UNITED STATES
NUCLEAR REGULATORY COMMISSION
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October 25, 2017

Mr. Daniel G. Stoddard
Senior Vice President and
Chief Nuclear Officer
Virginia Electric and Power Company
Innsbrook Technical Center
5000 Dominion Blvd
Glen Allen, VA 23060-6711

SUBJECT: SURRY POWER STATION, UNIT NOS. 1 AND 2 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7980 AND MF7981)

Dear Mr. Stoddard:

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

By letter dated January 27, 2017 (ADAMS Accession No. ML17033A162), Virginia Electric and Power Company (the licensee) submitted its mitigating strategies assessment (MSA) for Surry Power Station, Unit Nos. 1 and 2 (Surry). The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. The purpose of this letter is to provide the NRC's assessment of the Surry MSA.

Enclosure 1 transmitted herewith contains Security-Related Information. When separated from Enclosure 1, this document is decontrolled.

The NRC staff has concluded that the Surry MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute (NEI) 12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, and that the licensee has demonstrated that the mitigation strategies are reasonably protected from reevaluated flood hazards condition for beyond-design-basis external events.

This letter closes out the NRC's efforts associated with CAC Nos. MF7980 and MF7981.

If you have any questions, please contact me at 301-415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

Frankie Vega, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosures:
1. Staff Assessment Related to the
   Mitigating Strategies for Surry (Non-Public)
2. Staff Assessment Related to the
   Mitigating Strategies for Surry (Public)

Docket Nos. 50-280 and 50-281

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MITIGATION STRATEGIES FOR

SURRY POWER STATION, UNIT NOS. 1 AND 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE

RECOMMENDATION 2.1- FLOODING CAC NOS. MF7980 AND MF7981

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). That order requires holders of operating reactor licenses and construction permits issued under 10 CFR Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit to the NRC for review a final integrated plan (FIP) that describes how compliance with the requirements of Attachment 2 of the order was achieved. In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

The NRC staff and industry recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The NRC staff described this issue and provided recommendations to the Commission on integrating these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256). The Commission issued a staff requirements memorandum (SRM) on March 30, 2015 (ADAMS Accession No. ML15089A236), affirming that the Commission expects licensees for operating nuclear power plants to address the reevaluated flood hazards, which are considered beyond-design-basis external events, within their mitigating strategies.

Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625), has been endorsed by the NRC as an appropriate methodology for licensees to perform assessments of the mitigating strategies against the reevaluated flood hazards developed in response to the March 12, 2012, 50.54(f) letter. The guidance in NEI 12-06, Revision 2, and Appendix G in particular, supports the proposed Mitigation of Beyond-Design-Basis Events rulemaking. The NRC's endorsement of NEI 12-06, including exceptions, clarifications, and additions, is described in NRC Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163). Therefore, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Surry Power Station, Unit Nos. 1 and 2 (Surry) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated March 12, 2015 (ADAMS Accession No. ML15078A291), Virginia Electric and Power Company (Dominion, the licensee) submitted its flood hazard reevaluation report (FHRR) for Surry. By letter dated February 29, 2016 (ADAMS Accession No. ML16041A332), the NRC issued an interim staff response (ISR) letter for Surry. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Surry, which were to be used as suitable input for the mitigating strategies assessment (MSA). For Surry, the mechanisms listed as not bounded by the CDB in the ISR letter are local intense precipitation (LIP) and associated drainage, intake canal failure, and storm surge and river flooding combined effects. The NRC staff subsequently issued the staff assessment of the FHRR for Surry by letter dated December 21, 2016 (ADAMS Accession No. ML16323A200), containing additional details supporting the NRC staff's conclusions summarized in the ISR letter. The NRC staff review of the flood event duration (FED) and associated effects (AE) parameters associated with the flooding mechanisms not bounded by the CDB is provided below.

For the flood-causing mechanisms that are not bounded by respective current plant design-basis hazards, the ISR letter noted that in order to complete its response to the information requested by Enclosure 2 to the 50.54(f) letter, the licensee is expected to submit an integrated assessment or a focused evaluation, as appropriate, to address these reevaluated flood hazards, as described in NRC letter (ADAMS Accession No. ML15174A257), "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events". That letter describes the changes in the NRC's approach to the flood hazard reevaluations that were approved by the Commission in its Staff Requirements Memorandum to COMSECY-15-0019 "Mitigating Strategies and Flooding Hazard Reevaluation Action Plan" (ADAMS Accession No. ML15153A104).

By letter dated January 27, 2017 (ADAMS Accession No. ML17033A162), the licensee submitted its MSA for Surry for review by the NRC staff. The MSA is intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. The licensee provided supplemental information by letter dated April 13, 2017 (ADAMS Accession No. ML17111A893), in response to an NRC staff request for additional information.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

The NRC staff evaluated the Surry strategies as developed and implemented under Order EA-12-049, as described in the licensee's FIP dated January 25, 2016 (ADAMS Accession No. ML16033A353). The NRC staff's safety evaluation for Surry is dated August 4, 2016 (ADAMS Accession No. ML16158A432). The Surry safety evaluation concludes that the licensee has developed guidance and proposed a design that, if implemented appropriately, will adequately address the requirements of Order EA-12-049.

