



# TVA Clinch River SMR Project The PPE Approach to ESPA and Emergency Planning Exemptions

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NUC workshop - Innovations in Advanced Reactor Design, Analysis, and Licensing  
Centennial Campus at NCSU, Raleigh NC. September 17-18, 2019

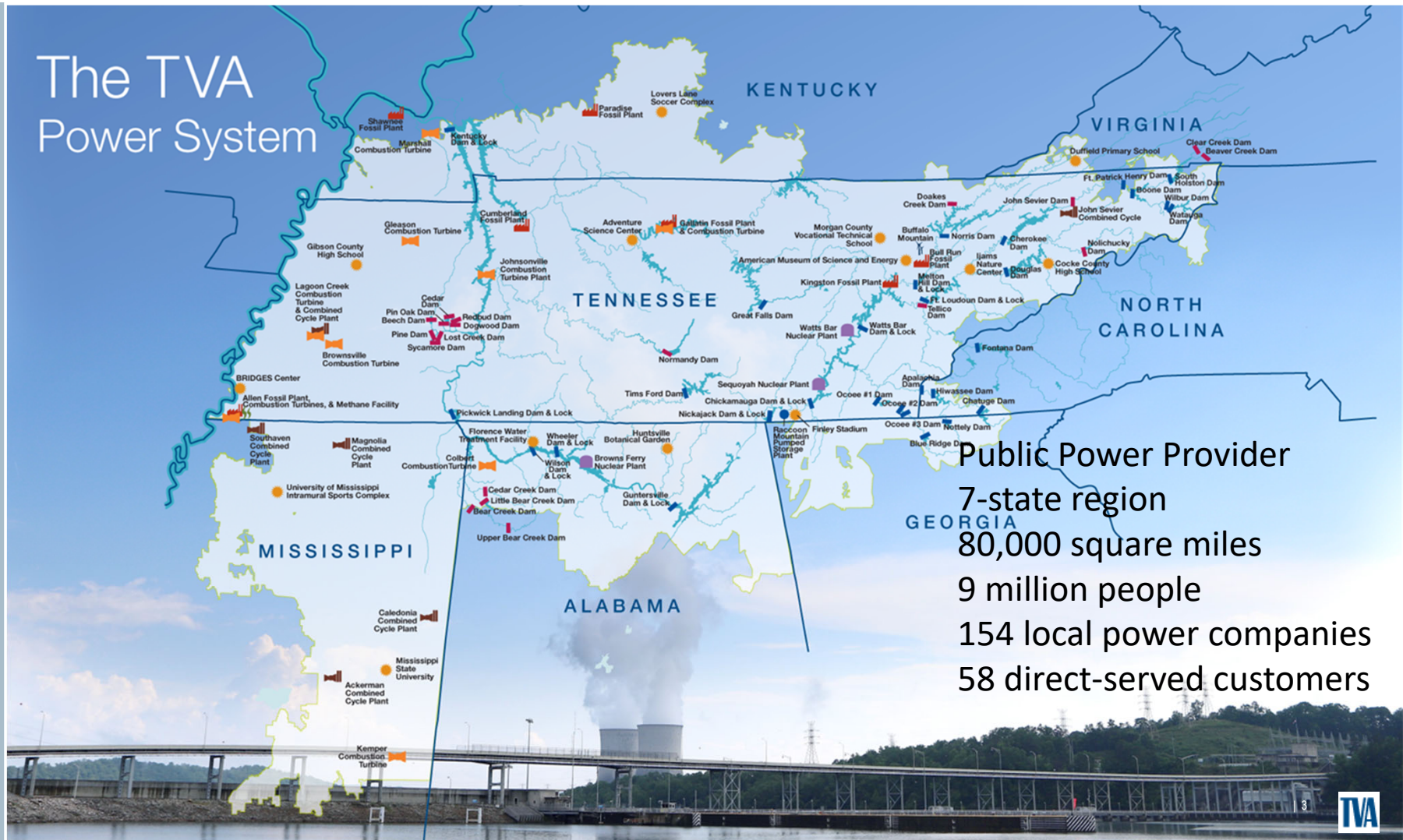


# TVA Created in 1933 to Make Life Better



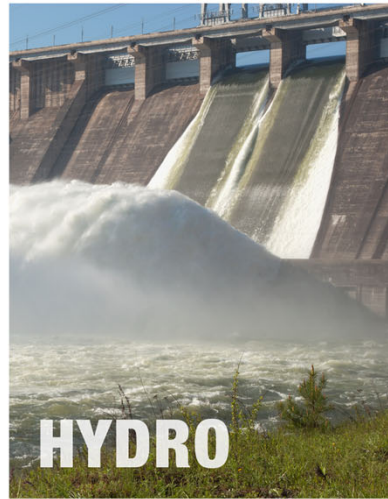
**“...a Corporation clothed with the power of government, but possessed of the flexibility and initiative of a private enterprise.”**  
- Franklin D. Roosevelt

