CHAPTER 9 ALTERNATIVES

Chapter 9 identifies and describes alternatives for siting, constructing and operating two or more Small Modular Reactors (SMRs) at the Clinch River Nuclear (CRN) Site as a demonstration of this new technology. The proposed federal action is the issuance, under the provision of Title 10 of the Code of Federal Regulations Part 52, of an Early Site Permit (ESP) to the Tennessee Valley Authority (TVA) approving the CRN Site as a suitable site for future demonstration of the construction and operation of two or more SMRs. TVA's goal in preparing the ESP application (ESPA) is to obtain U.S. Nuclear Regulatory Commission (NRC) approval of the CRN Site and to minimize the amount of additional environmental review needed for a combined license application (COLA). In addition, the submittal of an ESPA will allow TVA and NRC to address any unique issues that may be associated with the COLA for the Clinch River (CR) SMR Project, thereby establishing that an SMR demonstration project is a viable option. The alternatives described in Chapter 9 are shaped by TVA's unique objective, which is to demonstrate and deploy first-of-its-kind SMR technology within its power service area.

The descriptions in this chapter provide sufficient detail to facilitate the evaluation of the impacts of the various alternatives. Chapter 9 is divided into four sections:

- No-Action Alternative (Section 9.1)

  Section 9.1 describes the environmental impact if an ESP is not issued and the SMRs are not constructed or operated.

- Energy Alternatives (Section 9.2)

  Section 9.2 is not included as part of the ESPA. The Energy Alternatives discussion is provided at COLA.

- Alternative Sites (Section 9.3)

  Section 9.3 describes and evaluates the alternative sites considered for the CR SMR Project.

- Alternative Plant Systems (Section 9.4)

  Section 9.4 describes and evaluates plant and transmission system alternatives for the SMRs.

9.1 NO-ACTION ALTERNATIVE

Under the No-Action Alternative, the U.S. Nuclear Regulatory Commission (NRC) would not issue an Early Site Permit (ESP) for two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site and Tennessee Valley Authority (TVA) would not pursue a demonstration of SMR technology as a viable option for electric power production at the CRN Site. In accordance with NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plans*, the No-Action Alternative presupposes that no other similar facility would be built by TVA and no other similar strategy would be implemented by TVA to take its place. The environmental impacts associated with the CR SMR Project would not occur since the SMRs would not be constructed and operated at the CRN Site. Under the No-Action Alternative, the CRN Site would remain relatively unused and TVA would continue to manage the CRN Site for the specified land uses (Sensitive Resources Management and Project Operations). TVA would continue routine maintenance and clearing associated with the transmission lines that traverse the CRN Site. In addition, the Tennessee Wildlife Resource Agency's permit for use of TVA land for controlled hunting could be reinstated.

Under the No-Action Alternative, TVA would not have access to the energy-generating capacity of the CR SMR Project and would not be able to meet the objectives of the CR SMR Project:

- Power generated by SMRs could be used for addressing critical energy security issues. *TVA would not demonstrate that the use of SMR technology on or immediately adjacent to U.S. Department of Defense (DoD) or U.S. Department of Energy (DOE) facilities could provide secure electric power in the event of a national emergency without relying on a regional grid system. In addition, TVA would not demonstrate that SMR technology could potentially provide long-term, sustainable energy solutions to the DoD and DOE under Executive Order (EO) 13636 and Presidential Policy Directive 21, which were designed to strengthen the security and resilience of critical infrastructure against evolving threats and hazards(Reference 9.1-1)*.

- SMR technology can assist federal facilities with meeting carbon reduction objectives. *TVA would not demonstrate the ability of SMR technology to meet greenhouse gas emission reduction goals for federal agencies established by EO 13514 and EO 13693*. (Reference 9.1-2; Reference 9.1-3)

- SMR design features include underground containment and inherent safe-shutdown features, longer station blackout coping time without external intervention, and core and spent fuel pool cooling without the need for active heat removal. *TVA would not demonstrate SMR advancements in safety by eliminating design basis accident scenarios based on the incorporation of these key features. TVA would not demonstrate SMR advancements in security by development of a security–informed design which would provide the same or better protection against the threats large reactors must consider.*

- SMR power generating facilities are designed to be deployed in an incremental fashion to meet the power generation needs of a service area. *TVA would not demonstrate the incremental deployment of SMR technology to match load growth projections.*

Additionally, the No-Action Alternative would not result in the creation of new jobs, whereas construction and operation of SMRs at the CRN Site could result in hundreds of temporary and permanent new jobs, both direct and indirect. This increase in employment and procurement of needed goods and services associated with operation of SMRs at the CRN Site could inject millions of dollars into the regional economy. Although the No-Action Alternative would not result in the environmental effects that the proposed CR SMR Project would cause, the substantial technological and financial benefits to the local community, Tennessee Valley, and the nation that would result from the construction and operation of first-of-its-kind SMRs would not be realized under the No-Action Alternative. Therefore, construction and operation of the CR SMR Project is preferable to the No-Action Alternative.

9.1.1 References

Reference 9.1-1. The White House, "Executive Order 13636 - Improving Critical Infrastructure Cybersecurity," EO 13636, February 19, 2013.

Reference 9.1-2. The White House, "Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance," The White House, Office of the Press Secretary, EO 13514, October 5, 2009.

Reference 9.1-3. The White House Council on Environmental Quality, "Implementing Instructions for Executive Order 13693 Planning for Federal Sustainability in the Next Decade," June 10, 2015.

9.2 ENERGY ALTERNATIVES

This section is not required for an Early Site Permit Application.

9.3 ALTERNATIVE SITES

The Tennessee Valley Authority (TVA) is a corporate agency of the United States that provides electricity for business customers and local power distributors serving nine million people in parts of seven southeastern states. As authorized by the Tennessee Valley Authority Act, TVA is committed to maintaining a national leadership role in technological innovation (Reference 9.3-1). As part of this mission, TVA is working to meet future demand for cleaner power by developing technologies that will generate electricity in ways that are renewable and efficient.

In 2013, Executive Order (EO) 13636 was issued on *Improving Critical Infrastructure Cybersecurity* and *Presidential Policy Directive (PPD) 21 on Critical Infrastructure Security and Resilience* (Reference 9.3-2). EO 13636 and PPD-21 are designed to strengthen the security and resilience of critical infrastructure against evolving threats and hazards. More recently, EO 13693 was issued on *Planning for Federal Sustainability in the Next Decade* (Reference 9.3-3). In response to EOs 13636 and 13693 and PPD-21, TVA is proposing to demonstrate and evaluate small modular reactor (SMR) technology as a way to supply federal mission-critical loads with reliable power from generation and transmission that is less vulnerable to supply disruption from intentional destructive acts and natural phenomenon than typical commercial power generation facilities and transmission systems.

EO 13693 addresses the reduction of greenhouse gas emissions and alternative energy sources such as SMRs (Reference 9.3-4).

This section identifies and evaluates a set of alternatives to the TVA Clinch River Nuclear (CRN) Site. The purpose of this evaluation is to verify that a reasonable suite of candidate sites has been considered, and that there is no “obviously superior” site for the eventual construction and operation of two or more small modular reactors.

The objectives of the Clinch River (CR) SMR Project served as an initial basis for the alternative site selection process. As stated in Section 1.2, these objectives are to demonstrate that:

- Power generated by SMRs could be used for addressing critical energy security issues. Their use on or immediately adjacent to U.S. Department of Defense (DoD) or U.S. Department of Energy (DOE) facilities, using robust transmission (e.g., armored transformers, underground transmission), could address national security needs by providing reliable electric power in the event of a major grid disruption. A more reliable electric power supply could be accomplished by the SMR operation in “power island” mode with robust transmission to critical facilities. In addition, intentional destructive acts (e.g., terrorist attacks) and natural phenomena (e.g., tornadoes, floods, etc.) could disrupt the grid and the ability to restore most generation sources. SMRs can provide reliable energy for extended operation. Because nuclear reactors require fuel replenishment less frequently than other power generation sources (coal, gas, wind and solar), SMRs are less vulnerable to interruptions of fuel supply and delivery systems. TVA could demonstrate this “power islanding” and secure supply concept as part of the CR SMR Project by utilizing controls,

switching, and transmission capabilities to disconnect the SMR power plant from the electrical grid while maintaining power from the SMR power plant to a specified DOE power need. Such a demonstration would show that SMR technology is capable of supplying reliable power that is less vulnerable to disruption from intentional destructive acts and natural phenomena.

- SMR technology can assist federal facilities with meeting carbon reduction objectives. Energy-related carbon dioxide (CO_2) emissions account for more than 80 percent of greenhouse gas (GHG) emissions in the United States. Studies show that on average coal combustion generates approximately 894-975 grams of CO_2 per kilowatt-hour (g/kWh) of electricity generated. Natural gas generates an estimated 450-519 g/kWh. Nuclear power emission rates have been calculated to range from 6 - 26 g/kWh.
- SMR design features include underground containment and inherent safe-shutdown features, longer station blackout coping time without external intervention, and core and spent fuel pool cooling without the need for active heat removal. These key features advance safety by eliminating several design basis accident scenarios. Development of a security-informed design efficiently provides the same or better protection against the threats large reactors must consider. Physical security is designed into the SMR plant architecture, incorporating lessons learned from significant shifts in security posture since 2001, and the opportunity to build more inherently secure features into the initial design.
- SMR power generating facilities are designed to be deployed in an incremental fashion to meet the power generation needs of a service area. Generating capacity can be added in increments to match load growth projections. For the CR SMR Project, two or more SMRs would be constructed and brought into operation incrementally to achieve up to 800 MWe.

9.3.1 The Site-Comparison Process

The National Environmental Policy Act (NEPA) and Part 51.45 of Title 10 of the Code of Federal Regulations (CFR) require identification and assessment of alternatives to the proposed action. The U.S. Nuclear Regulatory Commission (NRC) licensing process specifically requires a siting study be conducted. The SMR Project Siting Study follows the framework outlined in the Electric Power Research Institute (EPRI) *Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application*. The process followed in the Siting Study is shown in Figure 9.3-1. Key criteria for assessing preliminary candidate area suitability were:

- Location within the TVA Power Service Area
- Sufficient acreage available to incrementally construct two or more SMRs
- Proximity to a federal installation
- Proximity to a water source
- Proximity to transmission lines
- Proximity to existing transportation infrastructure

The TVA Power Service Area was identified as the Region of Interest (ROI) for the SMR Project (Figure 9.3-2). Within the ROI, TVA established an exclusionary criterion based on project objectives associated with 1) assisting federal facilities with meeting carbon reduction objectives and 2) supplying federal mission-critical loads with reliable power from generation and transmission that is less vulnerable to supply disruption from intentional destructive acts and natural phenomena (two of the four objectives listed above).

Based on these exclusionary criteria, only areas which are in close proximity to TVA's six federal direct-served customers were considered as preliminary Candidate Areas. Direct-served customers are those customers that purchase their power directly from TVA and not through a third party power distributor. Table 9.3-1 lists TVA's federal direct-served customers in order of their respective power sales volume for the fiscal year 2014 (FY2014). Additional power generated by the SMRs that is not required by the selected direct-served customer would be incorporated into the regional electrical grid. Each of these federal properties contain infrastructure that is critical to the safety and security of the United States.

9.3.2 General Description of the Preliminary Candidate Areas

Oak Ridge Reservation, Tennessee

The approximately 34,000-acre (ac) Oak Ridge Reservation (ORR) is located in eastern Tennessee, within the Oak Ridge City limits, south of the City of Oak Ridge city center and north of Interstate (I) 40 (Figure 9.3-3). The ORR is located in the Tennessee Ridge and Valley geographic province and consists of generally hilly terrain (Figure 9.3-4). The majority of the site consists of forested and other undeveloped areas (Figure 9.3-5). The Clinch River, including the Melton Hill Dam, Melton Hill Reservoir, and the upper end of the Watts Bar Reservoir, borders the southern and eastern boundaries of the reservation. The ORR includes three DOE campuses with distinct missions: the Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex (Y-12 Complex), and the East Tennessee Technology Park (ETTP) (Figure 9.3-5). The ORNL is the DOE's largest multi-purpose laboratory conducting research in advanced materials exploration, alternative fuels, climate change, and supercomputing. The Y-12 Complex mission includes modernizing defense systems and reducing nuclear stockpiles worldwide. The ETTP is located on the former uranium enrichment complex, which is currently being remediated, revitalized, and transitioned into a private sector business/industrial park.

Redstone Arsenal, Alabama

The Redstone Arsenal is a 38,000-ac U.S. Army garrison located in the northern part of the State of Alabama, west of the City of Huntsville. The facility is bounded to the north by I-565 and to the south by the Wheeler Reservoir (Figure 9.3-6). The topography at Redstone Arsenal is flat to gently rolling terrain with the elevation ranging between 560 feet (ft) and 700 ft above mean sea level (msl); however, there are two steep hills in the northern part of the site (Figure 9.3-7). Less than approximately 13 percent of the installation is undeveloped land and the majority of that area is forested (Figure 9.3-8).

The primary mission of Redstone Arsenal is explosives training and research. The installation is a garrison for the following:

- U.S. Army Aviation and Missile Command
- U.S. Army Materiel Command
- DoD Missile Defense Agency
- U.S. Army Space and Missile Defense Command
- Aviation & Missile Research, Development and Engineering Center

Redstone Arsenal is divided into four major zones: Residential Zone, City Center, Professional Zone, and Industrial Zone (Figure 9.3-6). The Industrial Zone comprises the majority of the garrison property, covering the lower half and northwest corner of the property. Industrial and explosives operations, test areas, warehousing, and ammunition storage, which support the primary mission, are located within the Industrial Zone. A portion of the Wheeler National Wildlife Refuge (NWR) and recreational areas associated with the Tennessee River (Wheeler Reservoir) are also located in the Industrial Zone. (Reference 9.3-5) Additionally, the National Aeronautics and Space Administration's (NASA) Marshall Space Flight Center occupies approximately 1800 ac within the Redstone Arsenal reservation.

Fort Campbell, Kentucky

Fort Campbell is one of the largest installations managed by the U.S. Army. The installation occupies approximately 105,000 ac in portions of four counties: Montgomery and Stewart Counties in Tennessee and Christian and Trigg Counties in Kentucky (Figure 9.3-9). Hopkinsville, Kentucky to the north and Clarksville, Tennessee to the east are the closest major cities to Fort Campbell. Figure 9.3-10 shows the topography at Fort Campbell. Elevations range from approximately 400 ft to over 700 ft msl (Reference 9.3-6). A comparatively flat area is present along the eastern boundary and approximately 5000 ac of steep, highly dissected, hilly land is present along the western boundary. On the 105,000-ac installation, the majority of facilities occupy 15,000 ac along the eastern boundary. The remaining 90,000 ac (approximately 86 percent of the installation) is primarily undeveloped land (Figure 9.3-11). The undeveloped land includes areas used as ranges, impact areas, and maneuver areas dedicated to training. (Reference 9.3-7)

Fort Campbell is home to the following:

- U.S. Army's 101st Airborne Division (Air Assault)
- Two Special Operations Command units:
  - 5^{th} Special Forces Group (Airborne)
  - 160^{th} Special Operations Aviation Regiment (Airborne)

- 86th Combat Support Hospital
- 716th Military Police Battalion
- Additional medical and dental activities

Fort Campbell's primary mission is to "advance the combat readiness of the 101st Airborne Division (Air Assault) and the other non-divisional units posted at the installation through training, mobilization, and deployment" (Reference 9.3-7). Fort Campbell's garrison mission is to "support expeditionary forces and power projection [military force deployment] capabilities; to sustain, transform, and modernize the installation; to enhance well-being for the military community; to transform business processes to become effective, efficient, and equitable; and to develop and sustain an innovative, highly capable, mission focused workforce." (Reference 9.3-7)

Arnold Air Force Base, Tennessee

Arnold Air Force Base (AFB) is located in Coffee and Franklin Counties in central Tennessee. The installation is located east of the City of Tullahoma, southwest of I-24, and northeast of Tullahoma Highway (Figure 9.3-12). Arnold AFB occupies approximately 39,000 ac; 30,000 ac are designated as a Wildlife Management Area (WMA). No significant topographic features exist on Arnold AFB (Figure 9.3-13) and elevations generally range from 1000 ft to 1100 ft msl. Approximately 88 percent of land on Arnold AFB is undeveloped (Figure 9.3-14). These unimproved grounds are comprised of wetlands, open water (Woods Reservoir), cultivated pine forests, hardwood forests, and grasslands and early-successional habitat within utility rights-of way (Reference 9.3-8).

Arnold AFB is the home of the Arnold Engineering Development Center (AEDC), the largest and most advanced complex of flight simulation test facilities in the world. The center operates 43 aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, ballistic ranges and other specialized units. (Reference 9.3-9) The AEDC occupies 3600 ac roughly in the center of Arnold AFB. The University of Tennessee Space Institute is adjacent to Arnold AFB.

Naval Support Activity Mid-South, Tennessee

The 1479-ac Naval Support Activity (NSA) Mid-South is located in Millington, Tennessee approximately 20 miles (mi) north of downtown Memphis. NSA Mid-South is bordered on the south by Big Creek and I-269, and roughly on the west by railroad tracks that parallel Highway 51 (Figure 9.3-15). The installation is relatively flat with elevations ranging from 260 to 300 ft msl (Figure 9.3-16). The site consists of mostly developed land such as parking lots, buildings, and landscaped open spaces (Figure 9.3-17). The facility is the headquarters for the following:

- Navy Human Resources Center of Excellence
- Naval Personnel Command

- Navy Recruiting Command
- Navy Manpower Analysis Center
- U.S. Army Corps of Engineers Finance Center

NSA Mid-South employs more than 7500 military, civilian, and contract personnel. (Reference 9.3-10)

Columbus AFB, Mississippi

Columbus AFB is located in Lowndes County in northeastern Mississippi, 9 mi north of the City of Columbus. The installation is bounded on the east by Highway 45 and on the west by Barton Ferry Road (Figure 9.3-18). The topography is relatively flat, with an elevation of approximately 220 ft msl (Figure 9.3-19). The installation occupies 4931 ac, of which 4408 ac are federally owned. Approximately 16 percent of the site is undeveloped, including 190 ac of wetlands (Reference 9.3-11) (Figure 9.3-20).

Columbus AFB is the home of the 14th Flying Training Wing of Air Education and Training Command, and its primary mission is to train Air Force pilots (Reference 9.3-12).

9.3.3 Candidate Area Evaluation Process

The six preliminary Candidate Areas described in Subsection 9.3.2 (Figure 9.3-2) were evaluated against avoidance criteria based on the following safety considerations provided in the NRC Regulatory Guide (RG) 4.7, *General Site Suitability Criteria for Nuclear Power Stations*.

- Geology/Seismology
- Atmospheric Dispersion
- Exclusion Area and Low-Population Zone
- Population
- Emergency Planning
- Security Plans
- Hydrology
- Industrial, Military, and Transportation Facilities

Each preliminary Candidate Area was rated on a scale of one to three, with three designating area-wide suitability for siting with no area-wide concerns regarding the safety considerations, and one indicating the presence of significant issues associated with the safety considerations that would severely limit or potentially eliminate the ability to identify one or more Potential Sites within the Candidate Area.

Based on this evaluation, ORR, Redstone Arsenal, Arnold AFB, and Columbus AFB had no area-wide concerns regarding safety that would eliminate these installations from further consideration as Candidate Areas for potential SMR sites. Therefore, these four Candidate Areas were carried forward for further evaluation.

Fort Campbell and NSA Mid-South were eliminated from further consideration as Candidate Areas for potential SMR sites for the following reasons:

- The only significant water body at Fort Campbell is located within a seismic zone which exceeds the conservative limit of a peak ground acceleration (PGA) greater than a 10 percent g (the acceleration due to gravity) in any given 50-year (yr) time period.
- The NSA Mid-South Candidate Area is located within a seismic zone which exceeds the conservative limit of a PGA greater than a 10 percent g in any given 50-yr time period. NSA Mid-South also presents safety concerns due to its small size and limited water resources. In addition, the population density within a 20-mi radius of NSA Mid-South is 468 people per square mi. Although within the 500 people per square mi criterion, this population density is significantly greater than that for the other five Candidate Areas and could exceed 500 people per square mi within the time frame of the project's initial construction period.

9.3.3.1 Process for Identification of Potential Sites

Additional exclusionary and avoidance criteria were applied in a two-step process to identify Potential Sites within the four Candidate Areas. NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan,* defines "Potential Sites" as "those sites within the Candidate Areas that have been identified for preliminary assessment in establishing Candidate Sites."

The first step was to identify preliminary Potential Sites within the four Candidate Areas based on the following criteria: availability of land, proximity to a water source, proximity to sensitive resources such as wetlands and historic sites, proximity to transmission lines, proximity to existing transportation infrastructure, and obvious topographic concerns. To qualify as a Potential Site, a minimum of 120 contiguous ac was required, preferably in a square configuration. Up to 155 ac of additional laydown areas could be required during construction; however, laydown areas could be accommodated on any suitable nearby parcel, parking lot, or other area. Therefore, because of the flexibility in land requirements for the laydown areas, this component was not considered as a criterion in the development of preliminary Potential Sites. Access to a water source is essential; preference was given to sites immediately adjacent to a primary water source, but a site within 2 mi of a primary water source was considered. Easy access to transmission lines (onsite or within 5 mi) and availability of existing transportation infrastructure were also considered.

Twenty-four preliminary Potential Sites were identified within the four Candidate Areas. Identification of the preliminary Potential Sites included discussions with the ORR and Redstone Arsenal personnel to identify the largest available potential sites on their respective installations.

The second step was an evaluation of the 24 preliminary Potential Sites based on site-specific concerns related to safety considerations (RG 4.7) and environmental resources (NUREG-1555, Section 9.3, Site Selection Process) to eliminate sites that were obviously less preferable. These sites would be considered less likely to be licensable for nuclear power generation. This step resulted in the elimination of 11 of the preliminary Potential Sites; therefore, 13 Potential Sites were identified for further evaluation.

9.3.3.2 Process for Evaluation of Potential Sites

To identify Candidate Sites, the 13 Potential Sites were analyzed against suitability criteria based on the guidance provided in NUREG-1555, Section 9.3, Site Selection Process. The suitability criteria were derived from the following environmental resource concerns as provided in Table 9.3-1 of NUREG-1555.

- Land use
- Hydrology, water quality, and water availability
- Terrestrial resources (including endangered species)
- Aquatic biological resources (including endangered species)
- Socioeconomics (including aesthetics, demography, and infrastructure)
- Environmental justice
- Historic and cultural resources
- Air quality
- Human health
- Postulated accidents
- Fuel cycle impacts
- Transmission corridors
- Population distribution and density
- Facility costs
- Institutional constraints, as they affect site availability

The evaluation included rating each of the environmental resource concerns except environmental justice using a scale of one to five, with five being the most suitable. The environmental justice evaluation as defined by EO 12898 focuses on potential

disproportionately high and adverse impacts on minority and low-income populations (Reference 9.3-13). Numerical ratings are not applicable to the question of whether an impact is disproportionate or it is not disproportionate to a particular population. Therefore, numerical ratings were not assigned for environmental justice. Weighting factors associated with resource areas were developed using the basic Delphi Method approach. Nine key members of the technical team associated with preparation of the Environmental Report (ER) for the SMR Early Site Permit Application (ESPA) were selected to independently weight the importance of each of the criteria except environmental justice.

The results from the initial Potential Site screening criteria evaluation indicated that three ORR sites and one Redstone Arsenal site generated the highest total scores, and ORR Site 3 received the highest score.

The proposed site (CRN Site [ORR Site 3]), plus three Alternative sites (ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12), were carried forward for more detailed evaluation as Candidate Sites for siting two or more SMRs. These Sites are shown on Figures 9.3-21 and 9.3-22. Figures 3.7-2, 9.3-23, 9.3-24, and 9.3-25 show the proposed power block, transmission lines, intake, and discharge locations for the CRN Site and each of the Alternative Sites.

9.3.4 Generic Issues for Alternative Sites

Several issues were identified for which the potential impacts of construction and operation of two or more SMRs were sufficiently similar among the proposed and Alternative Sites. Detailed site-specific evaluation of those potential impacts would not contribute to the determination that one or more of the Alternative Sites are obviously superior to the proposed CRN Site. Other issues such as land use and ownership show sufficient variation among the Alternative Sites that a site-specific discussion is warranted. These non-differentiating criteria may include either, or both, construction and operational impacts and are discussed below. Site-specific criteria are discussed in more detail in Subsection 9.3.5.

For each criteria, a single significance level of potential impact (i.e., SMALL, MODERATE, or LARGE) was assigned consistent with the criteria that NRC established in 10 CFR Part 51, Appendix B, Table B-1, Footnote 3. Unless the impact is identified as beneficial, the impact is adverse. In the case of “SMALL,” the impact may be negligible. These definitions are as follows:

SMALL — Environmental effects are not detectable or are so minor that they neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the NRC has concluded that those impacts that do not exceed permissible levels in the NRC’s regulations are considered SMALL.

MODERATE — Environmental effects are sufficient to alter noticeably, but not to destabilize important attributes of the resource.

LARGE Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Air Quality

Air quality impacts of construction and operation of new SMRs would likely be similar at the CRN Site and the Alternative Sites. The construction impacts would include dust from disturbed land, roads, and construction activities and emissions from construction equipment. These impacts would be similar to the impacts associated with any large construction project. A discussion of measures that TVA takes to mitigate air quality impacts is provided in Chapter 4. The same or similar measures would be taken if SMRs were to be constructed at any of the Alternative Sites.

For purposes of the evaluation of Alternative Sites, it is reasonable to assume that the air quality impacts of emissions from vehicles used for construction worker transportation likely would be similar at each of the Candidate Sites, and would be SMALL and temporary. Impacts of operation of SMRs on air quality are related primarily to the operation of generators and cooling towers. The operation of generators is independent of the Candidate Site. Similarly, cooling tower drift is generally a function of cooling tower design, not the Candidate Site. The emissions from generators are subject to compliance with federal regulations. Cooling towers use current technology to minimize drift. Based on identified limiting meteorological parameters at the Candidate Sites, aspects of drift are addressed for each of the Alternative Sites.

The physical impacts of construction would be similar at each of the Alternative Sites. People who work or live around the Alternative Sites could be exposed to dust and gaseous emissions from construction activities. Construction workers and personnel working onsite would be the most impacted. Air pollution emissions are controlled by applicable best management practices and federal, state, and local regulations. Therefore, the impacts of construction activities on air quality are expected to be SMALL and temporary.