A brief summary of Surry's FLEX strategies, as described in the FIP, is listed below:

- For Phase 1, immediately following the occurrence of an extended loss of alternating current power/loss of ultimate heat sink (ELAP/LUHS) event, the reactor will trip and the plant will initially stabilize at no-load reactor coolant system (RCS) temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the steam generator (SG) power-operated relief valves (PORVs) or main steam safety valves (MSSVs). The turbine driven auxiliary feedwater pump (TDAFWP) will provide flow to the SGs to make up for steam release, with suction from the unit's Emergency Condensate Storage Tank (ECST) and, when the ECST volume is depleted, the emergency condensate makeup tank (ECMT). Under ELAP conditions, RCS inventory will diminish gradually due to leakage through reactor coolant pump seals and other leakage points. Some passive injection from the nitrogen-pressurized accumulators would occur as the RCS is depressurized below the accumulator cover gas pressure. The licensee determined that sufficient reactor coolant inventory is available throughout Phase 1 without RCS makeup. The operators strip non-essential electrical loads between 45 minutes and 75 minutes into the event. This will extend battery life to 14 hours for each unit. The Phase 1 coping strategy for spent fuel pool cooling is to monitor SFP level using instrumentation installed as required by NRC Order EA-12-051.

- For Phase 2, the primary strategy for core cooling would be to establish an indefinite source of SG makeup water by deploying a portable beyond-design-basis (BDB) high capacity pump, drawing from the settling pond or the circulating water discharge canal. This pump would be aligned to refill the ECST to provide a continued water source for the TDAFWP; alternately, the BDB high capacity pump could discharge to a portable BDB auxiliary feedwater (AFW) pump, which would serve as an alternative to the TDAFWP. In order to maintain sufficient borated RCS inventory in Phase 2, one portable diesel-driven high-pressure BDB RCS pump would be deployed at each unit to inject borated makeup water from the onsite refueling water storage tanks (RWSTs) or, as a contingency, portable boric acid mixing tanks. FLEX diesel generators (DGs) (480 Volt (V) alternating current (ac)) will be deployed to supply power to key instrumentation via the battery chargers and inverters within 14 hours of the initiation of the ELAP event. The FLEX DGs will repower the vital 120 Vac buses to power required instruments. Portable 120/240 Vac DGs are available as an alternate power supply to the 120 Vac vital bus circuits and key instrumentation, if the 480 Vac DGs are not available. The Phase 2 SFP cooling strategy is to initiate SFP makeup within 24 hours using the emergency SFP makeup line taking water either from the BDB high capacity pump through the BDB SFP makeup connection or, alternately, through the fire protection (FP) system which feeds the emergency SFP makeup line from the yard fire main loop directly.

- For Phase 3, the equipment from a National SAFER [Strategic Alliance of FLEX Emergency Response] Response Center (NSRC) will be transported to one of two onsite staging areas (B-1 and B-2). This equipment can be used as needed to replace Phase 2 equipment, and will utilize the same deployment pathways as Phase 2 equipment.

3.2 Reevaluated Flooding Hazards and Modified FLEX Strategies

By letter dated January 27, 2017 (ADAMS Accession No. ML17033A162), the licensee submitted its MSA for Surry for review by the NRC staff. The MSA is intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. As mentioned in the Surry MSA, all water levels and elevations for this staff assessment are based on mean sea level (MSL) unless otherwise noted. The licensee stated that modifications to the FLEX strategies would be necessary, and that these modifications would be implemented in accordance with the proposed NRC rule for mitigating beyond design basis events.

3.2.1 Storm Surge and River Flooding Combined Effects

For the storm surge and river flooding combined effects flood, the maximum reevaluated flood hazard water level on the west side of the plant (24.2 feet (ft.) MSL) is not bounded by the CDB water level (24.0 ft. MSL). In the Surry MSA, the licensee states that this reevaluated flood mechanism would not result in flooding of the west side of the main plant / power block, since the typical site grade is at an elevation of 26.5 ft. MSL. However, the maximum reevaluated flood hazard water level on the east side of the plant (38.8 ft. MSL) is also not bounded by the CDB water level (28.6 ft. MSL) and exceeds the elevation of the emergency service water pump house (ESPH) roof (33.5 ft. MSL) and the elevation of the exhaust line of the emergency service water pumps (36.5 ft. MSL). If the ESPH and emergency service water pumps were inundated during an ELAP, the intake canal would empty through the discharge canal before operators could manually close the circulating water isolation valves; the intake canal inventory could not be recovered with the emergency service water pumps inoperable. Also, the licensee states that the intake canal embankment near the low level intake would be subject to scour from wave action during a reevaluated storm surge combined effects flood, which could result in breach of the embankment and subsequent drain-down of the intake canal.

If the intake canal is lost, the Surry Phase 3 FLEX mitigating strategies include provisions for obtaining service water from the circulating water discharge canal using high capacity drafting pumps. The loss of the intake canal would not impact any other element of the licensee's FLEX strategy. Therefore, the licensee stated that the reevaluated flood hazard flood level at the east side of the plant does not impact the FLEX mitigating strategies requiring the use of service water. This reevaluated flood mechanism would not result in flooding of the main site/power block. The licensee concluded that the reevaluated storm surge and river flooding combined effects flood hazard on both the west side and the east side of the plant would have no impact on the FLEX mitigating strategies.

The staff has reviewed the licensee's current mitigating strategies, associated procedures, flood parameters and site elevations, and finds that the reevaluated storm surge and river flooding combined effects flood, for both the west and east sides of the plant, will not threaten the licensee's FLEX strategy.

