Exelon Generation

Order No. EA-12-049

RS-18-051

June 7, 2018

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

Limerick Generating Station, Unit 1
Renewed Facility Operating License No. NPF-39
NRC Docket No. 50-352

Subject: Report of Full Compliance with 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)

References:

1. NRC Order Number EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events," dated March 12, 2012
2. 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
3. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, dated August 2012
4. Exelon Generation Company, LLC's Initial 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 October 25, 2012
5. Exelon Generation Company, LLC 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 February 28, 2013 (RS-13-022)
6. Exelon Generation Company, LLC First 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, 2013 (RS-13-123)
7. Exelon Generation Company, LLC Second 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 28, 2014 (RS-14-012)

8. Exelon Generation Company, LLC Third 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 (RS-14-210)
9. Exelon Generation Company, LLC Fourth 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, 2015 (RS-15-021)
10. Exelon Generation Company, LLC Fifth 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, 2015 (RS-15-212)
11. Exelon Generation Company, LLC Sixth 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 26, 2016 (RS-16-024)
12. Exelon Generation Company, LLC Seventh 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 26, 2016 (RS-16-147)
13. Exelon Generation Company, LLC Eighth 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 28, 2017 (RS-17-020)
14. Exelon Generation Company, LLC Ninth 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, 2017 (RS-17-095)
15. Exelon Generation Company, LLC Tenth 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 28, 2018 (RS-18-012)
16. NRC letter to Exelon Generation Company, LLC, Limerick Generating Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049, (Mitigation Strategies) (TAC Nos. MF0847 and MF0848), dated January 10, 2014
17. NRC Letter, 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, dated March 12, 2012
18. Exelon Generation Company, LLC letter to USNRC, Response to March 12, 2012, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Enclosure 5, Recommendation 9.3, Emergency Preparedness – Staffing, Requested Information Items 1, 2, and 6 - Phase 2 Staffing Assessment, dated December 5, 2014 (RS-14-325)

19. NRC letter to Exelon Generation Company, LLC, Limerick Generating Station, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0847, MF0848, MF0854, MF0855), dated March 17, 2015

On March 12, 2012, the Nuclear Regulatory Commission ("NRC" or "Commission") issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events," (Reference 1) to Exelon Generation Company, LLC (EGC). Reference 1 was immediately effective and directed EGC to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event. Specific requirements are outlined in Attachment 2 of Reference 1.

Reference 1 required submission of an initial status report 60 days following issuance of the final interim staff guidance (Reference 2) and an Overall Integrated Plan (OIP) pursuant to Section IV, Condition C. Reference 2 endorsed industry guidance document NEI 12-06, Revision 0 (Reference 3) with clarifications and exceptions identified in Reference 2. Reference 4 provided the EGC initial status report regarding mitigation strategies. Reference 5 provided the Limerick Generating Station, Unit 1 OIP.

Reference 1 required submission of a status report at six-month intervals following submittal of the OIP. References 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 provided the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, and tenth six-month status reports, respectively, pursuant to Section IV, Condition C.2, of Reference 1 for Limerick Generating Station, Unit 1.

The purpose of this letter is to provide the report of full compliance with the 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) (Reference 1) pursuant to Section IV, Condition C.3 of the Order for Limerick Generating Station, Unit 1.

Limerick Generating Station, Unit 1 has developed, implemented, and will maintain the guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event in response to Order EA-12-049. The information provided herein documents full compliance for Limerick Generating Station, Unit 1 with Reference 1.

OIP open items have been addressed and closed as documented in References 6, 8, 9, and 10 and are considered complete pending NRC closure. EGC's response to the NRC Interim Staff Evaluation (ISE) open and confirmatory items identified in Reference 16 have been addressed and closed as documented in References 7, 8, 9, 10, 12, and 19 and are considered closed. EGC's response to the NRC audit questions and additional audit open items have been addressed and closed as documented in Reference 10, and are considered complete pending NRC closure. The following tables provide completion references for each OIP open item and NRC ISE open or confirmatory item, and NRC Audit Report open items.

Overall Integrated Plan Open Items

Section Reference	Overall Integrated Plan Open Item	Completion Response Reference
Sequence of Events (p.8)	The times to complete actions in the Events Timeline are based on operating judgment, conceptual designs, and current supporting analyses. The final timeline will be time validated once detailed designs are completed and procedures developed.	Reference 10
Sequence of Events (p.7) Installed Phase 1 Equipment (p.37)	Initial evaluations were used to determine the fuel pool timelines. Formal calculations will be performed to validate this information during development of the spent fuel pool cooling strategy detailed design.	Reference 8
Sequence of Events (p.7)	Analysis of deviations between Exelon's engineering analyses and the analyses contained in BWROG Document NEDC-33771P, "GEH Evaluation of FLEX Implementation Guidelines," and documentation of results was not completed and submitted with the Overall Integrated Plan (Reference 5).	Reference 6
Identify how strategies will be deployed in all modes (p.11)	Transportation routes will be developed from the equipment storage area to the FLEX staging areas. An administrative program will be developed to ensure pathways remain clear or compensatory actions will be implemented to ensure all strategies can be deployed during all modes of operation. Identification of storage areas and creation of the administrative program are open items.	Reference 10
Identify how the programmatic controls will be met (p.12)	An administrative program for FLEX to establish responsibilities, and testing & maintenance requirements will be implemented.	Reference 10
Sequence of Events (p.9)	Additional work will be performed during detailed design development to ensure Suppression Pool temperature will support RCIC operation, in accordance with approved BWROG analysis, throughout the event.	Reference10

Section Reference	Overall Integrated Plan Open Item	Completion Response Reference
Portable Equip Phase 2 (p.50)	Complete an evaluation of the spent fuel pool area for steam and condensation.	Reference 9
Installed Equip Phase 1 (p.47) Portable Equip Phase 2 (p.49)	Evaluate the habitability conditions for the Main Control Room and develop a strategy to maintain habitability.	Reference 10
Installed Equip Phase 1 (p.47) Portable Equip Phase 2 (p.50)	Develop a procedure to prop open battery room doors upon energizing the battery chargers to prevent a buildup of hydrogen in the battery rooms.	Reference 10

Interim Staff Evaluation Open Items

Open Item	Completion Response Reference
Item No. 3.1.1.2.A	Reference 8
Item No. 3.1.1.3.A	Reference 10
Item No. 3.1.2.2.A	References 7 and 10
Item No. 3.2.3.A	Reference 10
Item No. 3.2.4.2.C	Reference 8
Item No. 3.4.A	Reference 9

Interim Staff Evaluation Confirmatory Items

Confirmatory Item	Completion Response Reference
Item No. 3.1.1.4.A	Reference 10
Item No. 3.1.5.2.A	Reference 9
Item No. 3.2.1.1.A	Reference 8
Item No. 3.2.1.1.B	Reference 8
Item No. 3.2.1.1.C	Reference 8
Item No. 3.2.1.1.D	Reference 8
Item No. 3.2.1.3.A	Reference 10
Item No. 3.2.1.4.A	Reference 10
Item No. 3.2.1.4.B	Reference 7
Item No. 3.2.1.4.C	Reference 8
Item No. 3.2.1.7.A	References 10 and 19

Confirmatory Item	Completion Response Reference
Item No. 3.2.1.8.A	Reference 8
Item No. 3.2.1.8.B	Reference 8
Item No. 3.2.2.A	Reference 8
Item No. 3.2.4.2.A	Reference 9
Item No. 3.2.4.2.B	Reference 10
Item No. 3.2.4.4.A	Reference 12
Item No. 3.2.4.5.A	Reference 9
Item No. 3.2.4.6.A	Reference 10
Item No. 3.2.4.6.B	Reference 10
Item No. 3.2.4.8.A	Reference 8
Item No. 3.2.4.10.B	Reference 7
Item No. 3.2.4.10.C	Reference 19

NRC Audit Report Open Items

Audit Open Item	Completion Response Reference
AQ-22	Reference 10
OIP-4	Reference 10

MILESTONE SCHEDULE – ITEMS COMPLETE

Milestone	Completion Date
Submit 60 Day Status Report	October 25, 2012
Submit Overall Integrated Plan	February 28, 2013
Contract with National SAFER Response Center	November 29, 2012
Submit 6 Month Updates:	
Update 1	August 28, 2013
Update 2	February 28, 2014
Update 3	August 28, 2014
Update 4	February 27, 2015
Update 5	August 28, 2015
Update 6	February 26, 2016
Update 7	August 26, 2016
Update 8	February 28, 2017
Update 9	August 28, 2017
Update 10	February 28, 2018
Modification Development:	
Phases 1 and 2 modifications	February 28, 2018
National SAFER Response Center Operational	April 6, 2015
Procedure Development:	
Strategy procedures	April 15, 2018

Milestone	Completion Date
Validate Procedures (NEI 12-06, Sect. 11.4.3)	April 15, 2018
Maintenance procedures	April 15, 2018
Staffing analysis	December 5, 2014
Modification Implementation:	
Phases 1 and 2 modifications	April 15, 2018
Storage plan and construction	October 29, 2015
FLEX equipment acquisition	March 8, 2016
Training completion	February 8, 2018
Unit 1 implementation date	April 15, 2018

ORDER EA-12-049 COMPLIANCE ELEMENTS SUMMARY

The elements identified below for Limerick Generating Station, Unit 1 as well as the site OIP response submittal (Reference 5), the 6-Month Status Reports (References 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15), and any additional docketed correspondence, demonstrate compliance with Order EA-12-049.

Strategies - Complete

Limerick Generating Station, Unit 1 strategies are in compliance with Order EA-12-049. There are no strategy related Open Items, Confirmatory Items, or Audit Questions/Audit Report Open Items. The Limerick Generating Station, Units 1 and 2 Final Integrated Plan for mitigating strategies is provided in the enclosure to this letter.

Modifications - Complete

The modifications required to support the FLEX strategies for Limerick Generating Station, Unit 1 have been fully implemented in accordance with the station design control process.

Equipment – Procured and Maintenance & Testing – Complete

The equipment required to implement the FLEX strategies for Limerick Generating Station, Unit 1 has been procured in accordance with NEI 12-06, Sections 11.1 and 11.2, and has been received at Limerick Generating Station, Unit 1; and initially tested/performance verified as identified in NEI 12-06, Section 11.5, and is available for use.

Periodic maintenance and testing will be conducted through the use of the Limerick Generating Station, Unit 1 Preventative Maintenance program such that equipment reliability is achieved.

Protected Storage – Complete

The storage facilities required to implement the FLEX strategies for Limerick Generating Station, Unit 1 have been completed and provide protection from the applicable site hazards. The equipment required to implement the FLEX strategies for Limerick Generating Station, Unit 1 is stored in its protected configuration.

Procedures – Complete

FLEX Support Guidelines (FSGs) for Limerick Generating Station, Unit 1 have been developed and integrated with existing procedures. The FSGs and affected existing procedures have been verified and are available for use in accordance with the site procedure control program.

Training – Complete

Training for Limerick Generating Station, Unit 1 has been completed in accordance with an accepted training process as recommended in NEI 12-06, Section 11.6.

Staffing – Complete

The Phase 2 staffing study for Limerick Generating Station, Unit 1 has been completed in accordance with 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 (Reference 17), as documented in Reference 18.

National SAFER Response Center – Complete

EGC 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 Limerick Generating Station, Unit 1 with Phase 3 equipment stored in the National SAFER Response Centers in accordance with the site specific SAFER Response Plan.

Validation – Complete

EGC has completed the performance of validation in accordance with industry developed guidance to assure required tasks, manual actions and decisions for FLEX strategies are feasible and may be executed within the constraints identified in the Overall Integrated Plan (OIP) for Order EA-12-049.

FLEX Program Document - Established

The Limerick Generating Station, Unit 1 FLEX Program Document has been developed in accordance with the requirements of NEI 12-06.

This letter contains no new regulatory commitments. If you have any questions regarding this report, please contact David J. Distel at 610-765-5517.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 7th day of June 2018.

Respectfully submitted,

James Barstow
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosure: Limerick Generating Station Units 1 and 2 Final Integrated Plan Document – Mitigation Strategies for a Beyond-Design-Basis Event (NRC Order EA-12-049)

cc: Director, Office of Nuclear Reactor Regulation
NRC Regional Administrator - Region I
NRC Senior Resident Inspector – Limerick Generating Station
NRC Project Manager, NRR – Limerick Generating Station
Mr. Peter J. Bamford, NRR/JLD/JOMB, NRC
Director, Bureau of Radiation Protection – Pennsylvania Department of Environmental Resources
R. R. Janati, Chief, Division of Nuclear Safety, Pennsylvania Department of Environmental Protection, Bureau of Radiation Protection

Enclosure

Limerick Generating Station Units 1 and 2

Final Integrated Plan Document – Mitigation Strategies for a Beyond-Design-Basis External Event (NRC Order EA-12-049)

(91 pages)

Limerick Generating Station Units 1 & 2

FINAL INTEGRATED PLAN DOCUMENT

MITIGATING STRATEGIES NRC ORDER EA-12-049

June 2018

Table of Contents

1 Background

In 2011, an earthquake-induced tsunami caused Beyond-Design-Basis (BDB) flooding at the Fukushima Daiichi 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 on Units 1 & 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 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 (BDBEEs).

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 1) on March 12, 2012 to implement mitigation strategies for BDBEEs. The Order provided the following requirements for strategies to mitigate BDBEEs:

1. Licensees shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and Spent Fuel Pool (SFP) cooling capabilities following a BDBEE.

2. These strategies must be 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 BDBEEs:

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

NRC Order EA-12-049 (Reference 1) 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 comes first.

The Nuclear Energy Institute (NEI) developed NEI 12-06 (Reference 2), which provides 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 3), 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 4) required licensees to install reliable SFP instrumentation with specific design features for monitoring SFP water level.

NEI 12-02 (Reference 5) 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 6), conformance with the guidance in NEI 12-02 is an acceptable method for satisfying the requirements in Order EA-12-051.

2 NRC Order 12-049 – Diverse and Flexible Mitigation Strategies (FLEX)

2.1 Assumptions

The assumptions used for the evaluations of a Limerick Generating Station 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

- The reactor is initially operating at power, unless there are procedural requirements to shut down due to the impending event. The reactor has been operating at 100% power for the past 100 days.
- The reactor is successfully shut down when required (i.e., all control 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. The emergency cooling system initiates and operates normally, providing decay heat removal, thus obviating the need for further overpressure protection valve operation.
- On-site staff is at site administrative minimum shift staffing levels.
- No independent, concurrent events, e.g., no active security threat.
- All personnel on-site 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*, for Limerick Generating Station:

- No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) with installed sources of emergency on-site AC power 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.
- 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 FLEX 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 at a rate of 36 gpm, from the reactor recirculation pumps seal leakage at rated pressure (pressure dependent).
- 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 for the site security plan or other (license/site specific) requirements of 10CFR may be required.
- Site access is impeded for the first 6 hours, consistent with NEI 12-01 (Reference 7). Additional resources are assumed to begin arriving at hour 6 with limited site access up to 24 hours. By 24 hours and beyond, near-normal site access is restored allowing augmented resources to deliver supplies and personnel to the site.

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 event by providing adequate capability to maintain or restore core cooling, containment, and SFP cooling capabilities. 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. These pre-planned strategies developed to protect the public health and safety have been incorporated into the unit emergency operating procedures in accordance with established emergency operating procedure (EOP) change processes, and their impact to the design and license bases capabilities of the unit evaluated under 10 CFR 50.59.

The plant Technical Specifications (TS) 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 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 Specification (TSs) Requirements at the Surry Power Station", (TAC Nos. MC42331 and MC4332), dated September 12, 2006 (Reference 8).

3 Strategies

The objective of the FLEX strategies is to establish an indefinite coping capability to 1) prevent damage to the fuel in the reactor, 2) maintain the containment function and 3) maintain cooling and prevent damage to fuel in the SFP using installed equipment, on-site portable equipment, and pre-staged off-site resources. This indefinite coping capability will address an ELAP – loss of off-site power and emergency diesel generators (EDGs), but not the loss of DC power or AC power to buses fed by station batteries through inverters, with a simultaneous loss of access to the UHS and loss of motive force for UHS pumps, but the water in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. This condition could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a BDBEE.

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 the coincident ELAP/LUHS event. A safety function-based approach provides consistency with, and allows coordination of, existing plant EOPs. FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs), at Limerick these are the T-300 series of procedures.

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 on-site resources.
- Phase 2 – Transition from installed plant equipment to on-site BDB equipment.

- Phase 3 – Obtain additional capability and redundancy from off-site equipment and resources 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 FLEX strategy employed to mitigate the plant condition.

The 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 Limerick Generating Station. 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. These pre-planned strategies developed to protect the public health and safety are incorporated into the Limerick Generating Station EOPs in accordance with established EOP change processes, and their impact to the design basis capabilities of the unit evaluated under 10 CFR 50.59.

Before discussing the strategies that provide coping capability for reactor core cooling, containment integrity, and spent fuel pool cooling, a discussion of the fundamental strategies for restoring a source of AC power and a source of cooling water is provided below.

3.1 Electrical Strategies

3.1.1 480 VAC Power

The electrical support approach is a robust design and will withstand the BDBEE hazards scoped in for Limerick Generating Station (LGS).

The Limerick electrical strategy consists of the following components (Refer to Figure 1 FLEX Electrical Strategy (typical of one electrical division on one unit)):

- Two portable 500 KW diesel generators, stored in the FLEX Generator Storage Building, located in the Protected Area,

- An N+1 portable 500 KW diesel generator and +1 spare cables stored in the FLEX Pump Building, near the Spray Pond,

- 16 -100 ft interconnecting cables reels stored on the FLEX truck, an additional 16 - 300 ft cable reels stored on the FLEX cable trailer and 12 - 300 ft spare cables stored in the FLEX Generator building. The 300 ft reels are used for alternate connection strategies. These cables are all protected and stored in the FLEX Generator Storage Building.

- Two 480 VAC portable electrical distribution panels and the N+1 distribution panel are stored in the FLEX Generator Storage Building.
- Four portable 480 VAC motor control center (MCC) bucket inserts and two N+1 MCC buckets for use in back feeding the 480 VAC motor control centers that require power following a BDBEE.

Limerick has developed a primary and alternate strategy for supplying power to equipment required to provide core, containment, and spent fuel pool cooling using a combination of portable generators and cable reels stored in the seismically robust FLEX Generator Building. The primary strategy uses connections in the Division 1 and 2 EDG rooms to repower Division 1 and 2, 480 volt electrical buses and the alternate strategy uses connections in the Reactor Enclosure to repower Division 1 and 2 electrical buses. Once the buses are reenergized, the repowering of the Division 1 battery chargers supports extended Reactor Core Isolation Cooling (RCIC) operation and powering critical DC instrumentation. Repowering of the Division 2 battery chargers supports repowering critical DC instrumentation.

DC bus load shedding will ensure Division 1 battery life is extended to approximately 7:25 hours and Division 2 equipment approximately 14:30 hours (Reference 10). DC load shed of all non-essential loads would begin when it is recognized that the station is in an extended Station Blackout (SBO) condition, and will be completed within 120 minutes (Reference 11), this will ensure the station batteries can remain functional for the above-mentioned durations. The Limerick FLEX electrical strategy ensures that the Division 1 and Division 2 safety-related battery chargers are able to be energized prior to the batteries becoming exhausted.

In the Limerick electrical strategy, diversity is accomplished by providing a primary and alternate methods to repower key equipment and instruments utilized in FLEX strategies. The electrical connection points in the Limerick strategy are the seismically rated 480 VAC MCCs in the EDG rooms and the Reactor Enclosures, each MCC has a dedicated empty cubical reserved for the FLEX connection. The electrical path from the FLEX generators to the primary or alternate plant connection points consists of cables deployed on the ground.

