CHAPTER 6 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

Chapter 6 presents the details of the environmental monitoring programs that are instituted for the periods prior to application submission (site preparation), during construction, prior to operation (preoperational), and during operation of Clinch River Nuclear (CRN) Site. These monitoring programs establish a baseline of information that allows for the evaluation of future information and provide a method of quantifying the environmental effects of CRN Site operations.

The environmental measurements and monitoring programs are described in the following sections:

- Thermal Monitoring (Section 6.1)
- Radiological Monitoring (Section 6.2)
- Hydrological Monitoring (Section 6.3)
- Meteorological Monitoring (Section 6.4)
- Ecological Monitoring (Section 6.5)
- Chemical Monitoring (Section 6.6)
- Summary of Monitoring Programs (Section 6.7)

Monitoring details (e.g., sampling equipment, constituents, parameters, frequency, and locations) for each specific phase of the overall program are described in these sections.

Monitoring periods are defined as follows.

- Site Preparation Monitoring: These field monitoring and data collection activities are used to support the baseline discipline-specific descriptions presented in the environmental report.
- Construction Monitoring: These monitoring activities evaluate the impacts from site preparation and construction. These activities also detect any environmental impacts and allow comparison to Site Preparation baseline data for assessing the subsequent impacts of site preparation and construction.
- Preoperational Monitoring: These monitoring activities establish a baseline for identifying and assessing environmental impacts resulting from CRN Site operation.
- Operational Monitoring: These monitoring activities establish the impacts of plant operations and detect any environmental impacts.

6.1 THERMAL MONITORING

This section describes the thermal monitoring programs for surface water, which include site preparation monitoring to establish baseline conditions in water bodies potentially affected by the construction and operation of two or more small modular reactors (SMRs), and may include operational monitoring of Watts Bar Reservoir temperatures to identify potential impacts from operation of the SMRs.

6.1.1 Site Preparation Thermal Monitoring

Tennessee Valley Authority (TVA) used temperature monitoring data to obtain baseline information to characterize temperature regimes in the water body potentially affected by construction and operation of SMRs at the Clinch River Nuclear (CRN) Site. The baseline information was used to perform modeling of thermal impacts from the SMR discharge. The data also supports the assessment of circulating water system (CWS) discharge impacts to aquatic communities in Subsection 5.3.2.

A map showing the Clinch River arm of the Watts Bar Reservoir, CRN Site features (including intake and discharge locations), and thermal monitoring stations in close proximity to the CRN Site is shown in Figure 6.1-1. A map showing the locations of the thermal monitoring stations is provided in Figure 6.1-2.

The water body potentially affected by construction and operation of the SMRs is the Watts Bar Reservoir. The proposed intake structure for the CRN Site (CRM 17.9) is 5.2 miles (mi) downstream of Melton Hill Dam (CRM 23.1). The volume and temperature of water released from Melton Hill Dam is a significant factor in determining temperature conditions, and therefore potential thermal impacts, at the proposed discharge location at approximately CRM 15.5 (Reference 6.1-1). Therefore, temperature data from the Melton Hill Reservoir and further upstream also were collected as part of the thermal monitoring effort. Furthermore, to examine potential SMR thermal impacts throughout Watts Bar Reservoir, temperature data were collected downstream of the CRN Site on the Clinch River arm of the Watts Bar Reservoir, on the Emory River arm of the Watts Bar Reservoir, and on the Tennessee River (Watts Bar Reservoir) as far downstream as the discharge from Watts Bar Dam (Chickamauga Reservoir) and as far upstream as the forebay of Fort Loudoun Dam.

Thermal data for the Watts Bar Reservoir and the Melton Hill Reservoir are available from two separate sources: operational support monitoring and site preparation monitoring. Operational support monitoring includes data collection performed by TVA on an ongoing basis to support the operation of the TVA river system and TVA thermal power plants. Site preparation monitoring includes SMR-specific, interim, and temporary data collection performed by TVA to supplement the operational support monitoring. Information from both sources was used to support modeling of the thermal impacts from the SMR discharge.

As part of the routine reservoir operations data collection, water temperature is monitored in both reservoirs. This monitoring has included temperature measurements at 16 existing locations, which are shown in Figures 6.1-1 and 6.1-2 and summarized in Table 6.1-1. Of these locations, the closest to the CRN Site is the sample location near CRM 22.6. The sample near CRM 22.6 is located approximately 0.5 mi downstream of Melton Hill Dam, and represents the temperature of water released from Melton Hill Dam upstream of the proposed intake location, which is at approximately CRM 17.9. Temperature measurements at the 16 locations are made using a variety of different monitoring methods, including grab samples and dataware-plant monitors.

TVA also conducted additional site preparation thermal monitoring of the rivers and reservoirs in the vicinity of the CRN Site from October 2013 through December 2014. The purpose of this additional monitoring was to provide at least 12 months of additional data, consistent with NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan*, to assure that sufficient temperature data has been collected to characterize seasonal variations throughout an annual cycle. TVA collected field data to characterize river and reservoir conditions, and to provide additional input data for modeling simulations of the thermal effects of the proposed discharges associated with the construction and operation of the SMRs. Monitoring included temperature measurements upstream, adjacent to, and downstream of the CRN Site for one year, river velocity measurements under specified flow conditions, cross sections to define the river geometry, and monthly water quality sampling of Watts Bar Reservoir. Monitoring was conducted at 16 locations on the Watts Bar and Melton Hill Reservoirs. Of the 16 locations, three are on the Clinch River upstream of Melton Hill Dam, four are adjacent to the CRN Site, and nine are on the Watts Bar Reservoir downstream of the CRN Site. The sample location at CRM 16.1 provides temperature data near the proposed discharge location at approximately CRM 15.5. Temperature measurements were made at 15 minute intervals using monitors at multiple depths. The site preparation thermal monitoring locations are listed in Table 6.1-1, and are also shown in Figures 6.1-1 and 6.1-2.

The site preparation thermal monitoring data were used to establish baseline conditions, and to provide calibration data in two separate modeling efforts, one for thermal impacts in regions near the CRN Site (e.g., intake withdrawal zone and discharge mixing zone) and the other for impacts in regions beyond the CRN Site and throughout Watts Bar Reservoir.

The thermal impacts in regions near the CRN Site were evaluated using an unsteady, three-dimensional computational fluid dynamics (CFD) model for the portion of the Clinch River arm of Watts Bar Reservoir between approximately CRM 13 and CRM 21. The modeling effort for regions near the CRN Site used ambient river conditions based on temperature data from three of the operational support monitoring locations and one site preparation monitoring location. The operational support monitoring locations included the monitors on the taildeck of Melton Hill Dam at CRM 23.1, the monitoring location in the tailrace below the dam at CRM 22.6, and the monitoring locations downstream of the CRN Site at CRM 3.9, located near the Emory River confluence with the Clinch River arm of the Watts Bar Reservoir. The site

preparation monitoring locations included the monitoring location at CRM 16.1, which is located near the proposed discharge at approximately CRM 15.5. Data from the operational support monitors were used to develop a time history of the release temperature from Melton Hill Dam for the period of record including 2004 plus 2008 through 2013. For years 2005 through 2007, data were too sparse to develop a trustworthy record of the release temperature. Year 2004 was selected as the beginning of the historical record to be consistent with the current operating policy for the reservoirs on the Clinch River, which is expected to continue into the future. Prior to 2004, the reservoirs on the Clinch River were operated differently, resulting in potentially different seasonal variations in the Melton Hill Dam release temperature. Data for the monitors at CRM 22.6 and CRM 16.1 together were used to estimate the potential amount of summer heating and winter cooling in the Clinch River arm of the Watts Bar Reservoir between the Melton Hill Dam release and the CRN Site.

The modeling effort for regions beyond the CRN Site was conducted using CE-QUAL-W2, a general purpose water quality and hydrodynamic model for rivers and reservoirs. The applicablilty of the CE-QUAL-2 model to the SMR project was verified through a calibration study of the Watts Bar Reservoir, based on a comparison of model results and field measurements for the years 2004, 2008, and 2013. This model was used to assess the laterally-averaged, unsteady buildup of thermal effluent in the Clinch River arm of the Watts Bar Reservoir at the CRN Site, as well as the potential reservoir-wide effects, of operation of the SMRs. The CE-QUAL-W2 model was used not only to examine water temperature, but also to examine dissolved oxygen and algal biomass throughout Watts Bar Reservoir.

6.1.2 Construction and Preoperational Thermal Monitoring

Any discharges would be subject to monitoring to ensure compliance with a National Pollutant Discharge Elimination System (NPDES) permit, and this may include monitoring of the temperature of the discharge. Temporary discharges associated with construction is provided at combined license application (COLA), and will be defined in the NPDES permit application prior to construction. Because site preparation monitoring has been conducted to provide adequate baseline data, no additional preoperational monitoring is planned during construction.

6.1.3 Operational Thermal Monitoring

TVA used the results of the aforementioned unsteady, three-dimensional CFD model to evaluate the effect of operation of the SMRs for extreme summer and extreme winter conditions during various high-flow, low-flow, and reverse-flow events. The modeling results are depicted in Figures 5.3-3 through 5.3-6. The result concluded that the effects of the CRN Site thermal effluent from the SMRs could be managed within regulatory limits by defining a mixing zone of appropriate size for the discharge and by providing a minimum release from Melton Hill Dam. As discussed in Subsection 5.3.2.1, the latter requires a new outlet structure/bypass at the dam to provide the minimum release when the hydropower generating units at the dam are not in service.

The operational monitoring program remains to be developed, pending decisions regarding the design of the facility cooling system and related analyses of the impacts of the cooling system on the receiving water body. Discharge of cooling water and other effluents are subject to monitoring to ensure compliance with a NPDES permit, and this includes monitoring of the temperature of the discharge. Specific monitoring requirements, such as the number and location of monitoring stations, types of monitoring equipment and measurements, modeling, and thermal limits, will be developed in consultation with Tennessee Department of Environment and Conservation as part of the NPDES permit application process.

6.1.4 References

Reference 6.1-1. Tennessee Valley Authority, TVA Zone 5 and 6 Review Melton Hill, August, 2007.

Table 6.1-1 (Sheet 1 of 4)
Description of Thermal Monitoring Locations and Data Collection

Approximate Location by River Mile	Source of Thermal Data[1]	Description of Sample	Depth of Temperature Measurement	Start Date of Data Collection	End Date of Data Collection	Approximate Data Collection Frequency
TRM 529.9	TVA operational support	Release temperature from TVA hydro monitoring system at Watts Bar Dam (Reservoir Release Improvement).	Taildeck monitors on Units 1, 3, & 5	pre 1/1/2004	continuing	1 hour
TRM 529.9	TVA operational support	Release temperature at Watts Bar Dam for Watts Bar Nuclear Plant (Thermal Compliance) .	Taildeck monitor at depth about 5' on Unit 3	pre 1/1/2004	continuing	1 hour
TRM 530.1	SMR site preparation support	Onset remote (satellite) water temperature station on pontoon float in forebay of Watts Bar Dam.	Monitors at depths 3', 10', 20', 35', 50', 60', bottom	11/30/2012	2/20/2014	15-minute
TRM 532.5	TVA operational support	Temperature profile grab at about 2.6 mi upstream of Watt Bar Dam (Reservoir Ecological Health).	Grab depths vary from water surface to bottom among sampling dates	pre 1/1/2004	continuing	weekly to monthly from April to late August
TRM 567.0	SMR site preparation support	Onset remote (satellite) water temperature station on pontoon float just downstream of Clinch River confluence with Tennessee River.	Monitors at depths 3', 10', 15', 20', 30', & 40'	11/29/2012	2/3/2014	15-minute
TRM 602.2	TVA operational support	Release temperature from TVA hydro monitoring system at Fort Loudoun Dam (Reservoir Release Improvement).	Taildeck monitors at Units 1 & 4	pre 1/1/2004	continuing	1 hour
TRM 605.5	TVA operational support	Temperature profile grab at about 2.3 mi upstream of Fort Loudoun Dam (Reservoir Ecological Health).	Grab depths vary from water surface to bottom among sampling dates	pre 1/1/2004	continuing	weekly to monthly from April to late August
CRM 2.0	SMR site preparation support	Onset HOBO temperature string on tire float downstream of I-40 and Hwy 70 bridges.	Monitor depths 3', 5', 10', 15', 20', 25', & bottom	11/21/2012	2/3/2014	15-minute
CRM 2.6	SMR site preparation support	Onset HOBO temperature monitor on trash boom in KIF condenser discharge channel in King Creek Embayment, near CRM 3.0.	Monitor depth 3'	12/11/2012	12/19/2013	15-minute

Table 6.1-1 (Sheet 2 of 4)
Description of Thermal Monitoring Locations and Data Collection

Approximate Location by River Mile	Source of Thermal Data[1]	Description of Sample	Depth of Temperature Measurement	Start Date of Data Collection	End Date of Data Collection	Approximate Data Collection Frequency
CRM 3.9[2]	TVA operational support	Water temperature station on pontoon float just downstream of submerged dam and downstream of Emory River confluence with Clinch River for Kingston Fossil Plant (Thermal Compliance).	Monitor depths 5', 15, & 25'	11/1/2012	12/30/2013	1 hour
CRM 4.0	SMR site preparation support	Onset HOBO temperature string on tire float just upstream of submerged dam for Kingston Fossil Plant and downstream of Emory River confluence with Clinch River.	Monitor depths 3', 5', 10', 15', 20', 25', & bottom	11/21/2012	2/3/2014	15-minute
CRM 5.6	SMR site preparation support	Onset HOBO temperature string on tire float upstream of Emory River confluence with Clinch River, across the channel from Blackoak Ridge daybeacon.	Monitor depths 3', 10', 15', 20', 25', 30', & bottom	11/21/2012	2/3/2014	15-minute
CRM 13.0	SMR site preparation support	Onset HOBO temperature string on tire float downstream of transmission line crossing, and about 0.1 mi downstream of water intake of former K-25 gaseous diffusion plant. Actual location of temperature monitor is a bit downstream of CRM 13.0.	Monitor depths 3', 10', 20', & bottom	11/21/2012	2/5/2014	15-minute
CRM 16.1[2]	SMR site preparation support	Onset HOBO temperature string on pontoon float just downstream of Poplar Springs Creek and upstream of proposed SMR discharge. Instrumentation for stage and velocity also included at this location.	Monitor depths 5', 10', 15', & bottom	12/4/2012	2/20/2014	15-minute
CRM 16.2	SMR site preparation support	Onset HOBO temperature string on tire float in Poplar Springs Creek Embayment (creek empties into Clinch River near CRM 16.2).	Monitor depths 2' & bottom	11/21/2012	2/5/2014	15-minute
CRM 16.9	SMR site preparation support	Onset HOBO temperature string on tire float in Caney Creek Embayment (creek empties into Clinch River near CRM 16.9).	Monitor depths 3' & bottom	11/21/2012	2/5/2014	15-minute
CRM 19.0	SMR site preparation support	Onset HOBO temperature string about 1.1 mi upstream of SMR intake and about midway between Grubb Islands and Jones Island.	Monitor depths 3', 10', & 15'	11/21/2012	2/5/2014	15-minute

Table 6.1-1 (Sheet 3 of 4)
Description of Thermal Monitoring Locations and Data Collection

Approximate Location by River Mile	Source of Thermal Data[1]	Description of Sample	Depth of Temperature Measurement	Start Date of Data Collection	End Date of Data Collection	Approximate Data Collection Frequency
CRM 22.6[2]	TVA operational support	Onset remote (satellite) water temperature station on pontoon float in tailrace below Melton Hill Dam for Kingston Fossil Plant (Thermal Compliance).	Monitor depth 3'	5/1/2008	continuing	1-hour
CRM 23.1[2]	TVA operational support	Release temperature at Melton Hill Dam for Kingston Fossil Plant (Thermal Compliance).	Taildeck monitors at Units 1 & 2	pre 1/1/2004	12/31/2006, but very sporadic in 2005 & 2006	1-hour
CRM 23.5	SMR site preparation support	Onset HOBO water temperature station on pontoon float in forebay of Melton Hill Dam. Actual location of temperature monitor is closer to CRM 23.2.	Monitor depths 3', 6', 10', 20', 30', 50', & bottom	11/29/2012	2/10/2014	15-minute
CRM 23.5	TVA operational support	Temperature profile grab at about 0.4 mi upstream of Melton Hill Dam (Reservoir Ecological Health).	Grab depths vary from water surface to bottom among sampling dates	5/13/2004	continuing	bi-weekly to monthly
CRM 47.7	TVA operational support	Temperature monitoring for discharge of Bull Run Fossil Plant (Thermal Compliance).	After condenser discharge	pre 1/1/2004	continuing	1-hour
CRM 48.0	TVA operational support	Temperature monitoring for intake of Bull Run Fossil Plant (Thermal Compliance).	Before CCW pumps	pre 1/1/2004	continuing	1-hour
CRM 48.5	TVA operational support	Temperature string outside of skimmer wall for Bull Run Fossil Plant (Thermal Compliance).	Monitor depths 0.5', 2.5', 5' + Elev 789', 785', 781', 777', 773', & 771'	pre 1/1/2004	continuing	1-hour
CRM 66.3	SMR site preparation support	Onset HOBO water temperature monitor at Highway 61 bridge in Clinton, TN.	Monitor depth river bottom	3/27/2013	2/5/2014	15-minute
CRM 77.2	SMR site preparation support	Water temperature monitor at River Road boat ramp, about 3 mi downstream of Norris Dam and 0.9 mi downstream of the tailwater weir for Norris Dam.	Monitor depth about 3' depth	2/20/2013	11/21/2013	15-minute

Table 6.1-1 (Sheet 4 of 4)
Description of Thermal Monitoring Locations and Data Collection

Approximate Location by River Mile	Source of Thermal Data[1]	Description of Sample	Depth of Temperature Measurement	Start Date of Data Collection	End Date of Data Collection	Approximate Data Collection Frequency
CRM 77.2	TVA operational support	Water temperature monitor at River Road boat ramp, about 3 mi downstream of Norris Dam and 0.9 mi downstream of the tailwater weir for Norris Dam (Reservoir Releases Improvement) . Data available from TVA hydro monitoring system at Norris Dam.	Monitor depth about 3' depth	11/5/2012	continuing	1-hour
CRM 79.8	TVA operational support	Temperature profile grab at about 1 mi upstream of Norris Dam (Reservoir Ecological Health).	Grab depths vary from water surface to bottom among sampling dates	pre 1/1/2004	continuing	weekly to monthly from April to late August
ERM 1.8	TVA operational support	Temperature monitoring for intake of Kingston Fossil Plant (Thermal Compliance).	Monitors at depth between 15'-20' on Units 2, 5, & 8	pre 1/1/2004	continuing	1-hour
ERM 1.8	SMR site preparation support	Onset HOBO temperature string on tire float outside of intake channel skimmer wall.	Monitors depths 3', 10', 15', 20', 25', 30', & bottom	11/21/2012	2/5/2014	15-minute
ERM 5.0	SMR site preparation support	Onset HOBO temperature string on tire float at transmission line crossing, downstream of Little Emory River confluence with Emory River.	Monitor depths 3', 10', 20, & bottom	11/21/2012	2/5/2014	15-minute
ERM 18.3	TVA operational support	Temperature monitoring at Tennessee State Highway 299 bridge at Oakdale for Kingston Fossil Plant (Thermal Compliance). Located near U.S. Geological Survey stream gage 03540500, "Emory River at Oakdale".	Monitor depth river bottom	pre 1/1/2004	continuing	1-hour

1 TVA operational support refers to routine measurements from instrumentation systems providing data in support of the day-to-day operation of the TVA river system or TVA thermal plants. SMR site preparation support refers to supplemental, interim/temporary measurements provided, as needed, in support of any special studies to evaluate the environmental impact of the SMR plant on the source waterbody.