3.2.2 Local Intense Precipitation (LIP)

For LIP, the maximum reevaluated flood hazard water level (29.4 ft. MSL) is not bounded by the Surry FLEX design-basis flood elevation, since this flooding mechanism is not included in the CDB. In the Surry MSA, the licensee concludes that the reevaluated LIP flood hazard would potentially threaten the ability of operators to access the main steam valve house (MSVH) at each unit and locally throttle AFW flow in time to prevent overfilling of the SGs. The FLEX mitigating strategy at Surry requires that operators depart the main control room (MCR) within 20 minutes of the start of the ELAP event, and locally throttle AFW in the MSVH within 90 minutes after the start of the event. In its MSA, the licensee assumes that no travel between the MCR and the MSVH will be possible until after the one hour duration of the LIP. Therefore, the licensee proposed a "Modified FLEX" strategy which entails calling two additional operators to the site and stationing one in each MSVH prior to the onset of the LIP. The Surry MSA states that the station abnormal weather procedure may be revised to include severe weather triggers which would direct these actions. As part of the development of the Focused Evaluation, the licensee is assessing available warning time associated with the LIP event, consistent with NEI white paper "Warning Time for Maximum Precipitation Events," Revision 6, submitted to the NRC by letter dated April 8, 2015 (ADAMS Accession No. ML15104A157), and endorsed by the staff by letter dated April 23, 2015 (ADAMS Accession No. ML15110A080). The licensee anticipates that for the reevaluated LIP flood hazard, adequate warning time would be available from severe weather forecasting to perform actions required by this Modified FLEX strategy.

In its MSA, the licensee also concludes that the reevaluated LIP flood hazard could result in flooding of the emergency switch gear room (ESGR), including the battery rooms, which would render the ac and direct current (dc) emergency electrical power distribution system unavailable. The NRC staff asked the licensee to discuss whether the electrical strategy (for Phases 1, 2, and 3) is still valid with the switchgear being flooded. By letter dated April 13, 2017 (ADAMS Accession No. ML17111A893), the licensee responded to the NRC staff request by describing the actions they proposed in the case of a flooded switchgear. The staff evaluated the impact of ESGR flooding on the availability and functionality of required electrical equipment, particularly key instrumentation, during an ELAP response.

As an alternative to relying on instrumentation powered from the emergency power distribution system for display in the MCR, the necessary plant parameters for FLEX mitigating strategies in Phases 1, 2, and 3 are displayed at the remote monitoring panel (RMP), whose power cabling does not route through the ESGR. According to the licensee's assessment, the RMP is not adversely impacted by any reevaluated flood hazard. The RMP is powered by an uninterruptible power source (UPS) that contains its own battery charger and batteries (internal and external) with the capability to supply power for 12 hours. The UPS does not supply any loads during normal operation. The maximum design load for the RMP is 8.83 amperes (amps). The licensee performed pre-operability testing of the UPS that verified that it could supply greater than 12-hour battery capability at a discharge current of 8.83 – 10 amps.

Based on this information, the NRC staff finds that the licensee has demonstrated that the UPS is adequately sized to support a 12-hour duty cycle.

For Phase 2, the licensee would repower the UPS using a portable generator prior to the UPS batteries depleting. The licensee has two portable gasoline powered 120 Vac generators. One of the generators is rated at 6.5 kilowatts (kW) with a 30 amp rated receptacle and the other is rated at 5.5 kW with a 30 amp rated receptacle. These generators are stored in the BDB Storage Building, which is protected against the reevaluated LIP flood hazard and the reevaluated intake canal failure flood hazard.

When a portable generator is supplying power to the UPS and external battery cabinet, the input of the UPS is limited to 12 amps. The UPS has a power efficiency of 89 percent and therefore has a limited output of 10.68 amps. The UPS has an additional output power derating factor of 0.90 for the maximum ambient temperature of 90 degrees Fahrenheit (°F). The UPS can draw in up to 15 amps if a complete battery discharge occurs. The external battery cabinet charger is equipped with a 6 amp fuse; therefore, the maximum load is 21 amps, which is within the 30 amp rating of the generators. Therefore, the portable generators are adequately sized to power the RMP and recharge the associated UPS battery.

Licensee procedures 1/2-FSG-7, "Loss of Vital Instrumentation or Control Power," Revision 0, direct operators to isolate the RMP from the normal power supply and repower the RMP within 12 hours using one of the two small portable generators. These procedures provide an alternative strategy for manually obtaining FLEX key plant parameters locally. By letter dated October 4, 2017 (ADAMS Accession Number ML17284A178) the licensee noted that they would revise FSG-7 to explicitly include the 12-hour time constraint for repowering the RMP prior to depletion of the UPS, as well as directions for staging a 120 Vac generator and cable routing to avoid submerging the cables that will connect the 120 Vac generator to the RMP connection panel in flood water. The licensee has added these proposed changes to their corrective action program.

For Phase 3, the licensee plans to continue using its Phase 2 strategy. While the licensee does not have a formal procedure for repowering the RMP using offsite resources received from an NSRC, they will receive electrical equipment, including electrical generators with sufficient capacity. Therefore, the NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to repower the RMP, if necessary.

During a LIP event (or the reevaluated intake canal failure flood hazard event), the licensee would stage a portable 120 Vac generator above the flood level in the Unit 1 alleyway near the roll-up door from the mechanical equipment room. Operators would route the power cables from the generator into the Service Building and up to the RMP connection in the Cable Spreading Room. Based on this routing, the power cables will not be submerged in water.

