VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

January 25, 2016

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Serial No.: 14-395D
NLOS/DEA: R1
Docket No.: 50-280/281
License No.: DPR-32/37

**VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
SURRY POWER STATION UNITS 1 AND 2
COMPLIANCE LETTER AND FINAL INTEGRATED PLAN IN RESPONSE TO THE MARCH 12, 2012 COMMISSION ORDER MODIFYING LICENSES WITH REGARD TO REQUIREMENTS FOR MITIGATING STRATEGIES FOR BEYOND-DESIGN-BASIS EXTERNAL EVENTS (ORDER NUMBER EA-12-049)**

On March 12, 2012 the Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [the Order]. The Order requires a three-phase approach for mitigating beyond-design-basis external events. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from offsite. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Condition C.3 of the Order required all Licensees to report to the Commission when full compliance with the requirements of the Order is achieved.

This letter provides notification that Virginia Electric and Power Company (Dominion) has completed the requirements of the Order and is in full compliance with the Order for Surry Power Station Unit 2. Attachment 1 to this letter provides a summary of how the compliance requirements of the Order were met for Unit 2. Dominion provided notification that the requirements of the Order were met for Surry Power Station Unit 1 by letter Serial No. 14-395B dated July 22, 2015. Accordingly, with both units in compliance with the Order, Attachment 2 provides the Final Integrated Plan (FIP) for Surry Power Station Units 1 and 2.

Should you have any questions or require additional information, please contact Ms. Diane Aitken at (804) 273-2694.

Respectfully,

Mark Sartain
Vice President – Nuclear Engineering

Vicki L. Hull
NOTARY PUBLIC
Commonwealth of Virginia
Reg. # 140542
My Commission Expires May 31, 2018

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Mr. Mark D. Sartain, who is Vice President – Nuclear Engineering, of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 25TH day of JANUARY, 2016.

My Commission Expires: 5-31-18

Vicki L. Hull
Notary Public

A151
NRR

Attachments:

1. Order EA-12-049 Compliance Requirements Summary – Unit 2
2. Final Integrated Plan, Beyond Design Basis FLEX Mitigation Strategies, Surry Power Station

Commitments contained in this letter: None

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NRC Senior Resident Inspector
Surry Power Station

Attachment 1

Order EA-12-049 Compliance Requirements Summary

Virginia Electric and Power Company
Surry Power Station Unit 2

Surry Power Station Unit 2
Order EA-12-049 Compliance Requirements Summary

Surry Power Station developed an Overall Integrated Plan (OIP) (Reference 1), documenting diverse and flexible strategies (FLEX) in response to Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (the Order) (Reference 2). The OIP for Surry Power Station was submitted to the NRC on February 28, 2013 and was supplemented by Six-Month Status Reports (References 3, 4, 5, 6 and 7), in accordance with Order EA-12-049, along with an additional supplemental letter that was submitted on April 30, 2013 (Reference 8).

Full compliance with Order EA-12-049 was achieved for Surry Power Station Unit 2 on December 1, 2015. This date is prior to the required compliance date (the end of the Unit 2 second refueling outage after submittal of the OIP) as required by the Order. The information provided herein documents full compliance with the Order for Surry Power Station Unit 2.

Completion of the elements identified below for Surry Power Station Unit 2, as well as References 1, 3, 4, 5, 6, 7 and 8 document full compliance with Order EA-12-049 for Surry Power Station Unit 2.

NRC INTERIM STAFF EVALUATION (ISE) AND AUDIT ITEMS – COMPLETE

During the ongoing audit process (Reference 9), Dominion provided responses for the following items for Surry:

- ISE Open Items
- ISE Confirmatory Items
- Licensee Identified Open Items
- Audit Questions
- Safety Evaluation Review Items

The NRC report, "Surry Power Station, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051," (Reference 10) delineated the items reviewed during the Surry Power Station onsite audit. The report also identified additional audit items, specified as Safety Evaluation Review Items, which were added following the audit and required supplemental information to address.

Dominion's responses, or references to the source document for responses, to the NRC's ISE Open and Confirmatory Items (Reference 11), were provided in Attachment 2 of Dominion's letter Serial No. 14-395B dated July 22, 2015, which provided notification that the requirements of the Order were met for Surry Power Station Unit 1 (Reference 15). Attachment 2 of the July 22, 2015 letter also provided the responses, or references to the source document for responses, to Open or Pending Audit Questions and Licensee Identified Open Items related to Order EA-12-049 specified in Reference 10. The responses provided in Attachment 2 of the July 22, 2015 letter were applicable to both Surry Units 1 and 2. It is Dominion's position that no further actions are required for any of the above items.

MILESTONE SCHEDULE – ITEMS COMPLETE

Unit 2 Milestone	Completion Date
Submit Integrated Plan	February 2013
Develop Strategies	October 2013
Develop Modifications	December 2014
Implement Unit 2 Modifications	December 2015
Develop Training Plan	April 2014
Implement Training	August 2015
Issue FSGs and Associated Procedure Revisions	November 2015
Develop Strategies/Contract with NSRC*	March 2015
Purchase Equipment	February 2014
Receive Equipment	November 2014
Validation Walk-throughs or Demonstrations of FLEX Strategies and Procedures	March 2015
Create Maintenance Procedures	August 2014
Unit 2 Outage Implementation	December 2015

* NSRC is the National SAFER Response Center

STRATEGIES – COMPLETE

Strategy related ISE Open and Confirmatory Items, Audit Questions, and Safety Evaluation Review Items have been addressed as documented in Attachment 2 of Reference 15. The Surry Power Station Unit 2 strategies are in compliance with Order EA-12-049.

MODIFICATIONS - COMPLETE

The plant modifications required to support the FLEX strategies for Surry Power Station Unit 2 have been completed in accordance with the station design control process. The plant modification design changes (DCs) implemented in support of the FLEX strategies for Surry Power Station Unit 1 are as follows:

- FLEX Mechanical Connections (SU-12-00022)
- FLEX Power for Essential Instrumentation and Equipment (SU-13-01019)
- Beyond-Design-Basis (BDB) Storage Building (SU-13-00015)
- BDB FLEX Strategy Support Modifications (SU-13-01168)
- BDB Offsite Communications (SU-14-01034)
- BDB Emergency Equipment (SU-12-00005)
- Surry Spent Fuel Pool Mechanical Connections (SU-12-01219)
- Spent Fuel Pool Level Instrumentation (SU-13-01042)

Copies of these DCs have previously been provided to the NRC staff and are available for review.

EQUIPMENT – PROCURED, MAINTENANCE, AND TESTING - COMPLETE

The equipment required to implement the FLEX strategies for Surry Power Station Unit 2 has been procured in accordance with NEI 12-06, Section 11.1 and 11.2, received at Surry Power Station, initially tested, the performance verified as identified in NEI 12-06, Section 11.5, and is available for use.

Maintenance and testing will be conducted through the use of the Surry Power Station Preventative Maintenance program such that equipment reliability is maintained and is in compliance with EPRI guidelines where applicable to the FLEX equipment.

PROTECTED STORAGE - COMPLETE

The storage facility required to protect BDB equipment has been completed for Surry Power Station. The BDB equipment is protected from the applicable site hazards and will remain deployable to assure implementation of the FLEX strategies for Surry Power Station Unit 2. Dominion acknowledges that the storage of the N+1

50.54(hh)(2) pump in a structure outside of the protected BDB Storage Building represents an alternative to the requirements of NEI 12-06, Sections 5.3.1, 7.3.1, and 11.3.3. Accordingly, appropriate compensatory measures are in place with regard to the allowed unavailability of the BDB equipment. Specifically, if the site FLEX (N) capability is met, but not fully protected for the site's applicable hazards, the allowed unavailability is reduced to 45 days.

PROCEDURES - COMPLETE

FLEX Support Guidelines (FSGs), for Surry Power Station Unit 2, have been developed and integrated with existing procedures. The FSGs and affected existing procedures have been approved and are available for use in accordance with the site procedure control program.

TRAINING - COMPLETE

Training of personnel responsible for the mitigation of beyond-design-basis events at Surry Power Station Unit 2 has been completed in accordance with an accepted training process as recommended in NEI 12-06, Section 11.6.

STAFFING - COMPLETE

The staffing study for Surry Power Station has been completed in accordance with "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of Insights from the Fukushima Dai-ichi Accident," Enclosure 5 pertaining to Recommendation 9.3, dated March 12, 2012 (Reference 12). The staffing assessment was submitted by letter dated December 17, 2014, "Surry Power Station Units 1 and 2, March 12, 2012 Information Request, Phase 2 Staffing Assessment Report," (Reference 13) and supplemented by letter dated June 9, 2015, "Surry Power Station Units 1 and 2, March 12, 2012 Information Request, Supplemental Information Regarding Phase 2 Staffing Assessment Report, Recommendation 9.3." The supplemental information involved the use of Security personnel, procedures, training and staffing for BDB events.

No additional action, procedures, training, or staff are necessary and the FSG strategies can be successfully implemented using the current minimum on-shift staffing.

NATIONAL SAFER RESPONSE CENTERS - COMPLETE

Dominion has established a contract with Pooled Equipment Inventory Company (PEICo) and has joined the Strategic Alliance for FLEX Emergency Response (SAFER) Team Equipment Committee for off-site facility coordination. It has been confirmed that PEICo is ready to support Surry Power Station with Phase 3 equipment stored in the National SAFER Response Centers in accordance with the site specific SAFER Response Plan (Reference 14).

VALIDATION - COMPLETE

Dominion has completed validation testing of the FLEX strategies for Surry Power Station Unit 2 in accordance with industry developed guidance. The validations provide assurance that required tasks, manual actions and decisions for FLEX strategies are feasible and can be executed within the constraints identified in the Overall Integrated Plan (OIP) / Final Integrated Plan (FIP) for Order EA-12-049. The FIP for Surry Power Station, Units 1 and 2 is provided as Attachment 2 of this letter.

FLEX PROGRAM DOCUMENT - ESTABLISHED

The Dominion FLEX Program Document has been developed in accordance with the requirements of NEI 12-06 and is in effect for Surry Power Station Unit 2.

REFERENCES

The following references support the Surry Power Station Unit 2 FLEX Compliance Summary:

1. "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," February 28, 2013 (Serial No. 12-163B) (ML13063A181).
2. NRC Order Number EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ML12229A174).
3. "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 23, 2013 (Serial No. 12-163D) (ML13242A013).
4. "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 27, 2014 (Serial No. 12-163E) (ML14069A015).

5. "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 28, 2014 (Serial No. 14-395) (ML14251A035).
6. "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Six Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated March 2, 2015 (Serial No. 14-395A) (ML15069A234).
7. "Virginia Electric and Power Company, Surry Power Station Unit 2, Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 24, 2015 (Serial No. 14-395C) (ML15244B202)
8. Letter from Dominion to NRC, "Supplement to Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated April 30, 2013 (ML13126A208)
9. NRC letter to All Operating Reactor Licensees and Holders of Construction Permits, "Nuclear Regulatory Commission Audits of Licensee Responses to Mitigation Strategies Order EA-12-049," dated August 28, 2013 (ML13234A503).
10. NRC letter from John Boska, Senior Project Manager, JLD, Office of NRR, to David A. Heacock, President and Chief Nuclear Officer, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051," dated April 14, 2015 (ML15096A391).
11. NRC letter from Jeremy S. Bowen, Chief, Mitigating Strategies Branch Office of NRR, to David A. Heacock, President and Chief Nuclear Officer, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Interim Staff Evaluation Related to Overall Integrated Plan in Response to Order EA-12-049 (Mitigating Strategies)," dated February 19, 2014 (ML14002A145)
12. 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Recommendation 9.3, dated March 12, 2012 (ML2073A348).

13. Letter from Dominion to NRC, "Surry Power Station Units 1 and 2, March 12, 2012 Information Request, Phase 2 Staffing Assessment Report," dated December 17, 2014 (SN: 14-200).

14. NRC letter from Jack Davis, JLD, Office of NRR, to Joseph E. Pollock, Vice President, Nuclear Operations, NEI, "Staff Assessment of National Safer Response Centers Established in Response to Order EA-12-049," dated September 26, 2014 (ML14265A107).

15. "Virginia Electric and Power Company (Dominion), Surry Power Station Unit 1, Compliance Letter in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for the Mitigating Strategies for Beyond-Design-Basis External Events (Order EA-2012-049)," dated July 22, 2015 (Serial No. 14-395B) (ML15209A503)

Serial No. 14-395D
Docket Nos. 50-280/281
Order EA-12-049

Attachment 2

FINAL INTEGRATED PLAN

Beyond Design Basis

FLEX Mitigation Strategies

Virginia Electric and Power Company (Dominion)

Surry Power Station

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1. Background

In 2011, an earthquake-induced tsunami caused Beyond-Design-Basis (BDB) flooding at the Fukushima Dai-ichi Nuclear Power Station in Japan. The flooding caused the emergency power supplies and electrical distribution systems to be inoperable, resulting in an extended loss of alternating current (AC) power (ELAP) in five of the six units on the site. The ELAP led to (1) the loss of core cooling, (2) loss of spent fuel pool cooling capabilities, and (3) a significant challenge to maintaining containment integrity. All direct current (DC) power was lost early in the event at Units 1 and 2 and after some period of time at the other units. Core damage occurred in three of the units along with a loss of containment integrity, resulting in a release of radioactive material to the surrounding environment.

The US Nuclear Regulatory Commission (NRC) assembled a Near-Term Task Force (NTTF) to advise the Commission on actions the US nuclear industry should take to preclude core damage and a release of radioactive material after a natural disaster such as that seen at Fukushima. The NTTF report (Reference 1) contained many recommendations to fulfill this charter, including assessing extreme external event hazards and strengthening station capabilities for responding to Beyond-Design-Basis external events.

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 2) on March 12, 2012 to implement mitigation strategies for BDB external events. The Order included the following requirements:

1. Licensees shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities following a BDB external event.
2. Licensees shall develop strategies that are capable of mitigating a simultaneous loss of all AC power and loss of normal access to the ultimate heat sink (LUHS) and have adequate capacity to address challenges to core cooling, containment and SFP cooling capabilities at all units on a site subject to the Order.
3. Licensees must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to the Order.
4. Licensees must be capable of implementing the strategies in all modes.
5. Full compliance shall include procedures, guidance, training, and acquisition, staging or installing of equipment needed for the strategies.

The Order specifies a three-phase approach for strategies to mitigate BDB external events:

- Phase 1 - Initially cope relying on installed equipment and onsite resources.
- Phase 2 - Transition from installed plant equipment to onsite BDB equipment.
- Phase 3 - Obtain additional capability and redundancy from offsite equipment until power, water, and coolant injection systems are restored or commissioned.

NRC Order EA-12-049 required licensees of operating reactors to submit an overall integrated plan, including a description of how compliance with these requirements would be achieved by February 28, 2013. The Order also required licensees to complete implementation of the requirements no later than two refueling cycles after submittal of the overall integrated plan or December 31, 2016, whichever came first.

The Nuclear Energy Institute (NEI) developed NEI 12-06 (Reference 3), which provided guidelines for nuclear stations to assess extreme external event hazards and implement the mitigation strategies specified in NRC Order EA-12-049. The NRC issued Interim Staff Guidance JLD-ISG-2012-01 (Reference 4), dated August 29, 2012, which endorsed NEI 12-06 with clarifications on determining baseline coping capability and equipment quality.

NRC Order EA-12-051 (Reference 5) required licensees to install reliable SFP instrumentation with specific design features for monitoring SFP water level. This Order was prompted by NTTF Recommendation 7.1 (Reference 1).

NEI 12-02 (Reference 6) provided guidance for compliance with Order EA-12-051. The NRC determined that, with the exceptions and clarifications provided in JLD-ISG-2012-03 (Reference 7), conformance with the guidance in NEI 12-02 was an acceptable method for satisfying the requirements in Order EA-12-051.

2. NRC Order EA-12-049 – Diverse and Flexible Mitigation Capability (FLEX)

2.1 General Elements - Assumptions

The assumptions used for the evaluations of a Surry ELAP/LUHS event and the development of FLEX strategies are stated below.

Boundary conditions consistent with NEI 12-06, Section 3.2.1, *General Criteria and Baseline Assumptions,* are established to support development of FLEX strategies, as follows:

- The BDB external event occurs impacting both units at the site.
- Both reactors are initially operating at full power, unless there are procedural requirements to shut down due to an impending event. The reactors have been operating at 100% power for the past 100 days.
- Each reactor is successfully shut down when required (i.e., all rods inserted, no ATWS). Steam release to maintain decay heat removal upon shutdown functions normally, and reactor coolant system (RCS) overpressure protection valves respond normally, if required by plant conditions, and reseat.
- Onsite staff is at site administrative minimum shift staffing levels.
- No independent, concurrent events, e.g., no active security threat.
- All personnel onsite are available to support site response.
- The reactor and supporting plant equipment are either operating within normal ranges for pressure, temperature and water level, or available to operate, at the time of the event consistent with the design and licensing basis.

The following plant initial conditions and assumptions are established for the purpose of defining FLEX strategies and are consistent with NEI 12-06 Section 3.2.1, *General Criteria and Baseline Assumptions*:

- No specific initiating event is used. The initial condition is assumed to be a loss of offsite power (LOOP) with installed sources of emergency onsite AC power and station blackout (SBO) alternate AC power sources unavailable with no prospect for recovery.
- Cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available. Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available. The portion of the fire protection system that is robust with respect to seismic events, floods, and high winds and associated missiles is available as a water source.
- Normal access to the ultimate heat sink is lost, but the water inventory in the ultimate heat sink (UHS) remains available and robust piping connecting the UHS to plant systems remains intact. The motive force for UHS flow, i.e., pumps, is assumed to be lost with no prospect for recovery.

- Fuel for BDB equipment stored in structures with designs that are robust with respect to seismic events, floods and high winds and associated missiles, remains available.
- Installed Class 1E electrical distribution systems, including inverters and battery chargers, remain available since they are protected.
- No additional accidents, events, or failures are assumed to occur immediately prior to or during the event, including security events.
- Reactor coolant inventory loss consists of unidentified leakage at the upper limit of Technical Specifications, reactor coolant letdown flow (until isolated), and reactor coolant pump seal leak-off at normal maximum rate.
- For the spent fuel pool, the heat load is assumed to be the maximum design basis heat load. In addition, inventory loss from sloshing during a seismic event does not preclude access to the pool area.

Additionally, key assumptions associated with implementation of FLEX strategies are as follows:

- Exceptions to the site security plan or other requirements of 10 CFR may be required.
- Deployment resources are assumed to begin arriving at hour 6 and unlimited resources available after 24 hours.
- This plan defines strategies capable of mitigating a simultaneous loss of all alternating current (AC) power and loss of normal access to the ultimate heat sink resulting from a BDB external event by providing adequate capability to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities at all units on a site. Though specific strategies have been developed, due to the inability to anticipate all possible scenarios, the strategies are also diverse and flexible to encompass a wide range of possible conditions to protect the public health and safety. Each unit's Emergency Operating Procedures (EOPs) have been revised, in accordance with established EOP change processes, to clearly reference and identify appropriate entry and exit conditions for these pre-planned strategies. The EOPs retain overall command and control of the actions responding to a BDB external event. Also, the impact of these strategies on the design basis capabilities of the unit have been evaluated under 10 CFR 50.59.

- The plant Technical Specifications contain the limiting conditions for normal unit operations to ensure that design safety features are available to respond to a design basis accident and direct the required actions to be taken when the limiting conditions are not met. The result of the BDB external event may place the plant in a condition where it cannot comply with certain Technical Specifications and/or with its Security Plan, and, as such, may warrant invocation of 10 CFR 50.54(x) and/or 10 CFR 73.55(p). This position is consistent with the previously documented Task Interface Agreement (TIA) 2004-04, *Acceptability of Proceduralized Departures from Technical Specifications (TSs) Requirements at the Surry Power Station*, (TAC Nos. MC4331 and MC4332), dated September 12, 2006 (Accession No. ML060590273).

2.2 Strategies

The objective of the FLEX strategies is to establish an indefinite coping capability in order to 1) prevent damage to the fuel in the reactors, 2) maintain the containment function and 3) maintain cooling and prevent damage to fuel in the spent fuel pool (SFP) using installed equipment, onsite portable equipment, and pre-staged offsite resources. This indefinite coping capability addresses an extended loss of all alternating current power (ELAP) (loss of offsite power, emergency diesel generators and any alternate AC source, but not the loss of AC power to buses fed by Class 1E batteries through inverters) with a simultaneous loss of normal access to the ultimate heat sink (LUHS). This condition could arise following a Beyond-Design-Basis external event.

The plant indefinite coping capability is attained through the implementation of pre-determined strategies (FLEX strategies) that are focused on maintaining or restoring key plant safety functions. The FLEX strategies are not tied to any specific damage state or mechanistic assessment of external events. Rather, the strategies are developed to maintain the key plant safety functions based on the evaluation of plant response to an ELAP/LUHS event. A safety function-based approach provides consistency with, and allows coordination with, existing plant EOPs. FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs).

The strategies for coping with the plant conditions that result from an ELAP/LUHS event involve a three-phase approach:

- Phase 1 – Initially cope by relying on installed plant equipment and onsite resources.

- Phase 2 – Transition from installed plant equipment to onsite BDB equipment.
- Phase 3 – Obtain additional capability and redundancy from offsite equipment until power, water, and coolant injection systems are restored.

The duration of each phase is specific to the installed and portable equipment utilized for the particular FLEX strategy employed to mitigate the plant condition.

The FLEX strategies described below are capable of mitigating an ELAP/LUHS resulting from a BDB external event by providing adequate capability to maintain or restore core cooling, containment, and SFP cooling capabilities at both units at Surry. Though specific strategies have been developed, due to the inability to anticipate all possible scenarios the FLEX strategies are also diverse and flexible to encompass a wide range of possible conditions. These pre-planned strategies which have been developed to protect the public health and safety are incorporated into the Surry Emergency Operating Procedures (EOPs) in accordance with established EOP change processes and their impact on the design basis capabilities of the unit evaluated under 10 CFR 50.59.

An overall diagram of the following FLEX strategies showing the staging locations of BDB equipment and general hose routing is provided in Figure 1 (Mechanical) and Figure 6 (Electrical).

2.3 Reactor Core Cooling Strategy

Reactor core cooling involves the removal of decay heat through the secondary side of the Nuclear Steam Supply System (NSSS) and maintaining sufficient RCS inventory to ensure the continuation of natural circulation in the primary side of the NSSS. The FLEX strategy for reactor core cooling and decay heat removal is to release steam from the Steam Generators (SG) using the SG Power Operated Relief Valves (PORVs) and the addition of a corresponding amount of Auxiliary Feedwater (AFW) to the SGs via the turbine driven AFW (TDAFW) pump. The AFW system includes the Emergency Condensate Storage Tank (ECST) as the initial water supply to the TDAFW pump. Operator actions to verify and throttle AFW flow are required by the EOPs following an ELAP/LUHS event to prevent SG dryout and/or overfill.

RCS cooldown is initiated within the first 2 hours following a BDB external event that initiates an ELAP/LUHS event.

DC bus load stripping is initiated within 45 minutes following a BDB external event to ensure Class 1E battery life is extended to 14 hours. Portable generators are deployed to repower instrumentation prior to battery depletion.

RCS makeup and boron addition is initiated within 16 hours following a BDB external event to ensure natural circulation, reactivity control, and boron mixing is maintained in the Reactor Coolant System (RCS).

NOTE: The reactor core cooling strategy descriptions below are the same for both of the Surry units. Any differences and/or unit specific information is included where appropriate.

2.3.1 Phase 1 Strategy

Following the occurrence of an ELAP/LUHS event, the reactor trips and the plant initially stabilizes at no-load RCS temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the Main Steam Safety Valves (MSSVs) and/or the SG PORVs. The TDAFW pump provides flow initially from the ECST and then from the Emergency Condensate Makeup Tank (ECMT) to the SGs to makeup for steam release. Natural circulation of the RCS develops to maintain core cooling.

Operators respond to the ELAP/LUHS event in accordance with emergency operating procedures (EOPs) to confirm RCS, secondary system, and Containment conditions. A transition to ECA-0.0, *Loss of All AC Power*, is made upon the diagnosis of the total loss of AC power. This procedure directs isolation of RCS letdown pathways, verification of Containment isolation, reduction of DC loads on the station Class 1E batteries, and establishes electrical equipment alignment in preparation for eventual power restoration. ECA-0.0 directs the operators to establish manual control of the SG PORVs and directs local manual control of AFW flow to the SGs to control steam release and the RCS cooldown rate in order to initiate a rapid cooldown of the RCS to minimize inventory loss through the Reactor Coolant Pump (RCP) seals.

Secondary Side - The Phase 1 FLEX strategy for reactor core cooling and heat removal relies on installed plant equipment and water sources for supplying AFW flow to the SGs and steam release to the atmosphere. The TDAFW pump automatically starts on the loss of offsite power condition, and does not require either AC or DC electrical power to provide AFW to the SGs. In the event that the TDAFW pump does not start on demand or trips after start, an operator locally resets the turbine trip valve and the pump is restarted. Sufficient time (approximately 60 minutes) is available to restart the TDAFW pump to prevent SG dry-out (Reference 8).

Manual control of TDAFW pump flowrate to the SGs to establish and maintain proper water levels in the SGs is performed locally. Since the AFW discharge piping injection lines to the individual SGs are inside Containment and the throttle MOVs for controlling AFW flow to the individual SGs remain full open on a loss of power, the total flow to all three SGs is manually controlled by throttling the AFW pump discharge header gate valves located in the ground level (27'-6" elevation) of the Main Steam Valve House (MSVH), i.e., AFW pump room.

The MSVH is a seismically designed structure, also designed for full protection from all external events, including high winds and tornado missiles. Normal access to the MSVH is through the ground level (27'-6" elevation) of the Containment Spray Pump House (CSPH), which is not designed for missile protection. In the unlikely event of high wind / tornado-generated missile damage to the CSPH that prevents normal access to the MSVH, alternate MSVH access is available through the exterior personnel security door located on the 57' elevation via the MSVH exterior door access ladders. Control of AFW flow is required by approximately 90 minutes after ELAP at full power and associated TDAFW pump start to prevent overfill of the SGs.

The steam release is controlled by manually opening / throttling the seismically qualified, missile protected SG PORVs using the protected BDB SG PORV backup air bottle system which is installed in the MSVH ground floor 27'-6" elevation (AFW pump room). An analysis confirms that the protected BDB SG PORV backup air bottle system has adequate capacity with margin to operate the SG PORVs during RCS cooldown / decay heat removal long enough for equipment and manpower to be made available to replace or recharge the air bottles. The SG PORVs are equipped with a previously installed SG PORV backup air bottle system for manual operation. However, this backup air bottle system is located on the ground floor of the CSPH, which is a seismic concrete structure but is not designed for tornado missile protection on two of its four walls and the ceiling. Therefore, the SG PORV backup air bottle system in the CSPH cannot be credited as protected equipment for FLEX strategy. Brief access to the 57' elevation of the MSVH is required to isolate the normal Instrument Air supply line to the SG PORVs and align the backup air system directly to the SG PORVs' air operators for manual operation.

Note: Although not credited as part of the Phase 1 strategy, the AFW pump discharge headers are cross-tied between Surry Units 1 and 2. Consequently, the AFW cross-tie (which can be manually aligned) allows the TDAFW pump for one unit to supply the other unit's SGs during an ELAP / LUHS event. A single TDAFW pump has the capability of supplying AFW flow to support reactor core cooldown and decay heat removal of both units at some point in the event. However, if a single TDAFW pump is used to deliver AFW to both units, manually controlling level in the SGs for two separate units would be more challenging. Further, when delivering AFW to two units from a single TDAFW pump, the suction supply from the associated ECST is depleted at essentially twice the normal rate and the ECST needs to be replenished in half the normal time.

In accordance with the existing procedure for response to loss of all AC power, ECA-0.0, an RCS cooldown is initiated at a maximum rate of 100°F/hr to a minimum SG pressure of 300 psig, which corresponds to an RCS core inlet temperature of approximately 422°F. The rapid RCS cooldown minimizes the adverse effects of high temperature RCS coolant on Reactor Coolant Pump (RCP) shaft seal performance and reduces SG pressure to allow for eventual AFW injection from a portable pump in the event that the TDAFW pump becomes unavailable. The minimum established SG pressure is high enough to prevent nitrogen gas from the safety injection accumulators from entering the RCS.

The ECST is the primary source of water for the AFW pumps. The ECST Technical Specification minimum useable volume for heat removal in the steam generators is 96,000 gallons. This minimum usable ECST volume is sufficient for approximately 5.1 hours of decay heat removal including an assumed 100 °F/hr RCS cooldown to 300 psig steam pressure in two hours. Therefore, an alternate AFW source is aligned to the TDAFW pump suction within 5.1 hours after the start of an ELAP/LUHS.

Prior to depletion of the ECST, the ECMT is aligned to the suction of the TDAFW pump. The ECMT is a seismically qualified, missile protected tank which nominally contains 100,000 gallons of water. The water in the ECMT is normally aligned to be transferred to the AFW pump suction header using the installed AFW booster pumps, which are unavailable following an ELAP event. Water can be transferred without the booster pumps provided that the TDAFW pump is throttled to maintain adequate NPSH margin. A NPSH margin evaluation of the TDAFW pump at restricted flow rates (350 gpm max) taking suction from the ECMT determined the amount of water that can be removed through the idle AFW booster pumps to be 72,000 gallons. The water from the combination of the ECST and ECMT is depleted in approximately 14.2 hours.

Primary Side (RCS) - The RCS is cooled down and depressurized until SG pressure reaches 300 psig, which corresponds to a core inlet temperature of approximately 422°F. RCS isolation is verified to have occurred automatically, and RCS leakage is assumed to be through the RCP seals (See Section 2.3.8). Without additional RCS inventory, natural circulation continues until at least the onset of reflux cooling, conservatively set at 17 hours (See Section 2.3.7.2). K_{eff} is calculated to remain at less than .99 at the described RCS conditions (See Section 2.3.9). Additional boration is not necessary until subsequent cooldown to 200°F (Cold Shutdown) is initiated.

Electrical/Instrumentation – Load stripping of all non-essential loads begins within 45 minutes after the occurrence of an ELAP/LUHS and is completed within the next 30 minutes. With load stripping, the useable station Class 1E battery life has been calculated to be 14 hours for each unit (See Section 2.3.11).

