CHAPTER 13 TABLE OF CONTENTS

CHAPTER 13 CONDUCT OF OPERATIONS

13.3 EMERGENCY PREPAREDNESS

This section, in conjunction with Part 5, Emergency Plan, of the Early Site Permit Application (ESPA), describes emergency preparedness for a small modular reactor (SMR) facility at the Clinch River Nuclear (CRN) Site. This section contains the information required by 10 CFR 52.17, *Contents of applications; technical information*, and provides references, when appropriate, to Part 5 of the ESPA for additional information.

Tennessee Valley Authority (TVA) is submitting two distinct Emergency Plans for approval by the U.S. Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 52.17(b)(2)(i). Part 5A contains the major features of an emergency plan for a Plume Exposure Pathway (PEP) Emergency Planning Zone (EPZ) at the Site Boundary. Part 5B contains the major features of an emergency plan for a PEP EPZ consisting of an area approximately two miles in radius from the site center point. The Emergency Plans and EPZs are determined based on criteria that the selected SMR design must meet in order for the applicable Emergency Plan and EPZ to apply.

Both plans are based on the existing TVA generic emergency plan. The Emergency Plans comply with 10 CFR 50.47(b) and Appendix E to 10 CFR 50, considering the requested exemptions that are described in Part 6 of the ESPA. Under 10 CFR 52.7, *Specific Exemptions*, which is governed by 10 CFR 50.12, *Specific Exemptions*, the Commission may grant an exemption from the regulatory requirements in 10 CFR 50 if the exemption is authorized by law, will not present an undue risk to public health and safety, and is consistent with the common defense and security. A review of regulatory requirements was undertaken to identify potential exemptions from portions of 10 CFR 50.33(g), 50.47(b) and (c)(2), and Appendix E to 10 CFR 50, to the extent that these regulations apply to specific provisions of onsite and offsite emergency planning, and the regulations, as written, are not appropriate for SMRs. Two sets of exemptions have been developed for SMRs:

1. Exemptions for a PEP EPZ at the Site Boundary
2. Exemptions for an approximate two-mile[1] PEP EPZ

The appropriateness of the exemptions requested in Part 6 of this application is established using a consequence-based approach in accordance with U.S. Environmental Protection Agency (EPA) Protective Action Guides (PAG) (Reference 13.3-1). The proposed EPZ poses no undue risk to public health of safety. A PEP EPZ less than the “about 10 miles” cited in 10 CFR 50.47(c)(2) is justified based upon the significantly reduced risk of radiological release and offsite consequences expected for SMR designs. Specifically, SMR designs will have smaller radionuclide inventory and source terms; the projected rate of progression of postulated accidents is anticipated to be slower; and various design features will eliminate several normally considered design-basis accidents (DBAs). Further, beyond-design-basis accidents (BDBA) are projected to be significantly less likely.

TVA has not selected an SMR reactor technology to be built at the CRN Site. Therefore, a surrogate design has been defined as part of the CRN Site Plant Parameter Envelope (PPE). The surrogate design is reasonable for SMR designs because it has been informed by preliminary information from vendors of SMRs that have begun pre-application discussions (for design certifications) with the NRC. During preparation of a Combined License Application

1. The two-mile PEP EPZ corresponds to a radius of approximately two miles around the reactor center point, accounting for such conditions as demography, topography, land characteristics, access routes, etc.

(COLA), when TVA has selected a reactor design, TVA intends to demonstrate that the selected design conforms with the criteria described herein.

In the COLA, TVA intends to include one complete and integrated Emergency Plan; i.e., either the Part 5A Emergency Plan or Part 5B Emergency Plan based upon the selected SMR reactor technology.

The COLA Emergency Plan will demonstrate that the design of the facility presented in the COLA falls within the design parameters postulated in the ESPA. The Emergency Plan submitted as part of the COLA will be revised, as necessary, to address the selected SMR technology and it will reflect the appropriate regulatory exemptions, as approved by the NRC. The Emergency Plan submitted will require additional information to be addressed when TVA submits the COLA for the CRN Site, either within the Emergency Plan or as Emergency Plan Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC).

Certain aspects of the technology-specific Emergency Action Levels (EALs) required by 10 CFR 50.47(b)(4) and 10 CFR 50 Appendix E Section IV.B cannot be completed until actual as-built information is available and the Technical Specifications are finalized. TVA will adopt an EAL scheme consistent with industry standards developed to address SMR technology.

Basis for Emergency Preparedness Approach

TVA is committed to protecting the health and safety of the public as its highest priority. One important element in maintaining this commitment is planning for accidents.

NUREG-0396, *Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants*, introduced the concept of generic EPZs as the basis for preplanned response actions that would result in dose savings in the environs of a nuclear facility in the event of a reactor accident. The task force that developed NUREG-0396 considered several possible rationales for establishing the size of the EPZs, including risk, cost effectiveness, and the accident consequence spectrum. After reviewing these alternatives, the task force concluded that the objective of emergency response plans should be to provide dose savings for a spectrum of accidents that could produce offsite doses in excess of the EPA PAG. This rationale established bounds on the planning effort and identified the necessary planning elements. It also resulted in a planning basis that is easily stated and understood in terms of areas (or distances), timeframes, and radiological characteristics that correspond to the consequences of a wide range of possible accidents. This dose-based, consequence-oriented guidance also provided consistency and uniformity in the planning recommendations made to State and local governments.

10 CFR 50.47(b)(11) states, in part, that the onsite and offsite emergency response plans for nuclear power reactors shall include exposure guidelines consistent with EPA Emergency Worker and Lifesaving Activity Protective Action Guides. NUREG-0396 established a PEP EPZ of about 10 miles for large LWRs. NUREG-0396 and EPA-400 identified the PAG dose guidelines as doses at which public protective actions should be considered and undertaken. The revised EPA PAG (issued in 1992 as EPA-400-R-92-001) provides that licensed facilities that can demonstrate that accident doses at the Site Boundary would not exceed the PAG should not be required to have either defined EPZs or comprehensive offsite emergency planning.