# The TVA Power System

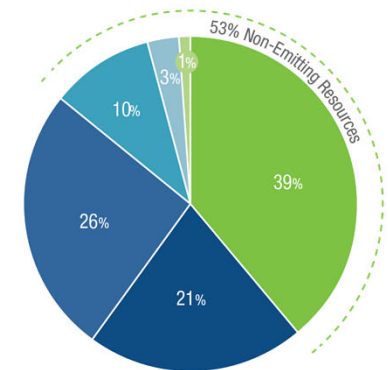




# Investing in Cleaner Energy



FY18 Actual Power System Mix



Generating Sources

- Coal
- Gas
- Nuclear
- Hydro
- Wind and Solar
- TVA Energy Efficiency

# Small Modular Reactors (SMRs)

SMRs are a next-generation nuclear technology with potential for improved safety and increased operational flexibility. SMRs,

- Support TVA's technology innovation mission
- Are consistent with TVA's vision to be one of the nation's leaders in cleaner, low-cost energy.
- Are defined as nuclear reactors 300MWe or less, enabling factory fabrication
- Could safely shut down and self-cool, with no operator action, no electrical power, and no additional water
- Have smaller reactor core inventory and radiological source terms
- Have slower accident progression and time to fuel damage is long enough to allow ad-hoc emergency planning
- Have the potential for reduced emergency planning zones

# Comprehensive Site Selection Process



## Program Background

- 2009 TVA began exploring potential SMR Project
- 2014 - TVA shifts to PPE approach

## Potential Candidate Areas

- Naval Support Activity Mid-South
- Oak Ridge Reservation
- Redstone Arsenal
- Arnold Air Force Base
- Columbus Air Force Base
- Fort Campbell

## Regional Screening Criteria

- Seismology considerations
- Cooling-water availability
- Population density
- Proximity to targeted customer



# Clinch River Site Oak Ridge Reservation

- TVA Managed Property, Owned by the United States of America
- Clinch River Site - 935 acres
- Barge/Traffic Area - 196 acres
- Neighbor to DOE ORNL, an interested customer
- Access to 500 KV and 161 KV transmission
- Site of former Clinch River Breeder Reactor Project
- Not currently used for power generating activities
- Some basic infrastructure exists (e.g., retention ponds, roads)
- Strong community support
- Abundant and skilled workforce



# Early Site Permit Application

## **Application includes:**

- Site Safety Analysis Report (SSAR)
- Environmental Report (ER)
- Emergency Plans (EP) (Part 5A, “Site Boundary” and Part 5B, “Two-Mile”)
- Exemptions and Departures (Part 6)