During facility operation, diesel generators used for auxiliary power at each of the Alternative Sites would have air pollution emissions. These generators would see limited use and, if used, would be used for only short time periods. Applicable federal, state, and local air pollution requirements apply to fuel-burning engines. At each Candidate Site boundary, the annual average exposure from gaseous radioactive emission sources is anticipated not to exceed applicable regulations during normal operations. Therefore, the impacts of facility operations on air quality are expected to be SMALL. As with construction impacts, potential offsite receptors are generally located well away from the site boundary at each of the Alternative Sites.

The portion of Roane County in which the Alternate ORR Sites are located is regulated as an attainment area for all air pollutants. However, neighboring counties (Anderson, Blount, Knox, and Loudon) and part of Roane County (not including the Alternate ORR Sites) are designated nonattainment for ozone and/or particulate matter 2.5 micrometers ($PM_{2.5}$). (Reference 9.3-14) Once a state implements mitigation measures to improve air quality in nonattainment areas and

an area meets the ambient air quality standards and other re-designation requirements under the Clean Air Act, U.S. Environmental Protection Agency (EPA) re-designates that area as a maintenance area. Maintenance areas are designated by pollutant. Roane County does not contain any maintenance areas (Reference 9.3-14).

At the Redstone Arsenal Alternative Site, Madison County is regulated as an attainment area for all of the air quality criteria pollutants; 1-hour (hr) ozone, 8 hr ozone, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter 10 micrometers (PM_{10}), $PM_{2.5}$, and lead (Reference 9.3-15). Therefore, similar to the three ORR Sites, the impacts of construction activities on air quality are expected to be SMALL and temporary, and the impacts of facility operations on air quality also are expected to be SMALL.

Aquatic Ecology

Aquatic ecological impacts that may result from construction and operation of two or more SMRs at the Alternative Sites include those associated with cooling water intake, consumption, and discharge. Ten operational impacts of cooling water systems on aquatic ecology (including issues concerning gas supersaturation, water quality, nuisance organisms, and others) determined to be applicable to current operating nuclear power plants, were evaluated in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Rev. 1. These impacts were found to be minimal for currently operating plants and, based on the smaller water use of SMRs, it is expected that such impacts would also be SMALL for two or more SMRs.

However, other potential impacts of water intake and discharge systems on aquatic ecosystems at nuclear power plants are site-specific and depend on factors related to features of the design and construction of these systems. Therefore, thermal loading and impingement and entrainment of fish and shellfish are discussed separately for each of the Alternative Sites.

Cooling Towers

The impacts of cooling tower drift and bird collisions for existing power plants were evaluated in NUREG-1437, Rev. 1, and found to be of minor significance for all plants, including those with various numbers and types of cooling towers. It is therefore concluded that the impacts of cooling tower drift and bird collisions with cooling towers resulting from operation of two or more SMRs at any of the Alternative Sites would be SMALL.

The surrogate plant design includes mechanical draft cooling towers. Therefore, mechanical draft cooling is the preferred technology. As stated in Table 3.1-2, item 3.3.10, the maximum expected noise level from cooling tower operation is less than 70 decibels on the A scale (dBA) at 1000 ft. This noise level is below the 80- to 85-dBA threshold at which birds and small mammals are startled or frightened (Reference 9.3-16). Thus, noise from operating cooling towers at any of the Alternative Sites would not be likely to disturb wildlife and would be considered SMALL

Transmission Lines

The impacts associated with transmission line operation evaluated in NUREG-1437, Rev. 1, consist of bird collisions with aboveground transmission lines and electromagnetic field (EMF) effects on flora and fauna. Bird collisions with aboveground transmission lines are of minor significance at operating nuclear power plants; including transmission line rights-of-way (ROWs) with variable numbers of power lines. Thus, although new or additional aboveground and/or underground transmission lines could be required for two or more SMRs at the Alternative Sites, these would likely result in negligible increases in bird collisions. The additional number of bird collisions, if any, would not be expected to cause a measurable reduction in local bird populations at any of the Alternative Sites and the potential impacts would be SMALL.

EMFs are unlike other agents that have an adverse impact (e.g., toxic chemicals and ionizing radiation) in that dramatic acute effects cannot be demonstrated and long-term effects, if they exist, are subtle. The NRC's review of biological and physical studies of EMFs described in NUREG-1437, Rev. 1, did not reveal consistent evidence linking harmful effects with field exposures. The impacts of EMFs on terrestrial flora and fauna are SMALL at operating nuclear power plants, including transmission systems with variable numbers of power lines. Therefore, the incremental EMF impact posed by addition of new transmission lines for the SMRs would be SMALL at each of the Alternative Sites.

Nonradiological Health Impacts

Nonradiological health impacts from construction of two or more SMRs on the construction workers at the Alternative Sites would be similar to those evaluated in Subsection 4.7.6. They include occupational injuries, noise, odor, vehicle exhaust, and dust. Additional data required, based on applicable federal and state air quality and noise regulations, will be provided during the construction phase at the selected Candidate Site. The individual Alternative Sites have characteristics that would require site-specific Health and Safety Plans (HSPs) for the construction phases. With the implementation of appropriate HSPs, no individual alternative site would be expected to have fewer, or more, construction-related accidents.

Occupational health impacts to operational employees would likely be the same for each the Alternative Sites. Thermophilic microorganisms would not be a concern at the Alternative Sites based on the proposed cooling process. Health impacts to workers from occupational injuries, noise, and electric fields would be similar at each of the Alternative Sites. No individual Alternative Site has characteristics that would be expected to lead to fewer, or more, operational accidents than would be expected for any of the other Alternative Sites. Noise and electric fields are monitored and controlled in accordance with TVA standards implementing Occupational Safety and Health Administration requirements at the selected Candidate Site and the impacts would be SMALL.

Radiological Impacts of Normal Operations

Exposure pathways for gaseous and liquid effluents from two or more SMRs on the proposed CRN Site or an Alternative Site will be similar. Gaseous effluent pathways include external exposure to the airborne plume, external exposure to contaminated ground, inhalation of airborne activity, and ingestion of contaminated agricultural products. Liquid effluent pathways include ingestion of aquatic foods, ingestion of drinking water, external exposure to shoreline sediments, and external exposure to water through boating and swimming.

Section 5.4 discusses the estimates of doses to the maximally exposed individual (MEI) and the general population for two or more SMRs at the proposed CRN Site for both liquid effluent and gaseous-effluent pathways. The estimated doses to the MEI were within the design objectives of 10 CFR Part 50, Appendix I. The same bounding liquid and gaseous effluent releases would be used to evaluate doses to the MEI maximally exposed individual and the population at each Alternative Site. Even with differences in pathways, atmospheric and water dispersion factors, and population, doses estimated to the MEI for the Alternative Sites would be expected to be SMALL and well within the regulatory limits.

Postulated Accidents

In Section 7.1, a suite of design-basis accidents for two or more SMRs at the proposed CRN Site was considered. The evaluation involved calculation of doses for specified periods at the exclusion area and low-population zone boundaries, and comparison of those doses to doses based on regulatory limits and guidelines. The release characteristics would be the same at each of the Candidate Sites.

As discussed in Section 7.1 for the CRN Site, the characteristics of local topography and meteorology result in doses for each accident sequence considered that are SMALL and below the corresponding regulatory limits and guidelines. Assessment of the meteorological conditions at the proposed CRN Site and three Alternative Sites did not indicate any limiting conditions. Therefore, it is highly unlikely that differences in local meteorological conditions would be sufficient to cause doses from design-basis accidents for two or more SMRs at any one of the Alternative Sites to exceed regulatory limits or guidelines and the potential impacts also would be SMALL.

9.3.5 Alternative Site Review

The three Alternative Sites were compared to the proposed CRN Site based on site-specific differentiating criteria. This comparison was performed to determine whether any one of the Alternative Sites is obviously superior to the proposed CRN Site. The Candidate Sites were evaluated in each area (Safety, Environment, and Socioeconomic). In the area of Safety, the Candidate Sites were evaluated to establish that no known limiting conditions exist at the Candidate Sites. In the areas of Environment and Socioeconomics, impacts were analyzed, and a single significance level of potential impact to each resource (i.e., SMALL, MODERATE, or

LARGE) was assigned consistent with the criteria that NRC established in 10 CFR Part 51, Appendix B, Table B-1, Footnote 3.

The proposed CRN Site is discussed as needed in this section to allow for a comparable rating. Proposed generic site layouts for the alternative sites are provided in Figures 3.7-2, 9.3-23 through 9.3-25. No weighting factors were applied to these criteria.

A summary of the results of the Alternative Site impact evaluations for Environmental and Socioeconomic criteria is provided in Table 9.3-2.

9.3.5.1 Safety Criteria

Geologic/Seismology

Although nuclear plants are designed to withstand a certain earthquake hazard, the prediction of earthquake timing and severity is subject to many uncertainties. Candidate Sites with the least seismic risk are rated the highest. Seismic activity can cause surface faulting, ground motion, ground deformation, and conditions including liquefaction, subsidence, and landslides.

The Modified Mercalli Scale is used within the United States to measure the intensity of an earthquake. The scale arbitrarily quantifies the effects of an earthquake based on the observed effects on people and the natural and built environment. Mercalli intensities are measured on a scale of I through XII, with I denoting the weakest intensity and XII denoting the strongest intensity. The lower degrees of the scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage. This value is translated into a PGA value to measure the maximum force experienced. The PGA is the maximum acceleration experienced by a building or object at ground level during an earthquake on uniform, firm-rock site conditions. The PGA is measured in terms of percent of “g.”

At a minimum, NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility,* suggests that for the Integrated Safety Analysis Summary, potential nuclear plant sites be evaluated for earthquake accelerations associated with a 250-yr and 500-yr earthquake. In accordance with the NRC’s “Reactor Site Criteria” (10 CFR 100) and “Domestic Licensing of Production and Utilization Facilities” (10 CFR 50), 10 percent g or less ground motion is consistent with safe nuclear plant shutdown and is therefore considered to be the conservative limit for the proposed Candidate Areas. The U.S. Geological Survey (USGS) Earthquake Hazards Program publishes seismic hazard map data layers that display the PGA with 10 percent (1-in 500-yr event) probability of exceedance in 50 yr. The locations of the Alternative Sites (within the two ORR Candidate Areas and Redstone Arsenal) with respect to the 10 percent probability of exceedance in 50 yr hazard map are provided in Figure 9.3-26.

The CRN Site and ORR Sites 2 and 8 are located within the southern part of the Valley and Ridge geologic province. The Valley and Ridge province in and around eastern Tennessee is a

tectonically active area and earthquakes are known to occur. Most earthquakes are small to moderate in intensity, many occurring below the level able to be felt and few causing noticeable damage. The largest earthquakes in eastern Tennessee in the vicinity of the ORR range from Mercalli intensity V to VII. The PGA for the ORR ranges from 30 to 40 percent g (Figure 9.3-26).

Redstone Arsenal Site 12 lies within the southern part of the Appalachian Highlands geologic province. The largest recorded earthquake in the region occurred in 1916 in Irondale, Alabama, south of Huntsville and north of Birmingham. The Redstone Arsenal is located in a region that experienced a Mercalli intensity of IV during this quake. (Reference 9.3-17) The PGA for the Redstone Arsenal ranges from 12 to 14 percent g (Figure 9.3-26).

No limiting conditions beyond normal nuclear plant design considerations for earthquake hazard protection were identified for the proposed CRN Site or the three Alternative Sites.

Atmospheric Dispersion

Although nuclear power plants are designed to withstand the impacts of natural atmospheric extremes (e.g., tornadoes, exceptional icing conditions, etc.), the atmospheric characteristics at a site are an important consideration in evaluating the dispersion of radioactive effluents from both postulated accidents and routine releases of gaseous effluents. For atmospheric dispersion, meteorological conditions at a site are monitored and evaluated as part of determining suitability for siting of nuclear plants. The observation of meteorological conditions over time provides input into statistical models. The models can be used to help predict probable atmospheric dispersion of releases. Topographic conditions also influence extreme weather and meteorological variations. Sites with better meteorological conditions are rated higher (e.g., limiting conditions affecting the transport and dispersion of plant emission would have a lower rating).

During operation of the SMR Project, potential emissions from radiological releases (routine and accidental) and non-radiological releases (auxiliary boilers and/or emergency generators, etc.) must be considered. Radiological emissions are modeled as ground level releases (as discussed in Subsections 2.7.5 and 2.7.6) and non-radiological releases would similarly be expected from or near ground level. Concentrations from ground level or near ground level emission sources would result in near field maximum concentrations; topography is of lesser importance as the modeled plume parallels the ground surface. Thus, maximum concentrations would be expected at or near the project's restricted property line (i.e., fenced area). Atmospheric dispersion is expected to be similar for the CRN Site and the two ORR alternative sites as:

1. The meteorology influencing dispersion would be much the same.

2. Emissions and plant design would not differ from one site to another.

3. Maximum concentrations would be expected in the near field.

4. The restricted, fenced area would be expected to be similar between sites.

For the CRN Site, TVA evaluated the effects of topography on local meteorology and concluded:

1. For “most meteorological variables, the Clinch River Nuclear Plant generally reflects the regional conditions”.

2. For light wind speeds, however, “terrain induces non-uniform wind flow through the site and in the immediate vicinity”.

Because the two ORR alternative sites are in the vicinity of the CRN Site, and because each of these sites is situated near the Clinch River, similar conditions would be expected at the two ORR Alternative Sites.

For the Redstone Arsenal 12 Site, the major difference from the CRN Site and ORR Alternative Sites is expected to be meteorology. Comparison of long-term monthly data from the National Weather Service (NWS) station at the Huntsville International Airport and NWS station at Oak Ridge demonstrates that monthly and annual wind speeds at the Huntsville NWS station are generally at least two times higher than the wind speeds reported at Oak Ridge NWS station, indicating better ventilation and potentially better dispersion in the Huntsville area (Reference 9.3-18; Reference 9.3-19). Lighter winds in the Oak Ridge area, as noted above for the CRN Site, are likely due in part to the topography around the Oak Ridge area. The topography around the Redstone Arsenal 12 Site, in contrast, is flat to gently rolling. Another factor affecting atmospheric dispersion is wind persistence. Both the Huntsville NWS station data and Oak Ridge NWS data indicate directionally dominant winds for consecutive months, though this is stronger for the Huntsville NWS station (Reference 9.3-18; Reference 9.3-19). For the Huntsville area, predominant winds are from the east-southeast to southeast for most of the year, while the Oak Ridge wind direction data reflects the northeast-southwest oriented terrain in the area. Under lighter wind conditions, as noted in the Oak Ridge area, winds directions are expected to be less persistent and more variable. Variable wind directions would likely improve diffusion as variable winds tend to spread and dilute the plume. The less persistent winds over continuous months and variable winds at the Oak Ridge sites would likely offset some of the ventilation benefits expected for the Huntsville area with its higher wind speeds.

Air quality modeling of atmospheric dispersion is generally based on a number of years of meteorology, thus increasing the likelihood that “worst case” conditions are considered. For ground level releases, “worst case” scenarios typically occur under stable conditions and low wind speeds. Modeling with an extended period of meteorology would likely produce such meteorological conditions, for some period of time, at any of the sites considered. In addition, the CRN Site and any of the alternative sites would be required to show that air quality would not be adversely impacted by demonstrating compliance with federal and state regulations.

Exclusion Area and Low-Population Zone

A reactor licensee is required by 10 CFR 100.21(a) to designate an exclusion area and to have authority to manage and control activities within that exclusion area. The size of the exclusion area is based on regulatory dose limits to the receptor at the boundary of the exclusion area in a postulated accident. A radius of 1 mi is assumed to be an acceptable distance from the center of the plant area to define the exclusion area for the purpose of this analysis. As stated in RG 4.7, Revision 3:

> *Transportation corridors such as highways, railroads, and waterways are permitted to traverse the exclusion area provided (1) these are not so close to the facility as to interfere with normal operation of the facility and (2) in case of emergency, appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway in order to protect public health and safety.*

The perimeter of the low-population zone (LPZ) is defined as the distance from the plant where the radiological dose following a postulated accident does not exceed regulatory requirements. The LPZ is determined as a part of the Site Safety Analysis Report. The perimeter of the LPZ must be no closer to the boundary of a densely populated center (population of more than 25,000) than 1.33 times the distance from the center of the reactor plant to the perimeter of the LPZ. Assuming a 2-mi LPZ, the distance to the densely populated center must be more than 4.66 mi from the center of the reactor plant.

No limiting conditions were identified for the proposed CRN Site or the three Alternative Sites, as discussed below.

Population

10 CFR 100.21(h) states that reactors should be located away from densely populated centers and areas of low population density are generally preferred. This criterion gives preference to a local site population density that is low (i.e., mean density less than 500 people per square mile out to a 20-mi radius). Each of the Alternative Sites was evaluated based on distances to nearby population centers and population totals within a 20-mi site radius.

The CRN Site and ORR Sites 2 and 8 are located approximately 25 mi west of Knoxville, Tennessee, which is the closest metropolitan area. The Knoxville, Tennessee 2010 city population is 178,874 (Reference 9.3-20). These sites are located within the city limits of Oak Ridge, Tennessee, which has a population of 29,330 (Reference 9.3-21). A total of approximately 837,471 people reside within a Census Bureau 20-mi radius of ORR (3470.8 square mi), with a population density of 241 people per square mi (Reference 9.3-22).

Redstone Arsenal Site 12 is located immediately west of the City of Huntsville, Alabama, which has a 2010 population of 180,105 (Reference 9.3-23). The next closest community is the City of Madison, Alabama, approximately 6 mi to the northwest, with a 2010 population of 42,938 (Reference 9.3-24). The population within a Census Bureau 20-mi radius of Redstone Arsenal

(3393.6 square mi) is approximately 642,726, with a population density of 189 people per square mi (Reference 9.3-25). Immediately west of Redstone Arsenal Site 12 is a residential community, the Riverwoods subdivision, which contains approximately 60 houses. Based on an average household size of 2.43 persons for Madison County, Alabama, the population of the subdivision is approximately 146 (Reference 9.3-26). If Redstone Arsenal Site 12 were selected as the preferred location for the SMR Project, radiation dose calculations at the site boundary would be performed and taken into consideration in the development of the site layout and facility design. Assessment of the population levels within a Census Bureau 20-mi radius of each Candidate Site did not indicate any limiting conditions that would prohibit the siting of two or more SMRs on any Candidate Site.

Emergency Planning

10 CFR 50.47(a)(1) requires that the applicant provide adequate protective measures in the event of a radiological emergency. Emergency planning activities include the development of adequate plans for the plume exposure pathway emergency planning zone (EPZ) and ingestion pathway EPZ. Per 10 CFR 50.47, the plume exposure pathway EPZ for nuclear power plants generally consists of an area approximately 10 mi in radius and the ingestion pathway EPZ generally consists of an area approximately 50 mi in radius. Assessment of the demography, topography, land characteristics, access routes, and jurisdictional boundaries associated with the Candidate Sites did not indicate any limiting conditions that would prohibit the development and implementation of appropriate emergency planning activities.

Security Plans

A licensable site for nuclear power development must be suitable for the development of adequate security plans and measures. Assessment of the characteristics and hazards of natural, existing, or proposed man-made features located in the proximity of the proposed CRN Site and the Alternative Sites did not indicate any limiting conditions that would prohibit the development and implementation of appropriate security plans. Additionally, since each of the Candidate Sites is part of a federal installation, each Candidate Site has an existing security plan.

Hydrology

Flooding

The Federal Emergency Management Agency (FEMA) develops Flood Insurance Rate Maps (FIRMs) determine which areas are Special Flood Hazard Areas subject to inundation by the 1 percent annual chance flood. FEMA defines the 1 percent annual chance flood (100-yr flood), also known as the base flood, as the flood which has a 1 percent chance of being equaled or exceeded in any given year. Assessment of the FEMA FIRMs at the proposed CRN Site and three Alternative Sites did not indicate any limiting conditions based on flooding potential. (Reference 9.3-27; Reference 9.3-28; Reference 9.3-29; Reference 9.3-30)

Water Availability

Nuclear power plants require that there be sufficient water available for cooling during plant operation and normal shutdown, for the ultimate heat sink, and for fire protection. Although this project involves the demonstration of two or more SMRs, which would require less water usage than a large nuclear plant and do not need an external ultimate heat sink; a dependable system of water supply is still required for system operations. As discussed in Subsection 3.3.1, the SMRs at the CRN Site will withdraw an average of approximately 18,423 gallons per minute (gpm), and a maximum of approximately 30,708 gpm.

The CRN Site and ORR Sites 2 and 8 are each bounded on the west-southwest by the Clinch River arm of the Watts Bar Reservoir (Figure 9.3-21). The CRN Site is also bounded on the south and east by the Clinch River arm of the Watts Bar Reservoir while ORR Site 8 is bounded on the south and east by the Melton Hill Reservoir. As discussed in Subsection 5.2.1.3.1, there is sufficient water in the Clinch River arm of the Watts Bar Reservoir to support the operation of two or more SMRs.

Unlike most of TVA's multipurpose tributary projects, Melton Hill Dam does not provide any significant flood damage reduction benefits, nor does it provide any significant seasonal flow regulation because of the little useful storage volume available. The average weekly discharge from Melton Hill Dam over its lifetime (1962-present) is 4832 cubic ft per second (cfs) with a maximum weekly discharge of 25,455 cfs. Figure 2.3.1-3 shows the expected flow frequency from Melton Hill Dam based on 100 yr of reservoir and system simulation conducted for the development of the current reservoir operating policy. The minimum discharge requirement for Melton Hill is 400 cfs average daily flow, but the frequency of this minimum flow continuing for as long as seven days is less than 0.1 percent as shown in Figure 2.3.1-3. (Reference 9.3-31) Because of the proximity of ORR Sites 2 and 8 to the CRN Site and because of their shared water source of the Clinch River arm of the Watts Bar Reservoir, it can be assumed that flows past these sites would be similar.

The southern boundary of Redstone Arsenal is defined by the Wheeler Reservoir (Figure 9.3-22), an impoundment of the Tennessee River operated by TVA with sufficient water to support the operation of two or more SMRs (Reference 9.3-32). The Tennessee River (Wheeler Reservoir) at the Whitesburg, Alabama gaging station (Figure 9.3-22) had an average monthly flow of approximately 42,230 cfs from 1924 to 1960 (Reference 9.3-33).

Assessment of the water availability at the proposed CRN Site and three Alternative Sites did not indicate any limiting conditions for plant operations.

Water Quality

NRC issuance of a construction permit, early site permit, or combined license is dependent on the applicant providing certification or waiver from the state that discharges from two or more SMRs will comply with applicable effluent limitations and other water pollution control requirements. Assessment of the water quality of the water bodies on the ORR and Redstone

Arsenal did not indicate any limiting conditions which would prohibit obtaining the appropriate permits.

Industrial, Military, and Transportation Facilities

Accidents associated with nearby industrial, military, and/or transportation facilities may affect the safety of a nuclear power plant. An assessment of the industrial, military, and/or transportation facilities surrounding the CRN Site and ORR Sites 2 and 8 did not indicate any limiting conditions that would prohibit the siting of two or more SMRs. The current land use associated with the areas surrounding Redstone Arsenal Site 12 would pose a limiting condition that would prohibit the siting of two or more SMRs at this site. However, Redstone Arsenal has provided a letter to TVA stating that the Arsenal mission would be modified to meet the land use requirements in the event that this site were selected as the preferred location for the SMR Project.

9.3.5.2 Environmental Criteria

Figures 3.7-2, 9.3-23, 9.3-24, and 9.3-25 show the proposed power block, transmission lines, and intake and discharge locations for the CRN Site, ORR Site 2, ORR Site 8, and Redstone Arsenal Site 12. The estimated area to be permanently affected during construction and operations at each Candidate Site is provided in Table 9.3-3. As the basis of comparison, a minimum of 120 contiguous ac was assumed to be required for the reactor block and ancillary support facilities at each of the four Candidate Sites, recognizing that that actual acreage could vary significantly depending on the final design for each site. For the evaluation, key differentiators between the Candidate Sites include the location of the power block within each Candidate Site, and associated lengths of potential ROWs for transmission lines and intake and discharge pipelines.

9.3.5.2.1 Land Use

Current land use at and around the four Candidate Sites was evaluated to assess compatibility of the SMR Project with existing conditions, future plans and areas requiring special consideration.

The CRN Site consists of approximately 935 ac of primarily undeveloped land located on the Clinch River arm of the Watts Bar Reservoir, immediately adjacent to the ORR. The site is owned by the federal government and managed by TVA. Limited infrastructure development and structures are present on the site. TVA manages the CRN Site, and the Watts Bar Reservoir Land Management Plan specifies two different land uses on this site. The majority of the site is designated as Zone 2 – Project Operations, and a strip along the reservoir shoreline is designated Zone 3 – Sensitive Resource Management. (Reference 9.3-34) Use of the CRN Site for an energy production and demonstration project is consistent with TVA-designated land use for the site and with land use on adjacent areas of the ORR. There is sufficient area in Zone 2 for siting two or more SMRs.

ORR Site 2 consists of approximately 614 ac of primarily undeveloped land located northwest of Bear Creek Road on the Clinch River arm of the Watts Bar Reservoir. The site is owned by the federal government and managed by the DOE. Limited infrastructure development and structures are present on the ORR Site 2, including the East Tennessee Technology Park Overlook and the Wheat Community African Burial Ground, both of which are publically accessible from TN 58. Use of the ORR Site 2 for an energy production and demonstration project is consistent with DOE-designated land use for the site and with land use on adjacent areas of the ORR. There is sufficient total area for siting two or more SMRs. Consideration would have to be made for maintaining public access to the ETTP Overlook and the Wheat Community African Burial Ground. Because these two areas are located immediately adjacent to U.S. 58, maintaining access would not be anticipated to significantly impact the space availability for two or more SMRs.

ORR Site 8 consists of approximately 424 ac on the Clinch River arm of the Watts Bar Reservoir and the Melton Hill Reservoir on the ORR. ORR Site 8 is owned by the federal government and managed by DOE. ORR Site 8 is located on a peninsula surrounded on three sides by the Clinch River arm of the Watts Bar Reservoir and the Melton Hill Reservoir. Limited infrastructure development and structures are present on ORR Site 8. There is sufficient total area for siting two or more SMRs. ORR Site 8 is currently designated in the ORR 10-Yr Site Plan for future aquatic-terrestrial interface studies (Reference 9.3-35).

