5.2 WATER-RELATED IMPACTS

This section provides information that describes the hydrological alterations, plant water supply, and water-related impacts of facility operations at the Clinch River Nuclear (CRN) Site. Water-related impacts from facility operations are addressed in the following subsections:

- Hydrologic Alterations and Plant Water Supply (5.2.1)
- Water-Use Impacts (5.2.2)

5.2.1 Hydrology Alterations and Plant Water Supply

This subsection presents an analysis of the impact of small modular reactor (SMR) operation on surface water and groundwater hydrology, as well as the sufficiency of the proposed water source to support facility operations.

5.2.1.1 Hydrologic Setting

5.2.1.1.1 Surface Water

A description of the hydrologic setting of surface water in the vicinity of the CRN Site is presented in Subsection 2.3.1.1. The CRN Site is located on the Clinch River arm of the Watts Bar Reservoir, which is the proposed water source and receiving water body for facility operations. The CRN Site is located on the reservoir between approximately Clinch River Mile (CRM) 14.5 and approximately CRM 19.0 (Reference 5.2-1). Within the CRN Site, the proposed surface water intake is located at approximately CRM 17.9, and the proposed discharge is located at approximately CRM 15.5.

Watts Bar Dam impounds the Watts Bar Reservoir. Watts Bar Dam is located on the Tennessee River at Tennessee River Mile (TRM) 529.9, approximately 52.4 river miles downstream of the CRN Site. The reservoir has approximately 722 miles (mi) of shoreline and over 39,090 acres (ac) of water surface (Reference 5.2-2). Water enters Watts Bar Reservoir from two primary sources: releases of water from the Melton Hill Dam on the Clinch River arm of the reservoir, and releases of water from Fort Loudoun Dam on the main body of the reservoir along the Tennessee River. Melton Hill Reservoir is located upstream of Melton Hill Dam, and releases water into Watts Bar Reservoir 4.1 mi upstream of the CRN Site. The Fort Loudoun Dam also releases water into Watts Bar Reservoir. Therefore, operations of both Melton Hill Dam and Fort Loudoun Dam can affect water levels and other characteristics on Watts Bar Reservoir. River flow direction at the CRN Site can be upstream, downstream, or quiescent, depending on the modes of operation of Melton Hill Dam, Watts Bar Dam, and Fort Loudoun Dam. For example, a flow reversal (upstream river flow) may occur from an abrupt shutdown of Melton Hill and Watts Bar Dams and by releasing water from Fort Loudoun Dam. (Reference 5.2-3)

The current operating policy of the Tennessee Valley Authority (TVA) river system, implemented in 2004, is defined by the TVA Reservoir Operations Study (ROS) (Reference 5.2-4). The daily average releases from Melton Hill Dam for 2004 through 2013 are shown in Figure 2.3.1-5. For this period, the overall average release from Melton Hill Dam, and consequently the expected approximate average river flow past the CRN Site during operations, is about 4670 cubic feet per second (cfs), equivalent to 2,095,896 gallons per minute (gpm). The maximum Melton Hill Dam daily average release observed for this period is about 21,700 cfs. The minimum single-day average release may be 0 cfs. The ROS guideline for the minimum daily average release over a 48-hour period from Melton Hill Dam is 400 cfs. The ROS guideline minimum daily average has been maintained since 2008, and, as discussed in Subsection 3.4.2.5, is ensured during SMR operations by installation of a continuous flow outlet (bypass) at Melton Hill Dam.

5.2.1.1.2 Groundwater

A description of the hydrogeological setting of groundwater in the vicinity of the CRN Site is presented in Subsection 2.3.1.2. The CRN Site is surrounded on three sides by the Clinch River arm of the Watts Bar Reservoir, which is likely to be the discharge area for CRN Site groundwater. The most likely pathway for groundwater flow is recharge in the upland areas with discharge to the Clinch River arm of the Watts Bar Reservoir. An alternate groundwater pathway is recharge in the upland areas with seepage to onsite drainages and surface water discharge into the Clinch River arm of the Watts Bar Reservoir. Natural discharge of the Valley and Ridge Province aquifers is primarily through streams, rivers, and springs. In the area of the CRN Site, the Clinch River arm of the Watts Bar Reservoir acts as a sink to which all groundwater migrates. Groundwater recharge is derived primarily from precipitation. Although periodic recharge from the Clinch River arm of the Watts Bar Reservoir during high stages of the reservoir may also be occurring, this is not considered to represent a significant part of the recharge to the aquifer.