## **ESPA based on a “plant parameter envelope” (PPE)**

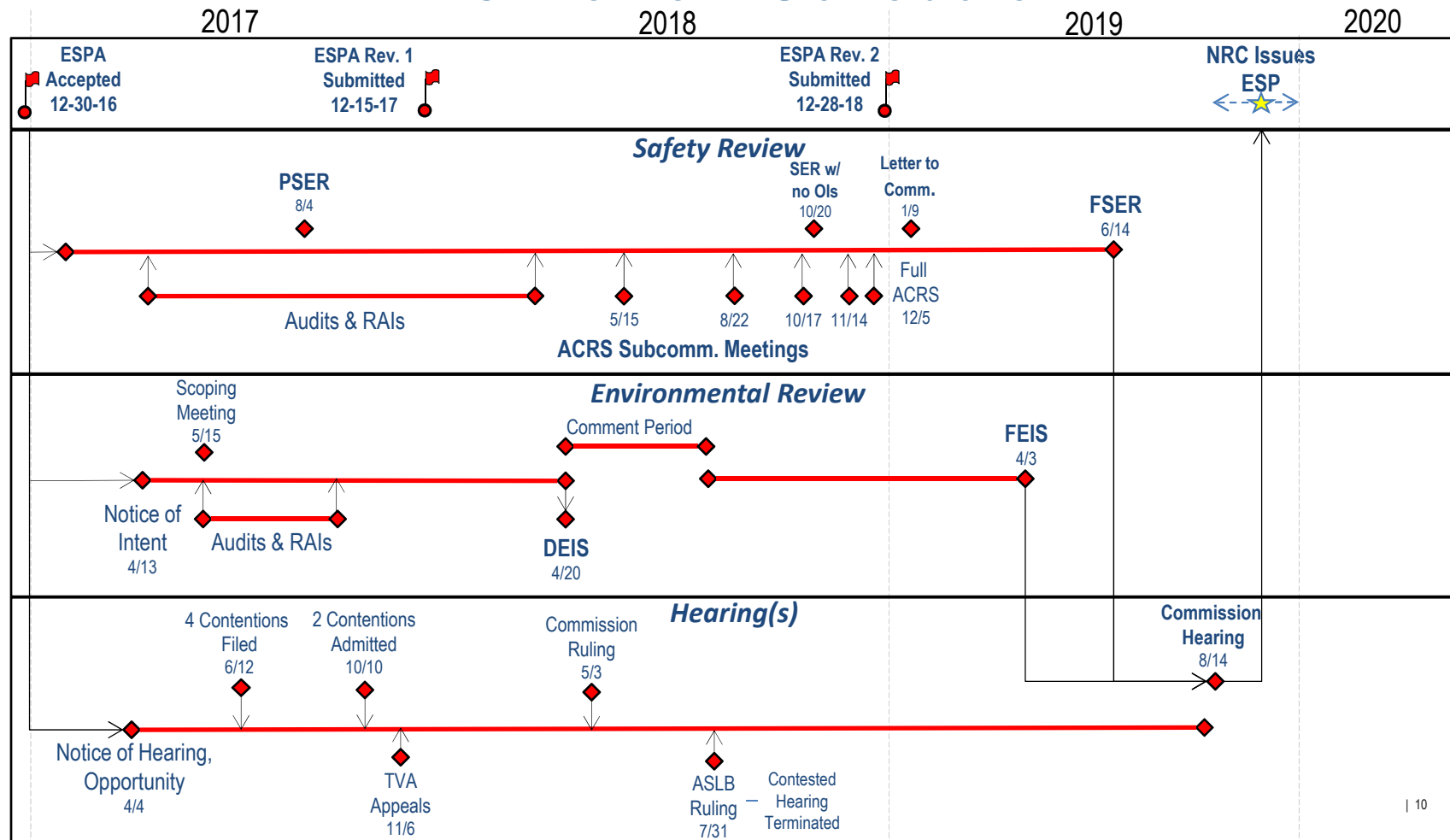
- Composite of reactor and engineered parameters based on the four U.S. light-water SMR designs under development when the application was prepared
- Developed based on NEI 10-01 guidance with margin added to specific parameters
- Up to 800MWt for a single unit with a combined nuclear generating capacity not exceeding 2420 MWt (800 MWe)
- Assumes two or more SMR units



# ESPA Review Summary

- TVA submitted ESPA May 2016
- NRC Accepted and Commenced Review in December 2016
- Contains more than 8,000 Pages
- Supported by over 80,000 pages in referenced documents
- Efficient Use of Audits
- Minimal Requests for Additional Information (RAIs)
- Early, Open, Frequent, Clear, and Candid Communication with NRC
- NRC FEIS, FSER, and Commission Hearing Completed 2019.

# NRC Review Schedule





# ESPA - PPE Approach

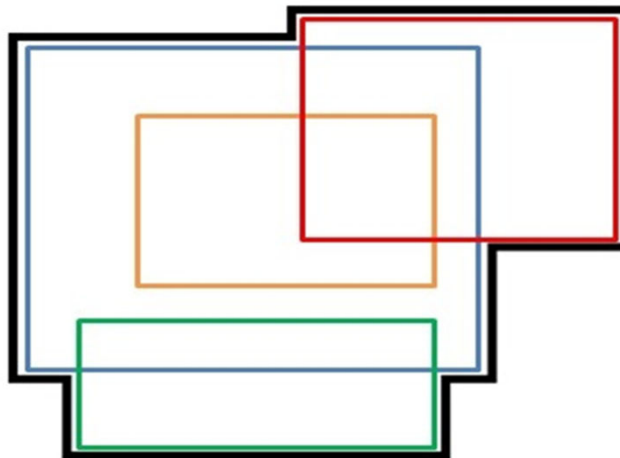
NEI 10-01 [Revision 1] Industry Guideline for Developing a Plant Parameter Envelope in Support of an Early Site Permit, May 2012

