19.0 PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

This Cchapter of the U.S. EPR Final Safety Analysis Report (FSAR) is incorporated by reference with supplements as identified in the following sections.

The U.S. EPR FSAR includes the following COL Item in Section 19.0:

> The COL applicant that references the U.S. EPR design certification will either confirm that the PRA in the design certification bounds the site-specific design information and any design changes or departures, or update the PRA to reflect the site-specific design information and any design changes or departures.

This COL Item is addressed as follows:

{The PRA in the U.S. EPR design certification bounds CCNPP Unit 3 as discussed in this chapter.}

19.1 PROBABILISTIC RISK ASSESSMENT

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

19.1.1 USES AND APPLICATION OF THE PRA

19.1.1.1 Design Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.1:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of site-specific design programs and processes during the design phase.

This COL Item is addressed as follows:

{No additional PRA-related design activities are anticipated for CCNPP Unit 3.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the design phase.

The PRA maintenance and update activities described in Section 19.1.2.4.1 will be performed as needed during the design phase.

19.1.1.2 Combined License Application Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.2:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the combined license application phase.

This COL Item is addressed as follows:

PRA uses in the combined license application phase include:

- identification of risk-informed safety insights associated with the design and operation.
- provide PRA importance measures for input to the Reliability Assurance Program (RAP).
- gain risk insights associated with establishing allowed outage times for certain equipment technical specifications.
- ~~for~~ input to the procedure development process/human factors.

{There are no risk-informed applications currently proposed.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the Combined License Application Phase.

19.1.1.3 Construction Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.3:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the construction phase.

This COL Item is addressed as follows:

{No specific PRA uses are anticipated during the construction phase. There are no risk-informed applications currently proposed.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the construction phase.

19.1.1.4 Operational Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.4:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase.

This COL Item is addressed as follows:

The PRA risk insights will be used to support typical licensee programs such as:

- the Significance Determination Process (SDP).
- Mitigating System Performance Index (MSPI).
- 10 CFR 50.65 Maintenance Rule and associated (a)(4) determinations.

{There are no risk-informed applications currently proposed.}

19.1.2 QUALITY OF PRA

No departures or supplements.

19.1.2.1 PRA Scope

No departures or supplements.

19.1.2.2 PRA Level of Detail

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.2:

> A COL applicant that references the U.S. EPR design certification will review as-designed and as-built information and conduct walk-downs as necessary to confirm that the assumptions used in the PRA, including PRA inputs to RAP and severe accident mitigation design alternatives (SAMDA), remain valid with respect to internal events, internal flooding and fire events (routings and locations of pipe, cable and conduit), and human reliability analyses (HRA) (i.e., development of operating procedures, emergency operating procedures and severe accident management guidelines and training), external events including PRA-based seismic margins, high confidence, low probability of failure (HCLPF) fragilities, and low power shutdown (LPSD) procedures.

This COL Item is addressed as follows:

As-designed and as-built information will be reviewed, and walk-downs will be performed, as necessary, to confirm that the assumptions used in the PRA, including PRA inputs to RAP and SAMDA, remain valid with respect to internal events, internal flooding and fire events (routings and locations of pipe, cable and conduit), and HRA (i.e., development of operating procedures, emergency operating procedures and severe accident management guidelines and training), external events including PRA-based seismic margins, HCLPF fragilities, and LPSD procedures. This shall be performed prior to fuel load.

19.1.2.3 PRA Technical Adequacy

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.3:

> A COL applicant that references the U.S. EPR design certification will conduct a peer review of the PRA relative to the ASME PRA Standard prior to use of the PRA to support risk-informed applications or before fuel load.

This COL Item is addressed as follows:

A peer review of the PRA relative to the ASME PRA Standard shall be performed prior to use of the PRA to support risk-informed applications or before initial fuel load.

19.1.2.4 PRA Maintenance and Upgrade

No departures or supplements.

19.1.2.4.1 Description of PRA Maintenance and Upgrade Program

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.4.1:

> A COL applicant that references the U.S. EPR design certification will describe the applicant's PRA maintenance and upgrade program.

This COL Item is addressed as follows:

The PRA is treated as a living document. The PRA Configuration Control Program maintains (updates) or upgrades the PRA in the manner prescribed by ASME RA-Sc-2007, "Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications" (ASME, 2007) and as clarified by Regulatory Guide 1.200 (NRC, 2007af). Thus:

- Not later than the date of initial fuel loading, the site specific PRA will be upgraded to contain Level 1 and Level 2 analyses, and to include those events and modes for which NRC-endorsed consensus standards on PRA existed one year prior to scheduled fuel loading.
- The PRA will be upgraded every four years until permanent cessation of operations. The upgraded PRA will include initiating events and modes of operation contained in NRC-endorsed consensus standards in effect one year prior to each upgrade.
- Not later than the date on which a site specific application for a renewed license is submitted, the PRA will be upgraded to cover all modes and all initiating events.

The PRA will be periodically updated, as necessary, according to update methods described below. When reviewing pending design changes and proposed model improvements, effect on core damage frequency (CDF) and large release frequency (LRF) will be estimated. Based on estimated effect, one of the following update methods will be used:

1. If the cumulative effect of pending changes is judged to either increase CDF to 1.0E-06 per year or greater, or increase LRF to 1.0E-07 per year or greater, then a PRA model

revision will be made in a timely manner, regardless of the next routine update-cycle schedule.

2. If the cumulative effect of pending changes is judged to not meet the above conditions, then the PRA model will be revised during the next scheduled update.