2.3.2 Phase 2 Strategy

The Phase 2 FLEX strategy for reactor core cooling and decay heat removal provides an indefinite supply of water for feeding the SGs following depletion of the ECST and the ECMT by deploying the BDB High Capacity pump to take suction from the Settling Pond or the Circulating Water Discharge Canal. As required by NEI 12-06, SG water injection using a portable BDB AFW pump is available through both primary and alternate connection locations if the TDAFW pump is unavailable.

RCS makeup is initiated within 16 hours of the ELAP/LUHS event using a portable pump to replenish RCS inventory and re-establish RCS level in the pressurizer. Two portable diesel driven BDB RCS Injection pumps (one per unit) are transported from the onsite BDB Storage Building and deployed for delivery of RCS inventory makeup and soluble boron for reactivity control from the Refueling Water Storage Tank (RWST) or from another borated water source for the remainder of the event.

A hose is connected to the BDB RCS Injection primary connection on the Containment Spray (CS) pump suction elbow to provide borated water to the suction of the BDB RCS Injection pump from the RWST. A high-pressure hose is routed from the discharge of the BDB RCS Injection pump to the primary RCS injection connection in the Safeguards Building or the alternate RCS injection connection in the basement of the Auxiliary Building to provide RCS inventory makeup for the remainder of the ELAP event (Figures 2 and 3 for Unit 1 and Figures 4 and 5 for Unit 2).

The Phase 2 FLEX strategy also includes re-powering of vital 120 VAC buses within 14 hours using a portable 480 VAC Diesel Generator (DG) stored onsite for each unit. Prior to depletion of the Class 1E batteries on each unit, selected vital 120 VAC circuits are re-powered to continue to provide key parameter monitoring instrumentation. Portable 120/240 VAC DGs are available as alternates to the 480 VAC DGs.

The primary FLEX strategy for re-powering 120 VAC vital bus circuits is through the use of pre-installed connections and the deployment of one 480 VAC DG per unit connected to the Class 1E 480 VAC bus. The 480 VAC DG allows for recharging the Class 1E batteries and restoring other AC loads in addition to the key parameter monitoring instrumentation. The portable 480 VAC DGs and the required color-coded power cables are transported from the BDB Storage Building to their deployment positions in the alleyways on the west and east sides of the Auxiliary Building (Figure 6). The power cables are connected to seismically-designed, tornado missile protected, connection receptacles in each respective unit's Upper Cable Vault.

The connection receptacles in the Upper Cable Vaults are connected to the Class 1E 480 VAC bus via pre-installed cable and conduit to Class 1E 480 VAC MCC breakers (Figures 7 and 8).

The 480 VAC generators are stored inside the BDB Storage Building. Augmented staff commences deployment of the 480 VAC generators approximately 6 hours after an ELAP event occurs. Deployment of the 480 VAC generators is completed in approximately 2 hours. This does not include approximately 2 hours for the one-time removal of any debris along the haul path or in the staging areas since debris removal should be complete prior to augmented staff arriving onsite. Therefore, it is reasonable to expect the 480 VAC generators can be placed in service within 8 hours of a loss of all AC power event occurring.

The alternate strategy for re-powering 120 VAC vital bus circuits is to use one 120/240 VAC DG per unit connected to the 120 VAC vital buses through pre-installed BDB receptacle panels, cabling, connections, and distribution panels. The portable 120/240 VAC DGs are stored in the BDB Storage Building and are deployed to the alleyways east of the Auxiliary Building for Unit 1 and west of the Auxiliary Building for Unit 2 (Figure 6). The generators are connected via cables to receptacle panels located in the Upper Cable Vault of each unit. The 120/240 VAC cables for each unit are stored on cable two 100' cable reels located each unit's Upper Cable Vault. Backup cables are transported from the BDB Storage Building on the same cable trailer as the 480 VAC cables for that unit.

Each 120/240 VAC DG has two output circuits that supply two BDB distribution panels which provide power to the vital 120 VAC buses and selected lighting circuits for that unit (Figures 9 and 10). The BDB receptacle in each unit's Upper Cable Vault is connected to the BDB distribution panels via pre-installed cable and conduit.

Deployment of the 120/240 VAC DGs for service commences at approximately 3-1/4 hours after the declaration of an ELAP event. Placing the 120/240 VAC DGs into service can be completed within 2 hours (this excludes an estimated two (2) hour time allotment for debris removal which is assumed to be completed within the first 4 hours following the event. It is therefore reasonable to expect the 120/240 VAC generators are available to supply power to the key instrumentation within six (6) hours of a BDB external event which initiates an ELAP.

Should the 480 VAC generators fail, then the 120/240 VAC generators are an alternate power source to repower key instrumentation. If not utilized as the alternate power source for key instrumentation, they are used to supply lighting and are one of the available sources to power the portable fans used to disperse hydrogen from the battery rooms when the 480 VAC generators are charging the batteries via the inverters.

2.3.3 Phase 3 Strategy

No phase 3 strategy is required for core cooling and decay heat removal. However, additional pumps are available from the National SAFER

Response Center (NSRC) to provide backup to the BDB High Capacity pumps, BDB RCS Injection pumps, BDB AFW pumps, Boric Acid Mixing Tanks, and the 480 VAC DGs. Additionally, a Reverse Osmosis/Ion Exchanger water processing system is provided from the NSRC to provide a method to remove impurities from alternate fresh water supplies to the TDAFW pump, the BDB AFW pumps, or the BDB RCS Injection pumps.

Use of the SGs for core cooling and decay heat removal is dependent on adequate reactor core decay heat generation if using the TDAFW pump and an available supply of clean water from onsite sources or from water processing units provided from the NSRC. Restoration of RHR provides an alternate method for removing decay heat and/or RCS cooldown to Cold Shutdown. Restoration of RHR requires the restoration of 4160 VAC power and portions of the Component Cooling, Service Water, and Containment Instrument Air systems.

Portable 4160 VAC generators are provided from the NSRC for each unit in order to supply power to either of the two Class 1E 4160 VAC buses on each unit. Additionally, by restoring the Class 1E 4160 VAC bus, power can be restored to the Class 1E 480 VAC via the 4160/480 VAC transformers to power selected 480 VAC loads.

Two 1MW 4160 VAC generators are connected to a distribution panel (also provided from the NSRC) in order to meet the required 4160 VAC load requirements for each unit. Due to the size of the equipment, the DGs are deployed to the area by the large opening in the Unit 2 Turbine Building Truckbay or outside of the existing EDG rooms (Figure 6). The Emergency Switchgear Room would be used to tie the 4160 VAC generators to one of the two Class 1E 4160 VAC buses for each unit. Necessary cable for any of the above connections are also provided from the NSRC.

2.3.4 Systems, Structures, Components

2.3.4.1 Turbine Driven Auxiliary Feedwater Pump

The TDAFW pump automatically starts and delivers AFW flow to all three SGs following an ELAP/LUHS event. Two air-operated pressure control valves (PCVs) supply steam to the TDAFW pump turbine. These PCVs are normally closed. The PCVs are actuated by DC solenoids in the air supply line. If the solenoids de-energize, air is vented to open the valves and admit steam to the turbine. Therefore, loss of DC power does not isolate the TDAFW pump steam supply valves. If there is a loss of instrument air, the PCVs fail "as-is." However, steam enters the PCVs from below the valve plug, thus the PCVs open with steam pressure. During an ELAP, the TDAFW pump turbine steam flow is controlled automatically by the governor valve or manually with the overspeed trip/throttle valve. Additionally, the supply steam PCVs' DC solenoids remain powered during an ELAP to maintain the capability of stopping / starting the TDAFW pump for controlling AFW flow to the SGs as an alternate to the credited strategy of locally throttling the TDAFW pump flow.

In the event the TDAFW pump fails to start, procedures direct the operators to manually reset and start the pump (which does not require electrical power for motive force or control). Approximately 60 minutes are available to manually start the pump and initiate flow prior to steam generator dryout (Reference 8). The TDAFW pump is sized to provide more than the design basis AFW flow requirements and is located in a structure designed for protection from applicable design basis external hazards.

2.3.4.2 Steam Generator Power Operated Relief Valves (SG PORVs)

Reactor core cooling and decay heat removal is accomplished by steam release from the seismically qualified, missile protected SGs. The SG PORVs are equipped with an existing SG PORV backup air bottle system for manual operation. However, this backup air bottle system is located on the ground floor of the CSPH, which is a seismic concrete structure but is not designed for tornado missile protection on two of its four walls or the ceiling. Therefore, the existing SG PORV backup air bottle system in the CSPH cannot be credited as protected equipment for FLEX strategy. As a result, steam release may be controlled by manually opening / throttling the SG PORVs using the protected BDB SG PORV air bottle system which is installed in the MSVH ground floor 27'-6" elevation (AFW pump room).

2.3.4.3 Batteries

The safety-related Class 1E batteries and associated DC distribution systems are located within safety-related structures designed to meet applicable design basis external hazards and is used to initially power required key instrumentation and applicable DC components. Load stripping of non-essential equipment has been conservatively calculated to provide a total battery service time of 14 hours of operation following an ELAP event.

2.3.4.4 Emergency Condensate Storage Tank

The Emergency Condensate Storage Tank (ECST) provides an AFW water source at the onset of the event. The tank is a safety–related, seismic, tornado missile protected structure and is, therefore, designed to withstand the applicable design basis external hazards stated in NEI 12-06 (Reference 3). ECST volume is maintained greater than or equal to 110,000 gallons per the Surry Technical Specification (Reference 9) and is normally aligned to provide emergency makeup to the SGs. The ECST minimum usable volume is approximately 96,000 gallons.

2.3.4.5 Emergency Condensate Makeup Tank

Prior to depletion of the ECST, the ECMT is aligned to the suction of the TDAFW pump. The ECMT is a seismically qualified, missile protected horizontal tank containing 100,000 gallons of water. The water in the ECMT is normally aligned to be transferred to the AFW pump suction header using the AC electric motor powered AFW booster pumps, which are unavailable following an ELAP event. Water can be transferred without the booster pumps provided that the TDAFW pump is throttled to maintain adequate NPSH margin. A NPSH margin evaluation of the TDAFW pump at restricted flow rates (350 gpm max) taking suction from the ECMT determined the amount of water that can be removed through the idle AFW booster pumps to be 72,000 gallons.

2.3.4.6 Condensate Polishing Settling Pond

The condensate polishing settling pond is located at the end of the discharge canal to the Northeast of the Surry main plant at an elevation of 35 feet. It is used to collect water discharged from the condensate polishing system as well as other outfalls. Water sent to the pond has a high concentration of total suspended solids that need to settle out prior to being released into the discharge canal. No additional chemical treatment is added to the settling pond water. The water in the settling pond is of a higher quality than water from the James River and is a source of water to refill the ECST or to makeup the SFP. The settling pond has a water volume of approximately 3,600,000 gallons of water. Refer to Section 2.15 for discussion of water quality.

2.3.5 FLEX Strategy Connections

2.3.5.1 Primary AFW Connection

The primary connection to supply AFW to the SGs is located on the TDAFW pump discharge line in the AFW pump room located in the MSVH (Figures 11 and 12). A flexible hose is routed from the BDB AFW pump discharge to the primary connection inside the AFW pump room. Hydraulic analysis of the flowpath from the BDB ECST refill connection to the primary BDB AFW pump discharge connection has confirmed that applicable performance requirements are met.

2.3.5.2 Alternate AFW Connection

In the event that the primary AFW connection is not available, an alternate AFW connection location is provided. The alternate AFW connection for SG injection from the BDB AFW pump discharge is located in the AFW cross-tie lines between the two units (Figures 11 and 12). The connection for each unit is located in the opposite unit's AFW pump room (ground floor of the MSVH). This connection is utilized in the event that the primary AFW connection or the AFW pump room for a particular unit becomes unavailable or inaccessible.

The bonnet assembly of one of the AFW cross-connect isolation MOVs, located in the AFW pump room, is removed and a flanged temporary hose connection adapter is installed on the valve to support connecting the BDB AFW pump discharge hose to the AFW cross-connect line. The location of the MOVs allows for easy hose routing. Additionally, structural steel above this valve facilitates rigging activities for disassembly.

Hydraulic analysis of the flowpath from the BDB ECST refill connection to the alternate AFW connection has confirmed that applicable performance requirements are met.

2.3.5.3 ECST Refill / AFW Pump Suction Connection

A suction and/or refill connection to the ECST is installed on the TDAFW pump suction line near the ECST discharge nozzle to provide a suction source to the portable equipment or to facilitate refill of the ECST. This connection is seismically designed and located inside the concrete enclosure (tornado missile barrier) enveloping the ECST and includes a hose coupling suitable for easy connection to a 5" flexible hose from a distribution manifold that is supplied with water from the BDB High Capacity pump or one of the other sources of water to refill the ECST and/or supply suction to the BDB AFW pump (Figures 13 and 14).

2.3.5.4 Primary RCS Injection Connection

A primary RCS injection connection has been installed which consists of a 3-inch connection point downstream of the Low Head Safety Injection (LHSI) pump discharge MOVs which supply the RCS hot legs. The new 3-inch piping is routed up to the 28'- 6" floor elevation of the Safeguards Building in close proximity to the personnel access door where it is terminated with a piston check valve and end connection suitable for a 1.5-inch high-pressure hose connected to the BDB RCS Injection pump. The primary RCS injection connection and its associated LHSI tie-in piping are located in a seismically designed concrete structure that is protected against snow, ice, high and low temperatures, flood, and high wind.

The BDB RCS Injection pump is deployed to the area outside of each Unit's Safeguards valve pit. The primary RCS injection hose connection is located near the access door and oriented such that the hose from the BDB RCS Injection pump discharge requires minimum bending when routing the hose into the Safeguards Building to make the connection.

2.3.5.5 Alternate RCS Injection Connection

The alternate RCS injection connection for the RCS makeup strategy for both units is located in the basement of the Auxiliary Building. A hose connection adapter can be connected to a 2" blind-flanged connection on the charging pump discharge header for each unit. This hose connection can provide a BDB RCS injection path into all three RCS cold legs via the safety injection system. (Alternatively, the SI system can be manually aligned to provide flow to the RCS hot legs.) In order to facilitate quick deployment of the BDB RCS Injection strategy, two (one per unit) standpipes have been installed from the Auxiliary Building basement to an intermediate staircase landing at elevation 20'-3", adjacent to the roll-up door in the Unit 1 alleyway. To use the standpipe a hose is connected from the BDB RCS Injection pump discharge to the top of the standpipe. An additional hose is connected from the bottom of the standpipe to the alternate RCS Injection connection for the appropriate unit. The standpipes are seismically restrained.

2.3.5.6 RWST Suction Connection

The primary supply of water to the BDB RCS Injection pump is through a suction connection from the RWST via a permanent hose connection. The connection is installed in one of two Containment Spray pump's suction elbows for each unit, allowing borated water from the RWST to be supplied to a portable BDB RCS Injection Pump (Figures 2 and 3).

In the event that one unit's RWST is damaged, each hose connection is capable of providing flow to the suction of both BDB RCS Injection pumps through either RWST.

Alternately, if neither RWST is available, portable Boric Acid Mixing Tanks are available to batch borated water and provide borated water to the suction of the BDB RCS Injection pumps.

2.3.5.7 Primary Electrical Connection

A receptacle panel for the 480 VAC DG cable connections is located in the Upper Cable Vault which provides connection to repower 480 VAC loads including battery chargers and essential instrumentation from a portable 480 VAC DG (Figure 6). A 480 VAC distribution panel has been added to each 480 VAC generator trailer that splits the load side of the 480 VAC generator output breaker into two circuits. Connections for both circuits are located on the receptacle panel. From the receptacle panel, cables are installed in seismically mounted raceways to the Class 1E 480 VAC bus via pre-installed cable and conduit to Class 1E 480 VAC MCC breakers.

The cables required to connect the 480 VAC DG to the receptacle panel are stored in the BDB Storage Building and are operable within the outside temperature ranges applicable to the site. Cables are transported to the deployment location of the generators on a separate cable trailer.

2.3.5.8 Alternate Electrical Connection

The receptacle panel for the 480 VAC DG connections located in the Upper Cable Vault also contains the 120/240 VAC DG cable connections (Figure 6). Two circuits from the 120/240 VAC generator are used to repower essential instrumentation, lighting, and battery room exhaust fans. From the receptacle panel, cables are installed in seismically mounted raceways to two distribution panels, one for each of the 120/240 VAC DG output circuits. Each BDB distribution panel has branch circuit breakers sized to feed the required loads.

The cables required to connect the 120/240 VAC DG to the receptacle panel are stored on two 100' cable reels in the Upper Cable Vault and are protected from seismic interactions, missiles, flood, snow and ice; and are operable within the outside temperature ranges applicable to the site. Backup 120/240 VAC cables are available on the cable trailer along with the 480 VAC cables.

2.3.5.9 4160 VAC Electrical Connection

Two (2) 1-MW 4160 VAC generators (per unit) delivered to the site from the NSRC are connected to a distribution panel (also delivered from the NSRC) in order to meet the required Phase 3 4160 VAC load requirements for each unit. Due to the size of the equipment, the 4160 VAC generators are deployed to areas either near the Truck Bay area south side of the Unit 2 Trubine Buildings (Figure 6) or by the existing Emergency Diesel Generator (EDG) Rooms (Figure 6). The area near the existing EDG rooms affords the simplest configuration to connect to one of the two Class 1E 4160 VAC buses for each unit, but space outside of these rooms is limited. Depending on the debris situation, the Turbine Building Truck Bay opening may be the more viable option for deployment. In this case, the Emergency Switchgear Room would be used to tie the 4160 VAC generators to one of the two Class 1E 4160 VAC buses for each unit (Figures 15 and 16). From the Truck Bay opening location, connections to energize the Class 1E 4160 VAC busses can also be made via transfer busses D, E, and F located in the normal switchgear room.

2.3.6 Key Reactor Parameters

Instrumentation providing the following key parameters is credited for all phases of the reactor core cooling and decay heat removal strategy:

- **AFW Flowrate**: AFW flowrate indication is available in the Main Control Room (MCR) until load stripping. Following load stripping, only SG "B" flow is available. SG "B" AFW flowrate indication is available throughout the event.
- **SG Water Level**: SG wide range (WR) water level indication is available in the MCR, and the Remote Monitoring Panel (RMP). Following load stripping, only the "A" SG WR level would be available in the MCR. SG narrow-range (NR) level indication is available in the MCR for SG A, B, and C throughout the event.
- **SG Pressure**: SG pressure indication is available from the MCR and the RMP (2 loops only). SG pressure indication is available for SG A, B, and C throughout the event.
- **RCS Temperature**: RCS hot-leg and cold-leg temperature indication is available in the MCR for all RCS loops until load striping. After load stripping, only RCS loop "B" is available. RCS hot-leg and cold-leg temperatures for 2 loops are available from the RMP. RCS hot-leg and cold-leg temperature indication is available as stated throughout the event.
- **RCS Pressure**: RCS wide range pressure indication is available in the MCR and the RMP. RCS pressure indication is available throughout the event.
- **Core Exit Thermocouple Temperature**: Core exit thermocouple temperature indication is available in the MCR. This temperature indication is available throughout the event.
- **ECST Level**: ECST water level indication is available in the MCR until load stripping. Following load stripping, ECST level is available locally from pressure indication installed on the ECST discharge piping, and local float level indicators.

- **Pressurizer Level:** Pressurizer level indication is available in the MCR and from RMP. Pressurizer level indication is available throughout the event.
- **Reactor Vessel Level Indication System (RVLIS):** RCS level indication from the RVLIS is available in the MCR. RVLIS is available throughout the event.
- **Excore Nuclear Instruments:** Indication of nuclear source range activity is available in the MCR and from the RMP. Indication is available throughout the event.

Instrumentation lost as a result of load stripping, is restored in Phase 2 when the BDB generators (either the 480 VAC or the 120/240 VAC generators) are deployed.

Portable BDB equipment is supplied with local instrumentation and instructions necessary to start and operate the equipment for use as directed by the associated FSGs. Use of this BDB equipment by the FSGs is based on inputs from the equipment suppliers, operating experience, and expected equipment function in an ELAP.

In the unlikely event that 125 VDC and 120 VAC Vital Bus infrastructure is damaged, FLEX strategy guidelines for alternately obtaining the critical parameters locally is provided in FSG-7, *Loss of Vital Instrumentation or Control Power.*

2.3.7 Thermal Hydraulic Analyses

2.3.7.1 Secondary Makeup Water Requirements

Calculations were performed to determine the AFW inventory required for core decay heat removal, RCS cooldown, and to maintain steam generator levels and dryout times associated with the volumes of various onsite AFW water sources. The conclusions from this analysis showed that the existing Emergency Condensate Storage Tank usable volume of approximately 96,000 gallons would be depleted in approximately 5.1 hours at which time another source of water would be required. An additional credited AFW source is the Emergency Condensate Makeup Tank (ECMT), which provides AFW makeup for an additional 9.1 hours. The Surry Discharge Canal (water from the James River) is the final credited water source for secondary makeup, but this source is considered as a last resort measure. Various other onsite clean water sources, including the Condensate Polishing Settling Pond, are available, depending on the nature of the BDB external event resulting in the ELAP event. These sources are detailed in Section 2.3.10.4.

2.3.7.2 RCS Response

The model used for the determination of RCS response was the same model used in the generic analysis in Section 5.2.1 of WCAP-17601 (Reference 10), and updated for Westinghouse 3-loop plants in WCAP-17792 (Reference 11). Section 5.2.1 of WCAP-17601 provides a Reference Case which assumes standard Westinghouse OEM RCP seal packages to determine the minimum adequate core cooling time with respect to RCS inventory (i.e., core uncovery). The Reference Case models a Westinghouse 4-loop plant with a core height of 12 feet (i.e., a 412 plant), a T_{cold} upper head, at 3723 MWt, with Model F Steam Generators and Model 93A/A-1 Reactor Coolant Pumps.

PWROG-14064 (Reference 12) indicates that the initiation time for reflux cooling is set to 17.0 hours for the WCAP-17601, Section 5.2.1, Westinghouse 4-loop T_{cold} Reference Case. PWROG-14064 also indicates that 17.0 hours can be used, as a conservative basis, for Westinghouse 3-loop T_{hot} plants (i.e., for Surry Units 1 and 2).

RCS inventory makeup begins within 16 hours following the onset of the ELAP condition. Based on information from WCAP-17601, WCAP-17792, and NRC interaction, reflux cooling is conservatively set at 17.0 hours with assumed leakage rates for Westinghouse OEM equivalent seals. Surry has replaced the OEM equivalent seals on all RCPs with Flowserve N-9000 seals. An evaluation applicable to Surry (performed for a North Anna unit) demonstrated that the integrated RCS leakage, with all Westinghouse OEM equivalent seals replaced with Flowserve N-9000 seals, is significantly less than the value used in WCAP-17792; therefore, additional margin to reflux cooling is available for Surry units. Since RCS inventory makeup begins within 16 hours following the onset of the ELAP condition with a makeup capacity greater than twice the assumed RCP seal leakage, the reflux cooling condition is avoided.

2.3.8 Reactor Coolant Pump Seals

Surry Units 1 and 2 are Westinghouse 3-loop plants with Westinghouse RCP pumps originally equipped with Westinghouse OEM RCP seals. Surry has replaced all the RCP seals on both units with Flowserve N-9000 seals. As stated in Section 2.3.7.2, an evaluation was performed comparing the integrated leakage for the all Flowserve seals configuration with the analyzed values used in WCAP-17792. Leakage from the Flowserve seals is based on the Flowserve White Paper (Reference 13). Based on the comparative evaluation, the integrated leakage for the Surry RCP seal configuration is bounded by the analyzed values used in WCAP-17601 and WCAP-17792.

2.3.9 Shutdown Margin Analysis

A Shutdown Margin (SDM) Analysis was performed for the reactor cores from Surry Units 1 and 2, Cycles 25 and 24, respectively. These reactor reload core designs were assumed to be representative of a typical Surry unit reload core. The analysis determined that at least 1% SDM (K_{eff} <0.99) is available following a reactor trip from full power and cooldown to the target SG pressure of 300 psig. However, in order to cooldown to below the SG target pressure, additional boron is needed. Calculations show that injection of approximately 2,400 gallons of 2600 ppm borated water from the RWST is adequate to meet shutdown reactivity requirements at the limiting End-of-Cycle condition and the core inlet temperature as low as 350°F. This additional boron requirement is met in less than one hour of RCS inventory makeup from the BDB RCS Injection pump. This makeup volume can easily be accommodated by RCS volume shrink without venting the RCS.

Since the RCS inventory makeup is initiated no later than 16 hours following an ELAP/LUHS event, the borated water injected into the RCS for inventory makeup is more than adequate to maintain core reactivity shutdown margin of 1% following an ELAP/LUHS.

Dominion's Nuclear Analysis and Fuel Department performs checks for every reload core to verify that the FLEX inventory management and reactivity control strategy remains adequate to maintain K_{eff} < 0.99 throughout the ELAP event.

The SDM calculation assumes a uniform boron mixing model. Boron mixing was identified as a generic concern by the NRC and was addressed by the Pressurized Water Reactor Owner's Group (PWROG). The NRC endorsed the PWROG boron mixing position paper (Reference 15) with the clarification that a one hour mixing time was adequate provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate (Reference 16). For 3-loop plants, such as Surry, the time to reach this condition (two-phase natural circulation flow is less than single-phase natural circulation flow) is conservatively set at 17.0 hours (See Section 2.3.7.2). Since RCS makeup is initiated within 16 hours and the makeup capacity is greater than the RCS leak rate at 16 hours, the reflux cooling condition is avoided and the NRC clarification regarding single-phase flow is addressed. Accordingly, a one hour mixing time is acceptable.

If one of the two BDB RCS Injection pumps stored in the onsite BDB Storage Building is unavailable, the available BDB RCS Injection pump may be used to supply RCS inventory makeup to both units by alternating RCS injection between the units. RCS injection would begin with the BDB RCS Injection pump supplying one of the two units within 15 hours. Then the pump would be aligned to the opposite unit for alternating injection within 16 hours. Sufficient discharge hose, shutoff valves and fittings are stored in the BDB Storage Building to allow connection of one BDB RCS Injection pump's discharge hose to the RCS injection points of both units. The alternating RCS injection process would be repeated until RCS level is indicated in the pressurizer(s), or until approximately 28 hours at which time a RCS Injection Pump is received from the NSRC and deployed for RCS makeup for one of the two units. Since the BDB RCS Injection pump flow rate is more than double the RCP seal leak rate associated with the Surry RCP seal configuration (three Flowserve seals), the approach of sharing the RCS Injection pump ensures adequate boron mixing which, therefore, maintains the required SDM previously discussed.

2.3.10 FLEX Strategy Pumps and Water Supplies

2.3.10.1 Beyond-Design-Basis (BDB) High Capacity Pump

The BDB High Capacity pump is a nominal 150 psid at 1200 gpm pump that is shared between several functions. The pump is sized to provide AFW water supply of 300 gpm to each unit and 500 gpm Spent Fuel Pool makeup simultaneously. Hydraulic analysis of the flowpath from each water source to the SFP and to the ECST or to the BDB AFW pump suction for both units has confirmed that applicable performance requirements are met.

The BDB High Capacity pump is a trailer-mounted, diesel driven centrifugal pump that is stored in the BDB Storage Building. The pump is deployed by towing the trailer to a designated draft location near the selected water source. One BDB High Capacity pump is required to implement the reactor core cooling and heat removal strategy for both units. Two high capacity pumps are available to satisfy the N+1 requirement.

The station's 50.54(hh)(2) high capacity pump can meet the FLEX strategy flow requirements for both core cooling and SFP cooling that credit the BDB High Capacity pump. Therefore, the 50.54(hh)(2) high capacity pump meets the N+1 requirement. The 50.54(hh)(2) high capacity pump is stored in the Emergency Response Building on site, which is reasonably protected from flooding, extreme heat, and extreme cold hazards.

2.3.10.2 BDB AFW Pump

Consistent with NEI 12-06, Appendix D, SG water injection capability is provided using a portable AFW pump through a primary and alternate connection. The BDB AFW pump is a nominal 450 psid at 300 gpm pump. The BDB AFW pump is a trailer-mounted, diesel engine driven centrifugal pump that is stored in the BDB Storage Building. The portable, diesel-driven BDB AFW pump provides a back-up method for SG injection in the event that the TDAFW pump can no longer perform its function due to insufficient turbine inlet steam flow from the SGs. Hydraulic analysis has confirmed that the BDB AFW pump is sized to provide the minimum required SG injection flowrate to support reactor core cooling and decay heat removal. Three BDB AFW pumps are available to satisfy the N+1 requirement.

2.3.10.3 BDB RCS Injection Pump

The PWROG Core Cooling Position Paper (issued in conjunction with WCAP-17601) recommends that the RCS Injection pump required delivery pressure be established at the maximum saturation pressure of the reactor vessel head +100 psi driving head to allow RCS injection. Following the formula in the position paper, the required delivery pressure for the RCS Injection pump at Surry is approximately 1763 psia. Accordingly, the BDB RCS Injection pump is capable of delivering a minimum flow of 45 gpm at a discharge pressure of greater than 2000 psig. Hydraulic analysis of the BDB RCS Injection pump with the associated hoses and installed piping systems confirm that the BDB RCS Injection pump minimum flow rate and head capabilities exceed the FLEX strategy requirements for maintaining RCS inventory.

One BDB RCS Injection pump is available for each Surry unit. However, in the event of a failure of one of the pumps, the pump design capacity is such that a single pump can be shared between the units, thus meeting the N+1 requirement with two pumps.

2.3.10.4 AFW Water Supplies

- **Emergency Condensate Storage Tank (ECST):** The ECST provides the source of AFW at the onset of the event. The tank is a safety-related, seismically designed, high wind/tornado missile protected structure and is, therefore, designed to withstand all applicable design basis external hazards. ECST volume is maintained with greater than or equal to 96,000 gallons of usable volume per Surveillance Requirement 3.7.6.1 of the Technical Specification (Reference 9) and aligned to provide emergency makeup to the SGs.
- **Emergency Condensate Makeup Tank (ECMT):** The ECMT is a safety-related, seismically designed, high wind/tornado missile protected horizontal structure and is, therefore, designed to withstand all applicable design basis external hazards. The water in the ECMT is normally aligned to be transferred to the AFW pump suction header using the AC electric motor powered AFW booster pumps, which are unavailable following an ELAP event. Water can be transferred to the AFW suction header without the booster pumps provided the TDAFW pump is throttled to maintain adequate NPSH margin. ECMT usable volume in this configuration is calculated to be 72,000 gallons.
- **Condensate Storage Tanks (CSTs)**: There are two main Condensate Storage Tanks (CSTs) at Surry, one for each unit. Each CST has a nominal capacity of 300,000 gallons of demineralized water. While the CSTs are not seismically designed or missile protected, they represent a preferred source of high

quality water to refill the ECST or makeup the SFP if they are available following a BDB event. ECST refill is accomplished through a gravity feed from the CSTs to the ECSTs using manual valves located in each Turbine Building Basement. This is the normal makeup path to the ECST as directed by station procedures. Additionally, the external hose connections on the CSTs permit water inside the CSTs to be accessed by a portable transfer pump.