- Supports an ESP application consistent with the requirements of 10CFR52
- Supports finality on siting issues prior to selecting a specific reactor technology
- Obtain four Vendor Information Worksheets
- Four SMR vendors, BWXT mPower, Holtec, NuScale, and Westinghouse,
- Select bounding parameters for the “surrogate” plant to effectively bound all designs
- Include “reasonable margin” for each PPE parameter
- Create PPE table and supporting basis documentation
- Includes normal and accident source terms

# ESPA - PPE Approach

Four SMR Vendors considered for the Clinch River Site

Vendor	MWt	MWe	Number of Units	MWt Total	MWe Total
BWXT mPower	530	171	4	2,120	684
Holtec	525	154	4	2,100	616
NuScale	160	47.5	12	1,920	570
Westinghouse	805	240	3	2,420	720





# ESPA - PPE Example: Owners Basis

## 1.2.1 Maximum Rainfall Rate

**Site Safety Analysis Report:** The plant shall be designed to withstand the most severe climatological events anticipated for the areas of concern. Included in this evaluation is consideration for the maximum local rainfall rates in a 1 hour period in 1 square mile.

### **Vendor Worksheets**

Vendor 1 Value: 19.4 inches within 1 hour,

Vendor 2 Value: 20 inches within 1 hour

Vendor 3 Value: 19.4 inches within 1 hour

Vendor 4 Value: 19.4 inches within 1 hour

**Site Value:** TVA Clinch River site maximum precipitation values determined from Hydrometeorological Report HMR 52, Figure 24: 18.8 inches/hour is the site characteristic.

**Conclusion:** Comparison of the vendor values to the site characteristic shows each of the listed vendor precipitation values are greater than the site characteristic values supporting the conclusion that each vendor will design a plant to withstand the maximum rainfall rate for the CRN Site.

