2.4 HYDROLOGY, WATER QUALITY, AND AQUATIC BIOLOGY

2.4.1 General

The various uses of water in the Browns Ferry area have been investigated. Ground and surface hydrology has been studied to determine the characteristics of both ground and surface water flow in the immediate plant area and the surrounding regional area. Water quality and biological monitoring programs have been developed and implemented to monitor water quality and biological life of Wheeler Reservoir during plant operation.

2.4.2 Hydrology

2.4.2.1 Ground Water

Ground water at Browns Ferry is derived from precipitation. Some of the precipitation evaporates, some runs off into streams, and some seeps into the soil. A portion of the water entering the soil is used by vegetation and some of it seeps downward to become ground water.

2.4.2.1.1 Regional Area

Studies of subsurface waterflow in the area indicate that ground water flows from the structural highs toward the structural lows. Elevations range from 556 at Wheeler Reservoir to 880 in the east Central part of Limestone County. Rock strata have a regional dip of about 20 ft/mile to the south and southwest, locally altered by minor anticlines and synclines. Both topography and drainage reflect the geologic structure of the area.

Rocks exposed in Limestone County are, from oldest to youngest, the Chickamauga limestone, Chattanooga shale, Fort Payne chert, and Tuscumbia limestone. The principal aquifer for Limestone County is the Mississippian Carbonate Regional Aquifer. At this site, the aquifer consists of the Tuscumbia Limestone and the Fort Payne Chert.

A mantle of residuum overlies the Fort Payne and Tuscumbia formations. Wells deriving their supply from the residuum are of low capacity. The residuum in the area consists of a mixture of silt, clay, chert, and discontinuous zones of chert gravel. The residuum is capable of storing large amounts of water, which are released at a slow rate to wells, springs, and solution channels in the underlying bedrock.

Ground water occurrence is restricted to fractures and solutional cavities in the bedrock. Generally large yields can be anticipated from Tuscumbia and Fort Payne formations.

2.4.2.1.2 Site Area

Ground water movement from the regional area into the Browns Ferry site area is controlled by topography and geologic structure. Recharge is also derived from local precipitation that has percolated through the residuum. Natural ground water movement in the area is from the plant site to the Tennessee River.

2.4.2.2 Surface Water

Surface water is derived from precipitation remaining after losses due to infiltration and evapotranspiration. It can be generally classified as local surface runoff or streamflow.

2.4.2.2.1 Surface Runoff

Surface runoff in the area flows down Poplar Creek, Douglas Branch, and Round Island Creek to the Tennessee River.

2.4.2.2.2 Streamflow

Since 1937, the U.S. Geological Survey has maintained streamflow records on the Tennessee River at Whitesburg, Alabama, 40 miles above the Browns Ferry site. The average daily streamflow at Whitesburg for the period 1924 to 1987 has been 42,910 cfs. The maximum streamflow occurred on March 19, 1973, and was 323,000 cfs. The minimum daily streamflow, 400 cfs, occurred on July 24, 1966, due to regulation of Guntersville Dam. Generally, minimum daily flows are much higher.

Flow duration data for the period 1925-1980 were prepared by the U.S. Geological Survey.

A flow duration curve prepared from flow data observed during the time period between 1925 and 1980 shows that streamflows equal or exceed the following values for the indicated percentages of the time:

Flow (cfs)	Percent of Time
2,000	99.7
3,000	99.5
10,000	96.2
15,000	90.7
28,000	67.9
42,000	35.8

Streamflow data for water years 1960 through 1964 indicate an average flow of about 32,000 cfs during the summer months and about 76,000 during the winter months.

Channel velocities at the Whitesburg gage average more than two feet per second under normal winter conditions and a little more than 1 ft/sec under normal summer conditions.** These average winter and summer velocities drop to about 0.7 ft/sec and 0.3 ft/sec, respectively, at Browns Ferry where the reservoir is wider and the slope of the water surface is less.

A flood equal to the maximum of record would produce average velocities up to 4 ft/sec in the channel and up to 2 ft/sec in the overbank area. Average velocities produced by a maximum probable flood, regulated, would be about the same magnitude.

A location plan and cross-sections of the reservoir at the silt ranges (SR), and adjacent to the plant site are presented in Figures 2.4-1a through 2.4-1e. A longitudinal channel profile throughout Wheeler Reservoir is presented in Figure 2.4-2. The figure also identifies the sources of dependable watershed drainage with direct inflows into Wheeler Reservoir.