- **Fire Protection (FP) / Domestic Water Tanks**: Two 300,000 gallon (each) FP tanks normally provide domestic water and fire protection water to areas inside the protected area. These tanks are not seismically qualified or missile protected, but if they survive a beyond design basis event, they are clean sources of water available to refill the ECST or makeup to the SFP. If the diesel fire pump is not available or the fire main is not intact, water inside both FP tanks is accessible by removing a blank flange from the common suction header to both tanks and installing a temporary hose connection adapter piece.

- **Primary Grade Tanks**: Two Primary Grade (PG) tanks contain high quality demineralized water. While the PG tanks are not seismically designed or missile protected, they are a source of water available to refill the ECST or makeup to the SFP, if one or both tanks survive a beyond design basis event. Each PG tank has a useable capacity of approximately 185,000 gallons.

- **Distillate Storage Tank (DST)**: The Distillate Storage Tank (DST) contains high quality water used to provide makeup to various plant systems. It is located at grade level just south of the Condensate Polishing Building. This tank is not seismically qualified or missile protected, but if it survives a beyond design basis event, it could provide approximately 322,000 gallons of clean water to refill the ECST or makeup to the SFP.

- **Main Turbine Condensers**: After a BDB event at Surry, water may be in the condenser hot well. This is an available alternate water source for the extended AFW water supply through existing 3-inch drain connections located on each of the condensate pump suction strainers. These suction strainer drains are used to drain the condenser during outages. Hoses are connected to the drain connections by adapter pieces and routed to a common manifold where a small portable transfer pump can be connected to transfer water out of the condenser hotwell. From the hotwell the water can be transferred to the unit-appropriate ECST via the portable transfer pump or a 4" blind-flanged connection located on the North side of the Turbine Building basement.

- **Gravel Neck Water Tank**: There is a 4,000,000 gallon tank at Gravel Neck Station, approximately 1 mile by road from the Surry site. Gravel Neck is a combustion turbine station. The water in this tank is supplied from a site well and goes through a reverse osmosis system and is then stored in this tank. The tank is not seismically protected nor missile protected and is not part of Surry Power Station. However, the tank is likely to survive in a tornado event that occurs at Surry Power Station due to the distance from site (approximately 2,500 ft southeast of Surry).

  The tank has an existing manway located where the vertical walls transition into the roof. It is possible to open the manway, insert a non-collapsible suction hose to the bottom of the tank, and pump the water to a fire hydrant on the road to Gravel Neck, approximately 500 ft to the southwest. This 12" fire protection line runs underground from Surry Power Station to Gravel Neck. Any available BDB portable pump could then be used to take suction from a hydrant in the fire protection system at Surry

- **Condensate Polishing (CP) Settling Pond**: The Condensate Polishing (CP) settling pond is located at the end of the discharge canal to the northeast of Surry at an elevation of 35 feet. It is used to collect water discharged from the condensate polishing system as well as other outfalls. Water sent to the pond has a high concentration of total suspended solids that need to settle out prior to being released into the discharge canal. No additional chemical treatment is added to the settling pond water. The water in the settling pond is of a higher quality than water from the James River and is a source of water to refill the ECST or to makeup the SFP. The settling pond has a water volume of approximately 3,600,000 gallons. The BDB High Capacity Pump can be used to draw water from the settling pond and pump it to the ECST, or to the suction of the BDB AFW pump, and/or to the SFP.

- **Discharge Canal (James River)**: The Discharge Canal is a protected source with essentially unlimited inventory, however, since it is brackish water, it is the least preferred alternate AFW supply source.

2.3.10.5 Borated Water Supplies

Two sources of borated water have been evaluated for use during a Beyond-Design-Basis event. Each borated water source is discussed below, in order of usage preference.

- **Refueling Water Storage Tank:** Each unit is equipped with one RWST located at grade level just outside of its respective Safeguards Building. The tanks are stainless steel, safety-related, seismically qualified storage tanks, but are not protected from high wind/tornado generated missiles. During "at power" operations each operating unit's RWST borated water volume is maintained at greater than 370,000 gallons at a boron concentration between 2300 and 2500 ppm. The RWST is the preferred borated water source for the RCS Injection strategies.

- **Portable Boric Acid Mixing Tank**: In the event that both RWSTs are unavailable or become depleted, portable Boric Acid Mixing Tanks are available to provide a suction source for the BDB RCS Injection pumps. These mixing tanks are transported from the onsite BDB Storage Building and positioned near the respective BDB RCS Injection pump. Dilution water is added to the mixing tank by either a portable transfer pump, the BDB AFW pump, or from the BDB High Capacity pump header taking suction from a clean water source. Bags of powdered boric acid are mixed with dilution water to achieve the proper concentration for maintaining adequate shutdown margin while making up RCS inventory. Each tank is equipped with an agitator to facilitate mixing of the boric acid which is continued throughout the injection process although complete dissolution of the powdered boric acid is not required. The maximum boron concentration that is mixed is below the level at which precipitation concerns occur, even at temperatures down to 32°F; however, two heaters are also available to prevent tank freezing, if necessary.

2.3.11 Electrical Analysis

The Class 1E battery duty life cycle of 14 hours for Surry was calculated in accordance with the IEEE-485 methodology using manufacturer discharge test data applicable to the FLEX strategy as outlined in the NEI white paper on Extended Battery Duty Cycles (Reference 17). The time margin between the calculated battery duration for the FLEX strategy and the expected deployment time for FLEX strategy equipment to supply the DC loads is approximately six (6) hours for Surry.

The strategy to re-power the stations vital AC/DC buses requires the use of diesel powered generators. For this purpose, each unit requires one 480 VAC portable diesel generator. One 120/240 VAC portable diesel generator per unit is available as an alternate re-powering option.

The 480 VAC diesel generators are 350 KW generators that are trailer-mounted with a 500 gallon double-walled diesel fuel tank built into the trailer.

The 120/240 VAC DGs are 40 KW (nominal rating), single phase, 60Hz, generators that are trailer-mounted with a 100 gallon double-walled diesel fuel tank built into the trailer.

Additional replacement 480 VAC generators and 4160 VAC diesel powered generators are available from the National SAFER Response Center (NSRC) for the Phase 3 strategy. The specifications and ratings for this equipment are listed in Table 2.

2.4 Spent Fuel Pool Cooling/Inventory

The Surry Spent Fuel Pool (SFP) is a common pool designed for both Unit 1 and Unit 2. The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide sufficient makeup water to the SFP to maintain the normal SFP level.

2.4.1 Phase 1 Strategy

A calculation has determined that with no operator action following a loss of SFP cooling at the maximum design heat load, the SFP reaches 212°F in approximately 12 hours and boil off to a level 10 feet above the top of fuel in 51 hours from initiation of the event. The Phase 1 coping strategy for spent fuel pool cooling is to monitor spent fuel pool level using instrumentation installed as required by NRC Order EA-12-051 (Reference 5).

2.4.2 Phase 2 Strategy

The Phase 2 strategy is to initiate SFP makeup using the emergency SFP make up line either from the BDB High Capacity pump through the BDB SFP makeup connection or, alternately, through the FP system which feeds the emergency SFP makeup line from the yard fire main loop directly. The BDB SFP makeup connection is on the exterior of the Fuel Building and is connected to the existing emergency SFP makeup line. Within 10 hours, the BDB High Capacity pump would be deployed from the BDB Storage Building to an area near one of several available draft points, preferably the CP settling pond (Figure 1). Within 24 hours the discharge hose from the pump is connected to the BDB SFP makeup connection via hoses and fittings to provide necessary makeup capabilities (Figure 17). Required hose lengths and fittings are also located in the BDB Storage Building. The BDB High Capacity pump is trailer mounted and is towed to the CP settling pond, along with the necessary hoses and fittings, by tow vehicles also located within the protected BDB Storage Building.

The BDB SFP makeup connection is permanently installed on an outside wall of the Fuel Building and ties directly into the emergency SFP make up line. It is sufficiently sized to maintain SFP level long-term, after a loss of SFP cooling with a makeup rate of 500 gpm, which exceeds postulated SFP boil off rates. The connection is designed to withstand design basis earthquake; design basis external flooding; storms with high winds (hurricanes, tornadoes, etc.) and associated missiles; snow, ice, and low temperatures; and extreme high temperatures.

The FP system feeds the emergency SFP makeup line from the yard fire main loop. The emergency SFP makeup line extends above the SFP so that water can be discharged directly into the pool. The water source for the alternate strategy using the FP system is the pressurized fire main which can be filled and pressurized with water from the Settling Pond by the BDB High Capacity pump. The yard fire main is seismically qualified, and it is buried at an approximate elevation of 21'.

Additionally, as required by NEI 12-06, spray monitors and sufficient hose length required for the SFP spray option are located in the BDB Storage Building.

2.4.3 Phase 3 Strategy

Additional Low Pressure/High Flow pumps are available from the NSRC as a backup to the onsite BDB High Capacity pumps.

2.4.4 Structures, Systems, and Components

2.4.4.1 Primary SFP Makeup Connection

The hose connection for the permanent, seismically designed BDB SFP makeup connection is located on the outside wall of the Fuel Building. The BDB SFP makeup connection is sufficiently sized to restore SFP level long-term after the loss of SFP cooling at a makeup rate of 500 gpm for SFP boil off.

The BDB SFP makeup connection line is a 4-inch line that tees into the existing 6-inch emergency SFP makeup line (Figure 17). The existing line runs vertically along the north inside (concrete) wall of the Fuel Building between the 21'-6" and the 27' elevations. The new seismically supported 4-inch line is routed from the new tee along and through the north inside wall to the exterior connection location. The new connection is supported from the outside wall of the Fuel Building at approximately the 31' elevation near the PG pump house in the vicinity above where the buried emergency SFP makeup header enters the Fuel Building (at 21'-6" elevation). A new check valve is installed inside the Fuel Building in the 6-inch line upstream of the tee to prevent back flow through the FP piping from the connection. A check valve in the new 4-inch line inside the Fuel Building prevents flow out of the new connection line in the event that the existing emergency SFP makeup connection is in use (supplied from the FP header). The new connection is a standard fire hose connection and is located outside the Fuel Building at approximately the 31' elevation.

Use of the BDB SFP makeup connection is the primary connection and does not require entry into the Fuel Building.

2.4.4.2 Alternate SFP Makeup Connection

The alternate Phase 2 strategy for providing makeup water to the SFP is to use the SFP refill equipment that is already in place. The FP system feeds the emergency SFP makeup line from the yard fire main loop. The emergency SFP makeup line extends above the SFP so that water can be discharged directly into the pool (Figure 17).

The water source for the alternate strategy is the pressurized fire main, which can be pressurized by the site Fire Pump, if available, or the BDB High Capacity pump. The yard fire main is buried and seismically qualified, and is expected to be able to provide water during a flooding event.

2.4.4.3 SFP Makeup Spray Option Connection

An additional alternate strategy utilizes a spray option to achieve SFP makeup. The spray strategy (as required by NEI 12-06 Table D-3 for providing spray at 250 gpm/unit) is to provide 500 gpm flow through portable spray monitors set up on the deck next to the SFP (Figure 17). A hose is run from the fire main or the discharge of the BDB High Capacity pump, through the Fuel Building door, and up to the SFP operating deck. From there, the hose is run to portable spray monitors. When deployed, the two spray monitors are connected via a wye that splits the pump discharge into two hoses. The two spray monitor hoses are routed from the new fuel storage area to the SFP. The oscillating spray monitors are set up approximately 30 feet apart and 16 feet back from the SFP. These spray monitors spray water into the SFP to maintain water level. In addition to the spray monitors, a connection and sufficient hose length is also available to run a separate hose directly into the SFP.

2.4.4.4 Fuel Building Ventilation

Ventilation requirements to prevent excessive steam accumulation in the Fuel Building are included in an existing site Abnormal Procedure (AP). The AP directs operators to open several rollup doors in the Fuel Building to establish a natural circulation flowpath. Airflow through these doors provides adequate vent pathways through which steam generated by SFP boiling can exit the Fuel Building. BDB FLEX Support Guidelines (FSGs) implement this method of ventilation for the Fuel Building.

2.4.5 Key Reactor Parameters

The key parameter for the SFP makeup strategy is the SFP water level. The SFP water level is monitored by the instrumentation that was installed in response to Order EA-12-051, *Reliable Spent Fuel Pool Level Instrumentation* (Reference 5).

2.4.6 Thermal Hydraulic Analyses

An analysis was performed that determined, with the maximum expected SFP heat load immediately following a core offload, that the SFP reaches a bulk boiling temperature of 212°F in approximately 12 hours and boil off to a level 10 feet above the top of fuel in 51 hours unless additional water is supplied to the SFP. A flow of 78 gpm replenishes the water lost due to boiling. Deployment of the SFP hose connection from the BDB High Capacity pump within 24 hours with a design flow of 500 gpm for the SFP provides for adequate makeup to restore the SFP level. At a minimum, it maintains an acceptable level of water for shielding purposes (greater than 10 feet above the top of the fuel).

2.4.7 FLEX Strategy Pump and Water Supplies

2.4.7.1 BDB High Capacity Pump (Refer to 2.3.10.1)

The BDB High Capacity pump is a nominal 150 psid at 1200 gpm pump that is shared between several functions. The BDB High Capacity pump is a trailer-mounted, diesel driven centrifugal pump. The pump is deployed by towing the trailer to a designated draft location near the selected water source. One BDB High Capacity pump is sized to provide an AFW water supply of 300 gpm each to Unit 1 and Unit 2 and 500 to gpm for Spent Fuel Pool makeup simultaneously.

2.4.7.2 Condensate Polishing (CP) Settling Pond

The Condensate Polishing (CP) settling pond is located at the end of the discharge canal to the northeast of the Surry main plant at an elevation of 35 feet. It is used to collect water discharged from the condensate polishing system as well as other outfalls. Water sent to the pond has a high concentration of total suspended solids that need to settle out prior to being released into the discharge canal. No additional chemical treatment is added to the settling pond water. The water in the settling pond is of a higher quality than water from the James River and is a source of water to refill the ECST or to makeup the SFP. The settling pond has a water volume of approximately

3,600,000 gallons of water. The BDB High Capacity Pump can be used to draw water from the settling pond and pump it to the ECST, or to the suction of the BDB AFW pump, and/or to the SFP.

2.4.7.3 Discharge Canal (James River)

The Discharge Canal is a protected source with essentially unlimited inventory, however, since it is brackish water, it is the least preferred SFP makeup supply source.

2.4.8 Electrical Analysis

The SFP is monitored by instrumentation installed in response to Order EA-12-051. The power for this equipment has backup battery capacity for 72 hours. Alternative power is provided within 72 hours using onsite portable generators, if necessary, to provide power to the instrumentation and display panels and to recharge the backup battery.

2.5 Containment Integrity

With an extended loss of all alternating current power (ELAP), Containment cooling is also lost for an extended period of time. Therefore, Containment temperature and pressure slowly increases unless the reactor is defueled. Structural integrity of the reactor containment building due to increasing Containment pressure is not challenged during the first several weeks of a BDB ELAP event. However, with no cooling in the Containment, temperatures in the Containment are expected to rise and could reach a point where continued reliable operation of key instrumentation might be challenged.

Conservative evaluations have concluded that Containment temperature and pressure remains below Containment design limits and that key parameter instruments subject to the Containment environment remain functional for a minimum of seven days. Therefore, actions to reduce Containment temperature and pressure to ensure continued functionality of the key parameters are not required immediately and utilize offsite equipment during Phase 3.

NOTE: The containment integrity strategy descriptions below are the same for both of the two Surry units. Any differences and/or unit specific information is included where appropriate.

2.5.1 Phase I

The Phase 1 coping strategy for Containment involves verifying Containment isolation per ECA-0.0, *Loss of All AC Power*, and monitoring Containment temperature and pressure using installed instrumentation. Control room indication for Containment wide range pressure is available for the duration of the ELAP. Containment temperature (taken at the 47' elevation) is available in the control room prior to load stripping and following repowering of the DC loads with either the 480 VAC or 120/240 VAC portable diesel generators.

2.5.2 Phase 2

The Phase 2 coping strategy is to continue monitoring Containment temperature and pressure using installed instrumentation. Phase 2 activities to repower key instrumentation (Section 2.9.3) are required to continue Containment monitoring.

Containment temperature is procedurally monitored and, if necessary, Containment temperature is reduced to ensure that key instruments inside Containment remain within analyzed limits for equipment qualification. The choice of equipment qualification as a temperature limit is conservative. Containment temperature reduction requires the implementation of a Containment cooling strategy utilizing equipment provided in Phase 3. The various Containment cooling strategy options are discussed in Section 2.5.3.

2.5.3 Phase 3

Necessary actions to reduce Containment temperature and ensure continued functionality of the key parameters utilize existing plant systems powered by offsite equipment during Phase 3. 4160 VAC power is needed to operate various station pumps. This capability is provided by two 1 MW 4160 VAC portable generators per unit provided from the NSRC. The portable 4160 VAC generators and a distribution panel for each unit are brought in from the National SAFER Response Center (NSRC) in order to supply power to either of the two Class 1E 4160 VAC buses on each unit. Additionally, by restoring the Class 1E 4160 VAC bus, power can be restored to the Class 1E 480 VAC buses via the 4160/480 VAC transformers to power selected 480 VAC loads.

If the Service Water (SW) pumps are not available, then Low Pressure/High Flow diesel driven pumps (up to 5,000 gpm) from the NSRC are available to provide flow to existing site heat exchangers to facilitate heat removal from the Containment atmosphere.

Several options were evaluated to provide operators with the ability to reduce the Containment temperature. Each of these options require the restoration of multiple support systems to effectively remove heat from the Containment and reduce Containment temperature and pressure.

Ventilation Cooling Option (Preferred)

The ventilation option for Phase 3 Containment cooling is to establish Containment ventilation by either establishing Containment Air Recirculation Fan (CARF) cooling or establishing Control Rod Drive Mechanism (CRDM) cooling.

To implement this option, the 4160 VAC generators from the NSRC are aligned to power a Class 1E 4160 VAC bus and a 480 VAC bus as described in Section 2.3.3. The 4160 VAC generators provide power to the existing Component Cooling (CC) Water system, the SW pumps (if available), an Instrument Air (IA) system compressor, and one of the CARF or the CRDM fan motors. The CARF and the CRDM fans are both 480 VAC motors. Containment ventilation flow would be established by starting either a CARF or CRDM fan, cooling with air flow through the respective cooling coil unit, and recirculating within the Containment. IA system pressure is restored to remotely operate valves inside Containment, as required.

Water to the Service Water (SW) System and to the Component Cooling Water (CC) Heat exchangers is typically supplied from the Circulating Water (CW) via the intake canal by gravity feed through the CCHXs. If adequate water volume remains in the intake canal following a BDB Event, design basis SW flow to each unit's CCHXs can be established by opening the appropriate motor operated valves in the SW system. If the CW intake canal does not have sufficient water supply, water can be added to the intake canal by the diesel driven Emergency Service Water Pumps or by deploying a Low Pressure / High Flow pump from the NSRC to pump water from the James River into the intake canal. If the CW intake canal is not available, then water to the Service Water System / CC HXs is established by taking suction from the discharge canal using a Low Pressure / High Flow pump from the NSRC and connecting to the service water supply header using a blind flange adapter available in the BDB Storage Building (Figures 18 and 19).

A single CC heat exchanger flowing design basis SW cooling water has significantly more heat removal capability than required for the CARF coils or CRDM fan coils in both units. CC flow is established through the CARF or CRDM cooling coil unit and the CC heat exchanger to transfer heat to the SW system. In this manner, heat from the Containment atmosphere is rejected to the ultimate heat sink via the recirculation of Containment air through the CARF or the CRDM cooling coil unit.

Spray Option

A spray option is available to spray water into the Containment using the Containment Recirculation Spray (RS) system utilizing clean water from the RWST or the CP Settling pond (Figures 20 and 21).

To utilize this option, the 4160 VAC generators from the NSRC are aligned to power one of the Class 1E 4160 VAC and 480 VAC buses on each unit as described in Section 2.3.3, which provides power to the RS pump 480 VAC (or 4160 VAC, depending upon the selected pump) motor.

The Containment sump must be filled to provide a suction water source for the RS pump. The water from the RWST can be pumped through the Containment Spray (CS) ring header nozzles into Containment using either the NSRC Low Pressure / Medium Flow pump (up to 2500 gpm) or the BDB AFW pump connected to the BDB RCS Containment Spray (CS) pump suction connection, located in the Containment Spray Pump House (CSPH), and discharging to the pre-fabricated BDB CS blind flange hose adapter connection on the CS pump discharge also located in the CSPH.

This spray flow fills the Containment sump in preparation for initiation of RS flow. When the sump level is adequate, either an inside or outside RS pump is started to draw water from the sump and recirculate flow through the RS heat exchangers and the spray nozzles. SW system flow is established through the RS heat exchangers to provide a heat sink in the same manner as the CC heat exchanger flow is established in the Ventilation Option previously discussed. In this manner, Containment atmosphere heat is rejected to the ultimate heat sink via the sump water recirculation spray flowpath.

2.5.4 Structures, Systems, Components

2.5.4.1 Ventilation Cooling Strategy

No mechanical equipment connections are required for the Containment ventilation cooling option if the CW intake canal is available. If the CW intake canal is not available, a Low Pressure/High Flow pump from the NSRC is connected to a 24" flanged opening in the 30" SW piping using a pre-fabricated hose adapter.

2.5.4.2 Spray Strategy

The Containment spray option requires connections of BDB equipment to transfer water from the RWST (or CP Settling Pond) into the Containment sump. The RWST suction connection for a Low Pressure/Medium Flow NSRC pump is located in the CSPH. The discharge connection is to the pre-fabricated BDB CS blind flange hose adapter connection also located in the CSPH.

The existing site equipment required to implement the Containment cooling options discussed above are components of safety-related systems and are both seismic category I structures and are also protected from high wind/tornado generated missiles, floods, and extreme high and low temperatures.

The CSPH is Seismic Category 1 but is not designed to withstand tornado generated missiles. The connections needed for the spray option are located inside the CSPH and are protected from high winds, earthquakes, flooding, extreme cold, ice and snow, and extreme high temperature.

The remaining equipment required to implement the Containment cooling options discussed above is delivered to the site from the NSRC and is not subject to the site BDB hazards initiating the ELAP.

2.5.5 Key Containment Parameters

Instrumentation providing the following key parameters is credited for all phases of the Containment Integrity strategy:

- **Containment Pressure**: Containment pressure indication is available in the main control room (MCR) throughout the event.

- **Containment Wide Range Temperature**: Containment wide range temperature indication is available in the MCR throughout the event (Train A only).
- **Containment Sump Level**: Containment sump level indication is available in the MCR once power is restored to each unit's vital AC/DC buses. Although this key parameter is available for all Phase 3 Containment cooling strategy options, it is only credited specifically for the Containment cooling spray option.

2.5.6 Thermal Hydraulic Analyses

Conservative evaluations have concluded that Containment temperature and pressure remain below Containment design limits and that key parameter instruments subject to the Containment environment remain functional for a minimum of seven days. The Containment temperature is procedurally monitored and, if necessary, the Containment temperature is reduced using the options available to ensure that key instruments inside Containment remain within their analyzed limits for equipment qualification.

2.5.7 FLEX Strategy Pump and Water Supplies

The NSRC is providing a Low Pressure/High Flow pump (nominal 5,000 gpm) which is used if required to provide cooling loads to the SW system. A Low Pressure/Medium Flow (nominal 2,500 gpm) pump is also available from the NSRC, if needed. Water supplies are as described in Section 2.3.10. If available, the Emergency Service Water pumps may be used, but are not specifically credited in the FLEX strategies.

2.5.8 Electrical Analysis

One (1) of the two (2) Class 1E 4160 VAC buses is required for each unit to repower the Containment cooling options described above. The 4160 VAC equipment supplied from the NSRC provides adequate power to perform the Phase 3 Containment cooling strategies. The necessary components to implement the various Containment cooling options have been included in the calculations to support the sizing of the 4160 VAC generators provided by the NSRC. Accordingly, two (2) 1-MW 4160 VAC generators and a distribution panel (including cable and connectors) are provided from the NSRC per unit.

2.6 Characterization of External Hazards

2.6.1 Seismic

Per NEI 12-06 (Reference 3), seismic hazards must be considered for all nuclear sites. As a result, the credited FLEX strategy equipment has been assessed based on the current SPS seismic licensing basis to ensure that at a minimum, N sets of credited BDB equipment remains accessible and functional after a Beyond Design Basis external event. The Surry seismic hazard is considered to be the earthquake magnitude associated with the design-basis seismic event. Per Section 2.5.6 of the Surry UFSAR (Reference 18), the design-basis earthquake is 0.15g for horizontal ground motion and 0.10g for vertical ground motion.

In addition to the NEI 12-06 guidance, Near-Term Task Force (NTTF) Recommendation 2.1, Seismic, required that facilities re-evaluate the site's seismic hazard. Surry Power Station subsequently re-evaluated the seismic hazard and developed a Ground Motion Response Spectrum (GMRS) for the site based upon the most recent seismic data and methodologies. A review of the re-evaluated hazard determined that seismic reviews performed for initial plant licensing bounded the GMRS in the 1 to 10 Hz frequency range and concluded that performance of further seismic risk evaluation was not required for Surry (Reference 33).

For FLEX strategies, non-seismic structures and equipment may fail in a manner that would prevent accomplishment of FLEX-related activities (normal access to plant equipment, functionality of non-seismic plant equipment, deployment of Beyond-Design-Basis (BDB) equipment, restoration of normal plant services, etc.). The diverse nature of the FLEX strategies has been discussed. The ability to clear haul routes from seismic debris to facilitate the deployment of the BDB Phase 2 equipment is addressed in Section 2.8.

2.6.2 External Flooding

The Surry site is located on the James River approximately 40 nautical miles from the mouth of the Chesapeake Bay where it enters the Atlantic Ocean. The sources of flooding in the James River at the Surry site are flood discharges due to watershed runoff and surge due to severe storms.

Flooding in the James River upstream of the site has not resulted in flooding at the site due to the wide flood plain at the site. An analysis of the probable rise in mean water level at the site associated with the flood discharges indicates that even for a flood discharge recurrence interval of only once in 50 years, the water level at the site would rise no more than 1 foot above normal mean river level, if not accompanied by unusual meteorological tides. There are no known or planned river control structures on the James River. Several small impoundments on tributaries in the upper reaches do exist; however, their size and location would preclude any effect or danger to the safety-related structures at the site.

The Probable Maximum Hurricane (PMH) is the most severe meteorological event at the Surry site and results in the most limiting flood level elevations at both the site and the intake structure. During a PMH, the James River stillwater level is 22.7 feet at the site. Accounting for maximum wave runup, the flood level of a PMH at the east end of the site, the intake structure, is approximately 28.6 feet. The east face of the intake structure is protected against this wave action. The intake structure is located more than a mile from the main site (power block) structures and has no credited role in the FLEX strategies for Surry. Maximum runup due to storm surges at the west side of the main site is 24 feet MSL. Critical equipment in this area is protected against flooding to Elevation 26.5 feet, which is the typical site grade. (UFSAR Section 2.3.1.2)

It is highly unlikely that the formation of ice on the James River would obstruct the flow and cause flooding, due to the salinity of the river below the site.

Tsunami and seiche-related flooding is not addressed in the Surry UFSAR. However, the Surry ISFSI SAR does address these events. Per the ISFSI SAR, the seiche is bounded by the PMH stillwater level and the site is protected from coastal tsunami events. (Reference 14)

Since the original submittal of the Overall Integrated Plan, Dominion has completed and submitted the Flood Hazard Reevaluation Report for Surry Power Station (Reference 19) requested by the 10 CFR 50.54(f) letter dated March 12, 2012. The reevaluation represents the most current flooding analysis for Surry. However, the impact of the flooding reevaluation on the execution and deployment of the FLEX strategies has not yet been determined and will be addressed through the Integrated Assessment process required by NTTF Recommendation 2.1: Flooding.

2.6.3 Severe Storms with High Wind

The current plant design basis addresses the storm hazards of hurricanes, high winds and tornados.

For hurricanes, since 1871, when more complete weather recordkeeping began, through 1987, a total of 56 tropical storms or hurricane centers passed within 100 nautical miles of the Surry site. After 1885, weather records differentiated between tropical storms (less than 73 mph) and hurricanes (more than 73 mph). From 1886 through 1987, there have been 34 passages of tropical storms and 10 hurricanes within 100 nautical miles of the site (Reference 18, Section 2.2.2).

For extreme straight winds – UFSAR Table 2.2-1 listed the fastest mile wind in Norfolk as 78 mph and in Richmond as 68 mph, both occurring in October 1954 during the passing of Hurricane Hazel (Reference 18, Section 2.2.2).

For tornados and tornado missiles, the Surry UFSAR indicates that between January 1951 and December 1987 there were a total of 49 tornados reported within a 50-mile radius of the site. For tornadoes and tornado missiles, Reference 13-1 indicates that the tornado model used for design purposes has a 300 mph rotational velocity, a 60 mph translational velocity, and a pressure drop of 3 psi in 3 seconds (UFSAR). Wind generated missiles include a utility pole and a 1 ton vehicle traveling at 150 mph.

On April 16, 2011, a tornado struck the Surry Power Station switchyard. Damage to equipment in the switchyard resulted in a Loss of Offsite Power and reactor trips on both unit 1 and 2, as reported in Surry LER 2011-001 (Reference 32).

2.6.4 Ice, Snow and Extreme Cold

The climatic characteristics of the site region are influenced by the Atlantic Ocean, the Chesapeake Bay, and the Appalachian Mountains. The Atlantic Ocean has a moderating effect on the temperature for the Surry region, whereas the Appalachians act as a barrier to deflect Midwest winter storms to the northeast of the Surry region. Snow is not common during winter in the Tidewater area of Virginia. A snowfall of 10 inches or more a month in the Tidewater area is expected to occur once every 4 years. In general, the total accumulated snow for the Tidewater is approximately 10 inches each year. Precipitation occurs mostly as rain in the site area (Reference 18, Section 2.2.2). The maximum monthly snowfall in Norfolk is 18.9 inches occurring in February 1980 and the maximum monthly snowfall for Richmond is 28.5 inches occurring in January 1940. The lowest temperature recorded in Norfolk was minus 3 deg F in January 1985 and in Richmond was minus 12 deg F in January 1940 (Reference 18, Table 2.2-1).