The Limerick electrical strategy meets the requirements of the order. Limerick followed the guidance provided in NEI 12-06 to develop this approach. The transition phase requires providing sufficient, portable, on-site equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off-site.

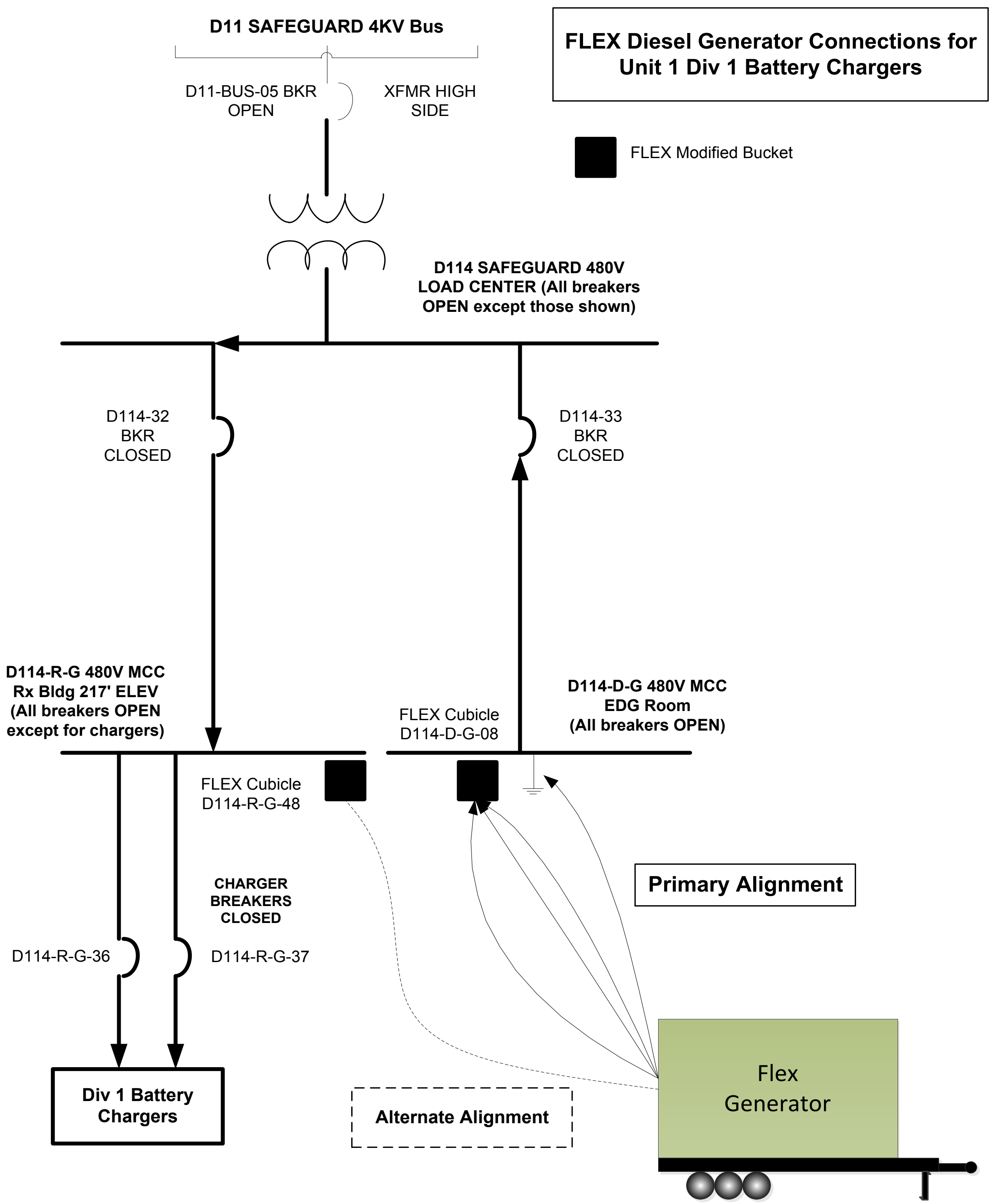

Figure 1 - FLEX Electrical Strategy (typical for one division)

3.1.2 DC Power

The Class 1E DC power system supplies 125 VDC power to various Class 1E loads (Figure 2). The primary power sources are the battery chargers. The system includes batteries, battery chargers, motor control centers, and DC distribution panels. The system is divided into four divisions, each with its own independent distribution network, battery and battery chargers. The RCIC system logic is powered from Divisions 1 and 3, the RCIC system valves and controls required for automatic and manual operation are powered from Division 1. The Division 3 RCIC loads are some isolation logic and MOV overload annunciators, these have been determined to not be required RCIC operation and therefore not be restored. The ADS SRV solenoids and some key instrumentation are all supplied from the Division 1 Class 1E DC power system. Other key instruments are powered from the Division 2 Class 1E DC power system. The station battery chargers can carry the DC bus loads and concurrently recharging the batteries.

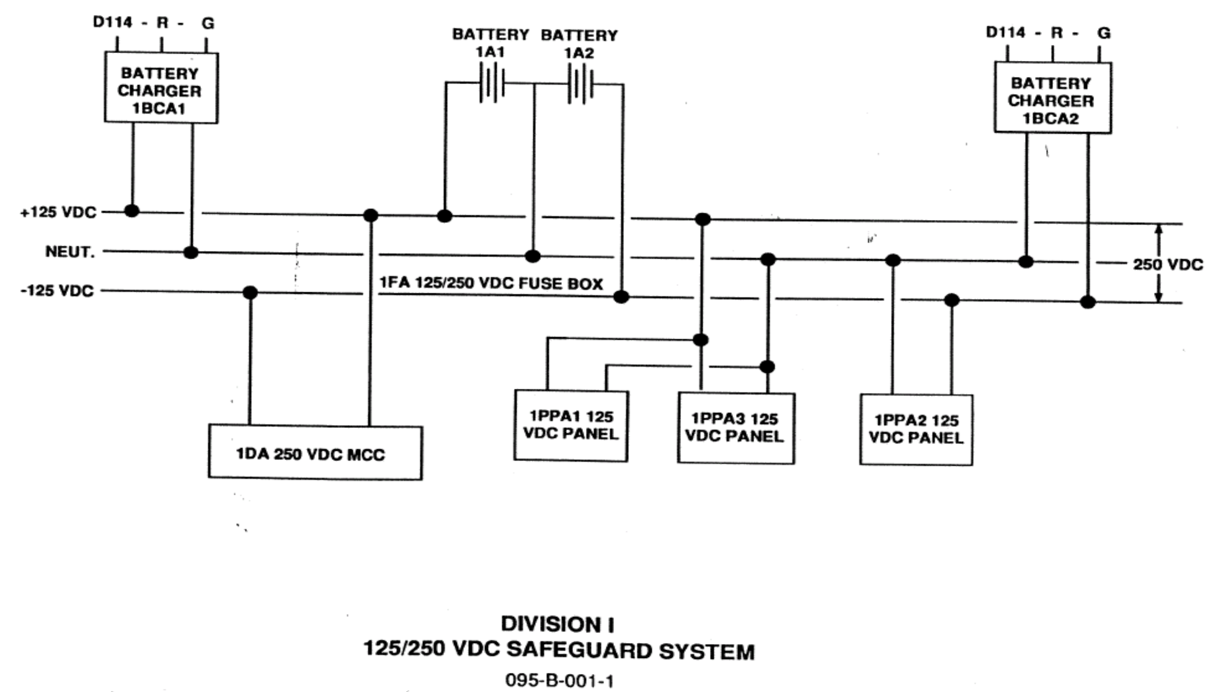

Figure 2 - DC Distribution (Typical)

3.1.3 120/240 VAC Auxiliary Power

Limerick has staged seven (7) portable 5,500 watt portable diesel generators in the FLEX generator storage building and one (1) 5,500 watt portable diesel generator in the FLEX pump storage building to provide a power supply for low voltage portable equipment. The generators have 120/240 VAC receptacles for equipment used in FLEX support strategies discussed in Section 4. Below are examples of the types equipment requiring 120 VAC power:

- Portable fans
- Portable tripod lights and light stringers
- Backup power to Spent Fuel Pool Level Indication
- Backup power to Main Control Room (MCR) satellite communications equipment
- Portable radio chargers
- Portable fuel transfer pump
- E.P. Satellite communications trailers (not FLEX required but share generators)

Extension cords and cord splitters for various strategies are staged in FLEX toolbags stored in the FLEX buildings with the equipment that requires the 120/240 VAC power. Additional spare cords are staged for general use. The portable equipment that uses the 120 VAC power is generally placed in the safety related Control Structure (divisional battery rooms and Main Control Room), but some portable equipment is used in other locations. The portable generators would be positioned near the Turbine Enclosure 23-line rollup door and temporary cords routed to the equipment in the control structure. The Turbine Enclosure structure has been evaluated to be seismically robust as documented in the USFAR and would survive the event allowing access through the Turbine Building to the Control Structure and Reactor Enclosure.

3.1.4 Electrical Analysis

Limerick has four (4) Class 1E station batteries in Divisions 1 through 4. Both the primary and alternate FLEX electrical strategies only repower the Division 1 and 2 battery chargers. The Division 1 battery has the shortest life due to a larger number of loads. The FLEX strategies ensure the Division 1 battery chargers are energized before the Division 1 battery coping time is exceeded. The Division 1 battery chargers are the focus of both strategies because the RCIC controls and DC valves are powered from Division 1 DC, as well as the Division 1 Automatic Depressurization System (ADS) Safety Relief

Valve (SRV) solenoids. After the Division 1 battery chargers are repowered, manpower commences connection of the cables to the previously setup FLEX generators to reenergize the Division 2 battery chargers. The Division 3 and 4 batteries are not credited in a BDBEE response.

ECR 14-00019 (Reference 9) performed an electrical review of the FLEX strategies and sized the FLEX generators. A DC battery coping calculation was performed in LE-0125 (Reference 10) for the Limerick Division 1 and 2 batteries under ELAP conditions. The coping times established for Division 1 with the 120 minute SBO load shedding limit per Procedure E-1 (Reference 11) is 7:25 hours. The coping times for Division 2 with the 120 minute SBO load shedding limit per Procedure E-1 is 14:30 hours. The FLEX generator also repowers the HCVS Battery Charger after 24 hours (Reference 72) , (Reference 73).

The strategy to sustain 2 of the station's safety-related DC buses requires the use of a 480 VAC diesel powered FLEX Generator to re-power the selected battery chargers via temporary connection points to the plant AC buses that supply the battery chargers. The circuit for supplying the bus connection points from the FLEX generator is described in section 3.1.1 and Figure 1.

The FLEX Generators are diesel driven, trailer-mounted units stored in the FLEX Generator Storage Building. Both are rated at 500 kW/625 kVA, 480 VAC, 3 phase, 60Hz, with an integral 500 gallon fuel tank capable of supporting approximately 14.5 hours of operation at full load. Per the FLEX diesel generator sizing calculation (Reference 9), the FLEX generator will be capable of supplying the required loads for both the Division 1 and the Division 2 systems on one unit for the FELX electrical strategy.

For FLEX Phase 3, the National SAFER Response Center (NSRC) will supply one Turbine Marine 1.1 MW (de-rated to 1 MW), 480 VAC, 3 phase 60 Hz generator per unit. This NSRC equipment is a backup to on-site Phase 2 equipment. The NSRC generators come with the same style and size connectors as the on-site Phase 2 FLEX generators.

3.1.5 Impact of Elevated Temperature

The following is a discussion of the impact of loss of normal ventilation to the Division 1 and Division 2 Battery Rooms.

3.1.5.1 Battery Rooms

The C&D type batteries used at Limerick for the Division 1 and 2 station battery systems have a robust design and extensive operating history. The qualification testing performed by C&D demonstrated good performance under elevated operating temperature environments. A Technical Evaluation (Reference 12) was performed to review the rate of temperature rise and hydrogen accumulation in the battery rooms following a loss of normal ventilation. During the first 6 hours when batteries are discharging the rate of temperature rise is low. Once the battery chargers are reenergized, the rate of temperature rise and hydrogen generation increases from the battery recharge. This evaluation determined that temporary air forced ventilation was required approximately 24 hours post event. Procedural guidance has been developed to prop open room doors and install a high velocity fan in the battery room doorway to pull fresh air from the corridor behind the battery rooms and exhaust the air to the large open Generator Services area on elevation 239'. After six hours post event, additional resources start to become available to assist in temporary fan and portable generator equipment setup.

Lastly, if loss or failure of a battery string were to occur, the battery charger has the capability to carry the anticipated loads indefinitely provided AC power remains available to support the charger.

3.2 Ultimate Heat Sink Water Strategy

Water from the UHS (Spray Pond) is used to accomplish the Phase 2 core cooling, containment heat removal, and SFP cooling strategies and is supplied to the plant using a portable diesel driven pump for each unit to re-pressurize the A and B Loop of the buried seismically designed RHRSW piping from the spray pond pump house to the RHR rooms.

Modifications were made in the safety related Spray Pond Pump House to allow the portable FLEX pumps to each be connected to either the A or B loop RHRSW piping. This assures redundant flow paths are available for both units from the Spray Pond to the A and B RHR rooms of each unit.

The RHRSW system is safety-related and designed to normally supply cooling water to the RHR heat exchangers for both units. The system is common to the two units and consists of two independent trains. Each train services one RHR heat exchanger in each unit, and provides sufficient cooling for safe shutdown, cooling, and accident mitigation of both units. The RHRSW system can be cross-connected to the RHR system through existing piping on one loop of each unit. Original plant design allows the RHRSW B train to be cross-connected to the Unit 1 RHR B train, and allows the RHRSW A train to be cross-connected to the Unit 2 RHR A train. Injection into the Unit 1 RHR B train and the Unit 2 RHR A train provides makeup for reactor pressure vessel (RPV) injection, Suppression Pool makeup and SPF makeup if it is required. This alignment is the preferred choice in the LGS procedures since the flow alignment can be made with minimal operator actions.

Additional diversity required by the FLEX order for RPV Injection, Suppression Pool makeup and SFP makeup or spray is provided by a modification that installed new valves and a hose cross connect to allow Unit 1 A Loop RHRSW to connect to A RHR and Unit 2 RHRSW B Loop and RHR B to be cross-tied. This cross-tie allows either train of RHRSW to provide flow to a train of RHR (A or B) in the event one of the trains is out of service or unavailable.

The required 5" hoses for connection of the FLEX pumps to the RHRSW system in the Spray Pond Pump House are stored on the bed of the FLEX truck and in the Spray Pond Pump House. For easy of deployment from the pump point of use to the area near the spray pond security fence the hose is staged in the truck bed.

Additional 5" hoses are stored in the Spray Pond Pump House in a dedicated cabinet. This allows the operators to connect 5" hoses to the valves in the pumphouse and deploy them outward towards the security fence and meet the hoses deployed from the pumps to the fence area. This reduces the required setup time. See Figure 3 for the UHS pump configuration.

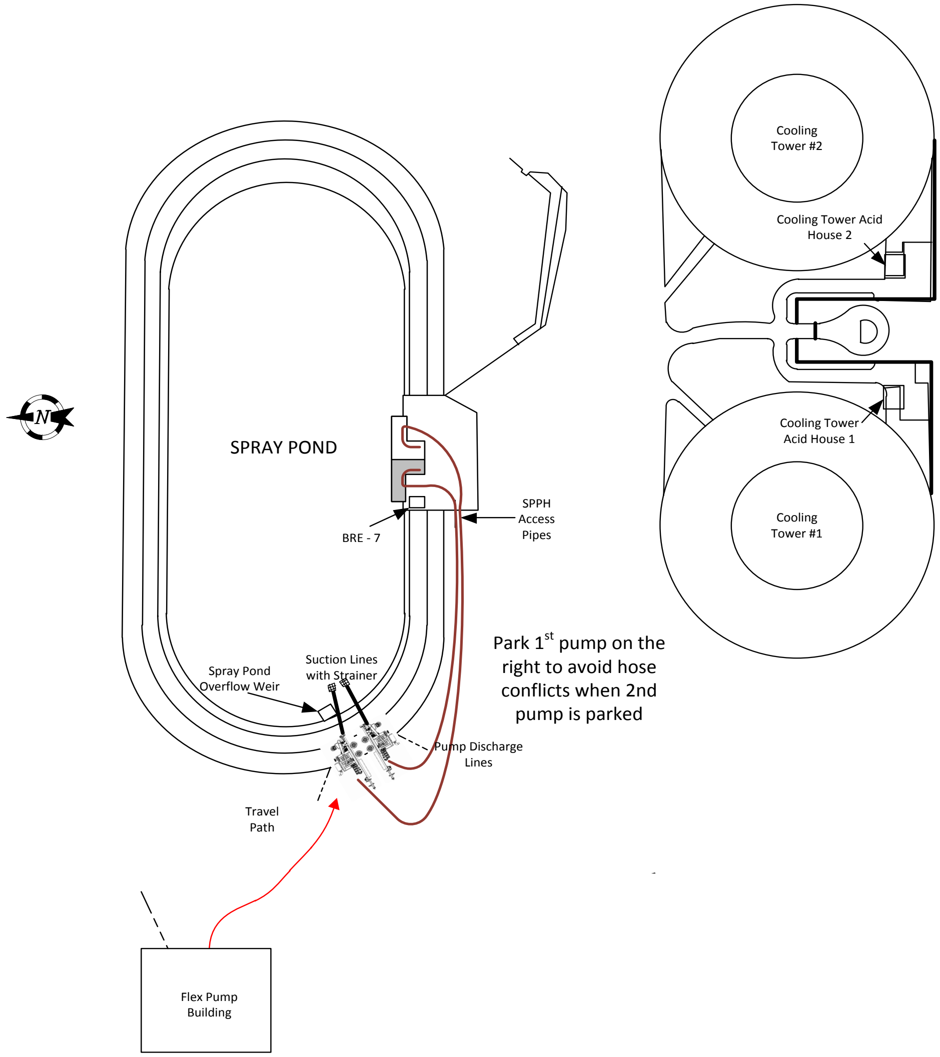

Figure 3 - FLEX Pump & Connection at SPPH

Access to the UHS water is provided through a new gate installed near the Spray Pond outlet weir. Hauling of the FLEX pumps from their storage location to the point of use is short and free of potential obstructions.

Engineering change package ECR 14-00013 (Reference 13) performed the design and analysis of the new piping and valves in the Spray Pond Pumphouse. ECR 14-00012 (Reference 14) developed calculation LM-0706 (Reference 15) that performed the hydraulic analysis of the portable diesel powered pumps and associated hose runs to confirm the system can deliver the required flow and pressures.

3.2.1 Hydraulic Analysis

The FLEX portable pumps are diesel engine driven, trailer mounted pumps that deliver a maximum flow of 1200 gpm at 227 psig. The FLEX Pump point of use is located near the Spray Pond outlet weir. The pumps use a 6" rigid lightweight suction hose lowered into the Spray Pond with a floating strainer attached. The FLEX pump discharges through 5" flexible discharge hose to the valves located in the Spray Pond Pump House.

The full hydraulic analysis is contained in Calculation LM-0706 (Reference 15). Below is a summary of the flow requirements per strategy:

Strategy	Flow	Basis
RPV Makeup	300 gpm	NEI 12-06 Rev. 0 Table C-1 (Reference 2)
Spent Fuel Pool Makeup	200 gpm	NEI 12-06 Rev. 0 Table C-3 (Reference 2)
Spent Fuel Pool Spray	250 gpm	NEI 12-06 Rev. 0 Table C-3 (Reference 2)

Figures 4 and 5 show the FLEX primary and alternate flow path for reactor and spent fuel pool makeup water strategies. The figures show Unit 1 (Unit 2 configuration is similar).