The licensee evaluated the impact of the reevaluated LIP flood hazard on the haul path for the portable 120 Vac generator (reevaluated LIP flood hazard flood depths bound the reevaluated intake canal failure flood hazard flood depths). Based on the licensee's evaluation, at 12 hours after an ELAP, the flood depths would be less than 0.5 ft. in the haul path from the BDB Storage Building to the access gate at the northwest corner of the Protected Area, and less than 1.4 ft. from the access gate to the staging location in the Unit 1 alleyway. According to the licensee, a portable 120 Vac generator would be transported from the BDB Storage Building via a BDB John Deere Gator or a trailer pulled by a BDB haul vehicle (tractor). If flood levels in the area of the staging location of the portable 120 Vac generator in the Unit 1 alleyway are high enough to inundate the generator, the Gator or the trailer could be parked in the staging location with the generator operating in the Gator or trailer bed until the flood level recedes sufficiently.

The NRC staff finds that the licensee's proposed strategy to power the RMP during a reevaluated LIP flood hazard event is reasonable.

Sections 3.4.4.4 and 3.9.1.1 of the NRC safety evaluation for the Surry mitigating strategies to satisfy NRC Orders EA-12-049 and EA-12-051 document the NRC's assessment of the licensee's analyses and FLEX strategy actions for mitigating the loss of ventilation as a result of an ELAP. The primary concern with regard to ventilation is the heat buildup that occurs when forced ventilation is lost in areas that continue to have heat loads. The key areas for execution of the licensee's FLEX mitigating strategies in all Phases are the MCR, the ESGR including the battery rooms, the MSVH (SG PORV area and AFW pump room), Containment, the Containment Spray Pump House (CSPH), and the Auxiliary Building.

From Section 3.4.4.4 of the NRC's safety evaluation and the Surry MSA, the licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation and also includes monitoring containment temperature and pressure using installed instrumentation. The licensee's Phase 1 coping strategy for containment in the flooded ESGR scenario relies upon key indications at the RMP, rather than in the MCR as was credited in the licensee's original mitigating strategies that were reviewed by the NRC. Similarly, from the NRC's safety evaluation, the licensee's Phase 2 coping strategy for containment is to continue monitoring containment temperature and pressure using installed instrumentation in the MCR. From the Surry MSA, the licensee's Phase 2 coping strategy for containment in the flooded ESGR scenario relies on indications at the RMP to continue monitoring containment temperature and pressure.

The licensee's analysis indicated that containment pressure and temperatures would remain well below the containment design limits for a period of greater than 7 days following an ELAP, and the licensee used these results to evaluate the effects of temperature and pressure on key instrumentation inside containment. They would procedurally monitor containment temperature and pressure in Phase 1 and Phase 2, and if necessary reduce containment temperature using one or more of the Phase 3 containment cooling strategy options provided in the FLEX Support Guidelines (1/2-FSG-12, "Alternate Containment Cooling," Revision 0). That is, the licensee would use various portable BDB and NSRC supplied pumps to provide Service Water to the Recirculation Spray Heat Exchangers, and provide RWST or fresh water through the containment spray system spray headers to fill the containment sump. After sufficient volume is in the sump, long-term containment cooling requires starting the Outside Recirculation Spray (ORS) pumps. The Phase 3 coping strategy for containment in the flooded ESGR scenario is different from that credited in the licensee's original mitigating strategies that were previously reviewed by the NRC in that the NSRC supplied 480 Vac combustion turbine generators (CTGs) would be used to power the ORS pumps rather than the NSRC supplied 4160 Vac CTGs. This is because the plant emergency power distribution system would not be available. The operation and capability of the ORS pumps is the same when powered by the NSRC 480 Vac CTGs as compared to the NSRC 4160 Vac CTGs. The 480 Vac CTGs are sized to support operation of the 300 horsepower ORS pump motor. The licensee plans to stage the 480 Vac CTGs near the Unit 1 and Unit 2 Safeguards Buildings and route the cable from the CTGs to inside the Safeguards Buildings. Based on the licensee's proposed routing, the power cables will not be submerged in water. Monitoring of containment temperature and pressure would be continued in Phase 3 using the RMP.

Section 3.9.1.1 of the NRC's safety evaluation for the Surry mitigating strategies to satisfy NRC Orders EA-12-049 and EA-12-051 documents the associated analyses and FLEX strategy actions for mitigating loss of ventilation from an ELAP. The licensee's analyses of loss of ventilation in the MSVH - AFW pump room, the CSPH, and the Auxiliary Building predicts that the temperatures in these areas would be expected to remain below 120 °F during an ELAP without taking any actions. An ELAP with the flooded ESGR scenario does not change the results of these analyses. Loss of ventilation in the MSVH – SG PORV area requires the FLEX strategy action of opening a MSVH external door during an ELAP. An ELAP with the flooded ESGR scenario requires the same action. The licensee's evaluations concluded that the MSVH could be accessed within the time required to open an external door during the reevaluated LIP flood hazard or the reevaluated intake canal failure flood hazard, which are the flood hazards that could result in ESGR flooding. The licensee's original mitigating strategies for coping with an ELAP included guidance for opening doors and providing portable fans for ventilation in the MCR and the ESGR (including the battery rooms). In contrast, no strategy actions are required to mitigate loss of ventilation in the MCR and the ESGR during the ESGR flooding scenario since neither of these areas would be available or relied upon.

Based on the above, the NRC staff finds that the licensee's proposed strategy is adequate to ensure that required electrical equipment, including key instrumentation, remains functional during a loss of ventilation as a result of an ELAP.