The Surry UFSAR does not provide historical data on ice storms in the site characterization, however, ice storms can occur at Surry Power Station and may cause hazardous travel and downed trees which may block the site access road and possibly deployment haul paths.

2.6.5 High Temperatures

The Atlantic Ocean has a moderating effect on the temperature for the Surry region. The peak temperature recorded in Norfolk was 104 deg F in August 1980 and in Richmond was 105 deg F in July 1977 (Reference 18, Table 2.2-1).

2.7 Protection of FLEX Strategy Equipment

FLEX strategy equipment is stored in a single 10,000 sq. ft. concrete building that meets the plant's design-basis for both seismic and tornado-missile protection. The BDB Storage Building was evaluated for the effect of local seismic ground motions consistent with the SPS Ground Motion Response Spectrum (GMRS) developed for the original site licensing basis (See Section 2.6.1) and found to have adequate structural margin to remain functional (i.e., collapse is not expected and access to the interior retained).

The BDB Storage Building is located on the south side of the site adjacent to the Protected Area (Figure 22). This location is above the flood elevation from the most recent site flood analysis. The BDB Storage Building was designed and constructed to protect the equipment from the hazards identified in Section 2.6.

Analysis of equipment stored in the BDB Storage Building have been performed to determine appropriate measures to prevent seismic interaction. The fire protection and HVAC systems in the BDB Storage Building are seismically installed. The lighting, conduits, electrical, and fire detection components are not seismically installed, but are considered insignificant and not able to damage BDB equipment.

The debris removal equipment required to support the implementation of the FLEX strategies is also stored inside the BDB Storage Building in order to protect them from the applicable external hazards. Therefore, the equipment remains functional and deployable to clear obstructions from the pathway between the BDB equipment's storage location and its deployment location(s). This debris removal equipment includes mobile equipment such as a front end loader and tow vehicles (tractors).

Deployment of the debris removal equipment and the Phase 2 BDB equipment from the BDB Storage Building is not dependent on offsite power. The building equipment doors are hydraulically operated with a battery backup and can also be opened manually.

The 50.54(hh)(2) high capacity pump can meet the flow requirements for both the FLEX core cooling and SFP cooling strategies cooling strategies that credit the BDB High Capacity pump and serves to meet the N+1 requirement. The 50.54(hh)(2) high capacity pump is stored in the Emergency Response Building on site, which is reasonably protected from flooding, extreme heat, and extreme cold hazards. The Emergency Response Building does not meet the requirements of NEI 12-06 Sections 7.3.1 and 5.3.1 because it is not fully protected against seismic, high wind/tornado missile, and hurricane events, respectively. Therefore, the storage arrangements for the 50.54(hh)(2) pump represent an alternate approach to the requirements of NEI 12-06, Sections 5.3.1, 7.3.1, and 11.3.3. Accordingly, Dominion has implemented compensatory actions to support this alternative approach for stored BDB equipment. The unavailability requirements for FLEX equipment are prescribed by Dominion Fleet procedure ADM-CM-AA-BDB-102 and include additional requirements to address the storage capability of FLEX equipment that is not fully protected.

These additional requirements are as follows:

> "The required FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is met. If the site FLEX (N) capability is met but not fully protected for the site's applicable hazards, the allowed unavailability is reduced to 45 days."

Additionally, ADM-CM-AA-BDB-102 provides appropriate guidance for reasonable protection during forecast adverse external conditions as follows:

> "If FLEX equipment is likely to be unavailable during forecast site specific external events (e.g., hurricane), then appropriate compensatory measures should be taken to restore equivalent capability in advance of the event."

Abnormal Procedure, 0-AP-37.01, "Abnormal Environmental Weather Conditions", accommodates this requirement as it invokes an evaluation of the availability of BDB equipment, which includes the 50.54(hh)(2) pumps, upon approaching severe weather.

These actions are intended to limit the potential vulnerability of the 50.54(hh)(2) pump. Therefore, the current on-site FLEX equipment storage configuration in conjunction with the procedural FLEX equipment unavailability requirements ensure reasonable protection for the 50.54(hh)(2) pump as an acceptable alternative to the NEI 12-06 guidance.

2.8 Planned Deployment of FLEX Strategy Equipment

2.8.1 Haul Paths

The deployment of onsite BDB equipment in Phase 2 requires that pathways between the BDB Storage Building(s) and various deployment locations be clear of debris resulting from BDB seismic, high wind (tornado), or flooding events. The stored BDB debris removal equipment includes a front end loader and tow vehicles (tractors) equipped with front end buckets and rear tow connections for moving or removing debris from the needed travel paths. A front end loader is also available to deal with more significant debris conditions.

Pre-determined FLEX strategy equipment haul paths have been identified and documented in the FLEX Support Guidelines (FSGs). Figure 22 shows the haul paths from the BDB Storage Building to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event. Additionally, the haul paths minimize travel through areas with trees, power lines, narrow passages, etc. to the extent practical. However, high winds can cause debris from distant sources to interfere with these haul paths. Debris removal equipment is stored inside the BDB Storage Building and is protected from the severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the BDB equipment stored in the BDB Storage Building and its deployment location(s).

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving "Staging Areas" locations and from the various plant access routes may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear.

2.8.2 Accessibility

The potential impairments to required site/plant access are: 1) doors and gates, and 2) site debris blocking personnel or equipment access. Maintaining site accessibility through doors and gates is applicable to all phases of the FLEX strategies, but is essential as part of the immediate activities required during Phase 1.

Doors and gates serve a variety of barrier functions on the site. One primary function, security, is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and HELB. These doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDB external event and subsequent ELAP event, FLEX strategies require the routing of hoses and cables through various barriers in order to connect portable BDB equipment to station fluid and electric systems. For this reason, certain barriers (gates and doors) are opened and remain open. This departure from normal administrative controls is necessary and is acceptable during the implementation of FLEX strategies.

The ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies. Security doors and gates that rely on electric power to operate opening and/or locking mechanisms are barriers of concern. The Security force initiates an access contingency upon loss of the Security Diesel and all AC/DC power as part of the Security Plan. Access to the Owner Controlled Area, site Protected Area, and areas within the plant structures are controlled under this access contingency as implemented by Security personnel. Access authorization lists are prepared daily and copies are protected from the various BDB external events for use post-ELAP event. The plant MCR contains a duplicate set of security keys for use by plant Operations personnel in implementing the FLEX strategies.

Vehicle access to the Protected Area is via the double gated sally-port at the Security Building. As part of the Security access contingency, the sally-port gates are manually controlled to allow delivery of BDB equipment (e.g., generators, pumps) and other vehicles such as debris removal equipment into the Protected Area.

2.9 Deployment of Strategies

2.9.1 AFW Makeup Strategy

The Condensate Polishing Settling Pond is a safety-related, seismic Category I earthen structure and remains available for any of the external hazards listed in Section 2.6. Additionally, the Surry Discharge Canal to the James River provides an indefinite supply of water, as makeup to the Emergency Condensate Storage Tank (ECST) for supply to the Turbine Driven Auxiliary Feedwater (TDAFW) pump or directly to the suction of the portable diesel driven BDB AFW pump. The James River remains an available water source for any of the external hazards listed in Section 2.6.

The portable, diesel driven BDB High Capacity pump is transported from the BDB Storage Building to a draft location near the selected water source. A flexible hose is routed from the pump suction to the water source where water is drawn through a floating suction strainer. An additional strainer is included in the discharge lines to the TDAFW or the BDB AFW pump that are sized to limit solid debris size and prevent damage. A flexible hose is routed from the BDB High Capacity pump discharge to the BDB ECST Refill connection or to the suction of the portable BDB AFW pump. Water from the selected water source can also be pumped to the Spent Fuel Pool.

Both the primary and the alternate BDB AFW pump discharge connections are located in the AFW pump room within the seismic Category I, tornado missile protected MSVH above the 27 foot floor elevation. The BDB ECST Refill connection is located inside of the ECST missile shield. Portable heating is provided in the event of an ELAP and extended extreme cold hazard to protect the connection from freezing. These connections are protected from the external hazards described in Section 2.6.

The alternate BDB AFW connection is to the AFW tie-in piping located within the seismic Category I, missile protected AFW pump room of the opposite units MSVH. The connection is protected from the other external hazards described in Section 2.6

Figure 1 provides a diagram of the flowpath and equipment utilized to facilitate this FLEX strategy. Figures 11 through 14 depict the detailed connection locations for the AFW makeup strategy.

2.9.2 RCS Makeup Strategy

The RCS Injection pumps are stored in the BDB Storage Building and are protected against all external hazards described in Section 2.6.

The primary RCS Injection connections are located inside of the Safeguards Building of each unit and provide a path to the RCS hot legs of that unit. Accordingly, these connections are protected against all BDB external hazards.

The alternate RCS Injection connections for each unit are located inside of the Auxiliary Building and provide a path to the RCS hot legs and cold legs of both units. Accordingly, these connections are protected against all BDB external hazards.

The suction connections from the RWSTs to the BDB RCS Injection pumps for each unit are located in the Containment Spray Pump House of each unit. Accordingly, these connections are protected against all BDB hazards except tornado missiles. Should the RWST or the primary RWST suction connection become unavailable, an alternate supply of borated water is available from the portable Boric Acid Mixing tanks stored in the BDB Storage Building.

Figure 1 provides a diagram of the flowpath and equipment utilized to facilitate this strategy. Figures 2 through 5 depict the detailed connection locations for the RCS injection strategy.

2.9.3 Spent Fuel Pool Makeup Strategy

The SFP makeup strategy initiates SFP makeup by utilizing the previously deployed BDB High Capacity pump or by using the existing FP system emergency SFP makeup piping. The BDB High Capacity pump hose connects to the BDB SFP makeup hose connection which is located on the outside wall of the Fuel Building and is seismically designed and missile protected. The BDB SFP makeup connection is sufficiently sized to restore SFP level long term following the loss of SFP cooling with a makeup rate up to 500 gpm. No deployment is required for use of the FP system emergency SFP makeup piping as a SFP makeup source.

Figures 1 and 17 provide a diagram of the flowpath and equipment utilized to facilitate this strategy.

2.9.4 Electrical Strategy

The 480 VAC DGs are stored in the BDB Storage Building and are protected from the BDB external event hazards identified in Section 2.6.

The 480 VAC DGs are deployed to the east or west alleyway (depending on the unit) adjacent to the 120/240 VAC DG deployment locations. The 480 VAC DGs each have a set of color coded cables which connect from the deployed generators to a receptacle panel located in the associated unit's Upper Cable Vault. The receptacle panel is seismically mounted, protected from missiles, flood, snow and ice, and operable within the outside temperature ranges specified for the site. The color coded cables from each generator output circuit are connected with proper phase rotation to the color coded mating receptacles in the receptacle panel. A phase rotation meter is provided in the receptacle panel for each 480 VAC circuit.

The 120/240 VAC diesel generators (DGs) are stored in the BDB Storage Building and are protected from the BDB external hazards identified in Section 2.6.

One (1) 120/240 VAC DG for each unit is deployed to the east or west alleyway (depending on the unit) adjacent to the Auxiliary Building. The 120/240 VAC DGs each have two output circuits and associated cables which connect from the deployed generators to a receptacle panel located in the associated unit's Upper Cable Vault. Each circuit on the 120/240 VAC DG includes an adjustable output breaker, weatherproof receptacle, flexible and weatherproof cable with weatherproof connectors at both ends.

The receptacle panel for the 120/240 VAC DG cables is the same panel used for the 480 VAC cables. From the receptacle panel, cables for the 120/240 VAC connections are in seismically mounted raceways which have been installed to two new BDB distribution panels, one for each output circuit. Each BDB distribution panel has branch circuit breakers sized to feed the required loads.

The connecting cables for the 480 VAC DG and backup cables for the 120/240 VAC DG for each unit are stored on cable trailers in the BDB Storage Building and are, therefore, protected from the BDB external event hazards identified in Section 2.6.

Figures 6 through 10 provide a diagram of the connections to the station electrical system utilized to facilitate this strategy.

2.9.5 Fueling of Equipment

Credited FLEX strategy equipment is stored in the fueled condition. Fuel tanks are typically sized to hold 24 hours of fuel. Once deployed during a BDB external event, a fuel transfer truck refuels this equipment in the first 24 hours or sooner as required. The general coping strategy for supplying fuel oil to diesel driven portable equipment being utilized to cope with an ELAP/LUHS is to draw fuel oil out of any available existing diesel fuel oil tanks on the Surry site. The following onsite fuel sources are available to refuel the FLEX equipment as required:

- EDG Fuel Oil Day Tanks – These tanks are in the Emergency Diesel Rooms. Each room contains a base tank under the frame of the diesel and a wall-mounted tank adjacent to the diesel; together the two tanks for each diesel are considered a Day Tank. Each of these six tanks has a capacity of 550 gallons, for a total of up to 3300 gallons. Fuel can be pumped from a base tank through a fill connection in the top of the tank, using a dip tube. Fuel can be obtained from the wall-mounted tank through a drain valve in the bottom of the tank.
- EDG Underground Diesel Fuel Oil Storage Tanks (2) – Each tank has a 17,500 gallon capacity. These tanks are protected from missiles (i.e., tornados) by virtue of the underground location and are also protected from seismic and flooding events. The fuel may be removed from the tanks through a sample fitting in the top of each tank; the sample fitting is blind flanged and protected by a concrete missile shield plug. Fuel can also be taken out by connecting one or more hoses to drain and sample connections on the pump suctions in the fuel oil pump houses adjacent to the tanks.
- EDG Above Ground Diesel Fuel Oil Storage Tank – This tank has a 210,000 gallon capacity. This tank is protected from flooding, but is not seismic or tornado protected. Fuel can be obtained using the tank drain valve located inside the flood wall. In the event the drain valve inside the flood barricade is not accessible, fuel oil can be drained utilizing the strainer drain valve.

- Gravel Neck Power Station, which is adjacent to the Surry site, has two above ground Diesel Fuel Oil Storage Tanks. Each tank has a nominal operating capacity of 3,000,000 gallons. These tanks are not seismic, tornado or flood protected.

Diesel fuel in the fuel oil storage tanks is routinely sampled and tested to assure fuel oil quality is maintained to ASTM standards. This sampling and testing surveillance program also assures the fuel oil quality is maintained for operation of the station Emergency Diesel Generators (EDGs).

Portable equipment powered by diesel fuel are designed to use the same low sulfur diesel fuel oil as the installed EDGs.

The above fuel oil sources are used to fill the fuel transfer truck that is stored in the BDB Storage Building. The fuel transfer truck has a capacity of approximately 1,100 gallons and has a self-powered transfer pump. The fuel transfer truck is deployed from the BDB Storage Building to refill the diesel fuel tanks of BDB equipment and to the various diesel fuel tank storage locations where it is refueled by either gravity fill or pumped full.

Based on a fuel consumption study, a conservative combined fuel consumption rate was determined to be 120 gal/hr. The fuel transfer truck has sufficient capacity to support continuous operation of the major BDB equipment expected to be deployed and placed into service following a BDB external event. At this conservative fuel consumption rate, the EDG day tanks and the two 17,500 gallon underground Fuel Oil Storage Tanks, which are protected from the BDB external hazards, have adequate capacity to provide the onsite BDB equipment with diesel fuel for approximately two weeks. The NSRC is also able to provide diesel fuel for diesel operated equipment, thus providing additional margin.

The diesel fuel consumption information above does not include diesel fuel requirements for the portable 4160 VAC diesel generators (DGs) to be received from the NSRC. More than adequate diesel fuel is available on site for these generators if either the above ground 210,000 gallon Fuel Oil Storage Tank or the 3,000,000 gallon Gravel Neck Fuel Oil Storage is available. If not, provisions for receipt of diesel fuel from offsite sources are in place to facilitate the Phase 3 re-powering strategy with the portable 4160 VAC DGs.

The BDB external event response strategy also includes a limited number of small support equipment that are powered by gasoline engines (chain saws, chop saws and small electrical generator units). These components are re-fueled using portable 5-gallon containers. The portable containers can be filled with gasoline using the 12 VDC fuel transfer carts that are stored in the BDB Storage Building. Gasoline can be obtained from the station's 8,500 gal underground gasoline fuel storage tank or from private vehicles on site. Oil for the 2-cycle engines is also available in the BDB Storage Building.

2.10 Offsite Resources

2.10.1 National SAFER Response Center

The industry has established two (2) National SAFER Response Centers (NSRCs) to support utilities during BDB events. Dominion has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs as required. Each NSRC holds five (5) sets of equipment, four (4) of which are able to be fully deployed when requested, the fifth set has equipment in a maintenance cycle. In addition, onsite BDB equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

In the event of a BDB external event and subsequent ELAP/LUHS condition, equipment is moved from an NSRC to a local assembly area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team. From there, equipment can be taken to the Surry site by helicopter if ground transportation is unavailable and staged at one of the two SAFER onsite Staging Areas. Communications are established between the Surry plant site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment is delivered to the site within 24 hours from the initial request. The anticipated order in which equipment is delivered is identified in Surry's *SAFER Response Plan* (Reference 20), however, the prioritization of equipment is subject to change due to the actual circumstances when the NSRC is contacted.

2.10.2 Equipment List

The equipment stored and maintained at the NSRC for transportation to the local assembly area to support the response to a BDB external event at Surry is listed in Table 2. Table 2 identifies the equipment that is specifically credited in the FLEX strategies for Surry, but also lists the equipment that is available for backup/replacement should onsite equipment be unavailable. Once the NSRC supplied equipment is transported to and staged at the local assembly area, the time needed for the replacement of a failed component is minimal.

2.11 Equipment Operating Conditions

2.11.1 Ventilation

Following a BDB external event and subsequent ELAP/LUHS event at Surry, ventilation providing cooling to occupied areas and areas containing FLEX strategy equipment is lost. Per the guidance in NEI 12-06, FLEX strategies must be capable of execution under adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDB external event resulting in an ELAP/LUHS. The primary concern with regard to ventilation is the heat buildup which occurs when forced ventilation is lost in areas that continue to have heat loads. A loss of ventilation analysis was performed to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and within equipment qualification limits.

The key areas identified for all phases of execution of the FLEX strategy activities are the Main Control Room (MCR), Emergency Switchgear Room (ESGR) including the battery rooms, Main Steam Valve House (MSVH) (SG PORV area and Auxiliary Feedwater (AFW) Pump Room), Containment Spray Pump House, and the Auxiliary Building. These areas have been evaluated to determine the temperature profiles following an ELAP/LUHS event. With the exception of the SG PORV area in the upper levels of the MSVH, results of the calculation have concluded that temperatures remain within acceptable limits based on conservative input heat load assumptions for all areas with no actions being taken to reduce heat load or to establish either active or passive ventilation (e.g., portable fans, open doors, etc.).

In the case of the upper level of the MSVH, an alternate to the normal forced air ventilation method is initiated within 2 hours of the ELAP to ensure that the temperatures remain within the acceptable range for equipment and personnel habitability. Acceptable temperatures can be maintained during normal operation with a failure of forced ventilation through the "stack effect" induced by opening an external door in the MSVH and allowing outside air to flow up through the MSVH ventilation opening in the top of the building. During an ELAP, the maximum heat load in this area is expected to be lower than during normal operation due to decreased Main Steam and Feedwater piping temperatures. Therefore, taking the same compensatory actions needed during normal operation provides acceptable temperatures following an ELAP event.

The temperatures expected in the upper level of the MSVH for local operation of the SG PORV (Section 2.3.1) are similar to conditions experienced during normal station operations, testing, and maintenance. Therefore, actions performed for FLEX activities are essentially the same as those performed for the current site procedure ECA-0.0, *Loss of All AC Power*, which addresses local operation of the SG PORVs.

An additional ventilation concern applicable to Phase 2 is the potential buildup of hydrogen in the battery rooms. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. Once a 480 VAC power supply is restored in Phase 2, the station Class 1E batteries can begin re-charging. However, prior to the beginning of the battery recharge, a 120 VAC power supply must be made available in the area of the battery rooms in order to power pre-staged portable fans to disperse the off-gassing hydrogen to a much larger area in order to prevent any significant hydrogen accumulation.

2.11.2 Heat Tracing

The large BDB pumps and DGs credited for FLEX strategies are provided with cold weather packages, some with small electrical generators to protect the equipment from extreme cold weather and help assure equipment reliability as well as to power additional heat tape circuits, if necessary. In addition, the Emergency Condensate Storage Tank refill connection pressure gauge instrument tubing credited for BDB and subject to freezing conditions in an ELAP event, is protected with the use of portable heaters.

2.12 Habitability

Habitability was evaluated as discussed in Section 2.11.1 in conjunction with equipment operabilty and determined to be acceptable.

2.13 Lighting

In order to validate the adequacy of supplemental lighting and the adequacy and practicality of using portable lighting to perform FLEX strategy actions, a lighting study was completed. Tasks evaluated included traveling to/from the various areas necessary to implement the FLEX strategies, making required mechanical and electrical connections, performing instrumentation monitoring, equipment operation, and component manipulation.

The areas reviewed contain emergency lighting fixtures (Appendix "R" lighting) consisting of a battery, battery charger and associated light fixtures. These emergency lights are designed and periodically tested to insure the battery pack provides a minimum of eight hours of lighting with no external AC power sources. Therefore, these currently installed emergency lighting fixtures provide adequate lighting to light pathways and implement the BDB strategies for Phase 1 mitigation strategy activities for eight hours.

Prior to the depletion of the Appendix "R" lighting, portable battery powered Remote Area Lighting Systems (RALS) would be deployed to support the FLEX strategy tasks. These RALSs are rechargeable LED lighting systems designed to power the LED lights for a minimum of seven hours at 6000 lumens or a maximum of 40 hours at 500 lumens.

There are no emergency lighting fixtures in the yard in or outside of the protected area to provide necessary lighting in those areas where portable BDB equipment is to be deployed. Therefore, the large portable BDB pumps and diesel generators are outfitted with light plants that are powered from either their respective diesel generators or batteries in order to support connection and operation. In addition to the lights installed on the portable BDB equipment, portable light plants are included in the FLEX strategies. These portable diesel powered light plants can be deployed from the BDB Storage Building as needed to support night time operations.

In addition to installed Appendix "R" lighting, the RALS, and the portable light plants, the BDB Storage Building also includes a stock of flashlights and headband lights to further assist the staff responding to a BDB event during low light conditions.

2.14 Communications

In the event of a BDB external event and subsequent ELAP/LUHS, communications systems functionality could be significantly limited. A standard set of assumptions for a BDB ELAP event is identified in NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, May 2012.

Communications necessary to provide onsite command and control of the FLEX strategies and offsite notifications at Surry can be effectively implemented with a combination of sound powered phones, satellite phones, and hand-held radios.

Onsite:

Dedicated sets of sound-powered phone headsets and cords are available for the implementation of the FLEX strategies between the control room, the Technical Support Center (TSC), and areas which implement the FLEX strategies (e.g., TDAFW pump, SG PORVs, etc.). The operation of this sound-powered phone subsystem is not dependent on the availability of the electric power system.

Indoor and outdoor locations where temporary BDB equipment is used may also be served with either hand-held radios, satellite phones, or sound-powered phone headsets connected with extension cords to nearby jacks.

There are dedicated hand-held radios available for the implementation of onsite FLEX strategies. Sufficient batteries and chargers are also available. Use of the hand-held radios is somewhat limited (on a point to point basis); however, a portable repeater mounted on a communications trailer enhances the effectiveness of the radios when the trailer is deployed.

Offsite:

Satellite phones are the only reasonable means to communicate offsite when the telecommunications infrastructure surrounding the nuclear site is non-functional. They connect with other satellite phones as well as normal communications devices.

NEI 12-01, Section 4.1 outlines the minimum communication pathways to the federal, state, and local authorities. Several handheld satellite phones are available for initial notifications. These phones are distributed between the Main Control Room, the Technical Support Center, the Emergency Operations Facility, Security, and Radiological Protection Office. Additionally, all of the local Offsite Response Organizations (OROs) that normally receive licensee notifications of an emergency declaration or a Protective Action Recommendation are provided with a satellite phone if they are within a 25 mile radius of the Surry site.

The MCR and TSC also have satellite phones available as deskset units. The antenna setup is a deployable system with fiber optics cable from the inside desk sets to an outdoor, battery powered, portable dish antenna. This portion of the communications strategy is intended to function on self-contained batteries from the time of its deployment to a time beyond the first 6 hours. If necessary, the portable dish antenna can be powered by a small portable electric generator available from the BDB Storage Building. Once augmented staff arrives on site a self-powered, mobile communications trailer designed to handle satellite voice traffic, as well as to function as a radio repeater to enhance onsite communications, is deployed from the BDB Storage Building.

2.15 Water Sources

2.15.1 Water Sources – Secondary Side

Table 3 provides a list of potential water sources that may be used to provide cooling water (AFW) to the Steam Generators (SGs); their capacities; and an assessment of availability following the applicable hazards identified in Section 2.6. The preferred water usage sources identified in Table 3 are provided in the sequence in which they would be utilized (see note on Discharge Canal), based on their availability after an ELAP/LUHS event. As noted in Table 3, at least three water sources would survive all applicable hazards for Surry and are credited for use in FLEX strategies.

The onsite water sources have a wide range of associated chemical compositions. Therefore, extended operation with the addition of these various onsite water sources to the Steam Generators (SGs) has been evaluated for impact on long term SG performance (heat transfer) and SG material (e.g., tube) degradation. The evaluation provides guidance for duration that the various onsite water sources can be used for core cooling/decay heat removal.

Use of the available clean water sources, tanks and condenser, are limited only by their quantities. The water supply from the James River and the CP Settling Pond is essentially unlimited by quantity, but is limited in quality and the concentration of total suspended solids (TSS).

The SG design corrosion limit corresponds to operating temperatures and pressures and is a conservative approach to the evaluation. Exceeding the expected time to reach the SG design corrosion limit would have an insignificant impact on the ability of the SG to remove core decay heat from the RCS due to the significantly lower than design SG temperature/pressure conditions. However, continued corrosion could become a tube integrity concern.

Reaching the limiting SG precipitation levels could potentially impact/reduce SG heat transfer capability. The accumulation of precipitates in the SG may eventually block flow through the SG. Precipitation accumulation is conservatively evaluated using a Total Suspended Solids (TSS) value of 500 ppm.

The evaluation shows that the water from CP Settling Pond could be used for approximately 21 days after Emergency Condensate Storage Tank (ECST) depletion before the SG design corrosion limit would be expected to be reached. If a conservative TSS level of 500 ppm is assumed for the CP Settling Pond, the limiting SG precipitation level would be expected to be reached about 10 days after ECST depletion. Water from the onsite wells (which provide makeup to the Fire Protection tanks) could be used for about 16 days after ECST depletion before the SG precipitation limit would be expected to be reached, however, inventory from the onsite well would be limited to approximately 1 week.

The evaluation shows that water from the James River could cause pitting of the SG tubes but is further limited by precipitation concerns to approximately 50 - 60 hours. On this basis, water from James River should only be considered for use in the SGs as a last resort.

The results of the water quality evaluation show that the credited, fully protected, onsite water sources provide an adequate AFW supply source for a much longer time than would be required for the delivery and deployment of the Phase 3 NSRC reverse osmosis (RO)/ion exchange equipment to remove impurities from the onsite natural water sources. The RO units have a capacity of up to 300 gpm. Once the reverse osmosis/ion exchange equipment is in operation, the onsite water sources provide for an indefinite supply of purified water.

2.15.2 Water Sources – Primary Side

Two FLEX strategy credited sources for borated water are available onsite: the Refueling Water Storage Tanks (RWSTs) (one per unit) and the BDB Boric Acid Mixing Tanks that are stored in the BDB Storage Building. These sources are discussed in Section 2.3.10.5. Borated water may also be available from the non-credited Boric Acid Storage Tank.

Clean water sources for use in batching borated water in the Boric Acid Mixing Tanks would be used in the same order of preference provided in Table 3 for the AFW sources, dependent on availability.

2.15.3 Spent Fuel Pool (SFP)

At Surry, any water source available is acceptable for use as makeup to the SFP, however, the primary source would be from CP Settling Pond via the BDB High Capacity pump. Water quality is not a significant concern for makeup to the SFP. Likewise, boration is not a concern since boron is not being removed from the SFP when boiling.

2.16 Shutdown and Refueling Modes Analysis

Surry Power Station is abiding by the Nuclear Energy Institute position paper entitled "Shutdown/Refueling Modes," dated September 18, 2013, addressing FLEX mitigation strategies in shutdown and refueling modes (Reference 21). This position paper has been endorsed by the NRC staff (Reference 22).

The reactor core cooling and heat removal strategies previously discussed in Section 2.3 are effective as long as the Reactor Coolant System (RCS) is intact and the steam generators (SGs) are available for use. The window between the loss of natural circulation availability (i.e., the SGs are isolated) and when the refueling cavity is flooded (at approximately 50-100 hours), is considered in the core cooling strategy development for the Cold Shutdown and Refueling Shutdown modes. During this window the reactor coolant loops are isolated and the RCS is vented with the removal of at least one Pressurizer Safety Valve (PSV).

Should an ELAP occur in this window, the immediate response to a loss of shutdown cooling is to dispatch an operator to initiate gravity feed to the RCS cold legs from the outage unit's Refueling Water Storage Tank (RWST). This gravity feed injection path utilizes MOVs in the Safety Injection (SI) system that can be manually operated to initiate RCS injection by gravity feed. The SI system is seismically qualified and located in missile protected facilities; therefore, providing assurance it would survive a BDB event and be available to support gravity feed from the RWST.

Unit shutdown procedures require the pre-deployment of a BDB AFW pump with supply and discharge hoses to serve as a low pressure RCS Injection pump, which provides a means to establish forced feed of borated water to the RCS cold legs from the RWST during an ELAP event with a unit in either the Cold Shutdown or Refueling Shutdown mode. When forced RCS injection is established by the BDB AFW pump, gravity feed to the RCS cold legs is no longer necessary.