2 Data point used in site preparation hydrothermal impact analysis.

Notes:
TRM = Tennessee River Mile
CRM = Clinch River Mile
ERM = Emory River Mile

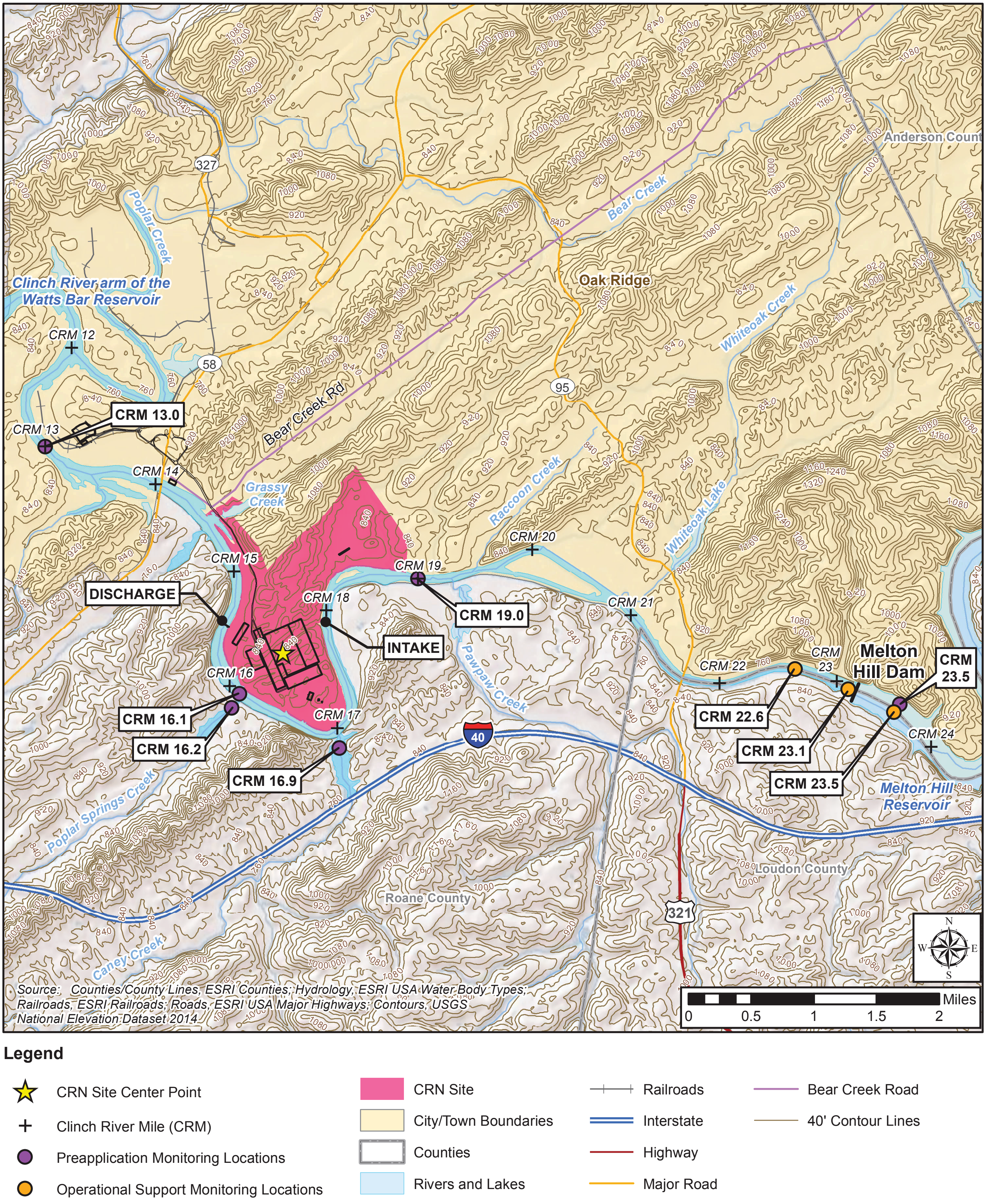


Figure 6.1-1. Thermal Monitoring Locations in Close Proximity to CRN Site

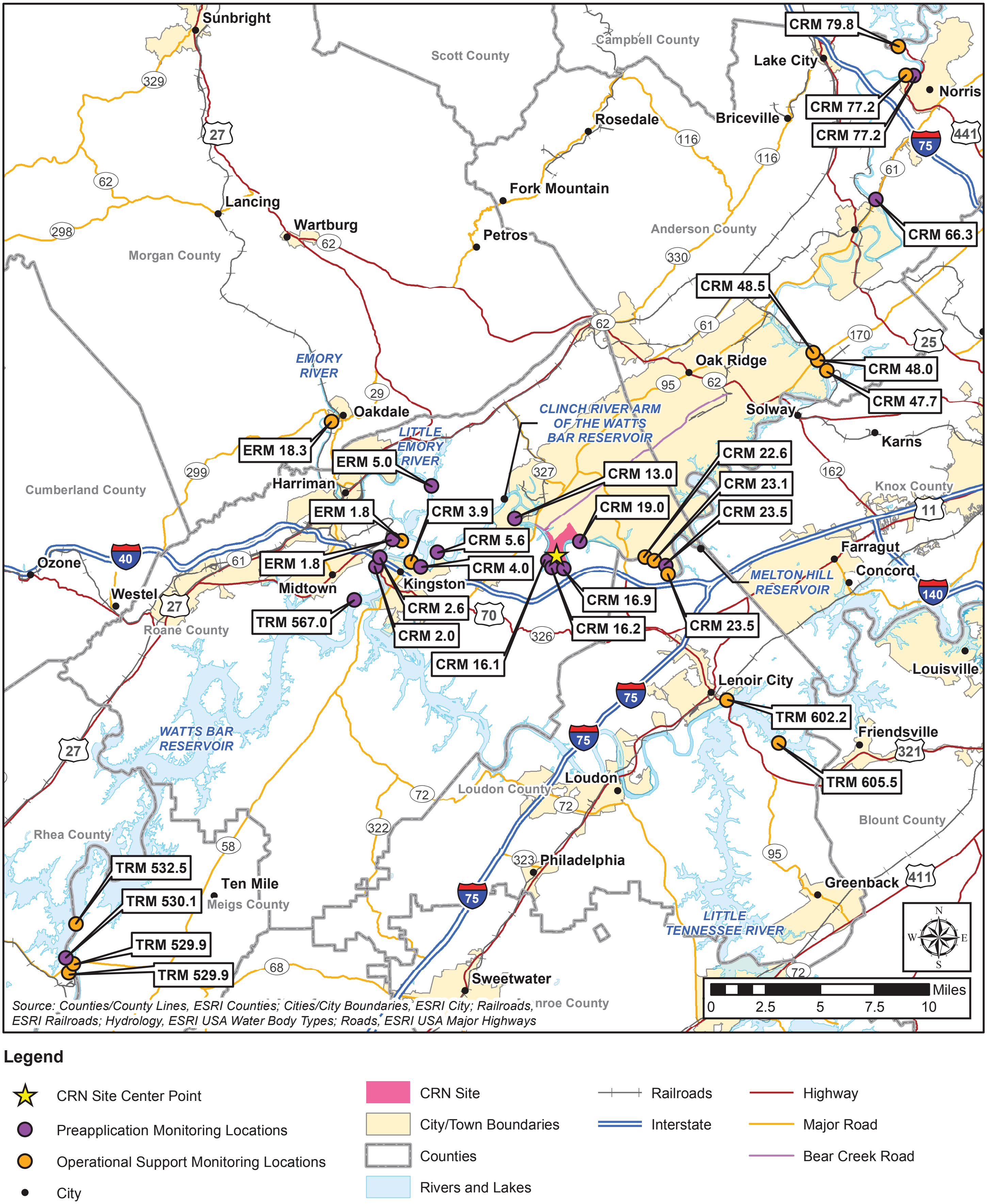


Figure 6.1-2. Thermal Monitoring Locations Used to Evaluate SMRs

6.2 RADIOLOGICAL MONITORING

A Radiological Environmental Monitoring Program (REMP) is used to support the preoperational and operational monitoring needs of a nuclear power plant and to provide baseline information prior to the commencement of plant operation. This section describes key points of a regulatory-compliant REMP and potential monitoring locations for the Clinch River (CR) Small Modular Reactor (SMR) Project.

6.2.1 Introduction

A REMP is designed to adequately characterize the radiological environment of the biosphere in the vicinity of a nuclear power facility. It provides data on measurable levels of radiation and radioactive materials in the site environs and provides baseline data on surveillance of principal pathways of exposure to the public. Programs are based on the guidance provided in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 4.1, *Radiological Environmental Monitoring for Nuclear Power Plants*, and the requirements of 10 CFR 20.1301. Preoperational monitoring programs are implemented two years before scheduled fuel load. The durations of the two-year preoperational programs for the various media at the Clinch River Nuclear (CRN) Site are given in Table 6.2-1. Because there are no radiological effluents during the preapplication, site preparation, preconstruction, or construction phases, radiological monitoring to assess the impact of radiological effluent releases is not necessary during those phases.

A REMP includes (1) the number and location of sample collection points and measuring devices, and the pathway sampled or measured; (2) sample collection frequency; (3) type and frequency of analysis; and (4) general types of sample collection and measuring equipment. The lower limits of detection for specific analyses are provided in the Off-Site Dose Calculation Manual (ODCM).

6.2.2 Radiological Environmental Monitoring Programs

A REMP is designed to monitor gaseous emissions and liquid effluents as well as direct radiation. The three primary sources of gaseous radioactive emissions include the gaseous radioactive waste management system, exhaust of non-condensable gases at the main compressor in the event of a leak from the primary system to the secondary system, and radioactive discharges from building ventilation exhaust. The plant vent provides the release path for containment venting releases and release from other design-specific areas such as the auxiliary building, the annex building, the radioactive waste building, the spent fuel building, and the gaseous radioactive waste system. In generic pressurized water reactor power block designs, the turbine building vents also provide a potential release path for the condenser air contaminated by a leak from the primary system to the secondary system. Liquid effluents are mixed with and diluted by the cooling tower blowdown before being discharged to receiving water bodies.

The REMP directs sampling of air, water, sediment, fish, invertebrates and food products, as well as measuring direct radiation. Milk samples are generally not monitored unless it is determined that milk-producing animals are present within 5 miles (mi) of a nuclear power facility. Tennessee Valley Authority's Clinch River land use census determined that there are no milk-producing animals currently present within 5 mi of the CRN Site. As stated in Subsection 6.2.2.2, the land use census is updated annually.

A REMP also includes sampling indicator and control locations within a 20-mi radius of the nuclear power facility. Indicator locations near the facility show any increases or buildup of radioactivity that might occur due to facility operation. Control locations farther away from the site are utilized to indicate the level of only naturally occurring radioactivity. Indicator results are compared to control and preoperational results to assess any impact the plant operation might have had on the surrounding environment. The lower limits of detection are provided in the ODCM.

6.2.2.1 Pathways Monitored

The following radiation exposure pathways are monitored as part of a nuclear power plant's REMP:

- Direct (dosimeters)
- Airborne (iodine and particulates)
- Waterborne (surface water and river sediment)
- Aquatic (fish tissue analysis)
- Vegetation (forage)

A description of the CR SMR Project monitoring and sampling locations to be utilized to monitor the exposure pathways is provided in Table 6.2-2 and approximate locations are shown in Figures 6.2-1 and 6.2-2. Monitoring locations consist of an inner ring of thermoluminescent dosimeters (TLDs) in the general area of the CRN Site with a TLD in each compass direction (T-1 through T-16), and an outer ring of TLDs located approximately 5 mi from the power block area (PBA; T-17 through T-32). In addition, particulate and airborne iodine are monitored close to the Site Boundary in the direction that has the highest calculated annual average ground level deposition. Monitoring is also provided at eight special interest locations identified in Table 6.2-2 (T-33 through T-40).

REMP sampling results and locations are evaluated to determine effects from seasonal yields and variations. Figures 6.2-1 and 6.2-2 show potential local (1-mi radius) and remote (5-mi radius) radiological sampling locations, respectively. Table 6.2-1 provides details of the radiation exposure pathways that are monitored during the preoperational period and the frequency of monitoring. Table 6.2-2 provides remote and local sample descriptions and potential locations. Table 6.2-3 provides the sampling frequencies as described in NUREG-1301, *Offsite Dose*

Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors.

The ODCM provides a detailed description of the monitoring program including number and location of sample collection points and measuring devices and the pathway sampled or measured, sample collection frequency and sampling duration, type and frequency of analysis, general types of sample collection and measuring equipment, and lower limit of detection for each analysis. Sampling media and sample size are defined in environmental monitoring and laboratory standard operating procedures.

Trending and comparison reviews provide information regarding changes in background levels and determine the adequacy of analytical techniques in light of program results and changes in technology, when being compared to baseline measurements. Changes in program implementation (including sampling techniques, frequencies and locations) may occur as a result of monitoring results.

Inter-laboratory comparison programs verify the accuracy and precision of radioactive analyses of environmental samples. These results are reported in an Annual Radiological Environmental Operating Report.

6.2.2.2 Land Use Census

A land use census is conducted annually, as required by the ODCM. The purpose of this census is to identify changes in land use within 5 mi of the CRN Site that require modifications to the REMP or the ODCM. This census also determines the location in each sector of the nearest residence, animal milked for human consumption, and garden of greater than 500 square feet producing broadleaf vegetation.

A land use census is conducted by:

- Field surveys in each meteorological sector out to 5 mi in order to confirm:
  - Nearest permanent residence
  - Nearest garden and approximate size
  - Nearest milking animal, if any
- Identifying locations on a map, measuring distances to the PBA and recording results on surveillance data sheets
- Comparing current census results to previous results
- Contacting the County Agent for verification of nearest dairy animals

6.2.3 Quality Assurance Program

A REMP is conducted in accordance with NRC RG 4.15, *Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations To License Termination) – Effluent Streams and the Environment*. Quality assurance is provided in the REMP through quality training, program implementation by periodic tests, the inter-laboratory comparison program, and administrative and technical procedures.

6.2.4 References

Reference 6.2-1. Tennessee Valley Authority, "Clinch River Small Modular Reactor Site Regional Surface Water Use Study - Revision 2," April 24, 2015.

Table 6.2-1
Duration of Preoperational Program for Specific Media

6 Months	1 Year	2 Years
Airborne iodine	Airborne particulates	Direct radiation
Iodine in milk[1]	Milk[1]	Fish and invertebrates
(while animals are in pasture)	(remaining analyses)	
	Surface water	Food products
	Groundwater	Sediment from shoreline
	Drinking water	

1 Milk samples are generally only collected if milk cattle are determined to be present within 5 mi of the CRN Site.

Table 6.2-2 (Sheet 1 of 3)
Potential Radiological Environmental Monitoring Program Sample Station Locations

Location	Description	Approx. Distance (mi)[1]	Direction Sector
Direct Radiation			
T-1	TLDs	0.2 (near power block area [PBA])	N
T-2		0.2 (near the PBA)	NNW
T-3		0.4 (near the entrance to the site)	NW
T-4		0.4 (near the holding pond)	WNW
T-5		0.2 (near the cooling tower)	W
T-6		0.2 (near the cooling tower)	WSW
T-7		0.2 (near the cooling tower)	SW
T-8		0.3 (near the cooling tower)	SSW
T-9		0.3 (near the cooling tower)	S
T-10		0.4 (near the holding pond)	SSE
T-11		0.2 (near the PBA)	SE
T-12		0.1 (near the PBA)	ESE
T-13		0.1 (near the PBA)	E
T-14		0.1 (near the PBA)	ENE
T-15		0.1 (near the PBA)	NE
T-16		0.1 (near the PBA)	NNE
T-17		5.0 (5-mi ring around the PBA)	N
T-18		5.0 (5-mi ring around the PBA)	NNW
T-19		5.0 (5-mi ring around the PBA)	NW
T-20		5.0 (5-mi ring around the PBA)	WNW
T-21		5.0 (5-mi ring around the PBA)	W
T-22		5.0 (5-mi ring around the PBA)	WSW
T-23		5.0 (5-mi ring around the PBA)	SW
T-24		5.0 (5-mi ring around the PBA)	SSW
T-25		5.0 (5-mi ring around the PBA)	S
T-26		5.0 (5-mi ring around the PBA)	SSE
T-27		5.0 (5-mi ring around the PBA)	SE
T-28		5.0 (5-mi ring around the PBA)	ESE
T-29		5.0 (5-mi ring around the PBA)	E
T-30		5.0 (5-mi ring around the PBA)	ENE
T-31		5.0 (5-mi ring around the PBA)	NE
T-32		5.0 (5-mi ring around the PBA)	NNE

Table 6.2-2 (Sheet 2 of 3)
Potential Radiological Environmental Monitoring Program Sample Station Locations

Location	Description	Approx. Distance (mi)[1]	Direction Sector
Direct Radiation			
T-33	TLDs	0.8 mi (near a close residence)	E
T-34		1 mi (close to residence)	W
T-35		0.8 mi (near a garden)	NE
T-36		4.7 mi (Oak Ridge National Laboratory)	NE
T-37		3.5 mi (Four Season Campground)	WSW
T-38		6.0 mi (Kingston Elementary School)	WSW
T-39		6.0 mi (Eatons Elementary School)	SE
T-40		2.5 mi (Poplar Springs Church)	WSW
Waterborne			
W-1	Surface Water	Approximately Clinch River Mile (CRM) 15.5 - Discharge Location	WNW
W-2		Approximately CRM 17.9 - Intake Location	NE
W-3	Groundwater	Samples to be taken from two of the 21 groundwater wells at the CRN Site if they are likely to be affected	TBD
W-4			TBD
W-5	Drinking	No drinking water samples are being taken because no water supplies would be affected by the discharge from the plant within 15 mi downstream	NA
W-6	Sediment from Shoreline	1.5 mi (Gallaher Recreational Area)	NNW
Airborne			
A-1	Airborne: Radioiodine and Particulates	Three samples from close to the three site locations, in different sectors, of the highest calculated annual average groundlevel D/Q; 0.25 mi (average D/Q 5.80E-08)	ENE
A-2		0.25 mi (average D/Q 5.98E-08)	ESE
A-3		0.25 mi (Average D/Q 5.49E-08)	SE
A-4		One sample from the vicinity of a community having the highest calculated annual average groundlevel D/Q 1 mi (D/Q 6.38E-09)	ESE
A-5		One sample from a control location, as for example 15 to 30 km from the site boundary, and in the least prevalent wind direction. As the least prevalent winds are from the NNW direction	SSE

Table 6.2-2 (Sheet 3 of 3)
Potential Radiological Environmental Monitoring Program Sample Station Locations

Location	Description	Approx. Distance (miles)[1]	Direction Sector
		Ingestion	
M-x	Milk	The survey done in accordance with the guidance provided in NRC NUREG-1301 did not find any locations where milk was being produced for human consumption	NA
F-1-x	Fish and Invertebrates	One sample of representative commercially and recreationally important species identified in the Table 2.4.2-1 to be taken from the vicinity of plant discharge area	TBD
F-2-x		One sample of representative commercially and recreationally important species identified in the Table 2.4.2-1 to be taken from area not influenced by discharge	TBD
FP-1	Food Products	One sample of each principal class of food products from any area that is irrigated by water in which liquid plant wastes have been discharged. Vegetation sampled during growing season.	TBD
FP-2		Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground level D/Q, if milk sampling is not performed. Vegetation sampled during growing season. 1 mi (D/Q 6.38E-09)	ESE
FP-3		0.75 mi (D/Q 5.57E-09)	NE
FP-4		One sample of each of the similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed. Vegetation sampled during growing season.	S

[1] All distances in the table are approximate and measured from the center of the site unless otherwise noted.

Notes:
T = TLD (direct radiation)
W = Waterborne
A = Airborne (particulates and iodine)
M = Milk
F = Fish
FP = Food Products (other than fish and milk)
km = kilometers
TBD = To Be Determined
NA = Not Applicable

Source: (Reference 6.2-1)

Table 6.2-3 (Sheet 1 of 2)
Site Preparation, Construction/Preoperational, and Operational Radiological Environmental Monitoring Program[1]

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations[2,3]	Sample and Collection Frequency[4]	Type and Frequency of Analysis[4]
1. Direct Radiation[5]	40 Monitoring Locations	Continuous monitoring with sample collection quarterly[6]	Gamma exposure rate – quarterly
2. Airborne Radioiodine and Particulates	Five Locations	Continuous sampler operation with sample collection at least weekly or more frequently if required by dust loading	Radioiodine Canister - Analysis for I-131 weekly Particulate Sampler - Gross beta radioactivity analysis following filter change[7]; Gamma isotopic analysis[8] of composite[7] (by location) quarterly
3. Waterborne			
a. Surface	Two Locations[10]	Monthly	Gamma isotopic[8] and tritium analysis monthly. Composite for tritium quarterly
b. Ground	Two Locations	Quarterly	Gamma isotopic[8] and tritium analysis Quarterly
c. Drinking[9]	None	None	
d. Sediment from Shoreline	One sample from downstream area	Semiannually	Gamma isotopic analysis semi-annually
4. Ingestion			
a. Milk	None	Semimonthly when animals are on pasture; monthly at other time	Gamma isotopic and I-131
b. Fish and Invertebrates	One sample of representative commercially and recreationally important species in vicinity of plant discharge and another sample from the area not influenced by the discharge.	Sample in season, or semiannually if they are not seasonal.	Gamma isotopic analysis[8] on edible portions.
c. I Food products (irrigation)	Samples depend on food products that are irrigated by the water in which the liquid wastes are discharge.	At the time of harvest.	Gamma isotopic analysis[8] and I-131 analysis.
c. II Food Products (broadleaf vegetation – near site)	Broadleaf vegetation grown nearest highest predicted annual average ground level D/Q	Monthly during growing season.	Gamma isotopic analysis[8] and I-131 analysis.