Redstone Arsenal Site 12 consists of approximately 130 ac of undeveloped forest and grassland located in the western part of Redstone Arsenal adjacent to the arsenal boundary. The surrounding area within the arsenal is also undeveloped. Use of Redstone Arsenal Site 12 for an energy production and demonstration project may be inconsistent with weapons system testing, which is the designated land use for the site and adjacent areas. However, Redstone Arsenal has provided a letter to TVA stating that the Arsenal mission will be modified to meet the land use requirements in the event that Redstone Arsenal were selected as the preferred location for the SMR Project. Additionally, a residential area is located adjacent to the western boundary of Redstone Arsenal in close proximity to Redstone Arsenal Site 12. If Redstone Arsenal Site 12 were selected as the preferred location for the SMR Project, radiation dosage calculations would be performed at the site boundary and taken into consideration in the development of the site layout and facility design.

Conclusion: The use of the CRN Site for an energy demonstration project is consistent with the designated land use for the site and with land use on adjacent areas of the ORR; therefore the impacts to established land use would be SMALL. At ORR Site 2, there are minor concerns associated with maintaining public access to the ETTP Overlook and the Wheat Community African Burial Ground; however, this would still result in SMALL impacts associated with land use. At ORR Site 8, there are potential conflicts (SMALL to MODERATE) with the ORR's 10-yr site planning activities. At Redstone Arsenal Site 12, there are MODERATE concerns associated with the land use designated for the site in the Arsenal's current Master Plan and the proximity of a residential community adjacent to Redstone Arsenal Site 12's western boundary.

However these concerns are partially mitigated by the installation's commitment to modifying the land use requirements.

9.3.5.2.2 Water Supply, Use, and Flood Hazard

Current water supply and use at and around the four Candidate Sites was evaluated to assess compatibility of the SMR Project with existing conditions, future plans and areas requiring special consideration. In addition, FEMA FIRMs were analyzed to determine each site's potential for inundation by the 100-yr, or 1 percent chance, flood.

The CRN Site is bounded to the west, south, and east by the Clinch River arm of Watts Bar Reservoir. Water-related impacts associated with the construction and operation of the SMR Project at the CRN Site are discussed in Sections 4.2, 5.2, and 5.3. The Clinch River arm of the Watts Bar Reservoir is capable of handling anticipated thermal discharges. Although some streams and water bodies in the area have been identified as impaired by the EPA, these designations should not prohibit further industrial development; however, these issues may be reflected in the site-specific National Pollutant Discharge Elimination System (NPDES) permit. The majority of this site is located outside of the 1% annual chance flood hazard zone (Figure 9.3-27) (Reference 9.3-27; Reference 9.3-28).

ORR Site 2 is located adjacent to the Clinch River arm of the Watts Bar Reservoir. The Clinch River arm of the Watts Bar Reservoir appears to be capable of handling anticipated thermal discharges. Although some streams and water bodies in the area have been identified as impaired by the EPA, these designations should not prohibit further industrial development; however, these issues may be reflected in the site-specific NPDES permit. The majority of this site is located outside of the 1% annual chance flood hazard zone (Figure 9.3-28) (Reference 9.3-27).

ORR Site 8 is located on a peninsula along the north bank of the Clinch River arm of Watts Bar Reservoir and Melton Hill Reservoir. Both the Clinch River arm of the Watts Bar Reservoir and the Melton Hill Reservoir are capable of handling anticipated thermal discharges. Although some streams and water bodies in the area have been identified as impaired by the EPA, these designations should not prohibit further industrial development; however, these issues may be reflected in the site-specific NPDES permit. Flooding potential exists in the immediate vicinity of ORR Site 8 along the banks of the Clinch River arm of Watts Bar Reservoir at elevations up to 752 ft. For areas above the Melton Hill Dam, the flooding potential exists to an elevation of 796 ft. The majority of this site is located outside of the 1% annual chance flood hazard zone (Figure 9.3-29) (Reference 9.3-28).

Redstone Arsenal Site 12 is located adjacent to the western edge of the Redstone Arsenal property. Based on hydrology, water quality, depth to aquifers in use, and water availability as a resource Potential Site rating, Redstone Arsenal Site 12 is suitable for the SMR Project. There are multiple options for use as a potential cooling water source. The various sources are capable of handling anticipated thermal discharges. Although two streams in the area have

been identified as impaired by the EPA, these designations should not prohibit further industrial development in the area; however, these issues may be reflected in the site-specific NPDES permit. Portions of the site adjacent to Indian Creek are designated as Zone A. The majority of this site is located outside of the 1% annual chance flood hazard zone (Figure 9.3-30) (Reference 9.3-29; Reference 9.3-30).

Conclusion: The analyses of the CRN Site in Sections 2.3, 4.2, and 5.2 concluded that impacts to water supply and water use from construction and operations would be SMALL. Based on the similarity of ORR Sites 2 and 8 to the CRN Site in terms of hydrology, water quality, and water availability, it was concluded that the construction and operational-related impacts to water supply and use would be SMALL at both sites. Likewise, it was concluded that the construction and operational-related impacts to water supply and use would be SMALL at Redstone Arsenal Site 12.

9.3.5.2.3 Terrestrial Ecology

RG 4.7 defines important plant and animal species based on one or more of the following conditions:

- Species is commercially or recreationally valuable.
- Species is officially listed as endangered or threatened.
- Species presence ensures the well-being of another species indicated by either of the two bulleted items above.
- Species is a critical component of the structure and function of a valuable ecosystem.
- Species is a biological indicator of radionuclides in the environment.

Of particular concern are potential effects to habitat areas used by important species. These areas include those used in the following ways:

- Breeding and nursery
- Nesting and spawning
- Wintering
- Feeding

Terrestrial resources for the proposed CRN Site and potential impacts are described in Sections 2.4, 4.3, and 5.6. Based on the analysis provided in these sections, it concluded that the construction and operations-related impacts to terrestrial resources would be SMALL.

ORR Site 2 is within the Southern Dissected Ridges and Knobs ecoregion and ORR Site 8 is mainly within the Southern Limestone/Dolomite Valleys and Low Rolling Hills of the Ridge and Valley ecoregion of eastern Tennessee (Reference 9.3-36). A dominant ecological feature of the

ORR is its large areas of mature eastern deciduous hardwood forest. Approximately 70 percent of the Reservation is forested. In addition to the oak-hickory hardwood forest, other natural forest types within the ORR include floodplain forests and small stands of hemlock and white pine. Undeveloped areas of the ORR also contain grassland, old fields at various stages of succession, unique or important vegetation communities, planted pines and hardwoods, wetlands, beaver ponds, and caves. This diversity of habitats supports a wide variety of wildlife species in the area. (Reference 9.3-37)

ORR Sites 2 and 8 each overlap at least one designated natural area that includes terrestrial biological resources. ORR Site 2 encompasses the 20-ac Northwest Pine Ridge Natural Area, a Potential Habitat Area (a designation which indicates it may support a commercially exploited, state-listed species), and a small portion of a Cooperative Management Area (the Grassy Creek Powerline Area, which is a 51-ac linear area managed cooperatively among agencies for special purposes such as wildlife management). Approximately half of ORR Site 8 encompasses most of the 293-ac Tower Shielding Bluffs Natural Area, which includes oak-hickory forest, steep slopes, and a rare species. Most of the remainder of Site 8 is within the Melton Dam Bluffs Natural Area, which supports diverse forest communities that contain limestone outcrops and two rare species. Wetlands (emergent herbaceous and woody wetlands) occupy approximately 3.8 percent of ORR Site 2 and 0.1 percent of ORR Site 8. The small wetland areas within these upland sites are located near the site boundaries (Figures 9.3-23 and 9.3-24), they likely could be avoidable when facilities are sited, and any unavoidable effects on wetlands could be mitigated in accordance with USACE guidelines.

Numerous terrestrial or wetland species that are federally or state-listed as endangered or threatened are known or reported to occur on the ORR. These include 22 state-listed species, of which eight also are federally listed (Reference 9.3-38). As noted above, rare species with a state status occur within ORR Sites 2 and 8. Information from the TVA Natural Heritage database indicates there are recorded occurrences of state-listed terrestrial species on ORR Sites 2 and 8. On ORR Site 2, there is a plant that is state-listed as threatened, shining ladies'-tresses (Spiranthes lucida), and a plant that is a state species of special concern, spreading false-foxglove (Aureolaria patula). On ORR Site 8, occurrences of the butternut and spreading false-foxglove have been recorded.

Natural vegetation in the Redstone Arsenal ecoregion is transitional between oak-hickory forest and mixed mesophytic forests. (Reference 9.3-39) In northern Alabama and at Redstone Arsenal, pines are also present in association with the hardwoods and in isolated stands (Reference 9.3-40). Forested habitats on Redstone Arsenal cover approximately 15,700 ac and include hardwood, mixed hardwood and pine, pine, and riparian and bottomland hardwoods. Approximately 50 percent of the pine area is pine plantations. The most extensive forest type is hardwood, which covers over 8500 ac. Hardwoods occur mainly in bottomland areas and in a few large stands on rocky slopes. (Reference 9.3-41) Wetlands cover over 20 percent of Redstone Arsenal (Reference 9.3-42).

Springs, sinks, and caves formed by dissolution of the limestone common in the Eastern Highland Rim provide habitats for unique cave-dwelling fauna, including fish, amphibians, and invertebrates (Reference 9.3-39). Caves also contribute to the richness of the bat fauna in the region. The community of other wildlife inhabiting the area comprises a diversity of species characteristic of the forest habitats of the region. (Reference 9.3-40) Wheeler NWR includes 4085 ac within the Redstone Arsenal boundary (Reference 9.3-43). Refuge lands surround the shoreline of Wheeler Reservoir from the dam to the southwest portion of Redstone Arsenal and extend to encompass Huntsville Spring Branch within the central portion of the Arsenal.

Redstone Arsenal Site 12 is in an upland area on Redstone Arsenal that is entirely forested. Woody wetlands occupy approximately 1.9 ac, or 1.5 percent, of Redstone Arsenal Site 12. The small wetland area is in the northeast corner of this upland site (Figure 9.3-25), it likely could be avoidable when facilities are sited, and any unavoidable effects on wetlands could be mitigated in accordance with USACE guidelines. This Alternative Site potentially could provide habitat for some terrestrial species that are federally listed, state-protected, or have other special status designations in Alabama. Five terrestrial or wetland species that are federally listed have the potential to occur in Madison County. Alabama does not designate species for protection by listing them as state endangered or threatened; instead, species are designated as protected under several regulations. In Madison County, 14 terrestrial or wetland species are state-designated as protected. (Reference 9.3-44) Information from the TVA Natural Heritage database indicates there are no recorded occurrences of federally or state-listed terrestrial species on or near Redstone Arsenal Site 12.

Conclusion: ORR Site 2 is largely designated as a Potential Habitat Area and a Natural Area that includes terrestrial biological resources. Its hilly topography would limit opportunities to site two or more SMRs so that these areas could be avoided and the impacts to terrestrial biological resources could be MODERATE. The analyses of the CRN Site in Sections 2.4, 4.3, and 5.6 concluded that impacts to terrestrial resources from construction and operations would be SMALL. ORR Site 8 is almost entirely within two large natural areas that include diverse communities and several rare species. ORR Site 8 would have a MODERATE potential to adversely affect terrestrial biological resources within major portions of these natural areas. Redstone Arsenal Site 12 would have a SMALL potential to have adverse effects on terrestrial biological resources.

9.3.5.2.4 Aquatic Ecology

Aquatic resources for the proposed CRN Site and potential impacts are described in Sections 2.4, 4.3, and 5.3. These sections concluded that the construction and operations-related impacts to aquatic resources would be SMALL.

Construction-related impacts on aquatic ecology are primarily due to dredging, in-water construction of intake discharge structures, or sedimentation from stormwater runoff. Operations-related effects on aquatic ecology are primarily related to environmental effects from

the operation of condenser cooling water systems. These typically include expected thermal release effects, as well as entrainment and impingement effects.

During normal operation, SMRs, like other types of nuclear power plants, can use external cooling water. Heat removed by the condenser cooling water system generates the majority of the thermal release. An important consideration in evaluating the suitability of the Alternate Sites is the proposed design of the condenser cooling water system. The heat rejection rate and make up water requirements of the auxiliary cooling systems of the surrogate SMR plant design are not dependent on site-specific characteristics. The use of closed-cycle cooling is a best available technology for minimizing the amount of water withdrawal required. The thermal effects of cooling tower blowdown to the receiving water body would be primarily a function of 1) the percentage of total flow in the source water body that the heated return water constituted in comparison to average and low flow in the receiving water body, and 2) whether or not the receiving water body is a reservoir, regulated river, or free-flowing river. For each Alternative Site, cooling tower blowdown would be returned to the source water reservoir, and thermal limits would be imposed by a site-specific NPDES permit for the protection of aquatic life. Figures 3.7-2, 9.3-23, 9.3-24, and 9.3-25 show the proposed discharge locations for each of the Candidate Sites.

Entrainment and impingement associated with intake structures of operating facilities have the potential to affect aquatic organisms by causing injury and mortality. Impingement occurs when organisms too large to pass through the screens of a water intake structure become pinned against the screens and are unable to escape. Impinged organisms can include large fish, turtles, invertebrates, and other aquatic organisms that are unable to avoid the high intake velocities near the intake structure. Entrainment is the involuntary capture and inclusion of organisms in the stream of water flowing through the screens and into the cooling water system. Small fish, fish eggs, plankton, and other aquatic organisms can be affected and experience high mortality rates. The effects of entrainment and impingement due to facility operation are unique to the aquatic community and the physical characteristics of the water withdrawal for the particular facility. Because the SMR Project is a new facility, it will be required to meet Clean Water Act Section 316(b) Phase I requirements for its cooling water intake at any of the Candidate Sites. Section 316(b) regulates cooling water intakes to minimize impacts from entrainment and impingement on populations of aquatic organisms.

Several aquatic species that are federally or state-listed as endangered or threatened are known or reported to occur on the ORR. These include seven species that are federally and state-listed (Reference 9.3-38). The evaluation of aquatic natural areas on the ORR by Baranski indicated that ORR Sites 2 and 8 are not known to support listed aquatic species (Reference 9.3-45). Information from the TVA Natural Heritage database indicates no recorded occurrences of federally or state-listed aquatic species in the reservoirs adjacent to ORR Sites 2 and 8.

The Clinch River arm of the Watts Bar Reservoir is the source of cooling water for the CRN Site and ORR Site 2, and Melton Hill Reservoir is the source of cooling water for ORR Site 8. Melton Hill Reservoir, created by the construction of the Melton Hill Dam on the Clinch River, consists

of approximately 5470 ac of water surface. (Reference 9.3-46) The flow of the Clinch River (Clinch River arm of Watts Bar Reservoir) in the vicinity of ORR is in excess of 1000 cfs (Reference 9.3-47). A detailed discussion of the thermal impacts to the Clinch River arm of the Watts Bar Reservoir from SMR operations at the CRN Site is provided in Section 5.3. ORR Sites 2 and 3 and the downstream end of ORR Site 8 are each situated in a similar hydrologic setting on the Clinch River arm of the Watts Bar Reservoir. Because there are no major tributaries entering the reservoir in this area, the flow rate and bathymetry, and therefore the ability for the reservoir to absorb the thermal impact, should be similar for these three sites. Minor differences in bathymetry could result in higher or lower impacts at any of the sites, but these differences would likely be addressed through micro-siting of the discharge structure and/or modification of continuous by-pass flow rates at Melton Hill Dam, as was done in the hydrothermal analysis for the CRN Site. Therefore, it is assumed that the thermal impacts associated with the operations of two or more SMRs at the ORR Alternative Sites would be similar to those discussed in Section 5.3 for the CRN Site.

The principal aquatic resource at Redstone Arsenal is Wheeler Reservoir, an impoundment of the Tennessee River that forms the southern boundary of the installation. Approximately one-third of the installation lies within the 100-yr floodplain (Reference 9.3-42). Other aquatic habitats on the installation include manmade ponds (excavations for gravel and quarrying), streams, and springs (Reference 9.3-48). The largest streams within the installation are Indian Creek, McDonald Creek, and Huntsville Spring Branch (Reference 9.3-42).

Wheeler Reservoir supports a fish community that includes largemouth bass, black crappie, bluegill, channel catfish, and other common species. The invertebrate community includes many species of native freshwater mussels and snails. (Reference 9.3-49)

Multiple aquatic species that are federally listed as endangered or threatened have the potential to occur in Madison County. In this county, 24 aquatic species are federally listed or proposed for listing, and 58 aquatic species are state-listed as protected (Reference 9.3-44). The potential for occurrence of listed or other special status aquatic species on Redstone Arsenal Site 12 is minimal due to the absence of significant aquatic habitats on the site. Information from the TVA Natural Heritage database indicates no recorded occurrences of federally or state-listed aquatic species on or adjacent to Redstone Arsenal Site 12.

As described previously, the Tennessee River (Wheeler Reservoir) at the Whitesburg, Alabama gaging station had an average monthly flow of approximately 42,230 cfs from 1924 to 1960 (Reference 9.3-33). Wheeler Reservoir at Whitesburg is approximately 1400 ft wide (Reference 9.3-50). Intakes along Wheeler Reservoir are used for domestic and industrial water systems by Redstone Arsenal (Reference 9.3-51). Swan Pond is located to the south of Redstone Arsenal Site 12. Indian Creek is located east and south of Redstone Arsenal Site 12. Wheeler Reservoir would be available as a potential cooling water source. The reservoir appears capable of handling anticipated thermal discharges. Although two streams in the area have been identified as impaired by EPA, these designations should not prohibit further industrial development in the area; however, these issues may be reflected in the site-specific NPDES permit.

Conclusion: The analyses of the CRN Site in Sections 2.3, 4.2, and 5.2 concluded that impacts associated with shoreline excavation and installation of the diffuser pipes during construction would be SMALL. Similarly, construction of two or more SMRs at ORR Sites 2 and 8 and Redstone Arsenal Site 12 potentially could have adverse effects on the Clinch River arm of Watts Bar Reservoir, Melton Hill Reservoir, and/or Wheeler Reservoir as a result of in-water construction of intake or discharge structures, or sedimentation from stormwater runoff. The potential for occurrence of listed or other special status aquatic species on these Candidate Sites is minimal. Construction Best Management Practices (BMPs) would be employed throughout construction-related activities and TVA would comply with associated permits. Therefore, the aquatic impacts associated with construction are likely to be SMALL and similar to those associated with the CRN Site.

The CRN Site and the three Alternative Sites exhibit acceptable flow characteristics for siting nuclear generation and would have a SMALL thermal impact. However, the Alternative Sites can also be analyzed based upon their relative ability to assimilate heat and the potential exists that the Alternative Sites could adversely affect aquatic resources in the receiving water body. Thus, although of the Alternative Sites would have a SMALL thermal impact; the Redstone Arsenal Site 12 could be considered more suitable than the ORR sites with respect to cooling water availability (42,230 cfs for the Wheeler Reservoir vs. 1000 cfs for the Clinch River arm of the Watts Bar Reservoir).

A detailed discussion of impingement and entrainment impacts for the CRN Site is included in Section 5.3; these impacts were determined to be SMALL. Based on the expected use of similar intake systems, cooling systems, and cooling water reservoirs at the Alternative Sites, as well as considerations such as the use of closed-cycle cooling, the small proportion of water that would be withdrawn, the expected design and location of the intake, and the composition of the aquatic community, the impacts from entrainment, impingement, or other effects on fish and other aquatic organisms due to the operation of the cooling water intake system would be SMALL. The results of this assessment and the expectation that Section 316(b) requirements would be met indicate that impacts on aquatic ecology at each of the three Alternative Sites would also be SMALL.

9.3.5.2.5 Socioeconomics

The primary effects considered in the evaluation of socioeconomic impacts related to plant construction are the capacity of the surrounding area to absorb those workers who would move into the plant vicinity and to support movement of construction supplies and equipment as well as workers. An influx of construction workers would result in increased demand on housing, community services (such as utilities, schools, hospitals, and police and fire protection), and the transportation infrastructure. Additionally, construction and increased population could affect the air quality, noise, and aesthetics of the area and the site specifically. Socioeconomic impacts of operation primarily relate to benefits derived from the plant's presence.

Air Quality

For the CRN Site the potential air quality impacts are described in Subsections 4.4.1.2 and 5.8.1.2. As discussed in Subsection 9.3.4, air quality impacts of construction and operation of new SMRs would likely be similar at the CRN Site and the Alternative Sites. The conclusion in these subsections is that preconstruction, construction and operational related impacts to air quality would be SMALL.

Industrial point sources of air emissions within 10 mi of Redstone Arsenal include solid waste disposal authorities, multiple dry cleaners, automotive manufacturing and systems companies, a hospital, and other industrial facilities (Reference 9.3-52). The Redstone Arsenal operates under a CAA Title V major source operating permit issued by the Alabama Department of Environmental Management in 2003 (Reference 9.3-53).

Madison County is regulated as an attainment area for all of the air quality criteria pollutants (1-h O3, 8-h O3, CO, NO2, SO2, PM10, PM2.5, and lead) (Reference 9.3-15).

The Sipsey Wilderness Area in Alabama is a Class I Regional Haze area located within the William B. Bankhead National Forest, approximately 40 mi southwest of the Redstone Arsenal (Reference 9.3-54).

Conclusion: The CRN Site, two Alternative ORR Sites, and Redstone Arsenal Site 12 are each in locations regulated as attainment areas for all criteria pollutants. Thus existing air quality in the vicinity of each of these sites is similar from an air quality perspective. Further, preconstruction and construction related air emissions and air emissions during operation of the SMR Project would be similar regardless of the site chosen. As noted in the discussions above, the SMR Project's impacts on air quality at the CRN Site, are expected to be small. For the alternative candidate sites, the same general construction activities and mitigation measures are anticipated as for the CRN Site. Also during operations, there are no appreciable differences in air emissions expected for the alternative sites. Therefore, the impacts to air quality from construction and operation of two or more SMRs at the two Alternative ORR Sites and the Redstone Arsenal Site 12 would likewise be SMALL.

Human Health

Potential human health impacts from radiological exposures for the CRN Site are described in Sections 4.5.6 and 5.4.3. These sections concluded that the preconstruction, construction, and operational related impacts to human health are within regulatory limits for the protection of human health and thus impacts would be SMALL.

Because the ORR Sites 2 and 8 are within the same geographic region as the CRN Site, site-specific meteorological data, water and other exposure pathways, and potential exposed populations are similar for the two Alternative ORR Sites. Therefore the human health impacts from ORR Sites 2 and 8 would be similar to the impacts from the CRN Site.

Potential human health impacts from radiological exposures for Redstone Arsenal Site 12 are also dependent upon site-specific meteorological data coupled with regional distributions of population, agriculture, and resources. Located immediately west of the City of Huntsville, Alabama and east of the 60-home Riverwoods subdivision, boundary dose would need to be determined and considered for facility design of the Redstone Site.

Health impacts from non-radiological hazards during construction and operational include localized impacts from noise, vibrations, and dust along with occupational injuries to workers. Such impacts are project-specific and generally not site-specific.

Conclusion: Because the two Alternative ORR Sites are within the same geographic region as the CRN Site, human health impacts from radiological exposures would be comparable and the impacts for all three sites would be SMALL. Like the ORR Candidate Sites, the estimated human health impacts from radiological exposures at Redstone Arsenal Site 12 are also expected to be SMALL because of the small, contained nature of the reactors and because of the anticipated use of a closed cooling water system in the Wheeler Reservoir. Health impacts from non-radiological hazards are not considered site-specific and the impacts at each site would be considered the same.

Population and Housing

The number of in-migrant workers is dependent on labor availability within commuting distance of the plant site. If an adequate supply of workers is available within reasonable commuting distance, few workers would choose to relocate to the site. The issue in siting, therefore, are the potential socioeconomic effects associated with any temporary influx of construction workers who live too far away to commute daily from their residence.

The capacity of communities to absorb an increase in population depends on the availability of sufficient resources such as adequate housing and community services (e.g., schools, hospitals, police, transportation systems, and fire protection) to support the influx without straining existing services. The factors considered in rating sites from the perspective of construction effects include labor requirements, location of labor pool, number of in-migrants, and the economic structure of affected communities. Regardless of the Candidate Site chosen, construction employment would be the same, with an estimated peak of approximately 3300 workers onsite during a 24-hr period, as indicated in Section 3.10.

In Subsection 3.10.2, several assumptions were used to bound the construction workforce composition with respect to workforce commuting and relocation. It was assumed that construction workers typically commute up to a maximum of 50 mi to the jobsite. It was assumed that 80 percent of the field craft labor workforce will be available to the project from within a 50-mi radius, or approximately 2033 local craft personnel (based on a peak construction personnel workforce number of 3300 and 77 percent field craft labor). The balance of the construction craft workforce (508 personnel) will come from outside the 50-mi radius. These personnel are assumed to relocate within the 50-mi area to minimize their commute distance

and seek temporary housing. It was also assumed that 80 percent of the field non-manual labor workforce (based on 23 percent field non-manual labor) or 607 personnel will relocate from outside the 50-mi radius, and seek permanent housing. The balance of the field nonmanual labor staff or 152 personnel will come from the local labor market within the 50-mi area, and commute.

The socioeconomic effects of operations are measured by the demands placed by the operations workforce on the surrounding region and the benefits afforded to local communities as a result of wages earned by the workforce and expenditures made to support operations at the facility. The factors considered in rating Candidate Sites from the perspective of operations effects are the same as those considered for construction-related effects. They include labor requirements, location of labor pool, number of in-migrants, and the economic structure of affected communities. The capacity of communities to absorb an increase in population depends on the availability of sufficient resources such as adequate housing and community services (e.g., schools, hospitals, police, transportation systems, and fire protection) to support the influx without straining existing services. Regardless of the Candidate Site chosen, operations employment will be the same, with an estimated 500 workers onsite for full plant operation, as indicated in Table 3.1-2, Item 16.3.1. An additional 1000 workers will temporarily work at the facility during periodic refueling and major maintenance activities, as presented in Table 3.1-2, Item 16.3.2.

It is assumed that 50 percent of the operations workers will be recruited and trained from within a 50-mi radius, based on the information presented in Section 3.10 and the size of the population and workforce in the counties surrounding the Alternative Sites. The remaining 50 percent will relocate from outside the 50-mi radius. It is assumed that all of the 1000 temporary workers required for the scheduled refueling outages will relocate from outside the region. It is conservatively assumed that 100 percent of these in-migrating workers will relocate within the four counties surrounding the ORR and the two counties surrounding Redstone Arsenal.

