3.7 POWER TRANSMISSION SYSTEM

3.7.1 Transmission System

The current transmission system within the Clinch River Nuclear (CRN) Site includes the 500-kilovolt (kV) Watts Bar NP – Bull Run FP line and the 161-kV Kingston FP – Fort Loudoun HP #1 line. Both of these lines are owned and operated by Tennessee Valley Authority (TVA).

The following 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 are based on a generating output of an 800 megawatt electric (MWe) surrogate plant include:

- Onsite construction of a 500-kV switchyard
- Loop in the Watts Bar NP – Bull Run FP 500 kV line (approximately 0.7 miles (mi) double circuit)
- Onsite construction of a new 161-kV switchyard for auxiliary station service
- Loop in the Kingston FP – Fort Loudoun HP #1 161-kV transmission line (approximately 0.2 mi double circuit)
- Upgrade terminal equipment
- Decrease breaker failure clearing time by changing the settings on breaker failure relays in the Watts Bar 500-kV switchyard (Reference 3.7-1)
- Re-conductor approximately 131 mi of 161-kV transmission lines
- Uprate approximately 191 mi of 161-kV transmission lines
- Rebuild approximately 13 mi of 161-kV transmission line
- Relocation of a portion of the Kingston FP-Fort Loudoun HP #1 161-kV transmission line within the Site Boundary
- Install a second 500/161-kV transformer at Bull Run (Reference 3.7-1)

Details on the transmission lines to be rebuilt, reconductored, or uprated are included in Table 3.7-1.

Depending on the final configuration and additional electrical capacity, additional uprating activities may be required. Additional detail on uprating activities is included in Subsection 3.7.3.8.

TVA plans to relocate the 161-kV line within the Site Boundary. The location of the existing transmission lines (500-kV and 161-kV) and the approximate proposed 161-kV transmission line relocation are provided on Figure 3.7-1.

As part of the “power islanding” concept discussed in Section 1.1.1,the Clinch River (CR) Small Modular Reactor (SMR) Project includes installation of a 69-kV underground transmission line along the existing Watts Bar NP – Bull Run FP 500-kV corridor which crosses CRN Site and ties into the Bethel Valley substation (Figure 3.7-2). The transmission work related to the installation of a 69-kV underground transmission line from the CRN Site to the Bethel Valley Substation would include:

- Expansion of Bethel Valley 161-kV Substation to receive 69-kV transmission line
- Construct underground 69-kV transmission line (approximately 5 mi) following an existing TVA 500-kV corridor on U. S. Department of Energy (DOE) property

Figure 3.7-2 shows the proposed route of the underground transmission line from the CRN Site to the Bethel Valley Substation.

Transmission system construction activities are expected to be completed within the CRN Site boundary and/or existing transmission line rights-of-way (ROWs). If needed, additional access roads or clearing would be addressed during the combined license application (COLA).

3.7.2 Transmission Line Corridors

The NESC is the basis for design criteria that are intended to limit the risk of shock and other hazards due to transmission lines. NESC standards provide minimum clearance distances required between conductors and any grounded objects such as buildings, trees, roads, and railroads. These clearances vary with voltage. TVA ROW widths would be selected to ensure the conductors are within the ROW and the minimum clearances, including an additional safety margin, are maintained. ROWs associated with the construction of tie-ins and the relocation of the 161-kV line will be constructed in accordance with NESC standards. 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 (mA). In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Rev. 1, the U.S. Nuclear Regulatory Commission indicated that the electrical shock issue is of small significance for transmission lines that are operated in adherence with the NESC.

Periodic inspections of TVA’s transmission lines are performed by aerial surveillance on a regular basis. These inspections are conducted to locate damaged equipment and any conditions that may interfere with normal operation of the line or adversely impact the surrounding area would be 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. Management of vegetation along the ROWs is necessary to ensure access to structures and to maintain adequate distance between transmission line corridors and vegetation.