Failure of Wheeler Dam would require Browns Ferry plant to be shut down. The postulation of this event required an investigation into the effectiveness of the remaining reservoir to provide adequate cooling water for the plant. If Wheeler Dam were to fail, a pool of water approximately 1000 feet wide and seven miles long (SR22 to SR31 on Figures 2.4-1b through 2.4-1e) would be available at the Browns Ferry plant site. The water would be trapped by a 529-ft elevation at the SR22 station. The cross-hatched areas on Figures 2.4-1b through 2.4-1e represent a trapped volume of about 69.6×10^6 cubic feet of water. The largest diffuser pipe reaches almost across the original river channel and extends above El. 529 for its full length. Thus, the trapped pool following a postulated failure of Wheeler Dam is essentially divided into two parts with about 33 percent downstream and 67 percent upstream of the diffusers.

The silt range profiles were taken from a survey made in August 1961; these profiles have been confirmed by 15 additional detailed silt range surveys made in August 1969 and a survey of SR24 and SR25 made in September 1989.
The results of six silt range surveys made over a 33-year interval (October 1936, May 1947, May 1953, June 1956, August 1961, and August 1969) confirm that the silting rate is insufficient to require extensive surveys at frequent intervals. This is consistent with findings from TVA's system-wide silt survey studies. Decisions about

** Velocity data obtained from "Tennessee River Computed Navigation Channel Velocities," TVA, July 1963.

future updates for the cross sections around Browns Ferry and the frequency of the update are based upon this review. Since silting is the only mechanism for significantly reducing the volume of water available in the pool, this surveillance program will ensure against undetected decreases in pool volume. Silt transport during drawdown following a Wheeler Dam failure should not be a serious problem because of the large number of deep water pools upstream of the plant site.

The minimum-of-record inflows from the dependable watershed drainages upstream of the Browns Ferry site and downstream of Guntersville Dam are as follows:

Source (cfs)	Years of Record	Year of Minimum Flow	Minimum Flow
Paint Rock River	1936-1987	1954	1.3
Flint River	1930-1981 1983-1987	1931	44
Indian Creek	Miscellaneous Data Measurements 1959-1972 1975-1987	1987	1.2
Limestone Creek	1939-1970	1962	8

These minimum flows are combined with the leakage flow from Guntersville Dam to give a minimum flow of 100 cfs in the original river channel. This total flow, in traversing the pool created at the Browns Ferry site by the failure of Wheeler Dam, would have an average residence time of about 11-1/2 days.

The Browns Ferry plant intake and discharge arrangements are shown in Figures 12.2-69 through 12.2-75b, sheets 1, 2, and 3. The intake channel to the pumping station is excavated to El. 523 and extends into the reservoir until it connects with the original channel where the aforementioned pool would be trapped. The pumping station floor elevation is at 518 which gives a minimum of 11 ft of water inside the structure. (Eleven feet of water provides adequate submergence for the RHR service water pumps to deliver the shutdown cooling water requirements of 36,000 gpm (80 cfs) to the plant. This is sufficient flow to remove the decay heat from all three reactors plus the heat rejection from eight diesel generator sets operating at full load.) All of the cooling water is discharged from the plant through either the RHRSW diffuser nozzles upstream of the CCW diffusers or the storm sewer into the intake forebay.

Heat rejection from the plant would result in a temperature distribution in the downstream portion of pool. Upstream diffusion of hot water will be retarded by the restricted communication between the two portions of the pool. A combined heat rejection from Browns Ferry plant of the decay heat from all three reactors and the heat rejection from four diesel generator sets operating at full load will produce thermal rises of the river, based on minimum flow (100 cfs), as follows:

Time after Shutdown	River Thermal Rise
10 hrs	23°F
1 day	18°F
5 days	11°F

As another alternative, an evaluation was made of the heat removal capacity of the downstream portion of the pool. The study showed that 3 times the heat rejected at 10 hours could be removed without exceeding an average temperature of 115°F, with zero wind velocity, and no credit for heat dissipation by flow out of the lower pool.

In summary, if Wheeler Dam were to suddenly fail, the Browns Ferry plant would be shut down and maintained in a safe condition indefinitely. If the minimum flow previously discussed were not available, measures would be taken as necessary to provide at least this minimum flow through Guntersville Dam.

2.4.2.2.3 Floods

The Browns Ferry site is located on the right bank of Wheeler Reservoir at approximately Tennessee River mile (TRM) 294. The lowest natural ground elevation in the site vicinity is about 560 feet above mean sea level and the average ground elevation is about 580.