5.2.1.2 Impacts of Facility Operations on Hydrology

5.2.1.2.1 Surface Water

Facility operations that could cause hydrological alterations to surface water include consumptive use of water from the reservoir, modification of shoreline stability, modification of wetlands or marshes by artificial fill, discharge of stormwater, and modification of flow or sedimentation characteristics as a result of Circulating Water System (CWS) intake and discharge flows.

The proposed water supply for makeup water to the CWS is surface water from the Clinch River arm of Watts Bar Reservoir. The water use from the reservoir is discussed in Section 3.3 and shown in Figure 3.3-1. The proposed intake withdraws an average of approximately 18,423 gallons per minute (gpm), and a maximum of approximately 30,708 gpm. Of this total, approximately 17,078 gpm average (approximately 25,608 gpm maximum) serves as makeup water for the CWS for the surrogate plant cooling towers. The proposed mechanical draft cooling towers consume some of this water through evaporation and drift. The average and maximum drift rate is 8 gpm, and the both the average and maximum evaporation rate is 12,800 gpm. For further explanation, see Subsection 3.4.1.4 for a discussion of average and maximum drift and evaporation rates. Of the water intake, 1345 gpm average (5100 gpm maximum) is directed to the plant and facilities, from which it is distributed to various auxiliary systems. The consumptive uses of water within these systems is negligible. The total blowdown rate for water which is proposed to be discharged to the holding pond from the CWS and auxiliary systems is an average of 4270 gpm, and a maximum of 12,800 gpm. Water from miscellaneous raw water uses, miscellaneous demineralized water users, and fire protection system is also discharged to the holding pond at an average rate of 445 gpm (maximum of 4200 gpm). Water from the holding pond along with water from the liquid radwaste treatment system is returned to the Clinch River arm of the Watts Bar Reservoir at an average rate of 5615 gpm and a maximum rate of 17,900 gpm.

Based on the average water withdrawal rate of 18,423 gpm discussed in the previous paragraph, and the average flow rate of 2,095,896 gpm in the portion of the reservoir adjacent to the CRN Site, the facility withdraws approximately 0.9 percent of the flow within the reservoir. Of this, the consumptive use of water is an average and a maximum of 12,808 gpm, which represents approximately 0.6 percent of the average flow rate. In the most conservative scenario, with a maximum water withdrawal rate of 30,708 gpm and a minimum daily average release of 400 cfs (179,520 gpm) from Melton Hill Dam, the facility withdraws approximately 17 percent of the daily average flow in the portion of the reservoir adjacent to the CRN Site, and approximately 7 percent of the daily average flow is consumed.

Considering Watts Bar Reservoir as a whole, these estimates are conservative, because the water released from Melton Hill Dam is not the only source of water for the reservoir. The Tennessee River below Fort Loudoun Dam comprises the main body of Watts Bar Reservoir and supports a much larger conveyance than that of the Clinch River arm of the reservoir. For example, for 2004 through 2013, the overall average release from Fort Loudoun Dam is about 18,310 cfs (compared to 4670 cfs for Melton Hill Dam). By comparison, the expected maximum consumptive use of water at the CRN Site, about 12,808 gpm (28.5 cfs), is essentially inconsequential compared to the combined average conveyances from Melton Hill Dam and Fort Loudoun Dam (0.1 percent). As such, hydrologic impacts of water consumption at the CRN Site on the overall flow and pool levels in Watts Bar Reservoir would be SMALL

As shown on Figure 3.4-3, the proposed intake system is constructed on the shoreline of the reservoir, along a length of approximately 50 feet (ft). Removal of sediment to maintain the intake during operations would be of a smaller scale than the shoreline excavation required for construction. In addition, removal of sediment to maintain the intake would be conducted following the same monitoring and consultation requirements as shoreline excavation during construction.

As discussed in Subsection 2.4.2.1.3, there are four perennial streams other than the Clinch River arm of the Watts Bar Reservoir, one intermittent stream, and 19 ephemeral steams/wet-weather conveyances (WWCs) on the CRN Site (Figure 2.4.1-2; (Reference 5.2-5)).