3.7.3 Transmission System Design Parameters

3.7.3.1 500-kV Switchyard and 161-kV Switchyard

The CR SMR Project includes the construction of a 500-kV switchyard and a 161-kV switchyard on the CRN Site. The switchyard area location has not been finalized. The switchyard footprint includes both the 500-kV and 161-kV switchyards. As shown in Table 3.1-2, Item 15.2, the acreage required for the two switchyards is shown in the Site Utilization Plan, Figure 3.1-1.

The 500-kV Switchyard may include transformers, breakers, switches, relays, real-time metering, and dual communication paths (Reference 3.7-2). Additional equipment would include connecting bus work, a supporting steel superstructure, ground wire towers, switch house, and equipment storage building (Reference 3.7-3). No underground utilities are planned for this switchyard. Figure 3.7-3 provides an aerial view of a typical 500-kV TVA switchyard.

The 161-kV switchyard may include transformers, breakers, switches, and associated relays (Reference 3.7-2). Major equipment may include connecting bus work, a supporting steel superstructure, ground wire towers, switch house, and equipment storage building (Reference 3.7-3). Figure 3.7-4 provides and aerial view of a typical 161-kV TVA switchyard.

3.7.3.2 500-kV Structures and Conductors

The proposed 500-kV transmission line connections would use self-supporting, galvanized, laced-steel structures. The electrical conductors (the cables that carry the electrical current) would consist of three sets of three cables bundled in a triangular configuration, suspended under the structure cross arms by insulators. Two single ground wires would be placed on the two highest points of the structures to provide lightning protection. In some cases, these ground wires may carry fiber optic or other communication circuits. Tower height may vary depending on final grade and land use but would normally range between 85 and 125 feet (ft). Tower foundations would normally be laced-steel grillage, one per leg, buried in the earth. Some towers where the line turns at an angle would require foundations of reinforced concrete. Figure 3.7-5 is a sketch of a typical structure with no underbuilt transmission lines.

The 0.7 mi double circuit loop into the 500-kV line would require two separate transmission lines with a 125 foot separation. This would require approximately 10 structures spaced approximately 1000 ft apart. A typical ROW for a 500-kV line is 175 ft wide.

3.7.3.3 161-kV Structures and Conductors

The proposed 161-kV transmission line connections would use a combination of single and H-frame steel-poles similar to those shown in Figure 3.7-6 (Reference 3.7-3). Structure heights would vary depending on final grade and land use but normally range from 80 to 110 ft.

Six conductors would be required to make up a double-circuit in alternating-current transmission lines (Reference 3.7-4). For a 161-kV transmission line, each single-cable conductor would be attached to porcelain insulators suspended from the structure cross arms. A smaller overhead ground wire or wires are attached to the top of the structures. This ground wire may contain fiber optic communication cables.

Poles at angles in the transmission line may require supporting guy wires. Some angle structures may be self-supporting poles or steel towers, which would require concrete foundations. Most poles would be directly imbedded in holes augured into the ground to a depth equal to 10 percent of the pole's length plus an additional 2 ft. Normally, the holes would be backfilled with the excavated material, but, in some cases, gravel or a concrete-and-gravel mixture would be used.

For the estimated 0.2 mi loop into the 161-kV transmission line, three double circuit structures would be required. Structures are typically spaced 600 ft apart. The typical ROW for this interconnection would be 100 ft wide.

TVA plans to relocate the 161-kV line within the Site Boundary.

3.7.3.4 Underground 69-kV Line

The proposed 5-mi underground transmission line would consist of three conductors that would be placed 36 inches (in.) deep with 12 in. horizontal spacing. The conductors would be direct buried with a protective cover. The transmission line would be buried under the existing 500-kilovolt (kV) Watts Bar NP – Bull Run FP line which crosses CRN Site and ties into the Bethel Valley substation (Figure 3.7-2).

Expansion requirements and other parameters would be defined once the design of the underground transmission line is finalized.

