 Reservoir, benthic habitat is degraded by intermittent flows, extensive scour, and slick metal hydroxide precipitate on submerged rocks.

The Ocoee Reservoirs also provide poor aquatic habitat because of high concentrations of heavy metals. Concentrations of several metals (especially zinc) exceed EPA criteria for the protection of aquatic life. Light penetration in Ocoee No. 1 Reservoir is often exceptionally good but, probably because of excessive concentrations of metals, there is little development of primary producers to support a food web.

Several of the tributaries to the Ocoee Reservoirs are high quality trout streams that either support self-sustaining trout populations or are stocked by Tennessee Wildlife Resources.

Threatened and Endangered Species: The Ocoee Reservoirs proper do not provide any habitat for threatened or endangered species. However, Ruth's Golden Aster occurs in soil-filled crevices of boulders along the Ocoee near Ocoee No. 2 Powerhouse. This federally listed endangered plant could potentially be impacted by sediment sluicing activities at Ocoee No. 3 or by flooding. To protect this species, TVA limits discharges during sluicing operations to 1400 cfs.

Wildlife: Most of the land bordering the Ocoee Reservoirs is within Cherokee National Forest, which supports a diverse upland wildlife community. The reservoirs and their tributaries are an important source of water to game species such as the wild turkey and white-tailed deer. Waterfowl and wetland wildlife usage of the reservoirs is minimal. This is especially true on Ocoee Nos. 2 and 3, which are small and relatively steep-banked and provide little habitat for waterfowl and other wetland wildlife species. Use of the Ocoee Reservoirs by waterfowl is also limited by the reduced benthic macroinvertebrate populations. Even though Ocoee No. 1 is a relatively steep-banked reservoir, some emergent and scrub/scrub wetlands have developed in areas of silt deposition on the upper portion of the reservoir, especially near the mouth of Rock Creek. Occasionally, wading birds such as great blue herons use these shallow wetland habitats.

No routine waterfowl surveys have been conducted on the Ocoee Reservoirs. Ocoee No. 1 Reservoir receives limited use by migrating waterfowl, especially fish-eating species. The reservoirs also support a small population of breeding wood ducks. Increased use of the reservoirs by waterfowl and other wetland wildlife species will be dependent on an overall improvement in biological productivity in the system.

Commercial Fishery

There is no commercial fin, mussel or turtle fishery in the Ocoee Reservoirs, and with present conditions, a commercial fishery is unlikely to develop.

Wastewater Assimilation

Tennessee Chemical Company has had several large discharges of process and sanitary wastewater and cooling water to the Ocoee River and its tributaries immediately upstream from Ocoee No. 3 Reservoir. Water quality impacts of these discharges have been discussed in detail elsewhere (Cox, 1990). Tennessee Chemical Company recently declared bankruptcy, and the facility is presently being operated by Boliden Intertrade, a Swedish company. At the time of this printing, it is not clear how the change in ownership will affect operation at this site.

There are no permitted wastewater discharges to Ocoee Reservoirs Nos. 1 or 2. The only discharge directly to Ocoee No. 3 Reservoir is treated domestic wastewater from the 50,000 gallons per day package treatment plant at Copper Basin Industrial Park. The City of Copperhill, Tennessee (which also treats the wastewater from McCaysville, Georgia) discharges treated wastewater to the Ocoee about a mile upstream from Ocoee No. 3 Reservoir. Recent flooding (February, 1990) disrupted operation of the Copperhill wastewater treatment plant, but the damage to the plant was repaired by mid-March (Stewart, personal communication).

Generally speaking, existing water quality is not an impairment to increased use for assimilation of oxygen-demanding wastes.

Shoreline Usage

Nearly all the shoreline of the Ocoee Reservoirs is within Cherokee National Forest. The only private dwellings on the federally owned shoreline are those that were built before the U.S. Forest Service stopped granting special use permits. Federal ownership of the shoreline is the most significant limit on increased use of the shoreline for residential and commercial development. Pool drawdown of Ocoee No. 1 Reservoir during the winter is not marked enough to significantly impact shoreline usage.

The U.S. Forest Service operates five public use areas on the Ocoee Reservoirs and the Ocoee River between the reservoirs: Mac Point, Parksville Beach, and Parksville Lake Recreation Areas on Ocoee No. 1 Reservoir; Thunder Rock Recreation Area near Ocoee No. 3 Powerhouse; and Tumbling Creek Recreation Area, slightly upstream from Tumbling Creek embayment of Ocoee No. 3 Reservoir. The Tennessee Department of Conservation operates public whitewater access sites at Ocoee No. 2 Dam (rafter put-in) and at Caney Creek (rafter take-out). There are no significant water quality-related constraints on further development of shoreline for public use.

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01/31/91