**Design Margin:** No additional margin will be included in this value.

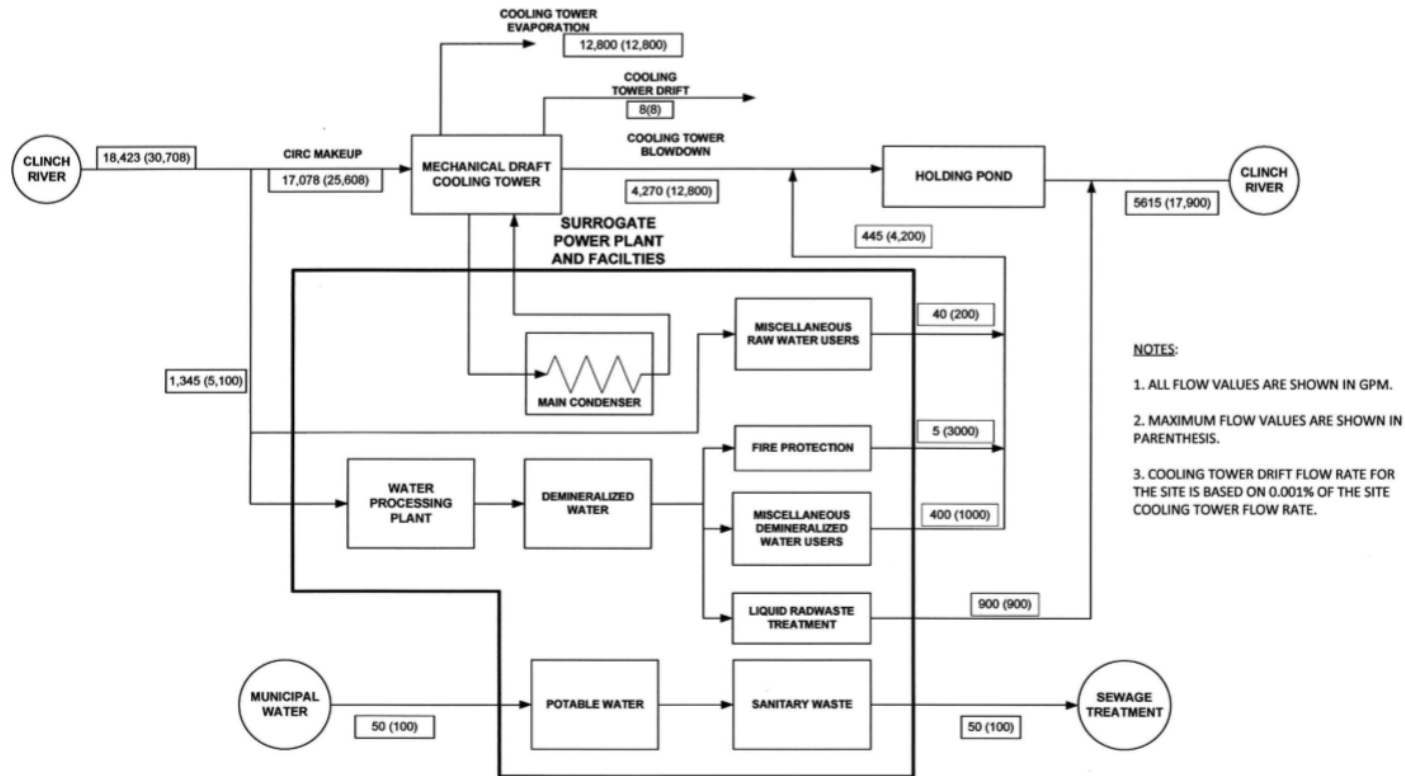
# ESPA - PPE Example Table

PPE Section	Definition	Comments	Parameter Type	PPE Value
<b>3.3 Mechanical Draft Cooling Towers</b>				
3.3.4 Blowdown Flow Rate	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs	Values for Site	Eng	Maximum: (2 COC) 12,800 gpm, Expected: (4 COC) 4,270 gpm See Figure 1
3.3.9 Makeup Flow Rate	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water system.	Values for Site	Eng	Maximum: 25,608 gpm, Expected: 17,078 gpm See Figure 1
3.3.14 Maximum Consumption of Raw Water	The expected maximum short-term consumptive use of water by the cooling water systems (evaporation and drift losses).	Value for Site	Eng	12,808 gpm



# ESPA - PPE Example Figure

Figure 1: CLINCH RIVER ARM OF THE WATTS BAR RESERVOIR WATER USE DIAGRAM (UNITS IN GPM)



# ESPA – Emergency Preparedness Approach

## Emergency Planning Information located in 3 Parts of the ESPA

- Part 2 – SSAR, PEP EPZ Sizing Methodology
  - SSAR, Section 13.3, *Emergency Preparedness*
  - Dose-Based, consequence-oriented and risk-informed approach
  - Reasonable assurance for adequate protection
- Part 5 - Emergency Plan
  - Two major features Emergency Plans
    - Part 5A – Site Boundary plume exposure pathway (PEP) emergency planning zone (EPZ) Emergency Plan
    - Part 5B – 2-Mile PEP EPZ Emergency Plan
- Part 6 - Exemptions and Departures
  - 2 sets of exemption requests – accompany the less than 10-mile EPZ emergency plans in Part 5
    - Exemption requests for a PEP EPZ at Site Boundary
    - Exemption requests for a 2-mile PEP EPZ