Table 6.2-3 (Sheet 2 of 2)
Site Preparation, Construction/Preoperational, and Operational Radiological Environmental Monitoring Program[1]

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations[2,3]	Sample and Collection Frequency[4]	Type and Frequency of Analysis[4]
c. III Food Products (broadleaf vegetation - background)	One sample of each of the similar broad leaf vegetation grown in the least prevalent wind direction.	Monthly during growing season.	Gamma isotopic analysis[8] and I-131 analysis.

1 Deviations are permitted from the required sampling schedule if specimens are unobtainable due to circumstances such as hazardous conditions, seasonal unavailability, and malfunction of automatic sampling equipment or other legitimate reasons. If specimens are unobtainable as a result of sampling equipment malfunction, corrective action shall be taken before the end of the next sampling period. All deviations from the sampling schedule will be documented in the Annual Radiological Environmental Operating Report pursuant to Control 1.4.

2 Specific parameters of distance and direction sector from the centerline of the plant vent stack and additional description where pertinent, will be provided for each and every sample location in tables and figure(s) in the ODCM.

3 At times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances, suitable alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the Radiological Environmental Monitoring Program given in the ODCM.

4 The following definition of frequencies shall apply to Table 6.2-3 only:

a. Weekly: Not less than once per calendar week. A maximum interval of 11 days is allowed between the collection of any two consecutive samples.
b. Semimonthly: Not less than 2 times per calendar month with an interval of not less than 7 days between sample collections. A maximum interval of 24 days is allowed between collection of any two consecutive samples.
c. Monthly: Not less than once per calendar month with an interval of not less than 10 days between collection of any two consecutive samples (maximum interval of 31 days).
d. Quarterly: Not less than once per calendar quarter (maximum interval of 92 days).
e. Semi-annually: One sample each between calendar dates (January 1 to June 30) and (July 1 to December 31). An interval of not less than 30 days will be provided between sample collections. The frequency of analyses is to be consistent with the sample collection frequency.

5 One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a TLD is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters.

6 Refers to normal collection frequency. Most frequent sample collection is permitted when conditions warrant it.

7 Airborne particulate sample filters are analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thorium daughter decay. In addition to the requirement for a gamma isotopic on a composite sample, a gamma isotopic is also required for each sample having a gross beta radioactivity which is >1.0 pCi/m^3 and which is also >10 times that of the most recent control sample.

8 Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

9 Discharges to the Clinch River arm of the Watts Bar Reservoir do not influence drinking water quality (see Subsection 5.2.2).

10 Offshore grab samples.

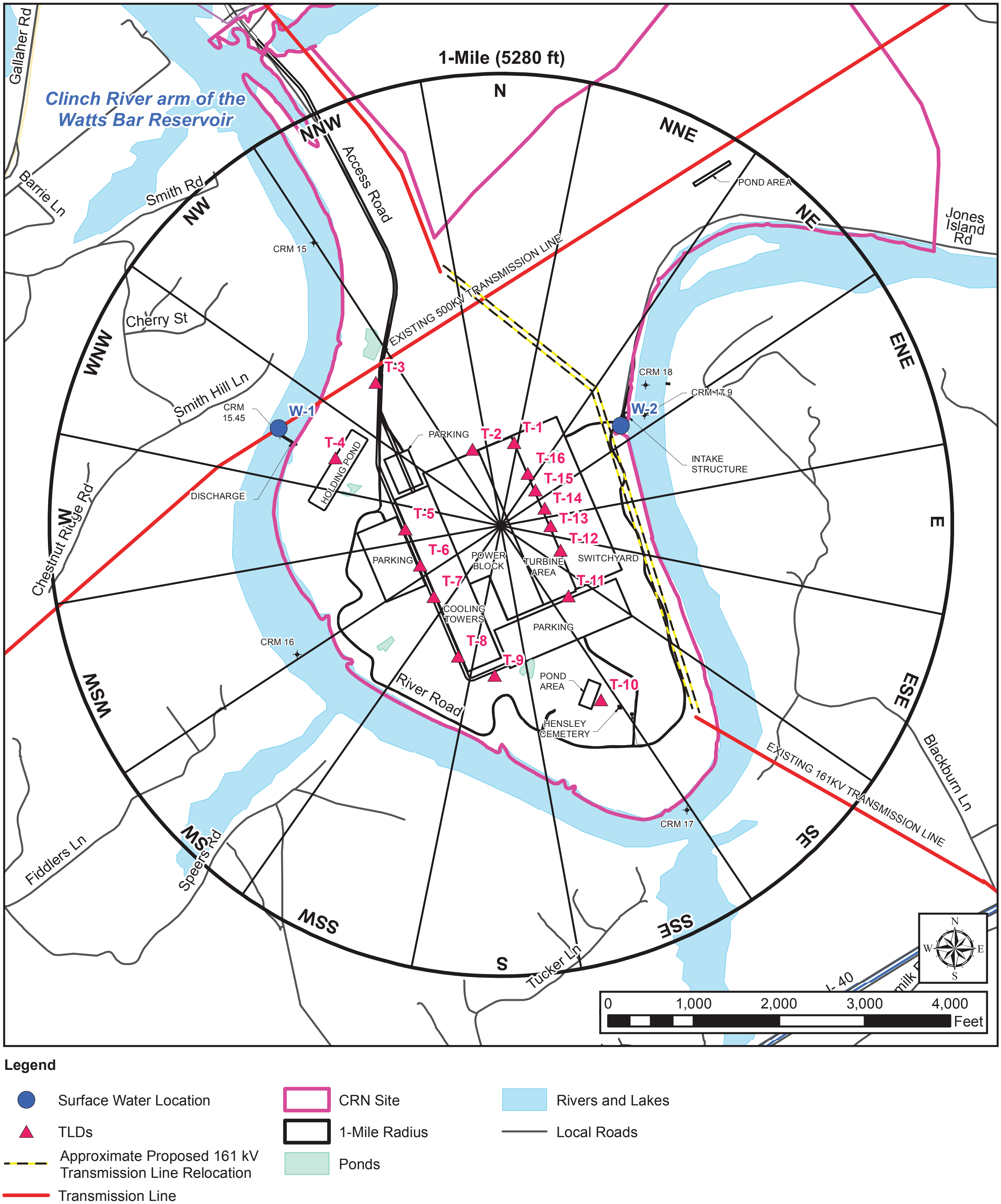
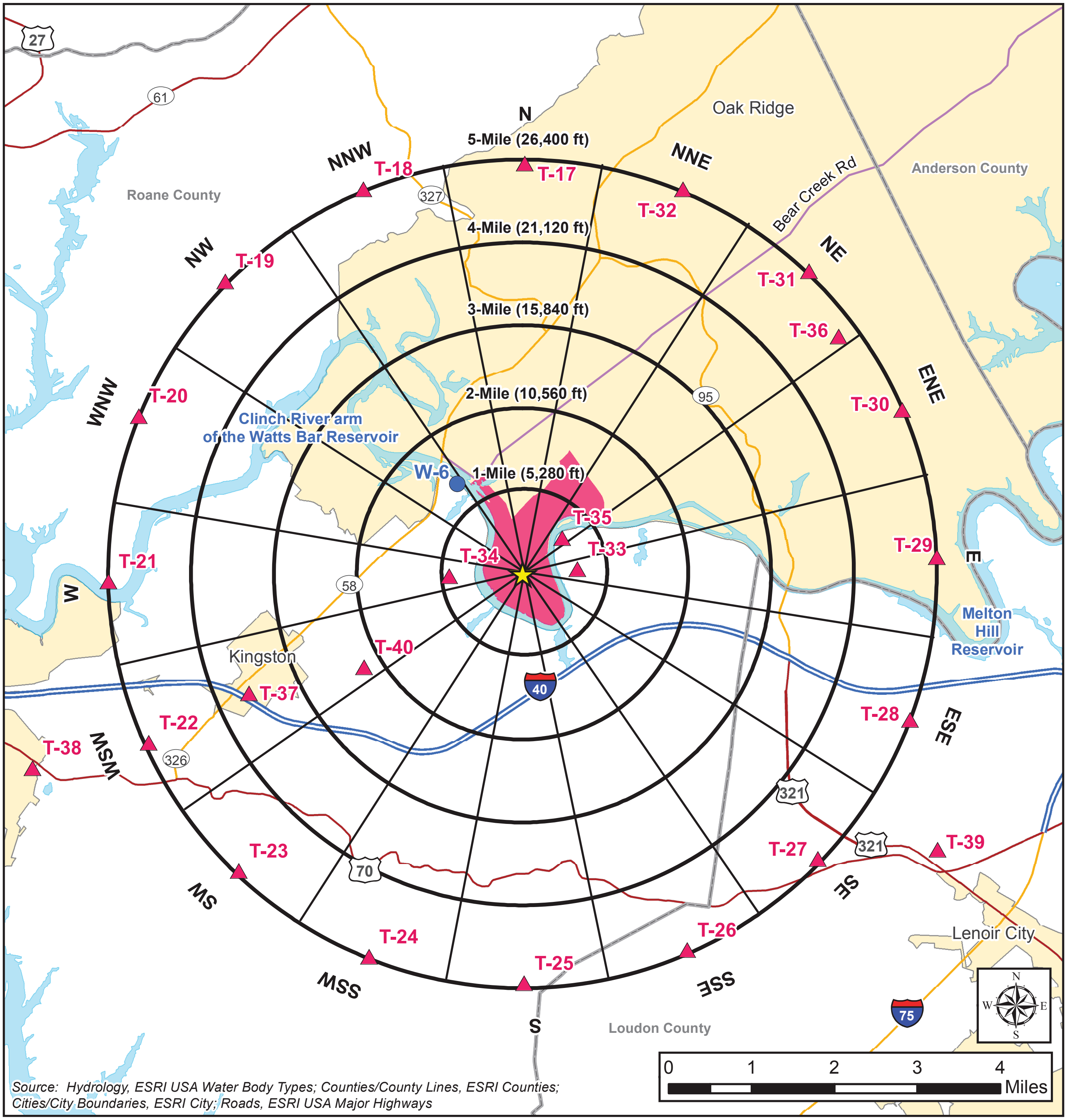


Figure 6.2-1. CRN Site Local Radiological Sampling Locations (1-Mile Radius)



Legend

- CRN Site Center Point
- Surface Water Location
- TLDs
- City/Town Boundaries
- Counties
- CRN Site
- Rivers and Lakes
- Interstate
- Highway
- Major Road
- Bear Creek Road

Figure 6.2-2. CRN Site Remote Radiological Sampling Locations (5-Mile Radius)

6.3 HYDROLOGICAL MONITORING

This section describes the hydrological monitoring program at the Clinch River Nuclear (CRN) Site. Discussions related to historic and current water use at and near the CRN Site are found in Subsections 2.3.2 and 2.3.3 and water use at the CRN Site for the Clinch River (CR) small modular reactors (SMR) Project is discussed in Section 3.3. Potential discharges from the CR SMR Project are discussed in Sections 3.4, and 3.6. Baseline environmental water quality is described in Subsection 2.3.3. As shown on Figure 3.3-1, effluent from the CRN Site discharges to the Clinch River arm of the Watts Bar Reservoir. Effluent discharges to navigable water bodies are governed by several regulations including the Clean Water Act (CWA), Title 40 of the Code of Federal Regulations (40 CFR) Part 122, 40 CFR Part 423, and state water quality standards. In order to discharge effluents to navigable streams, a National Pollutant Discharge Elimination System (NPDES) permit pursuant to Section 402 of the CWA is required. Prerequisites for obtaining an NPDES permit include collecting adequate baseline monitoring samples and providing a plan for collection of operational monitoring samples. The proposed hydrological monitoring program at the CRN Site is divided into four phases as outlined below:

1. Site preparation/preapplication monitoring on a seasonal basis to verify the existing hydrologic conditions, validate the design assumptions for hydrologic impacts, and validate the baseline hydrologic descriptions presented in Subsection 2.3.1.1.1
2. Construction monitoring to assess anticipated impacts from construction activities, and identify unexpected impacts
3. Preoperational monitoring to establish a post-construction baseline as a point of comparison in order to identify hydrologic impacts that may result from operation of the proposed SMRs
4. Operational monitoring to assess impacts to water quality resulting from operation of the SMRs

6.3.1 Site Preparation Monitoring

The purpose of the site preparation monitoring program is to provide data to support the assessment of potential impacts that may result from the construction and operation of the proposed SMRs at the CRN Site. The site preparation hydrologic monitoring process involved the collection and analysis process for surface water and groundwater data as described in Subsections 6.3.1.1 and 6.3.1.2, respectively.

6.3.1.1 Surface Water

The hydrology of the area around the CRN Site was described in Subsection 2.3.1.1.1. The following site preparation surface water monitoring tasks were conducted to verify hydrologic conditions.

- Hydrographic surveys of the Clinch River arm of the Watts Bar reservoir were performed from CRM 13 to CRM 21 in June 2013. The results of this survey, including a figure

depicting the bathymetry in the vicinity of the CRN SMR diffuser, are included in Subsection 2.3.1.1.2.8.

- An evaluation of the historical stream flow data for the Watts Bar Reservoir from 2004 through 2013 was conducted. A summary of this information is summarized in Subsection 2.3.1.1.2.4.
- Local surface water quality in the Upper Tennessee River Basin from 1994 to 1998 was evaluated and is summarized in Subsection 2.3.3.1.1.

Figure 2.3.1-14 shows the CRN Site features including boundaries and bathymetry of all surface-water bodies. Figure 2.6-2 shows the physiography of local region surrounding the CRN Site and the geologic features of the CRN Site are included on Figure 2.6-4. The locations of streams, ponds, and wetlands are shown on Figure 2.4.1-2, and the sampling locations for surface water and stormwater monitoring in the immediate vicinity of the CRN Site are shown in Figure 2.3.3-1. As stated in Subsection 2.3.1.1.2.9, there are currently no site-specific data available on erosion and sediment transport in the vicinity of the CRN Site. This information is to be addressed at the time of the combined license application.

6.3.1.2 Groundwater

As part of the site preparation monitoring, TVA collected samples to characterize groundwater quality at the CRN Site. Sampling was conducted on a quarterly basis to satisfy requirements for the preapplication monitoring program and to provide information regarding existing groundwater conditions. The list of parameters analyzed to characterize the groundwater at the CRN Site included:

- Volatile Organic Compounds
- Semivolatile Organic Compounds
- Pesticides/Polychlorinated Biphenyls
- Total Petroleum Hydrocarbons
- Metals, cyanide, and radionuclides
- Acid/base/neutral compounds, including Polycyclic Aromatic Hydrocarbons
- Field water-quality parameters (Reference 6.3-1)

In the fall of 2013, 37 observation wells were installed on the CRN Site, consisting of 15 clusters of two to three wells each. Each cluster consists of an upper and lower well, with some clusters containing an additional deep well. Sampling was performed in December 2013 to January 2014, April 2014, August 2014, and November 2014. The data were also used to help TVA to determine the potential for direct, indirect, and cumulative effects from operating a SMR at the CRN Site. (Reference 6.3-1)

As discussed in Subsection 2.3.1.2.1.3.1, site groundwater characterization activities included drilling 82 boreholes, installing 44 wells, monitoring groundwater level, performing packer tests in boreholes, performing slug tests in monitoring wells, performing an aquifer pumping test, and collecting groundwater geochemical samples. Groundwater level monitoring is discussed in Subsections 2.3.1.2.2.2 and 2.3.1.2.2.3, aquifer properties are discussed in Subsection 2.3.1.2.2.4, and geochemical results are discussed in Subsection 2.3.3.2. The groundwater characterization described in Subsection 2.3.1.2.1.3.1 was in addition to the site preparation monitoring conducted in 2013 and 2014.

6.3.2 Construction and Preoperational Monitoring

Hydrological monitoring is conducted during preconstruction and construction activities in order to assess and control the impacts from preconstruction and construction activities. During the preoperational monitoring period, data from ongoing monitoring programs may be used and evaluated as appropriate to establish a hydrological baseline. The following subsections outline general surface water and groundwater monitoring activities that may be conducted during the preconstruction/construction and preoperational monitoring periods. Site specific construction/preconstruction and preoperational surface water and groundwater monitoring plans are developed in accordance with all applicable regulations.

6.3.2.1 Surface Water

Surface water monitoring requirements for preconstruction and construction activities are developed as part of the permit application for an NPDES construction stormwater permit for discharges of stormwater associated with construction activities issued by the Tennessee Department of Environment and Conservation (TDEC). Additionally, prior to initiation of preconstruction activities, a completed and signed Notice of Intent for Construction Activity Stormwater Discharges and an associated Surface Water Pollution Prevention Plan (SWPPP) will be submitted to TDEC. Typical surface water discharges that may occur during preconstruction and construction activities include stormwater runoff and construction dewatering discharges. A SWPPP includes procedures to limit erosion, sedimentation, and other impacts to surface water as a result of preconstruction and construction activities. SWPPPs usually include erosion and sediment control measures and periodic inspections to ensure those measures are protective of site surface water. Additional monitoring activities may also be conducted as required by applicable permits.

6.3.2.2 Groundwater

Groundwater monitoring is conducted when preconstruction and/or construction activities have the potential to adversely affect site groundwater. Potential hydrologic effects resulting from construction activities could include increased groundwater recharge as a result of seepage from the cooling system holding pond and other stormwater retention ponds, changes in groundwater elevations caused by dewatering of foundation excavations, and/or general changing of the groundwater table due to topographic alterations.

Two years of quarterly sampling precedes the preconstruction and construction period. Eight quarterly sampling events provide a solid preoperational baseline dataset. Current plans include collecting samples from 19 existing wells, eight of which are to be redeveloped due to high turbidity issues. During the interim, the wells are locked and inspected. Groundwater monitoring during preconstruction and construction may also involve measuring water levels to monitor potential draw down caused by preconstruction and construction activities, sampling for the presence of new contaminants, and sampling for increased concentrations of known contaminants relative to site preparation monitoring results.

6.3.3 Operational Monitoring

In general, operational monitoring programs are designed to assess impacts to surface water flow, groundwater flow, sediment transport, and/or water quality resulting from facility operations. Details related to the operation of the proposed CR SMR Project at the CRN Site have not been yet been finalized; however, operational monitoring programs are designed to comply with all applicable regulatory requirements.

6.3.4 References

Reference 6.3-1. Tennessee Valley Authority, "Groundwater Quality Monitoring Report," Rev. 1, April 20, 2015.

6.4 METEOROLOGICAL MONITORING

The section describes the meteorological monitoring program at the Clinch River Nuclear (CRN) Site. This section also evaluates the program's adequacy for characterizing atmospheric transport and diffusion conditions representative of the CRN Site and surrounding area and providing a meteorological database for evaluation of the effects of construction and operation of two or more small modular reactors (SMRs) to potentially be built at the CRN Site.

This section provides a description and evaluation of the meteorological monitoring program, which includes:

- Meteorological tower location and instrument siting
- Meteorological parameters measured
- Meteorological Sensors
- Data recording and transmission
- Instrument maintenance and calibration
- Data acquisition and reduction
- Data screening and validation
- System accuracy

This evaluation demonstrates that the meteorological monitoring program for the CRN Site meets the relevant requirements of Title 10 of the Code of Federal Regulations (10 CFR) 50, Appendix I; 10 CFR 51.45(c); 10 CFR 51.50; 10 CFR 52.17(a)(1); 10 CFR 100.20(c)(2); the guidance in Section C of U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.23, *Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants*; Section C.4 of NRC RG 1.111,, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors*; and NRC RG 1.21, *Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste*.