The RWST is not protected from all of the five hazards discussed in Section 2.6 (i.e. tornado missiles). In the unlikely event that a tornado missile damages the RWST, procedures direct the operators to use the opposite unit's RWST. If both RWSTs are damaged the procedures direct injection of available clean secondary side water sources in the order specified in Table 3, with the exception of the brackish Discharge Canal. In this case, the flowrate is reduced to match the boil-off rate of the RCS to minimize dilution of the RCS when adding unborated water. The water supply from Emergency Condensate Storage Tank (ECST) would be available following a tornado event, thus providing a method for restoring core cooling for all hazards during the Cold Shutdown and Refueling Shutdown modes.

If an ELAP event results in a loss of RHR, the Operations staff is directed to establish "Containment Closure." This activity directs the evacuation of the containment and the closure of all open containment penetrations including the personnel access hatch and the equipment access hatch. Directions are also provided to secure Containment Purge ventilation. The Cold Shutdown and Refueling Shutdown core cooling strategy causes water/steam to "spill" into Containment causing the Containment pressure to slowly increase. In order to maintain the Containment within its design pressure limits, a vent path is necessary and is procedurally established following an ELAP event while in either the Cold Shutdown or Refueling Shutdown mode.

With the Containment Purge system operating (or aligned to operate), a Containment vent path can be manually established through the Containment Equalization Valve or the vent stack. The adequacy of these vent paths for stopping containment pressurization and depressurizing the containment has been confirmed by analysis.

2.17 Sequence of Events

Table 4 presents a Sequence of Events (SOE) Timeline for an ELAP/LUHS event at Surry. Validation of each of the FLEX time sensitive actions has been completed in accordance with the FLEX Validation Process issued by NEI and includes consideration for staffing. Time to clear debris to allow equipment deployment is assumed to be 2 hours. This time is considered to be reasonable based on site reviews and the location of the BDB Storage Building. Debris removal equipment is stored inside the BDB Storage Building and is, therefore, protected from the external hazards described in Section 2.6.

2.18 Programmatic Elements

2.18.1 Overall Program Document

A Dominion nuclear fleet procedure provides a description of the Diverse and Flexible Coping Strategies (FLEX) Program for Surry, North Anna and Millstone Power Stations. The key elements of the program include:

- Maintenance of the FSGs including any impacts on the interfacing procedures (EOPs, APs, etc.)
- Maintenance and testing of BDB equipment (i.e., SFP level instrumentation, emergency communications equipment, portable BDB equipment, BDB support equipment, and BDB support vehicles)
- Portable equipment deployment routes, staging areas, and connections to existing mechanical and electrical systems
- Validation of time sensitive operator actions
- The BDB Storage Building and the National SAFER Response Center
- Hazards considerations (Flooding, Seismic, High Winds, etc.)
- Supporting evaluations, calculations and BDB drawings
- Tracking of commitments and equipment unavailability
- Staffing, Training, and Emergency Drills
- Configuration Management
- Program Maintenance

In addition, the program description references: (1) a list of the BDB FLEX basis documents that are kept up to date for facility and procedure changes, (2) a historical record of previous strategies and their bases, and (3) the bases for ongoing maintenance and testing activities for the BDB equipment.

The instructions required to implement the various elements of the FLEX Program and thereby ensure readiness in the event of a Beyond-Design-Basis External Event are contained in a nuclear fleet administrative procedure.

Existing design control procedures have been revised to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures do not adversely impact the approved FLEX strategies.

Future changes to the FLEX strategies may be made without prior NRC approval provided: 1) the revised FLEX strategies meet the requirements of NEI 12-06, and 2) an engineering basis is documented that ensures that the change in FLEX strategies continues to ensure the key safety functions (Containment, core and SFP cooling) are met.

2.18.2 Procedural Guidance

The inability to predict actual plant conditions that require the use of BDB equipment makes it impossible to provide specific procedural guidance. As such, the FLEX Support Guidelines (FSGs) provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs ensures that FLEX strategies are used only as directed for BDB external event conditions, and are not used inappropriately in lieu of existing procedures. When BDB equipment is needed to supplement EOPs or Abnormal Procedures (APs) strategies, the EOP or AP directs the entry into and exit from the appropriate FSG procedure.

FSGs have been developed in accordance with Pressurized Water Reactor Owner's Group (PWROG) guidelines. The FSGs provide instructions for implementing available, pre-planned FLEX strategies to accomplish specific tasks in the EOPs or APs. FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

Procedural Interfaces have been incorporated into 1/2-ECA-0.0, *Loss of All AC Power*, to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into the following APs to include appropriate reference to FSGs:

- 0-AP-22.02, *Malfunction of Spent Fuel Pit System*
- 1/2-AP-27.00, *Loss of Decay Heat Removal Capability*

Additionally, a new abnormal procedure, 1/2-AP-10.27, *Loss of All AC Power While on RHR*, was prepared to provide the command and control function for the ELAP while on RHR since 1/2-ECA-0.0 does not apply in this operating mode.

FSG maintenance is performed by the Station Procedures group via the Procedure Action Request in the Dominion nuclear fleet document AD-AA-100, *Technical Procedure Process Control*. In accordance with site administrative procedures, NEI 96-07, Revision 1 (Reference 23), and NEI 97-04, Revision 1 (Reference 24) are to be used to evaluate changes to current procedures, including the FSGs, to determine the need for prior NRC approval. However, per the guidance and examples provided in NEI 96-07, Revision 1, changes to procedures (EOPs, APs, or FSGs) that perform actions in response events that exceed a site's design-basis should screen out. Therefore, procedure steps which recognize the BDB ELAP/LUHS has occurred and which direct FLEX strategy actions to ensure core cooling, containment, or SFP cooling should not require prior NRC approval.

FSGs have been reviewed and validated by the involved groups to the extent necessary to ensure that implementation of the associated FLEX strategy is feasible. Specific FSG validation was accomplished via table top evaluations and walk-throughs of the guidelines when appropriate.

2.18.3 Staffing

Using the methodology of (Nuclear Energy Institute) NEI 12-01, *Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities* (Reference 25), an assessment of the capability of the Surry Power Station on-shift staff and augmented Emergency Response Organization (ERO) to respond to a BDB external event was performed. The results were provided to the NRC in a letter dated December 17, 2014 (Reference 26).

The assumptions for the NEI 12-01 Phases 1 and 2 scenario postulate that the BDB event involves a large-scale external event that results in:

A. An extended loss of AC power (ELAP)

B. An extended loss of access to ultimate heat sink (LUHS)

C. Impact on both units (all units are in operation at the time of the event)

D. Impeded access to the units by offsite responders as follows:

- 0 to 6 Hours Post Event – No site access.
- 6 to 24 Hours Post Event – Limited site access. Individuals may access the site by walking, personal vehicle, or via alternate

transportation capabilities (e.g., private resource providers or public sector support).

- 24+ Hours Post Event – Improved site access. Site access is restored to a near-normal status and/or augmented transportation resources are available to deliver equipment, supplies and large numbers of personnel.

A team of subject matter experts from Operations, Maintenance, Radiation Protection, Chemistry, Security, Emergency Preparedness, and Industry Consultants performed tabletop exercises in February and March 2014 to conduct the on-shift portion of the assessment. The participants reviewed the assumptions and applied existing procedural guidance, including applicable FLEX Support Guidelines (FSGs) for coping with a BDB external event using minimum on-shift staffing. Particular attention was given to the sequence and timing of each procedural step, its duration, and the on-shift individual performing the step to account for both the task and time motion data analyses of NEI 10-05, *Assessment of On-Shift Emergency Response Organization Staffing and Capabilities* (27). The staffing analysis concluded that there were no task overlaps for the activities that were assigned to the on-shift personnel.

The expanded ERO analysis portion of the staffing assessment concluded that sufficient personnel resources exist in the current Surry augmenting ERO to fill positions for the expanded ERO functions. Thus, the ERO resources and capabilities necessary to implement Transition Phase coping strategies performed after the end of the "no site access" 6-hour time exist in the current program.

The staffing assessments noted above were performed in conjunction with the development of procedures and guidelines that address NRC Order EA-12-049. Once the FSGs were developed, a validation assessment of the FSGs was performed using communication equipment determined to be available after the BDB external event per the staffing studies. The validation process was performed and documented in accordance with NEI Guidance (Reference 28).

2.18.4 Training

Dominion's Nuclear Training Program has been revised to assure personnel proficiency in utilizing FSGs and associated BDB equipment for the mitigation of BDB external events is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process.

Initial training has been provided and periodic training is provided to site emergency response leaders on BDB emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of the FLEX mitigation strategies for BDB external events have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigation strategy time constraints.

Care has been taken to not give undue weight (in comparison with other training requirements) to Operator training for BDB external event accident mitigation. The testing/evaluation of Operator knowledge and skills in this area has been similarly weighted.

In accordance with Section 11.6 of NEI 12-06, ANSI/ANS 3.5, *Nuclear Power Plant Simulators for use in Operator Training* (Reference 29), certification of simulator fidelity is considered to be sufficient for the initial stages of the BDB external event scenario. Full scope simulator models are not upgraded to accommodate FLEX training or drills.

Where appropriate, integrated FLEX drills are organized on a team or crew basis and conducted periodically; with all time sensitive actions to be evaluated over a period of not more than eight years. It is not required to connect/operate equipment during these drills.

2.18.5 Equipment List

The equipment stored and maintained at the Surry BDB Storage Building necessary for the implementation of the FLEX strategies in response to a BDB external event is listed in Table 1. Table 1 identifies the quantity, applicable strategy, and capacity/rating for the major BDB equipment components only, as well as various clarifying notes. Specific details regarding fittings, tools, hose lengths, consumable supplies, etc. are not provided in Table 1.

2.18.6 N+1 Equipment Requirement

NEI 12-06 invokes an N+1 requirement for the major BDB FLEX equipment that directly performs a FLEX mitigation strategy for core cooling, containment, or SFP cooling in order to assure reliability and availability of the FLEX equipment required to meet the FLEX strategies. Sufficient equipment has been purchased to address the required functions at both units on-site, plus one additional spare, i.e., an N+1 capability. Therefore, where a single resource is sized to support the required function of both units a second resource has been purchased to meet the +1 capability. The existing 50.54(hh)(2) pump is counted toward the N+1, since it meets the functional and storage requirements outlined in NEI 12-06. In addition, where multiple strategies to accomplish a function have been developed, (e.g., two separate means to repower instrumentation) the equipment associated with each strategy does not require N+1 capability.

The N+1 capability applies to the portable FLEX equipment that directly supports maintenance of the key safety functions identified in Table 3-2 of NEI 12-06. FLEX support equipment provided for mitigation of BDB external events, but not directly supporting a credited FLEX strategy, is not required to have N+1 capability. The N+1 requirement does not apply to the BDB FLEX support equipment, e.g., vehicles, and tools. However, these items are covered by a fleet administrative procedure and are subject to inventory checks, unavailability requirements, and any maintenance and testing that are needed to ensure they can perform their required functions.

In the case of hoses and cables associated with FLEX equipment required for FLEX strategies, an alternate approach to meet the N+1 capability has been selected. These hoses and cables are passive components that are stored in a protected facility. It is postulated the most probable cause for degradation/damage of these components would occur during deployment of the equipment. Therefore the +1 capability is accomplished by having sufficient hoses and cables to satisfy the N capability + 10% spares or at least 1 spare length of hose and cable. This 10% margin capability ensures that failure of any one of these passive components would not prevent the successful deployment of a FLEX strategy.

2.18.7 Equipment Maintenance and Testing

Initial Component Level Testing, consisting of Factory Acceptance Testing and Site Acceptance Testing, was conducted to ensure the portable FLEX equipment can perform its required FLEX strategy design functions. Factory Acceptance Testing verified that the portable equipment performance conformed to the manufacturers rating for the equipment as specified in the

Purchase Order. Verification of the vendor test documentation was performed as part of the receipt inspection process for each of the affected pieces of equipment and included in the applicable Vendor Technical Manuals. Site Acceptance Testing confirmed Factory Acceptance Testing to ensure portable FLEX equipment delivered to the site performed in accordance with the FLEX strategy functional design requirements.

The portable BDB equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with NEI 12-06 (Reference 3) and INPO AP 913, *Equipment Reliability Process*, (Reference 30), to verify proper function. Additional FLEX support equipment that requires maintenance and testing have Preventive Maintenance to ensure it can perform its required functions during a BDB external event.

EPRI has completed and has issued *Preventive Maintenance Basis for FLEX Equipment – Project Overview Report* (Reference 31). Preventative Maintenance Templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

The PM Templates include activities such as:

- Periodic Static Inspections – Monthly walkdown
- Fluid analysis - Annually
- Periodic operational verifications
- Periodic performance tests

Preventive maintenance (PM) procedures and test procedures are based on the templates contained within the EPRI Preventive Maintenance Basis Database, or from manufacturer provided information/recommendations when templates were not available from EPRI. The corresponding maintenance strategies were developed and documented. The performance of the PMs and test procedures are controlled through the site work order process. FLEX support equipment not falling under the scope of INPO AP 913 is maintained as necessary to ensure continued reliability. Performance verification testing of FLEX equipment is scheduled and performed as part of the Dominion PM process.

A fleet procedure was established to ensure the unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment, and SFP cooling is managed such that risk to mitigation strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 as follows:

- Portable FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is available.
- If portable equipment becomes unavailable such that the site FLEX capability (N) is not maintained, initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) within 72 hours.

Additional guidance regarding the availability of the BDB High Capacity pump is discussed in Section 2.7.

3. References

1. Letter to All Power Reactor Licensees, *Request for Information Pursuant to Title of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near Term Task Force Review of Insights from the Fukushima Daiichi Accident*, March 12, 2012, U.S. Nuclear Regulatory Commission.
2. NRC Order Number EA-12-049, *Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events*, dated March 12, 2012.
3. NEI 12-06, *Diverse and Flexible Coping Strategies (FLEX) Implementation Guide*, Revision 0, dated August 2012.
4. NRC Interim Staff Guidance JLD-ISG-2012-01, *Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events*, Revision 0, dated August 29, 2012.
5. NRC Order Number EA-12-051, *Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation*, dated March 12, 2012.
6. NEI 12-02, Revision 1, *Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation,"* Nuclear Energy Institute, August 2012.

7. NRC Interim Staff Guidance JLD-ISG-2012-03, *Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation*, Revision 0, dated August 29, 2012.
8. *Virginia Electric and Power Company's Supplement to Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049),* dated April 30, 2013 (Serial No. 12-163C).
9. Surry Power Station Technical Specifications, Section 3.6.
10. WCAP-17601, Revision 0, Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock & Wilcox NSSS Designs, August 2012.
11. WCAP-17792-P, Revision 0, *Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs.*
12. PWROG-14064-P, Revision 0, *Application of NOTRUMP Code Results for PWRs in Extended Loss of AC Power Circumstances,* September 2014.
13. *White Paper on the Response for the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of AC Power (ELAP),* Revision 0, dated February 11, 2014 (Proprietary).
14. Surry Independent Spent Fuel Storage Installation (ISFSI) Final Safety Analysis Report, Revision 19, Section 2.4
15. "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on Boron Mixing in Support of the Pressurized Water Reactor Owners Group (PWROG)," dated August 16, 2013 (ML13235A135).
16. Letter to Mr. J. Stringfellow (Westinghouse) from Mr. J. R. Davis (NRC) dated January 8, 2014 endorsing the Westinghouse Position Paper on Boron Mixing (ML13276A183).
17. Letter to Mr. J. E. Pollock (NEI) from Mr. J. R. Davis (NRC) endorsing NEI White Paper entitled "Battery Life Issue," dated September 16, 2013 (ML13241A182).
18. Surry Power Station Updated Final Safety Analysis Report (UFSAR), Revision 44.
19. *Virginia Electric and Power Company Surry Power Station Units 1 and 2 Flood Hazard Reevaluation Report in Response to March 12, 2012 Information Request Regarding Flooding Aspects of Recommendation 2.1*, dated March 11, 2015, (ML15078A291).

20. *SAFER Response Plan for Surry Power Station,* dated December 19, 2014 (Document #51-9233430-000).

21. NEI Position Paper: "Shutdown/ Refueling Modes," dated September 18, 2013 (ML13273A514).

22. Letter to Mr. J.E. Pollock (NEI) from Mr. J. R. Davis (NRC) dated September 30, 2013 endorsing NEI Shutdown/Refueling Modes Position Paper, (ML13267A382).

23. NEI Guideline 96-07, Revision 1, *Guidelines for 10CFR50.59 Implementation,* November 2000.

24. NEI Guideline 97-04, Revision 1, *Design Basis Program Guidelines,* February 2001.

25. NEI 12-01, Rev. 0, *Guidelines for Assessing Beyond Design Basis Accident Response Staffing and Communications.*

26. Letter from D. A. Heacock to the USNRC transmitting *North Anna Power Station Phase 2 Staffing Report,* dated May 7, 2014, (Serial No. 14-199).

27. NEI 10-05, Rev. 0, *Assessment of On-Shift Emergency Response Organization Staffing and Capabilities,* June 2011.

28. NEI Guidance Document "FLEX (Beyond Design Basis) Validation Process" (APC 14-17 July 18, 2014)

29. ANSI/ANS 3.5-2009, *Nuclear Power Plant Simulators for use in Operator Training.*

30. INPO AP 913, Revision 3, *Equipment Reliability Process Description,* Institute of Nuclear Power Operations, March 2011.

31. *Preventive Maintenance Basis for FLEX Equipment – Project Overview Report* (EPRI Report 3002000623), September 2013.

32. Surry LER 2011-001-00, Letter Serial No. 11-312, June 14, 2011

33. *Virginia Electric and Power Company Surry Power Station Units 1 and 2 Response to March 12, 2012 Information Request - Seismic Hazard and Screening Report (CEUS Sites) For Recommendation 2.1,* dated March 31, 2014, (ML14092A414).

Table 1 – PWR Portable Equipment Stored Onsite

List Portable Equipment	Use and (Potential / Flexibility) Diverse Uses					Performance Criteria
	Core	Containment	SFP	Instrumentation	Accessibility	
BDB High Capacity diesel-driven pump (2)[1] and associated hoses and fittings	X	X	X			150 psid at 1200 gpm
BDB AFW pump (3) and associated hoses and fittings	X					450 psid at 300 gpm
BDB RCS Injection pump (2)[2] and associated hoses and fittings	X					3000 psid at 45 gpm
120/240 VAC generators (3) and associated cables, connectors and switchgear				X		40 kW
120/240 VAC generators (8)[4] and associated cables, connectors and switchgear (to power support equipment)					X	5.5-6.5 kW

Table 1 – PWR Portable Equipment Stored Onsite						
List Portable Equipment	**Use and (Potential / Flexibility) Diverse Uses**					**Performance Criteria**
	Core	**Containment**	**SFP**	**Instrumentation**	**Accessibility**	
480 VAC generators (2)[3] and associated cables, connectors and switchgear (to re-power battery chargers, inverters, and Vital Buses)		X		X		350 kW
Portable boric acid batching tank (3)	X					1000 gal
Light plants (2) + Light strings (15)[4]					X	
Front end loader (1)[4]					X	
Tow vehicles (2)[4]	X	X	X		X	
Hose trailer (2) and Utility vehicle (1)[4]	X	X	X		X	
Fans/blowers (10)[4]					X	
Air compressors (7)[4]	X	X			X	

Table 1 – PWR Portable Equipment Stored Onsite

List Portable Equipment	Use and (Potential / Flexibility) Diverse Uses					Performance Criteria
	Core	Containment	SFP	Instrumentation	Accessibility	
Fuel transfer truck (1) with 1,100 gal. tank and pumps	X	X	X	X	X	
Fuel carts with transfer pumps (3)[4]	X	X	X	X	X	
Communications equipment (Section 2.14)	X	X	X	X	X	
Misc. debris removal equipment[4]					X	
Misc. Support Equipment[4]					X	

Table 1 – PWR Portable Equipment Stored Onsite						
List Portable Equipment	Use and (Potential / Flexibility) Diverse Uses					Performance Criteria
	Core	Containment	SFP	Instrumentation	Accessibility	

NOTES:

1. One BDB High Capacity pump is needed to implement both the FLEX core cooling and SFP cooling strategies. This pump is stored in the BDB Storage Building and protected from the hazards identified in NEI 12-06. The 50.54(hh)(2) high capacity pump is credited to meet the N+1 requirement as a backup to the BDB High Capacity pump. This pump is stored onsite in a location other than the BDB Storage Building.
2. One BDB RCS Injection pump can be shared between units if necessary. A BDB RCS Injection pump from the NSRC is deployed from the NSRC by 28 hours, if required, to replace an unavailable onsite BDB RCS Injection pump.
3. 120/240 VAC generators are an alternate strategy to the 480 VAC generators. Therefore, only N is required.
4. Support equipment. Not required to meet N+1.

Table 2 – PWR Portable Phase 3 FLEX Equipment From NSRC

List Portable Equipment	Quantity Req'd /Unit	Quantity Provided / Unit	Power	Use and (Potential / Flexibility) Diverse Uses					Performance Criteria		Notes
				Core Cooling	Cont. Cooling/ Integrity	Access	Instrumentation	RCS Inventory			
Medium Voltage Generators	2	2	Jet Turb.	X	X		X		4160 VAC	1 MW	(1)
Low Voltage Generators	0	1	Jet Turb.		X		X	X	480 VAC	1100 KW	(2)
High Pressure Injection pump	0	1	Diesel					X	3000 psig	60 GPM	(2)
S/G RPV Makeup pump	0	1	Diesel	X				X	500 psid	500 GPM	(2)
Low Pressure / Medium Flow pump	0	1	Diesel		X	X			300 psid	2500 GPM	(2)

Table 2 – PWR Portable Phase 3 FLEX Equipment From NSRC

List Portable Equipment	Quantity Req'd /Unit	Quantity Provided / Unit	Power	Use and (Potential / Flexibility) Diverse Uses					Performance Criteria		Notes
				Core Cooling	Cont. Cooling/ Integrity	Access	Instrumentation	RCS Inventory			
Low Pressure / High Flow pump	1	1	Diesel	X	X				150 psid	5000 GPM	(3)
Lighting Towers	0	1	Diesel			X				40,000 Lu	(4)
Diesel Fuel Transfer	0	As Requested	N/A	X	X	X	X	X		264 Gal	(2)
Mobile Water Treatment	0	2	Diesel	X				X		150 GPM	(2)
Mobile Boration Skid	0	1	N/A					X		1000 Gal	(2)

Notes:

(1) - NSRC 4160 VAC generator supplied in support of Phase 3 for core cooling, containment cooling, and instrumentation FLEX strategies.

(2) - NSRC Generic Equipment – Not required for FLEX strategy – Provided as Defense-in-Depth.

(3) - NSRC Low Pressure/High Flow pump supplied in support of Phase 3 for core cooling and containment cooling FLEX strategies.

(4) - NSRC components provided for low light response plans.

Table 3 – Onsite Water Sources

Water Sources and Associated Piping that Fully Meet All BDB Hazards and Are Credited in FLEX Strategies

Water Sources	Usable Volume (Gallons)	Applicable Hazard					Time Based on Decay Heat[1]	Cumulative Time Based on Decay Heat[1]
		Satisfies Seismic	Satisfies Flooding	Satisfies High Winds	Satisfies Low Temp	Satisfies High Temp		
ECST (Phase 1)	96,000	Y	Y	Y	Y	Y	5.1 hours	5.1 hours
ECMT (Phase 1)	72,000	Y	Y	Y	Y	Y	9.1 hours	14.2 hours
Discharge Canal[2] (Phase 2 & Phase 3)	Essentially Indefinite	Y	Y	Y	Y	Y	N/A	N/A

Table 3 – Onsite Water Sources

Water Sources	Usable Volume (Gallons)	Applicable Hazard					Time Based on Decay Heat[1]	Cumulative Time Based on Decay Heat[1]
		Satisfies Seismic	Satisfies Flooding	Satisfies High Winds	Satisfies Low Temp	Satisfies High Temp		
Water Sources that Partially Meet BDB Hazards and Are Not Credited in FLEX Strategies.								
CST (2)	300,000 ea	N	Y	N	Y	Y	43.5 hours[3]	N/A
FP tanks (2)	300,000 ea	N	Y	N	Y	Y	43.5 hours[3]	N/A
PG tanks (2)	185,000 ea	N	Y	N	Y	Y	26.8 hours[3]	N/A
DST	322,000	N	Y	N	Y	Y	23.4 hours[3]	N/A
Condenser (2)	71,000 ea	Y	N	Y	Y	Y	10.3 hours[3]	N/A
Gravel Neck Tank	4,000,000	N	Y	N[4]	Y	Y	12.1 days[3]	N/A
Settling Pond	3,600,000	N	N	N	N	Y	10.9 days[3]	N/A
RWST (2)	370,000 ea	Y	Y	N	Y	Y	53.7 hours[3]	N/A

Footnotes:

1. Includes cooldown to a SG pressure of 300 psig beginning at 2 hours..
2. Water from the Discharge Canal is to be used as a makeup source for AFW and/or SFP only as a last resort.
3. Per unit times are based on a constant 114.9 gpm estimated usage. (Required flow rate at the end of the ECST and ECMT usage, i.e., 14.2 hours.)
4. The Gravel Neck tank is not rated for tornado missile protection. However, it likely would survive a tornado event at Surry Power Station due to separation distance (approx. 2500 ft Southeast of Surry).

Table 4 – Sequence of Events Timeline

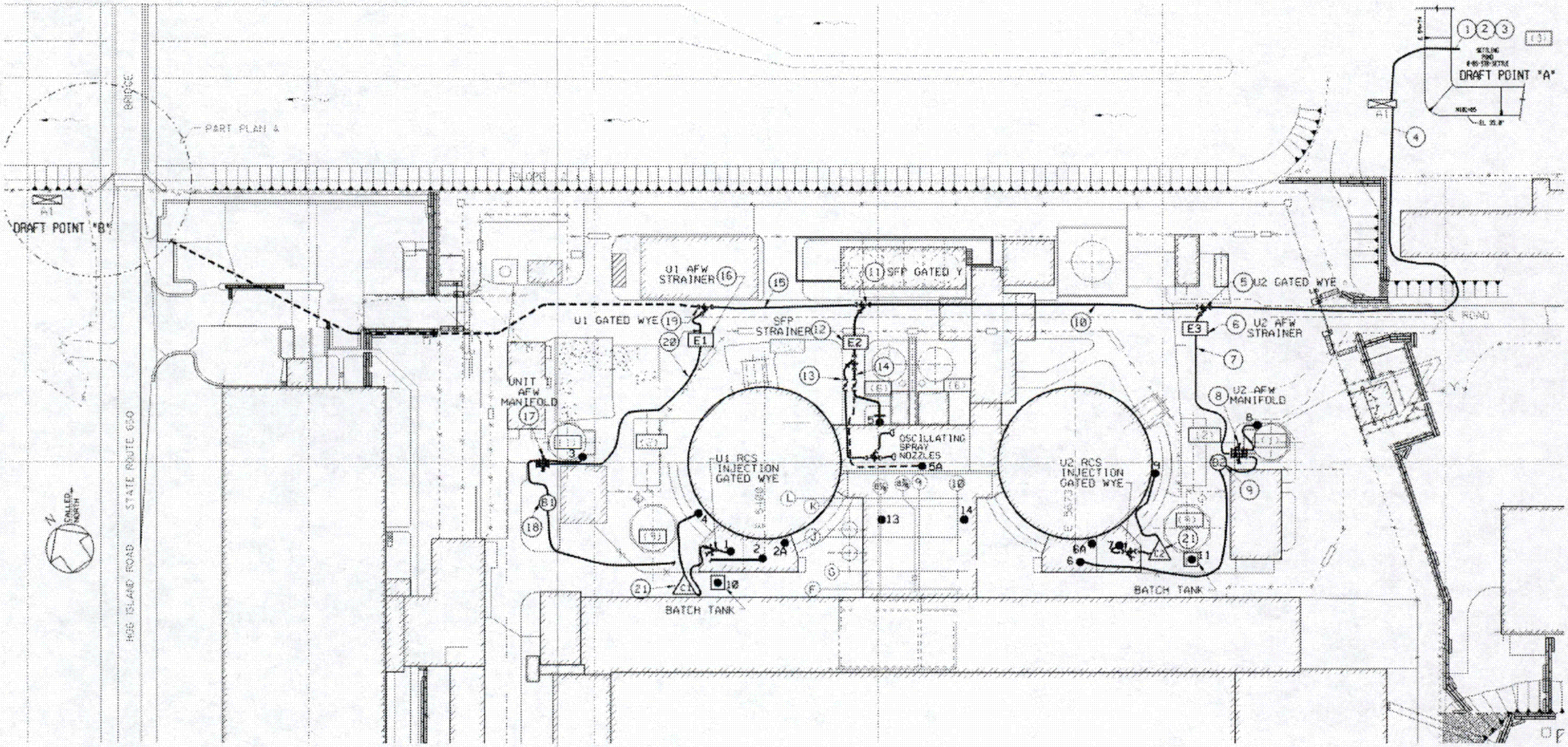
Action Item	Personnel	Activity	Start	Duration	Time Constraint Y/N	Requirement
		Event Starts	0		N	Plant @ 100% power
1	RO – U1 RO – U2	TDAFW pump starts. Verify Flow	15 sec.	1 min.	N	Original design basis for SBO event. 60 min to S/G dryout.
2	RO – U1 RO – U2	Loss of All Power Procedure is entered	15 sec.		N	SBO event required response.
3	RO – U1 RO – U2	Verify RCS/Containment Isolation	15 min.	5 min.	N	Preserve inventory in the RCS.
4	AO #2 AO #3	Throttle AFW flow to S/G's	20 min.	10 min.	Y	90 min to S/G overfill.
5	SRO	ELAP declared	≤ 45 min.		Y	
6	AO #3 RO #4	Load strip 120 volt DC and Vital AC buses.	≤ 45 min.	≤ 30 min	Y	75 min (extends emergency battery capacity to 14 hours).
7	AO #4 AO #5	Break Cond. Vacuum and Vent H2	90 min.	30 min.	Y	Safety – Prevent fire in Main Generator.

