

# Full-Scope Site Level 3 PRA Technical Analysis Approach Plan for Reactor PRA

Advisory Committee on Reactor Safeguards  
Reliability and PRA Subcommittee

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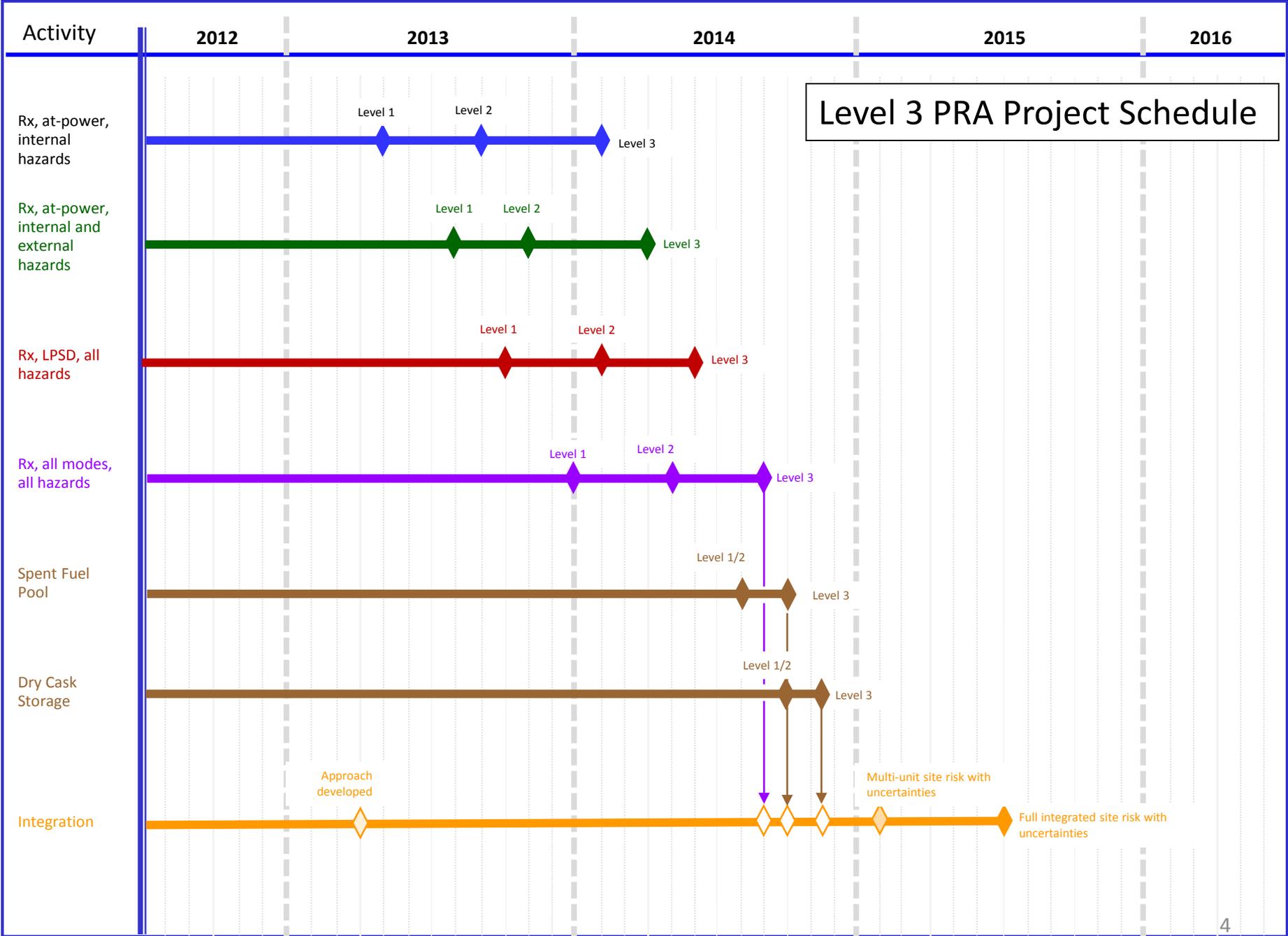
# Outline

- Level 3 PRA Project
  - Objectives
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  - Technical Analysis Approach Plan
    - Objectives
    - Scope and limitations
    - Approach Summary
    - Reactor PRA Technical Elements
    - Quality Assurance
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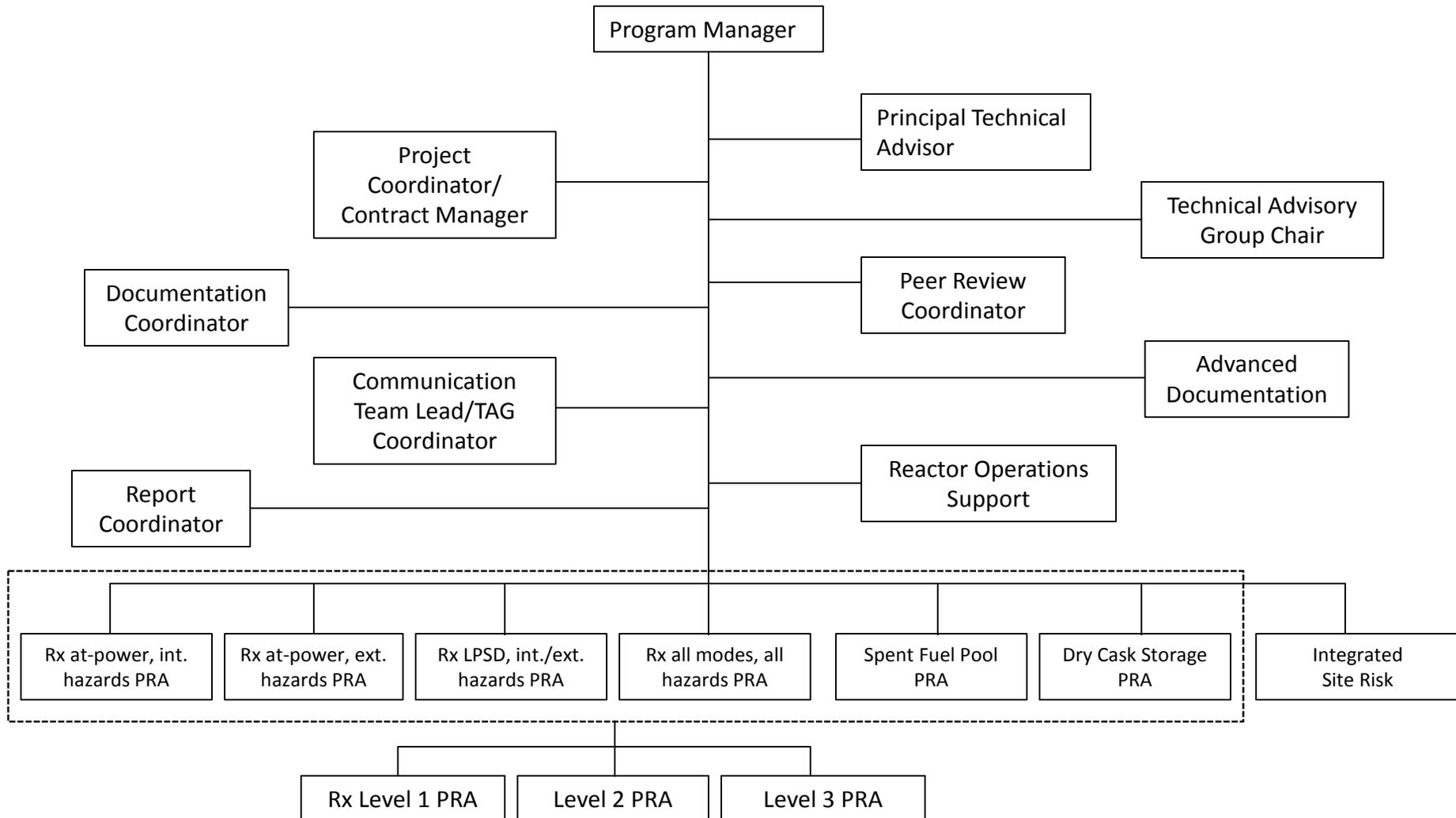
# Level 3 PRA Project – Objectives