The nominal temperature and wind sensor heights are 10 and 60 meters (m), although other heights may be stated in this document or reference documents. Exact measurement heights are given in the Environmental Data Station (EDS) Manual. (Reference 6.4-1)

6.4.1 Historical Data Collection at the CRN Site

The meteorological monitoring program at the CRN Site began in 1973 for the Clinch River Breeder Reactor Project (CRBRP) and ended in 1983. Subsequently, data were collected for the CRN Site Early Site Permit Application (ESPA) from 2011 until 2013. Various meteorological parameters were recorded from three meteorological towers originally installed to support the CRBRP. The locations of these meteorological towers are shown in Figure 6.4-1 and the data

collected at these towers during various time periods are summarized in Table 6.4-1 (Reference 6.4-1). Meteorological Tower 1 (Mt) was located on the west side of the CRN Site; data were recorded at Meteorological Tower 1 from April 11, 1973 to April 2, 1974 and from April 3, 1974 to March 2, 1978. Meteorological Tower 2 (Ms) was located along the north side of the CRN Site; data were collected from Meteorological Tower 2 from February 16, 1977 to March 6, 1978 and again from March 25, 1982 to November 4, 1983. Meteorological Tower 3 (Mp) was located on the southeast side of the CRN Site; data were collected at Meteorological Tower 3 from February 16, 1977 to March 6, 1978; March 25, 1982 to November 4, 1983; and again from April 21, 2011 to July 9, 2013 (Reference 6.4-1).

Meteorological Towers 1 and 2 have been removed. Meteorological Tower 3 was already present on the CRN Site when the ESPA was initiated and it met many of the current NRC requirements for placement of meteorological monitoring instruments. Therefore, Meteorological Tower 3 was refurbished in 2011 to meet NRC requirements and used to provide the meteorological monitoring data for the preapplication and preoperational phases of the ESPA (Reference 6.4-1). Meteorological Tower 3 was then removed in 2014. A new meteorological tower for the operational phase is expected to be constructed at the same location as the former Meteorological Tower 3.

6.4.2 Site Preparation Monitoring

For the CR SMR Project’s site preparation meteorological monitoring program, the meteorological data collection system at Meteorological Tower 3 was refurbished in 2011 to meet NRC RG 1.23 and other requirements, as outlined in Tennessee Valley Authority’s (TVA’s) Specifications for Meteorological Monitoring for TVA Nuclear Plants (Reference 6.4-1; Tennessee Valley Authority 2013). The site preparation meteorological monitoring program for the proposed SMRs is described in the following subsections.

6.4.2.1 General Site Description

The CRN Site is situated in a valley between two major mountain regions: to the northwest lie the Cumberland Mountains and to the southeast are the Great Smoky Mountains. These mountain regions orient this valley in a southwest to northeast alignment. (Reference 6.4-3) Locally, the Clinch River arm of the Watts Bar Reservoir runs along the east, west and south sides of the CRN Site. As stated in Subsection 2.2.1.1, the elevation of the CRN Site ranges from approximately 745 feet (ft) above mean sea level (msl) to approximately 940 ft msl.

The description of the topographic features of the CRN Site provided in Section 2.2, combined with the description of dispersion characteristics provided in Section 2.7, form the basis for assessing the adequacy of the meteorological monitoring program for the CRN Site.

6.4.2.2 Meteorological Tower Description, Location, and Exposure

TVA’s onsite EDS was used for meteorological data collection and transmission. The EDS included a 110-m meteorological tower (Meteorological Tower 3, with meteorological sensors

located at the 10-m and 60-m levels), surface meteorological sensors, and a small building equipped with office space, a computer/data logger, cellular modem, and related equipment. (Reference 6.4-1)

The meteorological tower was designed to withstand the simultaneous loads of the following:

- Wind velocity of 90 miles (mi) per hour (mph; 3-second gust), which is equivalent to a 50-year recurrence interval (per pressure loads given by Electronic Industries Association Code TIA-222-G).
- A vertical weight load of the tower, guy wires, and equipment. (Reference 6.4-1)

A system of lightning and surge protection circuitry with proper grounding was included in the facility design (Reference 6.4-1).

Meteorological Tower 3 was located at UTM coordinates 3974.21 kilometers (km) (Northing) and 736.88 km (Easting) on UTM Zone 16, approximately 830 ft to the south of the proposed facility area (Figure 2.1-1). The meteorological tower's base elevation was at 799.9 ft msl and the facility grade elevation is approximately 821 ft msl. The instrument building was located to the east-southeast of the meteorological tower. Because the area around the meteorological tower is relatively flat, the instrument building's base elevation was comparable to that of the meteorological tower's base elevation. The solar radiation instrumentation, not situated on the meteorological tower, was located near the meteorological tower at an elevation of 799.5 ft msl. (Reference 6.4-1)

The existing Meteorological Tower 3 and surface instruments were used to provide data that are representative of atmospheric conditions at the CRN Site, as well as the surrounding area. The meteorological tower location was such that the instrument sensors were not adversely influenced by buildings, man-made structures, obstructions, terrain, vegetation (as trees), and other activities onsite or in the surrounding area. The suitability of the meteorological tower location was confirmed by meteorologists knowledgeable of the surroundings and conditions that might affect the collection of meteorological data. The meteorological tower and surface sensor locations were reviewed annually in relation to their surroundings to compensate for changes and/or take corrective actions as necessary.

6.4.2.3 Potential Obstructions Surrounding Meteorological Tower

In accordance with NRC RG 1.23, wind measurements should be made at locations that avoid large buildings, man-made structures or natural obstructions. General guidance states that "sensors should be located over level, open terrain at a distance of at least 10 times the height of any nearby obstruction if the height of the obstruction exceeds one-half the height of the wind measurement." Since the lowest level wind measurement height was 10 m above the base of the meteorological tower, nearby obstructions with heights at or over 5 m (16.4 ft) above the meteorological tower base elevation out to a distance of 10 times the height of the nearby obstructions were evaluated.

Meteorological Tower 3 was situated on the southeastern portion of the CRN Site, which is characterized as a relatively flat plateau (Reference 6.4-4). The ground surface surrounding the location of the meteorological tower is characterized as an open, level field consisting of a mix of grasses, scattered low shrub-like plants, and bare dirt. A gravel road provides access to the meteorological tower site. The meteorological tower's location conformed to guidance regarding surface characteristics and also avoided the effects of parking lots and large paved areas that could potentially modify temperature measurements.

Both local terrain and the region's topography may potentially influence meteorological conditions at a project site. The meteorological tower was located on a plateau at an elevation of approximately 800 ft msl, similar to the grade of the proposed facility area. Because both the proposed facility area and meteorological tower location are on the south side plateau of the CRN Site, exposures are similar. Figure 6.4-2 shows the location of the former meteorological tower and a 6-mi radius. The location of the former meteorological tower on the plateau area provided good exposure to air flow for winds along the general southwest-northeast orientation of the terrain in the Oak Ridge region. This orientation aligns with the prevailing winds. Because terrain in some locations of the Oak Ridge area rises to near 1200 ft msl, the 60-m level represents exposure to regional conditions. The local surroundings of the CRN Site, including the combination of the Clinch River arm of the Watts Bar Reservoir and terrain along its shore, influenced wind readings at the meteorological tower under certain atmospheric conditions. Thus, it is concluded that the 10-m level represents the CRN Site's meteorological conditions.

As shown on Figure 6.4-3, potential wind measurement obstructions around the meteorological tower included: an instrument building, a small stand of trees to the southeast, a power line transmission tower, and the tree line at the edge of the open field in which the meteorological tower was situated.

The instrument building was located approximately 150 ft to the southeast of the meteorological tower at about the same base elevation as the meteorological tower (Reference 6.4-1). The height of the instrument building was approximately 10 ft. This height does not exceed "one-half the height of the lower wind measurement" (16.4 ft) stated as guidance in NRC RG 1.23. Therefore, it is concluded that the instrument building did not influence wind measurements taken at the meteorological tower.

The stand of trees is situated beyond where the instrument building was located and is approximately 225 ft to the southeast of the former location of the meteorological tower (Reference 6.4-1). This area is surrounded by a chain link fence with trees inside the fenced area. The chain link fence is approximately 6 ft high. At this height, the chain link fence is not an obstruction to wind measurements.

Both the trees within the fenced area and the nearby power line transmission tower were evaluated in detail by TVA as potential obstructions to measurements collected from the meteorological tower. The power line transmission tower is located approximately 400 ft northeast of the meteorological tower. Prior to initiating monitoring for the ESPA, TVA

meteorologists evaluated these obstructions and determined they would have minimal impact on data collected from the meteorological tower. TVA meteorologists also used sigma theta measurements to identify the potential impact of these two obstructions on measurements from the meteorological towers. ANSI-ANS-3.11-2005 defines sigma theta as “the standard deviation of the horizontal wind direction.” Sigma theta is an indicator of wind turbulence. Sigma theta values tend to be greater for winds from obstructed wind directions compared to winds from unobstructed wind directions. For the CRN Site, there was no indication of an increase in sigma theta for wind directions associated with potential obstructions compared to unobstructed wind directions on either side of the obstruction. It was concluded that the transmission tower and trees have minimal impact on the wind measurements at the CRN Site.

Trees line the open field surrounding the meteorological tower in an approximate circular manner. The tree line was approximately 310 ft to 440 ft from where the meteorological tower was located, depending on direction, with the only exception being the small stand of trees discussed above. Trees and other vegetation were evaluated during periodic meteorological monitoring site inspections of the meteorological tower. Four inspections were conducted to determine conformance with requirements of the meteorological tower within the context of its surroundings. These were performed by TVA on January 19, 2011 (preoperational); April 26, 2011; August 7, 2012; and April 9, 2013. Inspections demonstrated the meteorological measurement site was conditionally acceptable during the initial preoperational inspection and acceptable during the three later operational inspections.

6.4.2.4 Meteorological Measurements

The meteorological measurement program for the CRN Site was developed consistent with regulatory requirements. Prior to initiation of the meteorological monitoring program beginning in April of 2011, the data collection system was refurbished to meet NRC RG 1.23 and other specifications (Reference 6.4-1).

Meteorological sensors were located at the following levels:

- Wind speed and direction: 10-m and 60-m
- Dry bulb temperature: 10-m and 60-m
- Dew point temperature: 10-m and 60-m
- Solar Radiation: 1-m
- Rain Gauge: 1-m (Reference 6.4-1)

The wind speed and wind direction sensors were Vaisala Model 425 ultrasonic wind sensors. The wind speed sensor provided a digital signal, and had a resolution of 0.1 mph, and an operating range of 0.1 to 144 mph. The wind direction sensor also produced a digital signal, and had a resolution of 1 degree and operating range of 0 to 360 degrees. Note that the output or

recording range from the EDS computer was 0 to 99.9 mph for wind speed and 0 to 359 degrees for wind direction. (Reference 6.4-1)

Air temperature was measured using Weed Instrument Company, Model 101, platinum wire resistance temperature detectors (RTDs). The RTDs provided analog signals to the data logger in the range of 86 to 120 ohms. The output (recording) range of the temperature measurements were -30.00 degrees Fahrenheit (ºF) to +120.00ºF. The resolution of the temperature measurement was 0.01ºF. The temperature sensors were mounted within aspirated shields (R.M. Young Company, Model 43408). The solar radiation shields operated with an aspiration flow rate of 3.5 to 7.6 meters per second (m/s). The aspirated shields had a maximum radiation error of 0 to +0.4ºF. (Reference 6.4-1)

Delta-temperature is not provided directly as a meteorological tower measurement but was calculated using the meteorological monitoring program's computer software and the 60-m and 10-m recorded air temperature measurements. Delta-temperature was considered valid if both the 60-m and 10-m air temperatures were valid. (Reference 6.4-1)

The dew point sensors were a Vaisala, Model HMT337, Humidity and Temperature Transmitter for High Humidity Applications. The Vaisala unit was a capacitive humidity sensor with a warmed probe head and was mounted in a R.M. Young Company solar radiation shield (Model 43502). The aspiration shield flow rate was 5 to 10 m/s. The dew point sensors provided an analog signal (2.000 to 5.300 volts) to the EDS computer/data logger. The output (recording) range of the dew point temperature measurements was -4.00ºF to 85.00ºF, with a resolution of 0.01ºF. (Reference 6.4-1)

Solar radiation was measured with an Eppley Laboratories Model 8-48 pyranometer. The unit had a sensitivity of 0.001 Langleys per minute (ly/min) and response time of 5 seconds. The unit provided an analog signal to the EDS computer/data logger from -0.02 to 30.0 millivolts (mVolts). The output (recording) range from the EDS computer was 0.00 to 3.00 ly/min with a resolution of 0.01 ly/min. (Reference 6.4-1)

The meteorological monitoring program also included a Sutron Corporation, Model 5600-0420-1h, heated tipping bucket rain gauge. The rain gauge had a resolution of 0.01 inches (in.) of water and range of 0.00 to 10.00 in. of water (Reference 6.4-1). However, during the 27-month period from April 21, 2011 to July 9, 2013, there were repeated problems with the onsite rain gauge. NRC RG 1.23 requires annual 90 percent data recovery rates for proposed nuclear plant sites. Therefore, for this 27-month data collection period, TVA determined that the onsite precipitation data were invalid. Repeated instrument and power supply problems rendered the rainfall data collected onsite as unreliable for two periods which represent almost half of the data collection period. As a result, it was determined that the precipitation data collected onsite during this period would not be used for regulatory applications. Instead, near coincident hourly data from the Oak Ridge National Weather Service was used to describe rainfall for the CRN Site and its surroundings during that 27-month period. The Oak Ridge National Weather Service (NWS) Station is located 12 mi to the northeast of the CRN Site and

is a standard NWS Automated Surface Observing System. During the 27-month ESPA data collection period, the Oak Ridge NWS Station data indicated only 3 days of missing data (based on hourly observations versus daily totals). Hourly precipitation data for Oak Ridge NWS Station were taken from monthly Local Climatological Data publications produced by the National Climatic Data Center (NCDC). NCDC serves as a national clearinghouse which provides validated meteorological data for NWS Stations around the United States.

6.4.2.5 Meteorological Sensor Orientation

NRC RG 1.23 provides guidance with regard to situating sensors on a meteorological tower to alleviate potential tower effects on sensor readings. The CRN Site meteorological tower was designed in accordance with NRC RG 1.23 and other specifications (Tennessee Valley Authority 2013).

Wind sensors were situated at both the 10-m and 60-m levels of the meteorological tower. For areas such as the CRN Site located in a valley (oriented southwest to northeast, between the Cumberland Mountains and Great Smoky Mountains) and having “two distinct” prevailing wind directions, NRC RG 1.23 states wind “sensors should be mounted in a direction perpendicular to the primary two directions.” Consistent with this requirement, the wind sensor booms extended to the southeast of the meteorological tower to avoid influence of the tower on wind measurements. The originally installed sensor mounting arms were too short, being installed at 91 in. The sensors were moved to 100 in. from the meteorological tower on October 18, 2011. At 100 in. from the meteorological tower, the sensors were located 2.08 tower widths from the meteorological tower. (Reference 6.4-1)

In accordance with NRC RG 1.23, the air temperature sensors (at both 10-m and 60-m) were mounted in downward pointing radiation shields to avoid modification of heat sources. The sensor inlet was positioned to the east, 72 in. from the meteorological tower or equivalent to 1.50 tower widths from the meteorological tower. The dew point sensors were also placed in downward pointing shield and located at approximately 1 m directly above the air temperature sensor. (Reference 6.4-1)

The solar radiation pyranometer was located approximately 55 ft to the south of the meteorological tower, 4 ft above ground level (Reference 6.4-1).

6.4.2.6 Data Recording

The EDS consisted of an automated system that scans and records the meteorological sensors at constant intervals and Microsoft Windows™ based computer/data logger that collects, processes, transmits, and records meteorological data from the CRN Site. The EDS computer/data logger and associated equipment were serviced bi-weekly, at a minimum, in accordance with TVA Emergency Preparedness Field Support Procedures. In addition, unscheduled and non-routine maintenance was conducted as necessary. (Reference 6.4-1)

Data acquisition was performed onsite using a data logging system operated on the EDS computer. The data logger recorded, processed, and then transmitted data to a Remote Access Computer (RAC). Transmission of data from the EDS computer to the RAC was via cellular modem and TVA's external FTP server located in Chattanooga, Tennessee. (Reference 6.4-1)

The data logger, located on the EDS computer, was a Microsoft Windows™ based server running a Digital Equipment Corporation VAX/VMS real time emulator, an instrument multiplexer, a data acquisition switching unit and communications equipment (Reference 6.4-1). The data logger interrogated each meteorological sensor periodically and stored the instrument readings on the computer. The meteorological sensors, except the rain gauge, were interrogated every five seconds providing 720 readings per hour (Reference 6.4-1). The rain gauge was interrogated for the number of counts at 15 minute intervals. Analog signals from the temperature sensors and solar radiation sensor, along with counts from the rain gauge, were converted to digital form using an Agilent 34970A Data Acquisition Switch Unit (DASU). The output readings, along with digital signals from the wind sensors, were then processed by the EDS computer. Data were archived locally and periodically transferred for storage offsite. Data collected and maintained at the EDS computer was available, via cellular modem and the TVA FTP server, to the RAC. A two-part process was used to communicate the data to RAC. Hourly and 15-minute observations were copied to TVA's external FTP server. The FTP site maintained the data received from the EDS Computer. The RAC obtained the data from the FTP server, posted it on the EDS website, and saved the data for later FTP access (for data validation). Unvalidated data were also accessible through the FTP server located in Chattanooga. (Reference 6.4-1)

The meteorological monitoring system also included an uninterruptible power supply system (UPS) which consisted of internal batteries and DC-to-AC converter. This system had the capability of providing up to 30 minutes of power in case of a utility power interruption. Also, under normal conditions the UPS was used to control power to the instruments by removing electrical spikes, sags, surges, and noise. When utility power failed, the UPS provided AC power from its internal batteries. (Reference 6.4-1) The EDS also included a liquid propane-powered generator which could provide backup power to the meteorological equipment if needed (Reference 6.4-5).

Computer programs on the EDS computer received raw data from the meteorological sensors and processed meteorological parameters into 15-minute and hourly time averaged values (Reference 6.4-1). Time averaged values were transmitted to the RAC. Raw data were scanned from the meteorological sensors at 5 second intervals providing 720 instantaneous readings per hour (except for the rain gauge which provided counts at 15 minute intervals). The minimum number of raw data points required to compute a 15-minute time average is 45 instantaneous readings, and the minimum number of readings necessary to calculate an hourly average is 180. Output from the EDS computer program provided 15-minute and hourly average wind speed in mph, wind direction in degrees clockwise from north, temperatures in ºF, and solar radiation in Langley's per minute. (Reference 6.4-1)

Computer programs were developed, modified, and maintained in accordance with TVA's quality assurance program. This included verifying that code operated properly prior to use through a number of benchmark tests or independent reviews. The Computer Process Engineer was also responsible for data handling and processing at the RAC. (Reference 6.4-1)

6.4.2.7 Meteorological Data Analysis Procedure

Time-averaged data were sent hourly from the EDS computer to the RAC for review and the archiving of validated data. As noted above, checks were also performed every workday on the data archival channel.

The Environmental Monitoring and Analysis (EMA) team was responsible for the review and validation of meteorological data. The EMA reviewed data every workday, and if any problems were noted the EMA was responsible for contacting the appropriate personnel to resolve issues. Meteorological data were also validated by the EMA, prior to data being archived, to ensure the validated data satisfied minimum data collection requirements and the necessary recovery rates. (Reference 6.4-1)

NRC RG 1.23 requires 90 percent data recovery for joint frequency distributions (i.e., 90 percent data recovery for the composite of wind speed, wind direction and stability class) and 90 percent data recovery for the other individual meteorological parameters (Reference 6.4-1). Table 6.4-2 provides data recovery rates for the wind speed and wind direction data for the collection period from May 2011 to June 2013, along with data recovery rates for ΔT (temperature difference between 60-m and 10-m) for 2011, 2012, and 2013. Table 6.4-3 presents the data recovery rate for valid hours that concurrent wind speed, wind direction and stability class data were available for the generation of joint frequency distributions. Joint frequency distributions by stability class are based on the data collected at the 10-m level for the two year period from June 2011 through May 2013. These data demonstrate that all recovery rates exceed the 90 percent requirement. The inspection, servicing, and maintenance program for meteorological instrumentation and associated equipment had the objective of ensuring an annual joint data recovery of 90 percent for atmospheric stability (ΔT, temperature difference), wind speed, and wind direction at levels representing effluent release points.

Following validation, data were archived electronically as a permanent record.

6.4.2.8 Instrument Calibration and Maintenance

Calibration and maintenance of the meteorological monitoring program was designed to ensure the NRC RG 1.23 requirement of 90 percent data recovery was achieved. Both maintenance and calibrations were regularly scheduled to keep systems properly operating.