The PRA Configuration Control Program performs the following key functions:

1. Monitors PRA inputs and collects new information.
2. Maintains the PRA consistent with the as-built, as-operated plant.
3. Periodically upgrades the PRA to maintain consistency with developments of new methodologies, or to accommodate new requirements in scope and capability.
4. Ensures that the cumulative effect of pending changes is considered when applying the PRA.
5. Evaluates the effect of changes on previously implemented risk-informed decisions that used the PRA.
6. Maintains configuration control of computer codes used to support PRA quantification.
7. Documents the PRA Program, including changes and updates.

The key PRA terms “Maintenance” and “Upgrade” are defined as follows:

- **PRA Maintenance:** Update of PRA models to reflect plant changes such as design modifications, procedure changes, or plant performance (data).
- **PRA Upgrade:** Incorporation into a PRA system of a new PRA methodology or a significant change in PRA scope or capability. This could include, for instance, items such as a new human error analysis methodology, new data update method, new approach to quantification or truncation, or new treatment of common cause failure.

Industry peer review will be performed for the PRA upgrades, as they are defined above. Appendix A of ASME RA-Sc-2007 (ASME, 2007) provides example revisions to increase clarity on what constitutes an upgrade, versus an update and, therefore, what requires a peer review. When assessing a need for a peer review, consideration will also be given to scope or number of PRA maintenance activities performed. Although individual changes to a PRA model may be considered PRA maintenance activities, the integrated nature of several changes may make a peer review desirable. This is because multiple PRA maintenance activities can, over time, lead to considerable changes in the PRA insights (e.g., relative risk importance of SSCs), and a periodic peer review might be prudent.

Peer reviews will be performed in accordance with Regulatory Guide 1.200 (NRC, 2007a), which endorses NEI 00-02, “Probabilistic Risk Assessment (PRA) Peer Review Process Guidance” (NEI, 2002), with exceptions. Peer review findings and observations using this process will indicate what improvements are needed to raise the grade given for each PRA technical element. Review findings and observations will be dispositioned based on their importance.

19.1.3 SPECIAL DESIGN/OPERATIONAL FEATURES

No departures or supplements.

19.1.4 SAFETY INSIGHTS FROM THE INTERNAL EVENTS PRA FOR OPERATIONS AT POWER

19.1.4.1 Level 1 Internal Events PRA for Operations at Power

{Two CCNPP Unit 3 site-specific items have been identified as having the potential to affect the PRA model:

- Loss of Offsite Power (LOOP) frequency and duration
- Circulating Water System (CWS) and Normal Heat Sink (NHS)

These items are evaluated as follows for potential deviations from the U.S. EPR FSAR.

Loss of Offsite Power

LOOP frequencies used in the U.S. EPR FSAR PRA model are consistent with NUREG/CR-6890 (NRC, 2005). The LOOP value used in the PRA model is approximately 1.9E-02/yr. This value departs from the NUREG/CR-6890 base value of 3.6E-02/yr by not including consequential LOOP events (consequential LOOP is treated separately in the model) and crediting the U.S. EPR full load rejection capability for grid-related events.

NUREG/CR-6890 provides specific LOOP frequency values for each U.S. nuclear plant. The base value for LOOP at CCNPP Units 1 and 2, is approximately 2.9E-02/yr or 1.9E-02/yr if adjusted for full load rejection capability. These values include plant-centered and switchyard-centered LOOPs, as well as grid-centered and weather-centered LOOP events. A composite LOOP frequency is calculated by using the U.S. EPR FSAR-generated values for plant and switchyard centered LOOP events, and site-specific values for weather and grid centered LOOP events. This gives a LOOP event frequency (adjusted for consequential LOOP and full load rejection) of approximately 1.7E-02/yr for the CCNPP Unit 3 site. This LOOP event frequency is less than the value used in the U.S. EPR FSAR PRA model (1.9E-02/yr); therefore the U.S. EPR FSAR PRA model is conservative for LOOP event frequency for CCNPP Unit 3.

Circulating Water System

The CWS is not modeled in detail in the U.S. EPR FSAR PRA. Failures of the CWS are included in the determination of initiating event frequencies for loss of balance of plant (LBOP). The frequencies used for the initiating events are based on industry experience (NRC, 2007b).

The NHS is modeled as a support system to the CWS auxiliary cooling system, which provides cooling to the condenser. Failure of the NHS is assumed to result in a loss of main feedwater and startup and shutdown feedwater (SSS). The failure of the NHS for 24 hours following a plant trip is modeled to envelop all failures of the CWS.

The CWS design for CCNPP Unit 3 includes four 25% capacity circulating water pumps. The design for the NHS is a hybrid (wet/dry) cooling tower. It is judged that the U.S. EPR FSAR PRA adequately models the different aspects of the site-specific circulating water system.

It is concluded that the U.S. EPR FSAR PRA for Level 1 internal events at power is applicable and bounding for the CCNPP Unit 3 site. The site and plant-specific parameters do not have a significant impact on the PRA results and insights. Therefore, no changes to the U.S. EPR FSAR

Level 1 internal events PRA are necessary when considering specific CCNPP Unit 3 site and plant parameters.}

19.1.4.2 Level 2 Internal Events PRA for Operations at Power

{No departures or supplements.}

19.1.5 SAFETY INSIGHTS FROM THE EXTERNAL EVENTS PRA FOR OPERATIONS AT POWER

19.1.5.1 Seismic Risk Evaluation

No departures or supplements.

19.1.5.1.1 Description of the Seismic Risk Evaluation

No departures or supplements.

19.1.5.1.2 Results from the Seismic Risk Evaluation

19.1.5.1.2.1 Risk Metrics

No departures or supplements.

19.1.5.1.2.2 Significant Initiating Events and Sequences

No departures or supplements.

19.1.5.1.2.3 Significant Functions, SSCs, and Operator Actions

No departures or supplements.

19.1.5.1.2.4 Key Assumptions and Insights

The U.S. EPR FSAR includes the following COL Item in Section 19.1.5.1.2.4:

> A COL applicant that references the U.S. EPR design certification will confirm that the design-specific U.S. EPR PRA-based seismic margins assessment is bounding for their specific site.