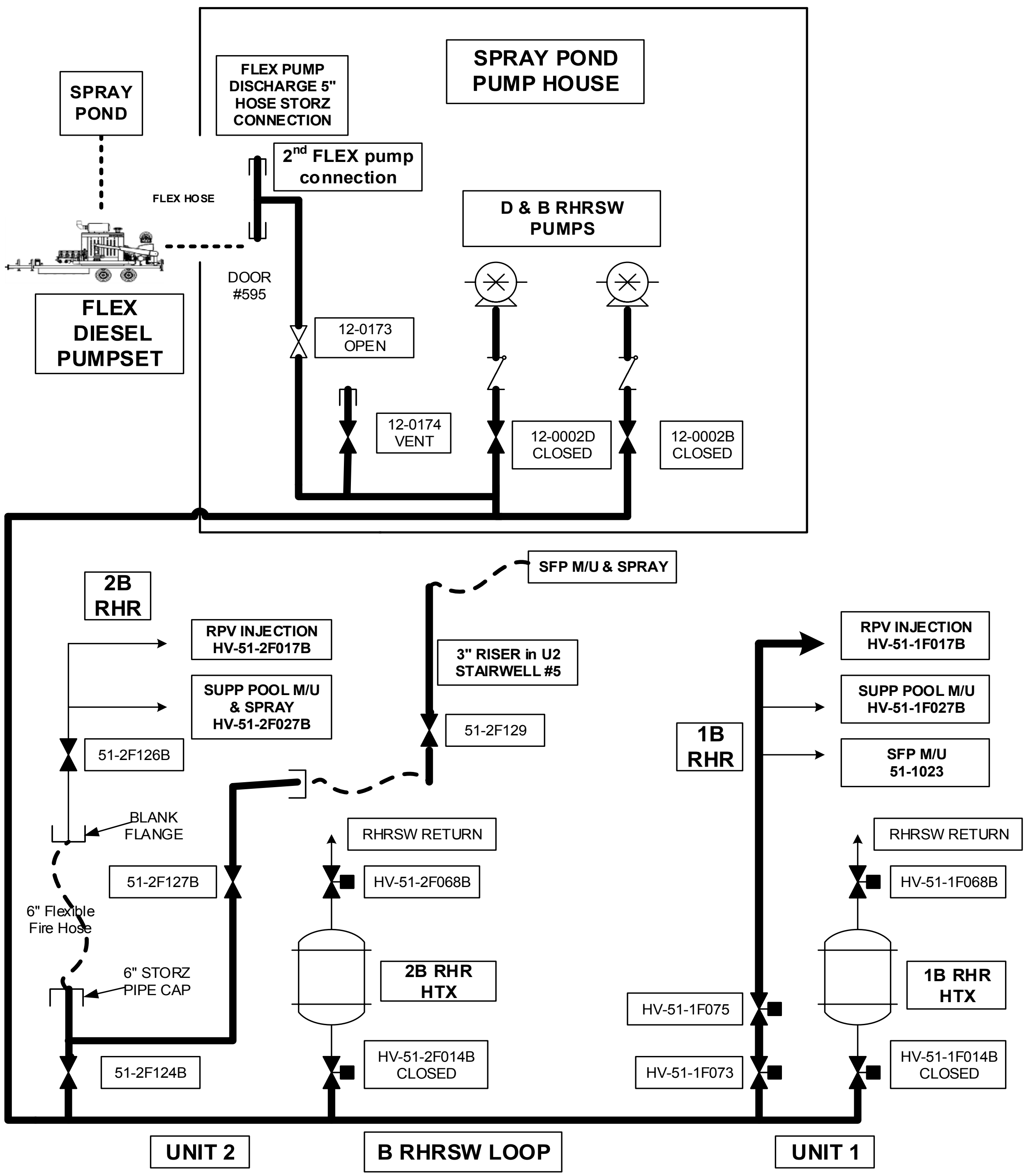

Figure 4 - FLEX Primary Water Strategy

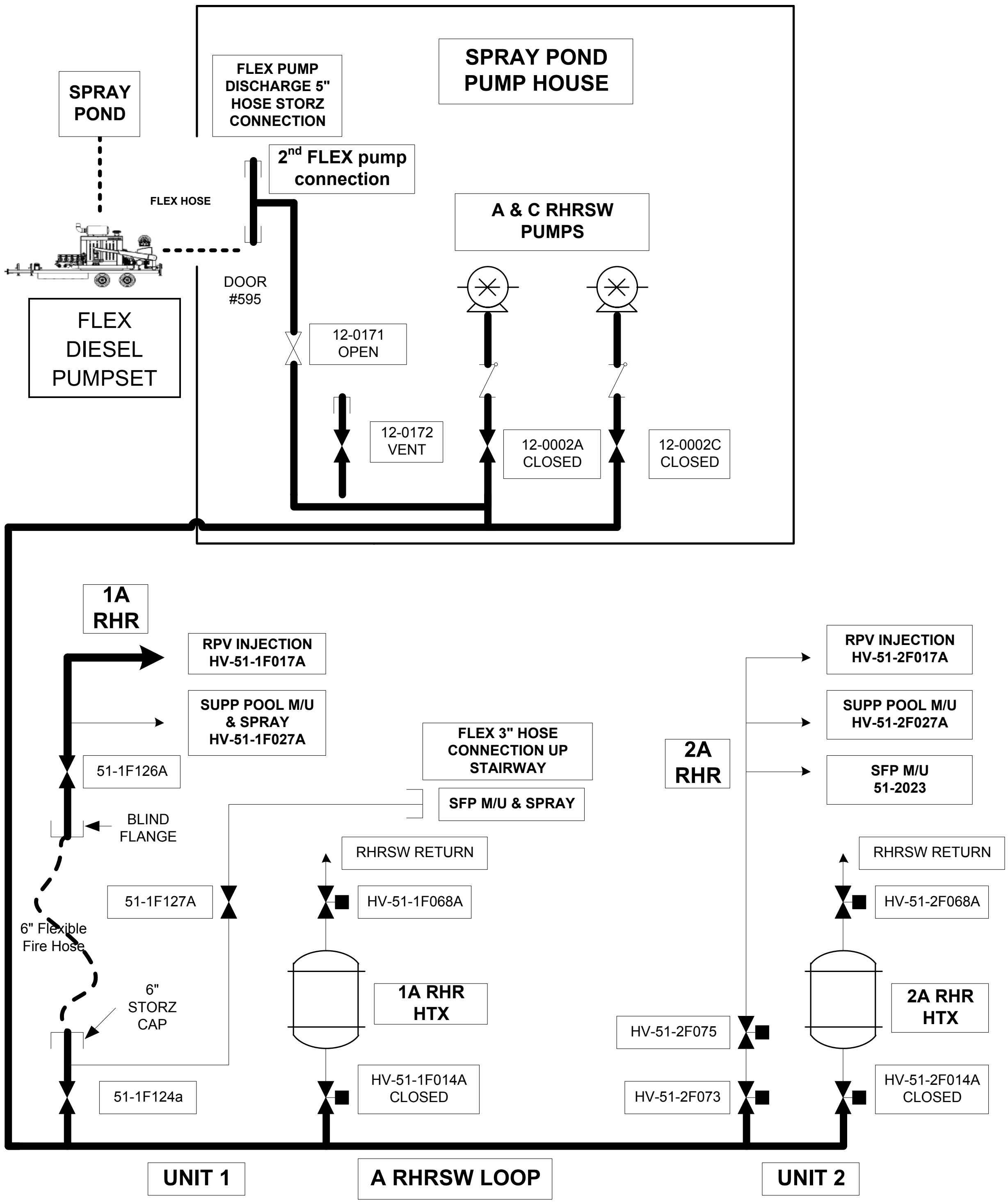

Figure 5 - FLEX Alternate Water Strategy

3.3 Reactor Core Cooling and Heat Removal

The FLEX strategy for reactor core cooling and decay heat removal is to run the RCIC system and provide makeup to the RPV for as long as decay heat can support RCIC operation. Safety Relief Valves (SRVs) will be cycled as needed for reactor pressure control. The RCIC injection source will be maintained for as long as possible, since it is a closed loop system using relatively clean suppression pool water. Decay heat rejected to the primary containment via the SRV discharge and RCIC exhaust to the suppression pool will be released to outside the Reactor Enclosure using the Hardened Containment Vent System (HCVS).

The containment integrity section of this plan will discuss a suppression makeup system lineup that provides a low pressure RPV makeup path to the suppression pool from the UHS. The need for suppression pool makeup occurs later following the event; however, low pressure RPV makeup from the UHS provided by the FLEX pump will be available by 6 hours after the event to ensure that reactor water level will remain above the Top of Active Fuel (TAF). The FLEX pump will be set up and remain in standby until RCIC is no longer available, at that time the transition to the FLEX pump will be made as directed by the EOPs.

3.3.1 Phase 1 Strategy

3.3.1.1 Power Operation, Startup, and Hot Shutdown

At the start of the SBO event (time = t_0) the reactor will scram as designed from the subsequent turbine trip on a load reject condition. Following a reactor scram, steam generation will continue at a reduced rate due to core fission product decay heat. In the event the reactor vessel is isolated, and the feedwater supply unavailable, SRVs will operate automatically to maintain reactor vessel pressure within desired limits. The water level in the reactor vessel will drop due to continued steam generation by decay heat. Upon reaching Reactor Vessel Water Level–Low Low, (-38", Level 2) the RCIC System will initiate automatically. RCIC can also be initiated manually from the Main Control Room or from the Remote Shutdown Panel (RSP). The HPCI system will also automatically initiate at the -38" level signal. The SBO procedure (E-1) directs the operators to promptly secure HPCI if it has auto started. GE Hitachi performed an evaluation titled NEDC-33771P Rev. 2 "GEH Evaluation of FLEX Implementation Guidelines" (Reference 17) that provided an initial review of the feasibility of BWR response to the ELAP event with RCIC running for an extended period. After determination by the operating crew that installed EDGs cannot be restarted and off-site power cannot be restored for a period greater than the SBO coping time (1 hour), the operating crew will determine the event is an ELAP and begin implementing the

FLEX strategies to cope with an ELAP event. It is assumed that this determination is made at some point in time after the event, but not longer than one 1 hour into the event. The overall coping time for core cooling in Phase 1 is 6 hours.

Fourteen (14) SRVs are installed on the main steam lines inside the drywell. The valves can be actuated in three ways: 1) five of the valves are part of the Automatic Depressurization System (ADS) logic and are equipped with a pneumatic accumulator and check valve arrangement. These accumulators are provided to ensure that the valves can be held open following loss of normal nitrogen supply to the accumulators, or 2) by mechanical actuation without power, or 3) manually from hand switches in the MCR.

The Primary Containment Instrument Gas (PCIG) system provides a safety-related long-term gas supply to the ADS SRVs, in the event that the non-safety related normal PCIG supply is unavailable. Two seismic Category 1 gas supplies (nitrogen bottles) are provided to assure the availability of the ADS valves for long-term operation. One set of gas bottles serves three ADS SRVs; another set serves the other two ADS SRVs. These long-term gas supplies have been designed to remain operable following a LOOP. Either set of bottles supplies the ADS SRVs with sufficient nitrogen for seven days of operation and are connected at all times during normal operation. These nitrogen bottles can be replaced with fresh bottles if a sustained supply of gas to the ADS valves is required beyond the 7 day supply.

The Suppression Pool provides a heat sink for steam relieved by these valves. SRV operation may be controlled manually from the control room to hold the desired reactor pressure. Each SRV can be actuated from one of two installed DC solenoid valves which open to supply pneumatic pressure to the valve operating piston. The suppression pool is vented via the HCVS to remove decay heat from the containment and to limit Suppression Pool temperatures. During Phase 1, reactor vessel makeup is provided from RCIC with suction from the suppression pool and reactor vessel pressure control is provided by the SRVs. Since these loads on the Division 1 battery, shedding of non-essential loads on the battery are performed to extend the DC coping time to over 7 hours.

Following stabilization of the plant after the event, a reactor cooldown is commenced at a rate not exceeding the 100°F/hr TS limit. Reactor pressure is maintained in the 200 to 300 psi range to preserve the steam driven RCIC turbine operation until RCIC operation is no longer viable. When RCIC operation is no longer viable, reactor pressure is further lowered so that the Phase 2 FLEX pumps can inject.

3.3.1.2 Cold Shutdown and Refueling

The overall strategy for core cooling for Cold Shutdown and Refueling are, in general, similar to those for Power Operation, Startup, and Hot Shutdown.

If an ELAP occurs during Cold Shutdown, water in the RPV will heat up. When temperature reaches 212°F the RPV will begin to pressurize. During the heat up, RCIC can be returned to service, or SRVs can be opened to prevent reactor heat-up and re-pressurization. During Refueling, many variables impact the ability to cool the core. In the event of an ELAP during Refueling, there are no installed non-electric plant systems to provide makeup water to cool the core. Thus, the deployment of Phase 2 equipment will begin immediately. To accommodate the activities of RPV disassembly and refueling, water levels in the RPV and the reactor cavity are often changed. The most limiting condition is the case in which the reactor head is removed and water level in the RPV is at or below the reactor vessel flange. If an ELAP/LUHS occurs during this condition then (depending on the time after shutdown) boiling in the core may occur in a relatively short period of time.

Per NEI Shutdown/ Refueling Position Paper (Reference 18) endorsed by the NRC (Reference 19), pre-staging of FLEX equipment can be credited for some predictable hazards, but cannot be credited for all hazards per the guideline of NEI 12-06. Deployment of portable FLEX pumps to supply injection flow should commence immediately from the time of the event. This is possible because more personnel are on site during outages to provide the necessary resources. During outage conditions, sufficient area and haul paths must be maintained in order to ensure FLEX deployment capability is maintained. See Section 10, "Shutdown and Refueling Analysis" of this document for more detailed information on Shutdown and Refueling conditions.

3.3.2 Phase 2 Strategy

A portable 480 VAC FLEX generator for each unit will be transported to an area south of the Reactor Enclosure and connected to the Division 1 AC distribution system to repower the Division 1 battery charger and enable the continued use of RCIC, SRVs, and vital instrumentation. Once the Division 1 battery chargers are restored to service, the FLEX generator will be connected to Division 2 battery chargers to ensure continued availability of vital instruments.

To accomplish low pressure RPV makeup when RCIC is no longer available, two diesel driven portable pumps (FLEX pumps, one per unit) will take suction on the Spray Pond and discharge into the RHRSW System, which is cross-connected to the respective unit’s

RHR System. The RHRSW system is safety-related and designed to normally supply cooling water to the RHR heat exchangers for both units. The system is common to the two units and consists of two independent trains. Each train services one RHR heat exchanger in each unit, and provides sufficient cooling for safe shutdown, cooling, and accident mitigation of both units. The RHRSW system can be cross-connected to the RHR system through existing piping on one loop of each unit. Original plant design allows the RHRSW B train to be cross-connected to the Unit 1 RHR B train, and allows the RHRSW A train to be cross-connected to the Unit 2 RHR A train. Injection into the Unit 1 RHR B train and the Unit 2 RHR A train provides RPV injection, makeup to the spent fuel pool and makeup to the Suppression Pool if required.

The injection valves for these systems are located outside the primary containment and can be operated manually with the handwheel or electrically via the FLEX generator if partial AC power on Division 1 or 2 has been restored.

RPV pressure will be further reduced with SRVs to achieve the flow rate necessary from the external water connection. The external connection is capable of meeting the decay heat boil-off rate specified in NEI 12-06, plus the maximum system leakage from reactor recirculation pump seals.

In Phase 2, containment integrity is maintained by normal design features of the containment and by venting the suppression pool using the HCVS system. Suppression pool temperature will be limited by controlling suppression pool pressure. Containment venting will prevent approaching containment pressure limits.

3.3.2.1 <u>Preferred RPV Make Up</u>

RCIC is the preferred RPV makeup system for as long as RCIC operation is viable. At Limerick, the suppression pool peak temperature during first 6 hours of the ELAP/LUHS is below the temperature that challenges long-term RCIC operation Reference 16).

As part of the overall ELAP effort, the Boiling Water Reactor Owners Group (BWROG) had General Electric Hitachi (GEH) evaluate RCIC turbine and pump mechanical components assuming pump suction from the suppression pool at elevated temperatures (Reference 21). The evaluation concluded that except for the turbine journal bearings and the pump seal, the mechanical components would remain functional with a pool temperature up to 300°F and a seven (7) day mission time. In a separate document the BWROG and GEH concluded that there is no expectation of loss of functionality based on the Babbitt material on the surface of the turbine journal bearings and the RCIC pump bearing with suppression pool temperature below 215°F (Reference 22). Exelon prepared position paper EXC-WP-10, "RCIC Operation at elevated Temperatures" (Reference 28), summarizing the various Industry studies performed that concluded RCIC could be run at higher than normal design temperatures. The MAAP analysis (Reference 16) of the FLEX containment strategy shows with containment venting starting about hour 3, peak suppression pool temperatures reach ~225°F at hour 6.

The expanded RPV level control band of TAF (-161") to +118” in procedure T-101 RPV Control (Reference 23) encompasses a wide variety of circumstances, including ELAP. During an ELAP, RPV water level will normally be maintained between +12.5” and Level 8 (+54”) provided FLEX equipment is available and operates as expected. The primary Phase 2 strategy discussed below, is capable of providing makeup to the RPV before steam pressure to RCIC is lost, allowing for a controlled transition of RPV level control from RCIC to FLEX equipment.

After RCIC is no longer available the preferred injection path for Unit 1 is from the UHS to RHRSW B Loop and into the 1B RHR system for injection to the reactor core. For Unit 2 the flow path is from the UHS to RHRSW A Loop and into the 2A RHR system for injection to the reactor core. These paths were selected as preferred since the in-plant alignment is performed via a valve lineup only and no temporary hoses being required.

3.3.2.2 Alternate RPV Make Up

If the primary RPV makeup strategy connection points are unavailable the alternate connection points can be used, these points use the opposite loop of RHR. For Unit 1 this from the UHS to RHRSW A Loop and into the 1A RHR system for injection to the reactor core. For Unit 2 the flow path is from the UHS to RHRSW B Loop and into the 2B RHR system for injection to the reactor core. These paths were selected as alternates because the equipment operators must install a 25 foot section of 6" hose between the RHR and RHRSW systems.

3.3.3 Phase 3 Strategy

The Phase 3 strategy is to continue to use the Phase 2 connections, both mechanical and electrical, and to only use the Phase 3 portable pumps and AC generator power if necessary. The Phase 3 equipment will act as backup or redundant equipment to the Phase 2 portable equipment and is deployed from an off-site facility and delivered to Limerick Generating Station. The off-site facility supplying this equipment is the National SAFER Response Center (NSRC) through executed contractual agreements with Pooled Equipment Inventory Company (PEICo). The NSRC will support initial portable FLEX equipment delivery to the site within 24 hours of a request for deployment per the Limerick

SAFER Response Plan (Reference 24). The Limerick SAFER Response Plan defines the actions necessary to deliver pre-specified equipment to Limerick Generating Station. The designated local offsite staging area C for Limerick is the Exelon Powerlabs in Coatesville PA. Equipment will be staged at staging area C to support deliveries of the SAFER equipment to Limerick Generating Station. Sufficient resources will be available, at the times required for Phase 3 implementation.

No plant modifications have been installed to support mitigating strategies for Phase 3. The connection of the majority of Phase 3 equipment can be made to connection points established for Phase 2 equipment and strategies. The remaining Phase 3 non-redundant equipment will be deployed as needed utilizing field established connections, without the reliance on plug and play type modifications. Other Phase 3 equipment that is not a backup or redundant to Phase 2 can be applied towards recovery efforts. The Emergency Response Organization (ERO) will need to develop plans on how to use this equipment to support recovery efforts. Depending on plant damage conditions this may require procurement of connection supplies and modifications to Limerick Structure Systems and Components (SSCs).