SMRs currently being designed incorporate design features that provide inherent improvements in safety and security, relying more upon natural processes, such as natural circulation, and less on active safety features. Security features are also built into the design to enable protection against terrorist threats more effectively and more efficiently. Design features that include, for

example, smaller radionuclide inventory, fewer accidents, reduced accident severity, slower rate of accident progression, underground construction, result in smaller radiological source terms.

The NRC has been evaluating a potential change in regulations regarding EPZ size for several years. In 2015 the NRC staff recommended that the NRC Commissioners initiate rulemaking to change regulations and guidance to allow dose-based, consequence-oriented EPZ sizing. The Commission approved the staff recommendation and initiated the rulemaking activity, while also directing the staff to consider exemptions from existing regulations for SMR-related applications that are submitted to NRC before the rulemaking is completed.

TVA's ESPA uses an EPZ sizing approach consistent with that recommended by the NRC staff, establishing a PEP EPZ boundary that ensures public protection from dose levels above the 1 rem limit established in the EPA PAG.

Based upon preliminary information received by the SMR vendors and more than two years of meteorology data taken at the site, TVA has concluded that a two-mile radius around the site provides reasonable assurance of public health and safety from any of the SMRs within the PPE. Further, it is possible that at least one of the SMR designs will demonstrate that the 1 rem limit established in the EPA PAG will not be exceeded at the Site Boundary.

TVA has chosen, therefore, to include two Emergency Plans in its application. The Emergency Plan associated with the two-mile PEP EPZ contains the same features as a traditional 10-mile EPZ Emergency Plan. In the case of the PEP EPZ being within the CRN Site Boundary, there is no longer a need for pre-planned, offsite radiological emergency response planning as traditionally defined by the NRC and the Federal Emergency Management Agency (FEMA). The hazards are deemed to be roughly equivalent to those of other industrial or chemical facilities. Therefore, emergency planning would be similar to those types of facilities and addressed in accordance with the State and local Comprehensive Emergency Management Plan (CEMP), sometimes referred to as an all hazards plan. In the case of the Clinch River SMR project, TVA will coordinate with the Tennessee Emergency Management Agency (TEMA) to develop a Multi-Jurisdictional Emergency Response Plan (MJERP) for the CRN Site, which would become part of the State's overall CEMP. Based on preliminary discussions with NRC and FEMA, TVA anticipates these activities and plans would be administered and owned by TEMA, and overseen by FEMA, but not included in the NRC license.

TVA has defined PEP EPZs that are smaller for the CRN Site, reflecting enhancements in safety margins, and the resulting reduced risks associated with the SMR designs being considered under the PPE. Risk-informed emergency planning maintains at least the same degree of public protection as existing plants without as significant an allocation of resources.

SECY-11-0152 recognizes that a scalable EPZ approach would allow for regulatory predictability for SMR applicants and for State and local officials; ensure the consistent application of NRC regulations and requirements in the review of emergency plans prepared for SMRs; and, most importantly, be consistent with the objectives of current emergency preparedness requirements and not result in a reduction in the protection of public health and safety. Approval of a scalable EPZ for the CRN Site also supports the TVA objective to demonstrate SMR technology: siting and building SMRs with a scalable EPZ size has benefits beyond TVA, as a number of utilities are planning to retire many older, obsolete fossil plants within the next several years, and the potential for SMRs as a viable repowering option has come into focus as a solution for fuel diversity and clean air considerations. For SMRs to replace many of these retiring fossil plants, an appropriately-sized EPZ will be a critical prerequisite because of the locations and site characteristics.

The approach for establishing a scalable EPZ, as described in the ESPA, is based on enhanced safety inherent in the design of SMRs (e.g., increased safety margin, reduced risk, smaller and slower fission product accident release, and reduced potential for dose consequences to population in the vicinity of the plant); concepts described in SECY-11-0152 utilizing the existing emergency preparedness regulatory framework and dose savings criteria of NUREG-0396; and the significant body of risk information available to inform the technical basis for SMR-appropriate EPZ-sizing, including severe accident information developed since NUREG-0396 was published in 1978. The EPZs established in the ESPA include criteria that will be demonstrated by the selected SMR design, using design- and site-specific probabilistic risk assessments (PRAs).

A dose/distance approach to establish the PEP EPZ boundary for light water-SMRs reflects the risk-informed concept described above, i.e., emergency plan requirements are commensurate with enhanced safety (e.g., accident source term and associated dose characteristics for the SMR designs). In consideration for establishing an appropriate PEP EPZ size for an SMR facility, it is the Applicant's responsibility to develop and implement the detailed methodology and criteria for review and approval by the NRC. Accordingly, the ESPA establishes criteria for sizing a PEP EPZ that the selected SMR design will conform to at the time of COLA submittal.

TVA is submitting two distinct Emergency Plans for approval by the NRC in accordance with 10 CFR 52.17(b)(2)(i). Part 5A contains an Emergency Plan for a PEP EPZ established at the CRN Site Boundary. Part 5B contains an Emergency Plan for a PEP EPZ consisting of an area approximately two miles in radius from the site center point. Both Emergency Plans are submitted for NRC approval in order to resolve site-related issues in advance of a COLA; much of the content of the two plans is identical. A dose-based, consequence-oriented approach results in a PEP EPZ size that is scalable as a function of postulated release from a given design. At the CRN Site, based on preliminary information from the vendors designing the four light-water SMRs under the PPE, the resulting PEP EPZ size (associated with meeting EPA PAG criteria) range from a two-mile radius down to the Site Boundary. Accordingly, the two Emergency Plans included in the ESPA correspond to a two-mile and a Site Boundary PEP EPZ.