In the Surry MSA, the licensee states that temporary flood protection modifications are being considered for the main plant / power block to prevent ESGR flooding during the reevaluated LIP flood hazard. Final design of these modifications will be described in the Focused Evaluation, and the licensee plans to enhance its "Modified FLEX" strategies. The licensee's intent is that the enhanced "Modified FLEX" strategies which credit these flood protection modifications would prevent ESGR flooding and allow continued monitoring of key instrumentation in the Control Room.

For an ELAP event occurring during shutdown conditions, the licensee is abiding by the guidance in the NEI position paper dated September 18, 2013 (ADAMS Accession No. ML13273A514), which was endorsed by the staff in a letter dated September 30, 2013 (ADAMS Accession No. ML13267A382). Unit shutdown procedures direct that the BDB AFW pump be pre-deployed near the shutdown unit's RWST prior to shutdown, in order to provide borated makeup to the RCS. If an ELAP event results in a loss of residual heat removal (RHR), the licensee would evacuate containment and close all open containment penetrations, and secure containment purge ventilation. In order to maintain containment within its design pressure limits, procedures direct operators to establish a vent path, which can be done manually through the containment equalization valve or the vent stack. In the mitigating strategies safety evaluation, the staff concluded that the licensee had developed procedures that, if implemented appropriately, would maintain or restore core cooling, SFP cooling, and containment following a beyond-design-basis external event in shutdown and refueling modes consistent with the guidance in NEI 12-06.

The licensee concludes in the Surry MSA, that the reevaluated LIP flood hazard has no significant impact on the FLEX mitigating strategies when the plant is in intermediate shutdown, cold shutdown, or refueling shutdown conditions; i.e., the Modes 5 and 6 FLEX mitigating strategies. (The Surry technical specification reactor operation conditions are not defined by the standard modes of operation, but the licensee's MSA does use mode of operation terminology.) After reviewing the licensee's FIP, shutdown procedures, and reevaluated flood parameters, the staff finds that the reevaluated LIP hazard does not significantly impact the licensee's FLEX mitigating strategies when the plant is in a shutdown mode.

In its MSA, the licensee also concludes that the procedures governing the FLEX mitigating strategy for an ELAP during Modes 5 and 6 can be enhanced to improve response during the reevaluated LIP flood hazard. The licensee states that Abnormal Procedure (AP) 10.27, "Loss of All AC Power While on RHR"; Flexible Support Guideline (FSG) 14, "Shutdown RCS Makeup"; and FSG-5, "Initial Assessment and FLEX Equipment Staging" may be revised to include abnormal weather procedure severe warning triggers to direct operator actions to ensure that the reactor core of the Mode 5/6 unit(s) is in the safest possible configuration, and to protect the pre-deployed BDB AFW pump(s) during the LIP reevaluated flood hazard.

In summary, the licensee's MSA states that the following Modified FLEX Strategies will be implemented so that its overall plant response strategies to an ELAP/LUHS event, concurrent with a reevaluated LIP flood hazard, using the current FLEX procedures, equipment, and personnel can be implemented as intended:

- The abnormal weather procedure may be revised to include severe weather triggers for calling two additional operators to the site, and stationing an operator in each MSVH prior to the LIP, to ensure that operator actions in the MSVHs can be performed under LIP conditions. In the meantime, the licensee stated that controlling AFW flow to prevent SG overfill can be accomplished by starting and stopping the TDAFWP.

- The abnormal weather procedure will be revised to include directions to install temporary flood protection which would prevent turbine building flood depths that would result in overtopping of the existing ESGR flood protection wall and subsequent flooding of the ESGR; and

- The abnormal weather procedure will be revised to include severe weather warning triggers to initiate operator actions to endure that the reactor core of a unit in Mode 5 or 6 is in the safest possible configuration and to protect the pre-deployed BDB AFW pump(s) during the reevaluated LIP flood hazard.

- FSG-5, "Initial Assessment and FLEX Equipment Staging", and FSG-7, "Loss of Vital Instrumentation or Control Power," will be revised to include explicit directions to connect the portable 120 Vac DG to the RMP prior to 12 hours after the initiating event, as well as directions for staging a 120 Vac generator and cable routing to avoid submerging the cables that will connect the 120 Vac generator to the RMP connection panel in flood water.

The staff notes that the procedural revisions and flood protection modifications that the licensee describes in its MSA are subject to future NRC inspection.

Consistent with NEI 12-06, Section G.4.2, the licensee identified the impacts of the reevaluated flood hazard to the Surry FLEX strategies. In its MSA, the licensee noted that the current FLEX mitigating strategies do not take credit for any required actions during the warning time or period of site preparation. However, in the course of developing the Focused Evaluation, the licensee is assessing available warning time associated with the LIP event consistent with NEI 15-05, "Warning Time for Maximum Precipitation Events", dated April 8, 2015 (ML15104A157) and endorsed by the staff by letter dated April 23, 2015 (ML15110A080). Provided that sufficient warning time is assessed to be available prior to the onset of the LIP event at the site, the NRC staff finds that it is reasonable that the FLEX strategy, using FLEX procedures modified as described in the MSA, equipment, and personnel, can be implemented as intended if the site abnormal weather procedure and FSGs 5 and 7 are revised as discussed above.