A schedule of calibration due dates was maintained at the responsible field office. Signal processing units were calibrated in place. The DASU, wind sensors, air temperature sensors, the dew point temperature sensor, and Eppley pyranometer were exchanged and laboratory calibrated. (Reference 6.4-1)

Sensor calibrations were performed using quality assurance procedures in accordance with the Nuclear Power Group specifications for calibrations and instrument servicing. These procedures include specific calibration instructions and report forms for recording calibration results. (Reference 6.4-1)

Sonic wind sensors, air temperature sensors, and dew point sensors remained in service no longer than 184 days or beyond the calibration due date, whichever came first. Eppley pyranometers were exchanged within one year of the last calibration (Reference 6.4-1). Table 6.4-4 provides a summary of the calibrations performed on the sensors and DASU which was also calibrated at least every six months. The DASU was used to take the analog signal from the temperature sensors and converted these signals to digital readings. The DASU was calibrated to the manufacturer's certification requirement.

Data traceability was also checked through calibrations and data checks that evaluated the entire channel from the sensor to data archival. This involved evaluating the following channel segments:

- Sensor Channel to Data Logger (EDS Computer)
- Data Logger (EDS Computer)
- Data Logger to Remote Access Computer
- Remote Access Computer to TVA Meteorological Data Archives

Channel checks/calibrations were also conducted at least every six months and whenever required following the completion of maintenance on the system. Checks were conducted on the archival channel each workday. (Reference 6.4-1)

Maintenance on the meteorological monitoring system was performed and the EDS computer was serviced, at a minimum, biweekly in accordance with TVA Emergency Preparedness Field Support (EPFS) procedures. In addition, non-routine maintenance was performed to any component of the meteorological monitoring system when necessary. A spare parts inventory was maintained to minimize extended periods of system outage. This included a spare EDS computer, spare sensors, and spare equipment components. (Reference 6.4-1)

6.4.2.9 System Accuracy

Based on Regulatory Position 4 in Section C of NRC RG 1.23, determining the accuracy of time-averaged data from digital measurement systems should account for errors introduced by sensors, cables, signal conditioners, temperature environments for signal conditioning and recording equipment, recorders, processors, data displays, and the data reduction process.

System accuracy reflects the performance of the total system, from the sensors, through all processing components, to the display of measured values in their final form. System accuracy can be estimated by performing system calibrations or by calculating the overall accuracy based

on the system's individual components. Accuracy tests involve configuring the system to near normal operation, exposing the system to multiple known operating conditions representative of normal operation, and observing the results. Industry guidance on methods for calculating system accuracy is provided in ANSI/ANS-3.11-2005

Table 6.4-5 provides information pertaining to each of the onsite meteorological sensors' accuracy and NRC RG 1.23 specifications. Information presented in Table 6.4-5 demonstrates compliance with NRC RG 1.23 specifications.

6.4.3 Operational Monitoring

Meteorological Tower 3 along with supporting equipment and structures used to collect data for the ESPA from April 2011 through July 2013 were removed from the CRN Site in October 2013. As mentioned above, Meteorological Tower 3, constructed in the 1970's, was refurbished for the collection of 24 months of meteorological data in support of the CRN Site ESPA. However, due to a number of issues regarding the structural and functional integrity of the meteorological tower and the meteorological tower not meeting all Federal Aviation Administration marking requirements, it was determined the meteorological tower would not be suitable for the long term operational phase of the CR SMR Project. A new meteorological tower is expected to be constructed at the location of the meteorological tower from which the 2011 through 2013 data were collected for collection of data during the operational phase of the CR SMR Project.

Although details related to the new meteorological tower are not finalized, the new meteorological tower and the new meteorological monitoring programs are expected to meet the same TVA and regulatory requirements satisfied by the preapplication/preoperational meteorological monitoring program, including TVA's Specifications – Meteorological Monitoring for TVA Nuclear Plants, Federal Aviation Administration requirements for ground obstructions, and NRC RG 1.23. This includes "life-of-the-program" routine inspections of the meteorological monitoring site, tower, and system components.

6.4.4 References

Reference 6.4-1. Tennessee Valley Authority, "Clinch River Nuclear Plant Environmental Data Station Manual," September, 2012.

Reference 6.4-2. Tennessee Valley Authority, Specifications - Meteorological Monitoring for TVA Nuclear Plants, Rev. 21, 2013.

Reference 6.4-3. National Oceanic and Atmospheric Administration, 2013 Local Climatological Data Annual Summary with Comparative Data - Oak Ridge, Tennessee, Website: http://www.ncdc.noaa.gov/IPS/lcd/lcd.html, 2015.

Reference 6.4-4. AECOM, "Final Clinch River Site Land Use and Recreation Technical Report - Revision 2," Greenville, SC, Tennessee Valley Authority, October, 2014.

Reference 6.4-5. AECOM, "Final Clinch River Site Solid and Hazardous Materials/Waste Review Technical Report," Greenville, SC, Tennessee Valley Authority, July, 2013.

Table 6.4-1
Onsite Meteorological Data Collection[1]

Meteorological Tower	Data Collected	Beginning Date	Ending Date	Height (m)
Tower 1 (Mt)	WS, WD, DBT	04-11-1973	03-02-1978	25 and 60
	WS, WD, DBT	04-03-1974	03-02-1978	10
	DPT	05-15-1975	03-02-1978	10
Tower 2 (Ms)	WS, WD	02-16-1977	03-06-1978	10
	WS, WD	03-25-1982	11-04-1983	10
Tower 3 (Mp)	WS, WD, DBT	02-16-1977	03-06-1978	10, 60, 110
	DPT	02-16-1977	03-06-1978	10
	SR, RF, AP	02-16-1977	03-06-1978	1
	WS, WD, DBT	03-25-1982	11-04-1983	10, 60, 110
	DPT	03-25-1982	11-04-1983	10
	SR, RF	03-25-1982	11-04-1983	1
	WS, WD, DBT	**04-21-2011**	**07-09-2013[2]**	**10 and 60**
	DPT	**04-21-2011**	**07-09-2013[2]**	**10 and 60**
	SR, RF, AP	**04-21-2011**	**07-09-2013[2]**	**1**

[1] Information in bold designated preapplication/preoperational meteorological monitoring program.
[2] End date not listed in EDS Manual, which was issued while monitoring was still in progress.

Notes:
WS = Wind Speed
WD = Wind Direction
DBT = Dry Bulb Temperature
DPT = Dew Point Temperature
SR = Solar Radiation
RF = Rainfall
AP = Atmospheric Pressure

Source: (Reference 6.4-1)

Table 6.4-2
Data Recovery Rates for Combined Wind Speed and Direction

Year	Month	Data Recovery Percentage at 10m	Data Recovery Percentage at 60m	Data Recovery Percentage (Temperature Difference between 60-m and 10-m)
2011	May	100.0	100.0	99.9
	June	96.7	100.0	
	July	98.9	100.0	
	August	100.0	100.0	
	September	100.0	100.0	
	October	99.6	99.6	
	November	100.0	100.0	
	December	100.0	100.0	
2012	January	93.0	93.0	98.9
	February	100.0	100.0	
	March	99.7	99.7	
	April	99.9	99.9	
	May	100.0	100.0	
	June	99.4	99.4	
	July	94.2	99.9	
	August	99.9	99.9	
	September	100.0	100.0	
	October	100.0	99.7	
	November	99.6	98.8	
	December	100.0	99.5	
2013	January	100.0	99.7	99.8
	February	99.9	99.9	
	March	99.9	99.9	
	April	100.0	100.0	
	May	100.0	100.0	
	June	99.7	99.7	
	All Months	**99.1**	**99.4**	

Notes:

RG 1.23 requires at least 90% data recovery on an annual basis. All monthly wind data exceed 90% data recovery; all annual and 12 month periods exceed 90% data recovery

Table 6.4-3
Combined Wind Speed, Wind Direction, and Stability Class Data Recovery Rate at 10-Meters for June 1, 2011 through May 31, 2013

Total Possible Hours of Data During Period	17,544
Total Hours of Missing Wind Speed, Wind Direction or Stability Class	164
Available Valid Hours for Joint Frequency Distribution	17,380
Data Recovery Rate (%)	99.1

Table 6.4-4
Calibrations of Meteorological Sensors

Sensor	Calibration Performed
Wind Speed	In wind tunnel (NIST certified)
Wind Direction	In wind tunnel (NIST certified)
Air Temperature	Calibrated against certified platinum resistance thermometer
Dew Point Temperature	Calibrated in laboratory environmental chamber
Solar Radiation	Factory calibrated against manufacturer's standard
Rain Gauge[1]	In the field calibration, calibrated against a known quantity of water

1 Although calibrations were performed on the rain gauge, as discussed in Subsection 6.4.2.4, rain gauge data from the CRN Site was not used. Instead, concurrent rainfall data from the nearby Oak Ridge NWS Station was used.

Notes:
NIST = National Institute of Standards and Technology (formerly the National Bureau of Standards)

Source: (Reference 6.4-1)

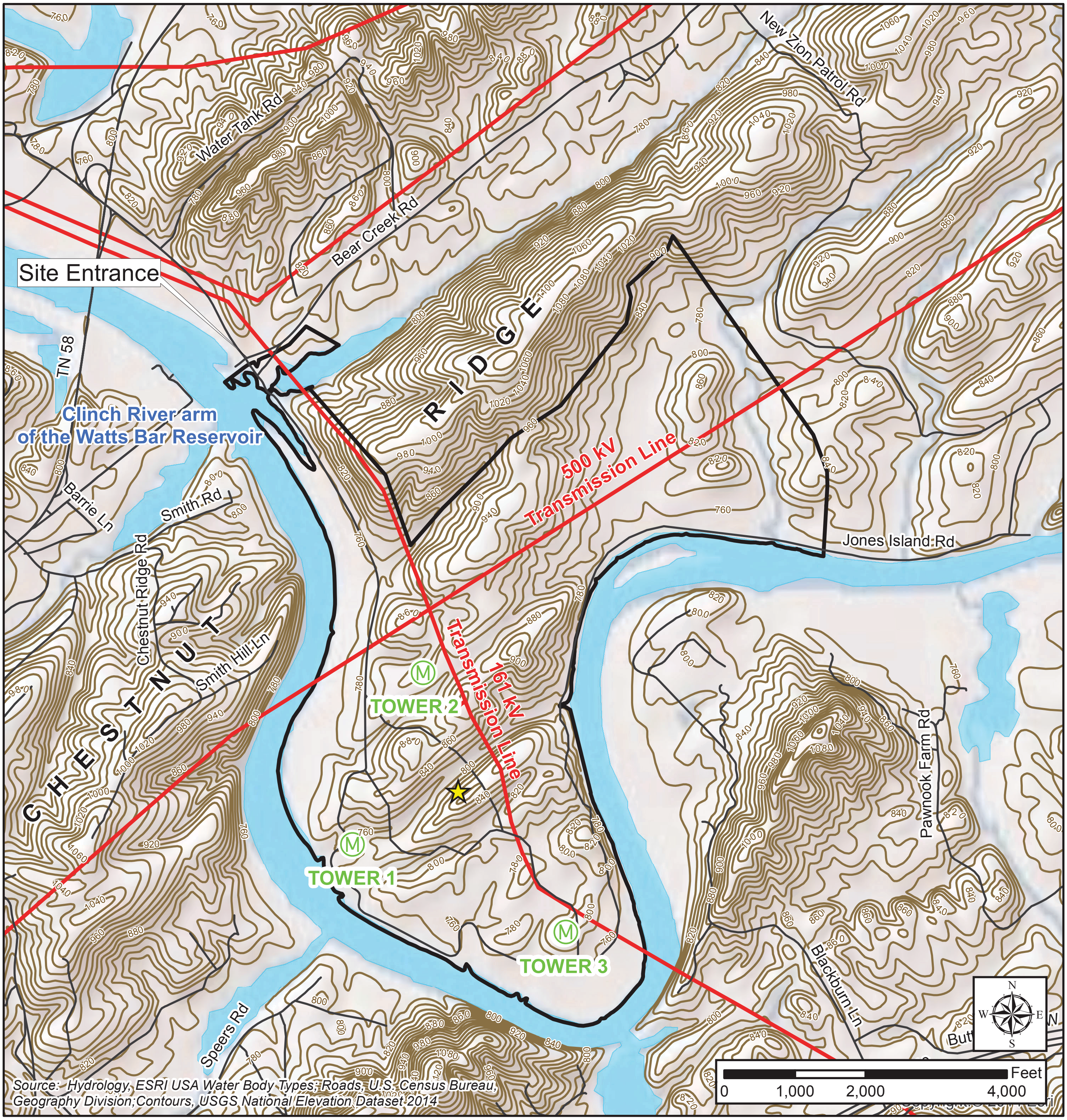
Table 6.4-5
Meteorological System Accuracy Versus Specifications

Variable[1]	Units	Specification		Sensor Accuracy	System Accuracy	
		ANS-3.11	RG 1.23		Instantaneous	Time-Averaged
Wind Speed	mph					
8.9 mph		±0.45	±0.45	±0.36	±0.36	±0.06
30.0 mph		±1.50	±1.50	±0.37	±0.37	±0.06
100.0 mph		±5.00	±5.00	±0.38	±0.39	±0.06
Wind Direction	° azimuth	±5.0	±5.0	±3.0	±4.3	±2.1
Air Temperature	°F					
[Day] High solar rad		±0.900	±0.900	±0.078	+0.702	+0.657
[Day] Low solar rad		±0.900	±0.900	±0.078	-0.202	-0.157
[Night] No solar rad		±0.900	±0.900	±0.078	±0.202	±0.157
Vertical Temperature Difference		±0.180	±0.180	±0.105	±0.148	±0.046
Dewpoint	°F	±2.700	±2.700	±2.236	NA	±0.507
Rainfall						
0.10 in. [2]	inches	±0.010	±0.010	±0.007	±0.009	NA
Solar Radiation (SR)	ly/min					
0.28 ly/min		±0.014	Not specified	±0.006	NA	±0.021
0.45 ly/min [3]		±0.023		±0.015	NA	±0.022
1.50 ly/min		±0.075		±0.027	NA	±0.026

1 If a condition or value is listed, error values are specific for that condition/value. Otherwise, error values apply to the entire expected sampling range.
2 ANS-3.11-2005 and NRC RG 1.23 specify that accuracy be estimated for a specific volume (2.54 mm, 0.10 inch).
3 0.45 ly/min is the lowest value at which the ANS-3.11-2005 specification is satisfied.

Notes:
Values are converted to the same units and rounded to the same precision.
NA = Not Applicable

Source: (Reference 6.4-1)



Legend

Monitoring Location

CRN Site Center Point

CRN Site

Rivers and Lakes

Transmission Line

Local Roads

20' Contour Lines

Figure 6.4-1. CRN Site Historical Meteorological Monitoring Locations

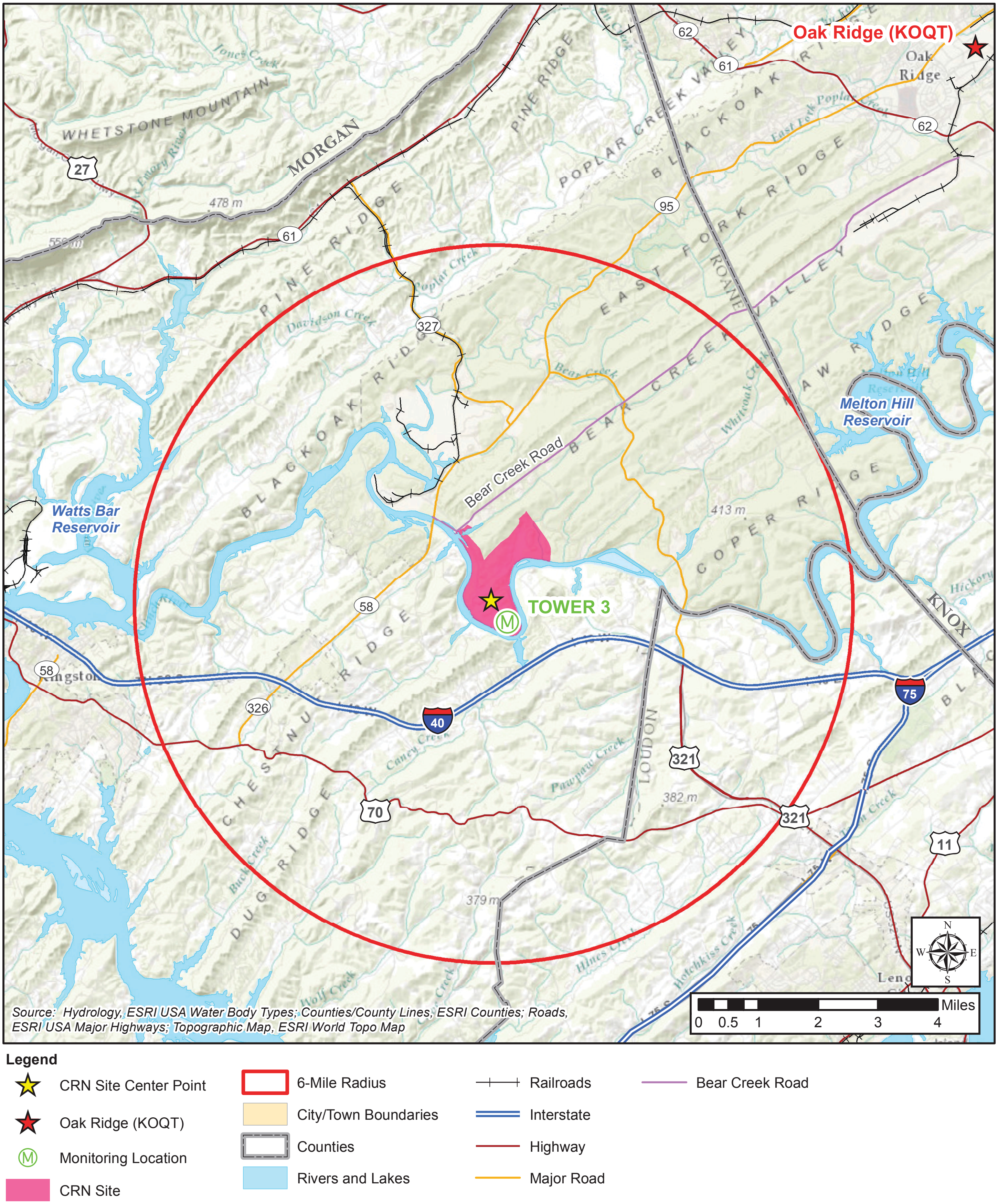


Figure 6.4-2. 6-Mile Vicinity Topographic Map

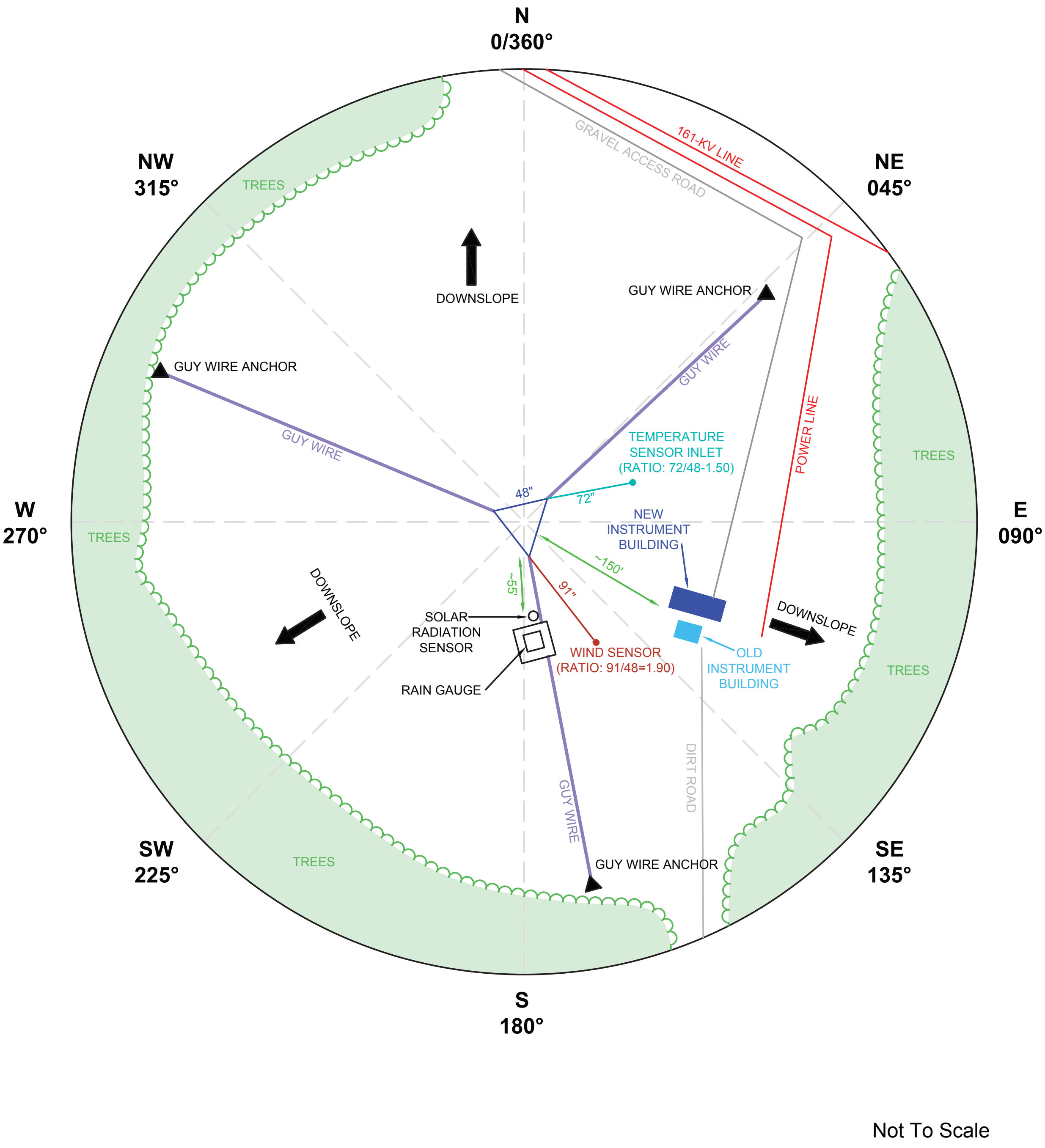


Figure 6.4-3. Meteorological Tower 3 EDS Site Layout

6.5 ECOLOGICAL MONITORING

This section addresses ecological monitoring of terrestrial ecology, land use, and aquatic ecology in the areas likely to be affected by site preparation, construction, and operation of two or more small modular reactors (SMRs). Figure 4.3-1 illustrates the layout of the Clinch River Nuclear (CRN) Site and improvements to be made in adjacent offsite areas, including delineation of areas to be permanently or temporarily cleared. Ecological monitoring programs are based on the anticipated environmental impacts from the new SMRs and expected permitting requirements. These programs focus on ecosystem components with the potential to be adversely affected by SMRs construction and/or operation. Tennessee Valley Authority (TVA) is responsible for all monitoring programs associated with TVA reservoirs, lands, transmission line rights-of-way, and power plants. TVA's ongoing and future ecological monitoring programs are designed to characterize baseline conditions and facilitate assessment of ecological effects through the various phases of the project, including site preparation, construction, and operation. The following subsections describe the ecological monitoring programs for terrestrial resources (Subsection 6.5.1) and aquatic resources (Subsection 6.5.2) at the CRN Site.