This COL Item is addressed as follows:

The PRA-based seismic margins assessment performed for the U.S. EPR FSAR is based on the assumption that the U.S. EPR is designed using the EUR-based certified seismic design response spectra (CSDRS) anchored to 0.3g for selected generic soil profiles. The seismic margins assessment used CSDRS times 1.67 to define the Review Level Earthquake (RLE), which is the targeted seismic margin. The seismic margins assessment for U.S. EPR FSAR remains valid if it can be demonstrated that the U.S. EPR FSAR seismic design parameters bound those for the site-specific seismic parameters , including the ground motion response spectra (GMRS) and site-specific soil profiles.

{A comparison of the GMRS versus the CSDRS is provided in Section 3.7.1 and demonstrates that the GMRS is much lower than that of the CSDRS, and when the spectra are considered in combination with the site-specific soil parameters, it is concluded that the seismic demands for CCNPP Unit 3 are much lower than that used for the U.S. EPR FSAR. Therefore, the U.S. EPR FSAR bounds site-specific parameters and they do not have a significant impact on the CCNPP Unit 3 PRA results and insights.}

19.1.5.1.2.5 Sensitivities and Uncertainties

No departures or supplements.

19.1.5.2 Internal Flooding Risk Evaluation

{Most systems considered as internal flooding sources, including the ESWS, are addressed as part of the standard design described in the U.S. EPR FSAR. Site-specific systems modeled in the PRA, such as the CWS could only cause flooding events in the Turbine Building. The internal flooding frequency in the Turbine Building in the U.S. EPR FSAR PRA is based on a generic conservative frequency; therefore, it is considered conservative for CCNPP Unit 3. The U.S. EPR FSAR internal flooding PRA is applicable for CCNPP Unit 3.}

19.1.5.3 Internal Fires Risk Evaluation

No departures or supplements.

19.1.5.4 Other External Risk Evaluations

The U.S. EPR FSAR includes the following COL Item in Section 19.1.5.4:

> A COL applicant that references the U.S. EPR design certification will perform the site-specific external event screening analysis for external events applicable to their site.

This COL Item is addressed as follows:

{A screening analysis of the risks posed by external events to the CCNPP Unit 3 site was performed. All of the external events listed in Appendix A of ANSI/ANS-58.21-2003 (ANSI, 2003) have been addressed. For each external event, a progressive approach is used following the guidance in ANSI/ANS-58.21-2003 and in NUREG-1407 (NRC, 1991).

The plant design bases for external events are compared against SRP screening criteria, as defined in NUREG-0800 (NRC, 2007c). If the event cannot be qualitatively screened, a quantitative PRA assessment is performed to assess the risk posed by that external event against SRP quantitative screening criteria, as defined in the appropriate section of NUREG-0800.

As defined in ANSI/ANS-58.21-2003, Table 19.1-1 provides a list of all external events considered. Also provided is the reason for screening each event or the relevant section where screening is discussed.}

19.1.5.4.1 High Winds and Tornado Risk Evaluation

{The risks posed by high winds, tornado wind loads and tornado missile events at the CCNPP Unit 3 site on U.S. EPR structures were evaluated versus NUREG-0800 acceptance criteria. The design requirements for safety-related structures of the U.S. EPR FSAR meet these criteria. The non-safety-related structures located on-site and not designed for tornado loads are evaluated in Section 3.3.

The non-safety-related structures which have systems and components modeled in the PRA include:

- Turbine Building
- Switchgear Building

- Transformer and Switchyard Areas
- Normal Heat Sink
- Nuclear Auxiliary Building
- {Ultimate Heat Sink Makeup Structure}

High Wind Load

The U.S. EPR safety related structures are designed to withstand high wind load characteristics as specified in NUREG-0800, Section 3.3.1. The SRP acceptance criteria for high winds specify that the design velocity pressure for safety-related structures must be greater than or equal to the velocity pressure corresponding to the speed of the 100-year return period 3-second wind gust. The design basis wind speed is 145 mph (233 kph) in open terrain with a 50-year mean recurrence interval. For the safety-related structures, the design wind speed is increased by an importance factor of 1.15 to obtain a 100-year mean recurrence interval.

As documented in Section 2.3.1.2.2.15, the 100 year return period 3-second wind gust for the CCNPP Unit 3 site is 102 mph (164 kph). This is significantly less than the design basis wind speed.

The non-safety-related structures located on-site and not designed for high wind loads are evaluated in Section 3.3, to show that their collapse would not result in an impact on any of the safety related structures. A subset of these structures that contain systems and components modeled in the PRA are listed below:

- Switchgear Building
- Transformer and Switchyard Areas
- Normal Heat Sink
- Turbine Building

The Ultimate Heat Sink Make-up Structure also contains equipment that supports systems and components credited in the PRA. However, it's function is not credited within the mission time assumed in the PRA model.

Tornado Wind Load

The U.S. EPR safety-related structures are designed to meet the design-basis tornado wind characteristics of Tornado Intensity Region I as specified in NUREG-0800, Section 3.3.2. Tornado Intensity Region 1 (Central U.S.) is the most limiting for tornado wind loads and is characterized by a maximum tornado wind speed of 230 mph (370 kph) (184 mph (296 kph) maximum rotational speed, 46 mph (74 kph) maximum translational speed). These design-basis tornado wind characteristics are bounding for all U.S. regions within the contiguous 48 states.

The safety-related structures of the U.S. EPR are designed for the tornado wind loads corresponding to a maximum tornado wind speed of 230 mph (370 kph). The tornado requirement for non-safety-related structures is that upon failure, they cannot cause failure of adjacent safety-related structures.