3.2.3 Intake Canal Failure Flood Hazard

For the intake canal failure flood hazard, the licensee's maximum reevaluated flood elevation [redacted] MSL) is not bounded by the CDB at Surry; the Surry design-basis only considers upstream dam failures on the James River and not hypothetical on-site dam failures. The reevaluated intake canal failure flood hazard could result in flooding of the ESGR, including battery rooms, with an impact to FLEX mitigating strategies similar to that of the reevaluated LIP flood hazard. The licensee concludes in its MSA, that the alternative strategy of monitoring key instrumentation at the RMP, as described above, would ensure that FLEX mitigating strategies could be executed as planned if the ESGR was flooded as a result of the reevaluated intake canal failure flood hazard. The licensee also notes that unlike the reevaluated LIP flood hazard, the intake canal failure is assumed to be a "sunny day" breach of the intake canal earthen embankment; therefore, there would not be sufficient advance warning time for operators to deploy the proposed temporary flood protection modifications to prevent ESGR flooding and loss of the emergency power distribution system.

As with the reevaluated LIP flood hazard, the staff finds that the licensee's revised strategy of using the RMP for monitoring of key parameters per FSG-7 and using alternate strategies for the repowering functions is adequate to ensure that required electrical equipment, including key instrumentation, remains functional during a flooded-ESGR scenario as a result of the reevaluated intake canal failure flood hazard.

For an ELAP event occurring during shutdown conditions, the licensee is abiding by the guidance in the NEI position paper dated September 18, 2013 (ADAMS Accession No. ML13273A514), which was endorsed by the staff in a letter dated September 30, 2013 (ADAMS Accession No. ML13267A382). Unit shutdown procedures direct that the BDB AFW pump be pre-deployed near the shutdown unit's RWST prior to shutdown, in order to provide borated makeup to the RCS. If an ELAP event results in a loss of residual heat removal (RHR), the licensee would evacuate containment and close all open containment penetrations, and secure containment purge ventilation. In order to maintain containment within its design pressure limits, procedures direct operators to establish a vent path, which can be done manually through the containment equalization valve or the vent stack. In the mitigating strategies safety evaluation, the staff concluded that the licensee had developed procedures that, if implemented appropriately, would maintain or restore core cooling, SFP cooling, and containment following a beyond-design-basis external event in shutdown and refueling modes consistent with the guidance in NEI 12-06. After reviewing the licensee's FIP, shutdown procedures, and reevaluated flood parameters, the staff finds that the reevaluated intake canal failure flood hazard does not significantly impact the licensee's FLEX mitigating strategies when the plant is in a shutdown mode.

The staff finds that the reevaluated intake canal failure flood hazard would not impact the FLEX equipment storage, haul paths, or Phase 3 NSRC staging areas, nor would it significantly impact the FLEX mitigating strategies for the scenario in which one or both units is in Mode 5 or 6.

3.3 Evaluation of Flood Parameters in the MSA

3.3.1 Confirmation of the Flood Hazard Elevations in the MSA

The NRC staff reviewed the flood hazard elevations in the MSA, and confirmed the flood elevations for LIP, failure of dams, and storm surge flood-causing mechanisms are consistent with the values in the ISR letter.

3.3.2 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by the licensee in its FHRR and MSA regarding the FED parameters needed to perform the MSA for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.2.1-1 of this assessment.

For the LIP flood-causing mechanism, the licensee stated that the flood depths and flood surface elevations vary by location in the main plant site/power block. The licensee used site-specific probable maximum precipitation (PMP) values to analyze the LIP flooding at the site. The 1-hour and 6-hour site-specific PMP values identified for the analysis were 12.4 in and 28.8 in, respectively. The licensee used the two-dimensional (2D) hydrodynamic computer model FLO-2D "FLO-2D Pro Model, Build No. 14.03.07. FLO-2D Software, Inc., Nutrioso, Arizona.Pro", in its assessment.

The water surface elevations at the site range from 26.9 ft. MSL at the door of the Fuel Oil Tanks Pump Room located at the northeast end of the site, to 29.4 ft. MSL at the doors into the Maintenance Building located at the southeast end of the site.

For the LIP flood-causing mechanism, the licensee stated in its MSA that the current FLEX mitigating strategies do not define or take credit for any required actions during the warning time/period of site preparation. As part of the development of the Focused Evaluation, Dominion is assessing available warning time associated with the LIP event consistent with NEI white paper "Warning Time for Maximum Precipitation Events," Revision 6, submitted to the NRC by letter dated April 8, 2015 (ADAMS Accession No. ML15104A157) and endorsed by the staff by letter dated April 23, 2015 (ADAMS Accession No. ML15110A080). The licensee anticipates that for the reevaluated LIP flood hazard, adequate warning time would be available from severe weather forecasting to perform actions required by the Modified FLEX strategies.

The licensee stated in its MSA that the period of inundation for the LIP flood event, which is defined as the time from the arrival of flood waters on the site to when water begins to recede from the site, is approximately 6 hours. The period of recession, defined as the time from when water begins to recede from the site to when water has completely receded from the site, is greater than 14 hours. Based on the LIP flood modeling that the licensee performed, at the end of the 20-hour period of analysis, flood waters are predicted to recede below the thresholds for many but not all of the doors of the main site/power block building.

The NRC staff reviewed the LIP flooding model input files provided as part of the FHRR and performed confirmatory analyses. In addition, the staff reviewed the information provided in the calculation packages and determined that the analyses and FED parameters provided by the licensee are appropriate. The NRC staff confirmed that the licensee's reevaluation of the periods of inundation and recession for the LIP and associated drainage uses present-day methodologies and regulatory guidance.