Action Item	Personnel	Activity	Start	Duration	Time Constraint Y/N	Requirement
8	AO #2 AO #3	Align Valves to ECMT	90 min.	30 min.	Y	5.1 Hrs. (Prior to Minimum ECST level)
9	RO – U1 RO – U2	Initiate RCS Cooldown	< 2 hrs.	~ 2 hrs.	Y	Decay heat removal, Cooldown of RCS. Initiation within 2 hrs meets the requirements of Generic ELAP analysis.
10	FBM #2 FBM #3	Clear Haul Path for transport of BDB Equipment.	2 hrs.	2 hrs.	Y	14 hrs. (Battery depletion)
11	FBM #2 FBM #3	Transport 120 VAC generators to repower lighting panels.	4 hrs.	2 hrs.	Y	Power for supplemental ventilation in Battery Rooms and App "R" lights batteries depleted in 8 hours. Repower limited lighting in MCR and ESGR (Note Flashlights and Head lamps are available to supplement.)
12	Augmented Staff	Arrive on Site	6 hrs.	On-going	N	Per NEI 12-06

Action Item	Personnel	Activity	Start	Duration	Time Constraint Y/N	Requirement
13	AO #6 AO #7 Aug. Staff	Transport and deploy 480 VAC Generators	6 hrs.	2 hrs.	Y	14 hrs. (Battery depletion)
14	3 people – (Aug. Staff)	Transport and Deploy BDB High Capacity Pump to Settling Pond (Drafting). For AFW suction source	8 hrs.	2 hrs.	Y	14.2 hours of AFW suction ECST + ECMT Volume Depleted.
15	4 people – (Aug. Staff)	Transport and deploy Communication equipment	10 hrs.	2 hrs.	N	Off-site communications
16	Aug. Staff	ECST Make-up	10 hrs.	4 hrs.	N	Provide Higher quality water for Steam Generator make-up
17	3 people – (Aug. Staff)	Transport and deploy BDB RCS Injection pump	12 hrs.	3 hrs.	Y	16.0 hours – Prior to reflux boiling (at 17 hours) and ensure adequate boron mixing (1 hour). Reactivity control: Not required for the first 37 hours if SG pressure >290 psig.

Action Item	Personnel	Activity	Start	Duration	Time Constraint Y/N	Requirement
18	3 people – (Aug. Staff)	Deploy BDB AFW Pumps	15 hrs.	5 hrs.	N	BDB AFW Pumps are deployed in STBY as a backup to the TDAFW pump
19	3 people – (Aug. Staff)	Route BDB High Capacity Pump (Drafting) hose and add inventory to SFP	20 hrs.	4 hrs. On-going (Batch)	Y	12 hours to boiling / 51 hours to water level at 10 feet above fuel.
20	Aug. Staff	Transport and deploy additional portable light plants as needed (supplemental lighting)	24 hrs.	2 hrs.	N	Supplemental lighting as needed. (lighting towers are installed on large portable BDB equipment.)
21	Aug. Staff	Initiate containment cooling strategy to reduce containment temperature	26 hrs.	24 hrs	N	Restore containment temperature to <120 deg. F within 7 days to protect key parameter instrumentation.

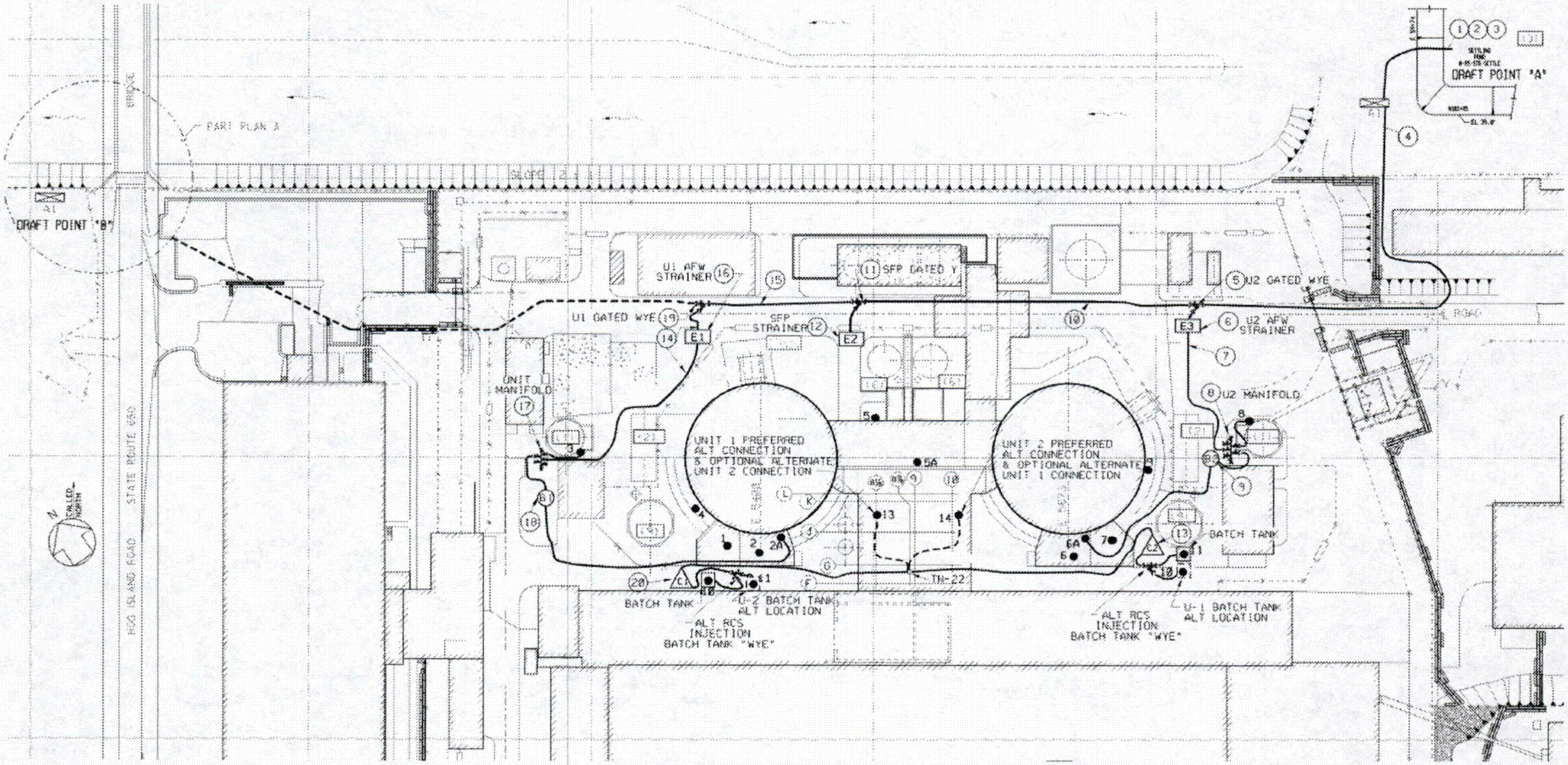
RO - Reactor Operator, **AO** - Auxiliary Operator, **FBM** – Fire Brigade Member



(Primary Strategy Layout)

Figure 1: Surry BDB FLEX Strategy Equipment and Hose Layout

(Page 1 of 3)



(Alternate Strategy Layout)

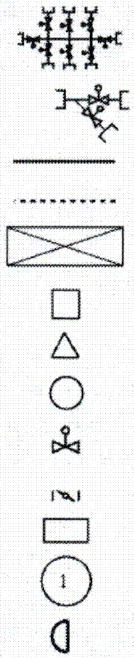
Figure 1: Surry BDB FLEX Strategy Equipment and Hose Layout

(Page 2 of 3)

LEGEND

1- RWST REFILL/SUCTION CONNECTION (U-1)
2- PRIM AFW TO AFW PUMP DISCHARGE HEADER (U-1)
2A- ALT.S/G FEED (U-1)
3- ECST REFILL (U-1)
4- LHSI INJECTION (U-1)
5- SFP REFILL
5A- ALT. SFP FILL
6- PRIM AFW TO AFW PUMP DISCHARGE HEADER (U-2)
6A- ALT. S/G FEED (U-2)
7- RWST REFILL/SUCTION CONNECTION (U-2)
8- ECST REFILL (U-2)
9- LHSI INJECTION (U-2)
10- PORTABLE BATCH TANK (U-1)
11- PORTABLE BATCH TANK (U-2)
12- U-1 ALT AFW PUMP SUCTION
13- U-1 ALT RCS PUMP DISCHARGE
14- U-2 ALT RCS PUMP DISCHARGE
A1- U-1 & U-2 BDB HIGH CAPACITY PUMP
B1- U-1 BDB AFW PUMP
B2- U-2 BDB AFW PUMP
C1- U-1 BDB RCS INJECTION PUMP
C2- U-2 BDB RCS INJECTION PUMP
E-1 U-1 BDB AFW STRAINER
E-2 SFP STRAINER
E-3 U-2 BDB AFW STRAINER

SYMBOLS



U1 & U2 AWF MANIFOLD
WYE - CONNECTION
ABOVE GROUND HOSE LAY
ALT. ABOVE GROUND HOSE LAY
BDB HIGH CAPACITY PUMP
PORTABLE BATCH TANK
BDB RCS INJECTION PUMP
BDB AFW PUMP
BALL VALVE
BUTTERFLY VALVE
STRAINER
BILL OF MATERIAL ITEM
OSCILLATING SPRAY NOZZLE

WATER SOURCES

(1)	U1/U2 EMERGENCY CONDENSATE STORAGE TANK (ECST) 1-CN-TK-1, 2-CN-TK-1
(2)	U1/U2 EMERGENCY CONDENSATE MAKEUP TANK (ECMT) 1-CN-TK-3, 2-CN-TK-3
(3)	CONDENSATE POLISHING SETTLING POND DRAFT POINT "A"
(4)	U1/U2 CONDENSATE TANKS (CST) 1-CN-TK-2, 2-CN-TK-2
(5)	U1/U2 CONDENSER HOTWELL
(6)	PRIMARY GRADE WATER TANKS (PG TANKS) 1-PG-TK-1A, 2-PG-TK-1B
(7)	FIRE PROTECTION WATER STORAGE TANKS (FP TANKS) 1-FP-TK-1A, 1-FP-TK-1B
(8)	DISTILLANT STORAGE TANK (DST) 2-WT-TK-101
(9)	REFUELING WATER STORAGE TANK (RWST) 1-CS-TK-1, 2-CS-TK-1
(10)	GRAVEL NECK (NOT SHOWN ½ MILE SE OF SPS)
(11)	DISCHARGE CANAL DRAFT POINT "B"

Figure 1: Surry BDB FLEX Strategy Equipment and Hose Layout

(Page 3 of 3)

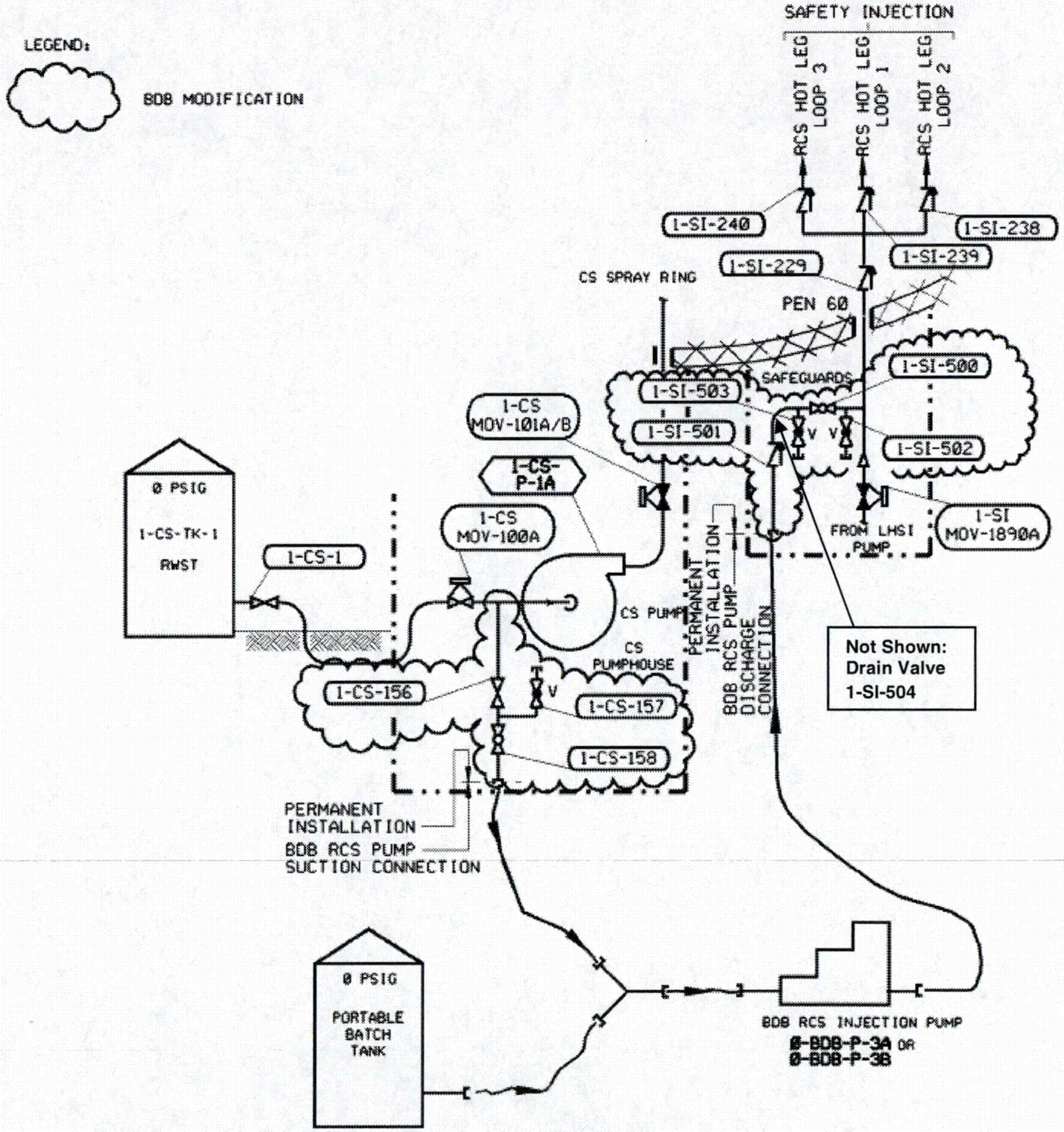


Figure 2: RCS Makeup Primary Mechanical Connection
Surry Unit 1

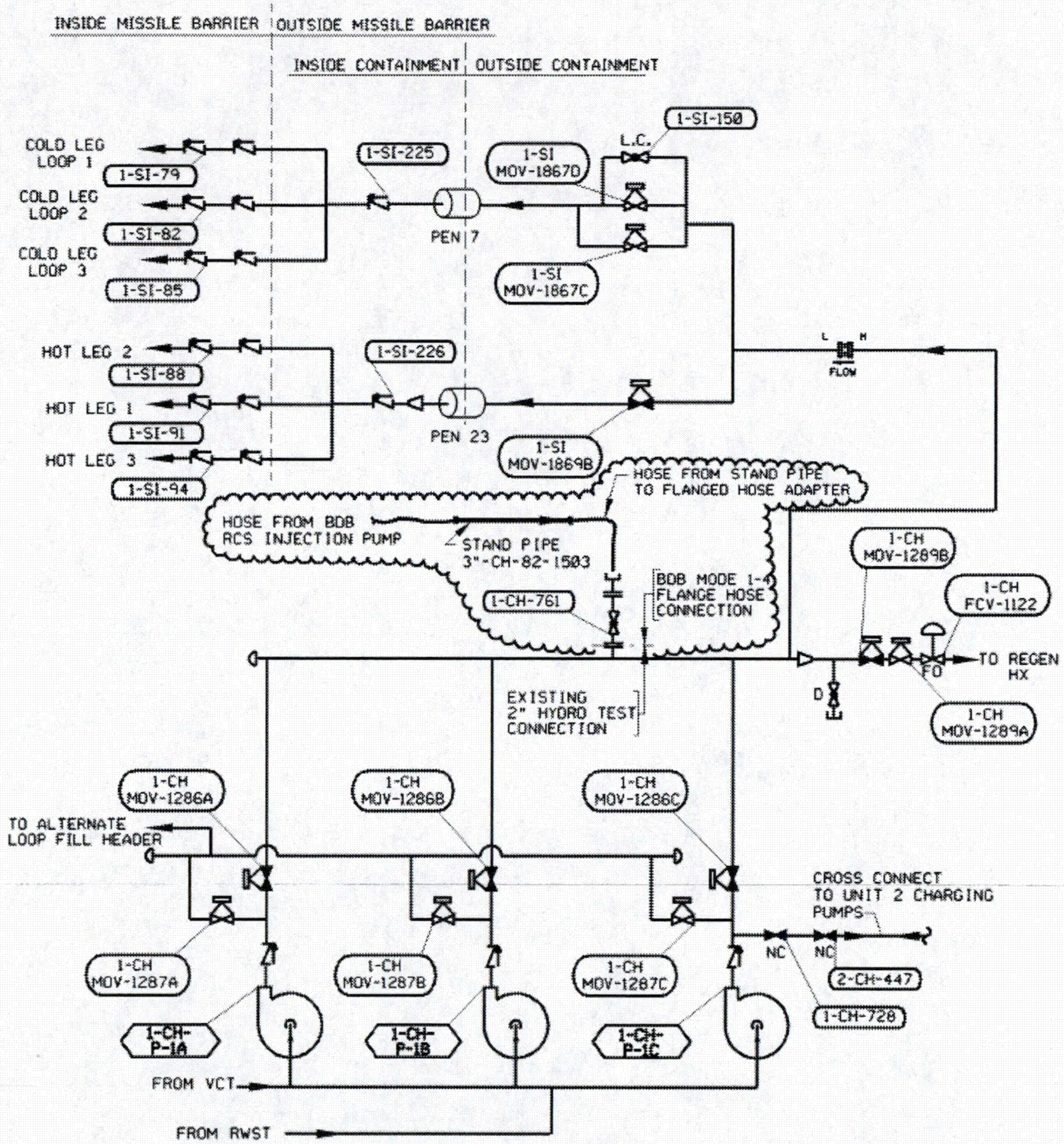


Figure 3: RCS Makeup Alternate Mechanical Connection
Surry Unit 1

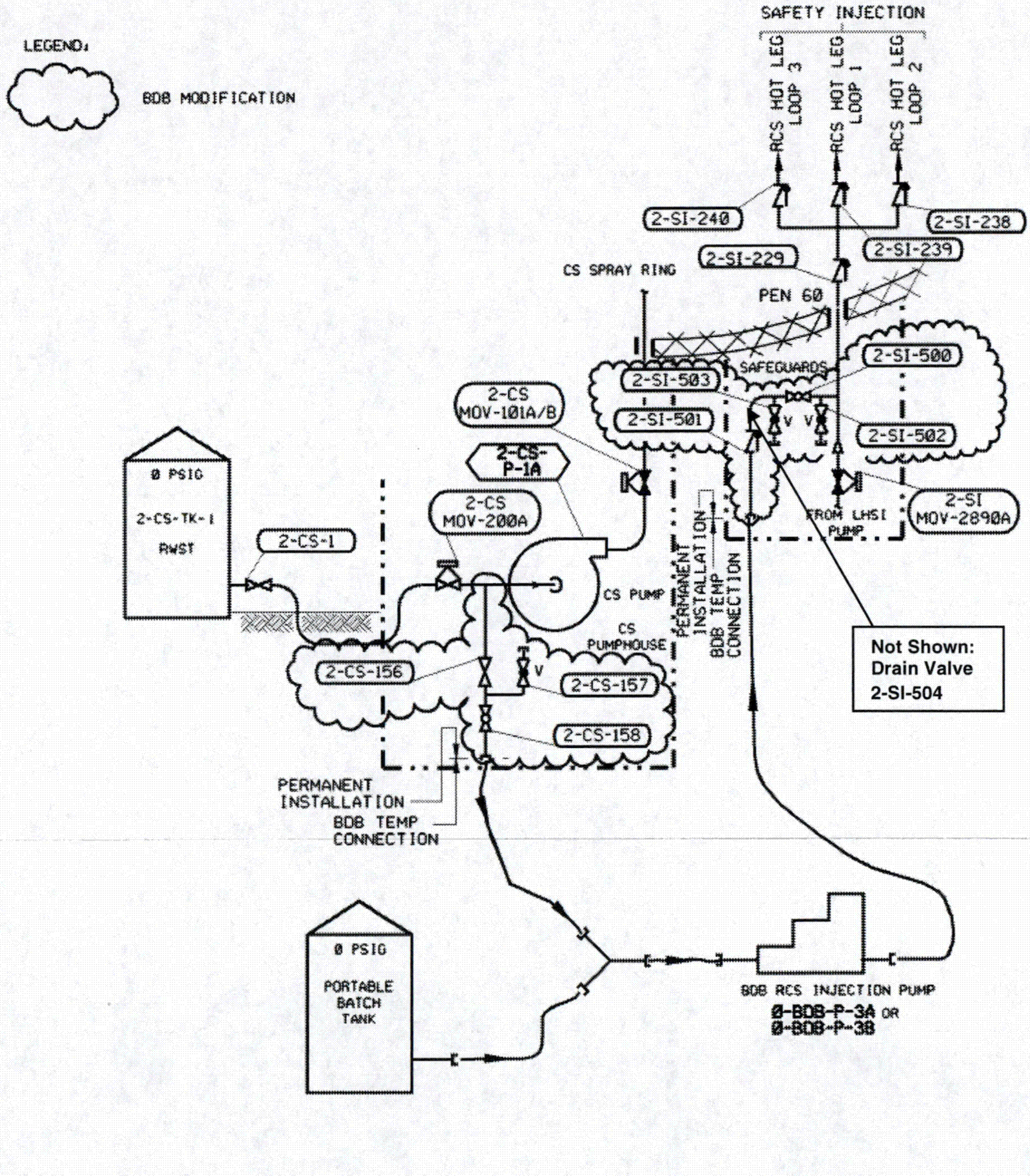


Figure 4: RCS Makeup Primary Mechanical Connection
Surry Unit 2

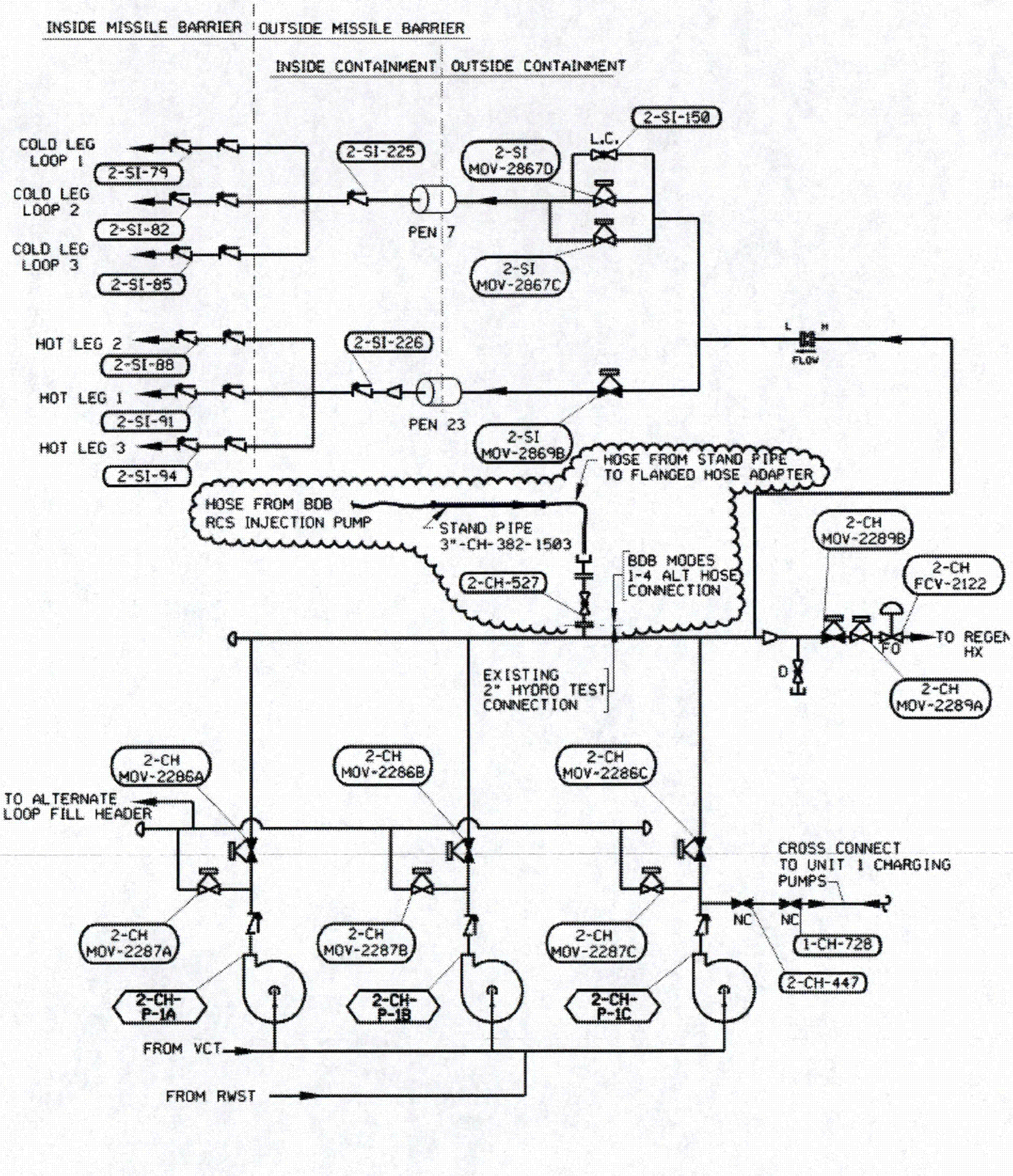


Figure 5: RCS Makeup Alternate Mechanical Connection Surry Unit 2

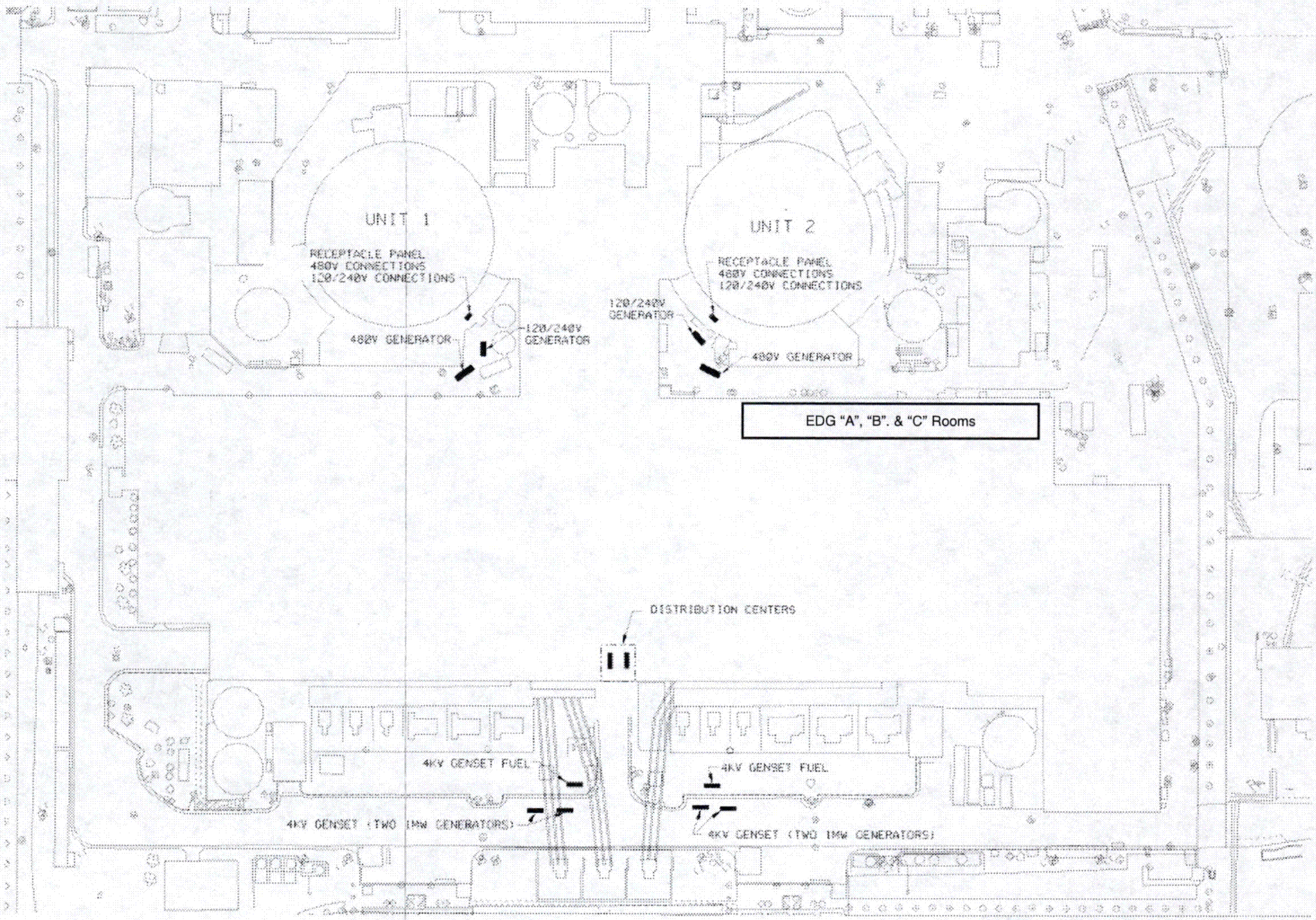


Figure 6: Surry BDB Electrical Connection 120 VAC, 480 VAC, & 4160 VAC General Layout

