5.6 TRANSMISSION SYSTEM IMPACTS

This section describes the impacts of transmission system operation for the Clinch River (CR) Small Modular Reactor (SMR) Project. As discussed in Section 3.7, the final design of the transmission infrastructure to support operation of two or more SMRs at the Clinch River Nuclear (CRN) Site, including corridors and switchyards, has not yet been finalized. Section 3.7 describes a general concept of the interconnection components and activities necessary to complete the connection between the CRN Site and the existing power transmission systems. As described in Subsection 3.7.1, activities related to the transmission system on the CRN Site include the construction of proposed switchyards, looping in transmission lines, and relocation of an existing transmission line within the site boundary. Transmission line upgrades in conjunction with the CR SMR Project are expected to include reconductoring, uprating, and rebuilding of some segments within the existing lines on and off the CRN Site. These upgrades, which would increase the electrical capacity of the existing transmission system, include activities such as moving features that interfere with clearance, replacing and/or modifying existing structures, installing intermediate structures, and modifying or replacing some of the existing conductors in order to increase ground clearance.

Additionally, Tennessee Valley Authority (TVA) plans to install an underground transmission line within an existing overhead transmission line right-of-way (ROW) which spans the CRN Site and ties into the Bethel Valley substation. As described in Subsection 3.7.3.4, the proposed underground transmission line would be installed approximately 36 inches (in.) below the ground surface. Impacts associated with construction in transmission line ROWs are discussed in Sections 4.1 and 4.3.

Subsections 5.6.1 and 5.6.2 discuss potential environmental impacts to terrestrial and aquatic ecosystems, respectively. Subsection 5.6.3 addresses potential operational impacts of the existing and proposed transmission lines to members of the public.

As described in greater detail in Section 3.7, two TVA transmission lines currently traverse the CRN Site, the east-west 500-kilovolt (kV) Watts Bar NP – Bull Run FP line and the north-south 161-kV Kingston FP – Fort Loudoun HP #1 line. Additional interconnection components and activities would be necessary to complete the connection between the CRN Site and existing power transmission systems and ensure that National Electrical Safety Code (NESC) standards are met. These components, based on an SMR surrogate plant at a generating output of 800 MWe, include onsite switchyards, loops in the two existing lines, various uprating activities, and relocation of an onsite portion of the Kingston FP – Fort Loudoun HP #1 161-kV transmission line. TVA also plans to install a 69-kV underground transmission line (approximately 5 miles [mi] in length) within the existing ROW of the Watts Bar NP – Bull Run FP 500-kV line on U.S. Department of Energy (DOE) property. The 69-kV line would tie into the Bethel Valley substation, also on DOE property. Figure 3.7-2 shows the existing transmission system on and adjacent to the CRN Site and the approximate proposed 161-kV transmission line relocation route. Figure 3.7-2 shows the route of the proposed underground 69-kV transmission line from the CRN Site to the Bethel Valley substation. It is expected that transmission system construction activities would be completed within the CRN Site and/or existing transmission line ROWs.

5.6.1 Impacts to Terrestrial Ecosystems

TVA manages transmission corridors to prevent woody growth from encroaching on energized transmission lines and potentially causing disruption in service or becoming a general safety hazard. In addition to maintaining an adequate distance between transmission line conductors and vegetation, management of vegetation along the ROWs is necessary to ensure access to structures.

TVA has procedures in place for use during ongoing transmission line ROW maintenance activities. In addition, TVA transmission line maintenance activities are subject to periodic National Environmental Policy Act review where resources within the ROW are assessed and characterized. TVA procedural documents such as *Right-Of-Way Vegetation Management Guidelines* and *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Transmission Construction and Maintenance Activities* provide guidance to TVA personnel conducting maintenance activities in transmission line ROWs (Reference 5.6-1; Reference 5.6-2). Activities addressed include such operations as re-clearing of vegetation, maintenance of access roads, and erosion control. Best management practices (BMPs) are provided for re-clearing methods such as cutting of trees and herbicide application, and for protection of sensitive resources. Structural controls, standards, and specifications are identified to maintain physical components within ROWs such as riprap and culverts.

Periodic inspections of TVA's transmission lines would continue to be performed by aerial surveillance on a regular basis. These inspections are conducted to locate damaged equipment; in addition, any conditions that may interfere with normal operation of the line or adversely impact the surrounding area are reported. During these inspections, the condition of the vegetation within and adjacent to the ROW are noted. These observations are then used to plan corrective maintenance or routine vegetation maintenance.