Both Emergency Plans are reflective of enhanced safety features and associated reduced risk. The Emergency Plan that coincides with the PEP EPZ at the Site Boundary is associated with projected accident releases that, consistent with EPA PAG criteria, do not require a formal offsite radiological emergency response plan, but rather represent a risk commensurate with other industrial hazards that can be adequately managed using an all-hazards approach to emergency planning. The other Emergency Plan reflects a PEP EPZ that establishes a plant-specific offsite radiological emergency response plan developed consistent with the guidance presented in NUREG-0654, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants (FEMA-REP-1)*, similar to those currently in use at operating nuclear power reactors, but with a smaller radius, again, commensurate with a reduced risk. The latter plan is provided in the event the selected design cannot meet the postulated release threshold required for the Site Boundary EPZ.

The two-mile Emergency Plan is representative of any future scalable (non-site boundary) PEP EPZ for any future SMR deployment. The same is true for the Site Boundary Emergency Plan, meaning the exemptions from existing regulations would inform NRC rulemaking and future applicants of the emergency preparedness requirements applicable to designs with sufficient safety margins and available land to ensure public health and safety is assured comparable to other industrial hazards.

The Site Boundary Emergency Plan represents the most significant departure from past practice. Both Emergency Plans have been developed consistent with TVA's Generic Radiological Emergency Plan and site-specific appendices.

As discussed in further detail in Subsection 13.3.3.1.3.3, establishment of the PEP EPZ at the Site Boundary would not require the development of formal offsite radiological emergency response plans and offsite protective actions would be addressed in accordance with an offsite CEMP.

For the Site Boundary EPZ, involvement by offsite response organizations (OROs) is dictated by the governing CEMP, and not subject to NRC/FEMA review and approval. This approach is consistent with establishing emergency planning commensurate with risk, i.e., wherein a reduced-risk SMR is at a level of risk, at least qualitatively, consistent with or lower than other industrial hazards governed by such a CEMP.

Currently, the NRC bases its finding of reasonable assurance on its review of onsite emergency preparedness and requires a finding from FEMA on the adequacy of State and local radiological emergency response plans, consistent with the Memorandum of Understanding (MOU) between NRC and FEMA Relating to Radiological Emergency Planning and Preparedness (Refer to Appendix A to Part 353). 44 CFR 350(b) directs FEMA's Radiological Emergency Preparedness (REP) Program to review State and local radiological emergency plans and preparedness. Approved plans and preparedness must be determined to adequately protect the public health and safety by providing reasonable assurance that appropriate protective measures can be taken offsite in the event of a radiological emergency. If the PEP EPZ was established at the Site Boundary, no such approval would be required.

However, establishment of the PEP EPZ at the Site Boundary would not affect the authority that FEMA has under its regulations in 44 CFR Chapter I for overall emergency management and assistance to state and local response organizations, nor would it affect the responsibilities of state and local governments to establish and maintain CEMPs. TVA expects to coordinate with TEMA as appropriate under either plan, irrespective of NRC approval of the TVA plans.

13.3.1 Physical Characteristics

13.3.1.1 Site Description

Chapter 2 provides a detailed description of the CRN Site and provides additional information regarding the physical characteristics of the proposed site, including the preliminary site layout and potential hazards in the site vicinity.

The CRN Site lies north of U.S. Interstate 40, approximately midway between the communities of Harriman and Farragut in the eastern portion of Tennessee. The United States Department of Energy’s (DOE’s) Oak Ridge Reservation (ORR) borders the north and east sides of the Clinch River Property, which covers an area of approximately 1200 acres located adjacent to the Clinch River Arm of the Watts Bar Reservoir in Oak Ridge, Tennessee.

This property comprises the Owner Controlled Area and the Site Boundary for the purposes of defining the area within which TVA can limit access for any reason. Part 5A contains the CRN Site Emergency Plan for a PEP EPZ consisting of the area at the Site Boundary. The CRN Site is defined as the Clinch River Property proposed as the location to construct and operate SMRs.

13.3.1.2 Area Population

The permanent resident population has been estimated using Census block data obtained from the U.S. Census 2010 and is projected to 2015 for this analysis. To determine the permanent resident population, the block data was loaded directly into geographic information systems (GIS) software and the permanent resident population and number of households were calculated. According to the U.S. Census 2010 data, projected to the year 2015, there are 856

permanent residents within the two-mile PEP EPZ of the CRN Site. According to the 2010 U.S. Census data, projected to the year 2015, there are approximately 186,500 permanent residents within 15 miles of the proposed CRN Site[2]. Additional details on the permanent resident population within the two-mile PEP EPZ are provided in the Evacuation Time Estimate (ETE) Report provided in Part 5B of the ESPA for the two-mile PEP EPZ.

A survey of the transient facilities was conducted to obtain information regarding the transient population expected at these locations. The survey was designed to obtain information related to the number of units at each facility, average yearly occupancy, average number of persons per occupied unit and average number of vehicles per occupied unit. The survey was used to estimate peak attendance at transient facilities. There is one campground/RV park within the two-mile PEP EPZ with an estimated peak population of 197 persons.

The ETE does not identify any physical characteristics unique to the CRN Site which pose significant impediments to the development of the Emergency Plan for the CRN Site. The roadway network is modeled in the ETE and is shown to be sufficient to handle the volume of traffic in the event of an emergency.

13.3.2 Emergency Plan

Part 5 of the ESPA contains the major features of two distinct Emergency Plans. Part 5A contains the CRN Site Emergency Plan for a PEP EPZ consisting of the area at the Site Boundary. Part 5B contains the CRN Site Emergency Plan for a PEP EPZ consisting of an area approximately two miles in radius surrounding the CRN Site.