Tornado Wind Load Quantitative Analysis

A more detailed quantitative analysis is performed to evaluate plant risk as a result of tornado impact on non-safety-related structures, which contain systems and components modeled in the PRA. The detailed quantitative analysis considers a bounding tornado event plant impact scenario and tornado event frequency. The screening core damage frequency associated with the bounding scenario is the plant impact (conditional core damage probability) multiplied by the event frequency.

As stated above, safety-related structures are screened from further evaluation based on NUREG-0800 criteria and their tornado design features. Therefore, it is assumed that a tornado event will not affect safety-related structures or associated systems and components. A bounding plant impact scenario is used to develop risk insights associated with a tornado wind loading on non-safety-related U.S. EPR plant structures, which contain systems and components credited in the PRA model. The following non-safety-related structures of the U.S. EPR plant and associated systems and components are considered in the bounding impact scenario.

1. Auxiliary Power Transformer Area and Switchyard Area - contain components related to offsite power. Unrecoverable loss of offsite power event (LOOP) is assumed in the bounding scenario.

2. Switchgear Building - contains the two station black-out diesel generators (SBO DG), non-1E switchgear equipment, load centers, motor control centers and 12-hour severe accident battery divisions. Failure of both SBO DGs and failure of all non-1E electrical buses and buses powered by the 12-hour severe accident battery divisions is assumed in the bounding scenario.

3. Turbine Building/Normal Heat Sink - contains systems and components associated with secondary heat removal, for example, main condenser and feedwater. The risk impact from a loss of these locations is enveloped by the impact from the switchgear building.

4. Nuclear Auxiliary Building - contains the operational chilled water system (OCWS). Note – because of its proximity to safety-related structures, the Nuclear Auxiliary Building is a reinforced concrete structure and designed for tornado loading per Regulatory Guide 1.76 (NRC, 2007d). Therefore, the plant impact scenario assumes that this structure and associated equipment are not affected by the postulated tornado event.

The U.S. EPR FSAR Level 1 PRA LOOP event tree model is used to calculate the conditional core damage probability (CCDP). Based on the above scenario, the CCDP is approximately 8.8E-04. The dominant CCDP sequence involves common cause failure of all four emergency diesel generators (EDGs), resulting in a station blackout event.

NUREG/CR-4461, Tornado Climatology of the Contiguous United States (NRC, 2007e) is used to determine the tornado strike frequency. The tornado strike frequency is the likelihood that a tornado will strike a given point or structure on an annual basis. It is calculated as the sum of two terms: (1) point structure probability (which is calculated based on recorded tornado dimensions within a certain area) and (2) the life-line term (which is based on the dimensions of the plant-specific target structure).

The point structure probability, life-line term, and the total strike probability are calculated for the local 2° box containing the CCNPP Unit 3 site (37-39° N, 76-78° W). The characteristic dimension used to calculate the plant-specific life-line term is the Turbine Building length of 300 feet (91 m).

Based on the NUREG/CR-4461 information, the CCNPP Unit 3 site-specific strike frequency of a tornado with a wind speed greater than 95 mph (152 kph), the design wind velocity for non-safety-related structures at CCNPP Unit 3 site, is determined as approximately 6.1E-05/yr.

The screening core damage frequency associated with the bounding scenario is the plant impact CCDP (8.8E-04) multiplied by the event frequency (6.1E-05/yr). The core damage frequency (CDF) for this scenario is approximately 5.4E-08/yr. Therefore, the frequency of a release resulting in dose exceeding the guidelines of 10 CFR 100 (CFR, 2008y) is judged to be less than 1E-07/yr, which is a criterion used in NUREG-0800 for external events screening.

Tornado Missiles

The U.S. EPR safety-related structures are designed for the tornado missile characteristics of Region 1 (most limiting U.S. region) as specified in NUREG-0800, Section 3.5.1.4. The design basis missiles include: (1) a massive high kinetic energy missile that deforms on impact, (2) a rigid missile that tests penetration, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers. Therefore, tornado missiles are screened for CCNPP Unit 3 according to NUREG-0800.

The bounding tornado strike scenario defined and quantified above conservatively assumes failure of all non-safety-related structures of the plant. The tornado strike scenario is judged bounding for all credible tornado and tornado missile events. Therefore, tornado missile effect on unprotected plant structures is not evaluated further.

High Winds and Tornado Evaluation Conclusion

The preceding plant high winds and tornado structural design bases allow the risk posed by high winds, tornadoes and tornado missiles to be screened for the CCNPP Unit 3 site. Additional analysis has demonstrated the robustness of the U.S. EPR design with respect to high wind and tornado events by showing that the risk posed by those events is low and the screening criteria are met.}

19.1.5.4.2 External Flooding Evaluation

{Section 2.4.3 through 2.4.7 provide an evaluation of the different flooding conditions considered for the CCNPP Unit 3 site, as well as the U.S. EPR FSAR's protection features against those conditions. The flooding conditions include the probable maximum flood (PMF) on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami and ice effect flooding. Maximum flooding levels due to local intense precipitation are also addressed.

Section 2.4.2 summarizes the flooding evaluations and provides required flood protection requirements. The maximum water level for Nuclear Island due to a local probable maximum precipitation (PMP) is Elevation 81.5 ft (24.8 m) with respect to the reference level. Safety-related structures of the Nuclear Island have a minimum grade slab or entrance at Elevation 84.6 ft (25.8 m) or higher. Grading in the power block area around the safety-related facilities is such that all grades slope away from the structures at a minimum of 1% towards collection ditches. Other than for local PMP flooding, the maximum estimated water surface elevations resulting from all design basis flood considerations discussed in Sections 2.4.2 through 2.4.7 are well below the entrance and grade slab elevations for the power block safety-related facilities. Therefore, flood protection measures are not required for the CCNPP Unit 3 Nuclear Island.