- Develop a Level 3 PRA, generally based on current state of practice methods, tools, and data,\* that (1) reflects technical advances since completion of the NUREG-1150 studies, and (2) addresses scope considerations that were not previously considered (e.g., multi-unit risk)
- Extract new insights to enhance regulatory decisionmaking and to help focus limited agency resources on issues most directly related to the agency's mission to protect public health and safety
- Enhance NRC staff's PRA capability and expertise and improve documentation practices to make PRA information more accessible, retrievable, and understandable
- Obtain insight into the technical feasibility and cost of developing new Level 3 PRAs

\* "State-of-practice" methods, tools, and data are those that are routinely used by the NRC and licensees or have acceptance in the PRA technical community.



# Level 3 PRA Project – Program Organization



# Technical Analysis Approach Plan (TAAP)

- Objective: To provide the guidance to be used in developing the Level 3 PRA.
  - Consistent with current best practice as defined in both national consensus standards and other regulatory and industry guidance documents
  - Enhance consistency in the development of the PRA models by the various analysts
  - Provide traceability of how the PRA model was constructed
  - Used to support development of review criteria for assessing the technical acceptability of the PRA model
- This PRA model is comprised of the following scope:
  - Radiological sources -- reactor cores, spent fuel pool, and dry cask storage
  - Impact population -- surrounding population
  - Reactor state -- all operating states
  - Challenges -- all hazards
  - Levels of risk analyzed -- Levels 1, 2 and 3

# TAAP – Limitations

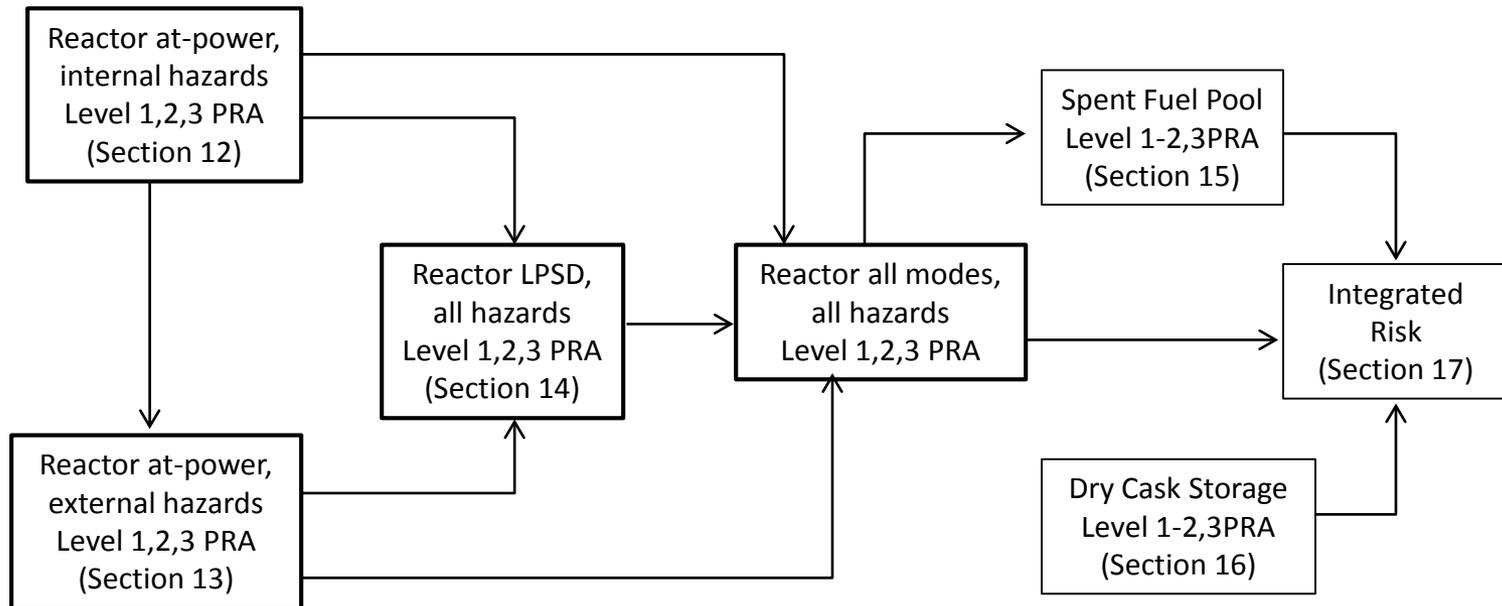
- The Level 3 PRA study is intended to be as complete and realistic as practical; however, the scope and level of realism will be balanced against resource and schedule limitations in a risk-informed manner.
  - Not all aspects of the study will necessarily receive the same level of analytical rigor, which will be a function of their relative risk significance.
- Some examples of some PRA technical elements that will not be addressed in the current study, but which are good candidates for further research to advance the state-of-the-art include:
  - aqueous transport and dispersion of radioactive materials
  - effects of aging on structure, system, and component reliability
  - consequential (linked) multiple initiating events (e.g., seismically induced fires and floods)
  - digital instrumentation and control, including software
- The staff intends to use the currently available suite of PRA standards (e.g., the ASME/ANS PRA standard) and other NRC and industry guidance documents to guide many of the technical aspects of this study.