Both CRN Site Emergency Plans include the following documents:

- TVA Generic Emergency Plan (as modified to include the CRN Site).
- CRN Site-specific appendix.

Part 5B also contains a CRN Site ETE Report associated with the two-mile PEP EPZ.

State, county, and city certification is discussed in Subsection 13.3.5.

13.3.3 Emergency Planning Zones

Sections 50.33(g) and 50.47(c)(2) of 10 CFR 50 and 10 CFR 50 Appendix E establish requirements for the size of the PEP EPZ and ingestion exposure pathway EPZ, and for the scope of emergency planning within these EPZs. The EPZs for the CRN Site are based on these requirements and the requested exemptions contained in Part 6 of the ESPA.

13.3.3.1 Plume Exposure Pathway Emergency Planning Zone

Part 5 contains two distinct Emergency Plans that are based upon the size and configuration of PEP EPZs that encompass the areas in which the plume exposure doses could exceed the EPA PAG, and for which there is a substantial risk that doses at which significant early health effects may occur. Emergency Plans are included in Part 5 based on two distinct sizes of the PEP EPZ:

2. NUREG/CR-7002, *Criteria for Development of Evacuation Time Estimate Studies*, indicates a 15-mile “shadow evacuation” as a factor licensees should consider in developing evacuation time estimates. No attempt is made in this ESPA to justify a smaller shadow evacuation radius (i.e., proportional to a two-mile EPZ), but rather a “standard” 15-mile radius is assumed for this application, which provides additional margin.

1. PEP EPZ consisting of the area at the Site Boundary (Emergency Plan 5A).

2. PEP EPZ consisting of an area approximately two miles in radius surrounding the CRN Site (Emergency Plan 5B).

The size and configuration of the approximately two-mile PEP EPZ surrounding the CRN Site was determined in relation to the local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. An illustration of the approximately two-mile PEP EPZ is provided in Part 5B.

The TVA approach is based on:

1. the expectation of enhanced safety inherent in the design of SMRs to significantly reduce the risk of radiological release and offsite consequences, including:

   – increased safety margin;

   – smaller cores and source terms;

   – reduced magnitude and probability of potential accident sequences; and

   – slower accident progressions that allow more time to implement mitigative actions.

2. application of the significant body of risk information available to inform the technical basis for the PEP EPZ size, including:

   – BDBA information developed since NUREG-0396 was published in 1978, including NUREG-1465;

   – information from the design-specific and plant-specific PRAs which address the use of a suitable design-specific PRA and accounting for uncertainties;

   – information from the PRA required for new plant designs to inform accident sequence selection, determine release timing and release magnitude, and determining offsite doses; and

   – operationally-focused mitigation capability and other features to address beyond-design-basis events (BDBEs).

The proposed technical criteria for determining the EPZ size consider the utilization of the existing emergency preparedness regulatory framework and dose saving criteria established in NUREG-0396. In summary, the proposed technical criteria for determining the EPZ size are:

- The EPZ should encompass those areas in which projected dose from design DBAs could exceed the EPA PAG.

- The EPZ should encompass those areas in which consequences of less severe core melt accidents could exceed the EPA PAG.

- The EPZ should be of sufficient size to provide for substantial reduction in early severe health effects in the event of more severe core melt accidents.

Additional detail on each criterion is described in Subsections 13.3.3.1.1 and 13.3.3.1.2, below.

13.3.3.1.1 Environmental Protection Agency Protective Action Guides

The primary purpose of the CRN Site PEP EPZ is to encompass those areas in which the plume exposure doses from DBAs and less severe core melt accidents could exceed the EPA PAG. Thus, areas outside of the CRN Site PEP EPZ would meet the EPA PAG dose limit of less than 1 rem total effective dose equivalent (TEDE) using 50 percent meteorology.

For the surrogate design in the ESPA PPE, a large break loss of coolant accident (LOCA) is selected as the reasonably bounding DBA. Qualitative projections of less severe BDBEs were considered in determining potential dose consequences are unlikely to exceed the EPA PAG limit, as PRA results do not exist for the surrogate design used in the ESPA PPE. For the selected SMR design, the COLA will confirm dose consequences outside the PEP EPZ do not exceed the EPA PAG limit of less than 1 rem TEDE for less severe BDBEs.

The methodology for verifying that dose consequences beyond the PEP EPZ do not exceed the EPA PAG limits includes:

- Step 1 - selecting appropriate accident scenarios;
- Step 2 - determining source terms for selected accident scenarios (source term in this context refers to fission product release to the environment as a function of time);
- Step 3 - calculating the dose consequences for selected accident scenarios at the PEP EPZ boundary; and
- Step 4 - comparing the dose consequences for selected accident scenarios with the EPA PAG.

Details on how each of these steps is performed are discussed below.

Step 1 - Accident Scenario Selection: DBA scenarios are identified in the postulated accidents defined in Final Safety Analysis Report (FSAR) Chapter 15 of the COLA.

Less severe core melt accidents include intact-containment, BDBA scenarios and accident scenarios with a mean Core Damage Frequency (CDF) >1 x 10^{-6} per reactor-year (rx-yr). The results from the plant-specific PRA are used to select scenarios through the following process:

- Initial selection: Select accident sequences with mean CDF > 1 x 10^{-8} per rx-yr.
- Sequence evaluation: Evaluate dominant cut sets for the > 1 x 10^{-8} per rx-yr sequences. Determine system and equipment availabilities and accident sequence timing.
- Scenario grouping: Group sequences with similar timing to core damage and similar equipment availabilities into accident scenarios.
- Scenario selection: Select accident scenarios with mean CDF > 1 x 10^{-6} per rx-yr.[3]

Step 2 - Accident Source Term Evaluation: DBA accident source terms are defined for Postulated Accidents in FSAR Chapter 15 of the COLA.