3.7.3.5 General Methods of Construction Switchyard

A construction assembly area (laydown area) would be required for worker assembly, vehicle parking, and material storage during construction. This area would be located within the CRN Site (Figure 3.1-2). Selection criteria used for locating the potential laydown area include:

- Relatively flat
- Well drained
- Previously cleared
- Preferably graveled and fenced
- Preferably wide access points with appropriate culverts
- Sufficiently distant from streams, wetlands, or sensitive environmental features
- Located adjacent to an existing paved road near the transmission line

Trailers used for material storage and office space would be parked in the laydown area. Following completion of construction activities, trailers, unused materials, and construction debris would be removed from the CRN Site.

The footprint of the 500-kV switchyard and the adjacent 161-kV auxiliary station is provided in the Site Utilization Plan, Figure 3.1-1 (Table 3.1-2, Item 17.2.1).

TVA would clear vegetation, remove topsoil, and grade for the required switchyard area. Equipment used during clearing would include chain saws, skidders, bulldozers, tractors, and/or low ground-pressure feller-bunchers. Marketable timber would be salvaged where feasible; otherwise, woody debris and other vegetation would be piled and burned, chipped, or taken off site. In some instances, vegetation may be windrowed along the edge of the CRN Site to serve as sediment barriers. All activities would be conducted in accordance with TVA Site Clearing and Grading Specifications. (Reference 3.7-3)

The site would be leveled using a cut and fill process. The areas of the site that are too high (sloped) would be "cut" down to a level elevation, and other areas that are too low would be "filled" to raise the elevation. Any additional fill required would be obtained from an approved/permitted borrow area. All activities would be conducted in accordance with TVA Site Clearing and Grading Specifications. (Reference 3.7-3)

Once the switchyard site has been graded, spoil would be removed in preparation for foundations. Temporary spoil storage would be located on the CRN Site in several designated areas. Silt fences, site drainage structures, and detention ponds would be installed as required during construction. The substation yard would be covered with crushed stone and enclosed with chain link fencing. (Reference 3.7-3) Construction activities would be conducted in accordance with TVA Transmission Construction Guidelines Near Streams, TVA Quality Protection for Transmission, Substation or Communications Construction, and TVA Substation Lighting Guidelines (Reference 3.7-5).

3.7.3.6 Transmission Line Tie-Ins and Relocation of the 161-kV Transmission Line

As discussed in Subsection 3.7.3.5 for the switchyard, a construction assembly area (laydown area) would be required for assembly, vehicle parking, and material storage during construction. The laydown area for the structures for the transmission line would be approximately 5 ac and would be located within the CRN Site. Selection criteria for this laydown area are the same as for the switchyard and substation laydown area. Trailers used for material storage and office space would be parked in the laydown area. Following completion of construction activities, trailers, unused materials, and construction debris would be removed from the CRN Site.

The transmission structure would be the most visible element of the electric transmission system. Its function would be to keep an adequate distance between the high-voltage conductors and the surrounding area. The transmission line structure type would depend on the line voltage, terrain, and whether the line is single circuit or double circuit. Transmission structure heights would vary depending on final grade and land use but normally range from 80 to 110 ft. The Federal Aviation Administration provides guidance for marking and lighting for structures that may affect navigable airspace. This guidance applies to structures that exceed an overall height of 200 ft above ground level or are located within three nautical miles of an airport. (Reference 3.7-6) Neither of these criteria applies to the 161-kV transmission line to be relocated.

Equipment used during the construction phase would include trucks, truck-mounted augers, and drills, as well as tracked cranes and bulldozers. Low ground-pressure-type equipment would be used in specified locations (such as areas with soft ground) to reduce the potential for environmental impacts.

Reels of conductor and ground wire would be delivered to various staging areas along the ROW, and temporary clearance poles would be installed at road crossings to reduce interference with traffic. A small rope would be pulled from structure to structure. It would be connected to the conductor and ground wire and used to pull them down the line through pulleys suspended from the insulators. A bulldozer and specialized tensioning equipment would be used to pull conductors and ground wires to the proper tension. Crews would then clamp the wires to the insulators and remove the pulleys.