# TAAP – Approach Summary

- Not meant to duplicate existing standards or other guidance documents
- Guidance on how this specific PRA model will be constructed
- Shows how the technical elements are related and interface with each other
- For each technical element, provides a high level description of:
  - Assumptions and limitations
  - Needed inputs
  - Analytical steps
  - Documentation and products
  - Task interfaces

# TAAP – Approach Summary

## Selected Approach



- Produces reactor Level 3 results before completing entire site study
- Provides additional time to resolve technical issues in less mature areas

# Reactor At-Power, Level 1 PRA for Internal Hazards

# Overall Assumptions

- Level 1 modeling is well established, particularly for internal events and internal floods.
  - Over 75 Level 1 PRAs covering internal events and internal floods have been performed in the U.S. and have been peer reviewed to the ASME/ANS PRA standard.
- A straight-forward process will be used to develop new enhanced model for Level 3 PRA project.
- Licensee PRA and associated documentation (including peer review report) will expedite the development.

# Level 1 Approach for Internal Events, Internal Floods, and Internal Fires

- Starting point is Vogtle SPAR model; use licensee PRA to enhance, as appropriate
- Use industry independent peer review of licensee PRA model to enhance confidence in licensee modeling and focus NRC staff audit
- Perform staff self-assessment
- Identify areas to be modified/revised/upgraded
- Perform independent peer review of NRC Level 1 at-power PRA model for internal hazards (?)

# Some Potential Challenges

## Internal Events PRA

- No significant challenges are anticipated.
- Thermal-hydraulic calculations to confirm success criteria will not be performed until after the initial internal events model is completed.

# Some Potential Challenges

## Internal Flood PRA

- Reevaluation of Vogtle internal flooding initiating event frequencies using up-to-date methods
- Resolution of peer review finding involving method and assumptions used for flood screening analysis
- Consideration of multi-unit internal flood scenarios
  - Vogtle flood analysis considers shared flood areas, but shared areas are not discussed in detail. No discussion of potential propagation paths or potential impacts of multi-unit floods.

# Some Potential Challenges

## Internal Fire PRA

- Assuring an acceptable level of completeness of internal fire scenarios to be modeled
- Performing a documented and credible review of task results that will be taken from the existing licensee fire PRA, such as:
  - Component selection and cable tracing
  - Spurious actuation modeling
  - Fire analysis
  - HRA quantification
- Handling components that are modeled in the licensee PRA but may not be present in the NRC Level 3 PRA model

# Reactor At-Power, Level 1 PRA for External Hazards

# Seismic Events

## Background

- The licensee is in the process of performing a seismic PRA.
- The NRC's Level 3 PRA model will leverage available information and calculations from the licensee's seismic PRA.
- ASME/ANS PRA Standard Section 5-2 identifies the technical requirements for a seismic PRA at-power.
  - Probabilistic seismic hazard analysis
  - Seismic fragility evaluation
  - Seismic plant response analysis
- Mix of in-house (RES staff) and contracted effort will be used.

# Seismic Events

## General Approach

- Use existing site-specific seismic hazard information to define seismic bins
- Customize the seismic demands on the structures, systems, and components (SSCs) to the actual site using approximate methods and existing information (FSAR and ongoing seismic PRA study) and will update those results as more information becomes available
  - Perform sensitivity analysis to assess bounding effects of approximations
- Use available site-specific seismic fragilities to calculate basic event failure probabilities for seismic bins
  - Perform in-house fragility calculations or use surrogate fragilities, where necessary

# Seismic Events

## General Approach (Cont.)

- Develop event tree and fault tree models for each seismic bin
  - Use existing event tree and fault tree models from internal events PRA, wherever applicable
- Assemble new data to be put in the model (including uncertainty parameters)
  - Hazard bin frequencies, seismic failure probabilities, new or affected human error probabilities, and other data
- Incorporate scenarios into Level 3 PRA model and quantify core damage frequency

# Seismic Events

## Assumptions and Limitations

- Licensee will be working on a seismic PRA in the same time frame as this project. The NRC's Level 3 PRA model will leverage information and calculations from the licensee's seismic PRA, as available and appropriate.
- A stable version of the internal events model will be available before the seismic scenario modeling task starts.

# Seismic Events

## Challenges

- Characterization of ground motion at the site using recent probabilistic seismic hazard models
- Changes in spectral characteristics of ground motion and site conditions challenge scaling of FSAR's in-structure spectral acceleration demands on SSCs
- Soil site with local site amplification effects that affect ground motion characteristics and related seismic hazard quantification
- Consideration of soil-structure interaction effects on calculation of in-structure spectral acceleration demands on SSCs
- Consideration of potential for site-specific soil failures, e.g., soil liquefaction

# High Winds, External Floods, and Other Events

## Background

- The licensee has not performed a PRA for high winds, external floods, or other events.
- Collective experience with detailed PRA modeling of these events is limited.
- ASME/ANS PRA standard Sections 7.2, 8.2, and 9.2 provide the technical elements for addressing these events.
- A mix of in-house (RES staff) and contracted effort will be used.

# High Winds, External Floods, and Other Events

## General Approach

- The general tasks for high-winds and external flood PRA include:
  - Hazard analysis
  - Fragility analysis
  - Plant response analysis, including quantification
- The general tasks for the other events include:
  - Review of plant-specific hazard data and licensing bases
  - Screening analyses
  - Modeling of unscreened hazards

# High Winds, External Floods, and Other External Events

## Assumptions and Limitations

- The analysis for these events may be qualitative, quantitative, or a combination of each, as warranted by the site-specific hazard characteristics.
- The high wind analysis is expected to be quantitative, leading to scenarios to be incorporated into the PRA model.
- The external flooding analysis is not expected to require a detailed quantitative PRA model.
- The other events under consideration will consist of the hazards listed in Appendix 6-A of the ASME/ANS RA-Sa-2009 PRA standard.

# Reactor Low Power and Shutdown, Level 1 PRA

# Low Power and Shutdown, Level 1 PRA

## State of Practice

- U.S. industry experience with Low Power and Shutdown (LPSD) PRA modeling is limited.
  - Many licensees use LPSD Qualitative Risk Assessments.
- Vogtle has not performed an LPSD PRA.
- Structure will closely follow the draft ASME/ANS LPSD PRA Standard
  - Has not yet achieved consensus acceptance
  - Has not yet been endorsed by NRC
- NRC staff has experience with developing limited-scope SPAR-Shutdown models.