Vegetation management along the ROW consists of two principal activities: felling of invasive trees adjacent to the cleared ROW, and vegetation control within the cleared ROW. Management of vegetation within the cleared ROW uses an integrated vegetation management approach based on BMPs designed to encourage low-growing plant species and discourage tall-growing plant species.

A vegetation re-clearing plan is developed for each transmission line segment based on the results of the periodic inspections described above. The two principal management techniques are mechanical mowing and herbicide application. Herbicides are applied in accordance with applicable state and federal laws and regulations. Only herbicides registered with the U.S. Environmental Protection Agency are used.

In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Rev. 1, the U.S. Nuclear Regulatory Commission (NRC) evaluated transmission line ROW management (cutting and herbicide application) during the license renewal term at all nuclear power plants. NRC concluded that continued ROW management would not lower habitat quality or cause significant changes in wildlife populations in the surrounding habitat, and that the impact on terrestrial resources would be SMALL for all nuclear power plants.

As described in Subsection 3.7.3.4, the proposed location of the underground transmission line is 36 in. below ground surface within the existing 500-kV ROW. The heat from underground transmission lines dissipates through the surrounding soil. Thus, operation of the proposed line is expected to increase the soil temperature adjacent to the line. However, this thermal effect is very localized and limited. Modeling of temperature effects from an underground 380-kV line under full load conditions indicated that the temperature increase at the surface directly above the line would not exceed 1 to 2 degrees Celsius (33.8 to 35.6 degrees Fahrenheit [°F]), and at a distance of 5 meters from this point, a soil temperature increase would not be detectable. (Reference 5.6-3) Similarly, soil temperature increases from the operation of a 69-kV underground line and the area affected are expected to be localized and limited. Soil temperature increases potentially could slightly alter the composition of the terrestrial vegetation and associated wildlife habitat directly above the line, but any effects would quickly decline with distance, and the affected area would be limited to the transmission line ROW, where vegetation is controlled.

Transmission lines generate coupled electric and magnetic fields, referred to together as electromagnetic fields (EMF). The voltage on the conductors of the transmission line generates an electric field that occupies the space between the conductors and other conducting objects such as the ground, transmission line structures, or vegetation. A magnetic field is generated by the current (movement of electrons) in the conductors. Electric fields from underground transmission lines are limited by insulation, and no electric field would be detected outside the cable. The strength of the magnetic field that surrounds the conductor decreases rapidly with distance. (Reference 5.6-3) Studies have found that magnetic and electric fields from transmission lines do not cause adverse behavioral, health, or reproductive effects in wildlife or other animals (Reference 5.6-4). Thus, EMF effects on terrestrial wildlife from operation of the underground 69-kV line would be negligible.

In summary, TVA has methods in place to protect terrestrial habitats from potential adverse effects associated with ongoing transmission line ROW maintenance activities. Potential thermal and EMF effects of the proposed underground transmission line on terrestrial habitats are expected to be negligible. Therefore, impacts to terrestrial ecosystems resulting from the operation and maintenance of transmission lines would be SMALL.

5.6.2 Impacts to Aquatic Ecosystems

Transmission lines within the vicinity of the CRN Site span several aquatic habitats, including a reservoir, creeks, and streams. The proposed location of the underground transmission line is within an existing 500-kV transmission line ROW. As discussed in Subsection 4.3.2.5, construction of the 69-kV line includes installation under short segments of several streams within the 500-kV ROW. The potential effects of transmission lines on aquatic ecosystems arise mainly from water quality effects associated with maintaining ROWs. TVA is responsible for many miles of transmission lines that span several aquatic habitats and, therefore, has procedures for ROW maintenance to protect aquatic resources. As described in Subsection 5.6.1, TVA has developed procedures for ROW maintenance activities such as erosion control and herbicide application, which are designed to maintain water quality in surface water bodies and wetlands in and near transmission line ROWs.

Streamside management zones (SMZs) refer to TVA-specified buffer areas surrounding bodies of water, including ponds, streams, and rivers. The size of the SMZ is specified depending on the slope of the surrounding area, the type of stream, and the particular resource that may be present in the stream. TVA follows established BMPs specifically directed toward avoiding or minimizing adverse impacts to SMZs and the associated waterbodies during maintenance activities. Use of hand held equipment for clearing trees reduces soil and shoreline disturbance. Applications of herbicides (except those labeled for aquatic use) are conducted so that chemicals are not applied directly or allowed to drift into intermittent or perennial streams or other water bodies. (Reference 5.6-1) Due to the use of these technologies when working near aquatic environments, adverse effects on aquatic ecosystems would be minimal.