Activities associated with the transmission line tie-ins and relocation would be conducted in according with the following TVA guidance:

- TVA Environmental Quality Protection Specification for Transmission Line Construction
- TVA Transmission Construction Guidelines near Streams (Reference 3.7-5)
- TVA Transmission Construction Standard TC-LCS-06.003.08, Grounding Improvements (Reference 3.7-7)
- TVA Construction Standard TC-LCS-06.003.06, Steel Towers (Reference 3.7-8)

3.7.3.7 69-kV Underground Transmission Line

The underground transmission line would be direct buried (does not require conduit) with a protective cover. Three conductors would be placed 36 in. deep with 12 in. horizontal spacing. The underground transmission line would be buried within the existing 500-kv ROW with a protective cover. Portions of the ROW are 360 ft wide. Equipment, land use, and construction methodology will be defined once the design of the transmission line is finalized.

3.7.3.8 Description of Various Uprating Activities

Uprates are typically performed to increase the electrical capacity of an existing transmission line. Due to the potential system loading of 800 MWe from the CR SMR, uprating ten 161-kV transmission lines, and reconductoring seventeen 161-kV transmission lines (Figure 3.7-7) would be required.

As a matter of context, an 'uprate' can be performed at a single point or at multiple locations along the transmission line. Likewise, reconductoring can occur at a specific line segment or along the length of the transmission line. The total length of the ten 161-kV, and seventeen 161-kV transmission lines that would require some uprates and reconductoring is approximately 191 and 131 mi, respectively. This represents the actual length of the specific transmission line itself, not necessarily the length or extent of the actual uprate or reconductor work. The affected segment of each transmission line requiring uprates or reconductoring are identified in Table 3.7-1, but the particular engineering solution necessary within these segment(s) would depend on the final configuration and additional electrical capacity of the CR SMR. Additionally, one section of the 12.7-mi long Volunteer No 1 – North Knox 161-kV transmission line would require rebuilding. This section of transmission line has already undergone uprating activities in the past and has reached its maximum electrical capacity as currently designed. The final configuration and electrical capacity of the CR SMR would drive the specific engineering solution, but it is expected that some structures may have to be replaced or modified and that the existing conductor may be replaced with a larger size to support the increased electrical load. Descriptions of uprate, reconductor, and transmission line rebuild activities are described below.

- Moving Structures that Interfere with Clearance: As more electricity is transmitted through a transmission line, the conductor temperature rises and the transmission line may sag. Structures located within the ROW may interfere with the ability to operate the transmission line safety and would be required to be moved.
- Replacement or Modification of Existing Structures or Installation of Intermediate Structure: Typical structure replacement, extensions or installation of intermediate structures would be performed with standard transmission line equipment such as bulldozers, bucket trucks, boom trucks, and forklifts. The end result of this work would be raising the existing conductor to provide the proper ground clearance. Disturbance would usually be limited to an approximately 100 foot circumference around the work structure.
- Conductor Modification: Conductor modifications would include conductor slides, cuts, or floating dead-ends to increase ground clearance. A cut involves removing a small amount of conductor and splicing the ends back together. A slide involves relocating the conductor clamp on the adjacent structure a certain distance toward the area of concern (i.e., "sliding" the clamp). No conductor is removed. A floating dead-end shortens the suspension insulator string of a structure to gain elevation at the attachment point of the conductor, increasing a span's clearance. These improvements require the use of a bucket truck; disturbance would be minimal and confined to the immediate area of the clearance issue.
- Conductor Replacement (Re-conductor): If the existing conductor size cannot support the transmission line's electrical load, the conductor would be replaced. Bucket trucks would be utilized for access and stringing equipment. Reels of conductor would be delivered to various staging areas along the ROW, and temporary clearance poles would be installed at road crossings to reduce interference with traffic. The new conductor would be connected to the old conductor and pulled down the transmission line through pulleys suspended from the insulators. A bulldozer and specialized tensioning equipment would be used to pull

conductors to the proper tension. Crews would then clamp the wires to the insulators and remove the pulleys. Wire pulls vary in length but would be limited to a maximum of 5 mi pulls. Pull point locations depend on the type of structures supporting the conductor as well as the length of conductor being installed and would typically be located along the most accessible path on the ROW (adjacent to road crossings or existing access roads). The area of disturbance at each pull point would typically range from 200 to 300 ft along the ROW.