# LPSD General Approach

- Define practical scope limitations while maintaining adequate characterization of LPSD risk
- Address each LPSD technical element for internal events
- Integrate LPSD internal events scenarios into the at-power model
- Address other hazards after experience gained with LPSD internal events and all hazards for at-power are complete
  - LPSD, internal flooding
  - LPSD, internal fires
  - LPSD, external hazards
- Address external review comments

# LPSD Technical Elements

- Reactor, LPSD, internal events, Level 1
  - Plant Operating State (POS) analysis
  - Initiating event analysis
  - Accident sequence analysis
  - Success criteria
  - Systems analysis
  - Human reliability analysis
  - Data analysis
  - Quantification
  - Uncertainty analysis

# LPSD Challenges

- Applying practical scope limitations to maintain a manageable model size
- Updating generic LPSD initiating event frequencies to include recent operating experience
- Reflecting plant-specific accident sequences and development of success criteria
- Other hazard analyses (internal floods, fires, and external hazards) for unique LPSD operating conditions and plant configurations

# Reactor Level 2 PRA

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# Background

- NRC risk tools rely on simplified LERF approach
- Some NRC feasibility modeling in recent past, including “integrated capabilities” project
- Mix of in-house (RES staff) and contracted effort
- Recent work in dynamic Level 2 PRA methods is promising, but beyond state-of-practice
- Licensee has a Level 2 PRA model:
  - Based on WOG simplified Level 2 modeling guidelines
  - Updated for license renewal SAMA, and thereafter
  - Will be leveraged, and modified as appropriate

# Technical Elements

- Technical Elements:
  - Level 1/2 PRA Interface – Accident Sequence Grouping
  - Containment Capacity Analysis
  - Severe Accident Progression Analysis
  - Probabilistic Treatment of Event Progression
  - Radiological Source Term Analysis
  - Evaluation and Presentation of Results
  - Level 2/3 PRA Interface
- Structure closely follows draft ASME/ANS Level 2 PRA Standard

# Model structure at-a-glance

- Traditional, contemporary model structure
- Level 1 end-states → containment systems extension → plant damage states → accident progression event tree(s) → release category binning → Level 3 PRA
- “Integrated” SAPHIRE8 Level 1 / Level 2 model
- Deterministic tools:
  - LS-DYNA (containment finite element analysis)
  - SCALE (decay heat and radionuclide inventories)
  - MELCOR (accident progression and source term)
  - specialized tools as needed

# Internal Hazards Key Assumptions

- Clearly relies on substantive completion of the Level 1 PRA
- Assumes internal events, flooding and fire can be accommodated by the same basic model
- Assumes units are identical (model = Unit 1 = Unit 2)
- Omits inadvertent criticality during reflood – specific instances where this is possible will be highlighted

# Some Challenges

- Consensus standard still in flux
- Characterization of SSCs for beyond-design-basis external hazards
- HRA – SAMGs and EDMGs
- Mechanistic modeling for energetic and lower-probability phenomena
- Equipment survivability determinations
- Treatment of uncertainty

# Examples of Challenges Specific to External Hazards and Low-Power/Shutdown

- External hazards:
  - Fragilities for SSCs not covered by the Level 1 PRA
- Low-power/shutdown:
  - Modeling of head-off, open containment, and flooded refueling cavity configurations
  - Modeling of connection to SFP
  - Modeling of unique source term effects (air oxidation, holdup if containment is not closed)

# Reactor Level 3 PRA (Offsite Consequence Analysis)

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# Background

- Will build on previous studies (e.g., SOARCA, Plant Vogtle SAMA analyses)
- Mix of in-house (RES staff) and contracted effort
- Assumptions and scope are preliminary and will be refined by project staff as necessary over the course of the analysis

# Technical Elements

- Technical Elements:
  - Level 2/3 PRA Interface
  - Protective Action Parameters and Other Site Data
  - Meteorological Data
  - Atmospheric Transport and Dispersion
  - Dosimetry
  - Health Effects
  - Economic Factors
  - Quantification and Reporting
  - Risk Integration
- Structure closely follows draft ASME/ANS Level 3 PRA Standard

# Tools

- WinMACCS/MACCS2: Atmospheric transport, protective actions, exposure, and health and economic impacts
- MELMACCS: Source term transfer from MELCOR to MACCS2
- SCALE: Fuel inventory analysis
- SECPOP2000: Development of demographic, land use, and economic data

# Key Assumptions

- Offsite consequences will focus on atmospheric releases, which is the current state of practice for severe accidents. MACCS2's straight-line Gaussian plume segment model will be used to model atmospheric transport, dispersion, and deposition.
- Site-specific population data will be based on the available data from the latest version of SECPOP, and extrapolated forward to a target year, as appropriate.
- Emergency response and other protective actions will include evacuation, sheltering, normal and hotspot relocation, decontamination, land interdiction, and ingestion of potassium iodide (KI) pills, as appropriate.
- Dose criteria for food/land interdiction and relocation will be based on federal guidance.
- Decontamination will be modeled using land use data and land value data based on current information from the Bureau of Economic Analysis.

# Key Assumptions (Cont.)

- A linear, no threshold (LNT) dose response model will be used. Other dose response models will be considered if time and resources permit.
- Dose conversion factors from the latest available Federal Guidance Report (currently FGR-13) will be used.
- The latest available risk factors will be used. Currently FGR-13 uses risk factors from BEIR V, although guidance for using risk factors from BEIR VII may become available soon.
- Economic costs will include costs for evacuation and relocation, moving expenses for displaced persons, decontamination, loss of land use of property, disposal of contaminated food grown locally, and condemned lands

# Challenges

- Development of source terms for input to the offsite consequence analyses will need to consider multi-source and multi-unit considerations.
- Dose criterion for decontamination after a severe accident is uncertain as no applicable long-term land cleanup goal or level currently exists, particularly for large areas. The current state of practice is to model decontamination to the level of meeting the habitability (return) criterion applicable at the particular site. Other decontamination criteria may be considered.
- The health effect of low doses is uncertain. The current state of practice is to use a linear, no threshold (LNT) dose response model. Other dose response models may be considered.