Less severe core melt accident scenario source terms are determined based on an NRC-accepted methodology.

3. If no scenarios are identified for a CDF > 1 x 10^{-6}, then a suitable surrogate source term and release sequence will be developed and justified.

Step 3 - EPZ Boundary Consequence Evaluation: The EPZ boundary consequences are calculated based upon a methodology that includes the following elements:

- Calculation of TEDE for cloud, inhalation, ground, and resuspension for the PEP EPZ.
- Assumption that ad hoc protective actions are taken beyond the PEP EPZ boundary. These ad hoc actions would involve relocating people from regions outside the PEP EPZ as appropriate. The timing of these protective actions is discussed further below.
- Appropriate BDBA analysis code input parameters for the applicable site and design-specific source terms.

The PEP EPZ boundary consequence calculation methodology for DBAs differs from that used for offsite dose in Chapter 15 analyses in that it is based on the methodology typically used in BDBA dose calculations.

The EPA PAG Manual (Reference 13.3-1), published in 1992, states that the PAG should be compared against the projected dose exposure during the first four days following the start of release. The four-day exposure was chosen based on the time needed to make measurements, reach decisions, and prepare to implement relocation. The four-day assumption is also included in the 2013 PAG Manual draft for interim use and public comment. Given modern technology such as GPS devices, remote monitoring, and in situ monitors with real time data transmittal, it is reasonable to assume that measurements would be made promptly—within a few hours. Once decisions on protective actions were made, notifications using traditional methods plus more modern approaches such as text messaging, internet, and social media could also be accomplished quickly. Relocations would be expected to take place within a few hours, based on typical evacuation time estimates. Thus, it is apparent that application of the four-day exposure assumption provides significant additional margin.

Step 4 - Comparison of Dose with PAG: The calculated dose consequences for DBAs and less severe core melt accidents at the PEP EPZ boundary are confirmed to not exceed the EPA PAG listed earlier in this section.

13.3.3.1.2 Substantial Reduction in Early Health Effects

The size and configuration of the CRN Site PEP EPZ also encompasses those areas in which there is a substantial risk that the plume exposure doses from more severe (less frequent) core melt accidents could exceed the doses at which significant early health effects may occur. Thus, for areas outside of the CRN Site PEP EPZ, to provide assurance of substantial reduction in early health effects, the conditional probability of dose exceeding 200 rem (whole body) for more severe core melt accident scenarios is $< 1 \times 10^{-3}$ per rx-yr.

This limit is similar to the limit used in NUREG-0396 (i.e., that the probability of exceeding a whole body acute dose of 200 rem drops rapidly as one approaches the PEP EPZ boundary).

Qualitative projections of more severe BDBEs were considered in determining potential dose consequences are unlikely to exceed the limit for substantial reduction in early health effects, as PRA results do not exist for the surrogate design used in the ESPA PPE. For the selected SMR design, the COLA will confirm the conditional probability of exceeding 200 rem (whole body) outside the PEP EPZ $< 1 \times 10^{-3}$ per rx-yr.

The methodology for verifying that areas outside of the CRN Site PEP EPZ meet the limits for substantial reduction in early health effects includes:

- Step 1 - Selecting appropriate accident scenarios.
- Step 2 - Determine source terms for selected accident scenarios (source term in this context refers to fission product release to the environment as a function of time).
- Step 3 - Calculate the dose consequences for selected accident scenarios at the PEP EPZ boundary.
- Step 4 - Calculate the distance at which the conditional probability to exceed 200 rem (whole body) exceeds 1 x 10^{-3} rx-yr.
- Step 5 - Compare that distance with the PEP EPZ.

Details on how each of these steps is performed are discussed below.

Step 1 - Accident Scenario Selection: More severe core melt accident scenarios include postulated containment failure/bypass accidents with the potential for higher consequences with mean CDF > 1 x 10^{-7} per rx-yr. In performing the accident sequence grouping as part of scenario selection, accident sequences with mean CDF > 1 x 10^{-8} per rx-yr should be considered in the initial sequence selection.

The set of accident scenarios with mean CDF > 1 x 10^{-7} per rx-yr is intended to encompass the less probable, more severe core damage scenarios. Use of 1 x 10^{-7} per year frequency as a basis for sequence selection has a number of precedents. The precedents include:

- NUREG-1338 and NUREG-1420 use a cutoff of 1 x 10^{-7} per year.
- NUREG-1150 uses a frequency cutoff of 1 x 10^{-7} per year for PRA accident sequence progression.
- Regulatory Guide 1.174 specifies that an increase of 1 x 10^{-7} per year in large early release frequency is permitted for proposed plant design changes.
- NUREG-0396, Figure 1-11, has a conditional probability range down to 1 x 10^{-3}, which corresponds to ~1 x 10^{-7} per year absolute frequency.
- The lowest frequency considered in NUREG-1860 was 1 x 10^{-7} per year. NUREG-1860 also states in Volume 2, Section C.3.7 that, “… the Framework would require EP to consider accident sequences down to a frequency of 1 x 10^{-7}/rx-yr, but no lower.”

Step 2 - Accident Source Term Evaluation: More severe core melt accident scenario source terms are determined based on an NRC-accepted methodology.

Step 3 - PEP EPZ Boundary Consequence Evaluation: PEP EPZ boundary consequence calculations for less frequent, more severe BDBEs will be based on the methodology accepted for the certified SMR BDBA source terms. The relevant consequence parameter is to provide substantial reduction in early severe health effects. Following the NUREG-0396 framework, this is represented by the probability of dose exceedance for a dose that could cause early severe health effects. For a given source term and site, the probability of dose exceedance tends to decrease as distance from the reactor increases.