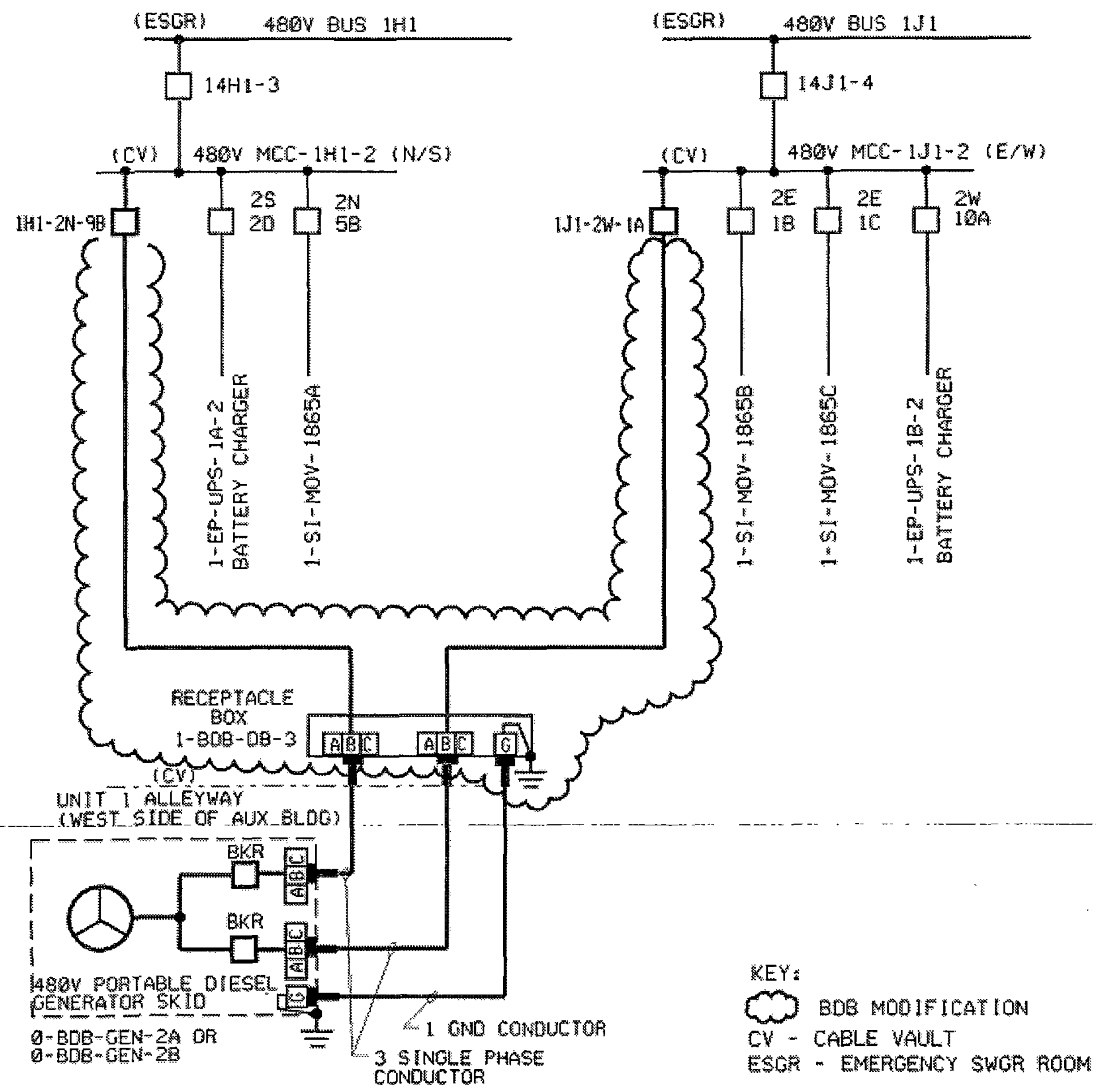


Figure 7: 480 VAC Portable Generator (BDB) Electrical Connection Panel
Surry Unit 1

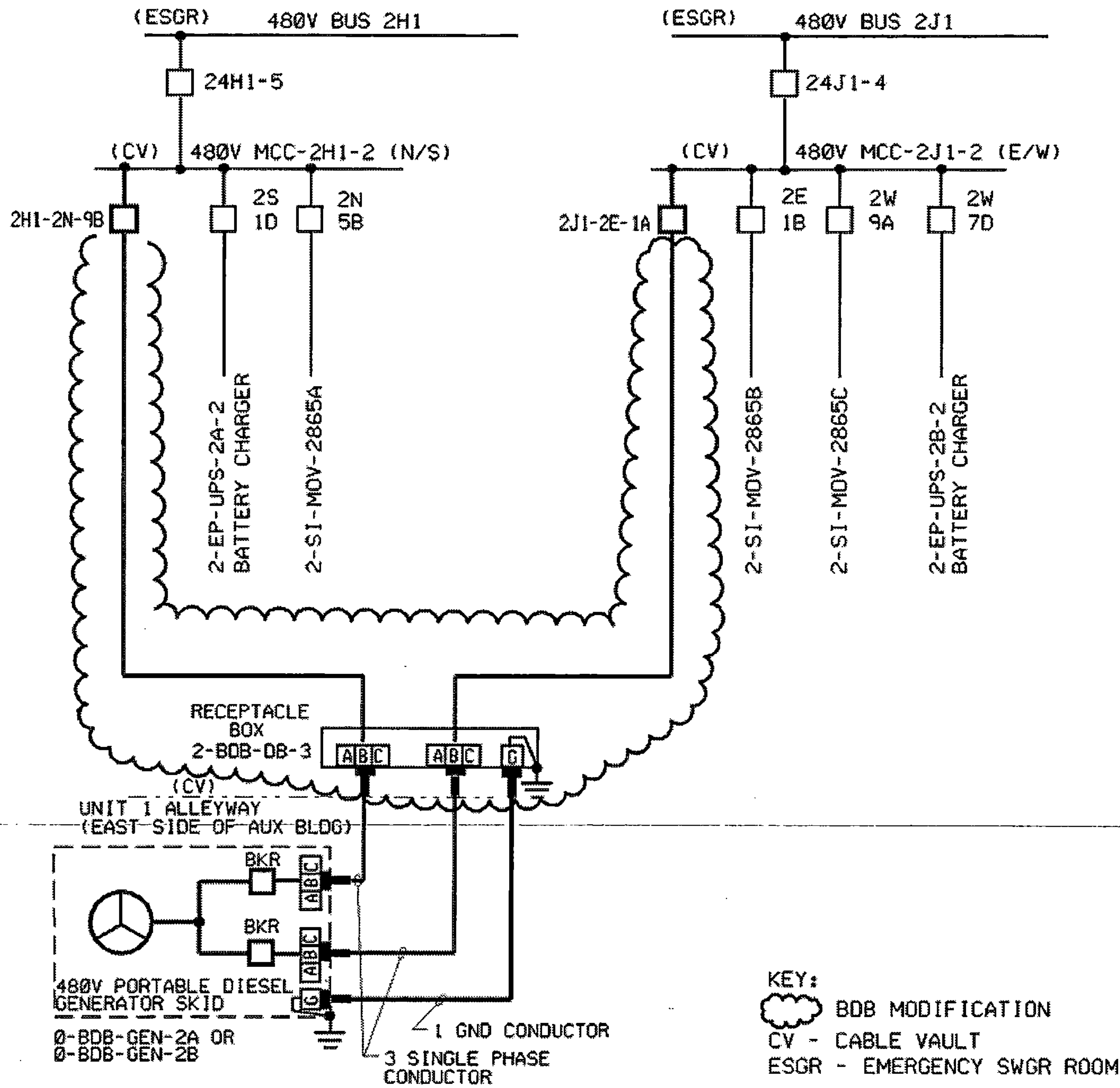
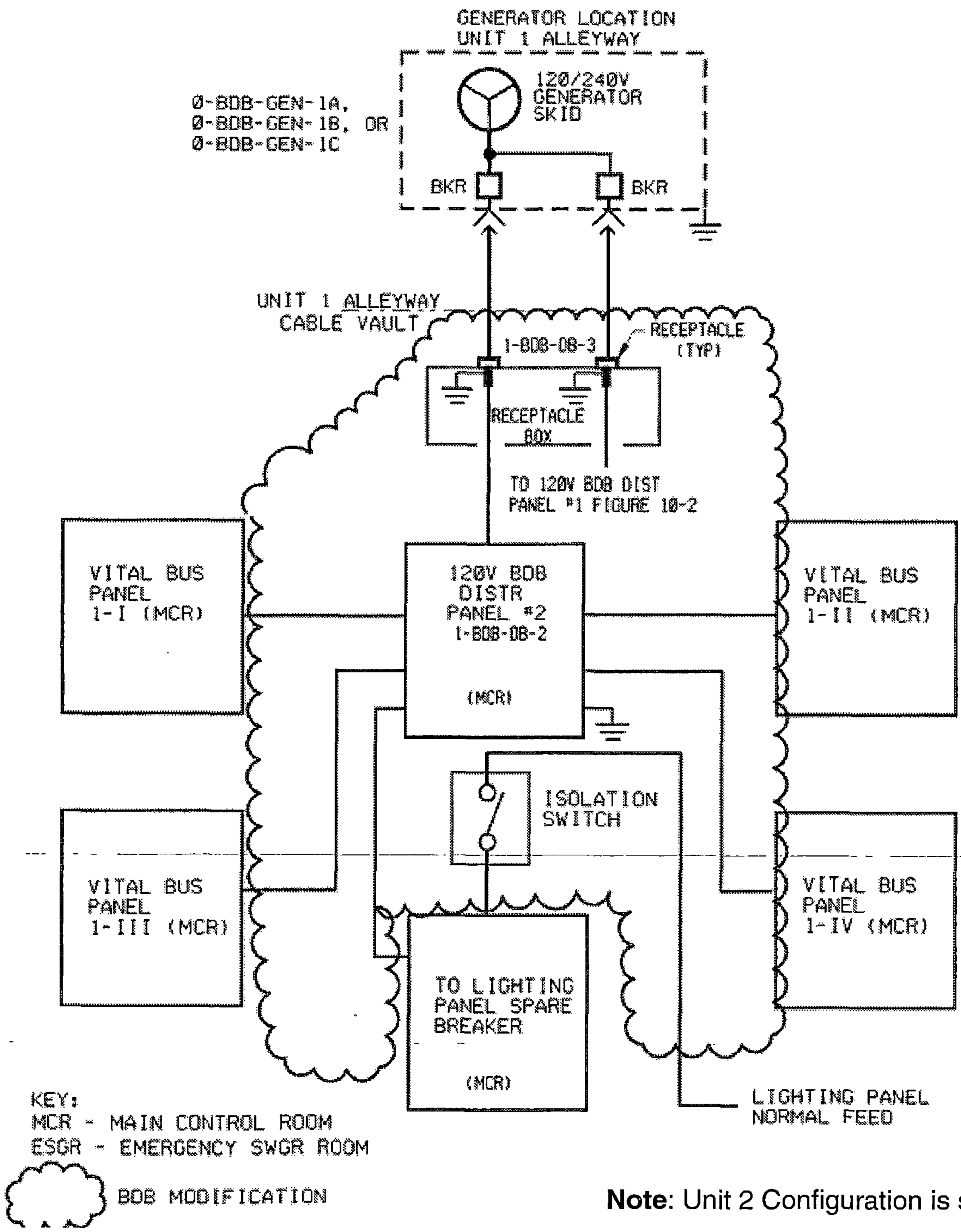
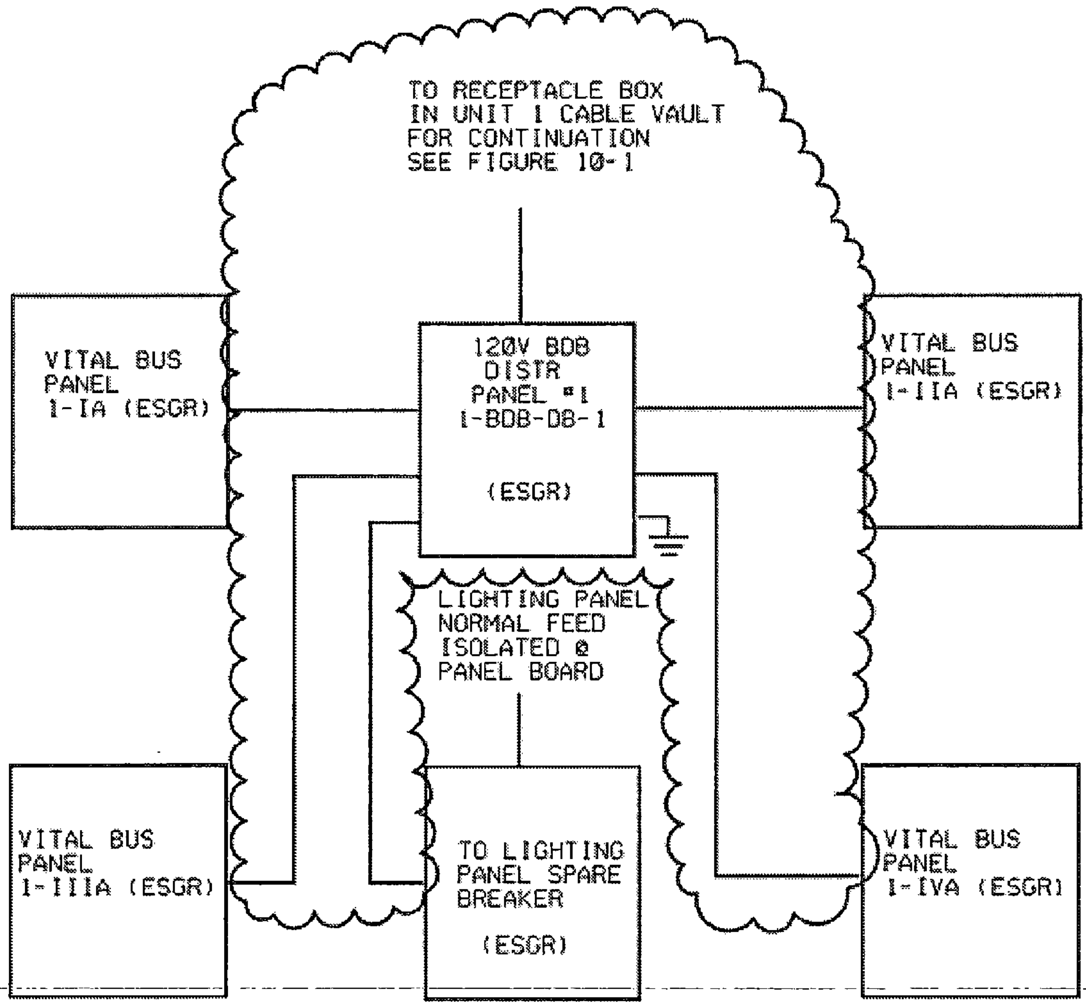


Figure 8: 480 VAC Portable Generator (BDB) Electrical Connection Panel
Surry Unit 2



Note: Unit 2 Configuration is similar.

Figure 9: 120/240 VAC Portable Generator (BDB) Electrical Connections
Panel #2 – Surry Unit 1



KEY:
MCR - MAIN CONTROL ROOM
ESGR - EMERGENCY SWGR ROOM
BDB MODIFICATION

Note: Unit 2 Configuration is similar.

Figure 10: 120/240 VAC Portable Generator (BDB) Electrical Connections Panel #1 – Surry Unit 1

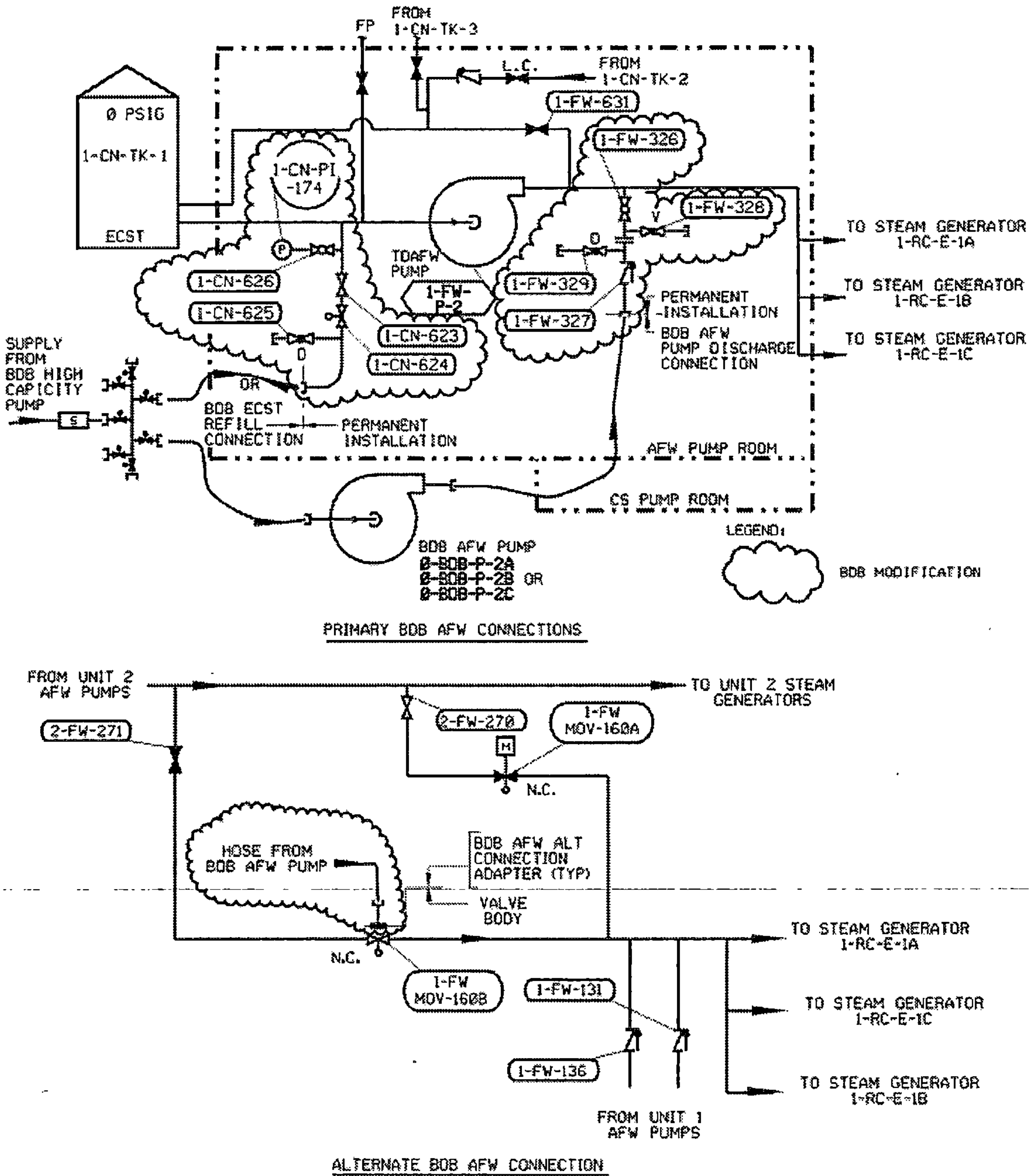
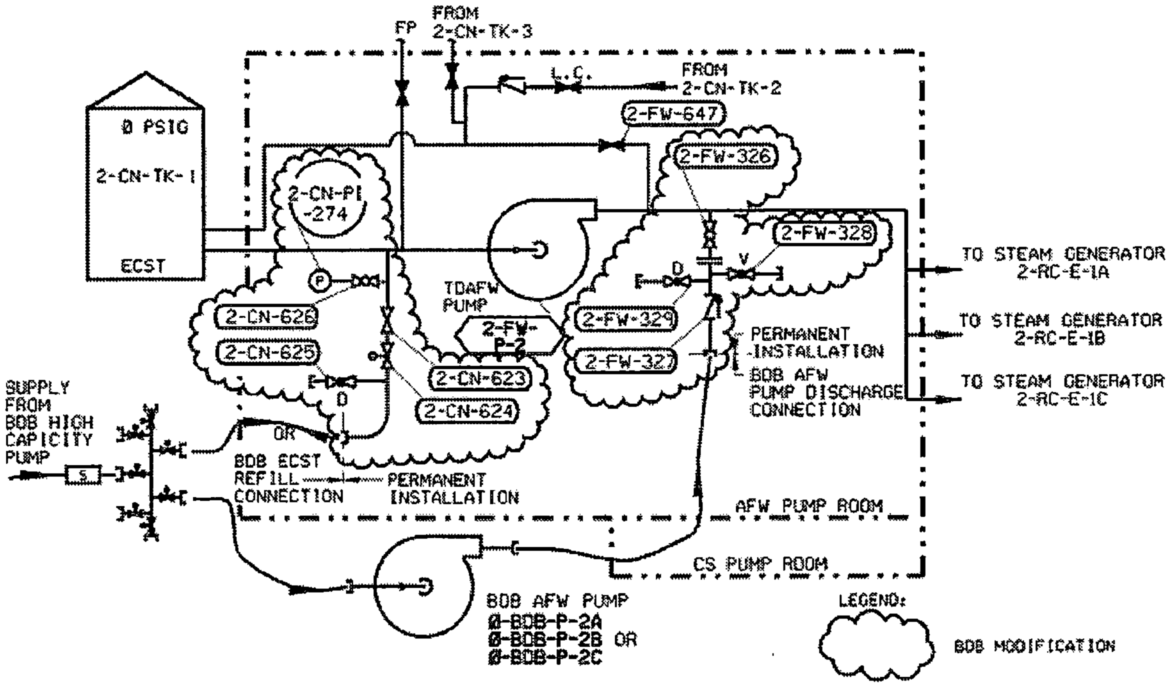
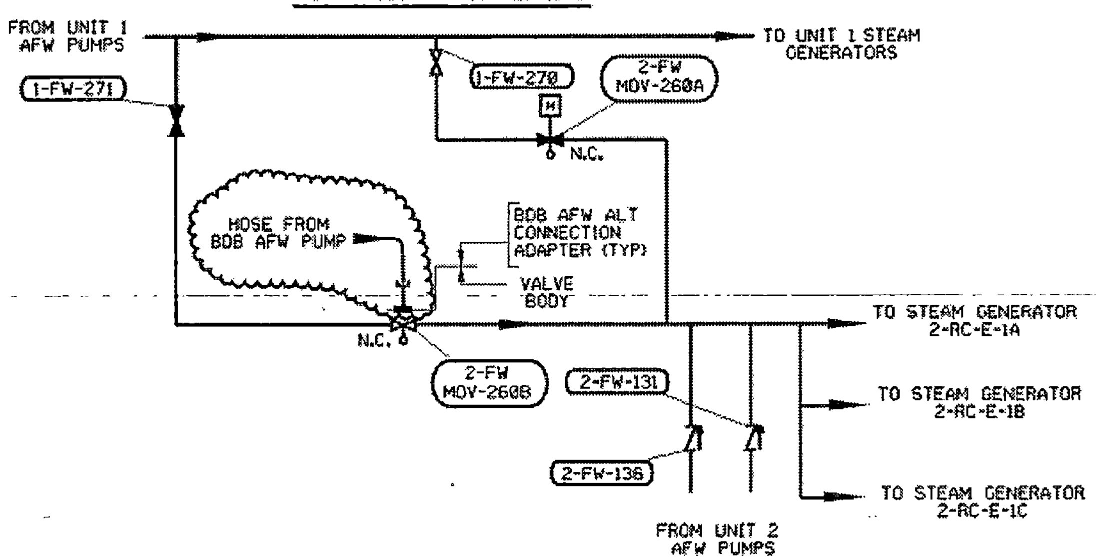


Figure 11: Core Cooling and Decay Heat Removal AFW Primary and Alternate Mechanical Connections – Surry Unit 1



PRIMARY BDB AFW CONNECTIONS



ALTERNATE BDB AFW CONNECTION

Figure 12: Core Cooling and Decay Heat Removal AFW Primary and Alternate Mechanical Connections – Surry Unit 2

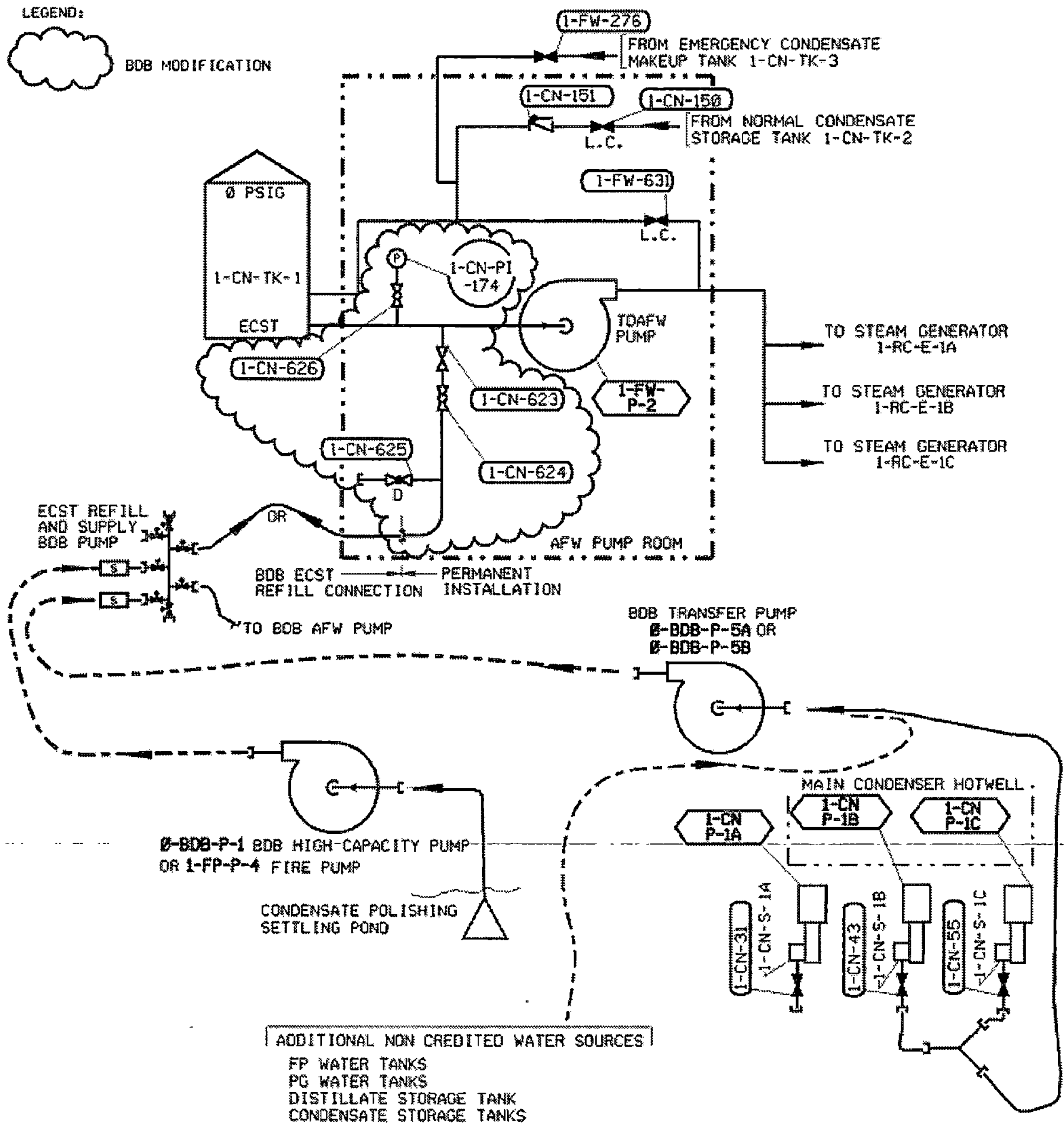


Figure 13: ECST Refill Mechanical Connections, Paths, and Sources
Surry Unit 1

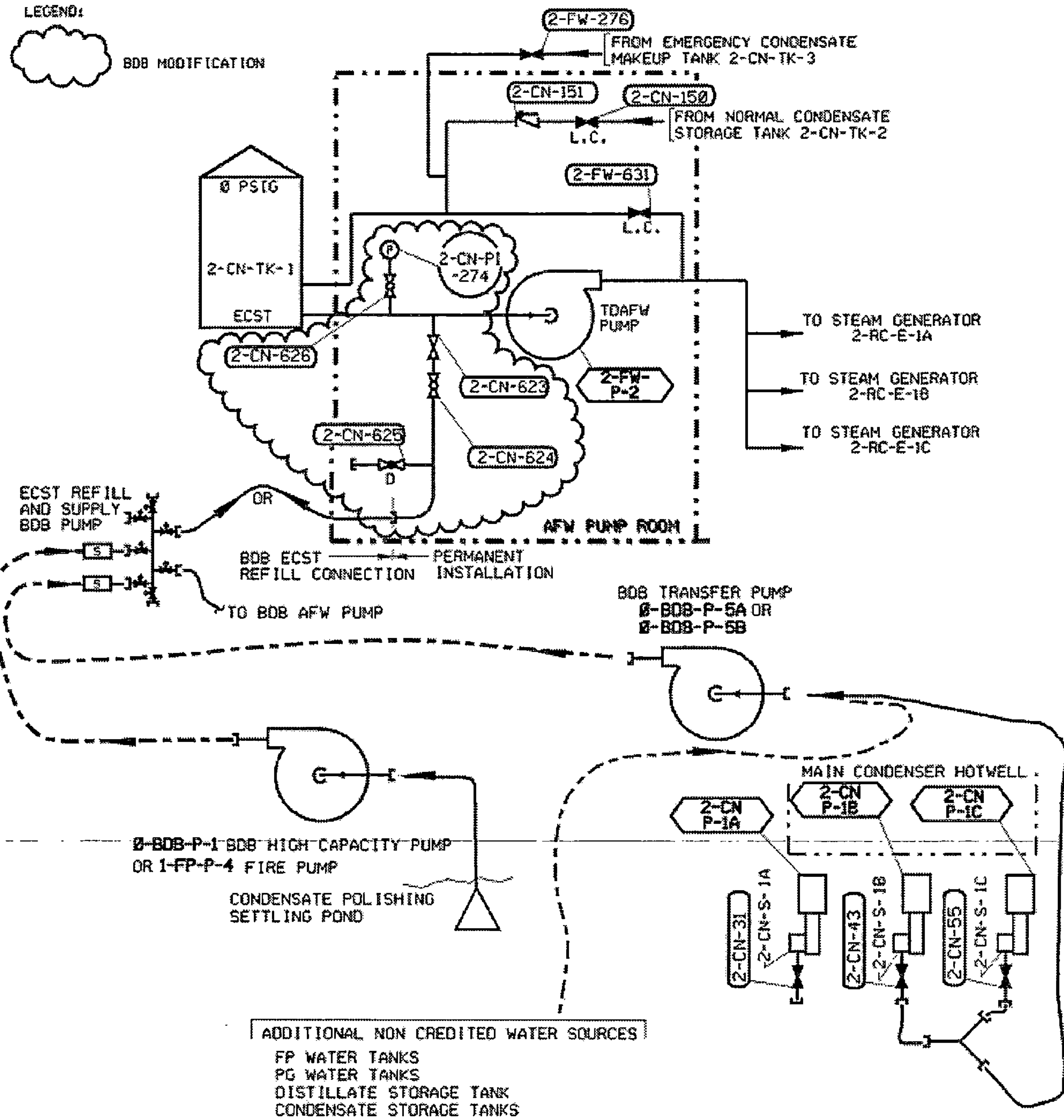


Figure 14: ECST Refill Mechanical Connections, Paths, and Sources
Surry Unit 2

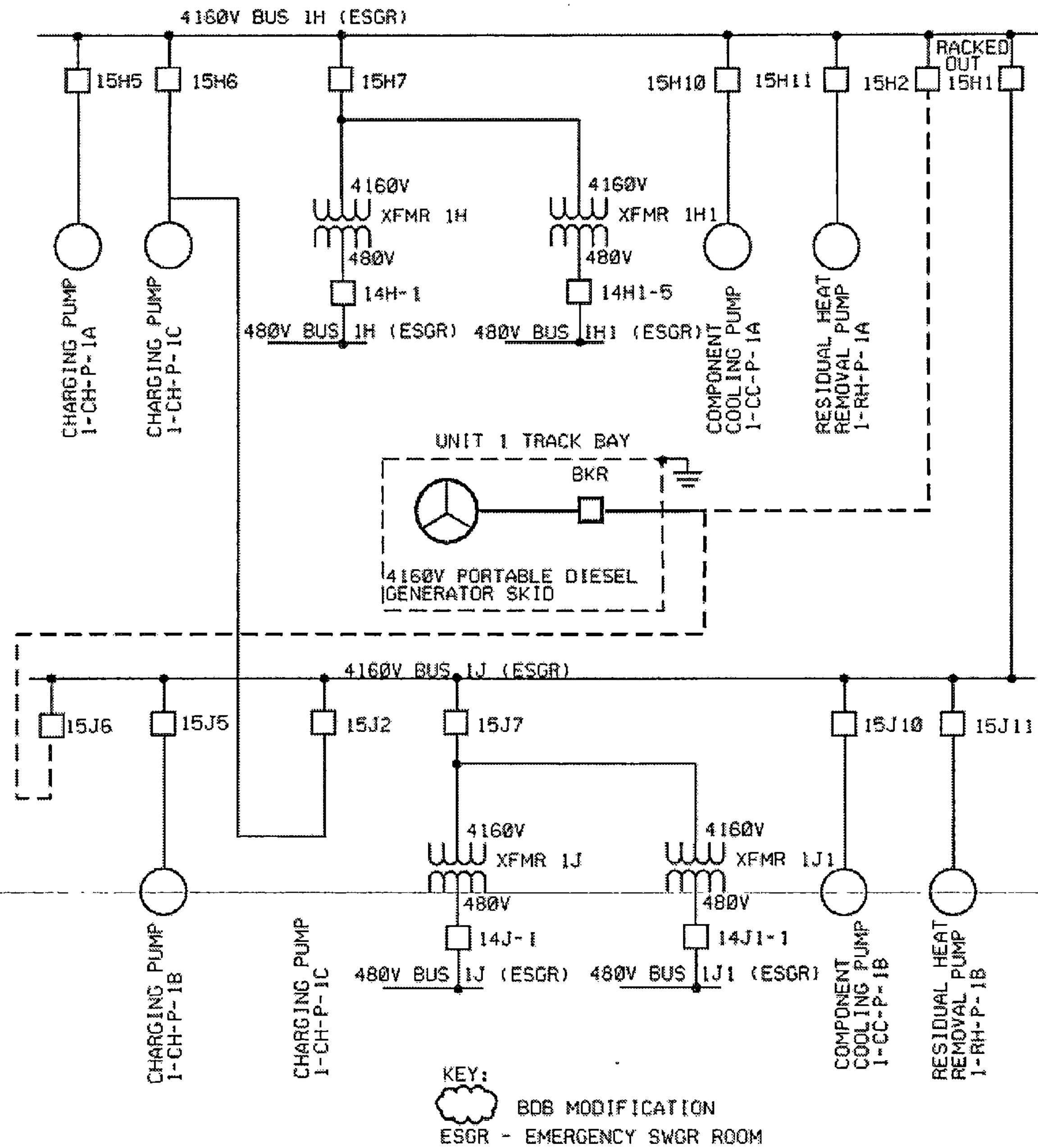


Figure 15: 4160 VAC Generator (NSRC) Electrical Connections to 4160 VAC MCC 1H and/or 1J – Surry Unit 1