The probable maximum flood (PMF) at Browns Ferry is calculated to reach El. 571.7. However, the site PMF level is being maintained at elevation 572.5. This is the flood which defines the upper limit of potential flooding at the plant. A concise definition of PMF is given in Section 1.2, while the determination of PMF is described in Appendix 2.4A.

2.4.3 Water Quality

Information reflecting the water quality, water temperature, and aquatic biota conditions in the vicinity of the Browns Ferry Nuclear Plant (BFN) were incorporated into the Final Environmental Statement, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Volumes 1, 2, and 3, TVA Office of Health and Safety, Chattanooga, Tennessee, September 1, 1972. Results of the preoperational water monitoring program for the period 1968 through 1973 are included in the report "Water Quality and Biological Conditions in Wheeler Reservoir Before Operation of Browns Ferry Nuclear Plant - 1968-1973." Results of the operational monitoring program for the period 1974 through 1980 were included in a series of five semiannual reports followed by five annual reports. The last report including the 1980 monitoring results was "Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant January 1, 1980-December 31, 1980," Volumes I and II.

These monitoring and reporting requirements under the jurisdiction of NRC were determined to be duplicative of the requirements imposed by the Browns Ferry NPDES permit (AL 0022080) issued on June 30, 1977. In response to TVA's letter dated July 27, 1981, NRC notified TVA of their concurrence with this determination by letter dated December 10, 1981, and accepted TVA's recommendation to delete these monitoring requirements from the Browns Ferry Environmental Technical Specifications. All subsequent water quality, biological, and thermal monitoring and reporting have been and will continue to be in accordance with the requirements of the Browns Ferry NPDES permit (Permit No. AL 0022080) and/or TVA policy.

The most recent comprehensive evaluation of the aquatic conditions of Wheeler Reservoir is contained in the report "A Supplemental 316 (a) Demonstration For

Alternative Thermal Discharge Limits For Browns Ferry Nuclear Plant, Wheeler Reservoir, Alabama," TVA, February 1983.

2.4.4 Water Use

The public and industrial water supplies which withdraw surface water from the Tennessee River in the 61-river mile reach from Decatur, Alabama to Colbert Steam Plant, not including Browns Ferry Nuclear Plant, are listed in Table 2.4-4.

2.4.4.1 Industrial

Major industrial water users are located both upstream and downstream of the Browns Ferry project. These users withdraw water from Wheeler Reservoir each day for process and cooling needs. Most of this water is subsequently returned to the reservoir.

2.4.4.2 Public

The major public uses of the reservoir are for water supplies, recreation, and waste disposal. Six public water supplies are taken directly from the Tennessee River portion of Wheeler, Wilson, and Pickwick Reservoirs within the reach from Decatur, Alabama, about 12 river miles upstream from the plant, to Colbert Steam Plant, about 49 river miles downstream from the plant. Eleven industrial supplies also withdraw water from the reservoirs in this same reach, and some use a portion of their withdrawal for potable water within the plant.

2.4.4.3 Browns Ferry Nuclear Plant

The Browns Ferry Nuclear Plant will use a large volume of water. When all three units are in operation, river water will be pumped through the plant at the rate of about 4,400 cfs. The temperature of this water will be elevated above its natural temperature. Heated condenser cooling water will be diffused into the main channel flow of the Tennessee River by a Diffuser System consisting of three perforated pipes laid side by side on the bottom of the channel near TRM 294. The Diffuser System is detailed in paragraph 12.2.7.5.

The containment, treatment, storage (including quantities), and pathways for release of liquid radiological effluents at BFN are detailed in Section 9.2 Liquid Radwaste System.

The nearest community surface water supply is at Decatur, Alabama, on Wheeler Reservoir 12 miles upstream from the Browns Ferry site. With normal operation of Guntersville and Wheeler Dams, there would be no flow upstream from Browns

Ferry that would reach Decatur. Should a slug release (i.e., a finite volume of contaminant released nearly instantaneously into a receiving waterway) occur at a time when upstream flow to Decatur could conceivably occur, the river control system could be operated to prevent the upstream flow.

The first downstream water intake is the West Morgan-East Lawrence Water Authority intake located at TRM 286.5 on the left bank of Wheeler Reservoir. An analysis was made to determine the minimum dilution to be expected between the diffusers and the intake at West Morgan-East Lawrence for both accidental slug and continuous plane source releases. The following assumptions were used in the analysis.

1. Because the water intake is located on the bank opposite the plant, minimum dilution would occur when the release is fully mixed over the cross section of the reservoir. This is accomplished by configuring the release as a plane source placed vertically across the width of the channel.

2. Mixing calculations are based on steady flow conditions in the reservoir. River flow is assumed to be 33000 ft^3/sec. This is the flow which is equaled or exceeded in the reservoir approximately 50 percent of the time.