Step 4 - Calculate the Conditional Probability of Exceeding the Dose at Which Early Health Effects May Occur: The conditional probability is computed in the following manner:

- For each of the selected accident scenarios the probability of exceeding 200 rem whole body acute dose is calculated as a function of distance (based on plume dispersion and thus radionuclide concentration in the plume being a function of distance).

- For a given distance, the scenario frequency-weighted probabilities are summed over all scenarios.

- The probability is normalized (divided) by total CDF.

- The normalized sums versus distance are plotted and the distance at which the result drops below 1 x 10^{-3} is determined.

Step 5 - Comparison against Substantial Reduction in Significant Health Effects Limit: The distance at which the calculated conditional probability of the dose consequences for more severe core melt accidents are determined to drop below 1 x 10^{-3}/rx-yr is confirmed to be contained within the PEP EPZ.

13.3.3.1.3 Additional Topics Related to the PEP EPZ

13.3.3.1.3.1 Multiple Reactors at the CRN Site

The surrogate design in the ESPA PPE includes multiple reactor units, and it is anticipated that the SMR design included in the COLA will also include multiple reactor units.

The reactor design complies with the requirements in 10 CFR 50 Appendix A, Criterion 5 — *Sharing of structures, systems, and components*, which states that, “Structures, systems, and components important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.” The design also complies with the criteria in NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition*, Section 19.0, *Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors*, which ensure that multi-module plants are designed and operated in such a way to prevent multiple core damages, to demonstrate that the accident sequences are not significant contributors to risk and large release events, and, if these events should occur, to mitigate their impact on the public health and safety.

As such it is not expected that DBAs or BDBEs would involve more than one reactor, and they are treated on a per-reactor basis. This means that source terms and dose consequences for a particular accident scenario are calculated for a single reactor.

The CRN Site’s programs to mitigate BDBEs, as described in Subsection 13.3.3.1.3.2, enhance the onsite emergency response capabilities for multi-unit events. The Emergency Plans in Part 5 include the means to determine and continually assess the magnitude of release from all reactor cores and spent fuel pools onsite, and sufficient staffing and communications capabilities to respond to a site-wide beyond-design-basis external event. The COLA will include Diverse and Flexible Coping Strategies that provide sufficient equipment and supporting staff to enable the core cooling, containment, and spent fuel pool cooling functions to be maintained or restored for all the power reactor units on the site.

13.3.3.1.3.2 Mitigation of Beyond-Design-Basis Events

Uncertainties, such as scenarios that may be difficult to quantify, extreme external events, malevolent acts, etc., are addressed through several means. The CRN Site will develop and

maintain strategies for the mitigation of BDBEs and the management of severe accidents as part of an integrated response capability, including supporting requirements for command and control, drills, training, and change control. BDBE mitigation and severe accident management strategies will reflect the capabilities and features of the facility-specific design. Additionally, compliance with the Mitigation of Beyond-Design-Basis Events (MBDBE) proposed rule (Reference 13.3-2), provides for significant additional confidence that such events would not result in impacts to public health and safety beyond the capabilities of the site to manage; this includes assessment of malevolent acts as well as prepositioning regional assets for mitigating BDBEs. As described in Subsection 13.3.3.1.3.1, the COLA will include Diverse and Flexible Coping Strategies that provide sufficient equipment and supporting staff to enable the core cooling, containment, and spent fuel pool cooling functions to be maintained or restored for all the power reactor units on the site. Pre-planned strategies in the Emergency Plan also provide a substantial base to expand emergency response actions beyond the established PEP EPZ boundaries, if needed.

13.3.3.1.3.3 Comprehensive Emergency Management Plan

The offsite component of the Emergency Plan for the two-mile PEP EPZ is developed in accordance with the guidance in NUREG-0654, considering requested exemptions that are described in Part 6 of the ESPA.

EPA PAG guidance provides that if EPA PAG cannot be exceeded offsite, EPZs need not be established for such cases (Reference 13.3-1). Therefore, formal offsite radiological emergency plans, such as those prepared for a two-mile PEP EPZ, are not necessary for a Site Boundary PEP EPZ.

The NRC requires a level of emergency preparedness commensurate with the potential consequences to public health and safety and common defense and security at the CRN Site. The Emergency Plans presented in Part 5 consider the proposed exemptions contained in Part 6 of the ESPA. Implementation of the Site Boundary PEP EPZ as in Part 5A does not rely on specific offsite actions. Projected consequences are such that conditions exceeding pre-planned actions can be carried out with ad hoc protective actions. This approach is described in more detail below. As addressed in the FEMA's Comprehensive Preparedness Guide 101, *Developing and Maintaining Emergency Operations Plans* (CPG-101) (Reference 13.3-3), if determined appropriate, government officials may utilize a CEMP approach to emergency planning to implement ad hoc protective actions to protect the public (Reference 13.3-3).

Although the likelihood of an accident or event resulting in offsite doses beyond the EPZ boundary exceeding the EPA PAG is extremely remote, the CRN Site Emergency Plan will describe the capabilities to determine if a radiological release is occurring and promptly communicate that information to OROs authorities for their consideration. Each ORO is responsible for deciding what, if any, protective actions should be taken based on its CEMP. The remainder of this section discusses the relationship of the Emergency Plan for the Site Boundary PEP EPZ to a CEMP.

A CEMP in this context, also referred to as an emergency operations plan or all hazards plan, is addressed in FEMA's CPG 101 (Reference 13.3-3), the foundation for State, territorial, Tribal, and local emergency planning in the United States. CPG-101 promotes a common understanding of the fundamentals of risk-informed planning and decision-making, and helps planners at all levels of government in their efforts to develop and maintain viable, all-hazards, all-threats emergency plans. A CEMP is flexible enough for use in all emergencies, and in the case of an Emergency Plan for the Site Boundary PEP EPZ, provides for adequate offsite response. It describes how people and property will be protected; details who is responsible for carrying out specific actions; identifies the personnel, equipment, facilities, supplies and other resources available; and outlines how all actions will be coordinated.