6.5.1 Terrestrial Ecology and Land Use

As described in Subsection 2.4.1, the CRN Site consists of approximately 935 acres (ac) of mainly undeveloped land on a peninsula formed by the Clinch River arm of Watts Bar Reservoir. As described in Subsection 4.1.1.1 and Table 4.1-1, land clearing for construction (140 ac) and operation (327 ac) of facilities would affect approximately half of the acreage on the CRN Site. Ecological communities in these areas comprise species that are characteristic of the ecoregion. Terrestrial ecological monitoring programs have documented baseline ecological conditions and support the assessment of potential effects on important species. Site conditions do not warrant land use monitoring.

6.5.1.1 Site Preparation Monitoring

Site preparation monitoring is needed to support applications for early site permits, construction permits, operating licenses, and combined licenses by providing field data to support descriptions of existing ecological communities (NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan*). A program of field studies was designed and performed by TVA, in accordance with U.S. Nuclear Regulatory Commission Regulatory Guide (RG) 4.2, *Preparation of Environmental Reports for Nuclear Power Stations*, RG 4.7 *General Site Suitability Criteria for Nuclear Power Stations*, and RG 4.11, *Terrestrial Environmental Studies for Nuclear Power Stations,* to obtain the information needed to characterize the ecological communities at the CRN Site. The information from these field studies was used to develop the descriptions of the terrestrial environment, including wetlands, provided in Subsection 2.4.1, Terrestrial Ecology.

TVA performed field studies on the Clinch River Property on a seasonal basis such that seasonal variations could be characterized throughout at least one annual cycle. Terrestrial vegetation communities were surveyed in 2011 and 2013, wetlands were surveyed in 2011, and terrestrial animals were surveyed in 2011 and 2013. The study methods and results of these surveys are described in Subsection 2.4.1. The various activities included in the site preparation monitoring program for animals are summarized in Table 6.5-1. In addition, supplemental field studies were performed in 2014 and 2015 within 101-ac portion of the Barge/Traffic Area, where road and intersection construction are planned including at the entrance to the CRN Site, at the TN 58 ramps, as well as at the barge facility.

Plant and wildlife species as well as terrestrial habitats found on the CRN Site generally are common and representative of the region. As described in Subsection 2.4.1.5, the only federally listed terrestrial species observed on the CRN Site were three bat species. In addition, species with a state status that were observed on the CRN Site or the surveyed Barge/Traffic Area (101-ac) were a hawk and two herbaceous plants. Other species with federal or state status potentially could occur in the habitats present in these areas, but only these five were observed during the course of multiple surveys. Twelve small wetlands were identified on the CRN Site, but as described in Subsection 2.4.1.2, no other important terrestrial habitats are present on the CRN Site.

6.5.1.2 Construction, Preoperational, and Operational Monitoring

Potential impacts on terrestrial ecology from facility construction and operation are discussed in Subsections 4.3.1, 5.3.3.2, and 5.6.1. Based on the characteristics of the terrestrial ecological communities studied under the site preparation monitoring program and the locations and extent of areas to be cleared for construction, the need for ecological monitoring during construction is expected to be minimal. Habitats for the two state-listed plants potentially occurring on the CRN Site are not expected to occur within the footprint of the planned facilities. Because at least three species of bats that are federally listed have been found to forage on the CRN Site, the U.S. Fish and Wildlife Service (USFWS) may require additional bat surveys during the construction period to monitor possible changes in use of the CRN Site by these species. Under Section 7 of the Endangered Species Act (16 U.S. Code [USC] 1531 *et seq.*), if proposed activities may affect listed bats or other federally listed species (i.e., cause harm, harassment, or other forms of “take”), the USFWS would be informed in a biological assessment as part of ongoing Section 7 consultation. If the USFWS determines that reasonable and prudent measures are needed to minimize take of a species, monitoring may be required in conjunction with an incidental take permit.

As noted in Subsection 2.4.1.4, an osprey nest was observed on a tower supporting the 161-kV transmission line on the CRN Site and, in accordance with Executive Order 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds, monitoring of this nest is proposed in order to assess responses of the ospreys to facility construction and operation. Bald eagles have been observed flying near the CRN Site and Barge/Traffic Area, but nests

have not been observed in the vicinity. In accordance with the Bald and Golden Eagle Protection Act (16 USC 668-668c), if ecological monitoring during the preoperational/operational period indicates bald eagle nesting activity on or near the CRN Site or Barge/Traffic Area, the USFWS would be contacted for advice and recommendations for how to avoid eagle disturbance and whether an eagle permit is necessary. Additional monitoring of terrestrial plant and animal communities during construction and preoperational phases is not warranted or proposed.

TVA would repeat field studies performed during the site preparation monitoring program for the period following construction in order to collect at least 1 year (yr) of preoperational and/or operational data for comparison to the baseline data. The ecological monitoring program in this phase may include seasonal species surveys of terrestrial communities. The activities included in a preoperational/operational monitoring program likely would be a subset of the site preparation terrestrial wildlife field studies summarized in Table 6.5-1.

6.5.2 Aquatic Ecology

As described in Subsection 2.4.2, the aquatic habitats with the potential to be affected by the proposed project include the Clinch River arm of the Watts Bar Reservoir, Melton Hill Reservoir, and the small streams and ponds on the CRN Site. Watts Bar Reservoir would be directly affected by water withdrawals and discharges. Melton Hill Reservoir may be affected indirectly through changes in water management to address downstream withdrawals for and thermal discharges from the proposed Clinch River SMR Project. Onsite ponds and streams may be directly affected if they are located within areas of the CRN Site required for development or operation of the SMRs. The ecological characteristics of these potentially affected water bodies are described in Subsection 2.4.2, Aquatic Ecology. The ecological communities in these water bodies consist of species that are characteristic of the region and not unique to the CRN Site. Aquatic ecological monitoring programs have documented baseline ecological conditions and support the assessment of potential effects on important aquatic species.

6.5.2.1 Site Preparation Monitoring

TVA characterized the aquatic communities in the vicinity of the Clinch River Property in 2011 (Reference 6.5-1). Investigations included analyses of fish eggs, larvae, juveniles, and adults; benthic macroinvertebrate and plankton communities; habitat characterization; and water quality. The study methods and results are described in Subsection 2.4.2.1.1. The studies serve to establish an ecological baseline for future trend analyses and support the assessment of potential impacts on aquatic ecology from construction and operation of the CR SMR Project, as discussed in Subsections 4.3.2, 5.3.1.2, 5.3.2.2, and 5.6.2.

As discussed in Subsection 2.4.2.1.1, TVA performed field studies in 2011 in the Clinch River arm of the Watts Bar Reservoir in the vicinity of the CRN Site. These studies characterized the fish community in winter, spring, summer, and fall. Ichthyoplankton (fish eggs and larvae) samples were collected in multiple events from February 2011 to January 2012 at transects

upstream and downstream of the CRN Site. The benthic macroinvertebrate community was surveyed in spring, summer, and fall of 2011, and an additional mollusk survey also was performed that focused on characterizing the mussel community of the reservoir segment adjoining the CRN Site. The plankton community in this reservoir segment was surveyed monthly from March through December 2011.

Additionally, TVA systematically monitored ecological conditions in its system of reservoirs since 1990 as part of its Vital Signs Monitoring Program, and the ongoing Reservoir Ecological Health monitoring program continues to monitor the aquatic communities of the reservoirs. Four Reservoir Ecological Health monitoring locations have been established in Watts Bar Reservoir (forebay near the dam, mid-reservoir, Tennessee River inflow, and Clinch River inflow). The Clinch River inflow area of the Watts Bar Reservoir is upstream of the CRN Site. Three locations are monitored in Melton Hill Reservoir (forebay, mid-reservoir, and inflow). Both of these reservoirs are monitored on a 2-yr cycle in even-numbered years for physical, chemical, and biological parameters. The Reservoir Ecological Health monitoring program characterizes and assigns a rating to the fish community and benthic community at each location. (Reference 6.5-1) Sampling of fish and benthic invertebrates occurred once in late fall/early winter at each location. In addition, fish tissue samples from each location are analyzed every 4 yr to monitor for the presence of potentially toxic contaminants. Fish were last collected for this purpose from Watts Bar Reservoir in 2012, and the next collection is scheduled to occur in 2016.

As described in Subsection 2.4.2, ponds and streams, including ephemeral streams/wet-weather conveyances on the CRN Site were mapped and classified in 2011, 2013, and 2014. Field studies were performed in 2014 to map and classify streams within specific areas on or near the CRN Site where construction of supporting facilities is proposed. These include the offsite Barge/Traffic Area and barge facility. Perennial and intermittent streams on the CRN Site and in the Barge/Traffic Area were sampled in 2015 to identify aquatic species present.

The aquatic species found in waterbodies surveyed at the CRN Site generally are common in similar habitats in the region. The assessment of federally listed species in Subsection 2.4.2.3.1 determined that of the 13 aquatic, federally-listed, threatened or endangered species and one candidate species with documented occurrences in Roane County, eight are mussels that are considered extirpated or for which the occurrences are historical only, and one is a cave salamander for which habitat is not present on or adjacent to the CRN Site. The remaining four species include three freshwater mussels and one fish. Although these species historically have occurred or potentially could occur in the vicinity of the CRN Site, recent surveys did not detect any federally listed species in the Clinch River arm of the Watts Bar Reservoir. The assessment of state-listed species in Subsection 2.4.2.3.2 determined that, of the aquatic species with a state listing or other state protected status and recorded occurrences in Roane County, four species potentially could occur in streams on the CRN Site or in the adjacent reservoir. However, none of these species have been observed during previous monitoring surveys.

6.5.2.2 Construction Monitoring

Aquatic organisms can be affected by construction-related activities principally through degradation of water quality or sediment quality resulting from soil erosion and stormwater runoff. The potential sources of erosion and runoff are the extensive site clearing and excavation activities required for development of onsite facilities, including the intake and discharge structures and offsite facilities, such as the barge landing, intersection modifications, and underground transmission line. TVA has established best management practices (BMPs) that are used during construction to prevent potential soil erosion and transport to Watts Bar Reservoir and the small streams draining the areas to be developed on and off the CRN Site.

Construction activities within or adjacent to navigable waterways (waters of the United States) would require permits from the U.S. Army Corps of Engineers. As discussed in Subsection 6.3.2.1, stormwater discharges are regulated by the Tennessee Department of Environment and Conservation (TDEC) under the National Pollutant Discharge Elimination System (NPDES). A Stormwater Pollution Prevention Plan (SWPPP) with proposed BMPs (including measures to limit erosion and sedimentation) would be completed before obtaining authorization to discharge. Additionally, no sensitive habitats or rare aquatic species are known to be present in the aquatic habitats potentially affected by construction. Compliance with the SWPPP and the lack of sensitive receptors would ensure that potential effects on aquatic communities from construction would be minor, localized, and temporary. Therefore, additional formal monitoring during the construction phase beyond that conducted under TVA’s Reservoir Ecological Health monitoring program would not be warranted.

6.5.2.3 Preoperational and Operational Monitoring

Potential impacts to aquatic ecology from facility operation are discussed in Subsections 4.3.2, 5.3.1, 5.3.2, 5.3.3, 5.3.4.1, 5.6.1, and 5.6.2. NUREG-1555 notes that for aquatic ecology monitoring “any necessary preoperational monitoring will ordinarily be defined in the NPDES permit” and “any necessary operational monitoring will be covered under the relevant NPDES permit.” TVA does not currently have an NPDES permit for the CRN Site. TVA expects to finalize the operational monitoring plan during the NPDES permitting process. An NPDES permit for the SMR likely would include a requirement for toxicity monitoring on at least an annual basis. The requirements for cooling water intakes under Clean Water Act (CWA) Section 316(b), for the purpose of minimizing adverse impacts from entrainment and impingement of organisms, also are implemented through the NPDES permitting process. As a new facility, the CR SMR Project would have to meet CWA Section 316(b) Phase I requirements for its cooling water intake.

TVA would repeat field studies following construction in order to collect at least 1 yr of preoperational and/or operational data (including aquatic monitoring) for comparison to the baseline data. The activities included in a preoperational/operational aquatic monitoring program likely would be a subset of the site preparation field studies.

A facility designed and operated in compliance with State Water Quality Standards for temperature, is unlikely to be required by TDEC to conduct significant new biological monitoring in the vicinity of the CRN Site. In the event TVA pursues a variance from those criteria under CWA Section 316(a), additional preoperational and operational monitoring would be addressed as part of that permitting process. Surveys and monitoring would be designed to allow statistical analysis comparing the communities present in the Clinch River before construction and operation to those present after the CR SMR Project is online.

6.5.3 References

Reference 6.5-1. Tennessee Valley Authority, "Biological Monitoring to Characterize the Aquatic Community near the Site of the Proposed Clinch River Small Modular Reactor 2011," Tennessee Valley Authority Biological and Water Resources, Chattanooga, Tennessee, January, 2013.

Table 6.5-1
TVA Field Activities included in the Terrestrial Wildlife Site Preparation Monitoring Program

Survey Type	Survey Location	Survey Description, Sample Size	Survey Seasons[1]				Targeted Animal Groups
			W	S	Su	F	
Visual and aural surveys by boat	Shoreline of Clinch River adjacent to CRN Site	One survey/season; boat driven at slow pace, noting aural and visual detections.	X	X	X	X	Overwintering and nesting birds, turtles, mammals
Visual and aural encounter surveys (VES) by foot	Linear transects (N = 7) (500 m) distributed across CRN Site and Clinch River Property	Four surveys/season/transect, walked beginning to end on 4 consecutive days per season, noting aural and visual detections.	X	X	X	X	Any species observed, but focused on birds and mammals
Sherman traps	Placed along same transects used for VES	Seven traps/transect/season spaced ~100m from transect endpoints, ~35 m from each other, opened and then checked for 3 consecutive days.	X	X	X	X	Small mammals
Cover boards	Placed along same transects used for visual encounter surveys	Six boards/transect/season spaced 100 m apart from transect endpoints and ~50m from each other, checked for 3 consecutive days.	X	X	X	X	Amphibians and reptiles
Minnow traps	Aquatic water bodies (streams and ponds, N = 6)) across CRN Site and Clinch River Property	12 traps (2 traps per site)/season, partially submerged; traps set and then checked for 3 consecutive days.	X	X	X	X	Frogs, toads, salamanders
Anuran call surveys	Aquatic water bodies across CRN Site and Clinch River Property	Five surveys (1/site)/season, post- sunset following a rain event.	X	X	X	X	Frogs and toads
Bat acoustic surveys	Water crossings and forested corridors	Six acoustic detectors, deployed on day 1 of survey and set to collect data for 4 consecutive nights.	NS	X	X	X	Bats
Bat mist-net surveys	Eight stations near water, open edges, or open forest understory	Two nets per station, at least 30 m apart. Nets open 5 hr per night during July 11-21, 2011.	NS	NS	X	NS	Bats
Opportunistic sitings	Wherever present on CRN Site and Clinch River Property	Aural, visual, and sign (e.g., scat) indicating animal presence.	X	X	X	X	Any observed wildlife noted

[1] W = Winter (February to early March); S = Spring (April to May); Su = Summer (July to August); F = Fall (September to November); NS = Not Surveyed

6.6 CHEMICAL MONITORING

The following section describes the chemical monitoring programs at the Clinch River Nuclear (CRN) Site for surface water and groundwater quality, including:

- Preapplication/Site preparation monitoring that supports, in part, the baseline water quality descriptions in Chapter 2
- Construction/preoperational monitoring intended to identify potential impacts of preconstruction, construction, and preoperational activities and provide a basis for identifying and assessing environmental impacts from the operation of two or more small modular reactors (SMRs)
- Operational discharge monitoring intended for evaluation of environmental impacts from the operation of two or more SMRs

Discussions related to historic, current, and future water use, and potential discharges and pollutant sources are found in Subsections 2.3.2 and 2.3.3 and Sections 3.3, 3.6, 5.2, and 5.5. Baseline environmental water quality is described in Subsection 2.3.3 and anticipated wastewater generation is described in Sections 3.6 and 5.5.

6.6.1 Site Preparation Monitoring

The purpose of the site preparation monitoring program is to provide data to support the assessment of potential impacts that result from the construction and operation of two or more SMRs. The program includes both ongoing surface water and groundwater monitoring conducted to collect baseline water quality data in support of the Early Site Permit application (ESPA) for the Clinch River (CR) SMR Project.