The total population of the four counties (Anderson, Knox, Loudon, and Roane counties, Tennessee) surrounding the ORR in 2010 was 610,092 (Reference 9.3-55). As projected by the State of Tennessee, the total population of these counties would be about 759,052 by the year 2040 (Reference 9.3-56). Anderson, Knox, Loudon, and Roane Counties had a total 2011 employment of 393,763 jobs. Government and government enterprises provide 12.6 percent of the jobs. Retail trade is the next largest employment sector, providing 11.2 percent of the jobs. Health care and social assistance is the third largest sector, with 11.0 percent of employment. The construction sector employs 21,524 persons, representing 5.5 percent of employment in the four counties. (Reference 9.3-57; Reference 9.3-58; Reference 9.3-59; Reference 9.3-60)

The construction workforce assumed for the SMR Project accounts for less than 1 percent of the total workforce (based on employment levels) within the four counties surrounding the ORR. Based on a comparison of the estimated plant construction workforce to area construction employment levels, the area would experience a construction workforce increase of approximately 15 percent.

For the ORR sites, the 500 operations workers assumed for the SMR Project account for 0.1 percent of the total workforce (based on employment levels) within the four counties surrounding the ORR and the 1000 temporary refueling outage workers represent 0.2 percent of the total workforce.

The two counties (Madison and Morgan Counties, Alabama) adjacent to Redstone Arsenal had a total population of 454,301 in 2010 (Reference 9.3-55). Population projections by the State of Alabama estimate a total population for these counties of 612,655 by the year 2040 (Reference 9.3-61). Madison and Morgan Counties had a total 2011 employment of 285,884 jobs. Government and government enterprises provide 18.8 percent of the jobs. Professional, scientific, and technical services, the next largest employment sector, provides 13.1 percent. Manufacturing is the third largest sector, with 11.0 percent of employment. Construction employs 12,427 persons, representing 4.3 percent of employment in the two counties. (Reference 9.3-62; Reference 9.3-63)

The construction workforce assumed for the SMR Project accounts for less than 2 percent of the total workforce within the two counties adjacent to Redstone Arsenal. Based on a comparison of the estimated plant construction workforce was compared to area construction employment levels, the area would experience a construction workforce increase of approximately 27 percent.

For the Redstone Arsenal site, 500 operations workers represent 0.2 percent of the total workforce within the two counties surrounding the facility, and 1000 refueling outage workers account for 0.4 percent of the total workforce.

Conclusion: Because the CRN Site and two Alternative ORR Sites would be drawing the workforce from the same communities, it was assumed that the increased demands on housing and community services, such as utilities, schools, hospitals, and police and fire protection would be the same. For both construction and operations, impacts would be SMALL. Due to the relatively smaller size of the current population and construction workforce in the vicinity of Redstone Arsenal, the area could have more difficulty accommodating the temporary influx of construction workers than the ORR sites; however, the overall impact would still be SMALL for both construction and operations.

Transportation

Construction of two or more SMRs requires dependable transportation alternatives for large vehicles and adequate road capacity to accommodate the construction workforce. The candidate sites were rated on the capacity of the surrounding transportation system to accommodate construction and worker vehicles required for construction of two or more SMRs.

A rural principal arterial, I-40, is located south of the CRN Site and ORR Sites 2 and 8 beyond the Clinch River arm of the Watts Bar Reservoir. Two rural principal arterials traverse the installation providing access to the center of the installation from I-40. The northwestern portion

of the installation is traversed by TN 58 and the northeastern portion of the installation is traversed by TN 95. TN 58 and TN 95 intersect near the center of the installation. No major roadway improvements are planned for the area. The City of Oak Ridge and the Tennessee Department of Transportation (TDOT) are planning a General Aviation Airport in the area to potentially support regional growth, job creation, and economic and community development (Reference 9.3-64). The construction date for this airport has not been established.

Southern Freight Logistics, specializing in warehousing, trucking, air, and rail transportation, is headquartered in Oak Ridge, Tennessee. This company has earned permits to transport hazardous waste or materials by the State of Tennessee, the U.S. Department of Transportation, and by the Interstate Commerce Commission. The company is located in the Heritage Center, which is in close proximity to I-40 and I-75 and within one day's drive of more than 65 percent of major United States metropolitan areas. Southern Freight Railroad is a "handling line" for Norfolk Southern Railroad. (Reference 9.3-65)

There is an inactive barge terminal once used by the DOE located at Clinch River mile (CRM) 13.1. This inactive barge terminal has access to TN 58 via the CRN Site access road and Bear Creek Road. There is currently no truck or rail access to or from this terminal. (Reference 9.3-66) This is the only known barge terminal in the vicinity of the ORR Sites. The ORR Sites are immediately adjacent to the Clinch River (Clinch River arm of the Watts Bar Reservoir). The Clinch River is a major tributary of the Tennessee River. The Tennessee River has a main navigable channel 652 mi long beginning at Knoxville and merging with the Ohio River in Paducah, Kentucky. This channel is controlled by a series of nine mainstream dams and locks which are part of TVA's integrated river control system consisting of a total of 49 dams and 15 navigation locks (Reference 9.3-67). Commercial navigation occurs on the Clinch River for 61 mi (Reference 9.3-68). The commercially navigable portion of the Clinch River extends from its mouth near Kingston, Tennessee upstream to Clinton, Tennessee. The navigable portion of the Clinch River includes a navigation lock at the Melton Hill Dam. The lock is 75 ft by 400 ft and has a maximum lift of 60 ft. (Reference 9.3-46) Therefore, barge access from all ORR Sites is feasible.

In Oak Ridge, Energy Solutions, LLC operates the 11.5-mi Heritage Railroad shortline serving the ETTP (Reference 9.3-69). A second shortline, operated by Knoxville and Holston River Railroad, extends 18 mi from Knoxville through Knox County (Reference 9.3-70). Both of these lines connect with rail lines operated by Norfolk Southern Railway Company. Norfolk Southern rail lines are located approximately 7.5 mi northwest and 9 mi southeast of the CRN Site. The line to the southeast runs through Knoxville, Tennessee, connecting Chattanooga, Tennessee with Johnson City and Kingsport, Tennessee. (Reference 9.3-71) There are currently no rail spurs to any of the ORR Sites. However, a rail spur (EnergySolutions Heritage Railroad) is located approximately 2.5 mi north-northwest of the center point of the CRN Site, northwest of TN 58 (Reference 9.3-72).

I-565 borders the northern portion of the Redstone Arsenal. The east side is bordered by US 231 and the west side by Zierdth Road. Traversing the installation are Martin Road that runs

east/west, and Rideout Road that runs north/south. Wheeler Reservoir forms the southern boundary of Redstone Arsenal. Barge access is available in Decatur, Alabama, approximately 22 mi southwest of Huntsville. The following roads and projects have been identified for improvement in the vicinity of the facility, according to the 2035 Huntsville Area Transportation Study dated March 2010 (Reference 9.3-73):

- Patton Road from Aerobee Road to Red Arsenal Road
- Martin Road from Zierdt Road to Rideout Road
- Southern Bypass that connects I-565 to US 231 through Redstone Arsenal

A major concern in the Tennessee Valley has been the lack of east-west routed limited-access interstate highways connecting Huntsville, Alabama, with cities such as Memphis, Tennessee; Atlanta, Georgia; and Chattanooga, Tennessee. (I-565, while an east-west interstate, is only approximately 22 mi in length and connects Huntsville to the north-south bound I-65 in Decatur, Alabama located to the southwest.) Studies have been conducted to determine a feasible interstate route to connect these urban areas in these three states, but funding for the project is pending (Reference 9.3-73).

Redstone Arsenal has a variety of options for transportation. Currently, the Huntsville urban area has excellent connectivity between the Huntsville International Airport and the highway system via I-565. The International Intermodal Center is located at the airport and is connected to the Wheeler Reservoir approximately 5.5 mi south of the airport. A River Port Development Study was conducted in 2000 that resulted in property being acquired for future port development. Cargo waterway service is available in the adjacent City of Decatur, Alabama, offering barge service for bulk commodities (Reference 9.3-73).

Further consideration for conventional intercity rail service has been studied concerning Amtrak between Huntsville, Alabama, and Birmingham, Alabama. However, Amtrak will not be adding any new service in the immediate future. (Reference 9.3-73)

Conclusion: The area surrounding the CRN Site and Alternative ORR Sites appears to have suitable accessibility for road, rail, and barge traffic. However, based on the traffic study conducted in association with the CRN Site, recommended modifications will be implemented and the resulting impacts to traffic during construction will be MODERATE and temporary and impacts to traffic during operations will be SMALL. The area surrounding Redstone Arsenal appears to have suitable accessibility for rail and barge traffic; however, there is a lack of limited-access interstate highways near Redstone Arsenal. Impacts to traffic during construction for Redstone Arsenal Site 12 would be SMALL to MODERATE, and impacts during operations will be SMALL.

Visual Intrusions

For the proposed CRN Site the potential visual resource impacts are described in Subsections 4.4.2.6 and 5.8.1.4. The conclusion in these subsections is that preconstruction, construction and operational related impacts to visual intrusions would be SMALL to MODERATE. The visual impacts associated with ORR Site 2 and ORR Site 8 would be similar to those identified for the CRN Site. Most of the structures associated with the SMR Project are not expected to be visible to the general public. From a distance of approximately 2 mi, the CRN facility would not be visible from most viewpoints. The average annual plume and the winter plume, however, draw the observer's attention to the CRN facility, inserting an industrial aspect to a mostly natural landscape. The plume impacts would be larger on a clear, cloudless day than on an overcast day. Therefore, due to the plume, the visual intrusion due to operation of the CRN facility at the CRN Site and the two Alternative ORR Sites would range from SMALL to MODERATE, depending on the location of the observer and the atmospheric conditions.

Visual intrusions at the Redstone Arsenal Site 12 would be expected to be similar to those at the CRN Site. The height of the project structures would be similar, and would be similarly shielded by trees and hills. The plume from the cooling towers would likely also be visible under certain atmospheric conditions. The impact of the visual intrusion of the plume would be expected to be SMALL to MODERATE, similar to that for the CRN Site.

Conclusion: The CRN Site, two Alternative ORR Sites, and Redstone Arsenal Site 12 are each located in a forested, hilly area which would shield the appearance of the construction site and the operational buildings from most observers. However, operation of the SMRs at any of the four sites would generate a cooling tower plume under certain atmospheric conditions, and this plume would be visible. For all four sites, the appearance of the plume under certain conditions is expected to have SMALL to MODERATE impacts to visual resources.

9.3.5.2.6 Environmental Justice

EO 12898 (59 FR 7629) directs Federal agencies to identify and address, as appropriate, potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations (Reference 9.3-13). Factors considered in evaluation of Candidate Sites in regard to environmental justice include the presence of minority and low-income communities that could potentially experience disproportionate adverse impacts. There are two components to consideration of potential environmental justice impacts: (1) whether the proposed action results in significant adverse health or environmental impacts and, if so, (2) whether disproportionate adverse impacts would be experienced by minority or low-income populations found within any of the communities near the Candidate Sites and whether those impacts differ between Candidate Sites. The environmental justice analysis for the ORR and Redstone Candidate Sites was conducted in accordance with the methodology described in Subsection 2.5.4.1.

Because of the proximity of the ORR Alternative Sites to the CRN Site, the demographic profile for the ORR Alternative Sites would be the same as described in Subsection 2.5.4 for the CRN Site. The geographic area of interest for environmental justice for the ORR Sites includes a 50-mi radius around the center of the CRN Site. Three states fall into this radius, Tennessee, North Carolina, and Kentucky. The geographic area of interest for environmental justice for Redstone Arsenal Site 12 includes a 50-mi radius around the center of Site 12. Two states fall into this radius, Alabama and Tennessee.

Minority Population

The analysis for minority populations around the ORR Candidate Sites followed the NRC criteria for identifying minority populations as described in Subsection 2.5.4.2. Table 2.5.4-1 presents the results of the minority population analysis. The distributions of aggregate minority and Hispanic ethnicity block groups within the 50-mi radius are displayed in Figure 2.5.4-1. For each of the 759 block groups within the 50-mi radius, a total of 18 met the NRC criteria for Black minority population; one block group met the criteria for a minority population of some other race. A total of four block groups met the criteria for Hispanic minority populations. A total of 20 block groups met the criteria for aggregate minority populations. For all categories except the North Carolina aggregate minority population, 20 percentage points greater than the state average was the limiting criterion. For the aggregate minority population in North Carolina, 50 percentage points was the limiting criterion. Only one block group, located in Sevier County, Tennessee, met the criteria for two or more minority categories.

Most of the block groups (18 of 20) with an aggregate minority population fall within Knox County, Tennessee, within the boundaries of the City of Knoxville. The largest number of block groups (3 of 4) with a Hispanic minority population occurs in Loudon County, Tennessee. No block groups in Roane County (in which the CRN Site is located) or in Anderson County contain minority populations (Figure 2.5.4-1). The identified aggregate minority population closest to the CRN Site is in census tract 9801 block group 01 located approximately 20 mi to the east in Blount County, Tennessee. The closest Hispanic minority population is located in census tract 602.02 block group 04 in Loudon County, Tennessee, approximately 9 mi southeast of the CRN Site.

In addition to the identification of minority populations based on census data, two locations of potential significance to minority communities were identified: the Wheat Community Burial Ground and the community of Scarboro. The African American Wheat Community Burial Ground is located approximately 1 mi northwest of the northern boundary of the CRN Site on TN 58. Approximately 90 to 100 graves with no inscribed markers are present within this cemetery. It is presumed that slaves and their dependents that lived and worked on plantations and farms in the area are buried here. Historical records indicate the cemetery dates from the mid-19th century. (Reference 9.3-74) The Scarboro community is a small residential area in Anderson County within the City of Oak Ridge, approximately 0.5 mi from the Oak Ridge Reservation Y-12 plant. It is separated from the Y-12 plant by Pine Ridge. The community was

established in 1950 to provide housing and an elementary school to African American Oak Ridge residents. Scarboro has remained predominantly African American. (Reference 9.3-75)

The analysis for minority populations around Redstone Arsenal Site 12 also followed the NRC criteria for identifying minority populations as described in Subsection 2.5.4.2. Table 9.3-4 presents the results of the minority population analysis for Redstone Arsenal Site 12. The distributions of aggregate minority and Hispanic ethnicity block groups within the 50-mi Redstone Arsenal Site 12 radius are displayed in Figure 9.3-31. For each of the 674 block groups within the 50-mi Redstone Arsenal Site 12 radius, a total of 56 met the NRC criteria for Black minority population; 14 block groups met the criteria for a minority population of some other race. No block groups met the criteria for Hispanic minority populations. A total of 74 block groups met the criteria for aggregate minority populations. For all categories except the Alabama aggregate minority population, 20 percentage points greater than the state average was the limiting criterion. For the aggregate minority population in Alabama, 50 percentage points was the limiting criterion. No block group met the criteria for two or more minority categories.

Most of the block groups (54 of 74) with an aggregate minority population fall within Madison County, Alabama, within the boundaries of the City of Huntsville (Figure 9.3-31). The identified aggregate minority population closest to Redstone Arsenal Site 12 is in census tract 011200 block group 1 located approximately 1.5 mi to the southwest of the site in the Town of Triana in Madison County, Alabama. This is also the closest Black minority population block group.

Triana, Alabama is located along Huntsville Spring Branch and adjacent to the Wheeler Reservoir/Wheeler National Wildlife Refuge. In 1979, extensive dichlorodiphenyltrichloroethane (DDT) contamination was discovered in Huntsville Spring Branch. Levels in fish taken from the stream significantly exceeded the federal limits for DDT. The source was a former DDT manufacturing facility located within the grounds of Redstone Arsenal and operated by the Olin Corporation from 1947-1970. The residents of Triana depended heavily on fish from Huntsville Spring Branch as both a food source and a source of income. In December 1982, the Olin Corporation reached an out-of-court settlement with the residents of Triana and the federal government. Olin provided compensation to the residents, funded a long-term healthcare program for the community, and cleaned up the DDT in the area. Since cleanup began in 1984, DDT levels in the major fish species have been reduced significantly and are at or near normal levels. (Reference 9.3-76)

Low Income Population

The analysis for low-income populations around the ORR Candidate Sites followed the NRC criteria for identifying minority populations as described in Subsection 2.5.4.3. Table 2.5.4-1 and Figure 2.5.4-2 illustrate the number and distribution of low-income block groups within the 50-mi radius based on the NRC criteria. Table 2.5.4-1 also displays the percentage of low-income individuals within each of the three states within the 50-mi radius. Among the 759 block groups within the 50-mi radius, 60 met the NRC criteria. The majority of the low-income population (27

block groups) in the geographic area of interest is in the City of Knoxville, in Knox County, Tennessee. There is one low-income population block group in Roane County where the CRN Site is located. The closest low-income population to the CRN Site is located in census tract 602.02 block group 01 in Loudon County, Tennessee, approximately 7 mi southeast of the CRN Site. As seen on Figures 2.5.4-1 and 2.5.4-2 there is some overlap between the locations of minority and low-income population groups around the ORR Candidate Sites.

The analysis for low-income populations around the Redstone Arsenal Site 12 also followed the NRC criteria for identifying minority populations as described in Subsection 2.5.4.3 Table 9.3-4 and Figure 9.3-32 illustrate the number and distribution of low-income block groups within the 50-mi radius based on the NRC criteria. Table 9.3-4 also displays the percentage of low-income individuals within both Alabama and Tennessee. Among the 674 block groups within the 50-mi radius, 13 met the NRC criteria. The majority of the low-income population in the geographic area of interest is in the City of Huntsville, in Madison County, Alabama. Census tract 002300 block group 5 contains the closest low-income population, and is located in Madison County, Alabama, approximately 6.5 mi northeast of the site. As seen on Figures 9.3-31 and 9.3-32 there is some overlap between the locations of minority and low-income population groups around Redstone Arsenal Site 12.

Conclusion: The environmental justice evaluation includes whether an alternative results in significant adverse health or environmental impacts and if those impacts would be disproportionately experienced by a minority of low-income population. Based on the evaluation of physical impacts (including land use, water and ecological resources, and human health) and socioeconomic impacts in Subsection 9.3.5.2, the potential for adverse and disproportionate impacts to minority and low-income populations for the CRN Site and two Alternative ORR Sites and Redstone Arsenal Site 12 would be SMALL.

9.3.5.2.7 Historic and Cultural Resources

This subsection provides an evaluation of alternative sites with regard to potential impacts to historic and cultural resources. A detailed discussion of CRN Site-specific information is included in Section 2.5.

As described in Subsection 2.5.3, no National Register of Historic Places (NRHP)-listed properties are located on or immediately adjacent to the CRN Site or the Barge/Traffic Area. Twenty-six NRHP-listed properties (23 individual properties and three historic districts) are located within a 10-mi radius of the center of the CRN property. As stated in Subsection 4.1.3, fifty-nine recorded archaeological sites, four isolated finds, one non-site locality, and one cemetery have been identified within or immediately adjacent to the approximately 1305-ac CR SMR Project archaeological Area of Potential Effect (APE). Of these sites, one is considered eligible for listing on the NRHP; 16 are considered potentially eligible for the NRHP; and 42 are considered not eligible for the NRHP. Ten of the eligible and potentially eligible sites are avoidable. Within the CRN Site, sites 40RE0107, 40RE0595, 40RE0549, 40RE0104, and 40RE0105 will potentially be impacted by CR SMR Project preconstruction and construction

activities. In the Barge/Traffic Area, sites 40RE138 and 40RE233 may be affected by CR SMR Project preconstruction and construction activities.

Approximately 45 known prehistoric sites, 250 historic pre-World War II structures, 32 cemeteries, several “historically significant” Manhattan Project-era structures, and six properties listed on the NRHP are reported within the reservation boundary in the 2011 Oak Ridge Reservation Annual Environmental Report. The prehistoric sites are predominantly burial mounds and archaeological evidence of previous structures. The six NRHP-listed sites are as follows (Reference 9.3-77):

- Freels Bend Cabin
- Graphite Reactor
- New Bethel Baptist Church and Cemetery
- Oak Ridge Turnpike Checking Station
- George Jones Memorial Baptist Church and Cemetery
- Scarboro Road Checking Station

There are no NRHP-listed properties located on or immediately adjacent to ORR Site 2. Eighteen NRHP-listed properties are located within a 10-mi radius of the center of ORR Site 2; all were previously described in Subsection 2.5.3. A total of nine cultural resource surveys have been conducted within portions of ORR Site 2 from 1974 through 2011. Within ORR Site 2 there are two archaeological sites (40RE233 and 40RE577) recommended as eligible for the NRHP, one site (40RE138) recommended as potentially eligible for the NRHP, and one site (40RE575) recommended as not eligible for the NRHP. Additionally, there is one historic cemetery, the Wheat Community African American Burial Ground (40RE219) located within ORR Site 2. (Reference 9.3-78) The proposed layout for ORR Site 2 (Figure 9.3-23) would avoid or be able to be easily adjusted to avoid the previously identified archaeological sites.

There are no NRHP-listed properties located on or immediately adjacent to ORR Site 8. Twenty-one NRHP-listed properties are located within a 10-mi of the center of ORR Site 8. The majority of these are the same structures described in Subsection 2.5.3, with the exception of Boyd-Harvey House. Two cultural resource surveys were conducted within the boundaries of ORR Site 8 in 1974 and 1996. Within ORR Site 8 there is one archaeological site (40RE117) recommended as potentially eligible for the NRHP (Reference 9.3-78). The proposed layout for ORR Site 8 (Figure 9.3-24) would avoid the previously identified archaeological sites.

Approximately 1000 archaeological sites have been identified at Redstone Arsenal and approximately 418 of these sites are potentially eligible for listing on the NRHP (Reference 9.3-79).

Four NRHP-listed sites are present within the Redstone Arsenal boundary. These sites include:

- Neutral Buoyancy Space Simulator
- Propulsion and Structural Test Facility
- Redstone Test Stand
- Saturn V Dynamic Test Stand

There are no NRHP-listed properties located on or immediately adjacent to Redstone Arsenal Site 12. A total of 50 NRHP-listed properties are located within a 10-mi radius of the center of Redstone Arsenal Site 12; five of these properties have been designated as National Historic Landmarks. The five National Historic Landmarks are: The Saturn V Space Vehicle, the Neutral Buoyancy Simulator, the Redstone Test Stand, the Saturn V Dynamic Test Stand, and the Episcopal Church of the Nativity (located in the City of Huntsville). Three cultural resource surveys were conducted within the boundaries of Redstone Arsenal Site 12 in 2000, 2003, and 2008. Within Redstone Arsenal Site 12 there are four archaeological sites (1MA879, 1MA880, 1MA882, and 1MA1552) recommended as potentially eligible for the NRHP and one site (1MA1553) recommended as not eligible for the NRHP. (Reference 9.3-78) The proposed layout for Redstone Arsenal Site 12 (Figure 9.3-25) would impact some of these archaeological sites but could be modified to avoid potential impacts.

As described in Subsection 4.1.3, to avoid, minimize, and mitigate potential effects to historic properties, TVA has executed a Programmatic Agreement (PA) pursuant to 36 CFR 800.14(b)(3). Should ORR Site 2, ORR Site 8, or Redstone Arsenal Site 12 be selected for siting the SMR Project, the APE would be revised and the Sites would be evaluated for archaeological resources in accordance with the stipulations of the PA.

Conclusion: Direct effects from SMR Project construction to historic properties are possible at the CRN Site and all three alternative sites. Based on final facility designs, Phase II testing many be required and a final assessment and any required mitigation would be dependent on the outcome of the Phase II testing. Therefore, impacts to historic properties at all four sites could be SMALL to MODERATE.

9.3.5.2.8 Waste Management

Potential impacts of waste management for the CRN Site on land use are described in Subsections 4.1.1.1 and 5.1.1.2. Additional impacts from the management of waste including solid nonradioactive, hazardous, and mixed waste, and discharges to air and water are described in Section 5.5. Impacts of radioactive waste disposal and transportation are described in Subsections 5.7.1.6 and 5.7.2, respectively. In the evaluations provided in each of these subsections, it was determined that the impacts of waste management at the CRN Site would be SMALL.

TVA expects to construct and operate an onsite landfill for construction, site clearing, and grading debris at the selected site. The construction landfill would be sized to accommodate the

anticipated materials and would be located in the permanently cleared laydown area on the selected site. The landfill would be constructed in accordance with all relevant permits and licenses. No radioactive, hazardous, or municipal waste would be disposed of in this landfill. The landfill would be closed at the end of the construction period. Construction and operational debris and associated waste not placed in an on-site disposal pit would be removed from the site and disposed of in an appropriately licensed disposal facility.

Conclusion: Waste management would be handled similarly at all three Alternative Sites and, like at the CRN Site, the impacts of waste management at all sites would also be SMALL.

9.3.5.2.9 Postulated Accidents

In Section 7.1, a suite of design-basis accidents for two or more SMRs at the proposed CRN Site was considered. The evaluation involved calculation of doses for specified periods at the exclusion area and low-population zone boundaries, and comparison of those doses to doses based on regulatory limits and guidelines. For the CRN Site, the characteristics of local topography and meteorology result in doses for each accident sequence considered that are below the corresponding regulatory limits and guidelines and were considered SMALL. The release characteristics would be the same at each of the Candidate Sites.

Assessment of the meteorological conditions at the proposed Candidate Site and three Alternative Sites did not indicate any limiting conditions. Topographic and meteorological conditions at the two alternative Oak Ridge sites (ORR Sites 2 and 8) are very comparable to the CRN Site. The Oak Ridge sites are situated along mountain ranges, with alternating ridges and valleys in the vicinity. In addition, the combination of high pressure associated with the Azores-Bermuda anticyclonic circulation and the nearby ridges result in generally light wind speeds (< 5 mi per hour [mph]) for all sites (Reference 9.3-19). Because the CRN Site is located in close proximity to the two ORR Alternate Sites, the onsite meteorological data is well representative of the meteorological conditions at these alternate sites.

Topographic conditions at the Redstone Arsenal Site include predominately flat terrain with the Tennessee River situated south of the site, and hills and plateaus surrounding the area to the north and east. Analyses of wind speed data obtained from the nearby NWS station in Huntsville, Alabama (located 9 mi to the northwest of Redstone Arsenal Site 12), show average wind speeds near 7 mph (Reference 9.3-18). Flatter terrain and higher average wind speeds than the CRN Site will result in more favorable dispersion conditions at Site 12.