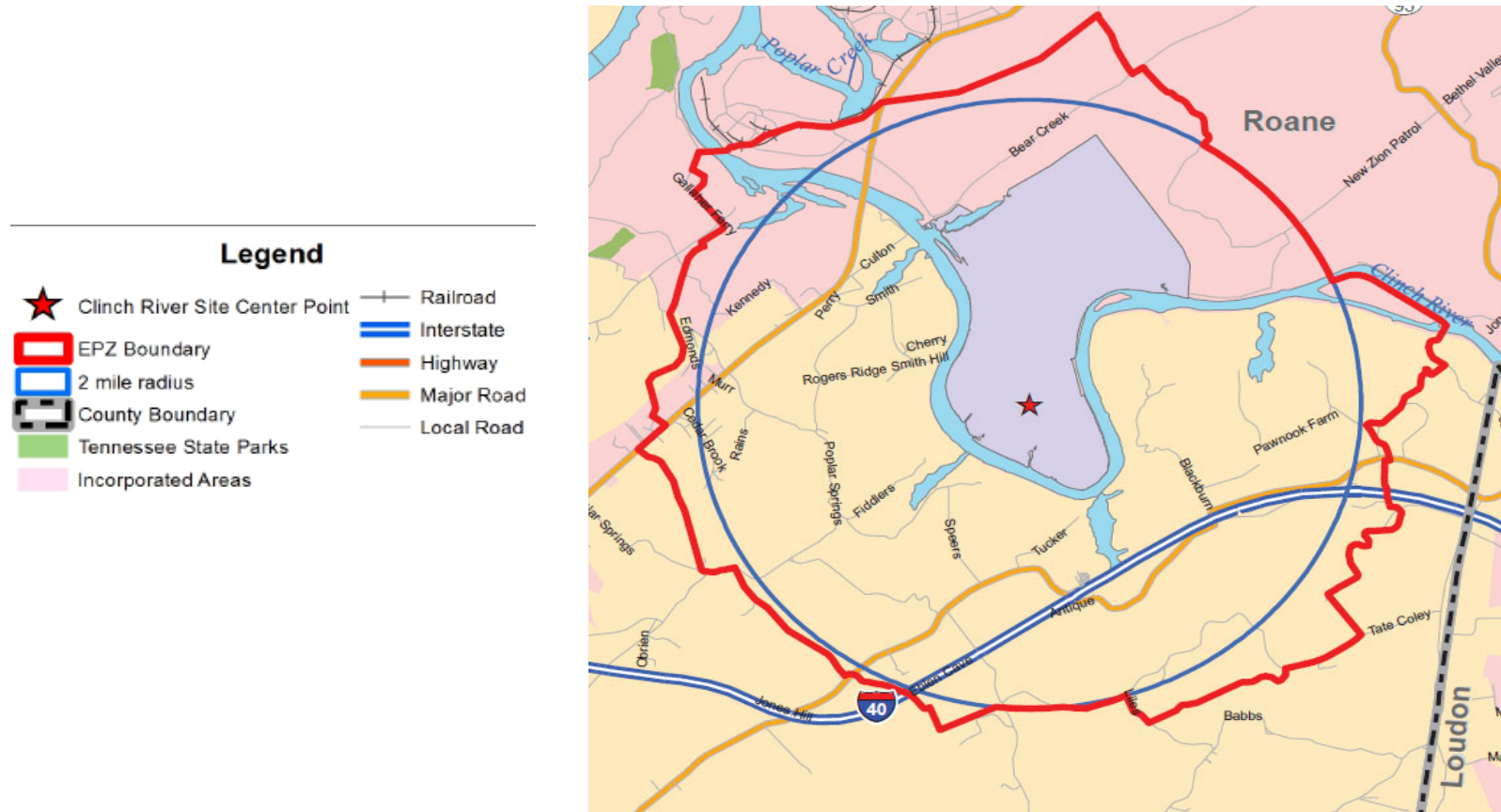
The final EPZ size for the Clinch River Site will be determined in COL or CP

## Part 5A – Emergency Plan (Site Boundary EPZ)





## Part 5B – Emergency Plan (2-Mile EPZ)



# Part 6 – Exemptions and Departures

Pursuant to 10 CFR 52.7, Specific Exemptions, which is governed by 10 CFR 50.12, Specific Exemptions, TVA requested exemptions from:

- 10 CFR 50.47(b) regarding onsite and offsite **emergency response plans** for nuclear power reactor
- 10 CFR 50.33(g) and 10 CFR 50.47(c)(2) to establish **PEP EPZ** for nuclear power plants
- 10 CFR Part 50, Appendix E, which establish the elements that make up the **content of emergency plans**

## Two Sets of Exemptions

- Exemptions for an approximate **2-mile PEP EPZ**
  - Deviate from 10-mile PEP EPZ
- Exemptions for a PEP EPZ established at the **Site Boundary**
  - Deviate from 10-mile PEP EPZ
  - Various elements of a formal offsite emergency plan
  - Evacuation time estimates
  - Certain elements of offsite notifications and exercises

## Part 2 – PEP EPZ Sizing Methodology

- SMR design and safety advancements
- Consistent with NUREG-0396 sizing rationale
  - Addresses a broad spectrum of accidents
  - Aligns with recommended dose criteria
  - Environmental Protection Agency (EPA) early-phase (Protection Action Guides) (PAGs) – **1 roentgen equivalent man (rem) total effective dose equivalent (TEDE)**