However, flood protection measures are required for the UHS Makeup Water Intake Structure and the UHS Electrical Building. The grade level at the UHS intake location is at elevation 10.0 ft (3.05 m). The maximum flood level at the intake location is elevation 39.4 ft (12 m) as a result of the surge, wave heights, and wave run-up associated with the probable maximum hurricane (PMH) as discussed in Section 2.4.5.

Flood protection measures for the UHS Makeup Water Intake Structure and the UHS Electrical Building, as described in Section 2.4.10, include structural measures to withstand static and dynamic flooding forces, water proofing and water tight doors and hatches. Furthermore, makeup water to the safety-related essential service water cooling tower structures is not required for more than six days of heat removal, if four trains are available. This would provide ample time to provide alternate means to supply the cooling towers. Makeup to the essential service water cooling tower structures is not credited in the U.S. EPR FSAR PRA.

Therefore, the applicable SRP screening criteria in NUREG-0800, SRP Section 2.4.10, are met for the different types of external flooding events, and the risk posed by external flooding can be screened for the CCNPP Unit 3 site.}

19.1.5.4.3 External Fire Evaluation

{As described in Section 2.2.3.1.4, the cleared zones surrounding CCNPP Unit 3 are of sufficient size to afford substantial protection in the event of a fire, and it is not expected that there would be any hazardous effects from fires or heat fluxes associated with wild fires, fires in adjacent industrial plants or from onsite storage facilities.

In addition, the impact of external smoke on the habitability of the main control room is considered in the design of the control room envelope (CRE) and the control room air conditioning system (CRACS) (refer to Section 6.4 and Section 9.4). The CRE has isolation capability in the event of external fire/smoke and the CRACS can be operated in full recirculation mode. The CRACS maintains the control room envelop at a positive pressure to prevent uncontrolled, unfiltered in-leakage during normal and accident conditions. The CRACS can support occupancy for eight people in the MCR and associated rooms for 70 hours without outside makeup air. Portable self-contained breathing apparatus (SCBA) are also available for use by the control room operators.

Therefore, an external fire will not have an adverse impact on the operation of CCNPP Unit 3. Therefore external fire events can be screened per NUREG-0800, Section 2.2.3.

19.1.5.4.4 Aircraft Crash Hazard Risk Evaluation

This section is added as a supplement to the U.S. EPR FSAR.

The risk posed by random airplane crash events to the CCNPP Unit 3 site are evaluated using a progressive screening approach. The location of the site with respect to airports, military training routes and airways was evaluated against the screening criteria presented in NUREG-0800, Section 3.5.1.6.

Screening Analysis for Airplane Crash

NUREG-0800, Section 3.5.1.6 acceptance criteria for airplane crash hazard stipulates that the frequency of an event causing radiological consequences greater than the 10 CFR 100 exposure guidelines should be less than 1E-07/yr. This acceptance criterion can be met provided that all of the following conditions exist:

- The plant-to-airport distance D is between 5 and 10 statute miles (8 and 16 km), and the projected annual number of operations is less than the numerical value of 500 D^2.
- The plant is at least 5 statute miles (8 km) from the nearest edge of military training routes, including low-level training routes, except for those military training routes associated with usage greater than 1000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation.
- The plant is at least 2 statute miles (3.2 km) beyond the nearest edge of a Federal airway, holding pattern, or approach pattern.

The following information is specific to the CCNPP Unit 3 site:

- The CCNPP Unit 3 site lies just within 10 statute miles (16 km) from the Patuxent Naval Air Station. The distances from the CCNPP Unit 3 site to various runways at Patuxent NAS vary from 43,100 ft to 52,736 ft (13,136 to 16,074 m). The Captain Walter Duke Regional Airport is also located just within 10 statute miles from the CCNPP Unit 3 site.
- The number of annual operations at Patuxent NAS is 52,626 and the number of annual operations at Captain Walter Duke Regional Airport is 52,618.

Using the screening methodology presented in NUREG-0800 and assuming a value of 10 miles for D, the total number of operations per year at Patuxent NAS and Walter Duke Regional Airport would have to be less than 50,000 operations (10 * 10 * 500) to meet the screening criteria. In addition, the CCNPP Unit 3 site is within 2 statute miles of a federal airway. Therefore, the risk from airplane crash at CCNPP Unit 3 cannot be screened using the above NUREG-0800 criteria. Therefore, an assessment was performed to quantitatively assess the risk posed by an airplane crash against NUREG-0800 acceptance criteria.

Detailed Airplane Crash Assessment

U.S. EPR FSAR Section 3.5.1.6 states: "The U.S. EPR design employs geographical separation or residence within shielded buildings to provide a minimum number of SSCs to achieve and maintain the plant in cold shutdown and prevent damage to fuel in the spent fuel pool following an aircraft hazard (ACH). Specifically, sufficient geographical separation between redundant or diverse SSCs limits the extent of damage from an ACH. Similarly, placing SSCs within shield buildings designed to prevent penetration by aircraft provides protection of redundant or diverse SSCs to achieve and maintain the plant in cold shutdown and prevent damage to fuel in the spent fuel pool."

Given the above U.S. EPR building design, a quantitative assessment of aircraft hazard was performed for various random aircraft hazard scenarios using the U.S. EPR FSAR PRA. The assessment is judged to be a conservative and bounding approach for screening purposes to satisfy Section 3.5.1.6 of NUREG-0800.

A detailed assessment was performed to better estimate the hazard posed by an airplane crash into CCNPP Unit 3. It consisted of the following steps:

1. Develop target sets based on similiar building structural strength (hardened or non-hardened), site location and expected response.

2. Calculate the estimated impact frequency (initiating event frequency) for each target set based on representative dimensions of the buildings within each target set.