3.3.4 Systems, Structures, Components

3.3.4.1 Reactor Core Isolation Cooling

The RCIC system is designed to assure that sufficient reactor water inventory is maintained in the reactor vessel thus assuring continuity of core cooling. RPV water is maintained or supplemented by the RCIC during the following conditions:

(1) When the RPV is isolated and maintained in the hot standby condition;

(2) When the RPV is isolated and accompanied by a loss of normal coolant flow from the reactor feedwater system;

(3) When a complete plant shutdown under conditions of loss of normal feedwater system is started before the reactor is depressurized to a level where the reactor shutdown cooling mode of the RHR system can be placed into operation.

When actuated, the RCIC system pumps water from either the condensate storage tank or the suppression pool to the RPV. For an SBO or ELAP condition the suppression pool must be used as the water source and if RCIC has not automatically swapped to the Suppression Pool, the operators are directed by procedure E-1 to make the swap. The required valves are DC powered and located in the reactor building where they are protected from all events. To prevent foreign objects in the suppression pool from entering the RCIC flow path, a strainer is located on the RCIC pump suction line in the suppression pool.

The RCIC system includes one turbine-driven pump, automatic valves, control devices for this equipment, and sensors and logic circuitry.

The RCIC logic is powered by the 125 VDC Division 1 system. Some RCIC components are powered by Division 3 DC, power, but are not critical for the system to operate. The motive power for inboard steam isolation valves is Division 3 standby AC power, while outboard steam isolation is Division 1 standby AC power. The AC driven containment isolation valves are normally open and are expected to remain open following the onset of the ELAP/LUHS. The remaining valves are driven by the Division 1 DC system.

The RCIC system automatic trips are directed to be defeated by T-101, RPV control to ensure RCIC remains in service.

3.3.4.2 Batteries

The safety related batteries and associated DC distribution systems are located within safety related structures designed to meet applicable design basis external hazards and will be used to initially power required key instrumentation and applicable DC components required for monitoring RPV level and RCIC operation. Within 120 minutes of ELAP/LUHS event onset, load shedding of non-essential equipment will be completed. This provides an estimated total battery service time of approximately 7:25 hours for the Division 1 batteries and 14:30 hours for the Division 2 batteries. This allows sufficient time to setup the FLEX generators and reenergize the battery chargers.

3.3.5 Key Reactor Parameters

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

- Wide Range RPV Level: LI-42-1R604 (U1), LI-42-2R604 (U2)
- Fuel Zone RPV Level: LI-42-1R610 (U1), LI-42-2R610 (U2)
- RPV Pressure: PI-42-1R605 (U1 Wide Range), PI-42-2R605 (U2 Wide Range)
- RPV Pressure: PI-49-1R602 (U1), PI-49-2R602 (U2)
- Drywell Temp: TE-57-122 (U1), TE-57-222 (U2) (read by TC Calibrator)
- Drywell Pressure: PI-42-170-1 (U1), PI-42-270-1 (U2),

- Suppression Pool Level: LI-52-140A (U1), LI-52-240A (U2)
- Suppression Pool Temp: TI-41-102 (U1), TI-41-202 (U2) (RSP)

The above instrumentation is available prior to and after DC load shedding of the DC busses during SBO/ELAP response procedure implementation for up to 7:25 hours (Division 1). Availability after 7:25 hours is dependent on actions to restore AC power to the Division 1 Battery Chargers.

In the unlikely event that battery chargers are damaged and non-functional rendering key parameter instrumentation unavailable, alternate methods for obtaining the critical parameters locally is provided in FLEX procedure T-370, Primary and Alternate Instrumentation during ELAP (Reference 68).

3.3.6 Thermal Hydraulic Analysis

MAAP computer code was used to simulate the Extended Loss of AC Power (ELAP) event for Limerick and is an acceptable method for establishing a timeline which meets the intent of NRC Order EA-12-049 (Reference 1). The graph in Figure 6 below uses data from the MAAP case of record (Case FLEX22) (Reference 16) and illustrates that RPV level remains above TAF using RCIC for RPV makeup during the first 6 hours of the event, and that RPV level is stabilized with RPV pressure in the 150 – 250 psig pressure band after a partial reactor blowdown (Figure 7). The 6 hour period was selected based on sufficient time to ensure the FLEX pumps can be setup to replace RCIC if required. RCIC will continue to be operated as long as possible and the transition to FLEX will only occur when RCIC is no longer available.

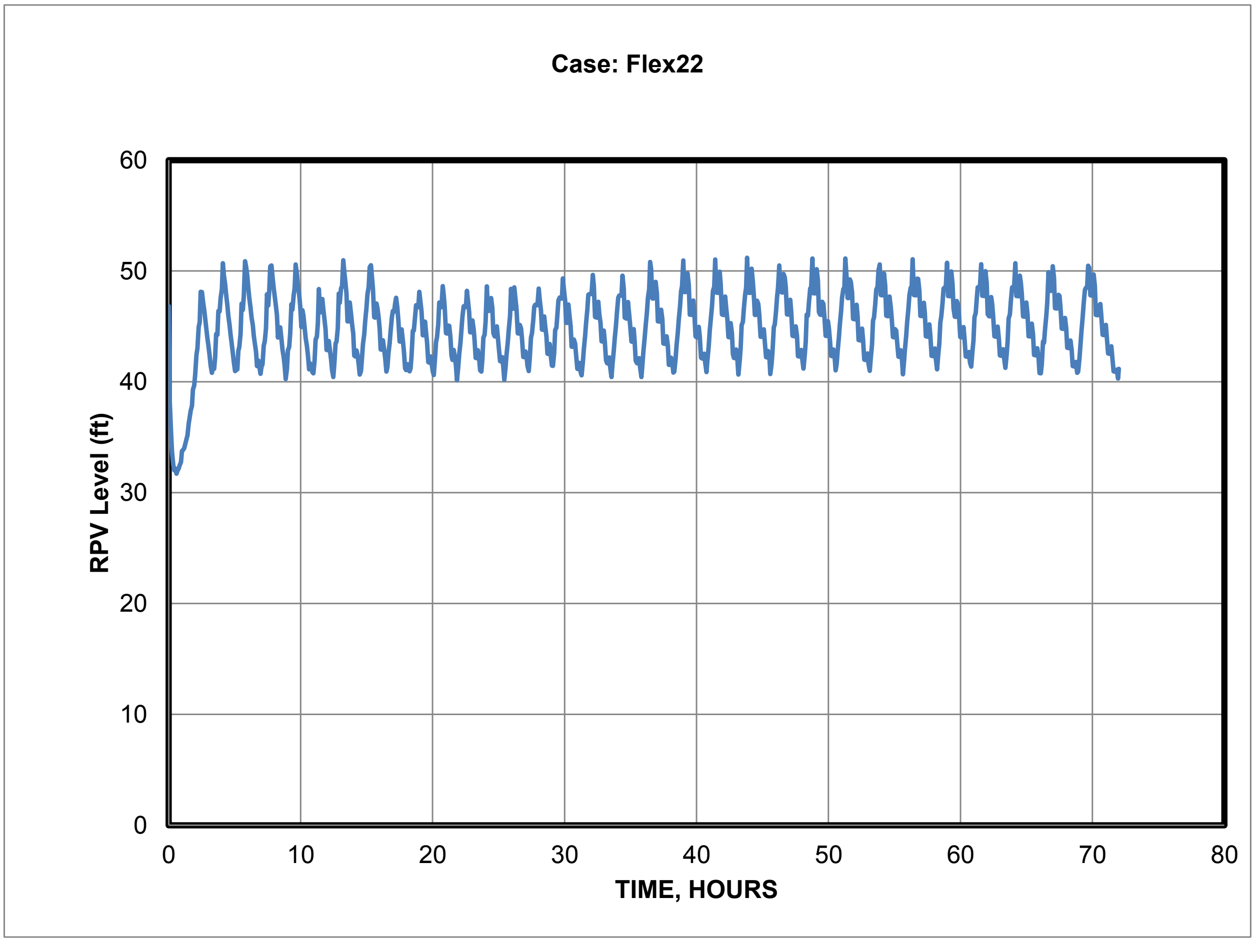

Figure 6 - RPV Level – First 6 Hours

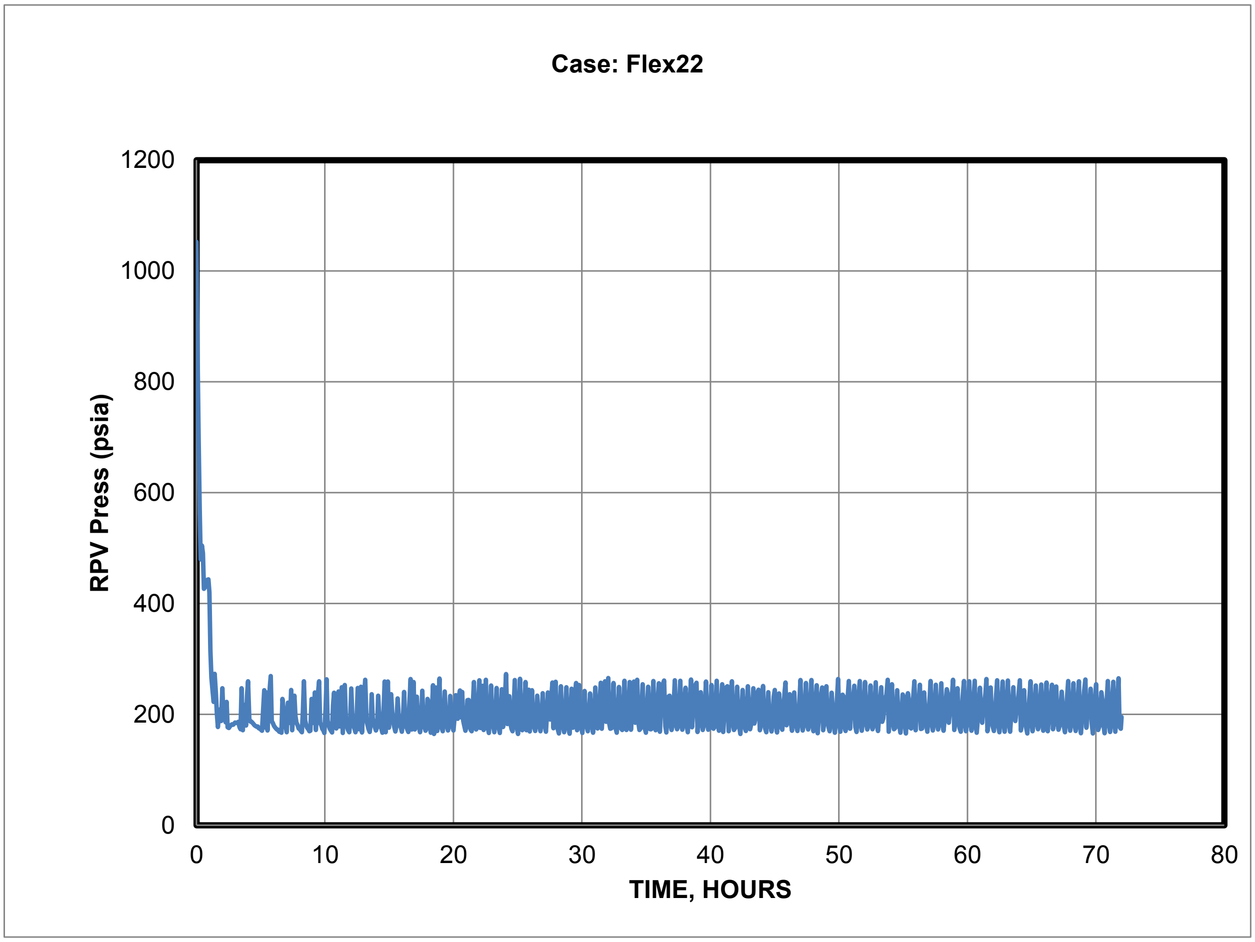

Figure 7 - RPV Pressure – First 6 Hours

3.3.7 Reactor Coolant System Leakage

A reactor coolant system leakage rate of 36 gpm from the recirculation pump seals was assumed in the ELAP MAAP analysis. This is consistent with existing Limerick SBO licensing bases and conservative relative to NUMARC 87-00 Rev. 1 requirements (Reference 25).

3.4 Containment Integrity

During an ELAP event, suppression pool temperature rises as the SRVs relieve RPV pressure to the suppression pool and operators conduct a forced cooldown with SRVs. RCIC will be used for RPV level control and the turbine exhaust adds heat to the pool. As suppression pool temperature rises, containment pressure will rise in kind.

The HCVS is designed and installed (Reference 72) and (Reference 73) to meet the operational requirements of NRC Order EA-13-109 (Reference 26). The HCVS system is placed in service locally in the Emergency Diesel Corridor 217' elevation at the Remote Operating Station (ROS) by opening the argon bottle and air bottle isolation valves. The HCVS rupture disc is burst using argon. The HCVS system is normally operated from the Main Control Room at Panels 10-C689 and 20-C689, but can be operated locally from the ROS. Pneumatic supply to valves and DC power for instrumentation and controls are provided by air bottles and an HCVS battery located in the diesel corridor. Both are capable of supporting system operation for at least 24 hours with no operator intervention.

3.4.1 Phase 1

During Phase 1, containment integrity is maintained by normal design features of the containment, such as the containment isolation valves. In accordance with NEI 12-06, the containment isolation actions delineated in the SBO procedure are sufficient.

RPV pressure will be gradually reduced with SRVs to approximately 200-300 psig while the suppression pool has sufficient heat capacity to absorb a portion of the sensible heat in the reactor. RPV pressure will be controlled between 200 – 300 psig. Decay heat will continue to heat up the suppression pool during the initial phase through RCIC exhaust and SRV operation.

Suppression Pool level and temperature instruments remain available during Phase 1 since they are powered from Division 1 DC. Drywell pressure instrumentation remains available since it is powered from Division 2 DC.

3.4.2 Phase 2

During Phase 2, the 480 VAC FLEX generator will be lined up to the Division 1 and Division 2 AC distribution systems to repower the battery chargers and sustain key DC instrumentation.

Suppression pool water addition is required later during the event to ensure the down comers remain submerged thus maintaining the pressure suppression capacity of the suppression pool. The suppression pool level band specified in T-102, Primary Containment Control (Reference 27) allows the operators to maintain level in the acceptable range. The valves that require manipulation for suppression pool makeup are located outside the primary containment and can be operated manually with the handwheel or electrically via the FLEX generator and partial repowering of selected AC buses.

3.4.3 Phase 3

The Phase 3 strategy for Containment Integrity is the same as described above for Phase 3 Reactor Core Cooling and Heat Removal using Phase 3 equipment to act as backup or redundant equipment to the Phase 2 portable equipment.

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3.4.4 Key Containment Parameters

The following instrumentation is available prior to and after DC load shedding of the DC busses during SBO/ELAP response procedure implementation for up to 7:25 hours. Availability after 7:25 hours is dependent on actions to restore AC power the Division 1 Battery Chargers using a FLEX generator.

- Drywell Temp: TE-57-122 (U1), TE-57-222 (U2) (read by TC Calibrator)
- Suppression Pool Level: LI-52-140A, LI-52-240A
- Suppression Pool Temp: TI-41-102 (U1), TI-42-202 (U2) (remote shutdown panel)

Availability for Drywell Pressure after 14:30 hours is dependent on actions to restore AC power the Division 2 Battery Chargers using a FLEX generator.

- Drywell Pressure: PI-42-170-1 (U1), PI-42-270-1 (U1), (Div 2)

In the unlikely event that battery chargers are damaged and non-functional rendering key parameter instrumentation unavailable, alternate methods for obtaining the critical parameters locally is provided in FLEX Support Guide T-370, Primary and Alternate Instrumentation during ELAP (Reference 68).

3.4.5 Thermal-Hydraulic Analyses

The MAAP computer code was used to simulate the Extended Loss of AC Power (ELAP) event for Limerick and is an acceptable method for establishing a timeline which meets the intent of NRC Order EA-12-049 (Reference 1). Several Limerick Modular Accident Analysis Program (MAAP) cases were run to analyze methods of containment heat removal using anticipatory containment venting with various size vents. The MAAP cases indicate that anticipatory venting will maintain margin to the primary containment design pressure limit.

The following time constraints were used as MAAP input parameters, or were identified in the FLEX operational strategy. MAAP Case FLEX22 from LG-MISC-012 is a set of conditions close to the LGS vent size. The HCVS detailed engineering design verified the vent size is adequate.

- RPV pressure is reduced using 1 SRV when Suppression pool temperature reaches 160°F and the reactor is depressurized to approximately 200 psi.
- Suppression Pool Heat Capacity Temperature Limit (HCTL) is reached approximately 3 hours post event. A partial Emergency Depressurization is performed per LGS T-102, Primary Containment Control (Reference 27).

The MAAP Case FLEX22 results are summarized below and shown graphically in Figure 8 MAAP Containment Results.

Peak SP Temp (°F)	225 (approx. hour 10)
SP Level (ft)	Min=9 (hr 70), Max=23 (T=0)
Peak Drywell Airspace Temp (°F)	240 (approx. 60 hours)
Peak Drywell Airspace Press (psia)	21 psia (when venting commenced)

3.4.6 Impact of Elevated Containment Temperatures

The Limerick MAAP scenario results indicate that at t_0 + 72 hours conditions in the drywell (i.e., pressures and temperatures) have either stabilized or are in a downward trend. Continued operation of the vent and lowering decay heat in the reactor will prevent further rises in drywell pressures and temperatures.

3.4.6.1 Equipment Environmental Concerns

USFAR Section 6.2.1.1.3.1 discusses the design value for drywell temperature as well as the calculated post-accident temperature being 340°F. The LGS MAPP runs showed the peak drywell air temperature for a FLEX event reaching approximately 240°F. Since post-accident drywell temperatures exceed the MAPP run values for a FLEX event, no further review was required.

The specific equipment items within the drywell of concern to FLEX strategy success include:

- SRV solenoids located in the drywell
- SRVs located in the drywell

3.4.6.2 Suppression Pool Temperature Concerns

The MAAP analysis discussed above indicates a peak suppression pool water temperature that slightly exceeds the Updated Final Safety Analysis Report (UFSAR) design temperature maximum temperature. This temperature is exceeded after the 6 hour period that the LGS FLEX strategy relies on RCIC for. The BWROG had General Electric Hitachi (GEH) evaluate RCIC turbine and pump mechanical components assuming pump suction from the suppression pool at elevated temperatures. The evaluation concluded that except for the turbine journal bearings and the pump seal, the mechanical components would remain functional with a pool temperature up to 300°F and a 7 day mission time.