Additionally, it is noted that the location of the exclusion area boundary (EAB) at each of the alternate sites can be defined as either within the currently government controlled areas (CRN Site and Redstone Arsenal Site 12) or within close proximity such that minimal impact to the surrounding land use would be required (ORR Site 2 and 8). (Note that the nuclear island for Redstone Arsenal Site 12 can be located to the southeast corner of the site such that the projected EAB would not extend past the Redstone Arsenal property boundary.)

Conclusion: It is unlikely that differences in local meteorological conditions would be sufficient to cause doses from design-basis accidents for two or more SMRs at any one of the Alternative Sites to exceed regulatory limits or guidelines or the impacts from a similar accident at the CRN Site. Therefore, the impacts from postulated accidents at all three Alternative Sites would also be SMALL.

9.3.5.3 Cumulative Impacts

Cumulative impact is defined in the regulations of the Council on Environmental Quality (CEQ) implementing the NEPA (40 CFR 1508.7) as follows:

> "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

The purpose of this subsection is to identify any federal, state, local or other activities within the region of the Candidate Sites that could have cumulative impacts in conjunction with the proposed action. Potential impacts would include large changes to any of the analyzed resources which would not occur if the project were not constructed.

Past actions are projects prior to the ESPA and present actions are projects occurring during the ESPA (including preconstruction), while future actions commence upon NRC authorized construction of the proposed unit and continue through operation and decommissioning of the proposed SMR. For the purposes of this evaluation, reasonably foreseeable actions are projects that are clearly indicated in an available long term master plan or comparable document and/or have received funding and/or have applied for a permit associated with construction or operation. Cumulative impacts can result from individually minor, but collectively significant, actions over time upon the same resources. A summary of past, present, and reasonably foreseeable projects that could have a cumulative effect within the ROI are listed in Table 9.3-5.

The cumulative impacts associated with construction and operation activities associated with the CRN Site are provided in Sections 4.7 and 5.11. A summary of the contribution of the Alternative Sites to cumulative impacts for each environmental and socioeconomic criteria is provided in Table 9.3-6. Due to the close proximity of ORR Sites 2 and 8 to the CRN Site, these sites have the same geographic area of interest. Thus, the geographic area of interest associated with these sites would be the same and the cumulative impacts for the resource areas evaluated would be the same for each of the three sites. Specifically, the incremental cumulative impacts for both construction and operation of the SMR Plant at the CRN Site would be SMALL for the resource areas evaluated with the exception of noise, transportation, and historic and cultural resources. The contribution of construction to cumulative transportation impacts would be MODERATE. The contribution of construction to cumulative noise impacts would be SMALL to MODERATE. Cumulative impacts to cultural resources from

preconstruction and construction of the SMR Project would be SMALL to MODERATE. The contribution of operations to cumulative impacts associated with noise, traffic, and historic and cultural resources would be SMALL. The contribution of operations to cumulative impacts associated with visual resources would be SMALL to MODERATE. Because the cumulative impacts would be the same for all three ORR Sites, the cumulative impacts associated with ORR Site 2 and 8 are not discussed further.

The following subsections are limited to discussions associated with the cumulative construction and operational impacts associated with Redstone Arsenal Site 12.

9.3.5.3.1 Cumulative Land Use Impacts

The geographic area of interest for land-use impacts is a 30-mi radius around Redstone Arsenal Site 12, including parts of Madison, Limestone, Lawrence, Morgan, Marshal and Jackson counties in Alabama and Lincoln County, Tennessee along with population centers Huntsville, Madison, Athens, Decatur, Hartselle and Arab (Reference 9.3-80).

The history of land use at the Redstone Arsenal is long and varied. Prior to the Army's acquisition of the site in the early 1940s, approximately 550 families were present in several small rural communities (Reference 9.3-81). The property was originally chosen for a chemical manufacturing and storage facility to supplement the production of the Chemical Warfare Service's only chemical manufacturing plant at Edgewood Arsenal, Maryland (Reference 9.3-82). Between 1942 and 1945, Redstone Arsenal produced incendiaries, chlorine gas, mustard gas, loaded ammunition units, hand grenades, colored smoke, and white phosphorus (Reference 9.3-83). After the end of World War II, activities at Redstone Arsenal were severely curtailed and the destruction of munitions and deconstruction of various buildings and programs commenced (Reference 9.3-84). In 1949, operations turned to missile research. Portions of the munitions arsenal were reactivated during the Korean War while missile research and development continued (Reference 9.3-85). Redstone Arsenal has remained military since its development during World War II.

Subsection 9.3.5.2.1 discusses current land use at Redstone Arsenal. Redstone Arsenal has seen several changes and expansions since the 2005 Base Realignment and Closure Program (BRAC) round. Several Army organizations have moved to Redstone Arsenal including the Army Materiel Command's four star headquarters, the Space and Missile Command's three star headquarters, the majority of the Department of Defense's Missile Defense Agency, the Army Security Assistance Command two-star headquarters, the Aviation Technical Test Center from Fort Rucker, and the second recruiting brigade and the second medical recruiting battalion from Georgia.(Reference 9.3-86) As the BRAC program continues, it is likely that more army and other military services and departments will be relocated to Redstone Arsenal. However, most of these departmental changes would occur in the residential, city center, and professional zones of the arsenal (Figure 9.3-6). These zones are not located near Site 12, which is located in the industrial zone (Reference 9.3-87). Construction and personnel relocations due to the BRAC program would not contribute to cumulative impacts to land use resources associated

with the construction and operation of the SMR Project, as these changes would occur in an already-developed area at Redstone.

Redstone Arsenal is developing a 468-ac office and mixed use park called Redstone Gateway (Reference 9.3-88). The park will be located south of the intersection of I-565 and Highway 255/Rideout Road) in the northwest portion of the professional zone in the arsenal (Reference 9.3-89). The Army plans to construct an estimated 10 to 14 megawatt solar power array on the arsenal property (Reference 9.3-90). Detailed plans have not been developed, but the array would take up considerable space, and probably be located in the industrial zone. The construction and operation of the array would be considered a change in land use, although the property has been developed before and is zoned for industrial use. Due to their large scale and potential proximity to Redstone Arsenal Site 12, these projects may contribute to cumulative impacts to land use during construction and operation of the SMR Project. However, impacts would be SMALL as land use has already been designated as professional and industrial for these areas.

Redstone Arsenal is developing a master plan for the future of the army resources located on site. Objectives include the continuation of administrative space consolidation, reduction of offsite office space leases, on-post facility revitalization, development plans for the airfield, the city center and the Huntsville Spring Branch, Goss Road development, Martin Road development, and improving transportation infrastructure both onsite and regionally. (Reference 9.3-91) The master plan and associated projects are designed to improve the existing conditions on and around the arsenal, and may contribute to cumulative impacts to land use in the area. However, potential impacts would be SMALL as the areas proposed for development have already been designated professional, residential, or industrial by Redstone Arsenal. Additionally, these areas have already been developed for various industrial or military uses. Therefore, although new developments may be occurring and are proposed, the land use category would not change. Thus, new developments would not contribute to any potential adverse cumulative impacts to land use associated with the SMR Project.

The City of Huntsville, located within a 30-mi radius around Redstone Arsenal Site 12, has developed a variety of master plans, including a long range transportation plan for the year 2040. This plan serves as a decision guide for the urbanized Huntsville area over the next 25 years, with an emphasis on the next 3 to 5 years. The plan includes a projection of an increase of 68,000 households and 133,000 jobs by 2040. The reason given for this massive growth is the BRAC program. (Reference 9.3-92)

According to the 2014 annual development review released by the City of Huntsville, between 101 and 254 residential building permits were issued for the census tract (112) immediately to the west of Redstone Arsenal Site 12. Less than five permits were issued within the census tract to the north of Redstone Arsenal Site 12. In addition to building permits, 101 to 282 certificates of occupancy were issued to residences within census tract 112, indicating that the structures had been built and were either occupied, or ready to be occupied.(Reference 9.3-93) This number of permits and occupancy certificates is the highest in the urbanized Huntsville area.

This high development rate indicates a strong influx of population to the area, and in the immediate vicinity of Site 12.

The developed areas near Redstone Arsenal Site 12 were not previously occupied by structures; therefore, this would constitute a change in land use in the geographic area of interest. It is likely that changes in population due to the construction and operation of the SMR Project would contribute to cumulative impacts to land use. Due to the SMR Project and growth in the Huntsville area related to changes at Redstone Arsenal, additional homes may need to be constructed to accommodate the projected increase in population. Although the City of Huntsville has already projected large population growth and is planning for this change, the cumulative impact to land use would be MODERATE to LARGE; however, the incremental contribution from the construction and operation of the SMR Project would be SMALL.

Other cities in the 30-mi radius around Redstone Arsenal Site 12 are planning for growth. The City of Madison, Alabama experienced a population growth of 41 percent since 2000 and anticipates 12 percent growth in the next five years. In their growth plan, the City identifies technology based employment in both Madison and Huntsville as the source of growth. The plan identifies six key development areas and addresses current and future growth-related transportation issues. Development guidelines include commercial development, residential development, walk-able and bike-able transportation routes, and major street network improvements. (Reference 9.3-94) Due to the projected growth in Madison, and existing development plans, the addition of a construction and operation workforce for the SMR Project is not expected to require an excessive amount of new development. This projected population increase in combination with the SMR Project construction and operation would have a SMALL impact to land use in the Madison area.

Two new residential developments are in progress in the Town of Triana, just southwest of Site 12 (Reference 9.3-95). The Terrace of Savannah and the Town Lake Subdivision are currently either under construction or are occupied. This residential development further illustrates the population increases in the vicinity of Redstone Arsenal Site 12. These projects could have a cumulative impact on land use in conjunction with the construction and operation of the SMR Project; however, these impacts would be SMALL. The Town of Triana has applied for a Community Development Block Grant in order to develop a comprehensive plan. (Reference 9.3-96) Impacts to land use due to the combined demands of a construction and operation workforce for the SMR Project and the projected increases in population in Triana would need to be addressed. With the comprehensive plan in place, cumulative impacts to land use would be mitigated.

The City of Arab, Alabama, located approximately 25 mi southeast of Redstone Arsenal, updated its zoning map in 2013. General business areas tend to be located along State Route 53 with high, medium and low residential areas in successive distances from the road. Industrial areas are located on the outskirts of the city. (Reference 9.3-97) The city developed a strategic plan in 2012. The broad focus areas in the plan are economic development, public services and infrastructure, quality of life, and tax base and revenue. Most of the plan focuses on

revitalization and expansion of the downtown area. Discussions regarding the possibility of developing a research park were also noted. Expansion of the sewer system and housing developments were addressed, predicting a minor increase in population. The plan states that a comprehensive plan would be developed in 2013; however, this plan is not available on the City website and may not have been completed yet. (Reference 9.3-98) Due to the distance from Redstone Arsenal Site 12, it is not likely that in-migrating SMR Project construction and operations workers would choose Arab as their home city, and only a minor increase in residential and business development would occur. Therefore, although the SMR Project would contribute to impacts to land use in Arab, these impacts would be SMALL.

The City of Hartselle, Alabama is located approximately 17 mi southwest of Redstone Arsenal. Hartselle has a zoning ordinance and map, although their comprehensive plan was not available on the city website at the time of this report. Due to the distance from Redstone Arsenal Site 12 and its small size, in-migrating workers are not likely to select Hartselle as a home city. Therefore, construction and operation of the SMR Project at Redstone Arsenal Site 12 would not contribute to cumulative impacts to land use in Hartselle.

Decatur, Alabama is located approximately 15 mi west of Redstone Arsenal. The City of Decatur's Planning Department developed a comprehensive master plan which was adopted in 1999 (Reference 9.3-99). Since 1999, the Downtown Decatur Redevelopment Authority has produced a series of plans and documents regarding goals and projects intended to revitalize downtown Decatur. The revitalization plans focus on the years 2015 to 2019 and describe plans for residential development in the city center, the establishment of the Education and Technology Business Park, development of the Decatur Downtown Commons, streetscape and economic development of the 6th Avenue Gateway Corridor. Additionally, enhancement and restoration of the Railroad Depot, and turning the River Clay Arts Festival into a signature benchmark event is planned. (Reference 9.3-100). The 2015 State of the City address states that approximately 280 new businesses opened in 2014, including expansions of existing industries. Ongoing projects include the renovation of the Decatur Depot, a jail expansion, Phase 2 of the construction of the Alabama Center for the Arts and several road and sewer projects. (Reference 9.3-101) With the rapid development and growth of the City of Decatur, the SMR Project construction and operations phases could contribute to cumulative impacts to land use in the Decatur area. The City of Decatur has considerable attractions which may appeal to commuting in-migrating workers. Additional population growth in the City of Decatur area could contribute to the need for additional housing, schools, hospitals and other community services, which would change land use practices. However, this impact to land use resources would be SMALL.

Athens, Alabama is located approximately 19 mi northwest of the Redstone Arsenal Site 12. The City of Athens adopted a land use and development plan in 2013, citing continued growth in Huntsville as a factor to its increasing growth. Prior to the plan, growth in Athens was largely suburban and low density. The plan recognizes that suburban sprawl, if allowed to continue, would degrade the character and aesthetics of the Athens area. Therefore, recommendations

for separate planning approaches to edge, suburban, and urban areas are given. The focus is on retaining the rural character of the edges, while using in-fill, high density housing and business neighborhoods within the city center and specific existing high density areas. (Reference 9.3-102) Cumulative impacts to land use due to the SMR Project construction and operation are possible due to the influx of new populations. A larger number of residents could spur development in currently undeveloped areas. However, as Athens has developed a highly detailed development plan, with an emphasis on in-fill and redevelopment, these impacts would be SMALL.

In addition to population growth pressures, the land-based treatment and disposal of nonradioactive solid waste will also impact land use in the geographic area of interest. Cumulative impacts from preconstruction and construction waste, as well as operational waste, is primarily related to the type and amount of waste generated and the available capacity of treatment and disposal facilities. While waste type and amount will be similar to the CRN SMR Project waste discussed in Subsection 3.6.3.3 and will be managed and mitigated using TVA procedures and BMPs, the available capacity of regional treatment and disposal facilities will be specific to Redstone Arsenal Site 12.

To minimize cumulative impacts to an offsite facility, TVA expects to construct and operate an onsite landfill for construction, site clearing, and grading debris at the selected site. The construction landfill would be sized to accommodate the anticipated materials and would be located in a permanently cleared laydown area on the selected site. The landfill would be constructed in accordance with relevant permits and licenses. No hazardous or municipal waste would be disposed of in this landfill. The landfill would be closed at the end of the construction period.

Preconstruction, construction and operational nonhazardous solid waste would be managed by a TVA-approved solid waste disposal vendor and disposed in a state-approved sanitary landfill. Similar to the CRN Site, the anticipated contribution to regional sanitary landfills is SMALL and the cumulative contribution is SMALL.

Hazardous wastes from construction and operational activities, including oil wastes, paint wastes, solvent wastes, laboratory wastes, and universal wastes, would be disposed using TVA management procedures and a TVA-approved vendor . Because TVA would employ waste management and minimization practices, the impact of this contribution would be SMALL. Similarly, because offsite disposal of hazardous waste in the immediate vicinity, excluding contributions from Redstone Arsenal, exceeded 10 million tons in 2014, the cumulative impact from construction and operational activities is also SMALL.

Conclusion: Although the site-specific land use impacts associated with the construction and operation of the SMR Project at Redstone Arsenal Site 12 would be MODERATE due to site-specific issues, the cumulative impacts to land use in the geographic area of interest would be SMALL.

9.3.5.3.2 Cumulative Water Use Impacts

Cumulative water-use and water quality impacts are presented separately for surface water and groundwater.

Surface Water Use Impacts

For purposes of this cumulative impact analysis, the geographic area of interest for surface water use impacts is the five-county area surrounding Redstone Arsenal Site 12. Although water use within the drainage basin of the Wheeler Reservoir could be impacted both upstream and downstream of Redstone Arsenal Site 12, the potential for the SMR Project to contribute to such impacts is expected to be highest in close proximity to Redstone Arsenal Site 12, and to decrease substantially with distance away from Redstone Arsenal Site 12.

As discussed in Subsection 9.3.5.2.2 the local surface water supply in Wheeler Reservoir is able to sustain two or more SMRs at Redstone Arsenal Site 12. Wheeler Reservoir is part of the TVA network of dams and reservoirs as discussed in Subsection 4.7.3.1. As discussed in Subsection 4.2.2.1, withdrawal and consumption of surface water for dust suppression during construction of the SMRs would be less than 0.002 percent of the minimum daily flow rate in the Clinch River arm of the Watts Bar Reservoir. Construction of the SMRs at Redstone Arsenal Site 12 would consume a similar amount of water and would not be expected to impact the flow rate in Wheeler reservoir. In addition, construction and operational discharges would provide a slight increase in flow from nonhazardous wastewater. Stormwater runoff, as well as discharges from dewatering preconstruction excavations and from cooling tower operational releases, would be released into the Wheeler Reservoir. Moreover, the TVA system has been designed, and is operated, with the purpose of moderating flow rates throughout the year by releasing water flow in periods of low precipitation, and by storing flow in periods of high precipitation. Therefore, if water use impacts are detected at Wheeler Reservoir, TVA could adjust flow rates during construction.

In addition to moderating flow rates, TVA's system of dams and reservoirs serves to provide water supply for a variety of municipal, industrial, and agricultural users in the geographic area of interest. The City of Huntsville pumps some of its water from the Tennessee River and some of it from groundwater sources. The City Utilities Department is responsible for supplying water to over 90,000 customers. Each of the City's two surface water treatment plants are capable of treating 48 million gallons per day (mgd) and the average daily pumpage is approximately 35 mgd. (Reference 9.3-103) The estimated surface water withdrawals in Madison County for the year 2010 totaled approximately 45 mgd (Reference 9.3-104). This withdrawal amount leaves the Huntsville Utilities Department approximately 51 mgd of treatment capacity. During construction, an estimated 5000 gallons per day (gpd) would be required for dust suppression. During operations, an estimated maximum of 30,708 gpm (44,219,520 gpd) would be required. Construction water use would not contribute to cumulative impacts to the Huntsville area water supply. Operations water use would result in approximately 44 mgd of additional water withdrawn from the Wheeler Reservoir/Tennessee River system. This withdrawal amount could

contribute to negative cumulative impacts to surface water supplies in the Huntsville area. However, with TVA's ability to adjust flows in the reservoir system, this impact would be considered SMALL.

The Limestone County Water and Sewer Authority serves approximately 20,000 customers and provides water to the City of Athens, City of Ardmore, City of Madison, East Lauderdale County, and Giles County, Tennessee. Its two water treatment plants have a total capacity of 7.25 mgd. The surface water portion of this supply is pumped from the Elk River at the North Limestone Treatment Facility located approximately 5 mi north of Elkmont. (Reference 9.3-105) Limestone County withdrew 2788 mgd of surface water in 2010. Of this total, 2724 mgd are used by the thermoelectric industry, which is generally a flow-through process. Approximately 20 mgd are used for public supply, agriculture, and mining. (Reference 9.3-104) As with the water supply to Huntsville, the construction of the SMR Project in Redstone Arsenal would not contribute to cumulative impacts to the local water supply. The withdrawal of 44 mgd for operations could contribute to negative impacts to the local water supply in Limestone County. However, as withdrawals are carefully monitored by TVA and flows through Wheeler Reservoir/the Tennessee River are adjusted accordingly, these impacts would be SMALL.

Decatur Utilities serves approximately 25,000 customers in all portions of the City of Decatur and provides water to the City of Hartselle, the Northeast Morgan County Water District, and parts of Limestone County. The town of Trinity and the West Morgan East Lawrence Water District have the capability to buy water from Decatur Utilities upon request. The water is obtained from Wheeler Reservoir. The Water Treatment Plant has the capacity to treat 68 mgd with an average of 30 mgd of raw water. (Reference 9.3-106) Morgan County withdrew approximately 119 mgd in 2010. Of this 78 mgd was for industrial use and presumably did not run through the treatment plant. (Reference 9.3-104) Therefore, approximately 27 mgd of treatment capacity remains in the system. As with the water availability in Huntsville and Morgan County, the construction of the SMR Project in Redstone Arsenal would not contribute to cumulative impacts to water use. With careful monitoring and adjustments, the operations phase would contribute only SMALL impacts to cumulative water use.

The Arab Water Works pumps water from the Brown's Creek Embayment in Lake Guntersville. In 2014, Arab Water Works distributed 1,402,057,000 gallons of water. (Reference 9.3-107) Marshall County withdrew 25 mgd of surface water in 2010 (Reference 9.3-104). There are no large population centers in Jackson County within the geographic area of interest. However, Jackson County withdrew 1065 mgd of surface water in 2010. Of this water, 1044 mgd were for thermoelectric use and presumably returned to the surface water system. (Reference 9.3-104) As these counties use relatively small amounts of surface water and TVA can potentially adjust water levels as needed to supply the SMR Project and the communities within the geographic area of interest, the construction and operation of the SMR Project would not contribute to cumulative impacts to surface water use and supply in Marshall and Jackson Counties.

As discussed in Subsection 4.7.1.2, the impact of global climate change on surface water availability in the region is unknown. The change in precipitation rates in the region due to global

climate change is unknown, but global climate change is still expected to reduce water availability through an increase in evaporation and transpiration rates as a result of increasing temperatures (Reference 9.3-108).

Conclusion: Indirectly, the increase in population due to construction and operational workforce in-migration could contribute to adverse impacts to water use and supply in the geographic area of interest. However, as most of the population centers in the geographic area of interest are already planning for population increases, these impacts would be SMALL.

Global climate change may reduce water availability through an increase in evaporation and transpiration rates. However, as there is abundant surface water in the Redstone Arsenal area, cumulative impacts due to climate change would be considered SMALL in the geographic area of interest.

Overall, past, present, and reasonably foreseeable future projects, combined with the additional potential for a decrease in surface water availability due to global climate change, result in cumulative impacts on surface water availability that would be SMALL. Although surface water uses for municipal, agricultural, and industrial purposes remove surface water from the geographic area of interest, TVA's management of the dam and reservoir system counteracts this adverse effect by beneficially storing excess surface water for use during periods of low precipitation, ensuring availability of water for all uses in all but the worst droughts. The incremental additional impact associated with surface water use for construction and operation of the SMRs would not reverse the beneficial effect of the reservoir management system. Therefore, its contribution would be SMALL.

Groundwater Use Impacts

The geographic area of interest for cumulative impacts to the quality of groundwater is the subwatersheds of the streams and creeks that drain to the reservoir near Redstone Arsenal, and/or areas that are directly connected to groundwater flow of Site 12.

The processes used to construct an SMR on Redstone Arsenal Site 12 would be the same as at the CRN Site. Dewatering may be necessary in order to construct the power blocks. As with the CRN Site, previous groundwater conditions are expected to resume after construction, and cumulative impacts are not expected. It is assumed that operating the CR SMR Project at Redstone Arsenal Site 12 would use surface water sources and therefore would not directly impact local groundwater use.

Conclusion: Construction and operation of the SMR Project at Redstone Arsenal Site 12 could contribute to cumulative impacts to groundwater indirectly due to combined strains on groundwater supply caused by climate change. Additionally, the construction and operation of the SMR Project at Redstone Arsenal Site 12 could indirectly impact groundwater supply by reducing the amount of aquifer recharge due to added surface water use. These cumulative impacts to groundwater use and supply would be considered SMALL.

Surface Water Quality Impacts

For purposes of this cumulative impact analysis, the geographic area of interest for surface water use impacts at Redstone Arsenal Site 12 is Wheeler Reservoir. Although projects within the drainage basin of the Tennessee River both upstream and downstream of Redstone Arsenal Site 12 can affect surface water quality throughout the entire basin, the potential for the SMR Project to contribute to such impacts is expected to be highest in close proximity to the Site, and to decrease substantially with distance away from the Site.

Indian Creek, Huntsville Spring Branch, and McDonald Creek, all of which empty into the Wheeler Reservoir, are the major systems flowing through the property. Intakes along the Wheeler Reservoir are used for domestic and industrial water systems by Redstone Arsenal (Reference 9.3-51). As part of TVA's river operations program, TVA has monitored the ecological health of the Wheeler Reservoir since 1994. Based on dissolved oxygen, chlorophyll, fish, bottom life, and sediment data from 1994 to 2011, Wheeler Reservoir rated either good or fair every year with the exception of 2007 and 2011, when it rated poor. Lower ecological health scores occur during years with lower flow because of higher chlorophyll concentrations and lower dissolved oxygen levels. (Reference 9.3-109)

Two streams on the Redstone Arsenal have been designated by the EPA as impaired: Huntsville Spring Branch and Indian Creek. The pesticide DDT was the primary cause of impairment for these two streams. No impaired water bodies have been identified on Site 12. (Reference 9.3-50)

Information on surface water quality in Wheeler Reservoir was obtained from studies of the U.S. Geological Survey in the Lower Tennessee River Basin, and the Alabama Department of Environmental Management (ADEM) 303(d) list. These studies provide a baseline for surface water and sediment quality based on analyses which occurred from 1999 to 2015, and therefore effectively represent the cumulative impact of past and present projects. Impacts to surface water and sediment quality as a result of industry, mining, agriculture, urbanization, and toxic spills and releases have been identified. Surface water quality impacts include elevated phosphorus and pH impacts as a result of agriculture; elevated concentrations of perfluorooctane sulfonate as a result of an industrial point discharge, and elevated mercury from atmospheric deposition (Reference 9.3-110). Although water quality impacts from past and present projects have been documented, surface water quality in the Lower Tennessee River Basin meets existing guidelines for drinking water quality and the protection of aquatic life (Reference 9.3-111). New pollutant sources due to the projected population increase in the geographic area of interest are expected; such as a planned expansion of the Madison wastewater treatment facility (Reference 9.3-112).

Global climate change may adversely affect surface water quality as increasing air and water temperatures, more intense precipitation and runoff, and intensifying droughts can result in increases in sediment, nitrogen, and other pollutant loads (Reference 9.3-108). Changes in agricultural practices, in response to climate change, can lead to increase in the release of

pollutants to streams. Other factors, including operation of new projects under the regulation of the Clean Water Act, and the inclusion of water quality standards in the development of TVA's river management programs, have had the opposite effect, resulting in improvement of surface water quality.