3. The concentration profile from an instantaneous (i.e. slug) release of contaminant is assumed to be Gaussian in the longitudinal direction.

4. The calculated contaminant concentration is conservative. Material discharged into the river does not degrade through radioactive decay, chemical or biological processes, nor is contaminant removed from the reservoir by adsorption to sediments or by evaporation.

All results are given in units of relative concentration, expressed as C/C_0 where C represents the concentration of contaminant at the point of interest, and C_0 is the concentration of contaminant at the point where it enters the reservoir. Dilution is the reciprocal of relative concentration.

The maximum relative concentration at the West Morgan-East Lawrence Water Authority intake due to a continuous plane source release rate Q (ft^3/sec) of contaminant is $3.0\ Q \times 10^{-5}$. The maximum relative concentration at this location due to an instantaneous plant source release of a volume V (ft^3) of contaminant is $3.2\ V \times 10^{-10}$. For the instantaneous relative concentration, the following parameter values were used:

channel width = 6000 ft,
channel depth = 35 ft,

longitudinal dispersion parameter = 200,
mixing coefficient (manning's n) = 0.03.

At the time of initial plant licensing, there were no private ground water wells located within one mile of the reactor building, and there were only eight houses located within one mile of the site perimeter which relied on groundwater as a source of water supply. Because all local groundwater in the plant site area flows directly to Wheeler Reservoir (see Section 2.4.2.1), it is improbable that any liquid released from the site could contaminate these sources of water supply through contamination of groundwater. Furthermore, with the containment provided for the liquid radwaste system (see Section 9.2), there is little likelihood of the release of liquid radwaste to the groundwater. In the event of any unusual release of radwaste liquid which could contaminate groundwater at the site, special local monitoring will be carried out in accordance with the Radiological Monitoring Plan, Browns Ferry Nuclear Plant, to ensure that the use of these wells will not result in undue hazards to any person, even though there is little likelihood of the wells becoming contaminated.

With the very unlikely event that the private wells located within one mile of the site perimeter could become contaminated, the public and industrial groundwater supplies in the site vicinity (all of which are located well beyond one mile from the site) would not be expected to be affected by plant operation. Consequently, the contamination of public and industrial groundwater supplies is not a concern at Browns Ferry requiring the monitoring and/or inventorying of such supplies. However, a periodic inventory of the private wells located within one mile of the site reactor building will be conducted. Table 2.4-6 contains a list of the private wells as inventoried in 1989. Figure 2.4-3 shows the location of the private wells within one mile and two miles of the plant.

2.4.5 Aquatic Biota

The historic aquatic biological conditions and their associated routine monitoring and reporting are identified in Section 2.4.3 Water Quality.

2.4.6 Monitoring Programs

All Browns Ferry related radiological water quality and aquatic biological monitoring programs are being conducted and reported in accordance with the Browns Ferry Nuclear Plant Radiological Environmental Monitoring Program as described in the Browns Ferry Offsite Dose Calculation Manual.

Since 1981, all nonradiological water quality, aquatic biological, and water temperature monitoring programs have been and will continue to be conducted and reported in accordance with the Browns Ferry NPDES permit (Permit No. AL

0022080) and/or TVA policy. (See Section 2.4.3 Water Quality for a discussion of these monitoring programs prior to 1981.)

2.4.7 Conclusions

Ground water movement in the area is from the plant site to the Tennessee River. The principal aquifer in the area is overlain by a mantle of residuum that retards the movement of shallow ground water. Migration of radionuclides in the residuum would be quite slow. It is highly unlikely that the private groundwater wells located within one mile of the site perimeter could be contaminated by operation of BFN. Special local groundwater monitoring of these wells would be implemented in the event of a liquid radioactive release to the groundwater at BFN. Consequently, the potential for contamination of the public and industrial groundwater systems in the BFN area is not a concern which requires monitoring or inventorying of these systems. A periodic inventory of private wells within one mile of the site area will be implemented. Surface water runoff from the plant site is to the Tennessee River.

Surface water runoff from the plant site is to the Tennessee River. Regulated by the TVA flood control system, the probable maximum flood would result in increasing Wheeler Reservoir level to 572.5 feet above sea level at the site. Safety-related structures are protected against all flood conditions up to El. 578 as discussed in response to Question 2.6 and would not be endangered by the probable maximum flood.

All nonradiological water quality, biological, and thermal monitoring and reporting related to BFN has been and will continue to be conducted in accordance with the requirements of the NPDES permit and/or TVA policy.