RCIC Suction and Discharge Piping

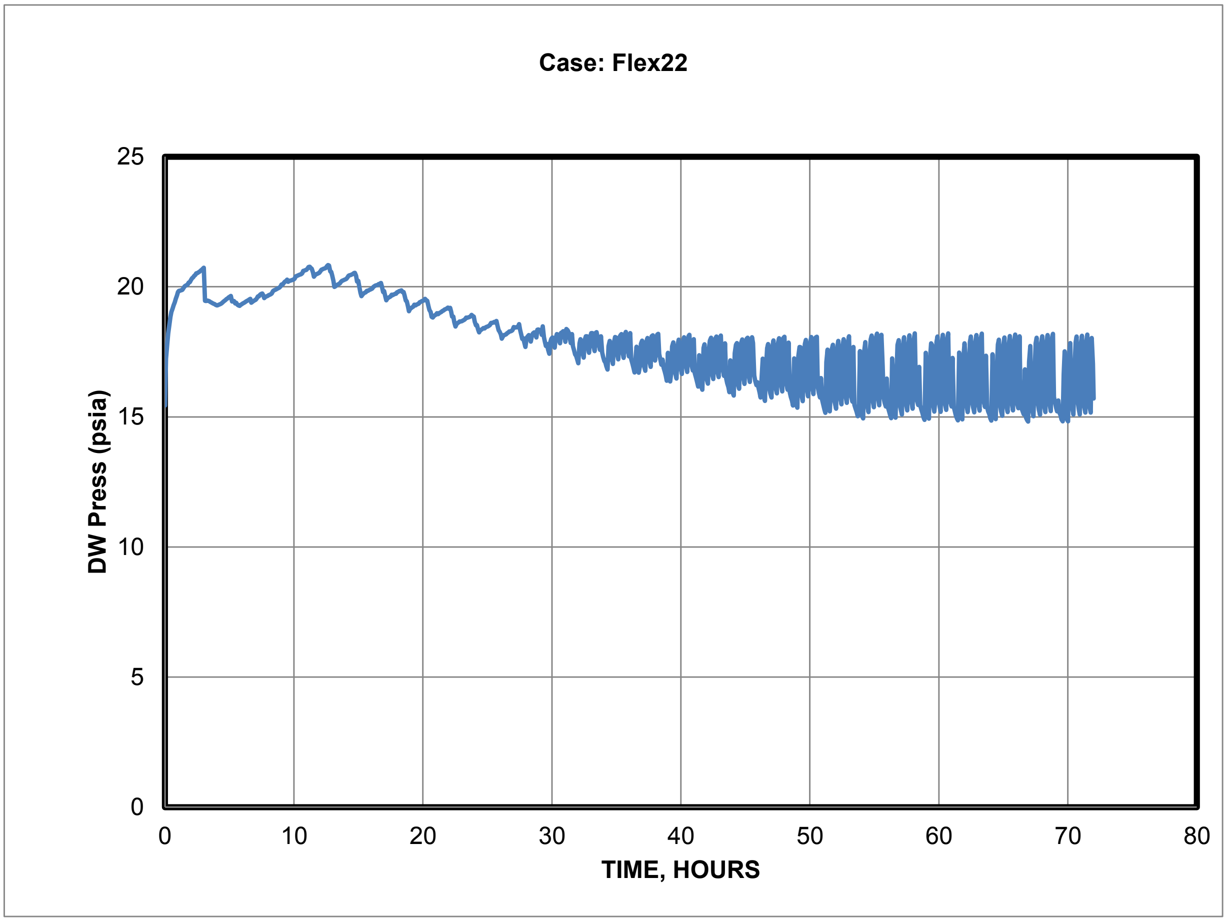
The RCIC suction and discharge piping design temperature is 170°F. Tech Eval 1550669-11 (Reference 74) evaluated the impact on this piping for water temperatures up to 250°F. This evaluation concluded that the RCIC suction and discharge piping and supports can withstand the additional thermal loading due to 250°F suppression pool temperature. The RCIC steam piping is excluded since the steam conditions will not exceed the current design basis piping will not exceed its design basis parameters.

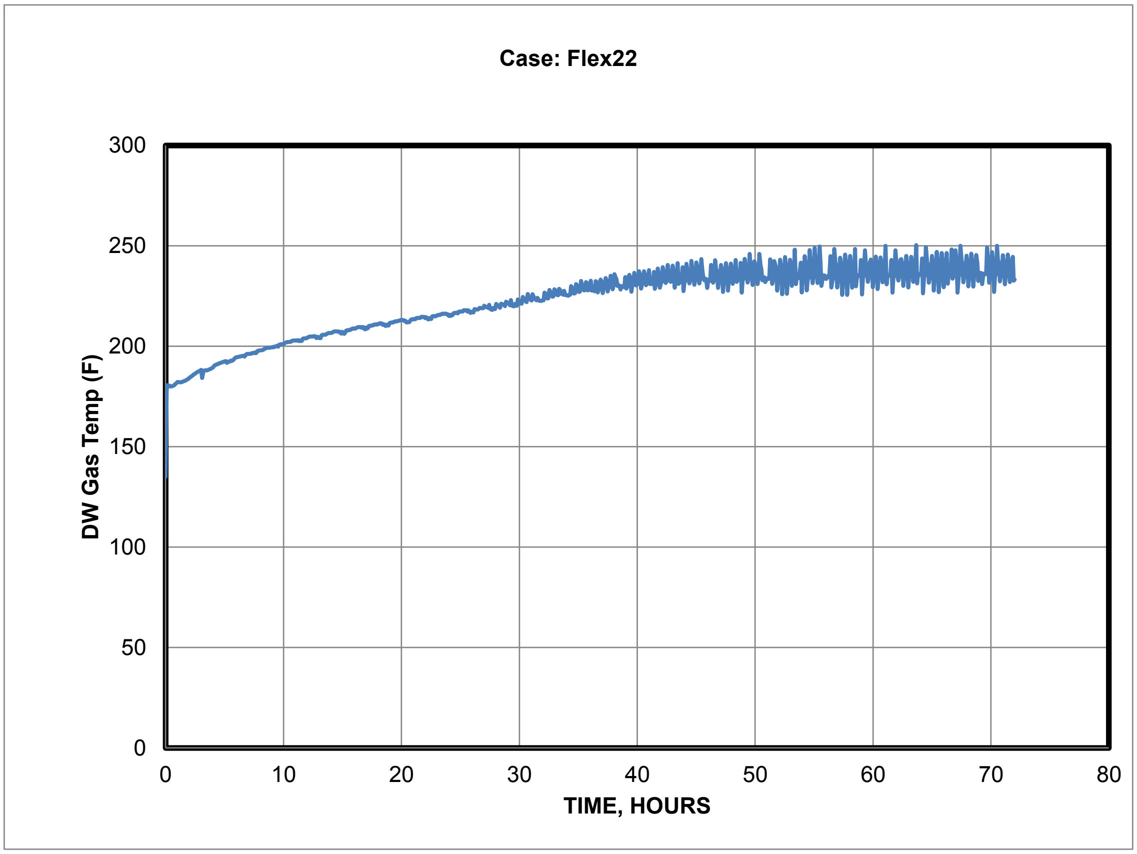
Suppression Pool Temperature Monitoring

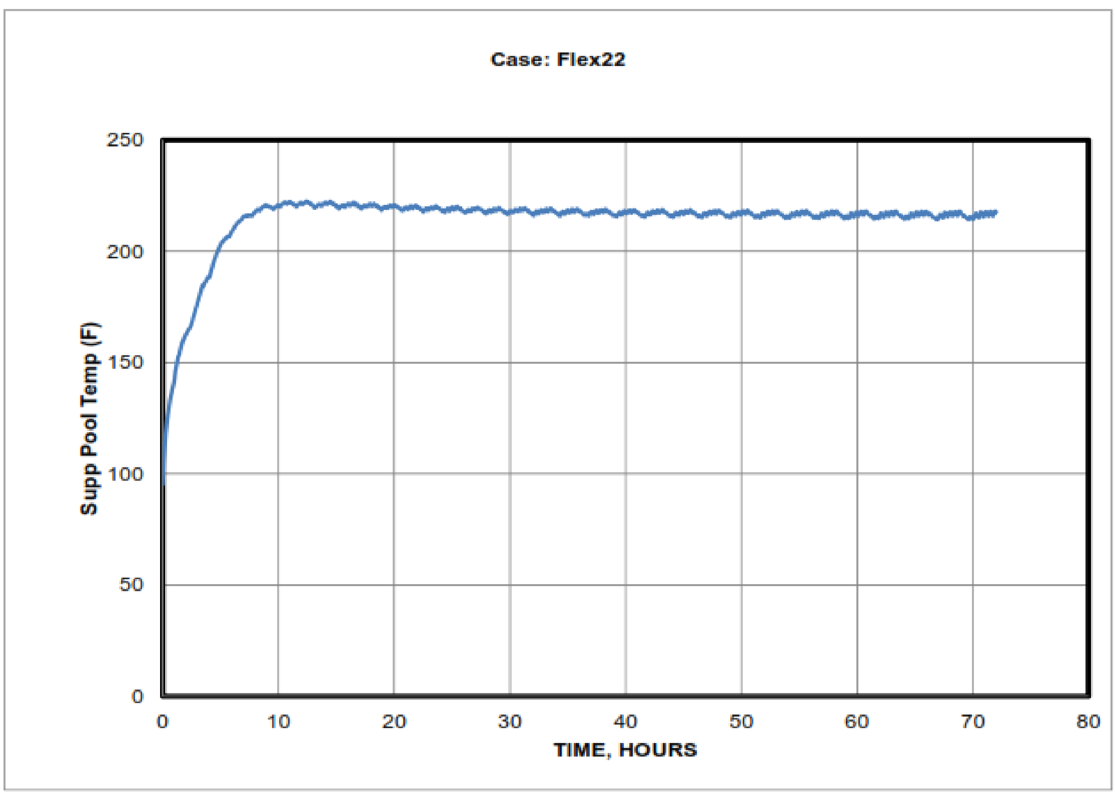
Resistance Temperature Detector (RTDs) in the suppression pool are used to monitor temperature. These temperature elements were qualified to the more severe drywell temperature profiles under normal and design basis accident conditions. Thus, these elements will not be adversely affected by the elevated suppression pool temperature.

Conclusion

Even with an elevated temperature beyond the normal suppression pool temperature following a BDBEE, the Suppression Pool and RCIC temperatures will be acceptable.


Case: Flex22
DW Press (psia)
TIME, HOURS
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80


Case: Flex22
DW Gas Temp (F)
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
TIME, HOURS


Case: Flex22
Supp Pool Temp (F)
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
TIME, HOURS

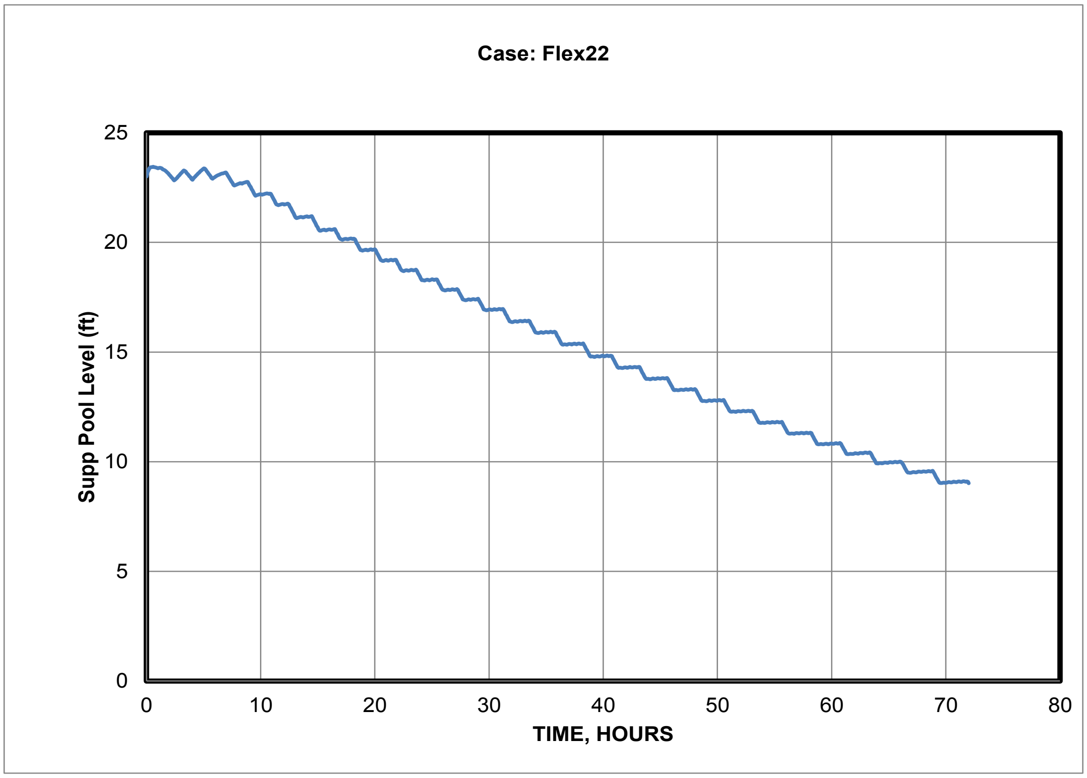


Figure 8 - MAAP Containment Results (4 graphs)

3.5 Spent Fuel Pool Cooling/Inventory

The Limerick SFP is a wet spent-fuel storage facility located on the Refuel Floor located inside a separate second secondary containment zone, above the Unit 1 and 2 Reactor Buildings. The pool provides underwater storage space for the reactor spent fuel assemblies which require shielding and cooling during storage and handling. The normal makeup water source is demineralized water, the safety related makeup water source to the SFP is from the Emergency Service Water (ESW). The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water to the SFP sufficient to maintain substantial radiation shielding for a person standing on the SFP operating deck and cooling for the spent fuel.

3.5.1 Phase 1 Strategy

There are no Phase 1 actions required. The FLEX strategy during Phase 1 of an ELAP/LUHS event for SFP cooling is to utilize the SFP water level instrumentation installed in response to NRC Order EA-12-051 to monitor the SFP water level. Within the first 6 hours, setup activities will commence to stage and setup a FLEX portable diesel driven pump for the addition of makeup water to the reactor. These setup activities also support preparation for SFP makeup when it is needed in order to restore and maintain the normal level in Phase 2. During the Phase 1 period, operators will perform T-346, Refuel Floor alignment for SFP Makeup, Spray and Ventilation (Reference 65) to set up the required hoses on the Refuel Floor prior to the fuel pool boiling and creating poor environmental conditions on the Refuel Floor. This procedure also directs opening doors to the South Stack to release some heat and steam.

3.5.2 Phase 2 Strategy

After the SFP reaches the boiling point and inventory begins to boil away, a source of makeup water will need to be provided to ensure the fuel in the SFP remains cool and radiological conditions on the fuel handling floor do not degrade. With the ELAP event in progress the normal seismically qualified Emergency Service Water makeup supply system will not be available to supply water to the SFP due to the ELAP. One of the two FLEX strategies will be used as described below.

The primary FLEX SPF makeup strategy is to use the B RHR system for Unit 1 (and A RHR for Unit 2). Once B RHR is pressurized as part of the FLEX reactor makeup strategy two options are available, a short flexible hose jumper is installed per T-322, SFP Makeup and spray From Spray Pond (Reference 66) to cross connect B RHR piping to the SPF cooling return to the SPF for Alternate Decay Heat Removal (ADHR). Alternatively, a combination of hoses and standpipe can be used to connect to the Unit 1 A RHR (Unit 2 B RHR) system at elevation 201 ft. in the RHR Heat Exchanger room and via the stair tower to supply water to the SPF.

Either route through stairtower #3 or #5 can supply direct makeup or supply monitor nozzles staged on the Refuel Floor to provide the SFP with spray capability. Two oscillating monitor nozzles are staged on the refuel floor that can be used to spray one or both fuel pools, additional nozzles are available on the B.5.b hose trailer (stored in a protected location).

3.5.3 Phase 3 Strategy

Phase 3 Strategy is to continue with the Phase 2 methodologies using a FLEX Pump. Additional High Capacity Pumps will be available from the NSRC as a backup to the on-site FLEX Pumps.

3.5.4 Structures, Systems, and Components

The Fuel Pool Cooling and Cleanup (FPC) System is designed to remove decay heat generated by the spent fuel assemblies from the SFP water. The FPC System is also designed to clarify and purify the spent fuel pool.

The SFP is designed for the underwater storage of spent fuel assemblies and control rods after their removal from the reactor. Maintaining an adequate water level in the SFP ensures the integrity of the spent fuel racks and decreases the radiation dose rate in the area around the pool.

3.5.5 Key SFP Parameters

The key parameter for the SFP Make-up strategy is the SFP water level. The SFP water level is monitored by the instrumentation that has been installed in response to Order EA-12-051, Reliable Spent Fuel Pool Level Instrumentation (Reference 4) and complies with the industry guidance provided by the Nuclear Energy Institute guidance document NEI 12-02 (Reference 5). Prior to installing this system, the SFP level monitoring system was composed of level switches that provide a signal to an alarm in the MCR when the water level in the SFP reaches either the hi or low alarm setpoint. This instrumentation system did not meet the requirements set forth under NRC Order EA-12-051.

Since the LGS spent fuel pools are separate pools for each unit, but normally cross connected the Spent Fuel Pool Level Indication (SFPLI) modification installed one instrument in each pool and they back each other up as primary and alternate channels. In the unlikely event that the gates must be installed to separate the pools, the required action will be entered for not having redundant level indicators in each pool. The modification installed two new Westinghouse Guided Wave Radar (GWR) wide-range level instrumentation systems for primary and backup indication of the SFP level. The system is composed of GWR level sensors, level transmitters and local electronics boxes that contain the level indication for the SFP. The Unit 1 and Unit 2 level sensors are located to ensure adequate channel separation, the level sensor signal cables run in separate conduits under the floor towards the north wall. The junction boxes along the north wall are separated as far as practical. The two-level sensors are separated by a distance which is a longer than the shorter dimension of the SPF specified by the NEI 12-02 guidance. The indications for the primary channel and backup channels are located in the Control Enclosure Auxiliary Equipment room located one elevation above the MCR.

The normal power feed to the primary and backup channels is provided from 120/208 VAC lighting panels. Upon a loss of normal power, an internal battery and Uninterruptable Power Supply (UPS) will supply backup power for up to 72 hours. A male 120 VAC receptacle on the bottom of the SFPLI panels (0A-S200 and 0B-S200) provides a means of supplying the system with power from an external electrical source, such as a portable FLEX generator. Procedure T-365 has been written to provide guidance for connection of backup power.

The SFP levels of interest are listed below (Figure 9). These are not setpoints, but instead are meant to correlate the indicated water levels to the amount of coverage over the fuel assemblies in the pool.

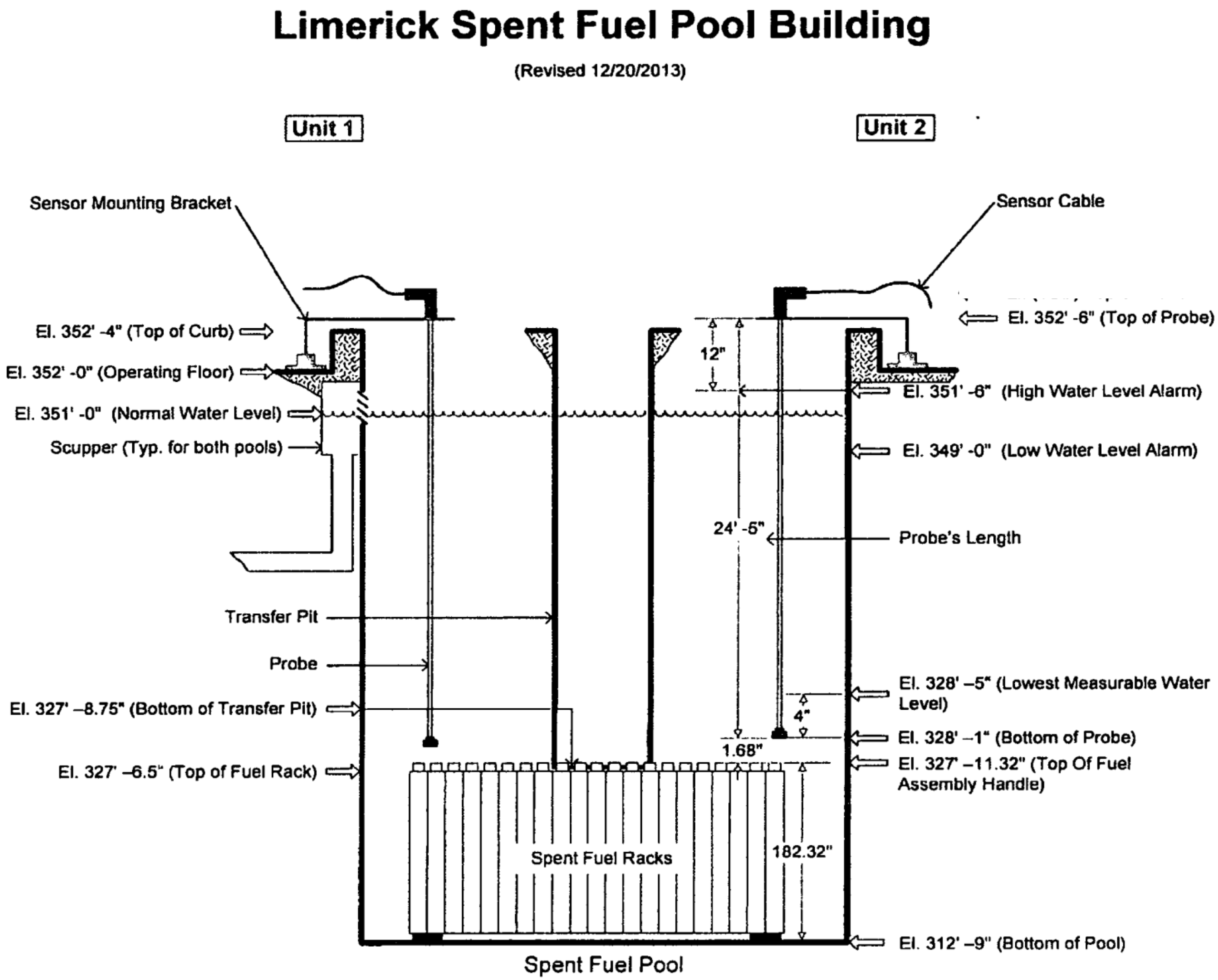


Figure 9 - Spent Fuel Pool Elevations

- Level 1 - This is the level that is adequate to support operation of the normal fuel pool cooling system. At Limerick, this corresponds to water level at elevation 351' (approximately 23' 6" above the top of the fuel rack).
- Level 2 – This is the level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck. Designation of this level should not be interpreted to imply that actions to initiate water make-up should be delayed until SFP water levels have reached or are lower than this point. At Limerick, this corresponds to water level at elevation 337.5' (approximately 10' above the top of the fuel rack).
- Level 3 – This is the level where fuel remains covered and actions to implement make-up water addition should no longer be deferred. Designation of this level should not be interpreted to imply that actions to initiate water make-up should be delayed until this level is reached. At Limerick, this corresponds to an instrument reading of zero feet at elevation 328' 5".