3. Incorporate the calculated initiating event frequencies with PRA event trees to analyze the plant response and obtain a conservative/bounding core damage frequency estimate for each scenario.

Because of the arrangement of structures on the U.S. EPR Site, there are several possible damage scenarios, depending on the direction of the impacting aircraft. The following three bounding and conservative scenarios were modeled:

- Airplane crash into Safeguards Building 1 or 4 - The frequency of impact was derived by combining the building dimensions of Safeguards Building 1 and 4.

- Airplane crash into the Turbine Building - This scenario disables all the equipment within the Turbine Building. In addition, Essential Service Water Cooling Towers 3 and 4 are located east of the Turbine Building and are assumed to fail in this scenario.

- Airplane crash into the Hardened Structures (Reactor Building, Fuel Building, and Safeguards Building 2 and 3) - The hardened buildings, along with the Nuclear Auxiliary Building were combined into one group. It is assumed that no systems within the hardened buildings would be disabled directly from the crash. Also, because no safety-related systems are located in the Nuclear Auxiliary Building, the results would be essentially the same (reactor trip with no direct failures of safety-related equipment).

The bounding scenario was an airplane crash into Safeguards Building 1 or Safeguards Building 4. It results in a core damage frequency of 1.5E-07. This core damage frequency does not allow screening aircraft crash events based on the NUREG-0800 acceptance criteria, i.e., a frequency of 1.0E-7 to exceed the guidelines of 10 CFR 100 (CFR, 2007b). Therefore, an assessment of the containment release frequency associated with this event was performed. To that effect, the bounding airplane crash scenario was assessed using the U.S. EPR FSAR Level 2 PRA model. As previously identified in Section 19.1.4.2, the U.S. EPR FSAR Level 2 PRA model is applicable to CCNPP Unit 3 without modification. All systems and equipment affected by the crash, including the Severe Accident Heat Removal System, are assumed to be unavailable for the Level 2 analysis. The results of this conservative assessment show that the frequency of any release (large or small) is approximately 3E-08/yr. Therefore, the frequency of a release resulting in a dose exceeding the guidelines of 10 CFR 100 (CFR, 2007b) is judged to be less than or equal to 3E-08/yr.

NUREG-0800, Section 3.5.1.6's acceptance criteria for airplane crash hazard requires that the frequency of an event causing radiological consequences greater than the 10 CFR 100 exposure guidelines should be less than 1E-07. Therefore, the risk posed by airplane crash hazard to CCNPP Unit 3 meets the SRP acceptance criteria.

19.1.5.4.5 Industrial and Transportation Accidents Risk Evaluation

This section is added as a supplement to the U.S. EPR FSAR.

The risks posed by potential industrial and transportation accidents to CCNPP Unit 3 are evaluated against the SRP screening criteria as defined in NUREG-0800, Section 2.2.3. The following approach is used: if the postulated event does not adversely affect the operation of the plant, the event can be screened if its frequency is less than 1.E-06/yr.

The following types of hazards are evaluated: highway hazards, waterway hazards, pipeline hazards, railroad hazards, and nearby facilities hazards:

Highway Hazards

In Section 2.2.3.1, an evaluation is made of the risks posed by an accident involving hazardous material occurring on the major highway in Calvert County, Maryland Highway 2/4, which is adjacent to the CCNPP Unit 3 site. CCNPP Unit 3 is located approximately 1.2 miles (1.9 km) from Maryland Highway 2/4 at its closest approach. For each type of event and for the largest amount of hazardous material susceptible to being involved in that event, the minimum separation distance (i.e., safe distance) is calculated. The results are summarized in Table 2.2-8 (for explosions), Table 2.2-9 (for flammable vapor clouds) and Table 2.2-10 (for toxic chemicals). In each case, the largest minimum separation distance is found to be less than 1.2 miles (1.9 km). Therefore, highway hazards would not adversely affect the safe operation of CCNPP Unit 3.

Waterway Hazards

In Section 2.2.3.1, an evaluation is made of the risks posed by an accident involving transportation of hazardous material along the Chesapeake Bay. Per Section 2.2.3.1.1, the distance between potential waterway traffic and the nearest structure (UHS makeup water intake structure) is about 2.2 miles (3.5 km). For each type of event and for the largest amount of hazardous material susceptible to being involved in that event, the minimum separation distance is calculated. The results are summarized in Table 2.2-8 (for explosions), Table 2.2-9 (for flammable vapor clouds) and Table 2.2-10 (for toxic chemicals). In each case, the largest minimum separation distance is found to be less than 2.2 miles (3.5 km). Therefore, waterway hazards would not adversely affect the safe operation of CCNPP Unit 3.

Pipeline Hazards

The Dominion Cove Point pipeline passes within the vicinity of the Calvert Cliff site. The closest distance between the plant and the pipeline is 1.54 miles (2.5 km). Section 2.2.3.1.1 addresses the risk from the pipeline and concludes that an explosion following a rupture in the pipeline would not adversely affect the safe operation of CCNPP Unit 3. The safe distance for exposure to thermal consequences from a rupture in the pipeline is 0.45 mi (0.72 km), which is significantly less than the actual separation.

Railroad Hazards

There are no railroads within 5 miles (8 km) of the CCNPP Unit 3 site. Therefore, this external event is screened per the SRP acceptance criteria.

Nearby Facilities Hazards

Section 2.2.1 identifies three potential external hazard facilities within 5 miles of the CCNPP Unit 3 site: CCNPP Unit 1 and 2, the Dominion Cove Point Liquid Natural Gas (DCPLNG) Terminal and the Dominion Cove Point pipeline (see above).

