4.5 Water Supply

4.5.1 Introduction

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

Resource Issues

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

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

- **Availability of Water Supplies.** Will implementation of a new reservoir operations policy change reservoir characteristics such that withdrawals for municipal and industrial uses are constrained?

- **Changes in Water Supply Delivery (Costs).** Will implementation of a new reservoir operations policy change reservoir characteristics in a manner that increases the cost of obtaining supplies, as expressed in pumping costs or costs for new or modified intake structures?

- **Changes in Water Supply Quality (Treatment).** Will implementation of a new reservoir operations policy change reservoir characteristics in a manner that degrades water supply quality and thereby limits water supply through increased treatment requirements?

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

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

4.5.2 Regulatory Programs and TVA Management Activities

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

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

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

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

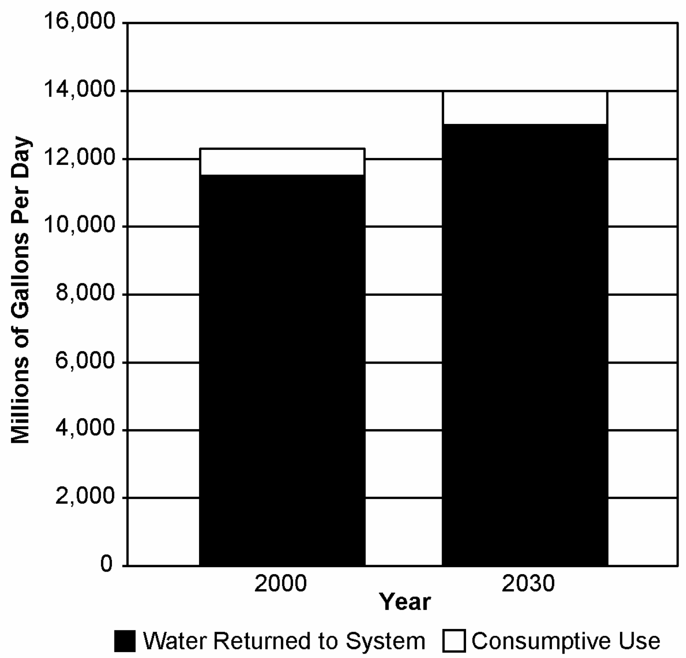
4.5.3 Water Supply Availability

Existing Conditions

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

In the study, demand for each use was defined in the context of changes in trends in consumption between 2000 and 2030 for reservoirs, tailwaters downstream from reservoirs, unregulated streams, and groundwater. The affected environment for water supply also was defined in terms of existing IBTs into and out of the Tennessee River watershed to provide a base for determining whether future IBTs would result in environmental consequences.

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

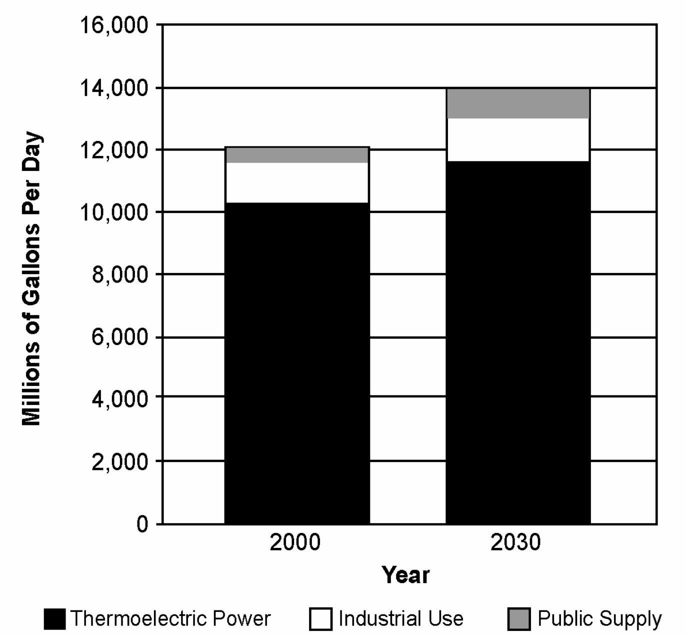


Source: Hutson et al. 2003.