Conclusion: Potential adverse impacts associated with construction of the SMR Project include erosion and sedimentation and elevated turbidity levels at the intake and discharge structures. With appropriate permitting and BMPs, these impacts are expected to be SMALL. Potential negative impacts to water quality during operations would be associated with the discharge, from the concentration and discharge of chemicals added to the recirculating cooling water to prevent corrosion and biofouling, or from elevated temperatures in the discharge. It was determined that Wheeler Reservoir would be capable of handling the anticipated thermal discharges.

Cumulative impacts to surface water quality from past and present activities have occurred, and are MODERATE. The impacts from past activities are detectable, but surface water and sediment quality generally complies with relevant regulatory criteria and is, therefore, not destabilizing. In addition, TVA's management has had a beneficial effect on water quality, by managing water flows to increase aeration and dilute industrial discharges. Given that construction-related discharges are managed in accordance with an approved stormwater pollution prevention plan (SWPPP) and NPDES permit for stormwater discharges, and BMPs would be followed during construction, the incremental contribution of preconstruction and construction activities on surface water quality would be SMALL.

Overall, past and present projects, combined with the additional potential for a decrease in surface water quality due to climate change, result in MODERATE cumulative impacts on surface water quality. However, the incremental additional impact associated with construction and operation of the SMRs would be SMALL.

Groundwater Quality Impacts

The geographic area of interest for cumulative impacts to the quality of groundwater is the subwatersheds of the streams and creeks that drain to the reservoir near Redstone Arsenal, and/or areas that are directly connected to groundwater flow of Site 12.

Redstone Arsenal was placed on the National Priorities List as a Superfund site in 1994 because of contaminated groundwater, soil, sediment and surface water resulting from arsenal operations and waste disposal practices and manufacture of DDT and other chemicals onsite. Contaminants of concern include solvents, metals, pesticides, chemical warfare material, and hazardous remnants from rocket fuel research, development, and testing, including perchlorate. NASA and the Army have addressed soil contamination with remediation and institutional controls to restrict digging and control land use. Fencing surrounds portions of the arsenal to prevent public access. Institutional controls also prohibit use of groundwater at the arsenal.

(Reference 9.3-113) Contaminants of concern in the groundwater include arsenic, mercury, perchlorate, and trichloroethylene (TCE) (Reference 9.3-114).

Conclusion: As the institutional controls at Redstone Arsenal prohibit the use of groundwater, water quality would not be impacted directly by the construction and operation of two or more SMRs at Site 12. Indirect impacts are possible due to run off from the SMR Project and recharge of the aquifer from surface water sources. However, in order for the SMR Project to impact groundwater in this fashion, a large amount of contaminants would have to released, either to the ground or surface water on the site. As this situation is unlikely during the course of construction or operation of the SMR Project due to use of BMPs and compliance with an Integrated Pollution Protection Plan, the SMR Project would not contribute to cumulative impacts to groundwater in the Redstone Arsenal geographic area of interest.

9.3.5.3.3 Cumulative Ecological Impacts

For the purposes of this cumulative analysis of the impacts of preconstruction and construction on terrestrial ecology, the geographic area of interest is defined as the area within approximately a 6-mi radius of Redstone Arsenal Site 12. This area is expected to encompass other projects and activities potentially capable of interacting with the SMR Project to affect ecological resources during preconstruction and construction. Much of the immediate geographic area of interest provides terrestrial ecology similar to the undeveloped, forested portions of Redstone Arsenal, offering alternative habitat.

Terrestrial Ecology and Wetlands Impacts

Subsection 9.3.5.2.3 describes the terrestrial ecology of Redstone Arsenal Site 12, which is completely forested and includes only 1.9 ac of wetlands. It concludes that impacts to terrestrial ecology during construction and operation of the SMR Project at Redstone Arsenal Site 12 would be SMALL. However, it is anticipated that most of the 130-ac site would be cleared of vegetation prior to construction. Much of the geographic area of interest immediately surrounding Redstone Arsenal Site 12 provides forested habitats similar to the habitat on this site and offers alternative habitat for displaced wildlife. The construction and operation of the SMR Project at Redstone Arsenal Site 12 would contribute incrementally to the conversion of forest to other land uses and the fragmentation of forest habitats that have already occurred and are likely to continue due to other development in the geographic area of interest.

Subsection 9.3.5.3.1 describes the land use patterns and trends in the Redstone Arsenal geographic area of interest, including several master plans developed by communities to address new development. Several of these plans (Huntsville, Decatur, and Athens) describe increasing populations and pressure to develop new housing and business areas. As there is increasing population and associated development predicted in the geographic area of interest, it is likely that some of this development would occur in currently undeveloped areas, contributing to cumulative impacts on terrestrial ecology. Madison County was only 18 percent developed in 1984. It is estimated that between 38 and 50 percent of Madison County would be

developed by the year 2020. (Reference 9.3-115) This 20 to 32 percent increase over a 36-yr period represents a significant loss of natural terrestrial areas in the county and a potentially large increase in habitat fragmentation. The City of Athens is similarly predicting a large population increase and associated development, although they do not provide an estimate of new areas to be developed. Athens has placed a priority on using infill in already urbanized areas to make up for growth instead of developing new subdivisions. (Reference 9.3-102) Although the construction and operation of the SMR Project at Redstone Arsenal Site 12 would contribute to cumulative impacts to terrestrial ecology, the loss of up to 194 ac (Table 9.3-federal installation would be minor within the context of the overall development trends in Madison County, which have had a MODERATE to LARGE impact on terrestrial resources in the geographic area of interest. Thus, the incremental contribution from construction and operation of the SMR Project to cumulative impacts on terrestrial ecology within the geographic area of interest would be SMALL.

Aquatic Ecology Impacts

Construction and operation of the SMR Project on Redstone Arsenal Site 12 potentially could have adverse effects on the Wheeler Reservoir through construction-related activities from activities such as dredging, in-water construction of intake or discharge structures, or sedimentation from stormwater runoff. As discussed in Subsection 9.3.5.2.4, the potential for occurrence of listed or other special status aquatic species on Redstone Arsenal Site 12 is minimal, due to the absence of significant aquatic habitats on this site and the lack of recorded occurrences of federally or state-listed aquatic species on or adjacent to this site. By employing BMPs and complying with the requirements of permits, the aquatic impacts associated with construction are likely to be SMALL.

Historical dam and reservoir projects to regulate the Tennessee River system have greatly altered the natural flow regime of the Tennessee River and its tributaries in the geographical area of interest. These changes have had SMALL to LARGE impacts on aquatic organisms and communities. Additional projects could occur in Wheeler Reservoir during the construction of the SMR Project. For example, TVA issued a Finding of No Significant Impact regarding the Limestone County request for permission to install a 30-inch pipeline across Wheeler Reservoir to connect the county to the Decatur water treatment plant. This project would also involve limited in-water construction. (Reference 9.3-116) Potentially, increases in population could increase demands on the reservoir and result in more in-water construction occurring simultaneously. Multiple construction projects within similar time-frames could cause cumulative negative impacts to aquatic ecology in Wheeler Reservoir. However, the use of BMPs and compliance with permits is expected to reduce sedimentation impacts and limit their extent to the immediate area of such projects. Thus, the contribution of construction and operation to cumulative impacts would be mitigated and remain SMALL.

As discussed in Subsection 9.3.5.2.4, operational impacts to aquatic ecology would center on the intake and discharge structures of the SMR Project. Potential chemical and thermal impacts would occur at the discharge, while biological impacts to aquatic organisms from impingement

and entrainment would occur at the intake. There are already public municipal and industrial water intakes and discharges in the Wheeler Reservoir watershed, including intakes in Wheeler Reservoir (Reference 9.3-51). The addition of thermal and chemical discharges from the operation of the SMR Project could result in adverse cumulative impacts to water quality, which could adversely affect the aquatic ecology in Wheeler Reservoir. However, with the implementation of BMPs, compliance with discharge permits, and performance of monitoring, water quality would be protective of aquatic life.

Impacts due to impingement and entrainment at the intake structure could also result in adverse cumulative impacts to aquatic ecology due to deaths of individual organisms and changes in population and community structure. However, as discussed for the operation of the SMR Project in Subsection 5.3.1.2, NRC has found that the effects of entrainment and impingement of aquatic organisms have not been a problem at nuclear facilities with a closed-cycle, cooling-tower-based heat dissipation system. Accordingly, the impacts from entrainment and impingement at the intake, as well as impacts from the discharge, on fish and other aquatic organisms due to the operation of the SMR Project would be SMALL.

Conclusion: Based on this analysis, the cumulative impacts on ecological resources in the geographic area of interest from past, present, and reasonably foreseeable future actions, including preconstruction and construction of the proposed SMR Project on Redstone Arsenal Site 12, would range from SMALL to MODERATE for terrestrial resources and from SMALL to LARGE for aquatic resources. The incremental contribution from construction and operation activities for the SMR Project to these cumulative impacts on terrestrial and aquatic ecology within the geographic area of interest would be SMALL.

9.3.5.3.4 Cumulative Socioeconomics and Environmental Justice Impacts

Subsection 9.3.5.2.5 describes the social and economic characteristics of the Redstone Arsenal area and the potential impacts related to construction and operation of the SMR Project at Redstone Arsenal Site 12. The physical impacts (noise, transportation, and air quality) as well as the socioeconomic impacts to the community (population, housing, economy, roadways, barge traffic, railroad transport, tax revenues, infrastructure, and community services) are addressed in this subsection.

The geographic area of interest for socioeconomic impacts is Madison, Morgan, and Limestone counties, Alabama, the three counties surrounding Redstone Arsenal. For transportation and air quality impacts, the geographic area of interest is a 10-mi radius around Redstone Arsenal Site 12.

Air Quality

The geographic area of interest for air criteria pollutants is Madison County, Limestone and Morgan Counties. Because the equipment which emits criteria pollutants is operated infrequently and for limited periods of time, it is expected the SMR Project's modeling impact

area would be within 10 mi. The area 10-mi away from Redstone Arsenal Site 12 would include the cities of Huntsville and Madison and portions of Madison, Limestone and Morgan Counties. As of 2015, the only county in Alabama that was in nonattainment was Pike County, due to lead (Reference 9.3-117).

Because climate change is global in nature and currently focuses on the policies established by national governing agencies, the project's geographic area of influence needs to be considered in the context of United States policy and national GHG emissions. Further, individual states are developing GHG regulations, thus consideration of GHG emissions under state regulations would in all likelihood also be necessary.

Cumulative impacts to air quality are possible if several construction projects are underway simultaneously. However, with the use of BMPs such as dust suppression and limiting cleared areas on active construction sites, impacts would be mitigated. Because of the temporary and limited nature of preconstruction and construction emissions, and the mitigation measures used to limit onsite construction activity emissions and mobile source emissions, the incremental contribution from the SMR Project is expected to be SMALL. The SMR Project would be constructed and operated under air permits issued by ADEM. Due to emissions regulations and construction management BMPs, cumulative impacts to air quality are also anticipated to be SMALL.

Noise

Cumulative noise impacts may occur if several large projects were under construction at the same time in close proximity. Redstone Arsenal master plan addresses the future of the Army resources located on site. Objectives include the continuation of administrative space consolidation, reduction of offsite office space leases, on-post facility revitalization, development plans for the airfield, the city center and the Huntsville Spring Branch, Goss Road development, Martin Road development, and improving transportation infrastructure both onsite and regionally. (Reference 9.3-91) Redstone Arsenal is developing a 468-ac office and mixed use park called Redstone Gateway (Reference 9.3-88). The park will be located near the intersection of I-565 and Highway 255 in the northwest portion of the professional zone in the arsenal (Reference 9.3-89). Due to its large scale and proximity to Redstone Arsenal Site 12, this project may contribute to cumulative impacts to noise during construction and operation of the SMR Project. The high rate of development in the Redstone Arsenal area could increase the noise impacts as it could place more residences closer to the SMR Project and the other new developments. If the development, including the SMR Project, the additions to Redstone Arsenal, and continuing residential areas were to proceed at the same time, cumulative noise impacts would be MODERATE.

The Redstone Arsenal is responsible for demolishing old and non-functional munitions, including unexploded ordnance. The facility accomplishes this by exploding ordinance on the arsenal grounds. The noise from these explosions can sometimes be heard as far away as Huntsville, Alabama. Occasionally, the noise and vibrations cause damage to structures in the

Huntsville area. (Reference 9.3-118) Redstone also tests aircraft and rockets on the facility. In order to lessen the existing noise impacts, the arsenal posts warnings on the Redstone Arsenal website, publicizing which days concussive activities will take place. (Reference 9.3-119) Given the existing high-level noise environment, although the construction and operation of the SMR Project at Redstone Arsenal Site 12 would contribute to cumulative impacts to noise (particularly during construction), it would be a minor component of overall noise in the area. Therefore, the incremental cumulative impacts to noise would be SMALL to MODERATE during construction and SMALL during facility operation.

Population and Housing

Subsection 9.3.5.3.1 discusses land use and the master plans of several surrounding population centers and the Redstone Arsenal. Overall, the geographic area of interest is rapidly developing due to the BRAC program and other large scale industrial and commercial developments. In addition to the increases in utilization of Redstone Arsenal, other companies are moving into the area. For example, Polaris is constructing a facility to build off-road vehicles on 450 ac in Limestone County that will employ up to 2000 workers (Reference 9.3-120). This facility would also add to the demand for new housing and infrastructure in the geographic area of interest.

The local master plans include large population increase estimates. Chapter 3.10 discusses the workforce needed to construct and operate two or more SMRs at the Clinch River site. Construction and operation of the SMR Project at Redstone Arsenal Site 12 would require a similar workforce. Subsection 9.3.5.2.5 discusses potential impacts to the local population and housing due to the construction and operation of the SMR Project at Redstone Arsenal. The cumulative impacts on population and housing in the geographic area of interest from past, present, and reasonably foreseeable future actions would be MODERATE. As the population in the geographic area of interest is already increasing, and new home construction is already occurring, the incremental contribution to impacts on population growth and housing from construction and operation of the SMR Project would be considered SMALL.

Economy and Tax Revenues

Subsection 9.3.5.2.5 discusses potential impacts to the economy of the Redstone Arsenal area if the SMR Project were to be constructed there. Most of these impacts are due to an increase in population and an increase in employment. Both of these increases would lead to an increase in sales and property tax revenues in the affected counties. This would represent a beneficial impact to the geographic area of interest. Additional possibilities include the over-straining of the police, fire and medical services due to an increase in the number of people requiring services. This would represent an adverse impact. New schools might need to be built as well. However, the increase in TVA in-lieu tax payments could be used by cities and towns in the geographic area of interest to hire additional personnel and construct new social infrastructure facilities as needed. Given the high rate of development and projected population increases in the geographic area of interest, the cumulative impacts to the economy due to the construction and operation of the SMR Project along with past, present, and reasonably foreseeable future actions would be MODERATE, and primarily beneficial. Although the employment increase and

amount of sales and property taxes associated with the SMR Project, as well as TVA in-lieu tax payments, would be large in absolute terms, the incremental impact of construction and operation would be SMALL when compared to the regional economy and the total amount of taxes collected within the geographic area of interest.

Transportation

The Redstone Arsenal master plan and associated projects are designed to improve the existing conditions on and around the arsenal and, therefore, are not expected to contribute to potential adverse cumulative impacts to traffic associated with the SMR Project. There may be temporary increases in traffic if construction projects are occurring concurrently, or if road improvements are scheduled during construction of the SMR Project. Theoretically, the planning process would compensate for traffic increases, but if many construction projects are underway simultaneously, coupled with a large increase in local population, cumulative impacts to traffic could be MODERATE. However, these impacts would be temporary and the projects would be expected to result in an overall beneficial impact to traffic resources in the vicinity.

The Alabama Department of Transportation (ALDOT) has 52 transportation projects projected for fiscal years 2015 through 2019. Of these projects, one is in Limestone County and the rest are in Madison County, generally in or near Huntsville. Projects vary from simple re-grading to bridge replacement and widening and extending existing roads. There will be a new Huntsville bypass and a new interchange at the entrance to Redstone Arsenal off of I-565. The projects are predicted to cost between 301 to 452 billion dollars. (Reference 9.3-121) These projects are likely to impact local traffic conditions while they are under construction. Indirect impacts can occur if delays on major roads cause travelers to use smaller local roads instead. Although impacts to traffic in the area are likely due to the combination of the multiple construction projects, these would be temporary and conditions would improve once the improvements have been completed.

The City of Huntsville has developed a variety of master plans, including a long range transportation plan for the year 2040. This plan serves as a decision guide for the urbanized Huntsville area over the next 25 yr, with an emphasis on the next 3 to 5 yr. The plan addresses future traffic volumes, roadway and intersection capacities, new transportation corridors, alternative transportation modes, pedestrian/bicycle trails, signalization needs, and funding alternatives. The plan includes a projection of a 68,000 household increase by 2040, and in increase in 133,000 jobs. The reason given for this massive growth is the BRAC program. The plan envisions bicycle and pedestrian paths and public transportation improvements, as well as a bypass road which will ring the Huntsville urbanized area. The objective is to relieve future traffic congestion and improve freight capacity in the area. (Reference 9.3-92) As with the Redstone Arsenal master plan, the 2040 transportation plan is geared towards eliminating potential adverse impacts to resources in the area. Therefore, if this plan is executed over the next 25 years, it would be expected to relieve cumulative impacts due to the SMR Project. Additionally, the plan requires regular updates, and if the Redstone Arsenal site were chosen for the SMR Project, the transportation master plan would be updated to reflect this new

development. Construction of the SMR Project in conjunction with ALDOT transportation projects, development in the area, and increased traffic levels associated with the projected increase in population are likely to impact traffic conditions in the area, resulting in MODERATE cumulative impacts to transportation. The incremental impact related to construction and operation of the SMR Project at Redstone Arsenal Site 12, which would contribute a small portion of the overall traffic increase in the area, would be SMALL.

Visual

The geographic area of interest for visual resources includes the 2-mi radius surrounding the SMR Project. The visual intrusion due to operation of the SMR Project would range from SMALL to MODERATE, due primarily to the visual effect of the plume from the cooling towers. Within the 2-mi geographic area of interest, there are no past, present, and reasonably foreseeable projects and facilities which are expected to impact visual resources. However, the cumulative impacts on visual resources associated with the industrial appearance of the plume during operations would be SMALL to MODERATE.

Infrastructure

Cumulative impacts to the local infrastructure, such as utilities, are possible due to the large amount of construction and development occurring in the Redstone Arsenal geographic area of interest. Although the local water treatment facilities are operating below capacity, with an influx of 68,000 persons to the Huntsville area plus additional developments like the Polaris plant, Redstone Arsenal's new developments, and the SMR Project, the municipal water supply would experience increased demand for treated potable water. However, with the increased tax revenue and a construction-oriented workforce in the area, potential impacts to infrastructure could be minimized with careful planning and monitoring of conditions. Based on the projected increase in population and the multiple proposed construction projects in the geographic area of interest, and associated increase in tax revenue available for construction of infrastructure improvements, cumulative impacts on infrastructure from construction and operation of the SMR Project in conjunction with past, present, and reasonably foreseeable future actions would be SMALL.

Education

Population increases and development activities in the Redstone Arsenal geographic area of interest would result in increased demand for educational services. An influx of 68,000 persons would include a considerable amount of children who would need educational services. Additionally, a demand for skilled workers could increase the demand for training programs and vocational schools. With the increased tax revenues in the local population centers, these demands on the educational systems would likely be mitigated. However, educational systems would have to be able to expand quickly enough to meet sudden increases in population due to the large scale construction projects that are ongoing and planned in the geographic area of interest. If the municipalities can react to changing demographics in a timely manner, cumulative impacts to education services during construction and operation would be SMALL.

Conclusion: Based on this analysis, the cumulative impacts on socioeconomic resources in the geographic area of interest from past, present, and reasonably foreseeable future actions, including construction and operation of the proposed SMR Project on Redstone Arsenal Site 12, would be SMALL for air quality, infrastructure, and education. Although the cumulative impacts would be MODERATE for noise, traffic, population and housing, and economy and tax revenues, the incremental contribution from construction and operation of the SMR Project on these socioeconomic resources would be SMALL. The cumulative impacts on visual resources associated with the industrial appearance of the plume during operations would be SMALL to MODERATE.

Cumulative Health Impacts

Cumulative impacts to human health including impacts from past, present, and reasonably foreseeable activities are discussed below. The geographic area of interest for impacts to human health is a 50-mi radius around Redstone Arsenal Site 12 including the Redstone Arsenal, Huntsville, and Decatur.

Nonradioactive health impacts from construction and operational activities at Redstone Arsenal Site 12 include localized impacts from noise, vibrations, and dust, along with occupational injuries to workers. Cumulative noise, vibration, and dust impacts from construction and operational activities would include current ongoing and planned developments at Redstone Arsenal. Future cumulative noise, vibration, and dust impacts would include possible roadway improvements and urbanization within 10 mi of Redstone Arsenal Site 12.

Cumulative health impacts to workers include occupational injuries coupled with noise, vibration, and emission impacts from current and future activities within the worker's commute region. Current and future activities within a 50-mi radius of Redstone Arsenal Site 12 including road, airport, and building construction along with munitions activities at Redstone Arsenal would contribute to cumulative health impacts to workers.

Further nonradioactive health impacts include effects from GHG emissions and particulates from transport of crew and supplies and from construction and operational activities at Redstone Arsenal Site 12. Cumulative health impacts to workers and the public from these GHG and particulate emissions would include state and national contributors. State and federal air permitting coupled with BMPs would help mitigate contributions from the proposed SMR Project along with current and future projects; thus helping minimize the health impacts from these emissions.

Operational discharge of nonhazardous wastewater from the closed cooling cycle into the Wheeler Reservoir will include biocides and corrosion inhibitors. Because discharge will be in compliance with the Site's NPDES permit and because project discharge will be less than 1 percent of the lowest reservoir flow rate at Redstone Arsenal Site 12, impact of the discharge on the water is SMALL and thus the health impact is SMALL. Contributions to nonradiological cumulative health impacts would also be SMALL.

In addition, projected climate change for the region contributes to the potential nonradiological health of the populace in the geographic area of interest. Models for northern Alabama often forecast warmer, wetter weather patterns with greater incidence of severe storm events. These severe storms tend to increase water pollution from runoff, including increased fertilizers, herbicides, and pesticides along with increased sedimentation impairing the water quality and contributing to adverse health effects (Reference 9.3-108). Additionally, less regular precipitation events coupled with increased evaporation and transpiration from increased air and water temperatures, may also lead to reduced availability of timely water resources and a need for crop irrigation; thus reducing the local availability of fresh water and food. Further, global changes in climate are expected to result in decreasing availability of food and water and thus negatively impact human health through increased competition for more limited resources (Reference 9.3-108).

Conclusion: Based on the analysis of cumulative human health impacts in the geographic area of interest from past, present, and reasonably foreseeable future actions, the incremental nonradiological health impact of the proposed project at Redstone Arsenal Site 12 would be SMALL. The cumulative impact of preconstruction and construction activities associated with the SMR Project is not expected to destabilize the health of the geographic area of interest. Therefore, the cumulative impact would be SMALL.

9.3.5.3.5 Environmental Justice Impacts

EO 12898 (59 FR 7629) directs federal executive agencies to consider environmental justice under NEPA. This EO ensures that minority and/or low-income populations do not bear a disproportionate share of adverse health or environmental consequences of a proposed project. TVA's policy is to consider environmental justice in its environmental reviews. (Reference 9.3-13)

The geographic area of interest for environmental justice impacts is the 50-mi radius around Redstone Arsenal Site 12. Subsection 9.3.5.2.6 provides baseline information on minority and low-income populations within the 50-mi region and evaluates the potential environmental justice impacts from construction and operation of the SMR Project at Redstone Arsenal Site 12. As described in Subsection 9.3.5.2.6, the potential for disproportional impacts to low-income and minority populations from construction and operations activities is SMALL.

The cumulative analysis considers impacts from construction and operation of the SMR Project at Redstone Arsenal Site 12 along with impacts from past, present, and reasonably foreseeable actions that could cause disproportionately high and adverse impacts on minority and low-income populations. The evaluation of potential health and environmental impacts on minority or low-income communities includes consideration of the cumulative impacts identified for the physical and socioeconomic resources discussed within Subsection 9.3.5.3.

Conclusion: Based on the evaluation of cumulative land use impacts, water-related impacts, and ecological and human health impacts in the geographic area of interest from past, present,

and reasonably foreseeable future actions, incremental physical impacts on the surrounding public from the SMR Project at Redstone Arsenal Site 12 would be SMALL. The evaluation of cumulative impacts for socioeconomic resources indicated that, although cumulative impacts would be MODERATE for noise, traffic, population and housing, and economy and tax revenues, the incremental contribution from the SMR Project on these socioeconomic resources would be SMALL. Given the SMALL incremental impacts overall, the potential for disproportionate impacts to minority and low-income populations would be SMALL.

9.3.5.3.6 Cumulative Impacts to Historic and Cultural Resources

As discussed in Subsection 9.3.5.2.7, approximately 1000 archaeological sites have been identified at Redstone Arsenal and approximately 418 of these sites are potentially eligible for listing on the NRHP. In addition, four NRHP sites are present within the Redstone Arsenal boundary.

The geographic area of interest for historic and cultural impacts is the 38,000-ac U.S. Army garrison and up to a 0.5-mi radius around Redstone Arsenal Site 12, should that distance exceed the Garrison boundary. Cumulative impacts to historic and cultural resources from past and present activities have occurred at Redstone Arsenal, and are MODERATE. The impacts from past activities resulted in the destruction, removal, and/or disturbance, of historic and cultural resources. Cultural resources are nonrenewable and therefore impacts are cumulative in nature. The preconstruction and construction activities associated with the SMR Project could contribute additional cumulative impacts to some cultural resources within the APE.

Conclusion: Based on the analysis of past and present activities in the area and the proposed project actions, it is expected that cumulative impacts to cultural resources from construction and operation of the SMR Project at Redstone Arsenal could be SMALL to MODERATE.