6.6.1.1 Surface Water Monitoring

6.6.1.1.1 River and Reservoir Compliance Monitoring Program

As part of the operation and management of the Tennessee River, Tennessee Valley Authority (TVA) monitors surface water quality and sediment data in the TVA reservoirs, including the Watts Bar Reservoir, as part of a reservoir system monitoring program. TVA monitors ecological conditions at 69 sites on 31 reservoirs. Each site is monitored biennially unless a substantial change in the ecological health score occurs during a 2-year (yr) cycle. If that occurs, the site is monitored the next year to ascertain whether the change was a trend or an anomaly. Roughly half the sites are sampled each year on an alternating basis. The program includes five ecological indicators (chlorophyll-a, dissolved oxygen (DO), sediment quality, benthic macroinvertebrates, and fish assemblage), which are monitored at up to four locations in each reservoir. To complete the ecological health scoring process, the 20 to 100 percent scoring range is divided into categories representing good, fair, and poor ecological health conditions relative to what is expected given the hydrogeomorphology of the reservoir. (Reference 6.6-1)

As part of this program, TVA has collected samples at four locations on Watts Bar Reservoir, usually on a 2-yr cycle: the forebay area of deep water near the dam at Tennessee River Mile (TRM) 531.0 (prior to 2000) and TRM 532.5 (after 2000), the middle part of the reservoir at TRM 560.8, the inflow area at the extreme upper end of the reservoir at TRM 600, and the inflow area in the Clinch River arm of the Watts Bar Reservoir at Clinch River Mile (CRM) 19 (Reference 6.6-2). The sampling focused on ecological health, but included general water quality parameters (i.e., DO, chlorophyll, and chemical analysis of sediment) as indicators of ecological health. (Reference 6.6-3)

6.6.1.1.2 Site Preparation Monitoring Program

To support the evaluation of the suitability of the CRN Site, TVA monitored the surface water on and in the immediate vicinity of the CRN Site. This program consisted of characterization of surface water in the Clinch River arm of the Watts Bar Reservoir, as well as characterization of stormwater runoff. In addition, water quality sampling, including sediment sampling, was performed between CRM 10.0 and 22.0. The resulting data provide information to determine existing conditions for surface water. (Reference 6.6-4)

The sampling locations for surface water monitoring in the immediate vicinity of the CRN Site are shown in Figure 2.3.3-1. Descriptions of these locations are as follows:

- CRS1 is a stormwater pond, identified as P01 in Figure 2.4.1-2, which drains the area northwest of the reactor footprint. It is located on the site near CRM 15.5, close to the proposed locations of the holding pond and the discharge. Several culverts drain into the pond area. Surface water samples were collected at one of the culverts as stormwater flows into the pond. (Reference 6.6-4)
- CRS2 is a stormwater pond, identified as P02 in Figure 2.4.1-2, located off River Road. It is located on the site, near CRM 16.2. There are three inflows associated with this stormwater pond. Surface water samples were collected at inflow location on the northern side of the pond. (Reference 6.6-4)
- CRS3 is a stormwater pond, identified as P06 in Figure 2.4.1-2, located on the southern tip of the peninsula. It is located on the site, near CRM 16.5. Surface water samples were collected where the pond discharge circumvents the discharge culvert. If river water was backed up to that location in the stormwater pond, then samples were collected from the inlet into the pond. (Reference 6.6-4)
- CRS6 is a stormwater pond, identified as P04 in Figure 2.4.1-2, located east of the reactor footprint, near the stream identified as S01. It is located on the site, near CRM 17.8. Surface water samples were collected from the weir if the pond was discharging; otherwise, they were collected from pond inflow. (Reference 6.6-4)
- CRS8 is the upstream river location on the Watts Bar Reservoir, located near CRM 18.3 (Reference 6.6-4).

- CRS9 is a downstream river location near the confluence of Grassy Creek, near CRM 14.5 (Reference 6.6-4).
- CRS10 is located at the mouth of Grassy Creek, at the outlet of the culvert, near CRM 14.5 (Reference 6.6-4).
- CRS11 is located on the downstream side of a culvert under Bear Creek Road, near CRM 14.3. Surface water samples were collected at the downstream side of the culvert under the road. Depending on the reservoir level, the surface water sample was collected at the safest accessible location between the outlet of the culvert and the point where the flow enters the reservoir pool. (Reference 6.6-4)
- CRS 12 is the downstream river location at the Tennessee State Highway 58 (Gallaher) Bridge near CRM 14.0, at approximately mid-stream (Reference 6.6-4).

Samples were collected in July 2013, March 2014, and May 2014 at locations CRS1, CRS2, CRS3, CRS6, CRS8, and CRS9. Samples were collected in November 2014 at all locations. Samples were collected in February 2015, April 2015, and June 2015 at locations CRS8, CRS10, CRS11, and CRS12. (Reference 6.6-4)

Access for sampling at sites CRS1, CRS2, CRS3, and CRS6 was by vehicle, while access for sampling at sites CRS8, CRS9, and CRS12 was by boat (Reference 6.6-5). For CRS10 and CRS11, the reservoir level determined the sampling method. For samples collected in November and May, access was by vehicle, since the water was too low to reach by the sites by boat. For the June samples the water was high enough to allow access by boat.

Surface water samples were grab samples collected during or within 24 hours (hr) following a rain event that was greater than 0.1 inches (in.) and occurred at least 72 hr following the previous measurable (> 0.1 in.) rain event. Where practicable, stormwater sampling and Watts Bar Reservoir sampling were performed on the same days. Onsite stormwater is routed to impoundments which hold runoff but do not normally discharge. Discharges from these basins are not expected barring an unusually large rainfall event. Therefore, stormwater (surface water) samples were collected from within the ponds. Reservoir (surface water) samples were collected at the point of concentrated flow. (Reference 6.6-4)

The surface water analytes and bottle types are listed in Table 6.6-1. Surface water sample results are provided in Tables 2.3.3-2 through 2.3.3-6.

The field procedures used for surface water sampling are provided in the following paragraphs.

Analytical sample collections and field analyses follow the applicable procedures from the U.S. Environmental Protection Agency (EPA) Region IV Field Branches Quality Systems and Technical Procedures (http://www.epa.gov/region4/sesd/fbqstp/). A field blank was collected for each parameter which is represented by a grab sample. (Reference 6.6-5)

The general field procedures used to satisfy surface water monitoring requirements included:

- Performing and documenting standardization of pH meter(s) immediately prior to monitoring
- Measuring and recording pH and temperature
- Collecting grab samples
- Placing all samples on ice and preparing for transport to the laboratory
- Documenting the following storm event information as part of the storm event monitoring:
  - Date
  - Duration (in minutes) and total rainfall during sampled storm event (in inches)
  - Number of hours between the beginning of sampled storm event and the previous event of 0.1 in. or greater
  - Flow rate during storm event sampling if discharging
  - Estimated total runoff discharged for storm event for each discharge
  - Description of the method(s) used for flow measurements and volume estimates for each discharge if applicable (Reference 6.6-5)

Field observations noted and recorded during each storm event sampling included:

- Floating materials or foam
- Oil sheen
- Appearance and odor of pond and/or discharge stream
- Possible sources of contamination
- Date and exact time of observation
- Name of person making observation (Reference 6.6-5)

Field analyses included measurement of pH and temperature (Reference 6.6-5).

6.6.1.1.3 Biological Monitoring Program

As part of the biological monitoring to characterize the aquatic community near the CRN Site TVA collected and analyzed surface water and sediment samples at selected locations on the Clinch River arm of the Watts Bar Reservoir between CRM 15.5 and 22.0. These data were collected in 2011 to characterize baseline conditions of the aquatic habitats and communities in the reservoir immediately upstream and downstream of the CRN Site. This program focused on ecological health, but included collection of surface water quality and sediment chemistry data as indicators of ecological health. Surface water samples were collected at four mid-channel locations, including three upstream locations (CRM 18.5, CRM 19.7, and CRM 22.0) and one downstream location (CRM 15.5). The surface water samples were collected monthly from March to December 2011. The surface water quality parameters measured are listed in Table

6.6-2. The surface water sample analytes are listed in Table 6.6-3, In June 2011, sediment samples were collected at three of the locations (CRM 15.5, CRM 18.5, and CRM 22.0). The sediment sample types and analytes are listed in Table 6.6-4. The results from the biological monitoring program are provided in Tables 2.3.3-4 through 2.3.3-8, and are described in Subsections 2.3.3 and 2.4.2. (Reference 6.6-6)

6.6.1.2 Groundwater Monitoring

The site preparation groundwater monitoring program, including descriptions of monitoring locations and sampling results, is described in Subsections 2.3.1.2, 2.3.2.2, and 2.3.3.2. Groundwater sampling was conducted on a quarterly basis to satisfy requirements for the site preparation monitoring program. Groundwater sample events were performed in December 2013/January 2014, April 2014, August 2014, and November 2014. Groundwater sampling results are provided in Tables 2.3.3-9 and 2.3.3-10. In fall of 2013, 37 monitoring wells were installed, consisting of 15 clusters of two to three wells each. Each cluster consists of an upper and lower well, and some clusters contain an additional deep well. The 21 monitoring wells listed in Table 2.3.1-3 were initially chosen as the groundwater monitoring wells. These wells are contained within nine of the 15 clusters that are distributed around the area of the construction footprint. Table 2.3.1-3 also provides a summary of installation details. The monitoring well locations are shown in Figure 2.3.1-18. (Reference 6.6-7)

Groundwater sampling for the first quarter occurred from December 2013 to January 2014. Well CRS-OW420U did not have enough water to purge properly or perform field analysis. Laboratory samples were collected, but may be biased from high turbidity and the underdeveloped well conditions. Well CRS-OW429L also did not produce enough water to purge properly and also did not recharge after purging. This well was not sampled for field or laboratory analysis. Wells CRS-OW428D, CRS-OW428L, CRS-OW420U, CRS-OW419L, and CRS-OW401L exhibited high turbidity readings. (Reference 6.6-7)

Second quarter groundwater sampling occurred in April 2014. Wells CRS-OW420U and CRS-OW429L did not have enough water to purge properly or perform field analysis. Some laboratory samples were collected, but may be biased from high turbidity and the underdeveloped well conditions. Wells CRS-OW401U, CRS-OW401L, CRS-OW416U, CRS-OW420U, CRS-OW428L, CRS-OW428D, and CRS-OW429L exhibited high turbidity readings. (Reference 6.6-7)

Third quarter groundwater sampling occurred in August 2014. Similar to previous events, well CRS OW420U was only able to be sampled for laboratory parameters. CRS-OW429L was removed from the sampling plan due to previous performance. Wells CRS-OW401L, CRS-OW401D, CRS-OW416U, CRS-OW420U, CRS-OW421U, CRS-OW421D, and CRS-OW428D exhibited high turbidity readings. (Reference 6.6-7)

Fourth quarter groundwater sampling occurred in November 2014. Wells CRS-OW420U and CRS-429L were both removed from the sampling plan due to previous poor sampling

conditions. Wells CRSOW421U, CRS-OW419L, CRS-OW416U, CRS-OW401L, and CRS-OW401U exhibited high turbidity readings. (Reference 6.6-7)

Groundwater samples were collected using a submersible bladder pump placed below the water level in the selected monitoring well, above the screen interval. For wells which exhibited low yields, disposable Teflon bailers were used to collect sample volumes. Field parameters (i.e., temperature, specific conductance, pH, DO, oxidation-reduction potential, and turbidity) were monitored during well purging using a flow-through cell and calibrated instruments. Each monitoring well was considered properly evacuated when field parameters remained stable after purging a minimum of three well volumes or after purging standing water in the well. Following sample collection in a temporary field container, water from each monitoring well was transferred to new, pre-labeled sample containers with appropriate preservatives (where applicable). Sample containers were then sealed, necessary data were recorded on a chain-of-custody form, and samples were placed in iced coolers for transport. All groundwater sampling was conducted in accordance with TVA's Technical Instructional document for Groundwater Sampling EMA-TI-05.80.42. (Reference 6.6-7)

The list of parameters analyzed to characterize CRN Site groundwater is provided in Table 6.6-5.

Various reference values were used to compare the groundwater quality data, including Maximum Contaminant Levels set by the Tennessee Department of Environment and Conservation (TDEC) and EPA regional screening levels (Reference 6.6-7).

6.6.2 Construction and Preoperational Monitoring

6.6.2.1 Surface Water Monitoring

Surface water monitoring requirements for the construction phase would be developed as part of the permit application for a National Pollutant Discharge Elimination System (NPDES) general stormwater construction permit issued by the TDEC. Prior to initiation of construction, a completed and signed Notice of Intent (NOI) for Construction Activity - Stormwater Discharges would be required to be submitted to TDEC. A site-specific Stormwater Pollution Prevention Plan (SWPPP) would be developed and submitted with the NOI. The SWPPP would be developed, implemented, and updated according to Part 3 of the Construction General Permit.

Shoreline excavation would be required for construction of the intake structure, along a length of shoreline approximately 50 ft wide. The diffuser pipe for the discharge would be partially buried, which would also require underwater excavation. The Lower Clinch River sediments are listed as impaired for mercury, polychlorinated biphenyls (PCBs), and chlordane. Also, legacy contamination, including radionuclides, from U.S. Department of Energy (DOE) activities is present in the portion of the Clinch River arm of the Watts Bar Reservoir adjacent to the CRN Site. TVA is party to an Interagency Agreement, along with the U.S. Army Corps of Engineers, DOE, TDEC, and Environmental Protection Agency, to coordinate review of permitting and other

use authorization activities which could result in the disturbance, re-suspension, removal, and/or disposal of contaminated sediments in the reservoir. The agreement, signed in 1991, defines how each agency would coordinate with the others to review proposed activities to determine their potential to disturb contaminated sediments. As stipulated by this agreement, it is expected that TDEC would require monitoring of sediment in the area(s) where dredging is proposed. In addition, acceptable best management practices would have to be implemented to ensure that dredging activity does not further degrade surface water quality. Any sediment removed may also contain manmade radionuclides. Coordination of the disposition of the sediment with DOE is also expected.

6.6.2.2 Groundwater Monitoring

Quarterly monitoring well sampling would be re-initiated for two years preceding the construction start date. Eight quarterly samples of concurrent data would provide a solid baseline dataset. Table 6.6-6 lists monitoring wells that could be included in this sampling. During the interim between completion of the water level monitoring in October 2015 and the re-initiation of groundwater sampling two years prior to start of construction, the monitoring wells would be inspected quarterly for damage, the locks maintained, and access maintained.

6.6.3 Operational Monitoring

6.6.3.1 Surface Water Monitoring

There is no operating facility and no existing NPDES permit at the CRN Site, so there is no existing operational surface water monitoring program. The ongoing preoperational surface water monitoring establishes surface water quality based NPDES permit limitations. Subsequent surface water monitoring requirements assure compliance with applicable TDEC Water Quality Standards. Operational surface water monitoring beyond that required for NPDES permit compliance is not anticipated.

6.6.3.2 Groundwater Monitoring

The location of groundwater monitoring wells to be monitored during SMR operation are unknown at this time, but would be provided following selection of a reactor design as part of the combined license application (COLA). The monitoring wells to be included would be a subset of the existing wells from the preoperational groundwater monitoring program. The manner in which the results of the operational groundwater chemical monitoring program would be compared to modeling predictions and the established baseline to identify and address adverse impacts would be established following selection of a reactor design, and would be evaluated as part of the COLA.

6.6.4 References

Reference 6.6-1. Tennessee Valley Authority, "Programmatic Environmental Impact Statement, Reservoir Operations Study," May, 2004.

Reference 6.6-2. Tennessee Valley Authority, "Final Environmental Impact Statement Watts Bar Reservoir Land Management Plan Loudon, Meigs, Rhea, and Roane Counties, Tennessee," February, 2009.

Reference 6.6-3. Tennessee Valley Authority, Watts Bar Reservoir Ecological Health Rating - 1994-2012, Website: http://www.tva.com/environment/ecohealth/wattsbar.htm, 2015.

Reference 6.6-4. Tennessee Valley Authority, "Clinch River Surface Water Quality Report - Revision 2," July 10, 2015.

Reference 6.6-5. Tennessee Valley Authority, "Surface Water Sampling Plan," Rev. 10, October 21, 2014.

Reference 6.6-6. Tennessee Valley Authority, "Biological Monitoring to Characterize the Aquatic Community near the Site of the Proposed Clinch River Small Modular Reactor 2011," Tennessee Valley Authority Biological and Water Resources, Chattanooga, Tennessee, January, 2013.

Reference 6.6-7. Tennessee Valley Authority, "Groundwater Quality Monitoring Report," Rev. 1, April 20, 2015.

Reference 6.6-8. Tennessee Valley Authority, "Workplan to Characterize Groundwater Quality on the Clinch River Small Modular Reactor Site," December 10, 2013.

Table 6.6-1
Surface Water Analytical Parameters and Bottle Types

Parameters	Holding Time	Sample Type	Bottle type
Temperature	15 minutes	Field Analysis and Grab Sample	Field Quart – 1L poly
pH	15 minutes	Field Analysis and Grab Sample	
Oil & Grease	28 days	Grab	1L wide mouth glass, spiked (HCL)
Total Cyanide	14 days	Grab	250 ml amber poly spiked (NaOH to pH>12)
Total Phenols (EPA Method 420.2)	28 days	Grab	250 ml amber glass spiked (H_2SO_4)
Biochemical Oxygen Demand	48 hours	Grab	1L poly
Total Suspended Solids	7 days	Grab	TSS – 500 ml poly
Color	48 hours	Grab	Color – 250 ml poly
Bromide	28 days	Grab	125 ml poly
Surfactants (MBAS)	48 hours	Grab	1L poly
Total Organic Carbon	28 days	Grab	250 ml amber glass w/septa, spiked (HCL)
Sulfide	7 days	Grab	500 ml poly spiked (ZnAc+NaOH)
Ammonia Nitrogen	28 days	Grab	250 ml poly spiked (H_2SO_4 +NaThio)
Nitrate/Nitrite (as N)	28 days	Grab	Nutrients/COD - 250 ml poly spiked (H_2SO_4)
Total Organic Nitrogen (as N)	28 days	Grab	
TKN, Total Phosphorous (as P)	28 days	Grab	
Chemical Oxygen Demand (COD)	28 days	Grab	
Fluoride (by IC)	28 days	Grab	125 ml poly
Sulfate (by IC)	28 days	Grab	
Aluminum, Magnesium, Calcium, Iron, Copper, Zinc, Barium, Boron, Cobalt, Manganese, Molybdenum, Tin, Titanium, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium, Silver, Thallium	6 months	Grab	500 ml poly spiked (HNO_3)
Hardness	6 months	Grab	
Acids/Base/Neutral Compounds	7 days	Grab	1 L amber
Gross Alpha, Gross Beta, Radium, Radium226	6 months	Grab	1-gallon cubitainer
PCB listed in Part C of EPA Form 2C	7 days	Grab	1 L glass

Source: (Reference 6.6-5)

Table 6.6-2
Surface Water Quality Parameters, Reporting Limits, and Methods of Analysis

Parameter	Reporting Limit	Units	Method Analysis
Alkalinity	20	mg/L	2320B
Ammonia Nitrogen	0.1	mg/L	350.1
Chlorophyll-a	1	µg/L	ASTM D3731
Dissolved Solids	10	mg/L	2540C
Hardness, Total (mg/L as CaCO3)	30	mg/L	130.1
Kjeldahl Nitrogen	0.1	mg/L	351.2
Nitrate-Nitrite	0.1	mg/L	353.2
Phosphate, Ortho	0.025	mg/L	4500P-E
Phosphorus, Total	0.003	mg/L	365.1
Suspended Solids	1	mg/L	2540D
Total Organic Carbon	1	mg/L	9060A
Turbidity	0.1	NTU	SM2130B
Temperature	0.1	C	Hydrolab®
pH	0.1	Stand. Units	Hydrolab®
Conductivity	0.1	µS/cm	Hydrolab®
Dissolved Oxygen	0.1	mg/L	Hydrolab®

Source: (Reference 6.6-6)

Table 6.6-3
Total and Dissolved Metals Analyses in Surface Water, Reporting Limits, and Methods

Metals, Total and Dissolved	Reporting Limit (µg/l)	Method of Analysis
Aluminum	100	200.7
Arsenic	1	200.8
Cadmium	0.5	200.8
Calcium	500	200.7
Chromium	1	200.8
Copper	1	200.8
Iron	100	200.7
Lead	1	200.8
Magnesium	1	200.8
Manganese	10	200.7
Nickel	1	200.8
Selenium	1	200.8
Zinc	10	200.8

Source: (Reference 6.6-6)