As discussed in Subsection 4.3.2.1, the current footprint of the planned permanent facilities would directly impact one small perennial stream (S01) and six WWCs (Figure 2.4.1-2 and Figure 4.3-1). Stream S01 is within the area to be occupied by the cooling water intake and the pipeline from the intake to the CR SMR Project. Impacts from intake and pipeline installation potentially would result in the permanent loss of the entire length of stream S01, approximately 925 ft of stream. Stream S01 is a small tributary to the Clinch River arm of the Watts Bar Reservoir. It is fed by a spring and small pond (P04) and flows through a small wetland (W008). Stream S01 is expected to be subject to the U.S. Army Corps of Engineers (USACE) jurisdiction. A biological survey of S01 in 2015 sampled the stream's entire length and found no fish and only a few small crayfish. (Reference 5.2-6) The WWCs located on the CRN Site are ephemeral drainages that flow only in response to precipitation runoff and do not support communities of aquatic organisms. The USACE has not made a final jurisdictional determination concerning the WWCs.

Given the small size of these features, permanent removal would not result in substantial hydrological impacts. The impacts to the stream would be further reduced by mitigation that likely would be required in accordance with USACE guidelines. In addition, the hydrologic function of these features in conveying stormwater from the CRN Site would be incorporated into the stormwater management system for the CRN Site.

There are currently stormwater runoff/collection ponds and associated piping on the CRN Site remaining from the Clinch River Breeder Reactor Project. Modifications to these ponds and piping would be made, as needed, to support the CR SMR Project. Stormwater would be managed in accordance with a site-specific Integrated Pollution Prevention Plan (IPPP). Stormwater best management practices are employed in the IPPP to prevent or minimize the discharge of pollutants with stormwater in accordance with all relevant permits and licenses such as the National Pollutant Discharge Elimination System (NPDES) industrial stormwater permit.

The proposed technology for the discharge is a submerged, bottom-mounted multiport diffuser. The basic diffuser design includes circular conduits aligned approximately perpendicular to the daily average flow in the river. The diffusers contain circular outlet ports situated in the upper, downstream quadrant of the diffuser conduits. The velocity of the flow discharging from the ports typically varies between approximately 8 and 10 ft per second. This diffuser technology is used at TVA nuclear power plants. The diffuser design meets objectives of maximizing thermal and chemical mixing while limiting local scour and the possible formation of problematic water velocities and flow patterns in the reservoir.

5.2.1.2.2 Groundwater

There are no facility operations that could cause hydrogeological alterations to groundwater. There is no proposed withdrawal of groundwater for use during operations. The impacts of dewatering during construction were discussed in Subsection 4.2.1.2, and were found to be SMALL. Any additional dewatering required during operations would be expected to be of a smaller scale than that required for construction. As discussed in Subsection 2.3.1.2.2.1, because surface water is abundant in the area, U.S. Environmental Protection Agency's (EPA) Sole Source Aquifer Program has not identified any sole source aquifers in Tennessee, and therefore there is no potential to impact Sole Source Aquifers. Based on these factors, operational impacts to groundwater hydrogeology would be SMALL.

5.2.1.3 Sufficiency of Water Supply for Facility Operations

5.2.1.3.1 Surface Water

As discussed in Subsection 5.2.1.2.1, the proposed facility withdraws an average of 0.9 percent of the average flow rate within the portion of the reservoir adjacent to the CRN Site. Of this, the most conservative scenario results in a consumptive use of approximately 7 percent of the minimum release from Melton Hill Dam. These are conservative estimates, as the water released from Melton Hill Dam is not the only source of water for the Watts Bar Reservoir. Although the continuous minimum release rate of 400 cfs from Melton Hill Dam is intended to ensure mixing of the thermal plume from the SMR, it is not necessary to provide adequate water supply for the SMR intake. Therefore, the Clinch River arm of the Watts Bar Reservoir has sufficient water available to support facility operations.

5.2.1.3.2 Groundwater

Because there is sufficient availability of surface water and no proposed use of groundwater, there are no impacts related to availability of groundwater for facility operations.

5.2.2 Water Use Impacts

This subsection presents an analysis of the water use impacts of SMR operation. These include the impact of operational water use on the availability of water for other users, and the impact of operations on water quality which could affect the use of that water by other users.

5.2.2.1 Water Availability

5.2.2.1.1 Surface Water

As discussed in Subsection 5.2.1.2.1, proposed facility operations require withdrawal of surface water to support the CWS and other plant systems. A portion of that water is consumed through evaporation and drift from the CWS, resulting in a localized net loss of water from the Clinch River arm of the Watts Bar Reservoir, and a regional net loss of water from the Tennessee River watershed. This net loss was evaluated for the potential to reduce the amount of water available to other users, including municipal and industrial users, recreational and navigational purposes, and aquatic ecology.