- Adding Surcharge: Sometimes when height and/or loading modifications are made to a structure, the addition of rock or dirt (surcharge) to structure footing would be required. These changes can create uplift on the existing tower footings or grillage; therefore a stone base settlement may be placed around the existing footings. The additional burden prevents the tower from rising under certain conditions (i.e., weather conditions or conductor loading). Typical installation of surcharge would be performed with tracked equipment with minimal ground disturbance. The stone would be piled around the footings as required and the depth would vary depending on the uplift on the affected structures.
- Modification of Local Power Company Transmission Lines: Local utilities distribution lines are lower in voltage compared to the transmission lines, and are final stage in the delivery of electricity to the end users. These are maintained by the local power company. These may intersect TVA transmission lines. If a local utility crossing does not have adequate clearance, TVA would request that the local utility lower or re-route the crossing.
- Rebuild: The rebuilding of a transmission line typically means installing intermediate structures between existing structures for added structural support and/or clearance or tearing down existing structures and replacing with more robust structures. A combination of intermediate and new structures may be used depending on the condition of the affected structures.

After the required uprate work is completed, the ROW would be re-vegetated using native, low-growing plant species in appropriate areas. Areas such as pasture, agricultural fields, or lawns would be returned to their former condition.

TVA maintains, and updates on a periodic basis, a database of both desktop and field- verified environmental resources (archeology/cultural resources, aquatics, botany, natural areas, terrestrial zoology, and wetlands) along existing transmission line corridors. In order to document current conditions TVA has characterized the environmental resources along the transmission line segments identified for future work. The potential for impacts to those resources, however, depend entirely on the specific engineering solution presented in the future based upon the final configuration and electrical capacity of the CR SMR. Field reviews would commence when the design is finalized and associated impacts described at COLA.

3.7.4 Predicted Noise Levels from Transmission System Operations

The 500-kV and 161-kV lines are already present on the CRN Site and no additional above-ground transmission lines would be constructed off-site. Therefore, there are no anticipated increases to the current ambient noise levels associated with the operation of the transmission system. Additional information on maintenance of transmission corridors, electric field effects, induced current hazards, corona noise, and radio/television interference is provided in Section 5.6.

3.7.5 References

Reference 3.7-1. Tennessee Valley Authority, "Interconnection System Impact Study," May 28, 2015.

Reference 3.7-2. Tennessee Valley Authority, "Final Interconnection System Impact Study, Clinch River 500-kV," July 24, 2014.

Reference 3.7-3. Tennessee Valley Authority, "Plateau 500-kV Substation Environmental Assessment, Cumberland County, Tennessee," November, 2013.

Reference 3.7-4. Electrotechnik, Single Circuit and Double Circuit Transmission Lines, Website: http://www.electrotechnik.net/2011/11/single-circuit-and-double-circuit.html, 2015.

Reference 3.7-5. Tennessee Valley Authority, "Selmer-West Adamsville 161-KV Transmission Line and Switching Station Environmental Assessment," January, 2015.

Reference 3.7-6. U.S. Department of Transportation, "Obstructing Marking and Lighting," AC 70/7460-1K, February 1, 2007.

Reference 3.7-7. Tennessee Valley Authority, "Transmission Construction Standard Grounding Improvements," TC-LCS-06.003.08, October 15, 2014.