As discussed for terrestrial ecosystems in Subsection 5.6.1, thermal effects from the 69-kV underground line potentially could occur in sediment and water of the stream segments that cross over the buried line. Such effects on aquatic systems were evaluated by the DOE in an Environmental Impact Statement (EIS) for a proposed 300-kV direct current underground transmission line, which would extend from Canada to New York City and would be installed largely beneath bodies of water. This EIS estimated that sediment temperature increases associated with the operation of that underground line would be less than 2°F at the sediment surface, not accounting for further temperature reductions that would result from advective heat losses to flowing water. Temperature changes in the water itself were estimated to be less than 0.01°F. Such changes in sediment or water temperatures would be negligible in comparison to seasonal fluctuations. As discussed for terrestrial ecosystems, EMF may be higher directly above an underground transmission line than below an overhead line, but electric fields are limited by insulation, magnetic fields weaken rapidly with distance, and such fields have not been found to cause adverse effects in wildlife or other animals. EMF effects on aquatic wildlife from operation of the underground 69-kV line would be negligible. (Reference 5.6-4)

TVA routinely implements measures to minimize potential adverse effects on aquatic habitats from ongoing transmission line ROW maintenance activities. Potential thermal and EMF effects of the proposed underground transmission line on aquatic habitats are expected to be negligible. Therefore, impacts to aquatic ecosystems resulting from the operation and maintenance of the transmission lines would be SMALL.

5.6.3 Impacts to Members of the Public

The possible effects from electrical transmission systems on members of the general public include exposure to EMF, electrical shock, exposure to noise, radio and television interference, and visual effects. Existing transmission lines currently connected to the energy distribution system are available for use by the CR SMR Project. As described in Section 3.7, existing line characteristics indicate the highest voltage line associated with the CRN Site is 500 kV. Also, a new 69-kV underground transmission line is proposed for installation within the existing Watts Bar NP – Bull Run FP 500-kV ROW.

5.6.3.1 Electromagnetic Field Exposure

Transmission lines and other types of electrical wiring generate EMF. The strength of the field depends on the current, design of the line, and distance from the line. Most of this energy is dissipated in the ROW and the very low residual amount is reduced to background levels near the ROW or energized equipment. (Reference 5.6-5) Existing offsite transmission lines are available to connect the CR SMR Project to the energy distribution system. Construction of new offsite overhead transmission lines is not proposed. However, as discussed in Section 3.7, some existing lines would be reconductored, uprated, or rebuilt to upgrade the transmission system as needed for the operation of the CR SMR Project. The EMF generated by the existing transmission lines would not be affected by operation of the CR SMR Project.

Installation of one new underground transmission line is proposed. Exposure to EMF is different for underground transmission lines. Electric fields from underground transmission lines are limited by insulation, and no electric field would be detected outside the cable. The strength of the magnetic field that surrounds the conductor decreases rapidly with distance. EMF strength may be higher directly above an underground line than under an overhead transmission line, but the width of the underground line EMF corridor is much less because the underground line occupies a narrower area. Mitigation measures can decrease the EMF fields related to underground transmission lines to negligible levels. (Reference 5.6-3)

Because public exposure to EMF from existing offsite transmission lines would not change and EMF fields associated with the new underground transmission line would be localized and can be decreased to negligible levels, impacts to the public resulting from EMF exposure would be SMALL.

5.6.3.2 Electrical Shock

In NUREG-1437, Rev 1, NRC indicates that the greatest electrical shock hazard from a transmission line is direct contact with the conductors and that tower designs preclude direct public access to the conductors. However, electrical shocks can occur without physical contact. Secondary shock can happen when humans make contact with either capacitively charged bodies (such as a vehicle parked near a transmission line) or magnetically linked metallic structures (such as fences near transmission lines). The shock received by the person could be painful. The intensity of the shock would depend on the EMF strength, the size of the object, and the degree of insulation between the object, the person, and the ground.

The NESC is the basis for design criteria that are intended to limit the risk of shock and other hazards due to transmission lines. The NESC calls for transmission lines to be designed with minimum vertical clearances to the ground so that the short-circuit current to ground produced from the largest anticipated vehicle or object is limited to less than 5 milliamperes. In NUREG-1437, Rev. 1, NRC indicated that the electrical shock issue is of small significance for transmission lines that are operated in adherence with the NESC. As described in Subsection 3.7.1, TVA plans to upgrade transmission lines in conjunction with the CR SMR Project. These upgrades (e.g., moving features that interfere with clearance, replacing and/or modifying existing structures, and modifying or replacing some existing conductors so as to increase ground clearance) would be needed to increase the electrical capacity of the existing transmission system. Maintaining the required clearance to meet NESC design criteria reduces the risk of electrical shock.