For the dam-failure flood-causing mechanism, the licensee reported in its FHRR and MSA reports that the reevaluated intake canal failure flood hazard is based on a stillwater elevation of [redacted] ft. MSL. This water elevation results from a postulated sunny-day catastrophic failure of the onsite Intake Canal as described in the FHRR. The licensee stated in its MSA that flood-water depths at the site are predicted from the beginning of the sunny-day intake canal failure to 40 hours after the start of the intake canal failure. The licensee also stated in its MSA that the period of inundation for this flood-causing mechanism is 3 hours while the period of recession is estimated to be more than 36 hours.

The NRC staff reviewed the dam breach and inundation model input files provided as part of the FHRR and performed confirmatory analyses. In addition, the NRC staff reviewed the information provided in the calculation packages as part of the audit (ADAMS Accession No. ML16183A021), and determined that the analyses and FED parameters discussion provided by the licensee are appropriate. Therefore, the NRC staff agrees with the licensee's conclusion that the FED parameters for dam failure are reasonable for the purposes of the MSA.

For the storm surge flood-causing mechanism, the licensee analyzed the combined effects of 25-year flooding of the James River with both probabilistic and deterministic probable maximum storm surge (PMSS) methodologies in the FHRR. The licensee reported the reevaluated flood levels based on a deterministic analysis in its FHRR for the storm surge combined effects for the site. The reevaluated storm surge and river flooding combined effects flood hazard flood level is reported to be 24.2 ft. MSL stillwater on the west side of the plant and this flood level would not result in flooding of the main plant/power block which has a nominal site grade of 26.5 ft. MSL. The PMSS on the east side of the site is reported to have a stillwater level of 24.2 ft., which would combine with a 14.6 ft. wave runup, resulting in a maximum flood level of 38.8 ft. MSL. This flood level would inundate and potentially damage the low level intake resulting in drain-down of the circulating water intake canal and loss of service water to the plant. However, the licensee also stated that the storm surge and river flooding combined effects reevaluated flood hazard does not impact the on-site FLEX mitigating strategies (Phase 1, Phase 2 and Phase 3). Therefore, the licensee excluded this flood-causing mechanism from further consideration in its MSA report and determined that the FED parameters for the storm surge flood-causing mechanism are not applicable. The NRC staff agrees with the licensee's approach and determines that it is appropriate and reasonable for the purposes of reviewing the on-site portion of the mitigating strategies response.

The NRC staff reviewed the storm surge inundation model input files provided as part of the FHRR and performed independent calculations. In addition, the NRC staff reviewed the information provided in the calculation packages as part of the audit and subsequently determined that the analyses and FED parameters provided by the licensee are appropriate. The NRC staff agrees with the licensee's determination regarding FED parameters for this flood-causing mechanism.

In summary, the staff agrees with the licensee's conclusion related to determining the FED parameters as the approach is consistent with the guideline provided by Appendix G of NEI 12-06, Revision 2. Based on this review, the NRC staff determined that the licensee's FED parameters for all flood-causing mechanisms are reasonable and acceptable for use in the MSA.

3.3.3 Evaluation of Associated Effects

The NRC staff reviewed the information provided by the licensee in its FHRR and MSA reports and other supporting documentation provided as part of the audit regarding reevaluated AE parameters for flood hazards not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by the NRC staff, and were transmitted to the licensee via the ISR letter. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.2.2-1 of this assessment.

For the LIP flood-causing mechanism, the licensee stated in the MSA that the hydrostatic and hydrodynamic loads are minimal. Maximum calculated flow velocities during LIP are as high as 5.0 ft./s (1.5 m/s), which the licensee states is unlikely to result in debris loading issues. This estimation is based on the result of a 2D numerical modeling method as described in the FHRR. The licensee also stated that the other associated effects, including sediment deposition and erosion, debris, and groundwater ingress, are minimal due to shallow water depths, relatively slow water velocities, and the fact that the protected area is completely impervious and does not contain natural sources of vegetation and debris. The license further stated that concurrent conditions, including adverse weather, are not considered in the formulation of the LIP event for the Surry site. The NRC staff confirmed the licensee's statements by reviewing the licensee-provided LIP model's input and output files. The NRC staff verified that the inundation depths and flow velocities are accurate and the modeling is reasonable for use as part of the MSA. Correspondingly, the NRC staff agrees with the licensee's assessment of the AE parameters for the LIP flood-causing mechanism.

For the storm surge and river flooding combined effects mechanism, the licensee analyzed in the FHRR the combined effects of 25-yr flooding of the James River with both probabilistic and deterministic PMSS. The AE parameters for the storm surge flood-causing mechanism are not applicable as the reevaluated flood levels on the west side of the plant for this mechanism will not inundate the plant site. Likewise, flooding on the east site of the plant will be addressed as part of Phase 3 of the FLEX mitigating strategies, as discussed in Section 3.2.1 above. Therefore, the licensee excluded this flood-causing mechanism from further consideration in the MSA report, and determined that AE parameters for this flood-causing mechanism are not applicable. The NRC staff agrees this approach is consistent with the guidelines provided by Appendix G of NEI 12-06, Revision 2 and determines that it is appropriate and reasonable for the purposes of this MSA.