- The safe distance for each of the hazardous chemicals inventories stored on the CCNPP Unit 1 and 2 sites is shown in Table 2.2-8 (for explosions) and Table 2.2-9 (for flammable vapor clouds). Toxic chemicals release is also evaluated. It is shown in Table 2.2-10 that the main control room would remain habitable after the worst case release in all but two (gasoline and ammonia) of the toxic chemical release scenarios identified. A probabilistic assessment is done for the two scenarios that were not qualitatively screened. It is found that the frequency of a gasoline truck accident or an ammonia tank spill is less than the screening criteria of 1E-06 per year.

- The DCPLNG terminal is located approximately 3.2 miles (5.1 km) away from the CCNPP Unit 3 site. Section 2.2.3.1.1 shows that the risk of an explosion resulting from a complete tank failure at the DCPLNG terminal would not adversely affect the safe operation of CCNPP Unit 3. The safe distance for exposure to a flash fire resulting from a total loss of the storage tanks is 1.0 mile (1.6 km), which is significantly less than the actual separation.

Based on the above evaluation, the risks posed by potential industrial and transportation accidents to the CCNPP Unit 3 site meet NUREG-0800 screening criteria.

19.1.5.4.6 Other External Events Risk Evaluation

This section is added as a supplement to the U.S. EPR FSAR.

Two types of external events from Table 19.1-1 are addressed in this section. These are turbine generated missiles and collisions with the UHS Makeup Water Intake Structure or UHS Electrical Building.

Turbine Missiles

NUREG-0800, Section 3.5.1.3 provides acceptance criteria for turbine missile hazard based on the frequency of a turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing. The acceptance criteria are 1E-04/year for favorably oriented turbines and 1E-05/yr for unfavorably oriented turbines. A favorable orientation is one that excludes the containment and all, or mostly all, safety-related structures, systems or components (SSCs) from the low trajectory missile (LTM) pathway. Meeting these criteria provides confidence that the frequency of unacceptable damage from turbine missiles is less than or equal to 1E-07/yr.

- CCNPP Unit 3 is designed so that the probability of steam turbine failure resulting in ejection of turbine disk (or internal structure) fragments through the turbine casing shall be less than 1E-04/yr for a favorably oriented turbine and shall be less than 1E05/yr for an unfavorably oriented turbine. The design includes a favorably oriented turbine with respect to containment. Detailed analyses and assessments show that the probability of turbine rotor failure resulting in ejection of the turbine rotor fragments through the turbine casing is less than 1E-04 for a favorable oriented turbine with respect to containment. Furthermore, reconciliation of minor energy turbine missiles for CCNPP Unit 3 shows that the potential missile effects on the Essential Service Water Buildings 3 and 4 (located directly adjacent to the Turbine Building in an unfavorable orientation) are consistent with RG 1.115 (NRC, 1977) in that the CCNPP Unit 3 design will ensure that minor missiles which could be ejected will not result in any damage to essential systems. Therefore, the risk to CCNPP Unit 3 from a turbine missile from the CCNPP Unit 3 turbine is within the NRC acceptance criteria as provided in NUREG-0800, Section 3.5.1.3.

- The threat to CCNPP Unit 3 from turbine missiles generated from CCNPP Units 1 and 2 was also considered. The CCNPP Unit 1 and Unit 2 turbines are unfavorably oriented to their respective safety-related buildings, and favorably oriented to the safety-related buildings of CCNPP Unit 3. The frequency of a turbine missile accident is found sufficiently low to screen SRP screening criteria for their own, unfavorably oriented safety-related buildings. Therefore, it can also be screened for the favorably oriented safety-related buildings of CCNPP Unit 3. Therefore, the threat to CCNPP Unit 3 from turbine missiles generated from CCNPP Unit 1 or Unit 2 turbines meets the acceptance criteria provided in NUREG-0800.

Collisions with UHS Makeup Water Intake Structure or UHS Electrical Building

CCNPP Unit 3 is located on a navigable waterway. The only safety-related structures located near the shore line are the UHS Makeup Water Intake Structure and UHS Electrical Building. These are safety-related structures located adjacent to the CWS Makeup Intake Structure. The UHS Makeup Water Intake Structure and the UHS Electrical Building for CCNPP Unit 3 are situated in an area that is set back from the Chesapeake Bay shoreline at the south end of the intake structure for CCNPP Units 1 and 2. Additionally, the portion of the Chesapeake Bay in the vicinity of the intake structure is sufficiently shallow that any vessel of significant size that could possibly cause damage to the intake structure would most likely run aground before it could impact the intake structure (Section 2.2.3.1.5). In the unlikely event of a collision involving the UHS Makeup Water Intake Structure or UHS Electrical Building, no initiating event would occur. If a plant trip were to occur (automatic or manual), the initial inventory of the four Essential Service Water Cooling Tower Structures would have adequate capacity for more than six days of heat removal assuming all four divisions are available. This would provide ample time to provide alternate means to supply the Essential Service Water Cooling Tower Structures. Makeup to the Essential Service Water Cooling Tower Structures is not credited in the PRA.}

19.1.6 SAFETY INSIGHTS FROM THE PRA FOR OTHER MODES OF OPERATION

{No departures or supplements.}

19.1.7 PRA-RELATED INPUT TO OTHER PROGRAMS AND PROCESSES

{No departures or supplements.}

19.1.8 CONCLUSIONS AND FINDINGS

No departures or supplements.

19.1.9 REFERENCES

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NRC, 2007e. Tornado Climatology of the Contiguous United States, NUREG/CR-4461, Revision 2, U. S. Nuclear Regulatory Commission, February 2007.