Table 6.6-4
Chemical Measurements in Sediments, Detection Limits, and Methods

Analysis	Method Detection Limit	Units	Method of Analysis
Metals			
Aluminum, Total	5	mg/kg	EPA 6010B
Arsenic, Total	0.5	mg/kg	EPA 7060A
Cadmium, Total	0.5	mg/kg	EPA 6010B
Calcium, Total	10	mg/kg	EPA 6010B
Chromium, Total	5	mg/kg	EPA 6010B
Copper, Total	1	mg/kg	EPA 6010B
Iron, Total	1	mg/kg	EPA 6010B
Lead, Total	5	mg/kg	EPA 6010B
Magnesium, Total	1	mg/kg	EPA 6010B
Manganese, Total	0.5	mg/kg	EPA 6010B
Mercury, Total	0.1	mg/kg	EPA 7471A
Nickel, Total	5	mg/kg	EPA 6010B
Zinc, Total	1	mg/kg	EPA 6010B
Organochlorine Pesticides and PCB’s			
Aldrin	10	µg/kg	EPA 8081A
alpha-BHC	10	µg/kg	EPA 8081A
beta-BHC	10	µg/kg	EPA 8081A
gamma-BHC (Lindane)	10	µg/kg	EPA 8081A
delta-BHC	10	µg/kg	EPA 8081A
Chlordane	10	µg/kg	EPA 8081A
Dieldrin	10	µg/kg	EPA 8081A
4,4'-DDD	10	µg/kg	EPA 8081A
4,4'-DDE	10	µg/kg	EPA 8081A
4,4'-DDT	10	µg/kg	EPA 8081A
Endosulfan alpha	10	µg/kg	EPA 8081A
Endosulfan beta	10	µg/kg	EPA 8081A
Endosulfan sulfate	10	µg/kg	EPA 8081A
Endrin	10	µg/kg	EPA 8081A
Endrin aldehyde	10	µg/kg	EPA 8081A
Heptachlor	10	µg/kg	EPA 8081A
Heptachlor epoxide	10	µg/kg	EPA 8081A
Methoxychlor	10	µg/kg	EPA 8081A
Aroclor 1016	25	µg/kg	EPA 8082
Aroclor 1221	25	µg/kg	EPA 8082
Aroclor 1232	25	µg/kg	EPA 8082
Aroclor 1242	25	µg/kg	EPA 8082
Aroclor 1248	25	µg/kg	EPA 8082
Aroclor 1254	25	µg/kg	EPA 8082
Aroclor 1260	25	µg/kg	EPA 8082
Toxaphene	500	µg/kg	EPA 8081A

Source: (Reference 6.6-6)

Table 6.6-5 (Sheet 1 of 4)
Groundwater Analytical Parameters

Field Analysis	Temperature pH Dissolved Oxygen Conductivity Oxidation Reduction Potential Turbidity
Lab Analysis – Major Ions	Calcium Sodium Potassium Chloride Alkalinity (HCO3)
Lab Analysis - Group A	Biochemical Oxygen Demand Chemical Oxygen Demand Total Organic Carbon Total Suspended Solids Ammonia (as N)
Lab Analysis - Group B	Bromide Total Residual Chlorine Color Surfactants Fluoride Nitrate-Nitrite (as N) Oil and Grease Phosphorus (as P), Total Radioactivity - (1) Alpha, Total Radioactivity - (2) Beta, Total Radioactivity - (3) Radium, Total Radioactivity - (4) Radium 226, Total Titanium, Total Sulfate (as SO4) Sulfide (as S) Aluminum, Total Barium, Total Boron, Total Cobalt, Total Iron, Total Magnesium, Total Molybdenum, Total Manganese, Total Tin, Total

Table 6.6-5 (Sheet 2 of 4)
Groundwater Analytical Parameters

Lab Analysis – Section 1	Antimony, Total Arsenic, Total Beryllium, Total Cadmium, Total Chromium, Total Copper, Total Lead, Total Mercury, Total Nickel, Total Selenium, Total Silver, Total Thallium, Total Zinc, Total Cyanide, Total Phenols, Total
Gas Chromatogram/Mass Spectrometer (GC/MS) Fraction[1] - Volatile Organic Compounds (VOCs)	Acrolein Acrylonitirle Benzene Bromoform Carbon Tetrachloride Chlorobenzene Chlorodibromomethane Chloroethane 2-Chloroethylvinyl Ether Chloroform Dichlorobomomethane 1,1-Dichloroethane 1,2-Dichloroethane 1,2-Dichloropropane 1,3-Dichloropropylene Ethylbenzene Methyl Bromide Methyl Chloride Methylene Chloroethane 1,1,2,2-Tetrachloroethane Tetrachloroethylene Toluene 1,2-Trans-Dichloroethylene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethylene Vinyl Chloride

**Table 6.6-5 (Sheet 3 of 4)
Groundwater Analytical Parameters**

GC/MS Fraction[1] - Acid Compounds	2-Chlorophenol 2,4-Dichlorophenol 2,4 Dimethylphenol 4,6-Dinitro-O-Cresol 2,4-Dinitro-phenol 2-Nitrophenol 4-Nitrophenol P-Chloro-M-Cresol Pentachlorophenol Phenol 2,4,6-Trichlorophenol
GC/MS Fraction[1] - Base/Neutral Compounds	Acenaphthene Acenaphtylene Anthracene Benzidine Benzo (a) Anthracene Benzo (a) Pyrene 3,5-Benzofluoranthene Benzo (ghi) Perylene Benzo (k) Fluoranthene Bis (2-Chloroethoxy) Methane Bis (2-Chloroethyl) Ether Bis (2-Chloroisopropyl) Ether Bis (2-Ethylhexyl) Phthalate 4-Bromophenyl Phenyl Ether Butyl Benzyl Phthalate 2-Chloronaphthalene 4-Chlorophenyl Phenyl Ether Chrysene Dibenzo (a,h) Anthracene 1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4 Dichlorobenzene 3,3-Dichlorobenzidine Diethyl Phthalate Dimethyl Phthalate Di-N-Butyl Phthalate 2,4-Dinitrotoluene 2,6-Dinitrotoluene Di-N-Octyl Phthalate 1,2-Diphenylhydrazine (as Azobenzen) Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Hexachloroethane Ideno (1,2,3-cd) Pyrene

Table 6.6-5 (Sheet 4 of 4)
Groundwater Analytical Parameters

GC/MS Fraction[1] - Base/Neutral Compounds (continued)	Isophorone Naphthalene Nitrobenzene N-Nitro-sodimethylamine N-Nitrosodi-N-Propylamine N-Nitro-sodiphenylamine Phenanthrene Pyrene 1,2,4-Trichlorobenzene
GC/MS Fraction[1] – Pesticides	Aldrin Gamma-BHC Alpha-BHC Delta-BHC Beta-BHC Chlordane 4,4' DDT 4,4' DDE 4,4'-DDD Dieldrin Alpha-Endosulfan Beta-Endosulfan Endosulfan Sulfate Endrin Endrin Aldehyde Heptachlor Heptachlor Epoxide PCB-1242 PCB-1254 PCB-1221 PCB-1232 PCB-1248 PCB-1260 PCB-1016 Toxaphene
Other VOCs	Hexane
Isotopes	Tritium Strontium 90 Technetium 99

1 Fractions defined in 40 CFR Part 136

Source: (Reference 6.6-8)

Table 6.6-6
Monitoring Wells Included in Sampling

CRS-OW401U	CRS-OW419L
CRS-OW401L	CRS-OW420L
CRS-OW401D	CRS-OW421U
CRS-OW415U	CRS-OW421L
CRS-OW415L	CRS-OW421D
CRS-OW416U	CRS-OW428U
CRS-OW416L	CRS-OW428L
CRS-OW418U	CRS-OW428D
CRS-OW418L	CRS-OW429U
CRS-OW419U	

6.7 SUMMARY OF MONITORING PROGRAMS

This section summarizes the environmental monitoring programs described in the preceding sections of Chapter 6. The summary is divided into three sections:

- Site preparation and construction monitoring
- Preoperational monitoring
- Operational monitoring

Table 6.7-1 lists the environmental monitoring programs within each section by resource and program.

6.7.1 Site Preparation and Construction Monitoring

The site preparation and construction thermal, radiological, hydrological, meteorological, ecological, and chemical monitoring performed and/or planned for the Clinch River (CR) Small Modular Reactor (SMR) Project are summarized below and in Table 6.7-1:

- Site preparation and construction thermal monitoring and modeling programs are detailed in Subsections 6.1.1 and 6.1.2, and include:
  - Data collection to establish baseline conditions and to provide calibration data for modeling the potential SMR thermal impacts throughout the Watts Bar Reservoir
  - Evaluation of thermal impacts in regions near the Clinch River Nuclear (CRN) Site using an unsteady, three-dimensional computational fluid dynamics model for the portion of the Clinch River arm of Watts Bar Reservoir near the CRN Site
  - Evaluation of thermal impacts in regions beyond the CRN Site using CE-QUAL-W2, that assesses the laterally-averaged, unsteady buildup of thermal effluent in the Clinch River arm of the Watts Bar Reservoir as well as the potential reservoir-wide effects of operation of the SMRs
  - Construction discharges subject to monitoring to ensure compliance with a National Pollutant Discharge Elimination System (NPDES) permit, including hydrological monitoring of the temperature of the discharge
- No radiological monitoring program (Section 6.2) is required during the site preparation and construction phase of the initial SMR. Operational monitoring associated with the initial SMR will be implemented during the construction of additional SMRs.
- Hydrological site preparation and construction monitoring programs are detailed in Subsections 6.3.1 and 6.3.2, respectively. These programs include:
  - Hydrographic surveys of the Clinch River arm of the Watts Bar reservoir in the vicinity of the CRN Site which were conducted.

- Groundwater characterization activities which included drilling 82 boreholes, installing 44 wells, monitoring groundwater level, performing packer tests in boreholes, performing slug tests in monitoring wells, performing an aquifer pumping test, and collecting groundwater geochemical samples were conducted.
- Construction discharges are subject to monitoring to ensure compliance with a NPDES permit, including hydrological monitoring of the effects of the discharge.
- Groundwater monitoring will be conducted to assess and control the impacts from construction at the CRN Site by monitoring groundwater. Groundwater monitoring during construction will likely involve measuring water levels to monitor potential draw down caused by construction activities, sampling for the presence of new contaminants, and sampling for increased concentrations of known contaminants relative to site preparation monitoring results.

* The site preparation and construction meteorological monitoring programs are detailed in Subsection 6.4.2. Two years of baseline meteorological data were collected for the CRN Site and surrounding area from April 2011 through July 2013.
* Terrestrial ecology and land use monitoring programs are described in Subsection 6.5.1. These programs include:
  - Site preparation field studies were conducted on the Clinch River Property on a seasonal basis such that seasonal variations could be characterized throughout at least one annual cycle. The following field studies were conducted during the following periods:
    - Terrestrial vegetation community surveys in 2011 and 2013
    - Wetland surveys in 2011
    - Terrestrial animal surveys in 2011 and 2013
    - Supplemental field studies performed in 2014 and 2015 at specific areas on or near the CRN Site where construction of supporting facilities is proposed
  - Additional monitoring of terrestrial plant and animal communities during construction and preoperational phases is not warranted.
* Aquatic ecology monitoring programs are described in Subsection 6.5.2. These programs include:
  - Aquatic site preparation field studies were performed in 2011 in the Clinch River arm of the Watts Bar Reservoir at locations immediately upstream of, adjacent to, and downstream of the CRN Site.
  - Ecological conditions in the Tennessee Valley Authority (TVA) system of reservoirs have been monitored since 1990 as part of ongoing ecological health and compliance monitoring programs.

- Ponds, perennial and intermittent streams, and ephemeral streams/wet-weather conveyances on the CRN Site were mapped and classified in 2011, 2013, and 2014. Water bodies on the Barge/Traffic Area were mapped and classified in 2014. Species present in perennial and intermittent streams in both areas were sampled in 2015.
- Additional formal monitoring of aquatic species during the construction phase beyond that conducted under TVA's ongoing ecological health and compliance monitoring programs is not warranted or proposed as discussed in Subsection 6.5.2.2.

- Details of the site preparation and construction chemical monitoring are provided in Subsections 6.6.1 and 6.6.2. These programs include:
  - Characterization of surface water in the Clinch River arm of the Watts Bar Reservoir, as well as characterization of stormwater runoff, was performed from July 2013 through June 2015.
  - Groundwater sampling was conducted on a quarterly basis, from December 2013 to January 2014 through November 2014, to satisfy site preparation monitoring program requirements.
  - Surface water monitoring requirements for the construction phase will be developed as part of the permit application for a NPDES permit.
  - Groundwater monitoring will be re-initiated for two years preceding the construction start date.

6.7.2 Preoperational Monitoring

The purpose of preoperational monitoring, generally conducted in the one or two years prior to the start up a nuclear power plant, is to establish baseline conditions. However, with staggered construction of multiple reactors, preoperational monitoring and construction monitoring can overlap and data collected can meet dual purposes. The information provided below and in Table 6.7-1 provides the preoperational monitoring planned for the CR SMR project:

- Thermal monitoring is addressed in Subsection 6.1.2. Because the site preparation monitoring already conducted provides adequate baseline data, no additional preoperational monitoring is planned during construction.
- As discussed in Section 6.2, a Radiological Environmental Monitoring Program (REMP) is initiated two years before scheduled fuel load. It includes monitoring of the environment by sampling air, water, sediment, fish and food products, as well as measuring radiation directly.
- Surface water monitoring requirements for preoperational activities will be developed as part of the permit application for an NPDES permit issued by the Tennessee Department of Environment and Conservation (TDEC).

- The preoperational meteorological monitoring program, as described in Section 6.4, has already been conducted and is the same as the site preparation and construction monitoring program. Two years of baseline meteorological data were collected for the CRN Site and surrounding area from April 2011 through July 2013.
- At least 1 year (yr) of preoperational and/or operational seasonal species surveys of terrestrial communities will be collected for comparison to the baseline data.
- At least 1 yr of preoperational and/or operational aquatic community studies will be performed to collect data for comparison to the baseline data.
- Preoperational surface water monitoring requirements will be developed as part of the permit application for a NPDES general stormwater construction permit issued by TDEC.
- Quarterly groundwater monitoring well sampling will be re-initiated for two years preceding the construction start date. Eight quarterly samples of concurrent data will provide a solid baseline dataset.

6.7.3 Operational Monitoring

Specific operational monitoring requirements and programs for the CR SMR Project have not yet been defined. The operational monitoring programs for thermal, hydrological, and chemical effects are developed when the final SMR design is selected. The operational radiological monitoring is defined by the REMP, and begins during the preoperational phase. A new meteorological monitoring program (including construction of a new meteorological tower at the location of the tower from which the 2011 through 2013 data were collected) will be established for operational monitoring. The operational phase meteorological monitoring program is similar to the preoperational meteorological program. No specific ecological monitoring is proposed for the operational phase.

Table 6.7-1 (Sheet 1 of 4)
Summary of Monitoring Programs

Resource	Program	Scope/Content	Applicable Section/Subsection for Additional Details
Site Preparation and Construction Monitoring			
Water	Thermal Monitoring	Thermal monitoring of the rivers and reservoirs in the vicinity of the CRN Site was conducted from October 2013 through December 2014. Also, temperatures in Watts Bar Reservoir and Melton Hill Reservoir have been monitored since 2000 as routine operation data collection. Construction discharges are subject to monitoring to ensure compliance with the NPDES permit including monitoring of the temperature of the discharge.	6.1.1
Human Health	Radiological Monitoring	No site preparation radiological monitoring has been performed. No monitoring required during site preparation and construction.	6.2.1
Water	Hydrological Monitoring	Hydrographic surveys of the Watts Bar Reservoir were performed in June 2013. Construction discharges are subject to monitoring to ensure compliance with the NPDES permit, including hydrologic monitoring of the effects of the discharge. Groundwater monitoring included installation of 37 observation wells in 2013, and sampling of those wells in 2013 and 2014. Groundwater monitoring during construction includes measuring water levels to monitor potential draw down caused by construction activities, sampling for the presence of new contaminants, and sampling for increased concentrations of known contaminants relative to site preparation monitoring results.	6.3.1.1 6.3.2.1 6.3.1.2 6.3.2.2
Meteorology	Meteorological Monitoring	For the CR SMR Project's site preparation meteorological monitoring program, the meteorological data collection system at Tower 3 was refurbished in 2011 to meet U.S. Nuclear Regulatory Commission Regulatory Guide 1.23, *Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants*. Table 6.4-1 presents the list of data collected at the meteorological tower, and the measurements are explained in Subsection 6.4.2. The meteorological monitoring program was initiated in April 2011 and data was collected through July 2013.	6.4.2

Table 6.7-1 (Sheet 2 of 4)
Summary of Monitoring Programs

Resource	Program	Scope/Content	Applicable Section/Subsection for Additional Details
Terrestrial	Ecological Monitoring	TVA performed site preparation field studies on the Clinch River Property and the CRN Site on a seasonal basis. Terrestrial vegetation communities were surveyed in 2011 and 2013, wetlands were surveyed in 2011, and terrestrial animals were surveyed in 2011 and 2013, and supplemental field studies were performed in 2014 and 2015 at specific areas on or near the CRN Site where construction of supporting facilities is proposed, as described in Subsection 2.4.1. Additional monitoring of terrestrial plant and animal communities during site preparation and construction phases is not warranted.	6.5.1.1
Aquatic	Ecological Monitoring	TVA performed site preparation field studies in 2011 and 2012 in the Clinch River arm of Watts Bar Reservoir at locations immediately upstream and downstream of the CRN Site. These studies characterized the baseline conditions of the aquatic habitats and communities in winter, spring, summer, and fall. Ponds and streams on the CRN Site were mapped and classified in 2011, 2013, and 2014. Species present in the perennial and intermittent streams were sampled in 2015. Additional monitoring during the construction phase beyond that conducted under TVA's ongoing ecological health and compliance monitoring programs is not warranted.	6.5.2.1 6.5.2.2
Water	Chemical Monitoring	Baseline water quality studies for surface water were conducted in 2013, 2014, and 2015. Baseline groundwater quality studies were conducted in 2013 and 2014. Surface water monitoring requirements are developed as part of the permit application for a NPDES permit issued by the TDEC. Quarterly groundwater monitoring well sampling is re-initiated for two years preceding the construction start date.	6.6.1 6.6.2

Table 6.7-1 (Sheet 3 of 4)
Summary of Monitoring Programs

Resource	Program	Scope/Content	Applicable Section/Subsection for Additional Details
Preoperational Monitoring			
Water	Thermal Monitoring	Because the site preparation monitoring already conducted provides adequate baseline data, no additional thermal monitoring is planned during the preoperational phase.	6.1.2
Human Health	Radiological Monitoring	The REMP includes monitoring of the environment by sampling air, water, sediment, fish, invertebrates and food products, as well as measuring radiation directly. The REMP is initiated two years before scheduled fuel load.	6.2
Water	Hydrological Monitoring	Surface water monitoring requirements for preoperational activities are developed as part of the permit application for a NPDES permit issued by TDEC.	6.3.2
Meteorology	Meteorological Monitoring	Refurbished meteorological Tower 3 was used to collect the meteorological monitoring data for the preoperational phase of the SMR project.	6.4.1
Terrestrial	Ecological Monitoring	Field studies performed during the site preparation monitoring program, which includes seasonal species surveys of terrestrial communities, are repeated for the period following construction, in order to collect at least 1 yr of preoperational and/or operational data for comparison to the baseline data. The activities included in a preoperational/operational monitoring program are a subset of the site preparation field studies.	6.5.1.2
Aquatic	Ecological Monitoring	Field studies performed during the site preparation monitoring program of aquatic communities are repeated for the period prior to startup of the initial SMR in order to collect at least 1 yr of preoperational and/or operational data (including aquatic monitoring) for comparison to the baseline data. The activities included in a preoperational/operational aquatic monitoring program are a subset of the site preparation field studies.	6.5.2.3

Table 6.7-1 (Sheet 4 of 4)
Summary of Monitoring Programs

Resource	Program	Scope/Content	Applicable Section/Subsection for Additional Details
Operational Monitoring			
Water	Chemical Monitoring	Preoperational surface water monitoring requirements are developed as part of the permit application for a NPDES general stormwater construction permit issued by TDEC.	6.6.2
Water	Thermal Monitoring	Thermal monitoring during the operational phase is developed, once the final SMR design is selected. Operational monitoring is in accordance with the NPDES permit, which is finalized prior to the start of operation.	6.1.3
Human Health	Radiological Monitoring	Radiological monitoring for the operational period is defined in the REMP.	6.2
Water	Hydrological Monitoring	Hydrological monitoring to assess impacts to water quality resulting from operation of the SMRs is developed once the final SMR design is selected.	6.3.3
Meteorology	Meteorological Monitoring	As part of the operational phase of the CR SMR Project, a new meteorological tower is expected to be constructed at the location of the old meteorological tower from which the 2011 through 2013 data were collected, and the new meteorological monitoring program is established for operational monitoring. It is expected to meet the same TVA and regulatory requirements satisfied by the preoperational meteorological program.	6.4.3
Ecology	Ecological Monitoring	No specific ecological monitoring is proposed.	6.5.1.2
Water	Chemical Monitoring	Preoperational surface water monitoring is used to establish surface water quality to demonstrate compliance with the NPDES permit limitations and surface water monitoring requirements to assure compliance with TDEC Water Quality Standards. The groundwater monitoring program is established once the final SMR design is selected.	6.6.3