# Human Reliability Analysis

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# General Approach (1)

- Human reliability analysis (HRA) is a supporting technical element for most operating modes, PRA types and hazards
- Based on existing HRA processes, HRA for this project consists of nine interrelated steps:
  - Definition and interpretation of HRA/PRA issue
  - Definition of HRA/PRA scope
  - Qualitative analysis
  - Identification and definition of human failure events (HFEs)
  - Quantification
  - Recovery analysis
  - Dependency analysis
  - Uncertainty analysis
  - Documentation

# General Approach (2)

- HRA needs for the overall Level 3 PRA project can be categorized in the following groups:
  1. Applicable HRA guidance & methods exist; operator performance is understood (e.g., reactor at-power, Level 1 PRA for internal events and internal fires)
    - If licensee PRA is available, HRA effort is expected to be limited to review, “spot checks” of results, and limited or no re-work of HRA qualitative and quantitative results
  2. Existing HRA guidance and methods can be modified or extrapolated; understanding of operator performance can be developed from generic and plant-specific experience (e.g., low power and shutdown [LPSD] PRA, seismic PRA, internal flood PRA, dry cask PRA)
    - Existing HRA guidance, methods, and approaches will be modified for specific PRA application
  3. Existing HRA methods are expected to have limited or no applicability; limited experience-base for development of an understanding of operator performance (e.g., Level 2 PRA, spent fuel pool PRA)
    - Extend or extrapolate existing HRA methods to extent appropriate; develop new constructs for other cases

# Key Assumptions & Limitations

- Procedures & other formal guidance that support operator actions addressed in the PRA exist & are currently being used & trained upon
- Action locations, equipment, control panels and so forth exist, are currently being used & trained upon
- Licensee's PRA(s) will form the basis for the NRC analysis, provided that it:
  - Is adequate for needs of NRC's Level 3 HRA/PRA effort with respect to scope & objectives
  - Meets the ASME/ANS PRA Standard requirements
  - Has a peer review
  - Requires no adjustment to success criteria or timing information relevant to HRA
  - Addresses key & relevant performance influencing factors
  - Has used HRA methods & approaches suitable for the application
  - Has included an HRA that was performed using HRA methods & approaches as they are intended to be used
  - Requires little or no re-work of HRA qualitative or quantitative analysis for post-initiator HFES
  - Requires no re-work for pre-initiator HFES

# Examples of Relevant Resources (1)

- Group 1, e.g.,
  - At-power, internal events Level 1 PRA
    - Previously performed HRA/PRA & “all” existing HRA guidance & methods
  - At-power, fire Level 1 PRA
    - EPRI/NRC-RES Fire HRA Guidelines, NUREG-1921/EPRI 1023001
- Group 2, e.g.,
  - LPSD PRA
    - Previously performed NRC LPSD PRAs, qualitative HRA work (e.g., NUREG/CR-6093)
  - For other, spatially-oriented PRA hazards (e.g., seismic PRA, internal flood PRA)
    - Any previous HRA/PRA experience coupled with expansions of NUREG-1921 (e.g., current EPRI effort to expand for seismic) & insights from relevant events
  - LPSD fire PRA
    - Extension & merging of guidance & methods for fire & LPSD HRA/PRA, separately
  - Dry Cask Storage PRA:
    - Any previous NRC or industry PRAs, coupled with recently published qualitative HRA reports (NUREG/CR-7016 & NUREG/CR-7017)

# Examples of Relevant Resources (2)

- Group 3, e.g.,
  - Level 2 & multi-unit risk
    - Any previous HRA/PRA studies that address severe accident progression (including international studies)
    - Plant-specific information (e.g., SAMGs, observations of Emergency Planning drills) collected as part of this project
    - Understanding of relevant human behavior (especially decision-making) from literature
    - Insights from relevant events
    - Relevant HRA development, including underlying literature search, for “IDHEAS” (i.e., current research in response to SRM M061020)

# Integrated Site Risk

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# Outline

- Technical Tasks
- PRA Modeling Issues
- Site Information Review
- Multi-Unit Accident Sequence Delineation
- Integrated Risk Metrics
- Challenges

# Technical Tasks

- Task 1: Technical approach
- Task 2: Multi-unit effects
- Task 3: Integrated Level 3 PRA model
- Task 4: Integrated uncertainty analysis

# White Paper to Identify Issues

- Prepared by contractor
- Issues
  - Multiple concurrent accidents (reactors, spent fuel)
  - Integrated treatment of multiple hazards
  - Account for the impact of core damage or radiological releases occurring in one unit on others

# PRA Modeling Issues

PRA Element and Associated Issues	Modeling Capabilities		
	Current Practice	Minor Revisions or Additions to Current Practice	Major Revisions or Additions to Current Practice
Plant Operating States	X		
Hazards and Initiating Events	X		
Accident Sequence Evaluation		X	
Success criteria	X		
Systems Analysis	X		
Data Analysis	X		
HRA			X
Dependency Analysis		X	