NRC, 2007f. An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities, Regulatory Guide 1.200, Revision 1, U. S. Nuclear Regulatory Commission, January 2007.}

Table 19.1-1—{Summary of External Events Evaluated for CCNPP Unit 3}
(Page 1 of 2)

External Event Hazard	Evaluation
Aircraft	Screened in Section 19.1.5.4.4
Avalanche	No nearby mountains.
Biological Events	The ultimate heat sinks for CCNPP Unit 3 are closed systems cooled by cooling towers. These would not be subject to biological events such as fish, or debris ingestion.
Shoreline Erosion	Shore erosion would be a slowly developing condition. There would be adequate time to respond to any significant shore erosion. The only safety-related structure located at the shore line is the UHS Makeup Water Intake Structure. In the case of an accident, the four Essential Service Water Cooling Tower structures would have adequate capacity for more than six days of heat removal assuming all four trains are available. This would provide ample time to provide alternate means to supply the cooling tower structures.
Drought	The CCNPP Unit 3 ultimate heat sink consists of four Essential Service Water Cooling Towers with a combined inventory for 72 hours of heat removal under DBA conditions (2 of 4 trains available). Enough inventory would be available for over 6 days of heat removal assuming all four trains are operational. Makeup is supplied from the Chesapeake Bay. Makeup sources should not be significantly impacted by a period of prolonged drought.
External Fire	Screened in Section 19.1.5.4.3
External Flooding	Screened in Section 19.1.5.4.2
Extreme Winds and Tornadoes	Screened in Section 19.1.5.4.1
Fire	Internal fires are analyzed in the U.S. EPR FSAR Level 1 PRA.
Fog	Fog can be a contributor to transportation accidents. Airplane crash and transportation accidents are covered in Section 19.1.5.4.4 and 19.1.5.4.5, respectively. An additional scenario could be the collision of a boat with the CCNPP Unit 3 Makeup Water Intake Structure. See Section 19.1.5.4.6 for a discussion of this scenario.
Frost	The impact of frost is bounded by snow and ice loads.
Hail	The impact of hail would be bounded by events such as tornado missiles. Therefore, it is not a significant risk.
High Tide	Screened in Section 19.1.5.4.2
High Summer Temperature	A maximum ambient air temperature of 115 °F is assumed for buildings within Nuclear Island. HVAC systems are designed with consideration of this outdoor temperature.
Hurricane	Hurricane flooding impacts are screened in Section 19.1.5.4.2 and hurricane winds are bounded be the analysis in Section 19.1.5.4.1.
Ice	The CCNPP Unit 3 minimum design live load due to precipitation (snow and ice) is 100 psf on the ground. This value includes the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation, in accordance with the requirements of NUREG-0800, Section 2.3.1. This bounds the CCNPP Unit 3 site specific design snow load of 53 psf. (Section 4.4.1).
Industrial or Military Facility Accident	Screened in Section 19.1.5.4.5
Internal Flooding	Internal flooding events are analyzed in the U.S. EPR FSAR Level 1 PRA
Landslide	No nearby mountains or steep slopes in the vicinity of CCNPP Unit 3. Therefore, no hazards are identified.
Lightning	The primary impact of lightning is a loss of offsite power. The effect of lightning is judged to be included in the loss of offsite power model of the U.S. EPR FSAR PRA, with the resulting CDF of 1.5E-07/yr.
Low Water Level	The CCNPP Unit 3 ultimate heat sink consists of four Essential Service Water Cooling Towers with a combined inventory for 72 hours of heat removal under DBA conditions (2 of 4 trains available). Enough inventory should be available for over 6 days of heat removal, assuming all four trains are available. Makeup is supplied from the Chesapeake Bay. Low water would be a slowly developing event with ample time to provide coping measures.
Low Winter Temperature	A minimum ambient air temperature of -40 °F is assumed for buildings within the Nuclear Island. HVAC systems are designed with consideration of this outdoor temperature.
Meteorite/Satellite	Low probability event.
Intense Precipitation	Screened in Section 19.1.5.4.2.

Table 19.1-1—{Summary of External Events Evaluated for CCNPP Unit 3}
(Page 2 of 2)

External Event Hazard	Evaluation
Onsite Release of Chemicals	Screened in Section 19.1.5.4.5.
Pipeline Accident	Screened in Section 19.1.5.4.5.
River Diversion	NA
Sandstorm	No nearby sand dunes or desert. No dust/sandstorms were reported in Calvert County between January 1 1993 and September 31, 2006 (FSAR Section 2.3.1.2.2.8)
Seiche	Screened in Section 19.1.5.4.2.
Seismic Activity	Plant seismic capacity is evaluated in the PRA-based seismic margins assessment. (Section 19.1.5.1).
Snow/Ice Loads	The CCNPP Unit 3 minimum design live load due to precipitation (snow and ice) is 100 psf on the ground. This value includes the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation, in accordance with the requirements of NUREG-0800, Section 2.3.1. This bounds the CCNPP Unit 3 site specific design snow load of 53 psf. (Section 4.4.1).
Soil Shrink-Swell	Lateral loads due to soil bearing pressure shall apply to all exterior walls up to the specified yard finished grade elevation. Lateral earth pressure shall be based upon the soil density of normally compacted, structural fill, and shall include the effects of groundwater. No hazards were identified.
Storm Surge	Screened in Section 19.1.5.4.2
Toxic Gas	Screened in Section 19.1.5.4.5
Transportation Accidents (other than aircraft)	Screened in Section 19.1.5.4.5
Tsunami	Screened in Section 19.1.5.4.2
Turbine Missile	Screened in Section 19.1.5.4.6
Volcanic Activity	No volcanoes in vicinity
Waves	Screened in Section 19.1.5.4.2
Other	None identified

19.2 SEVERE ACCIDENT EVALUATIONS

This section of the U.S. EPR FSAR is incorporated by reference.

19.3 OPEN, CONFIRMATORY, AND COL ACTION ITEMS IDENTIFIED AS UNRESOLVED

This section of the U.S. EPR FSAR is incorporated by reference.