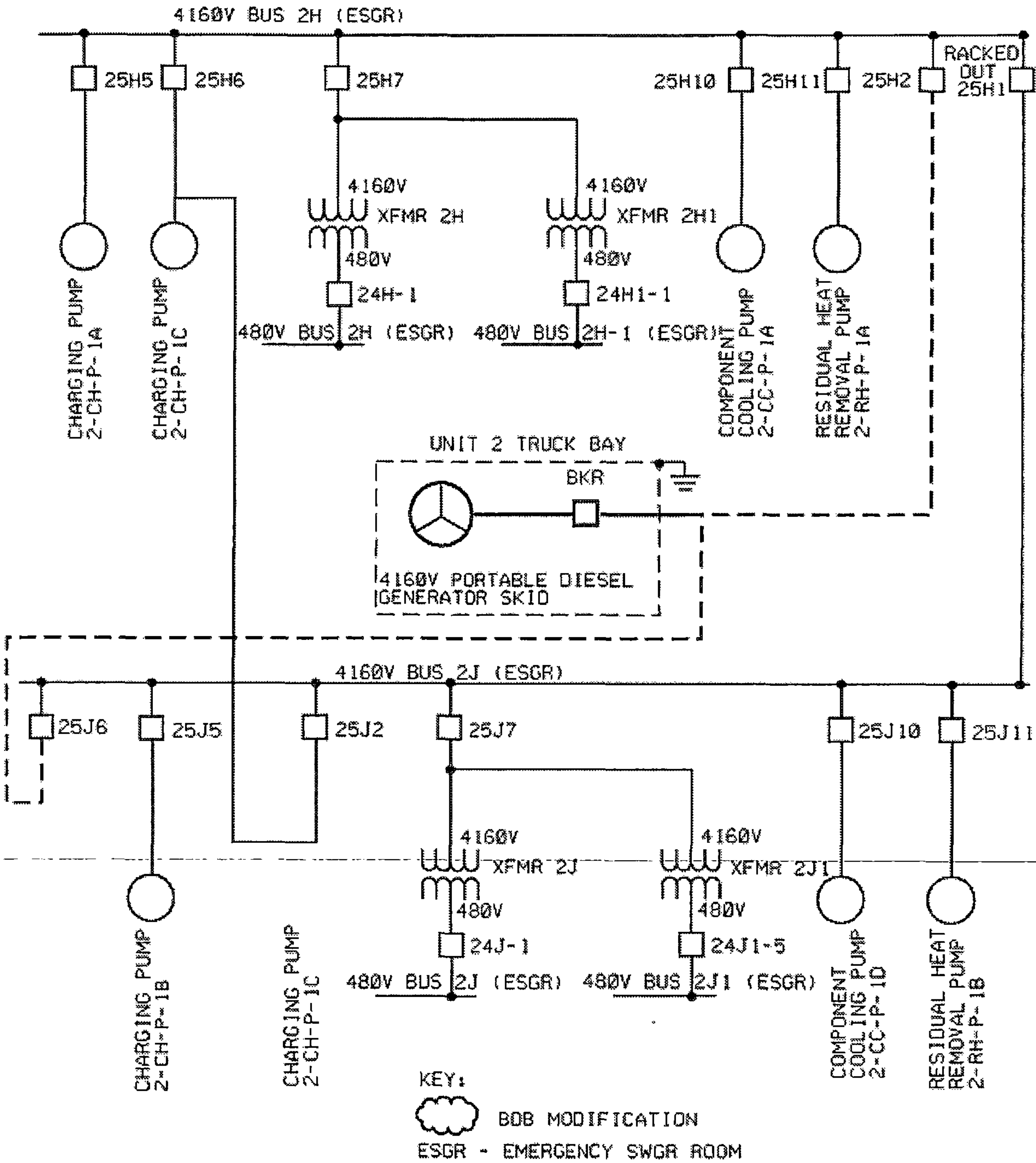


Figure 16: 4160 VAC Generator (NSRC) Electrical Connections to 4160 VAC MCC 2H and/or 2J – Surry Unit 2

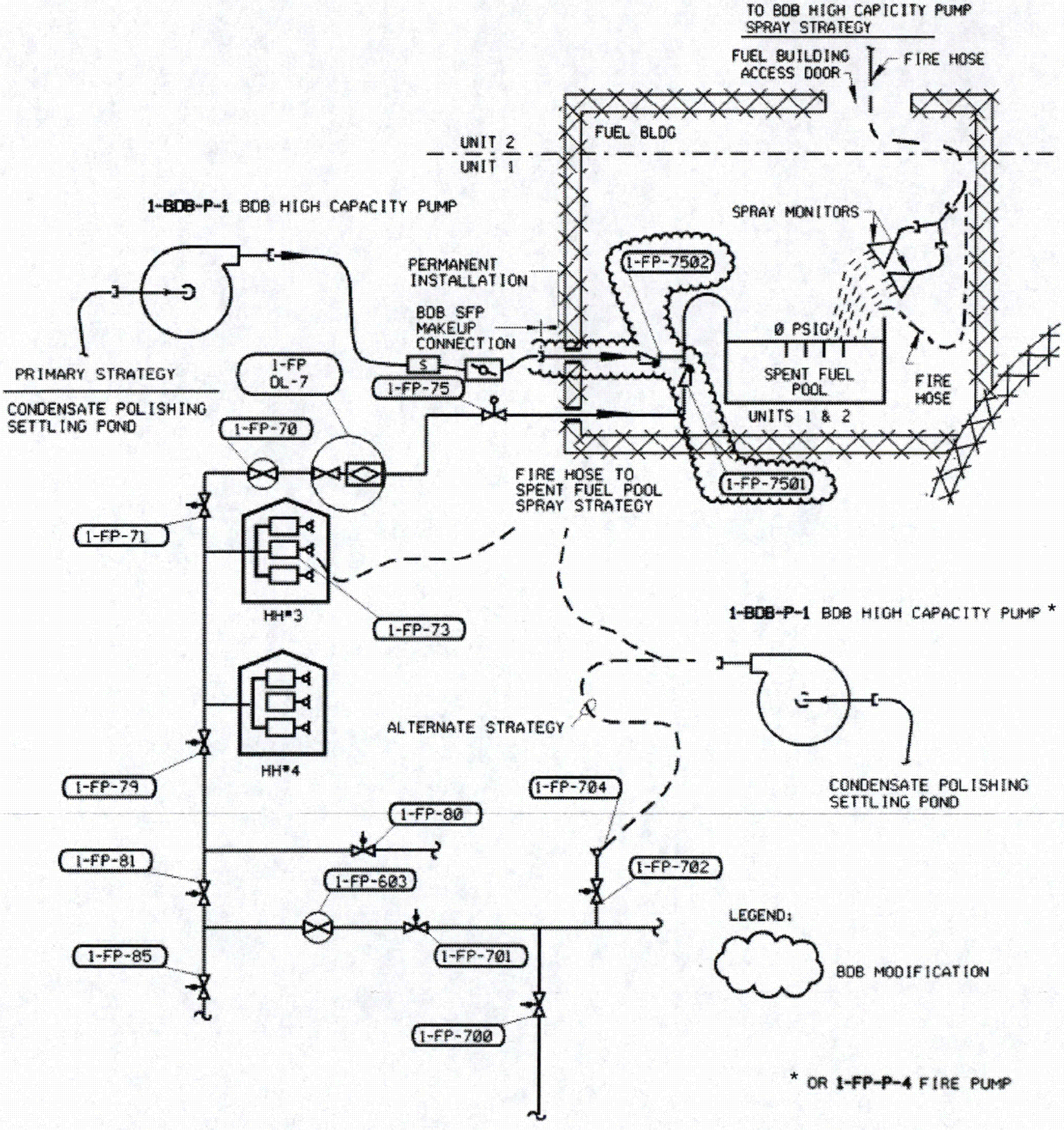


Figure 17: Spent Fuel Pool Cooling Primary and Alternate Mechanical Connections

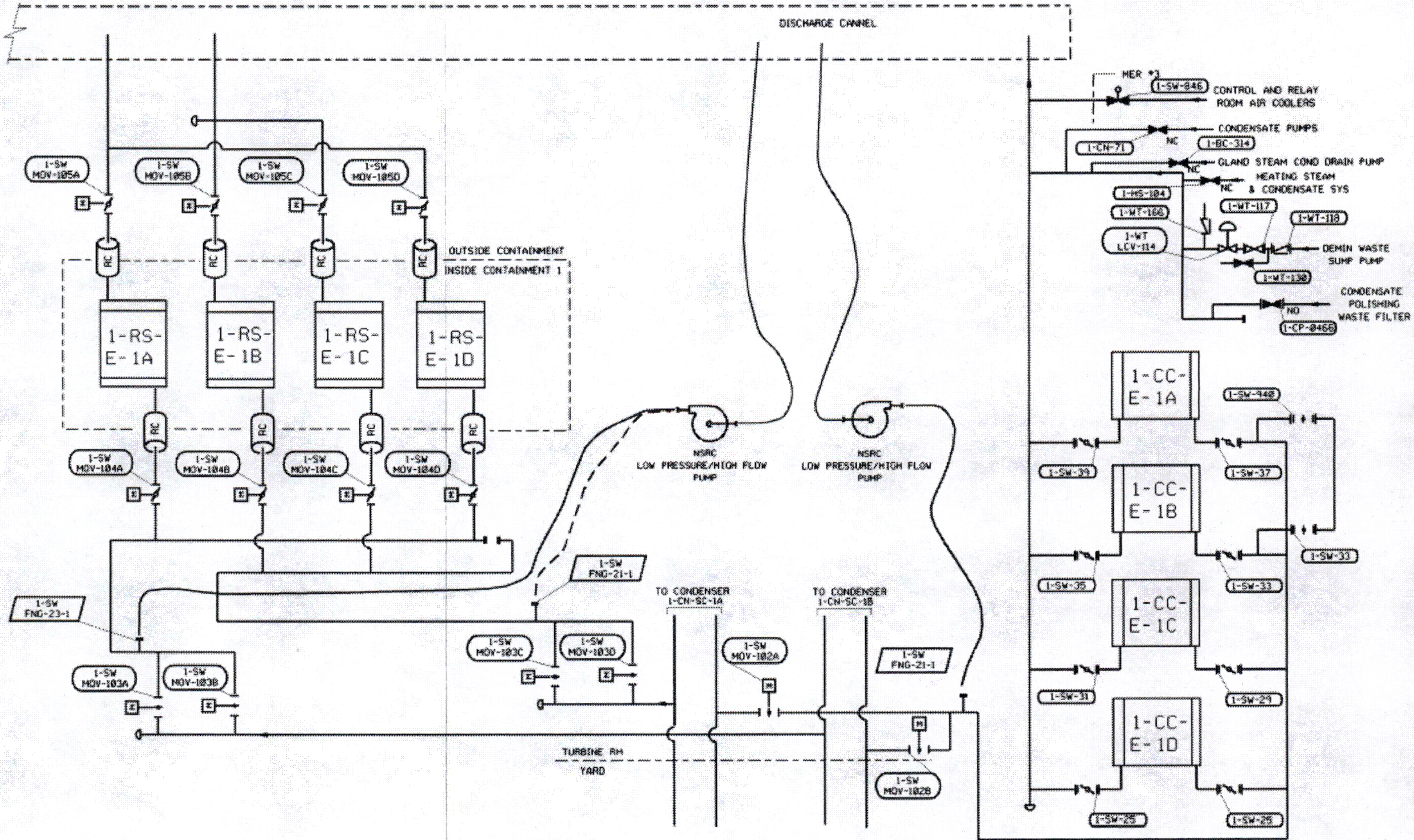


Figure 18: Phase 3 Containment Cooling Connections – Surry Unit 1

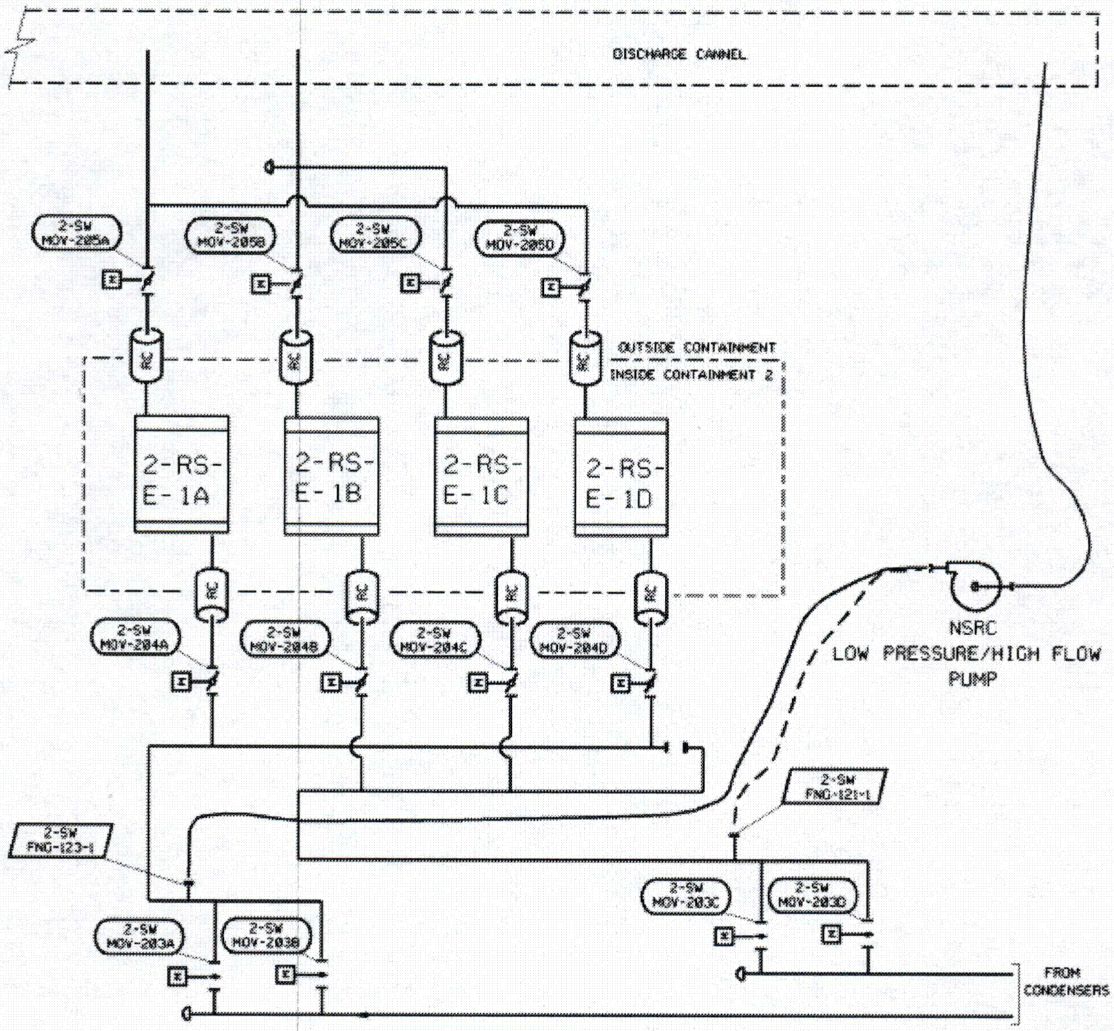


Figure 19: Phase 3 Containment Cooling Connections – Surry Unit 2

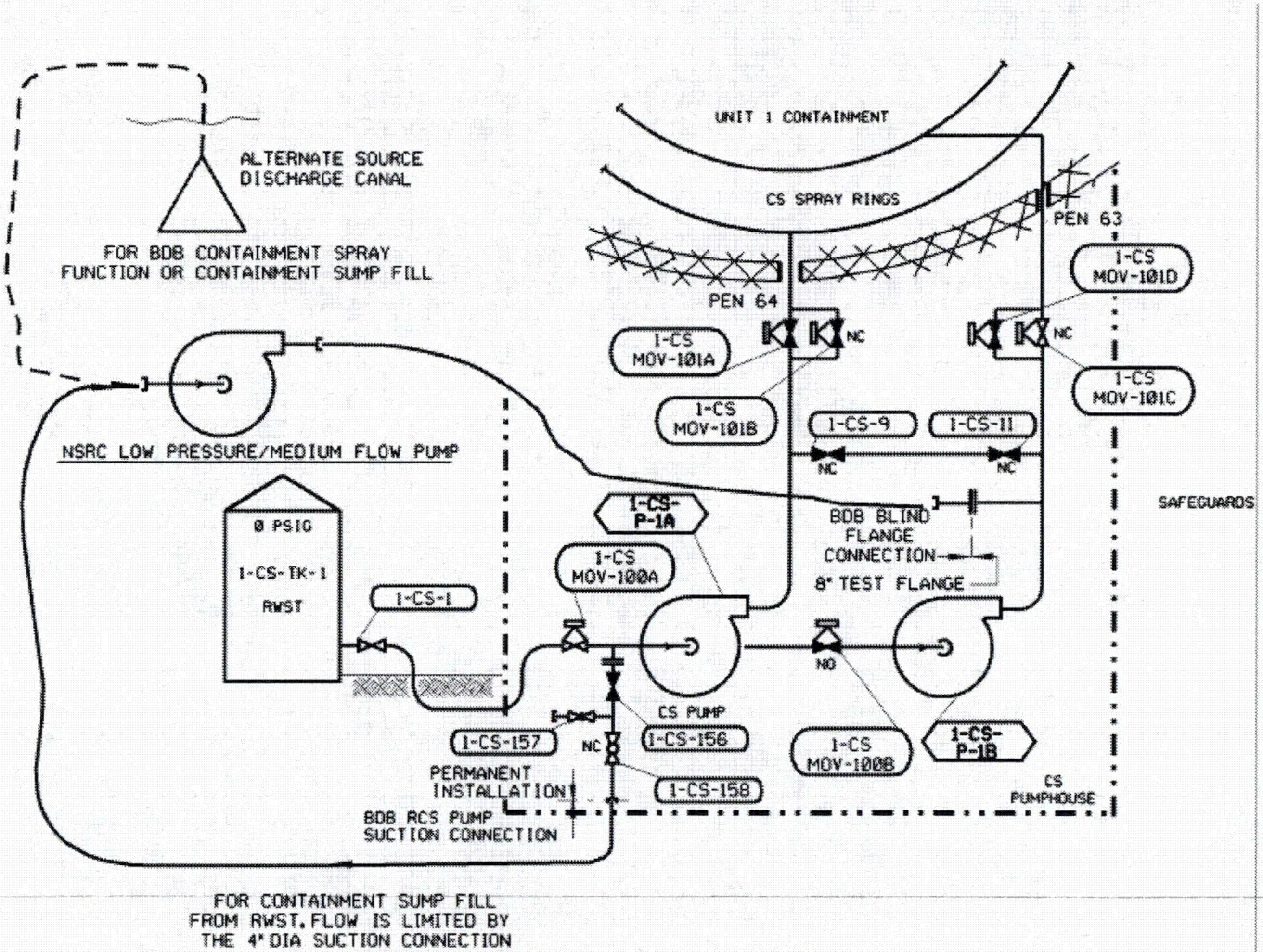


Figure 20: Containment Cooling Phase 3 Containment Spray
Mechanical Connections - Surry Unit 1

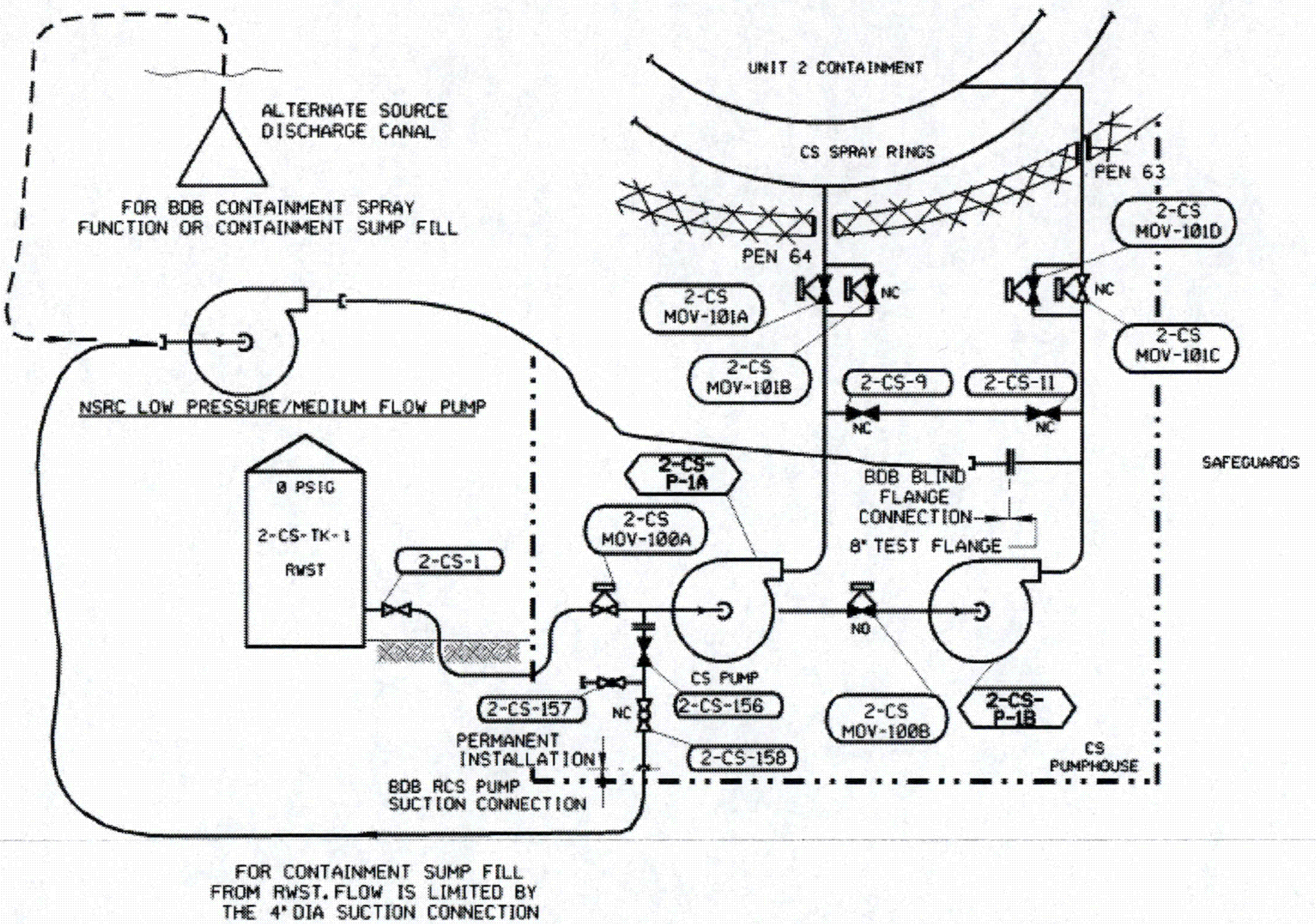


Figure 21: Containment Cooling Phase 3 Containment Spray
Mechanical Connections - Surry Unit 2

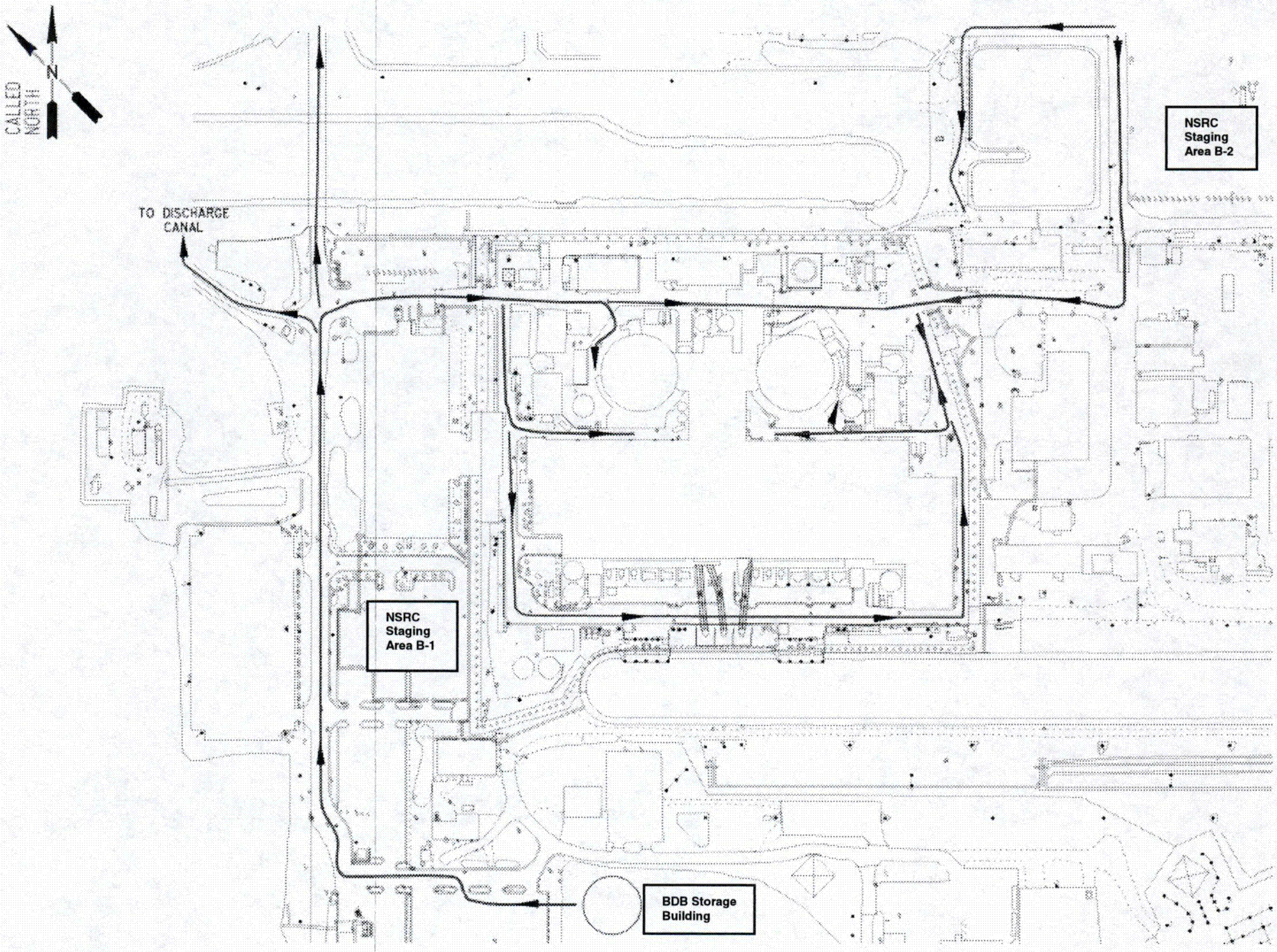


Figure 22: Haul Paths From BDB Storage Building and Staging Areas