## Part 2 – PEP EPZ Sizing Methodology Technical Criteria

- **Criterion A – design basis accidents**
  - EPA early-phase PAG dose less than 1 rem TEDE.
- **Criterion B – less severe core melt accidents**
  - Core Damage Frequency (CDF) greater than  $1\text{E-}6$  per reactor-year (rx-yr)
  - Intact containment
  - EPA early-phase PAG dose less than 1 rem TEDE.
- **Criterion C – more severe core melt accidents**
  - CDF greater than  $1\text{E-}7$  per rx-yr and
  - Containment bypass or failure
  - Sufficient size to provide Reduction in Early Severe Health Effects [distance at which the conditional probability to exceed 200 rem (whole body) exceeds  $1\text{E-}3$  per rx-yr] [1 in a 1000]

A future application would implement the EPZ size methodology, with site- and design-specific input, to determine the final EPZ size for the Clinch River Site



# Design-Specific Example Analysis

## Evaluates NuScale Power Plant at Clinch River Site

Criteria	Site Boundary Dose TEDE (rem)	EPA Early Phase PAG Limit TEDE (rem)
A	0.104	1
B	0.158	1
C	No accident scenarios met the required screening criteria.	

Site specific consequences are determined by the ratio of the  $\chi/Q$  methodology described in NEI 10-01

EPA-400 PAG Manual Protective Action Guides and Planning Guidance for Radiological Incidents *JANUARY 2017*

# Summary – Emergency Preparedness Approach

## Part 5 Emergency Plan

- Approval of the major features of the Site Boundary (Part 5A) and 2-mile emergency plan (Part 5B)
- A future application would describe a complete and integrated emergency plan

## Part 6 Exemptions

- Primarily to deviate from the current 10-mile PEP EPZ size requirement based implementation of the dose-based, consequence-oriented methodology

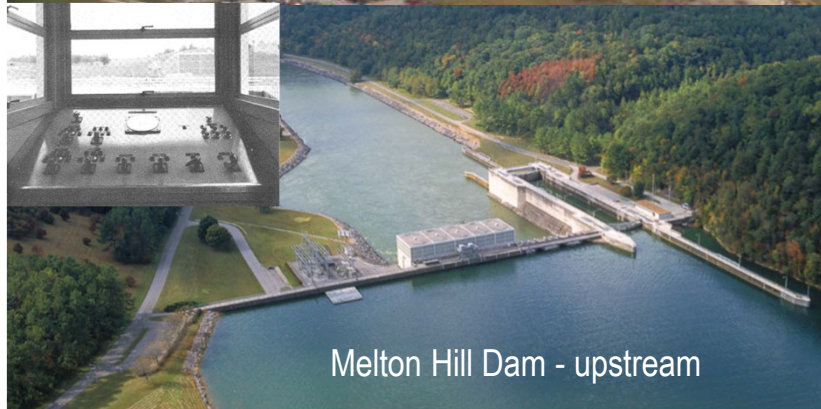
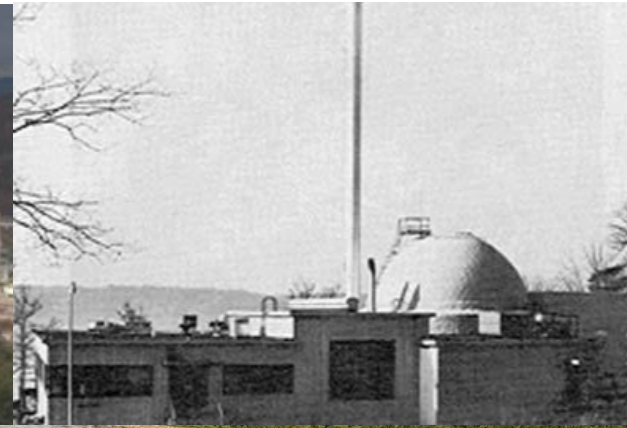
## Part 2 Plume Exposure Pathway EPZ Methodology

- Risk-informed, dose-based, consequence-oriented approach customized for SMR technology
- Approval to use the methodology for design and site specific implementation in a future application [COLA or CP]

# Question?



Kingston Fossil Plant – downstream



Melton Hill Dam - upstream



Artist Rendering NuScale SMR

# Acknowledgement and Disclaimer

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