The floor of the fuel transfer canal is at elevation 327'- 8.75". The instrument zero is set just above the floor of the transfer canal, so both instruments can read accurately down to the point where the transfer canal floor separates the two pools.

3.5.6 Thermal-Hydraulic Analyses

Below is a description of the SFP and the decay heat loading for the pool, effects from loss of cooling are also included which indicate for Case 2 (worse case) no operator action is required for 39.4 hours (time to boil off to 10 feet of water coverage above the top of fuel racks) with the fuel pools connected.

The Limerick spent fuel pool has a capacity of 3665 fuel assemblies in the Unit 1 pool and 3921 fuel assemblies in the Unit 2 pool. Limerick is licensed to store 4117 fuel assemblies in each of the SFPs Reference 29).

Calculation LM-0708 (Reference 30) reviewed two different circumstances for worst case fuel pool boil off. Case 1 assumes the plant had just off loaded 1/3 of the core during a refuel outage to the SFP five days after shutdown, the results are show below:

	Unit 1 SFP only	Unit 1 SFP, CWSA	Unit 1 SFP, CWSA & Unit 2 SFP
Time to Boil after Unit shutdown	5.18 hrs	7.10 hrs	9.96 hrs
Time to 10 feet above the Fuel Bundles after Boiling Starts	39.62 hrs	54.31 hrs	76.14 hrs
Time to 10 feet above the Fuel Bundles after Unit shutdown	44.8 hrs	61.4 hrs	86.1 hrs

Case 2 assumes the plant has entered a refuel outage and the full core has been offloaded to the SFP five days after shutdown.

	Unit 1 SFP	Unit 1 SFP + CWSA	Unit 1 SFP + CWSA + Unit 2 SFP
Time to Boil after Unit shutdown	2.10 hrs	2.88 hrs	4.56 hrs
Time to 10 feet above the Fuel Bundles after Boiling Starts	16.09 hrs	22.06 hrs	34.84 hrs
Time to 10 feet above the Fuel Bundles after Unit shutdown	18.2 hrs	24.9 hrs	39.4 hrs

3.5.7 Impact of Elevated Fuel Handling Floor Temperature

Calculation LM-0710 (Reference 31) performed a Gothic model to determine the bulk SFP area conditions following a BDBEE in order to determine the time after the occurrence of the BDBEE at which the SFP area exceeds 110°F, the dry bulb temperature limit for human habitability according to NUMARC 87-00, Rev. 1 (Reference 25). The LGS Refuel Floor is built to similar robust standards as the reactor enclosure, this provides a limited number of options to provide ventilation to limit the rate of temperature rise.

Several cases were analyzed:

- Case 1, Truck bays, Stairwell and South Stack doors are all opened at the onset of the BDBEE.
- Case 2, Truck bays, Stairwell and South Stack doors are all opened once boiling of the SPF occurs.

- Case 3, South Stack doors are opened at the onset of the BDBEE. All other doors remain closed.

Initial conditions for all cases are assumed as worst case as described in NEI 12-06 Section 3.2.1.6, where the Unit 1 full core has been offloaded into the SFP within five days after shutdown and the BDBEE occurs. During outage conditions the added around-the-clock staffing will allow the shorter timelines to be met.

All cases show that Refuel Floor temperature conditions deteriorate quickly once boiling commences and the limited options for opening doors for ventilation have minimal effect. During the Phase 1 period, operators will perform T-346, Refuel Floor alignment for SFP Makeup, Spray and Ventilation (Reference 65) to set up the required hoses on the refuel floor and route the hoses to the stair towers prior to the SFP boiling. This procedure also directs opening doors to the South Stack to release some heat and steam, even though the benefits noted in the calculation are minimal.

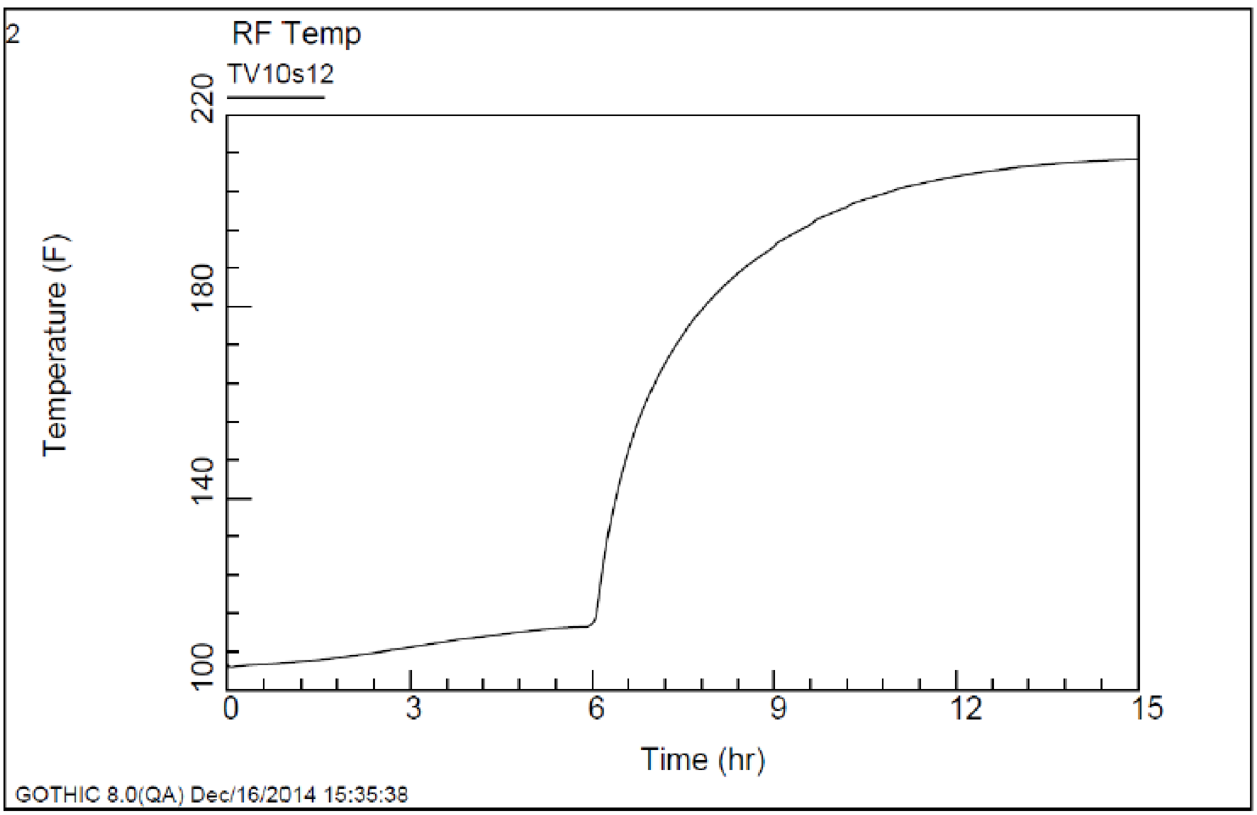


Figure 10 - <u>Refuel Floor Temperature Following a BDBEE</u>

Calculation LM-0710 showed area temperature rise is directly related to the onset of boiling, Figure 10 shows the rate of temperature rise after hour 6 (Case 1, unit 1 SFP only). Based on this for a normal 1/3 core offload and the fuel pools connected the time to boil is approximately 10 hours, this increases the amount of time available for the setup activities to be completed on the refuel floor prior to boiling occurring.

4 Support Strategies

4.1 Refueling FLEX Equipment

The FLEX strategies for maintaining functions and/or maintenance of functions involves several elements, including the supply of the diesel fuel to necessary to power generators, pumps, hauling vehicles, etc.

Fuel needs inside the protected area are obtained from the underground EDG Fuel Oil Storage Tanks (FOSTs) by re-powering the installed Diesel Generator Fuel Oil Transfer Pump for the Division 1 or 2 diesel and connecting a hose in the EDG room and a nozzle on the portable hose reel is used to dispense a supply of fuel oil to the FLEX equipment as required.

The tow vehicles are always maintained with greater than 50% full fuel tanks, providing sufficient fuel for equipment deployment.

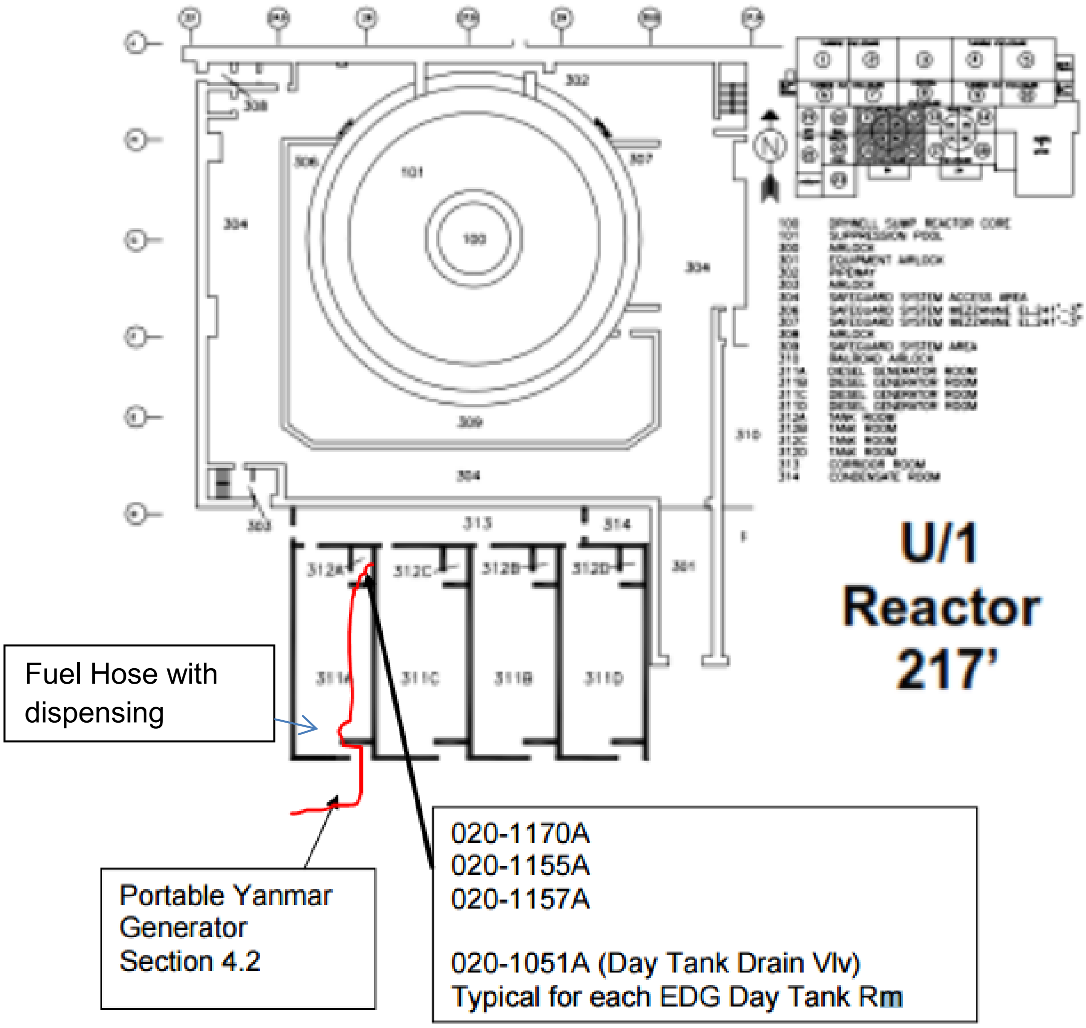


Figure 11 - Fuel Oil Strategy

4.1.1.1 <u>FLEX Pump Refueling Strategy</u>

The diesel-driven portable pumps used to supply makeup and cooling water to the plant are stored near their final deployment locations, inside the FLEX Pump Storage Building. Each pump trailer has an installed 250 gallon fuel tank. A stationary 1,000 gallon fuel tank with a 120 VAC fuel transfer pump (and backup manual hand pump) is installed inside the FLEX Pump Storage Building. The pumps are administratively maintained at greater than 80% fuel capacity and 750 gallons in the storage tank. This represents 37 hours of full load run time. The pumps are not started until at least 6 hours post event, therefore additional fuel would not be needed until at least 43 hours after the event. This simplified computation takes no credit for the pumps operating at less than full load for this duration.

The pump will run on stored fuel in its installed fuel tank and then be refueled from the fuel tank in the building. The building fuel tank could then be refilled either from offsite supplies later in the event or fuel could be transported from the protected area to the FLEX pumps using the tanks installed on the F-750 truck. While not credited for FLEX response the N+1 pump and generator stored in the FLEX pump building contain a combined total of 750 gallons of additional diesel fuel that could be transferred to the pumps, if needed.

4.1.1.2 FLEX Generator Refueling Strategy

The FLEX generators are refueled by deploying a fuel hose staged in the FLEX Generator Storage Building to the Division 1 or 2 EDG room. The hose is attached to a sample valve on the day tank makeup line in the EDG day tank room. The installed normal 480 VAC EDG fuel transfer pump is operated using the FLEX generator for power and delivers fuel through the hose reel to the FLEX generator (Figure 11). The FLEX generator tanks are administratively maintained greater than 80% full. As a backup there is a staged portable 120 VAC fuel transfer pump on a cart in the FLEX Generator Storage Building that can take suction from any one of the eight EDG Day Tanks by removing a drain cap and connecting a suction hose to the transfer cart. The discharge of the portable fuel transfer pump is routed outside to the south side of the Diesel Generator Building and used to refuel equipment. The portable fuel transfer pump is powered from a 120 VAC portable diesel generator used for lighting and radio charging.

The underground EDG FOSTs are seismically designed and protected from flooding. Each of the 4 underground FOSTs associated with an electrical division that is repowered for FLEX contain a TS minimum of 33,500 gallons of fuel and the 8 day tanks each contain a TS minimum of 250 gallons of fuel each.

4.1.1.3 Fuel Consumption

The fuel oil consumption requirements for FLEX equipment are documented in Technical Evaluation EC 623249 (Reference 67). Each of the eight LGS EDG underground fuel tanks contains a TS minimum of 33,500 gallons of fuel and each of the eight EDG day tanks contain a Tech Spec minimum of 250 gallons of fuel. These supplies are sufficient for a seven day supply at the maximum post-LOCA load demands. The quantity of fuel oil required for FLEX can be served by the respective fuel oil storage tank for well over 30 days. The ERO would be able to obtain additional fuel oil, if needed.

Equipment	Fuel Tank Capacity	Full Load Consumption Rate	Total Run Time	Run Time to 20% of FO Tank Capacity
FLEX Pump	250 gal	15.5 gal/hr	16.1 hrs	12.9 hrs
FLEX Generator	500 gal	34.4 gal/hr	14.5 hrs	11.6 hrs

For the FLEX generators, a kit of hoses, nozzle and fittings are stored in the FLEX building for each unit, this allows simultaneous refueling of the FLEX generators. A supply of portable five gallon transfer fuel cans are stored in the FLEX buildings that can be used to transfer fuel to the small portable generators.

The FLEX F-750 truck in the protected area has a 200 gallon bed mounted tank with Power Take Off (PTO) driven transfer pump and two (2) hose reels. This is not credited in any FLEX strategy, but provides a reserve fuel transfer capability.

4.2 ADS Air Supply

Of the 14 Safety Relief Valves (SRVs), eight are provided with an air accumulator located in the drywell capable of providing several lifts without backup air (5 Automatic Depressurization Valves (ADS) valves and 3 RSP valves). Additionally, the five (5) ADS SRVs are supplied with a safety grade long term pneumatic backup bank of Nitrogen bottles located in the Reactor Enclosure, providing enough gas for seven days of use. Since the total number of SRV lifts required to cooldown the RPV and remain depressurized is indeterminate, when the bottles near empty, the backup bottles can be replaced with spare bottles if required. Procedure guidance exists in S59.6.A, "Replacing PCIG/ADS Nitrogen Backup Bottles and Pressure Control Valve Adjustment" for bottle replacement.

While not part of a FLEX strategy, LGS currently has proceduralized Fire Safe Shutdown guidance to use a pre-staged hose and hose adapters to connect from the Division 2 Emergency Diesel Generator Starting Air Compressors to the ADS Backup Air Bottle charging line. The strategy is implemented by connecting a hose and opening several valves (Figure 12) and provides an indefinite supply of gas to two SRVs that does not required entry into the reactor enclosure to swap out nitrogen bottles.

The Division 2 EDG starting air compressors are supplied from the D*24-D-G MCCs which on each unit are re-powered by the FLEX generators.