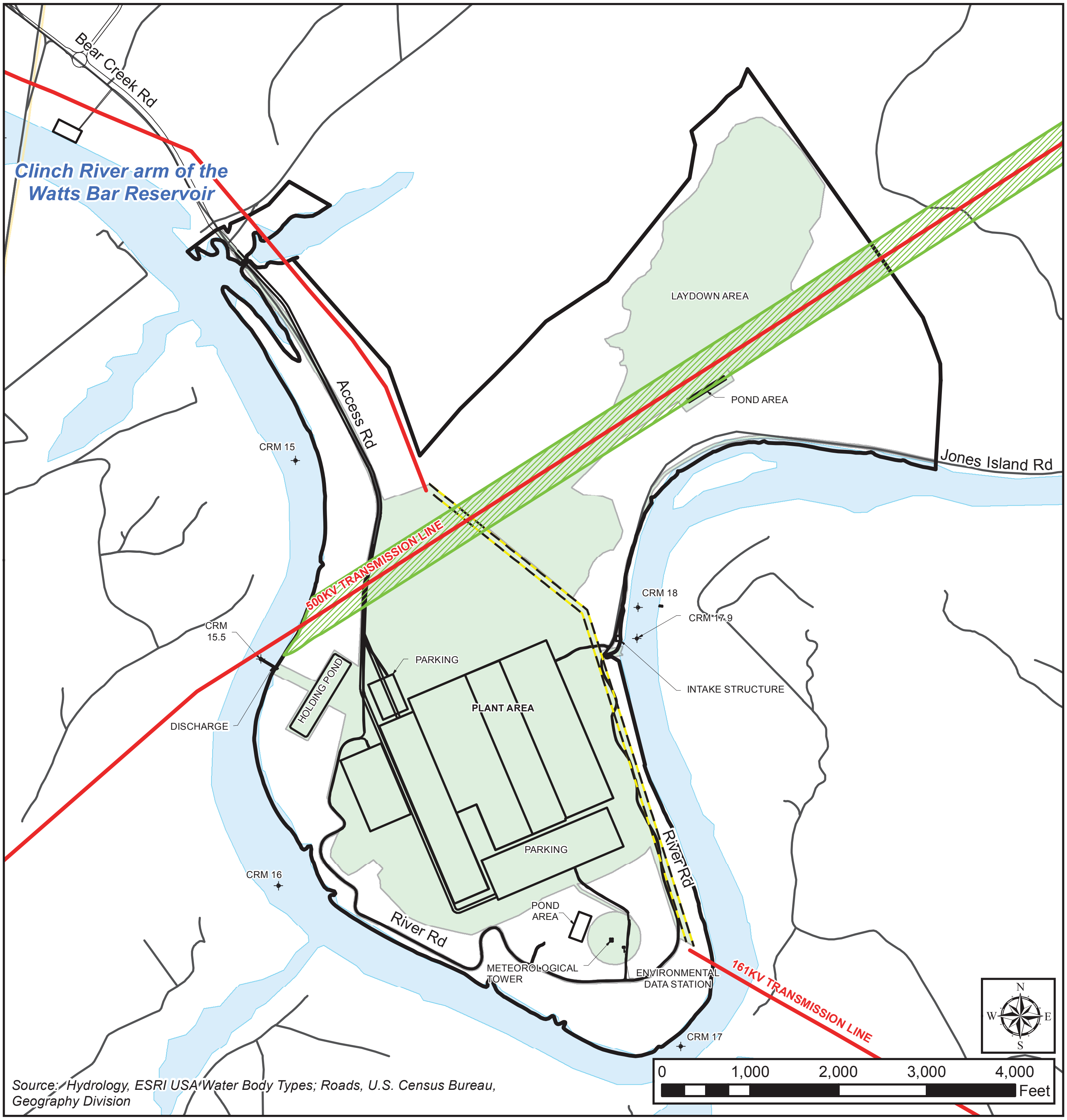
Reference 3.7-8. Tennessee Valley Authority, "Transmission Construction Standard Steel Towers," TC-LCS-06.003.06, October 15, 2014.