To evaluate the availability of water to support facility operations and potential impacts on other users, a Regional Surface Water Use Study was performed. Basin-wide water use was discussed in Subsection 2.3.2.1.1, and water use in the vicinity of the CRN Site was discussed in Subsection 2.3.2.1.3.

Potential local impacts to water availability on the Clinch River arm of the Watts Bar Reservoir, and in the Watts Bar Reservoir as a whole, were discussed in Subsection 5.2.1.2.1. That analysis demonstrated that the facility withdraws approximately 0.9 percent of the flow within the reservoir, and consumes approximately 0.6 percent of the average flow rate. In the most conservative scenario, the facility withdraws approximately 17 percent of the daily average flow in the portion of the reservoir adjacent to the CRN Site, and approximately 7 percent of the daily average flow is consumed. Based on this analysis, Subsection 5.2.1.2.1 concluded that hydrologic impacts of water withdrawal and consumption at the CRN Site on overall flow and pool levels in Watts Bar Reservoir would be SMALL. Because the hydrologic impact of water withdrawal and consumptive use of overall flow and pool levels would be SMALL, the impact on other local water users in the reservoir would also be SMALL.

Surface water is the primary water supply source for approximately 98.3 percent of the users in the Tennessee Valley watershed, including regional surface water users (Reference 5.2-3). Table 2.3.2-1 shows historical off-stream water use in the Tennessee River watershed from 1995 to 2010 and projected water use to 2035. Total water use peaked in 2005 and has decreased since then, mostly due to decline in water use for cooling at thermoelectric power plants.

TVA’s current reservoir operating policy was designed to meet the off-stream water needs of the Tennessee Valley out to the year 2030. The forecast of 2030 water needs was based upon a water use estimate prepared using year 2000 data. The estimates used to develop the reservoir operating policy were a total withdrawal in 2030 of 13,990 million gallons per day (mgd) (21,647 cfs) with a return of 13,010 mgd (20,131 cfs), for a net water demand of 980 mgd (1516 cfs). For the portion of the Clinch River arm of the Watts Bar Reservoir upstream of the CRN Site, the assumption used for the operating plan development was a net water demand 63 mgd (97 cfs) for 2030. (Reference 5.2-3)

As shown in Table 2.3.2-1, total water withdrawals are projected to decline approximately 21 percent by 2035. The current projection of water demand for the watershed for 2035 indicates a total withdrawal of 9449 mgd with a return of 8737 mgd, for a net water demand of 712 mgd. By category, water withdrawals are projected to change as follows: industrial withdrawals increase 31 percent to 1502 mgd, public supply withdrawals increase 30 percent to 938 mgd, and irrigation withdrawals increase 35 percent to 46 mgd. The 31 percent decline in thermoelectric water withdrawal is projected based on the anticipated retirement of older power plants, which utilize once-through cooling, and the introduction of new plants using closed-cycle cooling. The current 2035 net water demand projection for the Clinch River arm of the Watts Bar Reservoir upstream of the CRN Site is 26 mgd. (Reference 5.2-3)

The proposed SMR withdraws an average of 26 mgd (40 cfs) (44 mgd [68 cfs] maximum), which would increase the current projected total withdrawal within the Tennessee River Watershed to

9475 mgd (14,661 cfs) (9493 mgd [14,698 cfs] maximum). The proposed SMR withdrawal represents approximately 0.27 percent (0.46 percent maximum) of the current projected total withdrawal within the Tennessee River Watershed. The projected maximum consumptive water use from the CRN Site is 18 mgd (28 cfs). This increases the estimated projected net water demand to 730 mgd (1130 cfs) within the watershed and to 44 mgd (68 cfs) for the Clinch River arm of the Watts Bar Reservoir upstream of the CRN Site.

This proposed increase of net water demand represents approximately 2.5 percent of the current projected net water demand in the Tennessee River watershed. Both of these revised projections are within the initial projection estimates that were used in the development of TVA's reservoir operation system policy. Based on the above, the potential impacts of operation on other surface water users, both locally in the Clinch River watershed and regionally in the Tennessee River watershed, would be SMALL.

5.2.2.1.2 Groundwater

Groundwater is not used for safety-related systems or non-safety-related water supply purposes at the proposed CR SMR Project. There are no anticipated facility operation impacts to local groundwater resources (Reference 5.2-3).

5.2.2.2 Water Quality

As discussed in NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants Rev. 0, surface water quality impacts could occur from the concentration and discharge of chemicals added to the recirculating cooling water to prevent corrosion and biofouling, or from elevated temperatures in the discharge. The thermal impacts of the discharge are discussed in detail in Section 5.3. The other water quality impacts are discussed in this subsection.