9.3.5.3.7 Postulated Accidents

The geographic area of interest for postulated accidents is the same as the project's geographic area of interest - a 50-mi radius. This takes into consideration existing and proposed nuclear power plants that have the potential for increasing the probability-weighted consequence (i.e., risks) from a severe accident at any location with 50 mi of the alternative site. There are currently two nuclear power plants operating in Alabama - Browns Ferry, (Limestone County) and Joseph M. Farley (Houston County), the latter of which is well outside of the 50-mi radius, in southern Alabama. The license for the three reactors at Browns Ferry was renewed in 2007. The license for Joseph M. Farley was renewed in 2005. (Reference 9.3-122) As these licenses were renewed relatively recently, it is presumed that the currently operating plants would continue to operate during the construction and operation of the SMR Project. The Browns Ferry facility is located approximately 23 mi northwest of Redstone Arsenal Site 12. Additionally, TVA is considering completing two permitted reactors and has applied for a combined license to

operate an additional two reactors at the Bellefonte site in northern Alabama[1] (Reference 9.3-122) The Bellefonte site is approximately 45 mi northeast of Redstone Arsenal Site 12. The Browns Ferry and Bellefonte sites are located within the project's geographic area of interest, a 50-mi radius. If these reactors were operated during the lifetime of SMRs at the Redstone Arsenal, the probability-weighted consequences from a severe accident would increase.

As provided in Section 7.1, the environmental consequences of Design Basis Accidents (DBAs) at the CRN SMR Project site have been determined to be SMALL. The same SMR design and vendor would be selected regardless of the site; therefore consequences of DBAs at Redstone Arsenal Site 12 would also be SMALL. Safety evaluations at the Browns Ferry were addressed in the re-licensing process, and safety inspections occur at plants (Reference 9.3-123). In the event that the Bellefonte reactors are completed and taken online, they would also be required to submit safety evaluations to the NRC and be subject to NRC inspections, thereby demonstrating operation within the NRC's safety goals.

Conclusion: The severe accident risk from any nuclear power plant decreases with distance from the plant. However, the combined risk at any location within 50 mi of Redstone Arsenal Site 12 would be bounded by the sum of the risks of the operating plants that have overlapping geographic areas of interest. As consequences of DBAs and severe accidents for the SMR Project at Redstone Arsenal Site 12 and the other nuclear power plants in the geographic area of interest are all considered small, cumulative impacts to the risk of severe environmental accidents are also considered SMALL.

9.3.5.3.8 Fuel Cycle/Transport/Decommissioning

As discussed in Section 5.7, most of the impacts related to the uranium fuel cycle are offsite well beyond a 50-mi geographic area of interest. These offsite activities such as uranium mining and milling, conversion to uranium hexafluoride, enrichment of uranium-235, fabrication of reactor fuel, reprocessing of irradiated fuel, transportation and management of radioactive wastes, and disposal of the spent fuel would not be highly dependent on the location of the actual nuclear plant. Therefore, impacts at Redstone Arsenal Site 12 are expected to be similar to those at the CRN Site. However, impacts from transportation of radioactive materials and waste are based on the likelihood of an accident, which is dependent on traffic density and region-specific. However, due to the high level of regulation and safety precautions, these impacts would be SMALL.

Reasonably, the most likely cumulative impact due to fuel cycle operations and decommissioning would be related to the transportation of radioactive materials to and from Redstone Arsenal Site 12. Traffic conditions in the Huntsville, Alabama area could be riskier due to the large number of projects (higher traffic density) occurring in the area. Therefore, based on traffic volume within the geographic area of interest, incidents involving the transportation of

[1] Subsequent to completion of the Siting Study, TVA initiated a public process to evaluate the options for Bellefonte Units 1 and 2. In addition, the combined license application for Bellefonte Units 3 and 4 was withdrawn. These changes do not affect the conclusions of Redstone Arsenal Site 12 as an Alternative Site.

radioactive materials would be more likely for shipments associated with Redstone Arsenal Site 12 than the CRN Site.

Conclusion: Overall, cumulative impacts from increases in uranium fuel cycle operations and transportation would be considered SMALL.

9.3.6 Conclusions

The CRN Site was chosen as the preferred Candidate Site for the following reasons:

- Alternative Sites are not environmentally preferable to the proposed Candidate Site. Construction and operation of two or more SMRs at each of the Alternative Sites would result in environmental impacts that are equal to or greater than those at the CRN Site.
- The CRN Site is currently managed by TVA and is designated in TVA's land plan for TVA Project Operations, which includes power production. The site was previously considered a suitable location for the Clinch River Breeder Reactor Project (CRBRP).
- The CRN Site is significantly larger than the Alternative Sites, allowing for greater flexibility in the placement of two or SMRs and ancillary facilities in order to avoid or minimize environmental impacts, particularly impacts to natural areas and terrestrial ecology.
- A large portion of the CRN Site was cleared and grubbed for CRBRP activities and some infrastructure installed for the CRBRP remains. Although the Alternative Sites are part of federal installations and may contain limited infrastructure and structures, all three are greenfield sites requiring significant clearing.

The Alternative Site analysis compared the proposed CRN Site with other Candidate Sites to determine if there was any obviously superior site amongst them. The comparison included economics, technology, and institutional factors. The results of the comparison yielded no obviously superior site; therefore no further analysis is necessary, and the CRN Site remains TVA's preferred site. Tables 9.3-2 and 9.3-6 provide a summary of the impact evaluations for each of the Candidate Sites.

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Table 9.3-1
Sales Volumes of TVA Federal Direct-Served Customers FY2014

Federal Direct-Served Customer	Sales Volume (kilowatt hours)
Oak Ridge Reservation	805,309,953
Redstone Arsenal	432,047,135
Arnold Air Force Base	334,868,928
Fort Campbell	294,365,870
Naval Support Activity Mid-South	49,568,201
Columbus Air Force Base	30,374,174

Table 9.3-2
Summary of Impact Evaluations for Environmental and Socioeconomic Criteria

	CRN (ORR 3)	ORR 2	ORR 8	Redstone 12
Land Use	SMALL	SMALL	SMALL to MODERATE	MODERATE
Water Use	SMALL	SMALL	SMALL	SMALL
Terrestrial Ecology	SMALL	MODERATE	MODERATE	SMALL
Aquatic Ecology	SMALL	SMALL	SMALL	SMALL
Socioeconomics				
Air Quality	SMALL	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL	SMALL
Population and Housing	SMALL	SMALL	SMALL	SMALL
Transportation	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to LARGE
Visual Intrusion	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Environmental Justice	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Waste Management	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL

Table 9.3-3
Land Area (Acreage) to be Affected by Development of the Candidate Sites

	CRN (ORR 3)	ORR 2	ORR 8	Redstone 12
Standardized Plant area[1]	120	120	120	120
Transmission and pipeline corridors	0.4	7.2	8.4	74
Total	120	127	128	194

[1] For comparison purposes, 120 ac was used as the minimum size for the reactor block and ancillary support facilities, as specified in Section 9.3.5.2

Table 9.3-4 (Sheet 1 of 2)
Minority and Low-Income Populations within Redstone Arsenal Site 12 50-Mile Radius[1]

STATE/ County	Total Number of Block Groups	Black	American Indian or Native Alaskan	Asian	Native Hawaiian or Other Pacific Islander	Some Other Race	Multiracial[2]	Aggregate[3]	Hispanic	Low-Income[4]
		Minority or Low-Income Block Groups								
ALABAMA										
Blount	30	0	0	0	0	0	0	0	0	0
Colbert	9	0	0	0	0	0	0	0	0	0
Cullman	62	0	0	0	0	0	0	0	0	1
DeKalb	22	0	0	0	0	2	0	1	0	0
Etowah	11	0	0	0	0	0	0	0	0	0
Franklin	4	0	0	0	0	1	0	0	0	0
Jackson	33	1	0	0	0	0	0	1	0	0
Lauderdale	19	0	0	0	0	0	0	0	0	0
Lawrence	31	4	0	0	0	0	0	3	0	0
Limestone	43	1	0	0	0	0	0	1	0	0
Madison	191	43	0	0	0	3	0	54	0	5
Marshall	65	0	0	0	0	5	0	1	0	2
Morgan	75	4	0	0	0	3	0	10	0	2
Walker	2	0	0	0	0	0	0	0	0	0
Winston	11	0	0	0	0	0	0	0	0	0

Table 9.3-4 (Sheet 2 of 2)

Minority and Low-Income Populations within Redstone Arsenal Site 12 50-mi Radius[1]

STATE/ County	Total Number of Block Groups	Black	American Indian or Native Alaskan	Asian	Native Hawaiian or Other Pacific Islander	Some Other Race	Multiracial[2]	Aggregate[3]	Hispanic	Low-Income[4]
		Minority or Low-Income Block Groups								
TENNESSEE										
Franklin	10	0	0	0	0	0	0	0	0	0
Giles	18	1	0	0	0	0	0	1	0	1
Lawrence	8	0	0	0	0	0	0	0	0	0
Lincoln	24	2	0	0	0	0	0	2	0	2
Marshall	3	0	0	0	0	0	0	0	0	0
Moore	3	0	0	0	0	0	0	0	0	0
50-mi Region Total	**674**	**56**	**0**	**0**	**0**	**14**	**0**	**74**	**0**	**13**
	State Population	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
ALABAMA	4,779,736	26.2%	0.6%	1.1%	0.1%	2.0%	1.5%	33.0%	3.9%	18.6%
TENNESSEE	6,346,105	16.7%	0.3%	1.4%	0.1%	2.2%	1.7%	24.4%	4.6%	17.3%

[1] Block groups where minorities and low-income populations exceed 50 percent or exceed the state average by 20 percentage points or more.
[2] Persons who identified themselves as a member of two or more races.
[3] Everyone except persons who identified themselves as White, Not Hispanic or Latino.
[4] Based on poverty status of individuals in family households and in non-family households.

Table 9.3-5 (Sheet 1 of 3)
Summary of Past, Present and Reasonably Foreseeable Projects Considered in the Cumulative Analysis

Project Name	Summary of Project	Relative Location (from center of Redstone Arsenal Site 12)	Status
Superfund Triana Plume	Inactive non National Priorities List (NPL) site.	3.01 mi SW Zierot Road	Inactive nonNPL site.
Superfund U.S. Army / NASA Redstone Arsenal	Active NPL site. Soil, sediment, surface water, groundwater. Arsenic, mercury, polycyclic aromatic hydrocarbon, principal component analysis, and TCE.	3.32 mi NE	Active NPL site.
Superfund Triana Tennessee River	Steps have been taken to clean up contaminated soil, sediment, surface water resulting from waste handling practices from former business at the site	2.8 mi SW	Final NPL site.
Redstone Arsenal	US Army Garrison Ballistics, chemical weapons, and missile research.	3.67 mi NE	Operational since 1941.
Marshall Space Flight Center	NASA center for propulsion analysis and development.	3.07 mi NE	Operational since 1960.
Guntersville Dam	Hydroelectric generation on Tennessee River. Impounds Wheeler Reservoir (67,900 ac).	23.0 mi SE (near New Hope, Marshall County)	Operational since 1939. 140,400 kilowatt (kW) generating capacity.
Wheeler Dam	Hydroelectric generation on Tennessee River. Impounds Wheeler Reservoir (67,070 ac).	40.1 mi NW	Operational since 1936. 411,800 kW generating capacity.
Bellefonte Nuclear Power Plant	Units 1 and 2 permitted reactors; partially complete. Units 3 and 4 (AP1000) 2007 combined license application.	45.1 mi NE (Jackson County)	Built 1980. Withdrawn.
Brown's Ferry Nuclear Power Plant	Units 1, 2, and 3 (boiling water reactors).	23.6 mi NW (Limestone County)	Operational since 1974. License renewed 2006.
Sequoyah Nuclear Power Plant	Units 1 and 2 (pressurized water reactors).	100.0 mi NE (Soddy-Daisy, TN)	Operational since 1980. License renewed 2015.
Watts Bar Nuclear Reactor	Unit 1 operational (pressurized water reactor). Unit 2 construction completion date: 09/30/2016.	131.0 mi NE (Spring City, Tennessee)	Operational since 1996.
Joseph M. Farley Nuclear Power Plant	Two unit pressurized water reactors.	251.0 mi SE Columbia, Alabama	Operational since 1974. License renewed 2005.
Redstone Gateway	468 acre mixed use and office park.	5.69 mi NE Intersection of I-565 and Highway 255	Under development.
City of Huntsville	Urbanization plans incorporate projected growth of 68,000 homes by 2040 from Redstone activities.	10.0 mi NE	Current.

Table 9.3-5 (Sheet 2 of 3)
Summary of Past, Present and Reasonably Foreseeable Projects Considered in the Cumulative Analysis

Project Name	Summary of Project	Relative Location (from center of Redstone Arsenal Site 12)	Status
City of Madison	12 percent anticipated growth in technology employment over next 5 yr.	5.62 mi NW	Current.
City of Arab	Revitalization and expansion of downtown.	25.0 mi SE	Planned.
City of Hartselle	Small town.	17.8 mi SW	
City of Decatur	Highly planned, tightly zoned growth and development.	15.4 mi W	Current.
Decatur Education and Technology Business Park	Planned establishment to help cement development of Decatur Downtown Commons.	15.2 mi W	Planned development by 2019.
Decatur Railroad Depot	Restoration and enhancement.	16.0 mi W	Planned development.
Decatur Depot - Renovation	Expansion of jail.	16.0 mi W	Current.
Decatur - Alabama Center for the Arts	Phase 2 construction.	16.0 mi W	Current.
City of Athens	Highly detailed development plan emphasizing infill and redevelopment of exiting areas.	19.3 mi NW	Current.
Wheeler Reservoir / Tennessee River System	Much of water supply for City of Huntsville and Madison County.	30.3 mi NW	45 mgd to customers.
Various surface water treatment facilities	Facilities located within 6 county area.	Within 60.0 mi	Current.
Huntsville – South Parkway Treatment Plant	Tennessee River plant for Huntsville Utilities.	9.01 mi SE Whitesburg Bridge	Operational since 1964 35 mgd.
Huntsville – Southwest Treatment Plant	Huntsville Utilities.	4.67 mi SW (Triana Highway)	Operational since 1988. 35 mgd.
North Limestone Treatment Facility	Surface water pumped from Elk River.	29.7 mi NW (5 mi north of Elkmont)	2788 mgd (2724 mgd flow through).
Decatur Utilities	Surface water pumped from Wheeler Reservoir.	15.8 mi SW	119 mgd.
Arab Water Works	Surface water pumped from Brown's Creek Embayment, Lake Guntersville, Marshall County.	25.0 mi SE	1065 mgd (1044 mgd flow through).
Huntsville - Southeast Water Treatment Plant	Tennessee River plant under construction for Huntsville Utilities.	21.3 mi SE (East of New Hope, Marshall County)	Construction initiated 2015. Operational by 2018. 96 mgd peak.
Fort Payne-Tuscumbia groundwater aquifer	Local groundwater source. The aquifer is rather large, including areas north of the Tennessee River from North Alabama into Middle Tennessee and including south Kentucky.	37.2 mi NW (from approximated center point of aquifer)	Supplies water for most of Morgan County.

Table 9.3-5 (Sheet 3 of 3)
Summary of Past, Present and Reasonably Foreseeable Projects Considered in the Cumulative Analysis

Project Name	Summary of Project	Relative Location (from center of Redstone Arsenal Site 12)	Status
Lincoln and Dallas Well Treatment Plant	Huntsville Utilities.	11.3 mi NE	Operational since 1992.
Hampton Cove Well Treatment Plant	Huntsville Utilities.	13.7 mi E	Operational since 1996.
Williams Well	Huntsville Utilities.	1.19 mi NW	Operational since 1971.
Wheeler Dam and hydroelectric facility	Generates electricity and impounds Wheeler Reservoir.	40.1 mi NW	Operational since 1936.
Madison County – anticipated development	Madison County anticipates between 38 and 50% will be developed by 2020.	5.62 mi NW	Current.
Limestone County – proposed connection to Decatur Water Treatment Plant	30 inch pipeline across Wheeler Reservoir supplying water to Limestone County.	29.8 mi NW	Seeking FONSI status to allow construction.
Polaris Facility	450 acre production facility for all terrain vehicles.	7.74 mi NW Off I-565 Greenbrier Road (Huntsville, Lincoln County)	Under construction. Estimated completion: Spring 2016.
Connector I-565 and I-65 – Greenbrier Parkway	Limited access road from Athens to Greenbrier. (8.3 mi) Eventual connection to Huntsville-Browns ferry Road south of Athens.	8.80 mi NW	Estimated completion: 2016.
Madison - 1500 ac Industrial Megasite	Sewell Farm. Pre-certified as TVA Megasite for industrial development.	8.83 mi NW (North of Old Highway 20 intersection with Greenbrier Road in Lincoln County)	Pre-certified for large-scale manufacturing. Seeking TVA Megasite certification in 2015.
Huntsville International Airport (HSV)	Commercial international airport.	3.75 mi NW	Established 1967.
Huntsville – Jetplex Industrial Park and Jetplex South Park	1470 ac adjacent to HSV (Jetplex Supplier Park).	2.85 mi NW	1400 ac available for development.
Huntsville – Cummings Research Park	3843 ac. Second largest research and development park in the United States with industrial and educational use. More than 300 companies, 30,000 employees, and 11,000 students.	6.53 mi NE	Established 1962. Continued development.

Notes:
NE - Northeast NW – Northwest SE – Southeast SW – Southwest W – West

Table 9.3-6
Summary of Potential Incremental Cumulative Impacts of Construction and Operation to Environmental and Socioeconomic Criteria by Site

	CRN (ORR Sites 3, 2, and 8)		Redstone 12	
	Construction	**Operation**	**Construction**	**Operation**
Land Use	SMALL	SMALL	SMALL	SMALL
Water Use	SMALL	SMALL	SMALL	SMALL
Terrestrial Ecology	SMALL	SMALL	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL	SMALL	SMALL
Socioeconomics				
Air Quality	SMALL	SMALL	SMALL	SMALL
Noise	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL
Population and Housing	SMALL	SMALL	SMALL	SMALL
Economy and Tax Revenues	SMALL[1]	SMALL[1]	SMALL[1]	SMALL[1]
Transportation	MODERATE	SMALL	SMALL	SMALL
Visual Intrusion	Not Evaluated	SMALL to MODERATE	Not Evaluated	SMALL to MODERATE
Infrastructure	SMALL to MODERATE	SMALL	SMALL	SMALL
Education	SMALL	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL	SMALL
Environmental Justice	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL to MODERATE
Postulated Accidents	SMALL	SMALL	SMALL	SMALL
Fuel Cycle/Transport/ Decommissioning	SMALL	SMALL	SMALL	SMALL

[1] Denotes a beneficial impact

9.4 ALTERNATIVE PLANT SYSTEMS

This section discusses alternative plant systems for the proposed Clinch River (CR) Small Modular Reactor (SMR) Project. This information is provided to enable a comparison of the environmental impacts of the proposed system to that of the select alternatives. Because a final reactor selection has not been made, a Plant Parameter Envelope (PPE) approach to defining the various plant systems has been utilized. The proposed heat dissipation and circulating water systems for the new facility were initially presented in Chapter 3. Subsection 9.4.1 presents alternatives to the facility heat dissipation system, and Subsection 9.4.2 presents alternatives to the circulating water system.

9.4.1 Heat Dissipation Systems

There are multiple heat dissipation system alternatives, each having varying energy transfer mechanisms and, therefore, varying potential environmental impacts. The following subsections describe the proposed heat dissipation system and evaluate comparable alternatives based on guidance provided in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan*.

9.4.1.1 Proposed Heat Dissipation System

The purpose of a heat dissipation system is to dissipate heat energy to the environment. To meet cooling requirements of the proposed SMR units at the Clinch River Nuclear (CRN) Site and at the same time to provide environmental protection for the waters of Clinch River arm of the Watts Bar Reservoir, a closed system consisting of a mechanical draft cooling tower was selected as the preferred primary method of heat dissipation.

In this closed loop tower system, the main circulating water pumps circulate water through the condenser and to the towers where the heat is transferred to the air. Air flow through the cooling tower is conducted by large fans. Water returning from the towers flows back to the circulating water pumps via gravity. For the proposed heat dissipation system, makeup water is the only intake from and blowdown is the only discharge to the Clinch River arm of the Watts Bar Reservoir. Expected atmospheric effects from the operation of a mechanical draft cooling tower would include fogging and/or icing.

9.4.1.2 Screening of Alternatives to the Proposed Heat Dissipation System

The various heat dissipation system alternatives can be classified as one of two types of systems: once-through cooling system or closed-cycle cooling system. Based on the guidance provided in NUREG-1555, the following classes of heat dissipation systems were considered:

- Once-through systems
- Closed-cycle systems
  - Natural draft cooling towers

- Wet natural draft cooling towers
- Dry cooling towers
- Wet-dry cooling towers (hybrid towers)
- Cooling ponds
- Spray ponds

Once-through cooling systems involve the use of a large quantity of water which is withdrawn from a nearby water body, circulated through the condenser in order to absorb heat, and then discharged back into the initial water body. The water requirements for a once-through system are approximately 25,000 to 60,000 gallons of water per megawatt-hour (MWH) of electricity produced (Reference 9.4-1).

Closed-cycle cooling systems utilize comparatively much less water because the water performing the cooling is recirculated through the main condenser and the only additional water required is makeup water to account for expected system losses such as evaporation, blowdown, and/or drift. Examples of closed-cycle cooling systems include cooling towers (wet, dry, and wet-dry hybrid), cooling ponds, and spray ponds.

In the following subsections, these alternative systems are evaluated for use in the CR SMR Project. Because some of these alternatives were not feasible and/or environmentally desirable, detailed costs, operation and maintenance comparisons are not provided.

9.4.1.2.1 Once-Through Cooling Systems

In a once-through cooling system, water would be withdrawn at the intake pumping station from the Clinch River arm of the Watts Bar Reservoir and circulated through the condenser. The heated water would be discharged back into the Clinch River arm of the Watts Bar Reservoir. Even though once-through systems have characteristic advantages such as utilizing less land and minimal visual impacts, U.S. Environmental Protection Agency (EPA) regulations (Title 40 of the Code of Federal Regulations [40 CFR] 125) governing cooling water intake structures under Section 316(b) of the Clean Water Act (CWA) effectively prohibit newly constructed steam electric generating plants from using once-through cooling systems. Based on this regulation, once-through cooling was eliminated from further consideration.

9.4.1.2.2 Closed-Cycle Cooling Systems

The following subsections describe the alternative closed-cycle cooling systems considered in this ER.

Natural Draft Cooling Towers

Natural draft towers are essentially large chimneys designed to move air up through the structure by convection without the use of fans. A natural draft cooling tower can be

approximately 500 feet (ft) tall and usually has a hyperbolic shape. As hot water is pumped into a natural draft cooling tower, it is distributed through packing or fill material inside the tower. The fill material provides an interface for evaporation of the water and heating of the air to take place. As the water is being distributed, the exposed, lower portion of the tower allows ambient air to pass over the cold water basin at the bottom of the tower. This passing of ambient air over the cold water basin at the bottom of the tower and evaporation/air heating taking place at the top of the tower the creates a temperature and density differential which results in a natural draft as less dense warmer air rises to the top. As this differential is being produced, the hyperbolic shape of cooling the tower itself facilitates the upward flow of air.

Wet Natural Draft Cooling Towers

Wet natural draft cooling towers have very high construction costs but low operating cost, auxiliary power requirements, and noise impact because there is no mechanical equipment needed to move the air. Therefore, they can be very practical and cost-effective for locations with access to very large water volumes where consistent cooling is required over an extended time period. Potential environmental impacts resulting from the operation of natural draft cooling towers include cloud development and plume shadowing. Ground level fogging and icing are generally not a problem with larger natural draft cooling towers.

Because the Clinch River arm of the Watts Bar Reservoir provides an adequate water source, a wet natural draft cooling tower could be appropriate for consideration at the CRN Site. However, natural draft cooling towers require tall stacks to generate the airflow necessary for cooling. According to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Rev. 1*, natural draft towers are typically higher than 500 ft tall and mechanical draft towers are typically 100 ft tall. Due to the increased visual impact and the comparatively high construction cost, a natural draft tower is not preferable to a mechanical draft cooling tower.

Dry Cooling Towers

Dry cooling towers utilize conduction and/or convection to dissipate heat to the atmosphere. The condenser coolant is enclosed within a piping network that has no direct air-to-water interface. The heat transfer process is based on the thermal transport properties of the piping material and the dry bulb temperature of the air. Either natural or mechanical draft techniques can be used to move the air. Because there are no evaporative or drift losses in this type of system, water loss for dry cooling towers is typically lower than for wet cooling towers, but some makeup water is required. Also many of the problems associated with wet cooling systems, such as blowdown disposal, water availability, fogging and/or icing, are not applicable. Dry towers do have inherent technical obstacles, such as high turbine backpressure and possible freezing in cooling coils during periods of light load and startup.

In 2001, the EPA determined that dry cooling was not the best available technology for minimizing adverse environmental impacts. This was based on high capital, operating, and

maintenance costs for dry cooling, and the detrimental effects of dry cooling causes on electricity production caused by the reduction of the energy efficiency of steam turbines. EPA did recognize that dry cooling may be an appropriate technology for some facilities (such as those with limited cooling water availability or sensitive biological resources), and therefore did not restrict the use of dry cooling technology. (Reference 9.4-2) Because the CRN Site has adequate water, dry cooling towers are not preferable to mechanical draft towers for this plant.

Wet / Dry Cooling Towers (Hybrid Towers)

A wet/dry cooling tower, also referred to as a hybrid cooling tower, is composed of a wet section and a dry section. Hybrid cooling towers combine the high efficiency of the wet cooling tower with the reduced visible plume of the dry cooling tower. The hybrid tower generally functions as a wet cooling tower, but when the ambient temperature is low, the cooling tower may be operated as a dry cooling tower without water consumption or plume production. A dry section installed in the upper part of the tower heats wet air coming from the lower wet zone, thereby reducing or eliminating the visible water vapor plumes typically associated with wet cooling towers.

In a hybrid cooling tower, fans are located in the wet section as well as the dry section of the tower, and the hyperbolic shell produces a natural draft effect that reduces power consumption. Power consumption is also reduced by the application of two-speed motors (Reference 9.4-3). This design has the highest associated capital costs. Water consumption for a hybrid tower is based on the water use of the wet section and, in general, the water usage of a hybrid tower is one-third to one-half of that for a wet cooling tower. The cost increase for the hybrid systems versus the wet cooling systems does not overcome water use savings (Reference 9.4-4).

The advantages of the hybrid system are that it conserves water where water is limited and/or expensive, provides for plume abatement, and results in reduced evaporation, blowdown, and makeup water. However, the dry cooling portion of the hybrid tower is not as efficient as the wet cooling process because it requires the movement of a large amount of air through the heat exchangers to achieve the necessary cooling. This results in less net electrical power for distribution. Because water availability is not a primary issue at the CRN Site a hybrid cooling tower is not a preferred heat dissipation technique for use at the CRN Site.