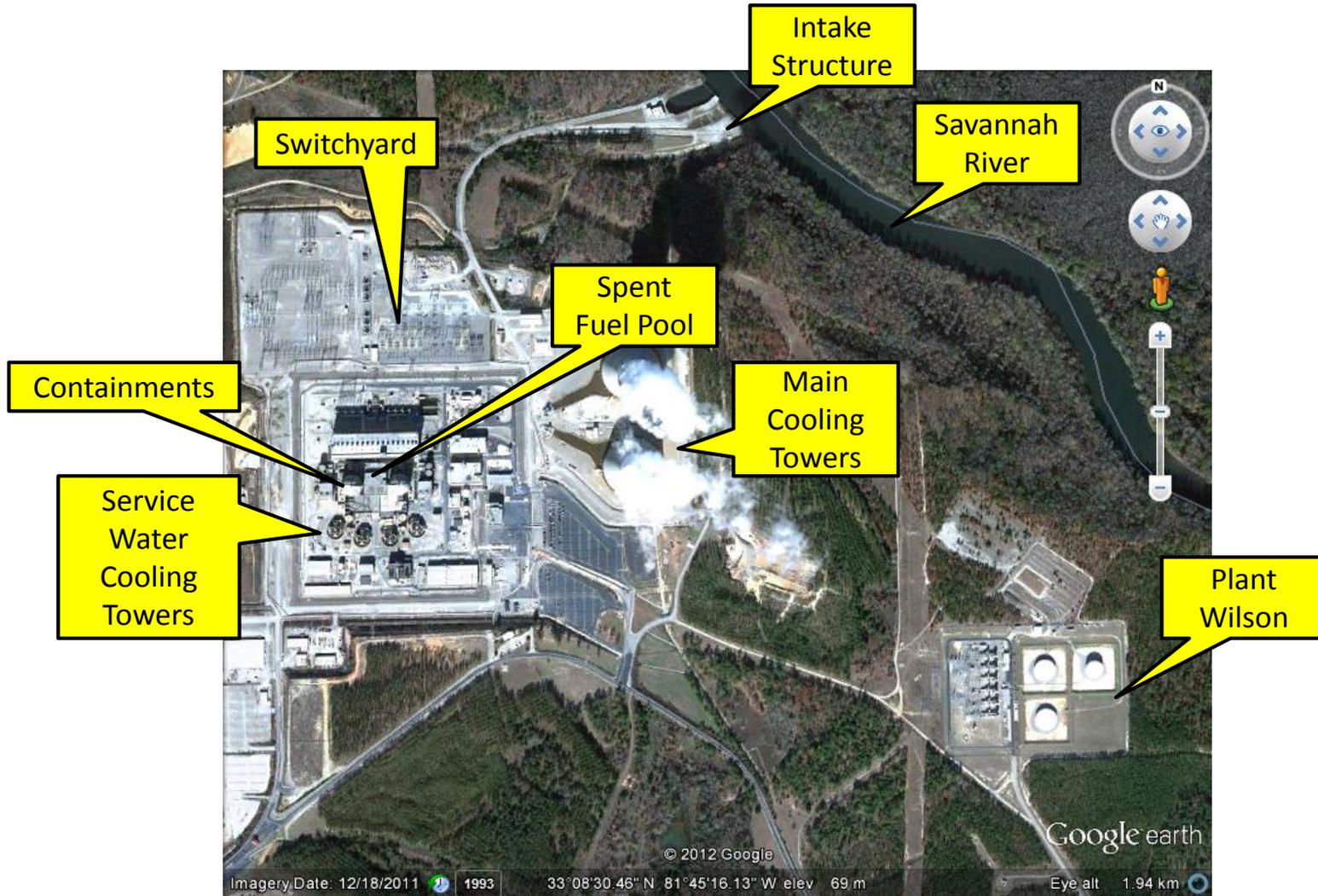
# PRA Modeling Issues (Con't.)

PRA Element and Associated Issues	Modeling Capabilities		
	Current Practice	Minor Revisions or Additions to Current Practice	Major Revisions or Additions to Current Practice
Structural Analysis			X
Containment Performance Analysis	X		
Analysis of Severe Accidents and Radiological Releases		X	
Offsite Consequence Analysis		X	
Risk Quantification and Integration			X
Uncertainty Analysis	X		

# Site Information Review

- What are we reviewing?
  - FSAR
  - SPAR internal events model
  - Information provided by licensee to support the project
- What are we looking for?
  - Shared systems
  - Systems that have cross-connects between the units
  - Common locations
  - Common-cause initiating events
  - Common-cause failures that need to be expanded to include both units
  - Recovery actions modeled in the PRA that credit the other unit

# Site Layout



# Site Information Review Observations

- Systems that are typically included in a PRA model (electric power, service water, etc.) are not shared between units
- Plant Wilson can only supply power to one unit at a time
- Some common locations may be important for some internal hazards (floods, fires)
- Candidate multi-unit initiating events
  - Loss of grid
  - Consequential LOOP
  - Internal hazards (fires, floods)
  - External hazards (seismic, floods, high winds)

# Delineation of Multi-Unit Accident Sequences

- Objective: Develop and quantify accident sequences that involve combinations of site radiological sources (reactors, SFP, dry casks)
- Challenges
  - Demonstrating completeness
  - Accounting for plant operating states (POSs)
  - Accounting for cross-unit dependencies (e.g., shared systems, CCFs, operator actions)
  - Achieving reasonable logic model solution times
  - Completing work within resource/schedule constraints

# Multi-Unit Sequence Types

- Type I: common-cause initiators (CCIs)
  - Directly and simultaneously affects both units
  - Examples: seismic events, external floods, high winds
- Type II: consequential initiators
  - Second unit is automatically tripped (or required to trip) due to an evolving sequence in the first unit (i.e., a direct cause-and-effect relation exists between the two units)
  - Examples: consequential LOOPs, shared support systems, internal fires or internal floods that propagate from one unit into another
- Type III: manual shutdown
  - Operators may decide to shut down the second unit due to
    - Core-damage in the first unit
    - Release from the first unit
    - T/S requirements
    - Management decision or NRC order
- Type IV: coincidental initiators
  - Unrelated initiators that occur within a short timeframe
  - Example: SBO in one unit, followed by LOCA in the second unit

# Multi-Unit Sequence Development

- In theory, multi-unit accident sequences may be formed by ANDing together two single-unit sequences
  - Brute-force approach may generate a very large number of multi-unit accident sequences
  - Qualitative screening: Some POS combinations may not be possible (e.g., simultaneous refueling in both reactors)
  - Quantitative screening: May use single-unit PRA results or auxiliary calculations to show that some theoretically possible multi-unit sequences have very low frequencies
- Need to develop an integrated logic model that includes all reactors, SFP, and dry casks
  - Adjust CCF group sizes
  - Account for shared systems and cross-connects (affects the modeling of recovery actions)
  - Account for dependent human failure events

# Integrated Risk Metrics

- Identifying candidate risk metrics
  - Balance desire for completeness and usefulness against project schedule and resource constraints
- Candidate risk metrics
  - Total early fatality risk
  - Total latent cancer fatality risk
  - Individual early fatality risk (0-1 miles)
  - Individual latent cancer fatality risk (0-10 miles)
  - Population dose risk (0-50 miles)
  - Offsite economic cost risk (0-50 miles)
  - Individual early injury risk
  - Individual cancer incident risk
  - Land contamination
- Candidate risk surrogates
  - Core-damage frequency (CDF)
  - Large release frequency (LRF)
  - Large early release frequency (LERF)

# Challenges

- Addressing PRA modeling issues
  - Delineation of multi-unit accident sequences
  - Human reliability analysis
  - Dependency analysis
  - Structural analysis
  - Analysis of severe accidents and radiological releases
  - Offsite consequences
  - Risk quantification and integration
  - Uncertainty analysis
- Managing expectations

# Uncertainty Analysis

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# Background

- Uncertainty analysis will address parameter and model uncertainty per NUREG-1855
  - Parameter uncertainty relates to the uncertainty in the computation of the input parameter values used to quantify the probabilities of the events in the PRA logic model.
  - Model uncertainty arises because different approaches may exist to represent certain aspects of plant response and there is also uncertainty with regard to a potentially significant contributor not being considered in the PRA.
- Scope completeness is not an issue, but level of detail and screening criteria are important