Given modern technology such as GPS devices, remote monitoring, and in situ monitors with real time data transmittal, it is reasonable to assume that radiological measurements would be made promptly—within a few hours. Once decisions on protective actions were made, notifications using traditional methods and more modern approaches such as text messaging, internet, and social media could also be accomplished quickly. Public relocations would be expected to take on the order of a few hours based on the location and population density characteristics of the CRN Site.

In addition to the accident frequencies discussed in Subsections 13.3.3.1.1 and 13.3.3.1.2, projected accident progression durations provide ample time to implement operationally-focused mitigation strategies and, if necessary, for offsite authorities to implement protective actions using a CEMP approach. Finally, additional assurance exists via compliance with the MBDBE proposed rule (Reference 13.3-2) that safety functions will be maintained in the highly unlikely event BDBEs. Together, these attributes provide significant confidence in protection of public health and safety.

13.3.3.1.4 COLA

TVA intends to include one complete and integrated Emergency Plan in the COLA based upon the selection of the SMR reactor technology. TVA intends to demonstrate that the design of the facility presented in the COLA falls within the design parameters postulated in the ESPA.

If the dose consequences of the SMR technology do not exceed the EPA PAG at the Site Boundary and do not present a substantial risk that doses at which significant early health effects may occur, then TVA could elect to establish the PEP EPZ at the Site Boundary in the COLA. In this scenario, TVA will coordinate with the OROs regarding establishment of the PEP EPZ boundary. If the requested exemptions that are described in Part 6 of the ESPA, related to the Part 5A Emergency Plan are approved, it would not affect the authority that FEMA has under its regulations in 44 CFR Chapter I for overall emergency management and assistance to State and local response organizations, nor would it affect the responsibilities of State and local governments to establish and maintain CEMPs.

If the dose consequences of the SMR technology do not exceed the EPA PAG at a two-mile radius and do not present a substantial risk that doses at which significant early health effects may occur, then TVA could elect to establish the PEP EPZ at an approximate two-mile radius in the COLA with consideration given to local emergency response needs and capabilities, including considerations of demography, topography, land characteristics, access routes, and jurisdictional boundaries. If the requested exemptions that are described in Part 6 of the ESPA, related to the Part 5B Emergency Plan are approved, the NRC would base its finding of reasonable assurance on its review of the onsite emergency preparedness and would require a finding from FEMA on the adequacy of State and local radiological emergency response plans. 44 CFR 350(b) directs FEMA's Radiological Emergency Preparedness (REP) Program to review State and local radiological emergency plans and preparedness. Approved plans and preparedness must be determined to adequately protect the public health and safety by providing reasonable assurance that appropriate protective measures can be taken offsite in the event of a radiological emergency.

If the dose consequences of the selected technology exceed the EPA PAG or present a substantial risk that doses at which significant early health effects may occur for the PEP EPZ boundary at a two-mile radius, then neither Emergency Plan included in Part 5 of this ESPA will be incorporated by reference in the COLA and a new Emergency Plan will be included in the COLA for NRC review.

The previous discussion regarding dose consequences and the selected EPZ that TVA could elect to describe in the COLA are summarized below:

Summary Determination of EPZ Size

Criteria Satisfied at:	Site Boundary EPZ	Two-Mile EPZ	EPZ Described in COLA
Distance ≤ Site Boundary	X		
Distance > Site Boundary, but ≤ 2 miles		X	
Distance > 2 miles			X

The COLA will include the following detailed information of the selected reactor technology that is pertinent to the Emergency Plan:

- DBA analysis information from Chapter 15 of the FSAR;
- PRA Level 1 information that defines and informs the selection of less severe and more severe accident sequences, including appropriate consideration of extreme external hazards;
- Level 2 PRA information to define fission product releases for the selected less severe and more severe accident sequences; and
- Offsite dose calculations that determine the dose associated with the selected less severe and more severe accident sequences.

The COLA will apply the methodology in Subsection 13.3.3.1.1 for EPA PAG and Subsection 13.3.3.1.2 for Substantial Reduction in Early Health Effects to the selected SMR reactor technology to determine an acceptable PEP EPZ.

The PRA-based evaluation to support the PEP EPZ included in the COLA will be based on plant-specific Level 1 and Level 2 PRA information available at the COLA. The PRA will address the following attributes:

- Applicable plant operating states (modes) including full power, low power and shutdown, and design-specific operating states unique to the selected SMR design (e.g., refueling and/or concurrent power operation and refueling).
- Accident initiators appropriate for PRA evaluation, including internal and external hazards.
- Applicable fuel handling accidents and spent fuel pool accidents.

If necessary to support the COLA, TVA will have an engineering assessment prepared for the reactor design selected in the COLA (qualitative or quantitative, as appropriate) to show that risks assessed by the PRA are adequately treated inside the PRA. For risks not assessed by the PRA, TVA will confirm the existence, functionality, and capability of features and processes in the design, operation, accident management, and emergency response to address any such risks and to provide confidence that the associated risk impact is acceptably low. The COLA will also address, as needed, security, limited operating experience, co-location (if necessary), or risks for which industry standards may not be available.

The PRA methodologies used to support the Emergency Plan will be addressed in the COLA.

13.3.3.2 Ingestion Exposure Pathway

The ingestion exposure pathway EPZ for the CRN Site will be described in the COLA.

13.3.4 Evacuation Time Estimates

An independent ETE study has been performed to provide estimates of the time required to evacuate permanent resident and transient resident populations from the two-mile PEP EPZ for various times of the day, week and year under favorable and adverse weather conditions. For the Emergency Plan in Part 5B, the ETE for evacuation of an approximately two-mile PEP EPZ is detailed in the ETE report provided in Part 5B. The analyses were conducted in accordance with the guidance provided in NUREG/CR-7002. For the Emergency Plan in Part 5A, an ETE study was not performed because the plan does not include evacuation of permanent and transient resident populations surrounding the CRN Site.