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

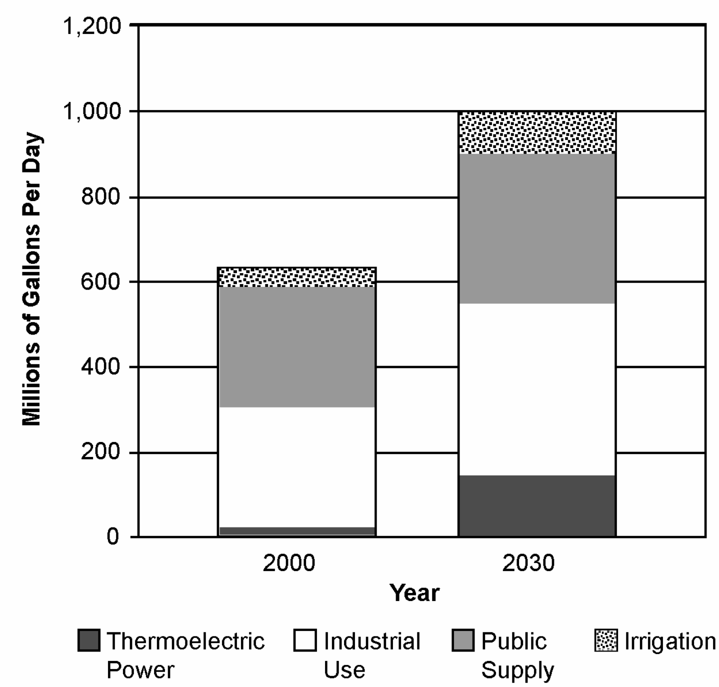
Figure 4.5-02 shows total water use in the Tennessee River watershed by category. Coal-fired and nuclear power generation used approximately 84 percent of the water in 2000; industrial use accounted for 10 percent; and public supply and irrigation accounted for 5 percent and 1 percent, respectively (Hutson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

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



Source: TVA data 2003.

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



Source: TVA data 2003.

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

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

Future Trends

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

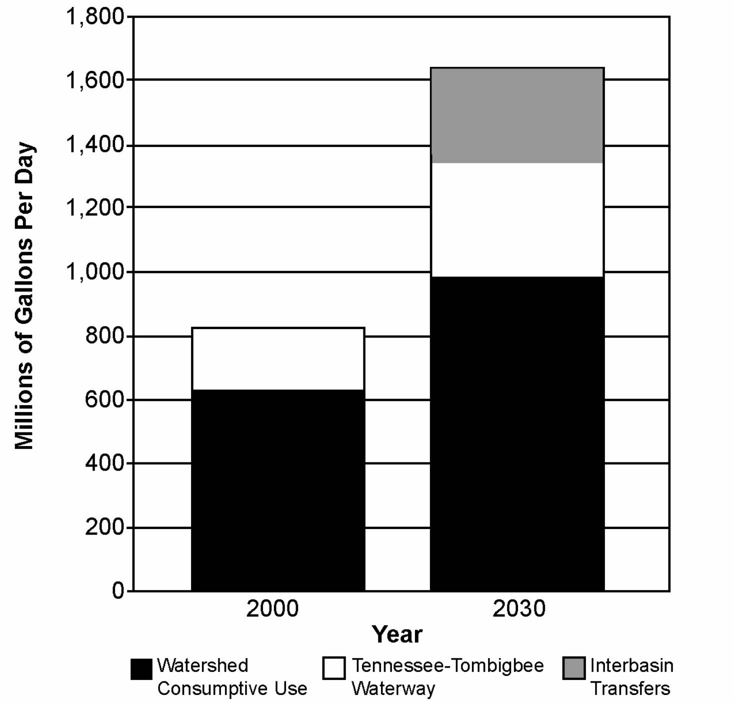
Consumptive use is expected to increase by 331 mgd (or 51 percent) over the next 30 years, as shown in Figure 4.5-03. This represents approximately 0.5 percent of total average winter river flow and 1.6 percent of average summer river flow (as measured at Kentucky dam). Almost 29 percent of the increase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

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

4.5.4 Water Supply Pumping Requirements

Existing Conditions

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



Note: No interbasin transfers occurred in 2000.
Source: TVA data 2003.

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

Future Trends

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

4.5.5 Water Supply Quality and Treatment

Existing Conditions

Public Supply

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

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

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

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

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

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

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

TVA has not conducted any studies to correlate reservoir operational conditions with the production of blue-green algae. Treatment plant operators interviewed also could not give guidance concerning when and how the blooms occur. There is some anecdotal evidence that stagnant water, during low-flow periods on isolated parts of the reservoirs and rivers feeding the reservoirs, might be the source of blooms. Treatment plant operators who add powdered activated carbon often trigger the start of the feeding season to water temperature.

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

Industry

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

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

Thermoelectric Generation

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

Future Trends

Public Supply

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

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

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

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

Industry

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

Thermoelectric Generation

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