Table 3.7-1 (Sheet 1 of 2)
Detailed Transmission Line Segment Information

Line Name	Total Line Mileage	Total Corridor Acres	Activity	Line Number	Affected Line Segment
Volunteer 1 - North Knox 161-kV	12.7	154	Rebuild	5092	120 – 212
Pineville - Sweet Gum Flats 161-kV	26.5	321	Reconductor	5125	448 – 212
LaFollette-Sweet Gum Flats 161 kV	10.9	132	Reconductor	5125	211 – 118
Coalmont-PTN WIND1 161 kV	5.95	72	Uprate	5167	941B-975
Watts Bar HP-Pikeville 161-kV	30.5	370	Uprate	5173	1-182A & 182A - 40
Pikeville Tap-Spencer Tap 161 kV	8.59	104	Uprate	5173	182A – 40
Great Falls-Spencer Tap 161 kV	14	170	Uprate	5173	442D - 182A
John Sevier 1-Cherokee Hydro 161 kV	37.6	456	Uprate	5186	E1 - E5 & 6 - 234
Fredonia-Peavine 161 kV	3.9	47	Reconductor	5204	198A – 215
Fredonia-Campbell Junction 161 kV	6.1	74	Reconductor	5204	172 - 198A
Rockwood-Peavine 161-kV	19.4	235	Uprate	5205	215-297 & A-G
Elza-Spallation Neutron Source 161 kV	3.53	43	Reconductor	5235	82 – 128
Oak Ridge National Lab-Spallation Neutron Source 161 kV	3.34	40	Reconductor	5280	86 – 119
White Pine-Greenville Tap 1 161 kV	23.65	287	Uprate	5624	E1 - E39 & 40 & E35 & 192 - 84
Bull Run-North Knox 161 kV	11	133	Reconductor	5659	1 to 55
Oglethorpe-J.C. Edwards 161 kV	2.32	28	Reconductor	5697	141 – 154
Concord-J.C. Edwards 161 kV	4.33	52	Reconductor	5697	154 – 178
Winchester-Estill Springs 161 kV	0.07	1	Reconductor	5702	1
Franklin-Estill Springs 161 kV	5.17	63	Reconductor	5702	E47 - 39A & 39 - 1

Table 3.7-1 (Sheet 2 of 2)
Detailed Transmission Line Segment Information

Line Name	Total Line Mileage	Total Corridor Acres	Activity	Line Number	Affected Line Segment
Harriman Tap-Rockwood 161-kV	9.1	110	Reconductor	5743	150-208A
Rockwood Tap – Harriman Tap 161-KV	1	12	Reconductor	5743	208A-44
Harriman Tap-Rockwood 161-kV	9.1	110	Reconductor	5743	150-208A
Braytown-Windrock 161-kV	3	36	Reconductor	5882	298A & 298-310
Elza-Windrock 161-kV	7.62	92	Reconductor	5882	298-361 & 298-310
Braytown-Huntsville (TN) 161-kV	23	279	Uprate	5882	189-213 & 213-298 &298A
Dumplin Valley-White Pine 161-kV	20.43	248	Uprate	5940	E136 - E120 & 120 - 164 & 164 - 185A
Douglas-Newport 161-kV	24.13	292	Reconductor	5957	51 - 181 & 1 - 50
White Pine-Newport 161-kV	7.9	96	Uprate	5957	84 & 1 – 116
	12.7	154	Total Rebuild		
	131.11	1589	Total Reconductor		
	191.02	2317	Total Uprate		



Legend

Transmission Line

Approximate Proposed 161 kV Transmission Line Relocation

500 kV Transmission Line Right-of-Way
where underground 69 kV line would be installed