Cooling Ponds

A cooling pond is a shallow reservoir with a large surface area used for removing heat from process water. Cooling ponds can be used to reduce the heat load to natural bodies of water from power plant discharge without the construction and operation costs associated with cooling towers. The natural body of water is not relied on for heat dissipation but is used as a source of makeup water to replace water lost to evaporation and as a receiving stream for blowdown from the cooling pond.

A cooling pond is typically used at locations where land is relatively inexpensive, cooling water is scarce or expensive, and/or where there are strict thermal loading restrictions. Impacts resulting from the discharge of heated water into a cooling pond include thermal impacts such as altered stratification and atmospheric impacts such as steam fogging and/or icing. Once cooled, water in the cooling pond can be reused, thereby reducing the overall quantity of water utilized.

Based on the anticipated production of 800 megawatts electrical (MWe) at the CRN Site (Table 3.1-2, item 16.6) and the general rule of thumb of 1.5 acres (ac) of cooling pond surface area per MWe of nuclear production, a cooling pond for the CR SMR Project would require approximately 1200 ac (Reference 9.4-5). Because the area of the CRN Site is only 935 ac, the use of a cooling pond as an independent technology is not feasible.

The facility design includes a small-scale holding pond located on the western side of the CRN Site as described in Subsection 3.4.2.2. While discharge flow mixing in the holding pond does reduce water temperature and moderate flow rates in the discharge, the pond is not intended to serve as a primary means of heat dissipation.

Spray Ponds

The spray pond cooling technology utilizes a series of spray nozzles located in a relatively long and narrow pond. Water from the condenser is sprayed into the air, where it is cooled by evaporation, and then allowed to fall into the pond where it is drawn into the intake structure to be pumped back to the condenser. Water lost in spray ponds through the evaporation process requires makeup from a nearby source. Spray ponds require considerably less land use to dissipate the same amount of heat versus conventional cooling ponds. In general, land use as a function of plant output at power plants utilizing spray ponds is approximately 1 ac per 15 MWe generated; therefore, approximately 53 ac would be required at the CRN Site for a spray pond (Reference 9.4-6).

The evaporative heat transfer associated with spray ponds is less efficient than that for a mechanical or natural draft cooling tower. The comparatively lower airflow associated with a spray pond results in an increase in the amount of land area required for the spray pond to dissipate the same amount of heat when compared to a wet cooling tower. This increased land use compared to a cooling tower results in increased negative effects to terrestrial and aquatic ecosystems. Therefore, a spray pond heat dissipation system is not preferable to the proposed mechanical draft cooling tower for the CRN Site. The use of a smaller scale spray cooling system as a mechanism for moderating temperatures in blowdown from cooling towers is included in the discharge alternatives presented in Subsection 9.4.2.2.2.

9.4.2 Circulating Water Systems

This subsection presents a discussion of alternatives to the following components of the Circulating Water System (CWS): intake systems, discharge systems, water supply and water

treatment processes. This review only considers those alternatives that are applicable to the CRN Site, and are compatible with the proposed heat dissipation system discussed in Section 3.4 and Subsection 9.4.1.

9.4.2.1 Proposed Circulating Water System

This subsection summarizes the components of the CWS proposed for the facility.

9.4.2.1.1 Intake System

The proposed water intake is described in Subsection 3.4.2.1. The approximate location of the intake is shown in Figure 3.4-1. The proposed intake structure is located on the eastern side of the CRN Site, at approximately Clinch River Mile (CRM) 17.9. Figure 3.4-2 shows the general configuration of the intake structure with respect to the shoreline, and Figure 3.4-3 provides a more detailed conceptual depiction of the intake channels, trash racks, flow baffles, and pumps. A cross-sectional view of the intake is shown in Figure 3.4-4.

The intake structure is designed to meet the bounding makeup water requirements of the heat dissipation system by drawing water directly from the Clinch River arm of the Watts Bar Reservoir. As shown on Figure 3.4-2, the intake structure is constructed on the shoreline with the front face located at the existing river bank. This is a common intake to all power units that accommodates pumps, trash racks, and appropriate water screen technology. The design of the intake structure will comply with the CWA 316(b) regulations. The maximum water velocity at the intake, trash flow rack and water screens will be less than 0.5 ft per second, as required by the CWA, Section 316(b) Phase I requirements specified in 40 CFR 125.84.

9.4.2.1.2 Discharge

The proposed discharge is described in Subsection 3.4.2.3. A detailed, conceptual layout of the discharge is shown in Figure 3.4-5. The blowdown from the CWS is transported from the mechanical draft cooling tower to the discharge through a pipeline. The blowdown passes through an instrumentation vault for measurement of flow and temperature, and then continues through the approach conduits to two diffuser conduits.

As shown on Figure 3.3-1, between the mechanical draft cooling tower and the discharge, the blowdown passes through a holding pond, where it mixes before it continues through another pipeline to the discharge. Although discharge flow mixing in the holding pond acts to reduce water temperature and moderate flow rates in the blowdown; the use of the holding pond is not intended for purposes of heat removal from the facility discharge or for management of discharge flow rates in the hydrothermal analysis.

To maintain acceptable thermal limits for the discharge, a bypass provides a continuous flow of approximately 400 cubic ft per second (cfs) within the Clinch River arm of the Watts Bar Reservoir at Melton Hill Dam.

The facility's discharges will be regulated by the Tennessee Department of Environment and Conservation (TDEC) through a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit will include discharge limits established to protect receiving waters, and monitoring to ensure compliance with those limits. Temperatures and chemical concentrations for all discharges will be in compliance with the terms and conditions of the NPDES permit.

9.4.2.1.3 Water Supply

The proposed water supply for operation of the CWS is described in Subsections 3.3.1 and 3.4.1.4. The proposed water source is the Clinch River arm of the Watts Bar Reservoir.

A water-use diagram for the conceptual facility is provided in Figure 3.3-1. The diagram shows the average and maximum flow rates for the intake from and discharge to the reservoir, the rates for consumptive uses, and the relationships between the various water flow systems. The intake withdraws an average of approximately 18,400 gallons per minute (gpm), and a maximum of approximately 30,700 gpm. The mechanical draft cooling tower consumes some of this water through evaporation and drift. The average and maximum drift rate is 8 gpm, and the expected and maximum evaporation rate is 12,800 gpm.

9.4.2.1.4 Water Treatment

The proposed treatment of the water supply for operation of the CWS is described in Subsection 3.3.2. Biocides and other chemicals are used to treat cooling and process water. Specific anti-fouling methods are to be defined in the combined license application (COLA), after an SMR design has been selected. The quantities and concentrations of chemicals to be used are to be in accordance with a Biocide/Corrosion Treatment Plan (B/CTP), submitted as part of the NPDES permit application to the TDEC.

9.4.2.2 Alternatives to the Proposed Circulating Water System

The purpose of this subsection is to identify and analyze reasonable alternatives to the proposed CWS. The analysis of each alternative system considers various factors during construction and operation, for comparison with those of the proposed system. These factors are covered in separate sections: intake system, discharge system, water supply, and water treatment system.

9.4.2.2.1 Intake System

There are no viable alternatives for the general location of the proposed intake structure. To avoid intake of heated water from the discharge, the structure is located on the upstream portion of the CRN Site, and the discharge is located on the downstream portion. The specific location is to be determined following final facility design based on navigational needs, protection of the intake structure and other design considerations, as well as economic considerations associated with ease of access.

As shown in Figure 3.4-2, the proposed intake structure is located directly on the shoreline, at surface water level. Any potential alternative configurations, such as intake from a pipe extending out into the reservoir, or intake from a canal dug into the bank, would result in increased costs for the additional infrastructure, as well as increased environmental impacts associated with excavation. Therefore, alternative conceptual configurations of the intake structure were not considered.

9.4.2.2.2 Discharge

Potential alternatives for managing the SMR blowdown were developed, and cursory analyses of the alternatives were performed in sufficient detail to recommend a preferred alternative for the discharge. The analyses included: (1) developing order-of-magnitude estimates for the capital cost of the alternatives, (2) summarizing any impacts that the alternatives may have on hydroelectric power production at Melton Hill Dam (as well as any other notable operating and maintenance (O&M) impacts), and (3) examining the hydrothermal performance of the alternatives in terms of the likelihood of satisfying the regulatory guidance for the mixing zone and regulatory requirements for instream water temperature. The alternatives developed for the discharge are summarized in Table 9.4.2-1.

Alternative 0, the base case, included routing the blowdown directly to the reservoir without any changes in the existing release characteristics at Melton Hill Dam. Other than specific design details related to the intake and discharge structures, this alternative was basically the same as the proposed blowdown system for the former Clinch River Breeder Reactor Project (CRBRP). Hydrothermal analyses reported for the CRBRP suggested that in today's regulatory climate, this alternative would not likely gain acceptance because of the type of mixing zone required and the potential impacts on reservoir temperature.

For Alternative 1 and Alternative 2, a new low level outlet structure (bypass) would be added at Melton Hill Dam to provide a continuous release of 400 cfs of water. The SMR blowdown would still be routed directly to the reservoir. The bypass would ensure sufficient flow is provided at all times to dilute the plant thermal discharge, even during extreme winter conditions with SMR discharges over 30 degrees Fahrenheit (°F) warmer than the reservoir. For Alternative 1, the bypass would be equipped with a valve to control the discharge. For Alternative 2, the bypass would be equipped with a small hydroelectric generating unit to recapture some of the hydroelectric value forfeited by the Alternative 1 bypass. The proposed modification to releases from Melton Hill Dam via the bypass is within the current Tennessee Valley Authority (TVA) reservoir operation policy for minimum daily average flow of 400 cfs at this location and thus would not require a change in operating policy. In the initial analysis, the recommended amount of flow for the bypass was 200 cfs. A revised analysis was also performed which recommended a bypass of 400 cfs. Although Alternative 1 and Alternative 2 required modifications at Melton Hill Dam, these modifications operationally could be provided within the current TVA policy for managing flows in the Clinch River arm of the Watts Bar Reservoir (e.g., 200 cfs falls within the minimum daily average flow currently specified for Melton Hill Dam, which is 400 cfs). In terms

of hydrothermal impacts at the location of the SMR discharge, Alternatives 1 and 2 would be identical.

For Alternative 3, the SMR blowdown would be routed directly to the reservoir; however, the plant withdrawal from and discharge to the reservoir would be reduced by increasing the design cycles of concentration (COC) for the CWS. In this alternative, there would be no modifications at Melton Hill Dam. The COC represents the ratio of the concentration of dissolved solids in the plant discharge to the same for the plant withdrawal. The water in the reservoir below Melton Hill Dam is low in dissolved solids, so much so that it may be possible to increase the COC of the CWS loop by a factor of two. In turn, this would decrease the plant discharge by about 50 percent. A lower plant discharge would perhaps reduce the impact of the blowdown in the reservoir during long periods of idle operation at Melton Hill Dam. Alternative 3A also would include an increase in the COC by a factor of two, but in addition would contain an oriented spray cooling system (OSCS) to further cool the blowdown before discharging it to the reservoir.

For Alternatives 4 and 5, a holding pond would be provided on the CRN Site to store the blowdown during periods of idle operation at Melton Hill Dam. The blowdown in the pond would be emptied to the reservoir as a batch release during subsequent periods when Melton Hill Dam is releasing water to the reservoir. In the most extreme cases, this release would need to be accomplished in about 1.5 hours (hr). Alternative 5 differs from Alternative 4 in that it would also include an OSCS to further cool the blowdown. Alternative 5A is basically Alternative 5 without a holding pond. In this manner, Alternative 5A is the same as Alternative 0 with the addition of an OSCS to further cool the blowdown (again, without any changes in the existing release characteristics at Melton Hill Dam).

Order-of-magnitude estimates for the capital cost of the alternatives are summarized in Table 9.4.2-2. Also shown are some notable O&M impacts. The physical components needed for the various alternatives are placed in one of two categories: onsite and offsite. Onsite components include equipment located on or immediately adjacent to the CRN Site, and offsite components include equipment situated beyond the immediate area of the CRN Site. Offsite components were included only in Alternatives 1 and 2, which include modifications at Melton Hill Dam. Based solely on capital cost, and if all of the options to Alternative 0 were viable in terms of hydrothermal impacts in the reservoir, the results of Table 9.4.2-2 suggest Alternative 3 would be the best option for the SMR discharge. In fact, even if Alternative 0 was viable, the capital costs suggest that it would be better to abandon Alternative 0 in favor of Alternative 3. The cost of a small hydro unit at Melton Hill Dam causes Alternative 2 to have the highest capital cost. Alternatives 1 and 2 also have notable impacts on hydroelectric operations, creating losses in energy production and capacity at Melton Hill Dam. Other notable O&M impacts include the likely need for additional water treatment to help control the soluble mineral content of CWS flow for Alternatives 3 and 3A. Also, O&M expenses are required for operating the oriented spray cooling systems included in Alternatives 3A, 5, and 5A.

For all of the alternatives, it is anticipated that the best technology to mix the plant discharge in the reservoir would be the use of a bottom-mounted/submerged multiport diffuser. As an integral

part of the hydrothermal analyses, cursory diffuser designs were developed for each alternative included in Table 9.4.2-1. For Alternatives 4 and 5, the design would require a diffuser with a discharge capacity of 281 cfs. For this flow, the size and arrangement of the diffuser conduits could not be reasonably accommodated within the regulatory guidelines for mixing zones. Other potential challenges exist concerning impacts on navigation and recreation, and the overall sensibility/perception of flushing a large volume of water to the reservoir in a short period of time. For these reasons, these alternatives were not considered any further.

In the same manner as Alternative 0, Alternatives 3, 3A, and 5A would each include a continuous discharge of SMR blowdown directly to the reservoir in extreme events with no release from Melton Hill Dam. In these types of events, the magnitude of the temperature impacts would be influenced primarily by the temperature of the facility discharge. For extreme events in the winter, the temperature of the facility blowdown for Alternative 3 would be the same as Alternative 0, and Alternatives 3A and 5A would be nearly the same as Alternative 0. For Alternative 3 it would be the same: 31°F warmer than the ambient water temperature. For Alternatives 3A and 5A, in the winter the OSCS would reduce the discharge temperature only slightly, from 31°F to 29°F above the ambient water temperature. In this manner, the results of the Alternative 0 simulation suggest that extreme operating conditions for Alternatives 3, 3A, and 5A could potentially challenge regulatory requirements for the facility thermal discharge. There is also a concern associated with restricting plant operational flexibility with high COC in Alternatives 3 and 3A. For these reasons, Alternatives 0, 3, 3A, and 5A were not considered any further.

Because Alternatives 4 and 5 were previously excluded, only Alternatives 1 and 2 remained. For these alternatives, Fluent simulations were conducted for both extreme winter and extreme summer conditions. The simulations included unsteady events wherein for the first hour, the flow in the reservoir was provided solely by hydroelectric operation at Melton Hill Dam. For the next 46 hr, hydroelectric operation was idled and the bypass was initiated with a release of 200 cfs in the initial analysis, and 400 cfs in the revised analysis. In the final (48th) hour of the simulation, hydroelectric operation was resumed as in the first hour (without the bypass). For both cases (i.e., winter and summer), the results predict temperatures that are considered favorable for obtaining acceptance for all pertinent regulatory guidelines and requirements. That is, it is anticipated that a mixing zone of acceptable size and shape can be successfully defined, and the impact on reservoir temperature appears to fall within the limits for temperature change, temperature rate of change, and reservoir water temperature.

Provided in Table 9.4.2-3 is an assessment summary of the alternatives based on the hydrothermal analyses. Alternatives 0, 3, 3A, and 5A (those with no modifications to the dam) were expected to experience challenges with the size of the discharge mixing zone and/or the ability to satisfy regulatory requirements for water temperature, particularly for extreme events in the winter. Alternatives 4 and 5, which rely on a holding pond to store blowdown during no release events from Melton Hill Dam, were also expected to experience challenges related to the size of the mixing zone, and perhaps also adverse impacts related to navigation and recreation during flushing of the holding pond. For these reasons, none of these alternatives

were preferred. In contrast, model simulations of extreme events for Alternatives 1 and 2, which included a continuous minimum flow at Melton Hill Dam, suggested that these alternatives could likely satisfy regulatory requirements for both the size of the mixing zone and reservoir temperature without adversely impacting navigation, recreation, or other uses of the reservoir. For these reasons, from the standpoint of hydrothermal impacts, Alternatives 1 and 2 were recommended as preferred among the alternatives considered. Additional studies (e.g., studies detailing the exact features of the bypass and related costs and benefits) would be required to select one of these two alternatives as the best suited.

The discharge location evaluated in the thermal analysis of Alternatives 1 and 2 is at approximately CRM 15.5. A preliminary location at CRM 15.9 was initially evaluated, and was determined to not be favorable for dissipating waste heat in the reservoir. This was because a submerged island within the reservoir was identified at that location by the bathymetric surveys, and it was determined that this feature would encumber mixing of the plant effluent and produce a shore-hugging thermal plume. As a result, the thermal analysis identified a location further downstream, near CRM 15.5, which takes advantage of turbulence created by the submerged island to enhance mixing. It also locates the discharge further from semi-stagnant tributary embayments (such as Poplar Springs Creek), and increases the distance between the plant water intake and discharge.

9.4.2.2.3 Water Supply

CWS makeup water is to be withdrawn from the Clinch River Arm of the Watts Bar Reservoir. Reservoir water use is discussed in Section 3.3, and is summarized in Subsection 9.4.2.1.3. The sufficiency of the water supply for facility operation and the impact of water use from the reservoir are analyzed in Section 5.2.

The analysis in Section 5.2 demonstrated that the maximum expected water use from facility operations would require withdrawal of approximately 17 percent, and consumption of approximately 7 percent, of the minimum continuous flow released from Melton Hill Dam. In addition, the flow from Melton Hill Dam is a relatively small contributor to the overall amount of water available in Watts Bar Reservoir compared to the flow from Fort Loudon Dam. Inflows to Watts Bar Reservoir from the mainstream of the river are much greater than from its tributaries. Therefore, Section 5.2 concluded that the Clinch River arm of the Watts Bar Reservoir has sufficient water to supply facility operations.

Section 5.2 also summarized the results of a Regional Surface Water Use Study which analyzed current and projected future water use in the Tennessee River watershed and in the portion of the Clinch River Basin upstream of the CRN Site (Reference 9.4-7). That analysis demonstrated that the maximum expected water withdrawal from plant operations is approximately 0.4 percent of total surface water withdrawals in the Tennessee River watershed, and that maximum consumptive water use is approximately 3.9 percent of total water consumption. The analysis concluded that there is sufficient water available to supply water use projections out to 2035.

Because surface water is readily available, and can be accessed without adverse impacts to other users, no alternative sources of water supply were evaluated.

9.4.2.3 Water Treatment

Concentration of dissolved salts in makeup water resulting from evaporative water losses require the discharge of a certain percentage of the mineral-rich stream (blowdown) and its replacement with fresh water (makeup). Nuclear power plants are required to obtain an NPDES permit to discharge effluents. These permits are renewed every five years by the state's water quality permitting agency (in this case, TDEC). The periodic NPDES permit renewals provide the opportunity to require modification of power plant discharges or to alter discharge monitoring in response to water quality concerns. Effects of cooling tower discharges are considered to be of small significance when water quality criteria (e.g., NPDES permits) are met. In considering the effects of closed-cycle cooling systems on water quality, the U.S. Nuclear Regulatory Commission (NRC) evaluated the same issues that were evaluated for open-cycle systems. Based on review of literature and operational monitoring reports, consultations with utilities and regulatory agencies, and comments on the draft Generic Environmental Impact Statement for License Renewal of Nuclear Plants, discharge of cooling tower effluents has not been a problem at existing nuclear plants.

As discussed in Subsection 9.4.2.1.4, specific anti-fouling methods are to be defined at COLA, when a final SMR design is selected. The quantities and concentrations of chemicals to be used are to be in accordance with a B/CTP, submitted as part of the NPDES permit application to the TDEC. Therefore, no alternative water treatment methods have been evaluated.

9.4.3 Transmission Systems

As indicated in the Interim Staff Guidance Combined License and Early Site Permit No. 026 (COL/ESP-ISG-026), *Environmental Issues Associated with New Reactors*, issued October 2014, alternative transmission line routing is no longer evaluated because transmission lines are not NRC authorized construction.

9.4.4 References

Reference 9.4-1. Macknick, J, Newmark, R, Heath, G, and Hallett K C, "Operational water consumption and withdrawl factors for electricity generating technologies," December 20, 2012.

Reference 9.4-2. U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System: Regs Addressing Cooling Water Intake Structures, Website: http://www.gpo.gov/fdsys/pkg/FR-2001-12-18/pdf/01-28968.pdf, December 18, 2001.

Reference 9.4-3. Cooling Technologies, "Hybrid Cooling Towers - Cooling Towers without visible plume," 2013.

Reference 9.4-4. U.S. Environmental Protection Agency, "Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities," EPA-821-R-01-036, November 9, 2001.

Reference 9.4-5. Edinger, J.E. and Buchak, E. M., "Surface Heat Exchange and Hydrothermal Analysis, Transport Processes in the Oceans 7: 214, 1977.

Reference 9.4-6. Exelon Generation, "Victoria County Station Environmental Report Chapter 9," May 30, 2012.

Reference 9.4-7. Tennessee Valley Authority, "Clinch River Small Modular Reactor Site Regional Surface Water Use Study," April 10, 2014.

Table 9.4.2-1
Discharge Alternatives Evaluated to Attenuate Impact of SMR Blowdown

Alternative	Description
0	Blowdown directly to reservoir with existing release characteristics at Melton Hill Dam (base case)
1	Blowdown directly to reservoir + provide minimum continuous bypass release at Melton Hill Dam via new low level outlet conduit with control valve. Bypass release was 200 cfs in initial analysis and 400 cfs in the revised analysis.
2	Blowdown directly to reservoir + provide minimum continuous bypass release at Melton Hill Dam via new small hydro unit. Bypass release was 200 cfs in initial analysis and 400 cfs in the revised analysis.
3	Blowdown directly to reservoir + reduce blowdown 50% by doubling cooling system COC
3A	Blowdown directly to reservoir + reduce blowdown 50% by doubling cooling system COC + OSCS to further cool blowdown
4	Store blowdown to holding pond when Melton Hill Dam idle, and empty holding pond as a batch release when Melton Hill Dam operation resumes
5	Store blowdown to holding pond when Melton Hill Dam idle, and empty holding pond as a batch release when Melton Hill Dam operation resumes + OSCS to further cool blowdown
5A	Blowdown directly to reservoir (no holding pond) + OSCS to further cool blowdown

Table 9.4.2-2
Order-of-Magnitude Capital Costs and Notable O&M Impacts for Alternative Systems

Alternative	Approx Capital Cost ($ million)			Notable O&M Impacts[1] (Compared to Base Case)
	Onsite	Offsite	Total	
0	2.4	none	2.4	NA
1	2.4	5 - 10	7.4 - 12.4	• Loss of 8760 MWH on-peak hydro energy/year at Melton Hill Dam • Loss of 45.0± MWe hydro capacity at Melton Hill Dam
2	2.4	14 - 20	16.4 - 22.4	• Loss of 600 MWH on-peak hydro energy/year at Melton Hill Dam • Loss of 43.2± MWe hydro capacity at Melton Hill Dam
3	1.4	none	1.4	• Water treatment likely also needed to help control soluble mineral content of CWS flow
3A	4.4	none	4.4	• Water treatment likely also needed to help control soluble mineral content of CWS flow • Energy (35 hp pump)+labor, materials & equipment for routine control/upkeep of OSCS
4	9.3	none	9.3	NA
5	12.9	none	12.9	• Energy (50 hp pump)+labor, materials & equipment for routine control/upkeep of OSCS
5A	7.5	none	7.5	• Energy (50 hp pump)+labor, materials & equipment for routine control/upkeep of OSCS

[1] Excluding any SMR derates and shutdowns to satisfy regulatory guidelines and requirements.

Note:
NA = Not Applicable

Table 9.4.2-3
Assessment Summary of Discharge Alternatives

Alternative	Hydrothermal Assessment Summary	
0	Per Fluent simulations, this alternative cannot ensure compliance with regulatory guidance for size of mixing zone and requirements for water temperature, at least for extreme winter events with long periods of idle hydro operation at Melton Hill Dam.	Not preferred
1	Per Fluent simulations, this alternative is considered favorable for obtaining regulatory acceptance for the size of mixing zone and requirements for water temperature, for both extreme winter events and extreme summer events containing long periods of idle hydro operation at Melton Hill Dam.	**Preferred**
2	Per Fluent simulations, this alternative is considered favorable for obtaining regulatory acceptance for the size of mixing zone and requirements for water temperature, for both extreme winter events and extreme summer events containing long periods of idle hydro operation at Melton Hill Dam.	**Preferred**
3	Per Fluent simulations for Alternative 0, challenges expected relative to the ability of this alternative to ensure compliance with regulatory guidance for size of mixing zone and requirements for water temperature, at least for extreme winter events involving long periods of idle hydro operation at Melton Hill Dam. Concern also exists in restricting plant operational flexibility with a high COC.	Not preferred
3A	Per Fluent simulations for Alternative 0, challenges expected relative to the ability of this alternative to ensure compliance with regulatory guidance for size of mixing zone and requirements for water temperature, at least for extreme winter events involving long periods of idle hydro operation at Melton Hill Dam. OSCS does not provide significant additional cooling for extreme winter events. Concern also exists in restricting plant operational flexibility with a high COC.	Not preferred
4	This alternative likely cannot ensure compliance with regulatory guidance for size of mixing zone. Potential issues also exist for navigation and recreation during flushing of the holding pond. Overall operational and public perceptions of flushing a large volume of water to the reservoir in a short period of time is likely to be poor.	Not preferred
5	This alternative likely cannot ensure compliance with regulatory guidance for size of mixing zone. Potential issues also exist for navigation and recreation during flushing of the holding pond. Overall operational and public perceptions of flushing a large volume of water to the reservoir in a short period of time is likely to be poor. OSCS does not provide significant additional cooling for extreme winter events.	Not preferred
5A	Per Fluent simulations for Alternative 0, challenges expected for this alternative relative to the ability of this alternative to ensure compliance with regulatory guidance for size of mixing zone and requirements for water temperature, at least for extreme winter events involving long periods of idle hydro operation at Melton Hill Dam. OSCS does not provide significant additional cooling for extreme winter events.	Not preferred