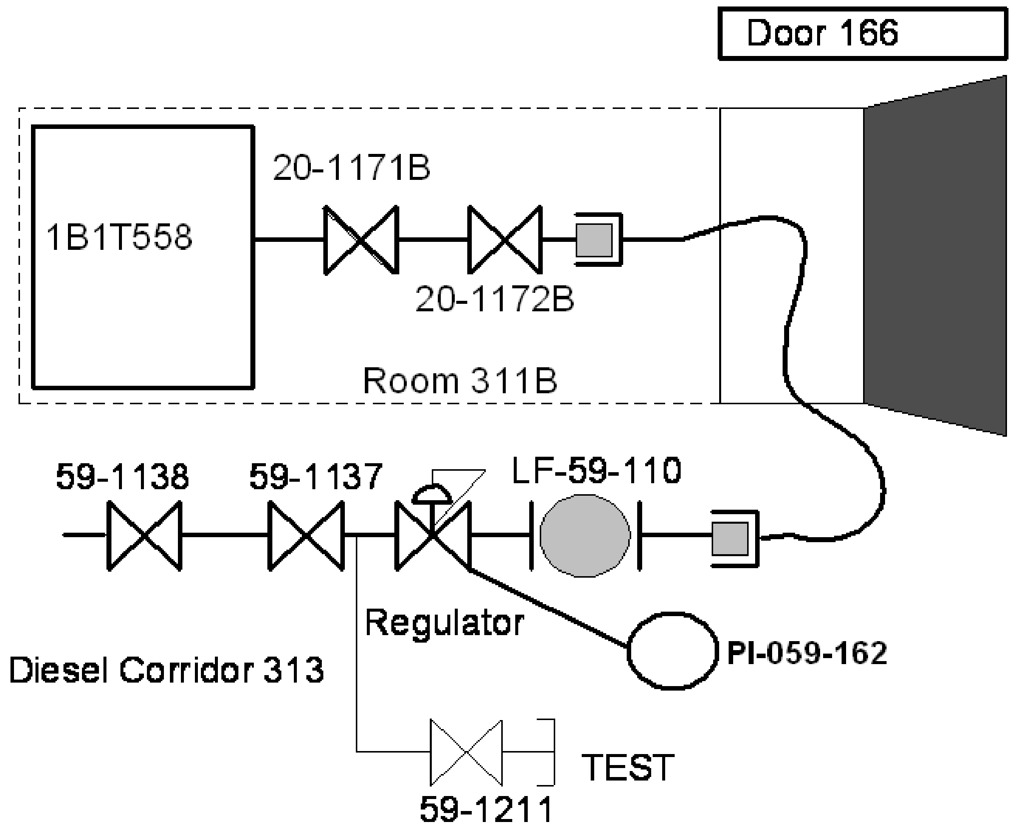


Figure 12 - Back up ADS Gas Supply from EDG Starting Air Compressor

4.3 Ventilation

4.3.1.1 RCIC Room

The analysis of RCIC Pump Room temperatures during an Extended Loss of AC Power is contained in Calculation LM-0689 (Reference 32). This analysis provided recommendations for maintaining the room below the equipment qualification limit of 158°F. The recommendations were already incorporated in to E-1, Station Blackout as optional, but for an ELAP condition, the actions to open the blowout panel on El 217' and room doors on el 177' are required to ensure RCIC will remain operational for as long as required.

4.3.1.2 Battery Rooms

Technical Evaluation 1550669-05 (Reference 12) reviewed the Division 1 and 2 Battery rooms using some conservative assumptions for room heat uprate and hydrogen generation from battery recharge. During the first 6 hours after the event when batteries are discharging, the rate of temperature rise is low. Once the battery chargers are reenergized the rate of temperature rise and hydrogen generation increases from battery recharge. This evaluation determined that temporary air forced ventilation was required approximately 24 hours post event. Procedural guidance has been developed to prop open room doors and install a high velocity fan in the battery room doorway to pull in fresh air. The Division 1 and 2 battery rooms are next to each other with a common door between the rooms. Fresh air is pulled from the corridor, through the battery rooms and exhausted to the large open Generator Services area on elevation 239'. The portable fan is powered form a portable diesel generator.

After six hours post event additional resources start to become available to assist in temporary fan and portable generator equipment setup.

4.3.1.3 Refuel Fuel Floor

Calculation LM-0710 (Reference 31) performed a Gothic model to determine the bulk SFP area conditions following a BDBEE in order to analyze the habitability conditions on the Refuel Floor and identify the timeline for completing required FLEX strategy actions in the affected area for spent fuel pool cooling. This is discussed in section 3.5.7.

In order to complete the required actions on the Refuel Floor while conditions are still habitable, FLEX Support Guide T-346, Refuel Floor Alignment for SFP Makeup and Ventilation (Reference 65) was written to provide the steps necessary to prestage hoses on the Refuel floor and open the airlock doors to the South Stack.

4.3.1.4 Main Control Room

Calculation LM-0157, Control Heatup Analysis in an Event of Station Blackout (Reference 36), determined the MCR temperature transient when all MCR cooling is lost due to an SBO. The MCR temperature reaches a peak value of 101°F at a time of 60 minutes after the SBO. The calculation was re-assessed as part of power rerate with no changes in results.

A Technical Evaluation was performed under 1550669-04 (Reference 37) to evaluate MCR temperature rise during ELAP conditions. During ELAP conditions there is more down powered equipment in the MCR and therefore temperature increases are less. This evaluation showed temperatures remain less 110°F after 24 hours.

NUMARC 87-00 (reference 25) indicates that 110°F for light work conditions is acceptable. Limerick has developed procedure guidance to installed portable fans in the MCR doorways to improved ventilation. This information is included in T-362, Main Control Room Potable Ventilation and Lighting (Reference 40).

Additionally, a toolbox approach, e.g., rotation of personnel, will be employed if further mitigating actions are required.

4.4 Lighting

4.4.1.1 Phase 1

A lighting review was conducted and documented in AR 1340416-46-35 (Reference 33). This evaluated the lighting available to make required hose and electrical connections, perform instrumentation monitoring and the associated travel paths to/from the various areas. Battery powered (Appendix “R”) emergency lights, backed up by LED hard hat lamps, battery operated LED flashlights and LED lanterns, provide adequate lighting for all primary connection points and implementation of the FLEX strategies. There are spare batteries staged for use in each of the FLEX buildings for use in the headlamps and flashlights. The Appendix “R” emergency lights located in many plant areas are designed and periodically tested to ensure the battery pack will provide a minimum of 8 hours of lighting with no external AC power sources.

The FLEX trucks each have a roof mounted spot light in addition to the normal headlights. The debris removal skid steer loaders include headlights for night operations. The FLEX buildings are equipped with LED emergency lighting units that will provide illumination within the building for obtaining equipment in the buildings.

4.4.1.2 Phase 2 and 3

Once the FLEX generator has repowered portions of the 480 VAC system, some reactor building lighting is powered from Division 2 can be restored as directed in T-334 (Reference 34) . LED tripod lights and lighting stringers are staged in the FLEX Generator Storage Building to provide additional lighting during Phase 2 and 3. These would be powered from the portable diesel generators.

The portable pumps have been retrofitted with 12 volt LED “Scene lights” powered form the engine driven alternator to provide general area lighting at the pump suction location to support the UHS water strategy.

4.5 Water Removal

NEI 12-06 section 5.3.3.2 states “consideration should be given to the impacts from large internal flooding sources that are not seismically robust and do not require ac power (e.g., gravity drainage from lake or cooling basins for non-safety-related cooling water systems)". For Limerick, the potential for drainage from non-seismic systems is limited. The Turbine Enclosure is isolated from the Reactor Enclosure. Large non-seismic piping such as the Circulating Water lines that connect to the cooling tower are located in the Turbine Enclosure. The Turbine Enclosure to Reactor Enclosure common wall is sealed to prevent any flooding impact to SSCs in the Reactor Enclosure. The Reactor Enclosure has previously been evaluated as acceptable through the Moderate Energy Line Break (MELB) program.

4.6 Communications

Exelon employs a defense in depth approach to ensure a reliable communication system is available for the MCR and TSC. If during a BDBEE the telephone systems become non-functional, operators and ERO personnel shall employ a diverse communications strategy:

4.6.1.1 Fixed Satellite Telephone Systems:

For the MCR a fixed satellite system is available with four (4) satellite phones handsets permanently installed. The MCR system has an uninterruptable back-up power supply and the capability to connect to an AC source supplied by a portable generator. Since the roof mounted satellite dish is not robustly protected from all hazards, a portable trailer mounted dish is stored in the FLEX Generator Storage Building. This can be deployed post event and connected via fiber optic link to the fixed system in the MCR.

4.6.1.2 Handheld Satellite Phones

If the MCR satellite phone system becomes nonfunctional, the MCR staff has three (3) portable satellite phones available to meet the immediate communications requirements. These satellite phones are portable and must have a clear view of the southwest sky. The portable satellite phones along with spare batteries and battery chargers are stored in the MCR area. One of the portable generators staged in the FLEX Generator Storage Building is designated for the purpose of recharging batteries.

4.6.1.3 Portable Satellite Systems

For the MCR, a portable back-up satellite dish and communication case is available, in the event that the permanently mounted satellite system fails after a BDBEE. The portable communication case and satellite dish can be deployed and tied into the hardwired system since the majority of the components, other than the non-seismically mounted satellite dish, are in safety-related or seismically rated structures.

Technical Support Center (TSC)/Operation Support Center (OSC) staff has access to a portable satellite communication case and satellite dish. These portable satellite communication systems are mounted on trailers and stored in the FLEX Generator Storage Building and would be powered from one of the portable diesel generators.

4.6.1.4 Radios

Onsite communications is performed using the installed plant radio system with 72 hour battery backed repeaters on the two Operations channels for most conditions. Portions of the radio system are not robust during a tornado event. If the radio system is damaged, the handheld radios can be used in the talk-around mode. This feature allows station emergency workers to utilize existing station radios without the aid of a repeater or antenna system. This capability may be limited to line of sight communication. A total of 19 two-way radios and 17 spare batteries are on charge. Additionally, 28 spare batteries available to be placed on charge are stored in the FLEX Generator Storage Building. This is in addition to the radios carried by the duty operating crew. One of the portable generators staged in the FLEX Generator Storage Building is designated for the purpose of recharging batteries for communications equipment.

4.6.1.5 Bullhorns

The primary system to notify plant personnel is the Public Address (PA) system. NEI 12-01 states, if portions of the PA system are not powered from a battery-backed source, then reasonable alternate methods should exist to provide emergency notification to the plant staff in the areas that would not receive an announcement. Limerick has installed a battery backup UPS that powers portions of the PA system. This UPS requires manual switching activities to be placed in service, this battery backup was installed to provide intra plant communications in critical areas for FLEX plant actions but can also be used for evacuation announcements. To substitute for the areas not covered by the battery backed UPS or prior to performing the manual switching to energize the UPS power source, bullhorns are the credited means for site evacuations. As part of the NEI 12-01 response, three bullhorns were procured and are stored in the FLEX Generator Storage Building and can also be used for evacuation announcements.

4.7 Heat Tracing

The equipment used to support the FLEX strategies is stored either inside the plant or in the FLEX storage buildings which are protected from snow, ice, and extreme cold in accordance with NEI 12-06, and are temperature controlled. FLEX connection points are all located inside qualified structures which are temperature controlled; therefore, heat tracing is not used or required. Equipment/tools that support making the connections are stored inside in the vicinity of the connection points or in the FLEX buildings.

4.8 Foul Weather Deployment Considerations

The Limerick FLEX water and electrical strategies do require some outdoor deployment of pumps, generators, hoses, and cables. Both buildings contain a supply of foul weather gear (gloves, rain coats and ice trekers (anti slip shoe covers). Operators and Security officers need to travel to the FLEX Pump Storage Building located outside the protected areas. The building is close enough to be walked to or a short drive in a vehicle. The FLEX truck includes tools for breaking ice on the Spray Pond if required to submerge the suction hoses. The building contains the pump deployment truck which can be used as a warming area for personnel if needed. The operators and personnel that deploy the FLEX generators only need to travel to the FLEX Generator Storage Buildings located in the protected area. The transport of the generators to the area near the EDG is a short deployment with minimal outdoor cable runs to the buildings.

5 External Hazard Determination

5.1 Seismic

Per the UFSAR Section 2.5, the seismic criteria for LGS include two design basis earthquake spectra: Operating Basis Earthquake (OBE) and the Design Basis Earthquake (DBE) (Safe Shutdown Earthquake).

The DBE and the OBE are 0.15g and 0.075g, respectively. These values constitute the design basis of LGS. Per the UFSAR, the buildings and equipment that have been designed for seismic loads include, but are not limited to, the Reactor Building, Control Structure, Diesel Generator Enclosures, Spray Pond Pump House, High Pressure Coolant Injection, and Reactor Core Isolation Cooling. Per NEI 12-06, all sites will consider the seismic hazard. (Reference 1), (Reference 2) The robust FLEX equipment storage buildings are designed and constructed to NEI 12-06 requirements.

Soil liquefaction was reviewed for Limerick Generating Station. Based on the UFSAR, the soil at the seismic Category I spray pond was analyzed for liquefaction potential. The soils at other seismic Category I facilities were not analyzed since these soils are not saturated and the potential for becoming saturated is negligible. Based on the UFSAR, the spray pond does not have a soil liquefaction concern. The site area including haul paths from the FLEX buildings to the point of use were evaluated for liquefaction per Tech Eval 1550669-08 (Reference 41).

5.2 External Flooding

As discussed in the UFSAR, the design basis flood level of the Schuylkill River at the site is 207 feet, including wave activity. The shortest horizontal distance from the contour at elevation 207 feet to the nearest safety-related structure is approximately 200 feet. Grade level is no lower than elevation 215' at any of the safety-related structures, and none of the safety-related structures has exterior openings below elevation 217'. Therefore, the safety-related structures are secure from Schuylkill River flooding and no special provisions for flood protection are necessary. Therefore, Limerick is built above the design basis flood level and is considered “dry” by the NEI guidance and dry sites are not required to evaluate flood-induced challenges.

The other area that was reviewed for effects of flooding was the spray pond. Based on the UFSAR, the maximum flood level at the spray pond 254.9 feet. The lowest elevation for the spray pond pump house is 268 feet. Therefore, the spray pond pump house does not have a flooding concern.

It should also be noted the Limerick Station has been analyzed for a Local Intense Precipitation (LIP), transient flood. The effects of a LIP are analyzed in calculation NPB-117 (Reference 75). Based on the results and due to the analyzed flood plains at LGS, storage of equipment (in the FLEX buildings) and deployment pathways are not affected by a LIP event per Tech Evaluation 1550669-08 (Reference 41).

5.3 Severe Storms with High Wind

Limerick Generating Station is located at approximately 40°13'26" north latitude and 75°35'16" west longitude. Per Figure 7-1 of NEI 12-06, Limerick is susceptible to hurricanes due to location. Per Figure 7-1, peak wind gusts at Limerick will be between 140 and 150 mph. Also, according to the UFSAR and Figure 7-2 of NEI 12-06, Limerick Generating Station is susceptible to Tornado induced winds and is classified as region 2 with maximum wind speeds of 170 mph. The Limerick safety related structures are able to withstand a rotational wind velocity of 300 mph, as given in the UFSAR. Also, safety-related structures have been assessed for tornado missiles and determined to be acceptable, per the UFSAR. The robust FLEX equipment storage buildings are designed and constructed to NEI 12-06 requirements. The challenges produced by a tornado event would be debris in the way of the FLEX deployment path. IR 1560443-06 (Reference 42) provides a travel path assessment and evaluation of debris following the event.

5.4 Ice, Snow and Extreme Cold

The guidelines provided in NEI 12-06 (Section 8.2.1) generally include the need to consider extreme snowfall and low temperatures at plant sites above the 35th parallel. The Limerick Generating Station site is located above the 35th parallel and thus the capability to address impedances caused by extreme snowfall need to be provided. Per the UFSAR, the temperature in the region of Limerick Generating Station site rarely exceed 100°F or drop below 0°F.

Also, per Figure 8-2 of the NEI 12-06, LGS is classified as a Level 4 Ice Severity. A Level 4 Severity for ice means Severe Damage to power lines and/or existence of large amounts of ice.

Also, the spray pond (UHS at LGS) was reviewed for icing conditions. The spray pond, per the UFSAR, is designed to operate during icing conditions. Return flow to the pond is initially directed to the winter bypasses, which inject the warm return water directly to the pond volume. The bypasses are directed toward the ends of the pond to allow the return water to circulate and mix with the pond volume, and avoid hydraulic short-circuiting. The increasingly warmer pond water causes any ice layer present on the pond surface to melt. Once a hole is formed in the ice layer, a return path for spray water is available, and the spray networks may be used as water temperature dictates.

During beyond-design-basis external events (BDBEE) conditions, there would be no warm water return from normal plant systems to the spray pond. Therefore, the water source connections were designed to ensure the water source will be available during cold water conditions.

Since Limerick Generating Station is Level 4 Severity, an assessment for impact of snow, ice, and extreme cold was considered for storage and deployment of the FLEX equipment.

5.5 High Temperatures

NEI 12-06 states that all sites must consider high temperatures. The issues here are similar to cold and ice in that the equipment must be sufficiently protected from the high temperatures that it will still be able to function when necessary. Per the UFSAR, the temperature in the region of Limerick Generating Station site rarely exceeds 100°F or drops below 0°F. Per the UFSAR, the maximum temperature measured in the local area (Philadelphia) from 1874 to 1976 was 106°F in August 1908.

Therefore, Limerick Generating Station must assess high temperatures protection and deployment of FLEX equipment.

6 Storage Building/Haul Routes

6.1 Protection of FLEX Equipment/Storage Buildings

Limerick has constructed two hardened FLEX storage structures. One is a 40' x 60' robust structure located in the protected area south of the Reactor Enclosure and the second is a 60' x 90' robust structure located near the west end of the Spray Pond. These structures have been designed to meet the requirements to protect the stored equipment from all of the external events identified in NEI 12-06, such as earthquakes, storms (high winds, and tornadoes), extreme snow, ice, extreme heat, and cold temperature conditions.

The buildings are constructed with steel reinforced poured in place concrete walls and roofs with Barrier1 Systems doors in front of the roll-up garage doors, providing protection from tornado generated missiles.

FLEX portable equipment such as FLEX pumps, FLEX generators, small portable generators, cable trailer, trucks with plows, skid steer loaders and satellite communications trailers are all stored in the buildings. The large pumps and generators are secured with tie-down straps to anchors integrated into the floor slab to protect them during a seismic event. The cabinets and shelving units are secured with tie-down straps to anchors installed in the walls to prevent overturning during a seismic event.

All building doors, including the tornado missile resistant doors can be opened manually with no power assist required.

6.2 Haul Routes

Limerick has limited the need for large amounts of debris removal in the first several hours of the BDBEE event through the design considerations discussed below:

- The FLEX Pump storage building is located less than 200 feet from the point of use near the Spray Pond. Access to the UHS for the FLEX pump is inside through a new gate installed in the Spray Pond fencing. (Figure 13)
- The fuel tank in the FLEX pump building has sufficient hose to allow refueling without moving the pumps.
- The FLEX generator storage building is a short haul distance to the generator point of use. (Figure 14)
- The N+1 pump is stored in the same robust structure as the N pumps and is readily available.

Should a BDB event occur while the N generator is unavailable, then debris removal is a consideration. The N+1 generator is staged in the FLEX Pump Storage Building and must be transported to the Protected Area if needed for use.

Debris removal equipment is stored inside each of the FLEX storage buildings in order to be reasonably protected from the applicable external events such that the equipment is likely to remain functional and deployable to clear obstructions from the pathway between the equipment's storage location and its deployment location. Deployments of the FLEX and debris removal equipment from the FLEX buildings are not dependent on electrical power.

The haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event (Reference 41).

The deployment of onsite FLEX equipment to implement coping strategies beyond the initial plant capabilities (Phase 1) requires that pathways between the FLEX buildings and the staging/deployment locations be clear of debris resulting from seismic, high wind (tornado), or excessive snow/ice. Clearing of FLEX deployment pathways has been incorporated into the Limerick snow removal plan.