For the sunny-day dam failure flood-causing mechanism, the licensee stated that flood levels and maximum flow velocities resulting from the intake canal failure are bounded by the reevaluated LIP flooding hazard values. The licensee reported in the MSA that the hydrodynamic and hydrostatic loading against buildings at the site are likely to be minimal due to the generally shallow flood depths and low flood velocities during the intake canal failure event. The protected area is completely impervious and does not contain natural sources of vegetation and debris. The maximum velocities of up to 4.4 fps during the intake canal failure event are unlikely to result in debris loading issues.

The licensee also stated in its MSA that for the intake canal failure flood-causing mechanism, sediment deposition and erosion and sediment loading at plant grade are minimal, as the protected area is completely impervious and does not contain natural sources of vegetation and debris. The maximum velocities of up to 4.4 fps during the intake canal failure event are unlikely to result in erosion and sediment loading issues. The licensee reported in its MSA that this flood-causing mechanism does not include any AEs of concurrent site conditions and that groundwater ingress is also considered minimal associated effect as the protected area is completely impervious.

The NRC staff confirmed the licensee's statements by reviewing the licensee-provided model input and output files. The NRC staff verified that licensee reported AE parameters are appropriate for this MSA review. Correspondingly, the NRC staff agrees with the licensee's conclusion regarding the AE parameters for the sunny day dam failure event reviewed in this MSA.

In summary, the NRC staff concludes the licensee's methods were appropriate and the AE parameter results for all flood-causing mechanisms are reasonable for use in the MSA.

3.3.4 Evaluation of Flood Protection Features

The NRC staff finds that it is reasonable that the Surry FLEX strategy, using current FLEX procedures, equipment, and personnel, can be implemented as intended if temporary flood protection for the ESGR is provided as discussed in the Surry MSA. In its MSA, the licensee states that these flood protection modifications are being considered for implementation as part of the focused evaluation. The staff notes that the flood protection modifications that the licensee describes in the Surry MSA are subject to future NRC inspection.

In the absence of additional flood protection for the ESGR, or in the case of a "sunny day" failure of the intake canal earthen embankment (in which case no time would be available for operators to deploy temporary flood protection) the staff finds that the licensee's strategy for monitoring key instrumentation from the RMP in a flooded-ESGR scenario and using alternate strategies for the repowering functions should be effective to ensure the success of the FLEX strategy.

4.0 <u>CONCLUSION</u>

The NRC staff has reviewed the information provided in the Surry MSA and supplemental information provided in response to the NRC staff's request for additional information related to current FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 3 of this staff assessment, and found that:

- Impacts to the FLEX strategies have been adequately identified;

- The licensee proposed changes to FLEX strategies and procedures should provide reasonable protection from the reevaluated hazards; and

- The licensee has provided an adequate description and justification of flood protection features necessary to implement the FLEX strategy to account for the reevaluated LIP flood hazard.

Therefore, the NRC staff concludes that the licensee's proposed modified FLEX strategies should be effective during a postulated BDB event for the reevaluated flood-causing mechanism(s), including associated effects and flood event duration. The NRC staff confirmed that the Surry flood hazard MSA was performed consistent with the guidance in Appendix G of NEI 12-06, Revision 2, as endorsed by JLD-ISG-2012-01, Revision 1. Based on the licensee's appropriate hazard characterization, methodology used in the Surry MSA evaluation, and the description of its modified FLEX strategies, the NRC staff concludes that the licensee has demonstrated that these mitigation strategies, if appropriately implemented, should be capable of providing adequate plant protection during the reevaluated flood hazard conditions.

Table 3.2.1-1. Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Consistent with NEI 15-05 (NEI, 2015)	6 hours	14+ hours
Failure of Dams and Onsite Water Control/Storage Structures	Minimal (1)	3 hours	36+ hours
Storm Surge (2)	Not Applicable	Not Applicable	Not Applicable

Source: (MSA)

Notes:

1. The sunny-day dam failure of the intake canal assumes a catastrophic failure of the earthen embankment that provides little warning time between initiation of the failure and the resultant flood.

2. The FED parameters for the storm surge flood-causing mechanism were not developed by the licensee, as the reevaluated flood levels on the west side of the plant for this mechanism will not inundate the plant site and the flooding on the east site of the plant will be addressed as part of the Phase 3 FLEX mitigating strategies response.

TABLE 3.2.2-1. ASSOCIATED EFFECTS PARAMETERS NOT DIRECTLY ASSOCIATED WITH TOTAL WATER HEIGHT FOR FLOOD-CAUSING MECHANISMS NOT BOUNDED BY THE CDB

Associated Effects Parameter	Local Intense Precipitation and Associated Drainage	Failure of Dams and Onsite Water Control/Storage Structures	Storm Surge (1)
Hydrodynamic loading at plant grade	Minimal	Minimal	Not Applicable
Debris loading at plant grade	Minimal	Minimal	Not Applicable
Sediment loading at plant grade	Minimal	Minimal	Not Applicable
Sediment deposition and erosion	Minimal	Minimal	Not Applicable
Concurrent conditions, including adverse weather - Winds	Minimal	Minimal	Not Applicable
Groundwater ingress	Minimal	Minimal	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	Minimal	Minimal	Not Applicable

Source: (FHRR and MSA)

Notes:

1. The AE parameters for the storm surge flood-causing mechanism were not developed by the licensee, as the reevaluated flood levels on the west side of the plant for this mechanism will not inundate the plant site, and the flooding on the east site of the plant will be addressed at Phase 3 of the FLEX mitigating strategies.

SURRY POWER STATION, UNIT NOS. 1 AND 2– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED OCTOBER 25, 2017

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