For underground transmission lines, no electrical fields are detected outside the cable. The electric field extending from an underground transmission line is limited by insulation, and outside the cable no electrical field would be detected. (Reference 5.6-3) Therefore, the most likely potential for electric shock from an underground transmission line is associated with direct contact, such as digging.

Given that TVA maintains the transmission lines in compliance with NESC guidelines, impacts to members of the public due to electrical shock would be SMALL.

5.6.3.3 Noise

As discussed in NUREG-1437, Rev. 1, transmission lines can generate a small amount of sound energy during corona activity, which is a partial discharge of electrical energy. During corona events, the ionization of the air that surrounds conductors of the high-voltage transmission lines, which is caused by electrostatic fields in these lines, generates impulse corona currents. When the voltage on a particular phase is high enough, a corona burst occurs, and a noise is generated. This audible noise from the line can barely be heard in fair weather on higher-voltage lines. During wet weather, water drops collect on the conductor and increase corona activity so that a crackling or humming sound may be heard near the line. This noise is caused by small electrical discharges from the water drops.

For 500-kV transmission lines, this corona noise, when present, is usually approximately 40-55 A-weighted decibels (dBA). The maximum recorded corona noise has been 60-61 dBA. (Reference 5.6-5) As discussed in Subsection 4.4.1.1, noise levels below 65 dBA outside a residence are generally considered to be acceptable Therefore, the corona-related noise potentially generated by transmission lines would be acceptable.

As described in Subsection 3.7.3.4, the depth of the proposed underground transmission line would be 36 in. below the ground surface. Corona discharge is not an issue with underground lines except at aboveground components such as substations, since the energized conductors are fully enclosed in a semi-conducting layer within the insulated cables that serve to equalize the electrical gradient at the surface of the components (Reference 5.6-6). The underground line is not expected to generate noise that would be audible from above the ground surface.

The 500-kV and 161-kV lines that would serve the CR SMR Project are already operating and the noise levels they produce are expected to continue to remain acceptable. The underground transmission line planned for construction is not expected to generate audible noise. Therefore, there are no anticipated increases to the current ambient noise levels associated with the operation of the transmission system, and the effect on noise would be SMALL.

5.6.3.4 Radio and Television Interference

Corona activity from transmission lines can also generate EMF noise at frequencies used for radio and television signals. If interference were to occur with radio or television reception, it would be due to unusual failures of power line insulators or poor alignment of the radio or television antenna and the signal source. Both conditions are correctable and would be repaired if reported to TVA. (Reference 5.6-5) As described in Subsection 5.6.3.3, corona discharge and the associated interference is not an issue with underground transmission lines. Therefore, there are no anticipated increases in corona activity associated with operation of the transmission system and the impact of the transmission lines on radio and television signals would be temporary and SMALL.

5.6.3.5 Visual Impacts

Continued operation of the existing transmission lines associated with the CR SMR Project would not affect the visual character of the area. The transmission towers and cleared corridors are already in place. The location of the proposed new 69-kV transmission line is underground within the existing 500-kV transmission line ROW. However, a portion of the existing 161-kV line located on the CRN Site would be re-routed to the east, along the Clinch River arm of the Watts Bar Reservoir. The new towers and cleared corridor would be visible from the reservoir and several residences across from the CRN Site. Given the presence of the other transmission lines on the CRN Site and in the area, and the industrial nature of the proposed project, the effect of the re-located transmission line would not noticeably alter important attributes of the area’s visual character. Therefore, although the re-located transmission line would alter viewscapes in the immediate vicinity of the CRN Site, the overall impact of the transmission system on visual resources would be SMALL.

5.6.4 References

Reference 5.6-1. Muncy, J. A., "A Guide for Environmental Protection and Best Management Practices," 2012.

Reference 5.6-2. Tennessee Valley Authority, "Right-Of-Way Vegetation Management Guidelines; Energy Delivery Environmental Protection Procedures," Revision 3, September 23, 2013.

Reference 5.6-3. Golder Associates, "Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables," PPSMDE081295, May, 2008.

Reference 5.6-4. U.S. Department of Energy, "Champlain Hudson Power Express Transmission Line Project Environmental Impact Statement," September, 2013.

Reference 5.6-5. Tennessee Valley Authority, "Power Supply Improvement Project," 2005-107, April, 2008.

Reference 5.6-6. Aspen Environmental Group, Final Mitigated Negative Declaration and Supporting Initial Study for PG&E's Embarcader-Potrero 230 kV Transmission Project (Section 5.18), Website: http://www.cpuc.ca.gov/Environment/info/aspen/embarc-potrero/toc-fmnd.htm, October, 2013.