Although cooling towers are considered to be closed-cycle cooling systems, concentrations of dissolved salts accumulate in the circulation system as a result of evaporative water loss. To maintain proper cooling, a certain percentage of the mineral-rich stream (blowdown) must be discharged and replaced with fresh water (makeup). In addition, cooling tower water chemistry must be maintained with anti-scaling compounds and corrosion inhibitors because cooling towers concentrate solids (minerals and salts) and organics that enter the system in makeup water. Similarly, a biocide must be added to the system to prevent the growth of fouling bacteria and algae.

The facility's wastewater discharges would be regulated by the Tennessee Department of Environment and Conservation (TDEC) through a NPDES permit. The anticipated constituents and their concentrations in the facility's non-radioactive liquid waste discharges are provided in Table 3.6-1, and the average and maximum flow rates for the discharges are discussed in Section 3.4 and Subsection 3.6.3.2. An NPDES permit includes discharge limits established to protect receiving waters, and monitoring to ensure compliance with those limits. Temperatures and chemical concentrations for all discharges would be in compliance with the terms and conditions of the NPDES permit. Biocides and chemicals used for water treatment are added in part per million concentrations, are used in accordance with a TDEC-approved Biocide/Corrosion Treatment Plan, and are largely consumed serving their purposes. TDEC takes the potential for these substances being in the discharge into consideration when establishing requirements for appropriate chemical parameter monitoring and acceptable limits in the NPDES permit. Therefore the impact from these discharges would be SMALL.

As shown in Figure 3.3-1, the projected blowdown flow rate for normal facility operations is an average of 4270 gpm, and a maximum of 12,800 gpm. An additional 445 gpm (average) and 4200 gpm (maximum) are discharged from miscellaneous power plant systems and fire protection system and 900 gpm (average and maximum) are discharged from the liquid radioactive waste system. The total discharge flow rate from the facility to the Clinch River arm of the Watts Bar Reservoir is 5615 gpm (average) and 17,900 gpm (maximum).

Subsection 2.3.1.1.2.4 presents the historical flow rate information for the Clinch River arm of the Watts Bar Reservoir. The release of water from Melton Hill Dam is the main source of water for flow in the Clinch River arm of the Watts Bar Reservoir at the CRN Site. The daily average releases from Melton Hill Dam for 2004 through 2013 are shown in Figure 2.3.1-5. For this period, the overall average release, and consequently the expected approximate average reservoir flow past the CRN Site, is approximately 4670 cfs. The minimum daily average release is 0 cfs. However, the development of the CR SMR Project includes implementation of a bypass structure at Melton Hill Dam to ensure a continuous release of at least 400 cfs.

On average, the CRN plant discharge is about 0.3 percent of the expected average reservoir flow past the plant, and about 3 percent of the minimum release from Melton Hill Dam. In the most conservative scenario, the maximum plant discharge represents about 10 percent of the reservoir flow past the plant when the maximum discharge occurs coincidentally with the minimum daily average release from Melton Hill Dam. However, even in this conservative situation, the characteristics and constituents of the plant discharge still are proposed to be managed within the water quality criteria specified in the plant NPDES permit. As such, water quality impacts would be SMALL.

5.2.3 References

Reference 5.2-1. Tennessee Valley Authority, "Watts Bar Reservoir Land Management Plan, Panel 4 Map," February, 2009.

Reference 5.2-2. Tennessee Valley Authority, Watts Bar Reservoir Website, Website: http://www.tva.com/sites/wattsbarres.htm, 2015.

Reference 5.2-3. Tennessee Valley Authority, "Clinch River Small Modular Reactor Site Regional Surface Water Use Study - Revision 2," April 24, 2015.

Reference 5.2-4. Tennessee Valley Authority, "Programmatic Environmental Impact Statement, Reservoir Operations Study," May, 2004.

Reference 5.2-5. Howard, Charles S., Henderson, Andrew R., and Phillips, Craig L., "Clinch River Small Modular Reactor and Barge/Traffic Site Evaluation of Aquatic Habitats and Protected Aquatic Animals Technical Report - Revision 4," Tennessee Valley Authority, November 20, 2015.

Reference 5.2-6. Henderson, Andrew R. and Phillips, Craig L., "Clinch River Small Modular Reactor and Barge/Traffic Site Stream Survey Report - Revision 2," Tennessee Valley Authority, November 20, 2015.