Cleared Areas

CRN Site

Rivers and Lakes

Local Roads

Figure 3.7-1. CRN Site Transmission System

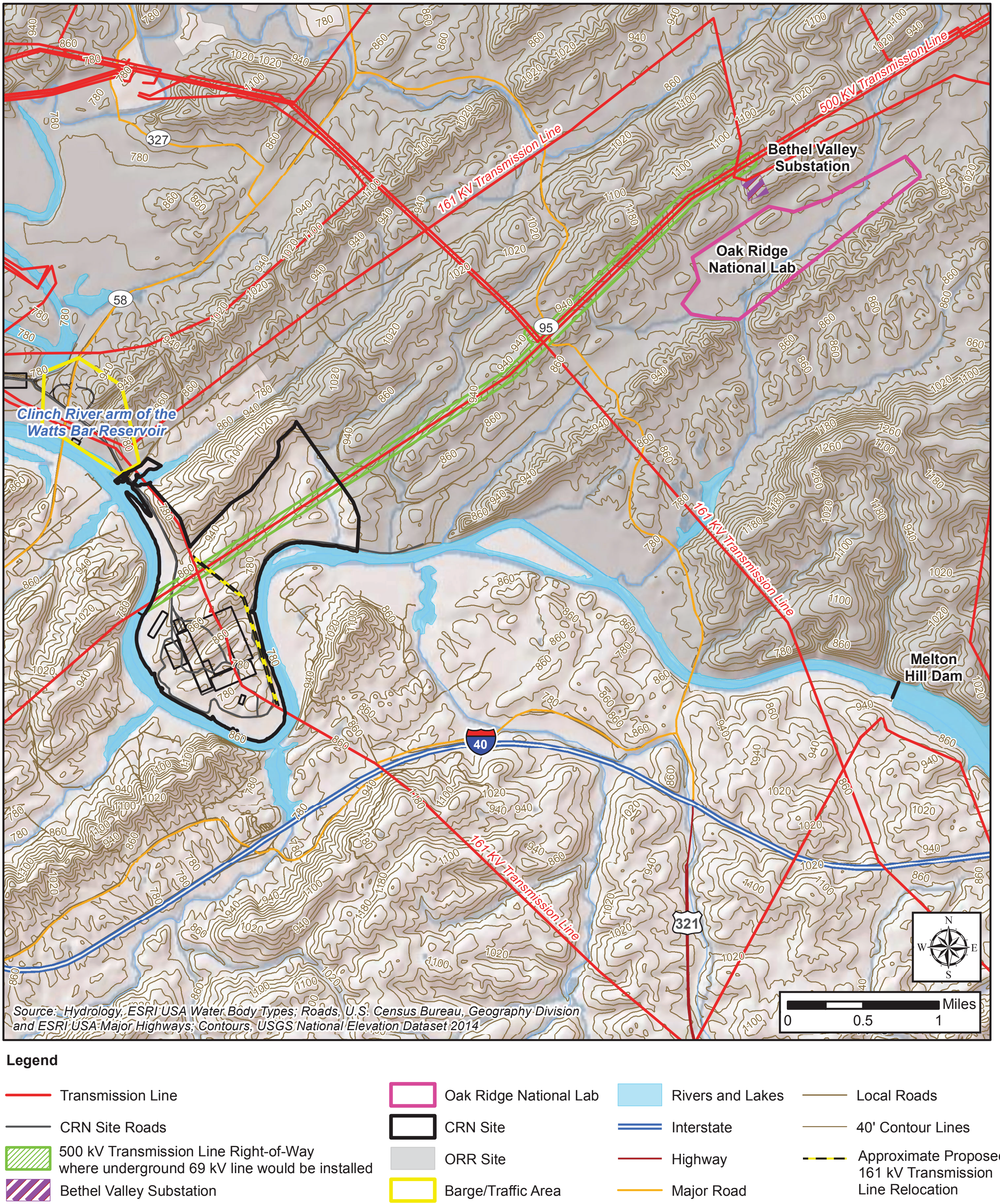


Figure 3.7-2. Transmission Systems in the Vicinity of the CRN Site

Figure 3.7-3. Typical TVA 500 kV Switchyard