# Approach for Addressing Parameter Uncertainty

- Enter basic event distribution information from other tasks (e.g., data analysis and HRA).
- Define epistemic (state-of-knowledge) correlation groups
- Propagate parameter uncertainty in the PRA model using a sampling process (e.g., Monte Carlo)
- To what extent parameter uncertainty is treated across the PRA and for integrated site risk is still to be determined

# Approach for Addressing Model Uncertainty

- Identify and characterize sources of modeling uncertainty and related assumptions
- Perform qualitative screening of the sources of model uncertainty and related assumptions
- Perform sensitivity analyses (sensitivity test)
- To what extent model uncertainties will be addressed is still to be determined

# Quality Assurance

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# Background

- Quality assurance is a key factor in any analysis to ensure technical acceptability.
  - Essential to demonstrate (document) that the PRA model is technically acceptable
- Objective is to ensure that both
  - Technical approach (methods, tools, data) is acceptable
  - Implementation (actual construction of the PRA model) was performed in an acceptable manner

# Quality Assurance

Four major elements to quality assurance

1. Use of established methods, tools and data
2. Qualified personnel
3. PRA model fidelity
4. Technical review of the methods, tools, data and developed models

# First Three Elements

- The PRA model will be based on methods, tools and data that have been established and accepted in the risk community. Examples include
  - Consensus standards
  - Internal and external guidance documents
  - Accepted generic SSC performance data (where plant specific data is not available)
  - Validated codes
- Personnel qualification depend on whether analyst is:
  - Performers who construct the actual pieces of the PRA model and depending on their role, need to have some level of expertise (i.e., on the job training is acceptable)
  - Reviewers review and make judgments on actual aspects of the PRA mode, must have a defined level of expertise (i.e., on the job training is not acceptable)
- PRA model fidelity
  - The objective is to ensure that the various analysts are using the same data, same models, consistent assumptions, etc.
  - Both documentation and PRA model control are essential in ensuring the fidelity of the PRA model.

# Fourth Element: Technical Reviews

Four different types of technical reviews planned:

1. Technical Advisory Group
2. Project Self-Assessment
3. Independent Peer Review
4. Advisory Committee on Reactor Safeguards

# Technical Advisory Group (TAG)

- Objective of TAG:
  - Review progress in the development of the Level 3 PRA
  - Provide insights, advice and guidance on the technical bases, tools, methods and data
  - Provide insights, advice and guidance on the results of the study
- TAG members are senior level advisors in PRA and supporting technical disciplines, as well as an experienced PRA representative from EPRI
- TAG will play a key role in resolving technical or programmatic issues
- TAG will meet at key milestones as determined by the TAG chairman and the Level 3 project manager
- The TAG coordinator will be responsible for summarizing the meeting minutes (as approved by the TAG chairman)
  - The Level 3 project manager (or designee) will be responsible for identifying issues that need to be addressed in the project (based on the meeting and minutes) and how each issue was resolved

# Project Self-Assessment (SA)

- Objective of Project SA:
  - To oversee the quality of the work being performed by both the staff and contractor
  - Identify any issues and allow a chance for them to be fixed in real time
- The SA is performed to determine that the PRA model is consistent with available PRA standards and other guidance, both as-endorsed by the staff
- Task leaders will initiate and perform the detailed self-assessment
  - May be multiple layers of SA because of multiple team leaders
    - Each layer involves checking the process and perhaps auditing some technical aspects
  - The purpose of SA by each team leader is to ensure the work fits into the scope of the model defined by that team leader
- SA will take advantage of previous independent peer reviews
- Each SA will be fully documented
  - The findings and observations based on the self-assessment will be documented along with how each finding and observation was resolved.
  - This document will be developed by the task leaders and the associated team leaders.



# Independent Peer Review

- Objective of Independent peer review:
  - To provide an independent review of the technical acceptability of the PRA model
- Because of the scope of the Level 3 PRA project, the independent peer reviews will be performed at key milestones, as opposed to performing the peer review at the end of the project.
  - Will allow any identified issues to be fixed in real time, minimizing the extent of potential re-work
  - Will be coordinated with self-assessment
- Peer review team needs to meet the qualifications stated in both RG 1.200 and the PRA standard
  - Performed to a written process
  - Team members are independent
  - Team members together and separate have the required qualifications
- Should there be an independent peer review on that portion developed by Vogtle and previously peer reviewed?
  - Now “owned” by the staff

# Advisory Committee on Reactor Safeguards

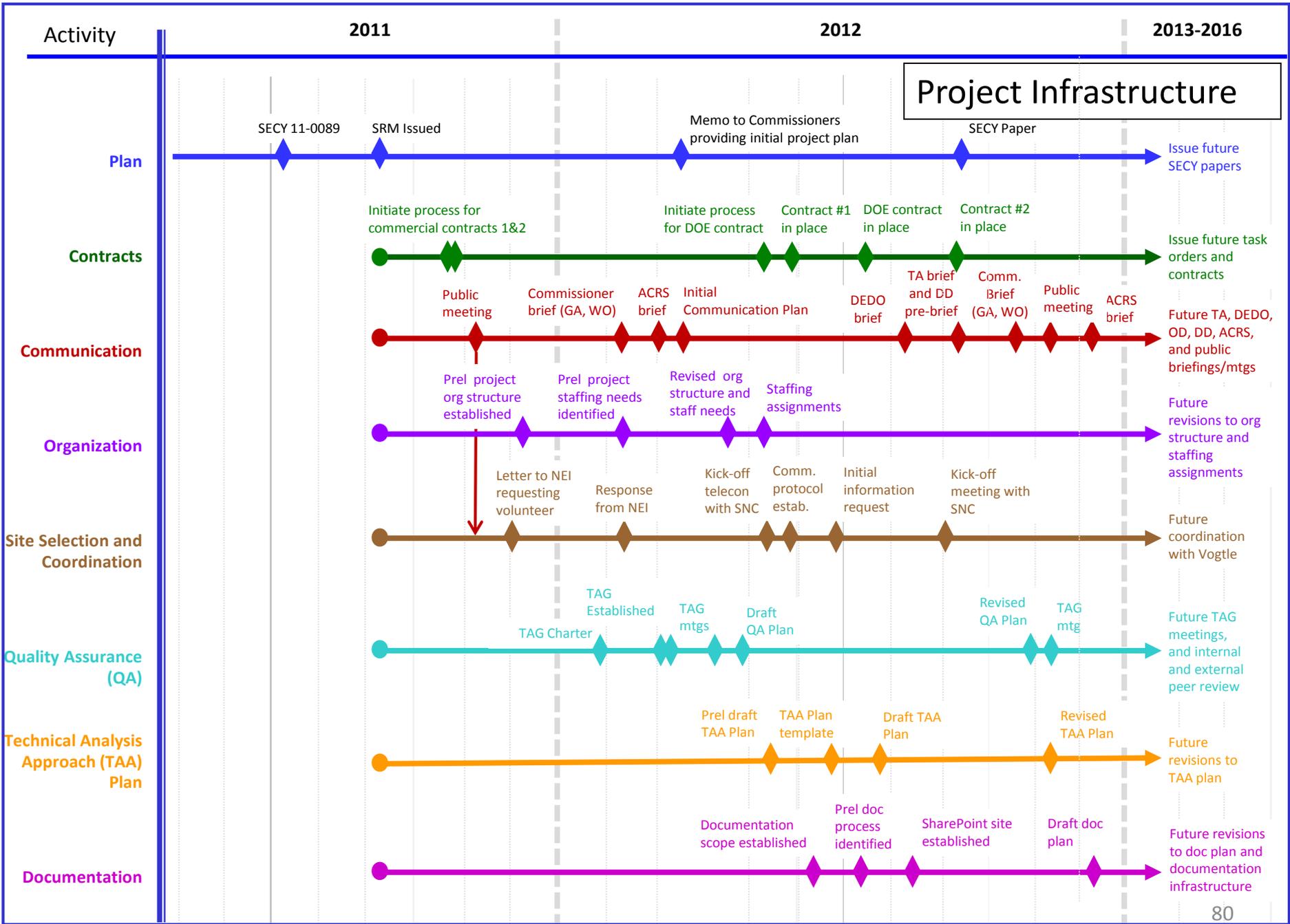
- The objective is for the ACRS to
  - Review progress in the development of the Level 3 PRA project
  - Provide insights, advice and guidance on the technical approach, methods, tools and data for the project, as well as on the project results
- The ACRS Reliability and PRA Subcommittee will be briefed approximately twice a year to obtain their feedback.