13.3.5 Contacts and Agreements

TVA has held numerous discussions with State, county, and local agencies and emergency response organizations. These discussions have been productive and indicative of broad support from these organization in further development of CRN emergency plans, as indicated by letters of support from the State of Tennessee, Anderson County, Roane County, and the City of Oak Ridge (References 13.3-4 through 13.3-7).

Certification letters from the State of Tennessee, Roane County and the City of Oak Ridge will be obtained by TVA and provided in the COLA.

Surrounding emergency response organizations currently support DOE's ORR. TVA will maintain arrangements with local medical facilities to receive patients from the CRN Site. A Letter of Agreement (LOA) for local medical facility services for the CRN Site will be obtained by TVA and provided in the COLA. TVA has an existing agreement with the Radiation Emergency Assistance Center/Training Site in Oak Ridge, Tennessee, for radiological medical support (Reference 13.3-8).

TVA will maintain arrangements for offsite ambulance assistance to the CRN Site. A LOA for ambulance service for the CRN Site will be obtained by TVA and provided in the COLA.

TVA will maintain arrangements for local firefighting support. The senior offsite fire official responding to the CRN Site will coordinate response activities with the TVA Incident Commander. The CRN Site is responsible for providing radiological protection and proper safety clearance in affected areas. A LOA for local firefighting support for the CRN Site will be obtained by TVA and provided in the COLA.

TVA will maintain agreements with local law enforcement agencies to provide law enforcement support when necessary. A LOA for local law enforcement agency support for the CRN Site will be obtained by TVA and provided in the COLA.

13.3.6 References

13.3-1. EPA, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA 400-R092-001, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C., May 1992.

13.3-2. Federal Register, Proposed Rule, *Mitigation of Beyond-Design-Basis Events*, 80 FR 70609, November 13, 2015.

13.3-3. FEMA, “Developing and Maintaining Emergency Operations Plans,” Comprehensive Preparedness Guide (CPG) 101, Ver. 2.0, November 2010.

13.3-4. Letter from David W. Purkey, Deputy Commissioner, Tennessee Emergency Management Agency to Daniel P. Stout, Senior Manager, Small Modular Reactors, TVA, Subject: Support for TVA Small Modular Reactor Project, July 27, 2015.

13.3-5. Letter from Terry Frank, Anderson County Mayor, to Dan Stout, Senior Manager, Small Modular Reactors, TVA, Subject: Support for TVA Small Modular Reactor Project, December 11, 2015.

13.3-6. Letter from Ronald B. Woody, County Executive, and Ron Berry, Commission Chair, Roane County, to Daniel P. Stout, Senior Manager, Small Modular Reactors, TVA, Subject: Support for TVA Small Modular Reactor Project, March 2, 2016.

13.3-7. Letter from Mark S. Watson, City Manager, City of Oak Ridge, to Daniel P. Stout, Senior Manager, Small Modular Reactors, TVA, Subject: Support for TVA Small Modular Reactor Project, February 24, 2016.

13.3-8. Letter from Michele G. Branton, Contracting Officer’s Representative, Department of Energy, to John Parshall, Program Manager, State and Local Emergency Preparedness, TVA, Subject: Letter of Agreement – Radiation Emergency Assistance Center/Training Site (REAC/TS) Support, March 27, 2015.

13.6 PHYSICAL SECURITY

In accordance with 10 Code of Federal Regulations (CFR) 100.21(f), the Clinch River Nuclear (CRN) Site characteristics are such that adequate security plans and measures can be developed pursuant to 10 CFR 73. A security assessment conducted as part of the combined license application (COLA) addresses security for the new units. The COLA addresses site-specific design features of the selected Small Modular Reactor technology that support site security, detailed security monitoring equipment design, and security methods for screening station operating personnel.

The CRN Site is sufficiently large to implement the requirements of 10 CFR 73.55, including adequate distances between safety-related structures and the required security boundaries and consideration of land-based and waterborne vehicle bombs. Spatial separation is not limited because of natural topography of the CRN Site and planned structures for the site would not limit spatial separation.

Because the CRN Site is bordered on the east, west, and the south by the Clinch River arm of the Watts Bar Reservoir, vehicle access is limited to the north and northeast side of the property. Additionally, no highways, railroads, or waterways traverse the exclusion area, owner controlled area, or protected area.

The CRN Site is not remote such that availability of material, equipment, or services would be delayed in support of maintaining security systems and operations.

No security hazards were identified in the CRN Site vicinity.

The effects of acute and prolonged exposure to severe weather and resulting environmental conditions are not expected to challenge engineered controls and administrative controls for operations. Engineered and administrative controls are not challenged in the event of flooding or low water at the CRN Site, and minimum standoff distances are not impacted by flooding or low water.

The geological and seismology characteristics for the CRN Site have been determined to be suitable for the seismic design of a plant falling within the plant parameter envelope. The identified regional seismic characteristics do not challenge or pose an impediment to engineered and administrative controls required for a physical protection system. Security plans and measures can be developed that comply with applicable codes and standards for the structural designs and specifications and provide assurance of systems or equipment capable of operating in anticipated seismic conditions.

Because the detailed site layout design has not been finalized at the Early Site Permit Application stage, TVA has not identified possible planned culverts or unattended openings that could extend from the outside to the inside of the designated Protected Area. The site-specific security assessment conducted for the COLA identifies and describes the specific security design features implemented to address planned culverts or unattended openings. The resulting Security Plan describes the measures taken to ensure assessment, observation, detection, and surveillance requirements are met, and/or appropriate barriers are installed to prevent potential exploitation of any planned culverts or unattended openings.