# Project Status and Path Forward

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# Project Accomplishments

- Selected subject site (Vogtle Units 1 and 2)
- Established Technical Advisory Group (including EPRI representation)
- Developed contracting strategy, preliminary project schedule, organizational structure, and staffing plan
- Provided initial project plan and communications plan to Commission
- Established communication protocol with Southern Nuclear Operating Company (SNC), held kick-off meeting, and working to obtain necessary plant information and coordinate interactions
- Developing technical analysis approach plan and quality assurance plan
- Briefed TAG on the above plans



# Path Forward

- Continue with technical work in all areas, including:
  - Develop Reactor Level 1 PRA internal events and internal floods model in SAPHIRE
  - Meet with licensee to discuss modeling of internal fire and external hazards
  - Develop MELCOR input deck for use in analyzing system success criteria, accident sequence timing, and severe accident progression
  - Investigate methods for addressing HRA for external events, LPSD, and post-core-damage
  - Investigate methods for addressing integrated site risk
- Continue to interact with internal and external stakeholders, including:
  - Brief TAG, public, and ACRS on approach for spent fuel pool PRA and dry cask storage PRA in Spring 2013
  - Brief TAG, public, and ACRS on resolution of challenges and initial results for reactor PRA in Summer/Fall 2013

# Back-Up Viewgraphs

# Additional Information on IE Analysis

- Consequential and concurrent initiating events are outside the scope.
- The EPRI/NRC modeling of support systems initiating events (SSIEs) shall be used for applicable support systems.

# Additional Information on Success Criteria

- Licensee success criteria and sequence timing assumptions will be scrutinized based on existing information.
  - Licensee has performed extensive MAAP4 analysis.
  - No dedicated MELCOR analysis based on schedule/resource constraints.
  - Existing information includes past studies, MAAP4 modeling experience, and ongoing MELCOR analysis for a similar plant (Byron, Unit 1).

# Additional Information on Success Criteria (Cont.)

- Vogtle, Unit 1 MELCOR 2.1 model is being developed for focused success criteria analysis for other modes/hazards (including use in Level 2 PRA).
  - Reactor coolant system, main steam system, containment, reactor protection signals, and engineered safety features.
  - TRACE 4-loop Westinghouse model also available for LBLOCA/ATWS, if necessary.

# Additional Information on Internal Flooding PRA

## General Approach

- The approach is consistent with the general approach used for internal events.
- The existing SPAR model does not include internal flooding.
- Review the licensee's internal flooding PRA model, model documentation, and peer review report to confirm technical adequacy of the licensee's internal flooding analysis.
  - Investigate any findings and observations from the external peer review of the licensee's model.
  - Perform a selective audit of the licensee's model and model documentation against the current ASME/ANS PRA Standard.
  - Perform a site visit to confirm aspects of the analysis. This may include plant walkdowns, interviews with plant staff, and review of drawings and P&IDs.
- Integrate the internal flooding scenarios into the internal events model.

# Additional Information on Internal Flooding PRA

## Assumptions and Limitations

- The licensee's internal flooding PRA has undergone peer review against the ASME PRA Standard.
- Any supplemental analysis and information gathering performed by the staff will be minimal.
- A stable version of the internal events model will be available before internal flood scenarios can be integrated.

# Additional Information on Internal Fire PRA

## Background

- The licensee has performed an internal fire PRA which has undergone external peer review, though the licensee has not yet received the final peer review report.
- The licensee's fire PRA will be used to identify (or define) fire scenarios for incorporation into the NRC's Level 3 PRA model.
- NUREG/CR-6850 (EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities) will be used to identify areas that may require additional analysis, if practical.
- Mix of in-house (RES staff) and contracted effort.

# Additional Information on Internal Fire PRA

## Assumptions and Limitations

- Licensee's fire PRA model and documentation, including external peer review report, are available.
- A stable version of the internal events model will be available before the fire scenario modeling task starts.
- Fire scenarios affecting Unit 1 will be modeled.
  - Differences with Unit 2 will be identified.
- The project will rely on analyses already performed for the following areas:
  - Cable tracing/selection for fire PRA
  - Circuit analysis for spurious actuations
  - Fire modeling.

# Additional Information on LPSD PRA

## Initiating Event Analysis

- In general, obtain initiating event frequencies from:
  - NUREG/CR-6928, “Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants”
  - EPRI Technical Report 1003113, “An Analysis of Loss of Decay Heat Removal Trends and Initiating Event Frequencies (1989-2000)”
- Review more recent LPSD operating experience to determine if updated frequencies are needed