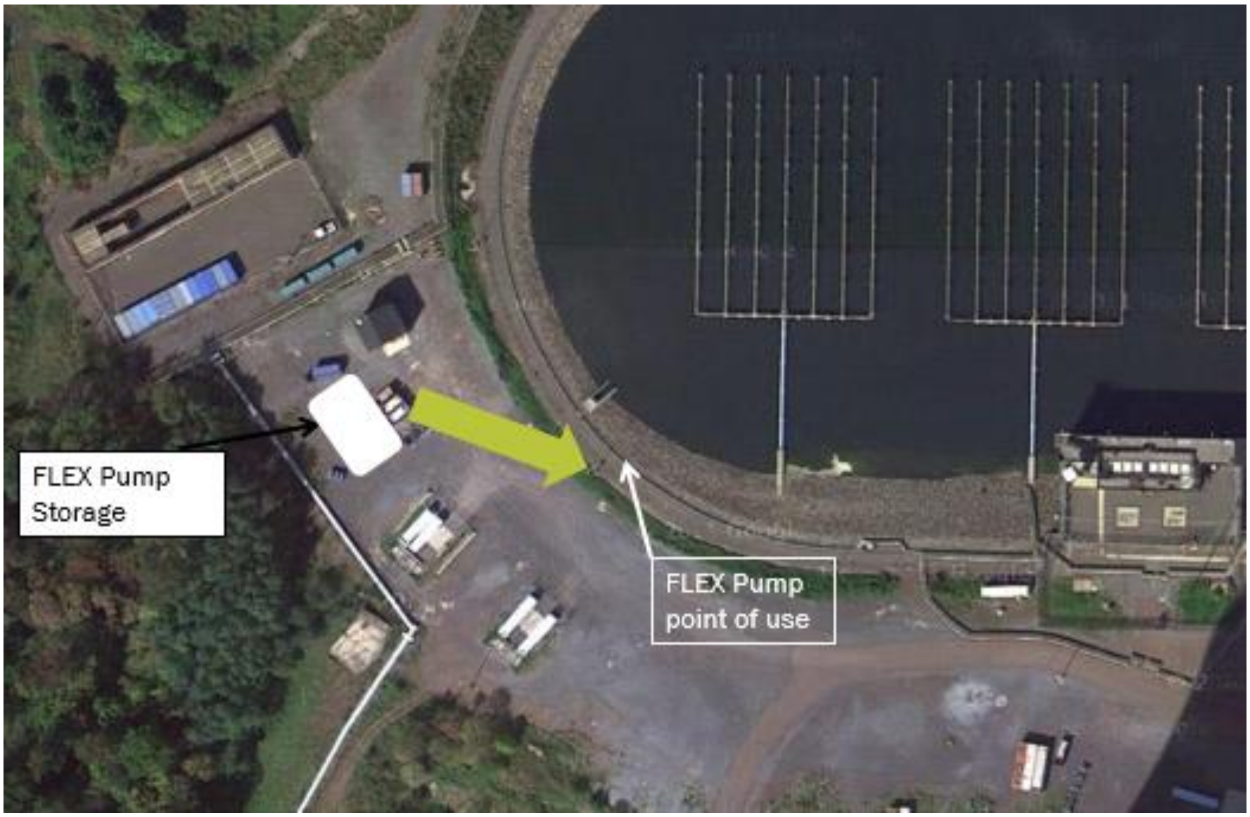


Figure 13 - FLEX Pump Storage Building and Haul Route

Figure 14 - FLEX Generator Storage Building and Haul Route

6.3 Accessibility

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

Doors and gates serve a variety of barrier functions on the site. One primary function is security and is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and High Energy Line Break (HELB). As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following an a BDBEE and subsequent ELAP/LUHS event, FLEX coping strategies require the routing of hoses and cables through various barriers in order to connect FLEX equipment to station fluid and electrical systems. For this reason, doors will be opened and remain open. This relaxation of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping 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. Operators responding to the BDBEE will obtain security keys from the shift manager key locker in the MCR, this will open security doors normally controlled by electronic key card reads. The FLEX storage building doors and spray pond gates can be manually opened.

7 Deployment of Strategies

7.1 Electrical Strategy

The strategy uses one portable FLEX diesel generator per unit to energize portions of the Division 1 and 2, 480 VAC plant distribution system necessary to implement the core cooling, containment integrity, and SFP cooling strategies. There is a primary strategy that utilizes Division 1 and 2 motor control center (MCC) connections in the EDG rooms (Figure 15) and alternate strategies that utilize Division 1 and 2 MCC connections in the Reactor Enclosure EL 217'. (Figure 16)

Either the primary or alternate strategy is implemented by deploying four (4) 4/0 cables (three per phase, plus ground), for the affected electrical division from the FLEX generator distribution panel to the primary or alternate MCC connection point. All cable runs are at plant grade elevation 217 and no cable runs across different elevations are required. Sufficient 100 ft cables, mounted on reels, are staged on the FLEX truck bed to connect the primary strategy on Division 1 and 2 for both units. A cable trailer is stored in the FLEX generator storage building with 300 foot cable reels for use for the alternate connection points or if debris prevents moving the FLEX generators close to the primary connection points. Sufficient cable lengths are available that the generators can be staged anywhere in the area south of the EDG building and cables be deployed to the primary or alternate connection points.

Each FLEX generator has a portable distribution panel mounted on wheels that is positioned next to the generator and connected using short cables stored on the FLEX generator trailer. The panel divides the generator output in to three separate circuits, each with over current protection. 4/0 cables are then run from the distribution panel to the point of use for Division 1 and 2. The third circuit on the distribution panel is a spare. Doors into the buildings are blocked open to the cables to pass through. Each MCC has a spare cubical dedicated to FLEX, the operator opens the MCC door and inserts a spare MCC frame with the twist lock TCP Wire & Cable Corp. cable connectors. The cables from the reels are then connected to the MCC.

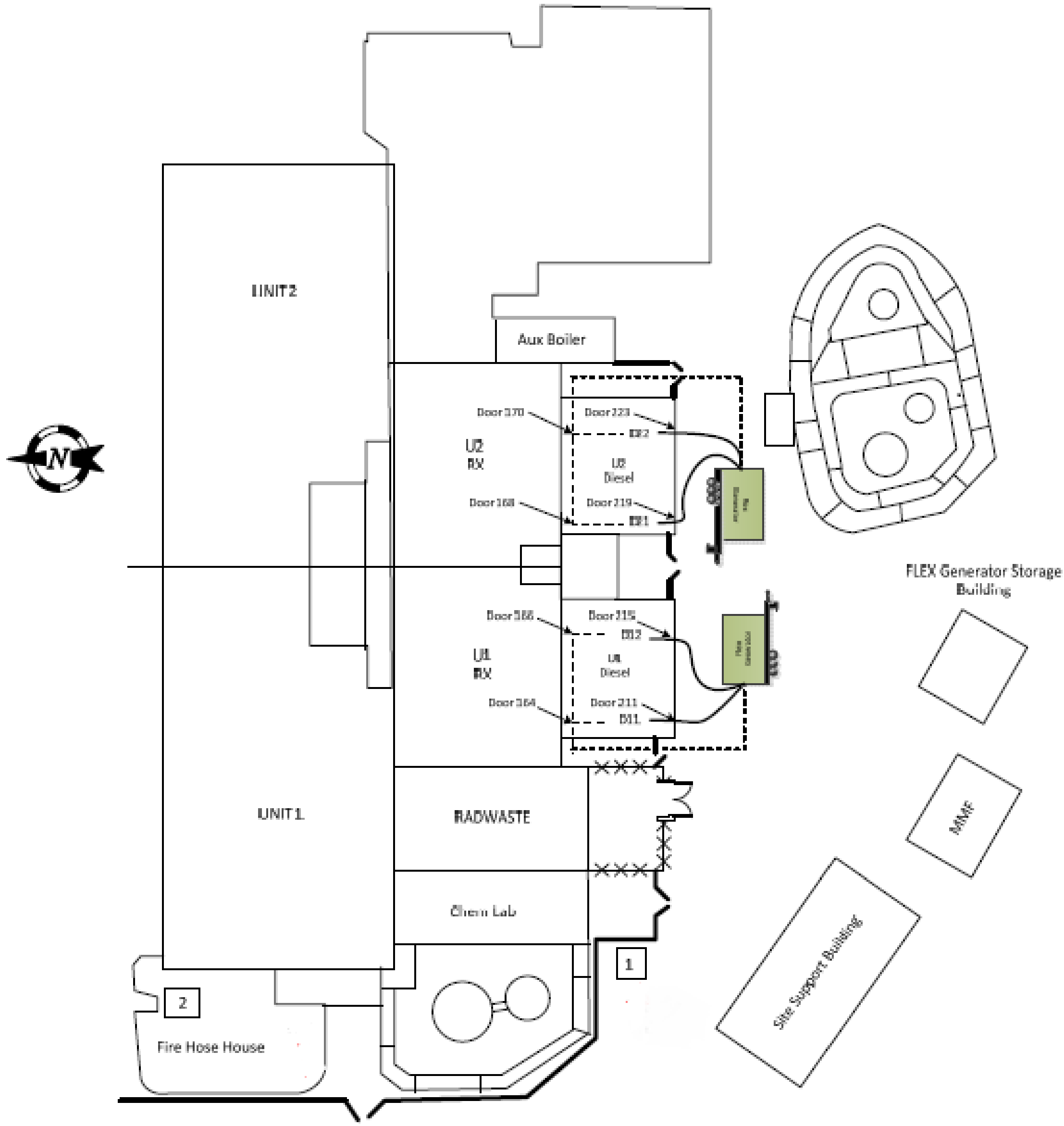


Figure 15 - FLEX Generator Primary Electrical Deployment (typical for T-333 and T-334)

A decision by the MCR to use either the primary or alternate strategy for the electrical connection will be made early on based on accessibility of the primary connection points. Once the cable deployment for one of these strategies is completed and the plant 480 VAC systems aligned per T-333 (Division 1) (Reference 35) and T-334 (Division 2) (Reference 34), the FLEX Generator is started and load applied to the generator.

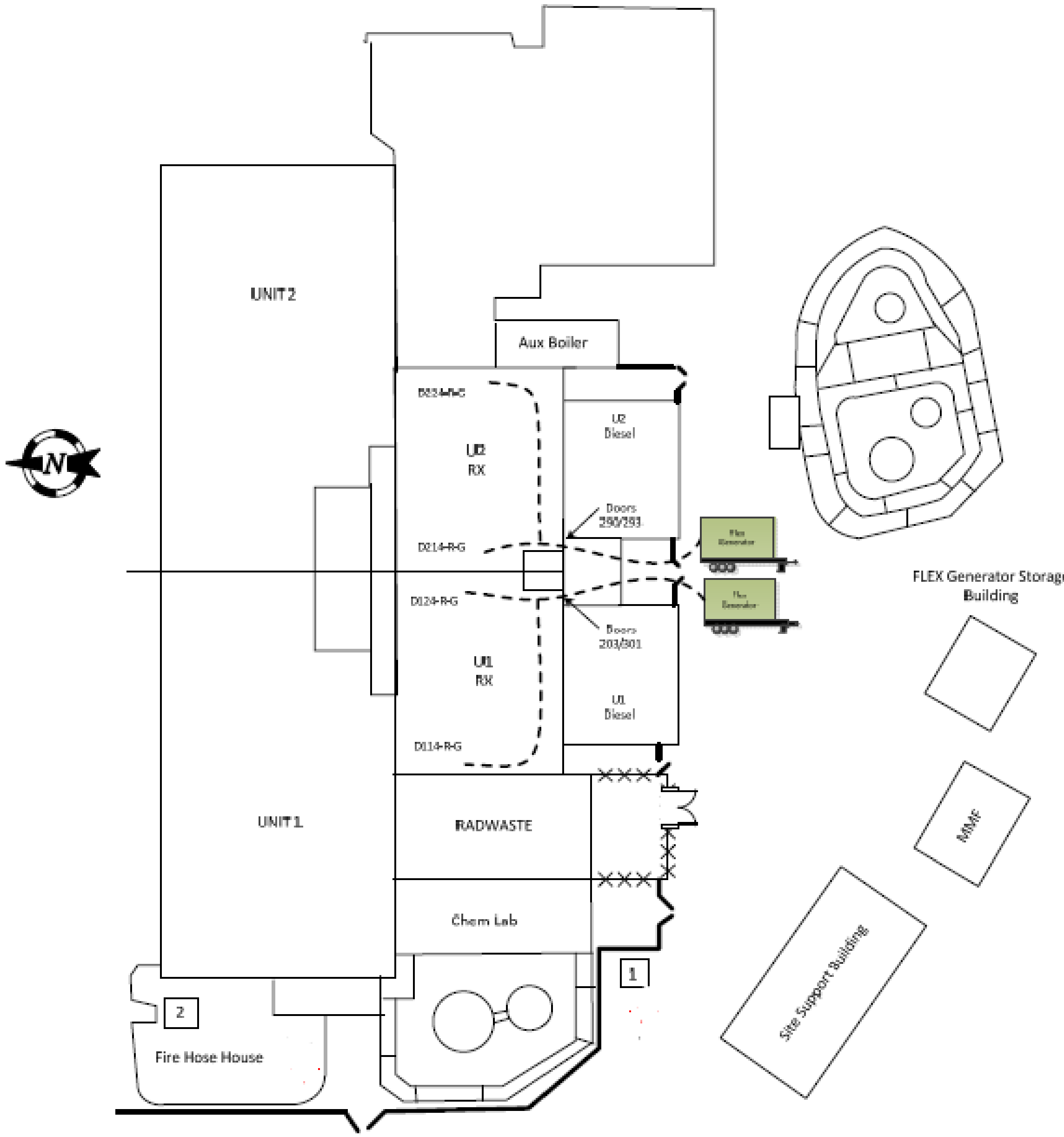


Figure 16 - FLEX Generator Alternate Electrical Deployment (typical for T-333 and T-334)

7.2 <u>UHS (Spray Pond) Water Supply Strategy</u>

The UHS at Limerick is a Spray Pond that serves the safety-related functions of providing cooling water, and acting as a heat sink for the ESW system and the RHRSW system during accident conditions. The UHS is designed to withstand the most severe natural phenomenon or site-related event (e.g., SSE, tornado, hurricane, flood, freezing, or transportation accident), and reasonably probable combinations of less severe phenomena and/or events, without impairing its safety function.

The pond is lined to minimize seepage. The pond bottom and soil cut slopes are covered with a soil-bentonite lining, while the rock-cut slopes are lined with shotcrete. The pond is provided with a seismic Category I overflow weir to accommodate normal water level fluctuations, and an emergency spillway to limit the maximum water level in the pond during maximum precipitation conditions.

A new gate was added in the fence near the spray pond outlet weir to allow the FLEX pumps to be easily positioned near the pond and their suction hoses placed into the water.

To begin supplying Spray Pond water to the plant following a BDBEE, an operator for each unit and two (2) security officers travel to the FLEX Pump Storage Building. Debris removal equipment is obtained, if required and a travel path cleared between the building and the Spray Pond. The FLEX pumps are then transported from the storage building to the Spray Pond and parked near the water. 5" discharge hose is stored on the truck bed and is layed from the pumps towards the Spray Pond pump house (Figure 17). One of the security officers will unlock the protected area fence surround the Spray Pond Pumphouse to allow an operator into the pump house area. The operator and the security officer will deploy hoses staged in the pumphouse towards the fence line. The hoses can be deployed through tubes installed through the protected area fence as the primary method or through the personnel access gates as the alternate. Sufficient 5" hose is stored in the pump house to allow the crew to deploy hose from the pump house connection points for each unit to the protected area fence and connect to the hoses from the FLEX pumps.

Once the hose connections are made, an operator starts the FLEX pumps and vents the hose connection in the Spray Pond pump house. At this point the RHRSW piping can be pressurized to supply water for reactor or spent fuel pool makeup. Communications between personnel in the plant protected area and personnel setting up in at the Spray Pond can be via normal radio, if available, or via radio in talk-around mode. Radio talk-around mode allows direct portable radio to radio communications without the use of the normal radio repeater. This has been demonstrated to reach from the plant yard area to the Spray Pond, to allow communications with the operators working at the Spray Pond.

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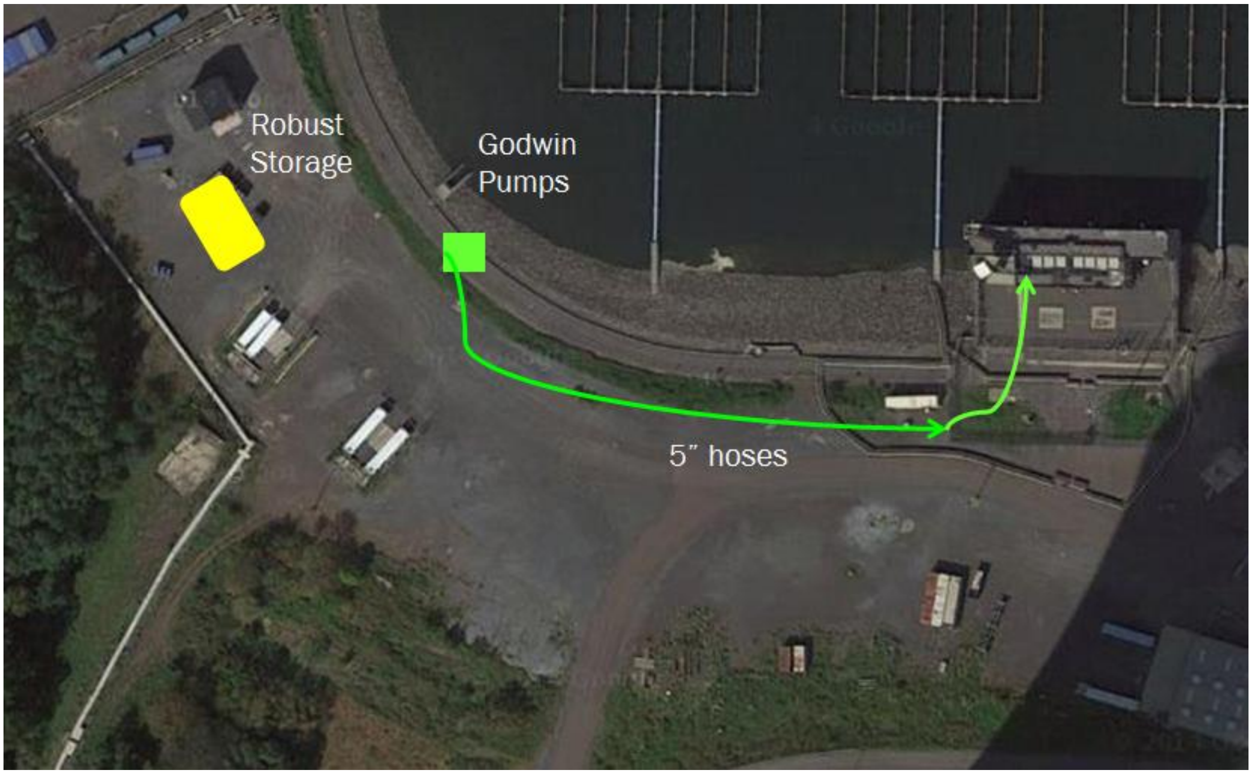

Figure 17 - FLEX Pump and Hose Deployment Path

7.3 RPV Make-up Strategy

The Limerick strategy for RPV makeup utilizes RCIC to the maximum extent. Initial operator actions are swap the RCIC suction source to the suppression pool since the preferred Condensate Storage Tanks (CST) suction source is not robustly constructed. When RCIC is no longer available the FLEX pump can supply spray pond water to the RPV using RHRSW and the A or B RHR Low Pressure Coolant Injection (LPCI) injection line. Section 7.2 describes how the FLEX Pump supplies UHS water to the RHRSW system. Each Limerick unit had a permanent connection already installed between RHRSW and RHR with double motor operated valve (MOV) isolation. This flow path is the primary FLEX strategy since minimal operator actions are required to establish an injection flow path. For Unit 1 this path connects the B loop of RHRSW to the B RHR system and for Unit 2 the A loop of RHRSW is connected to the A RHR system.

To meet the alternate injection path requirements, a modification was installed on each Unit's in the RHR room to add valves to the opposite RHRSW loop and the RHR train. A toolbox is pre-staged in the RHR room where the connection is made. This toolbox contains the hose, gasket and tools required to install the 25 foot hose jumper. (Figure 18)

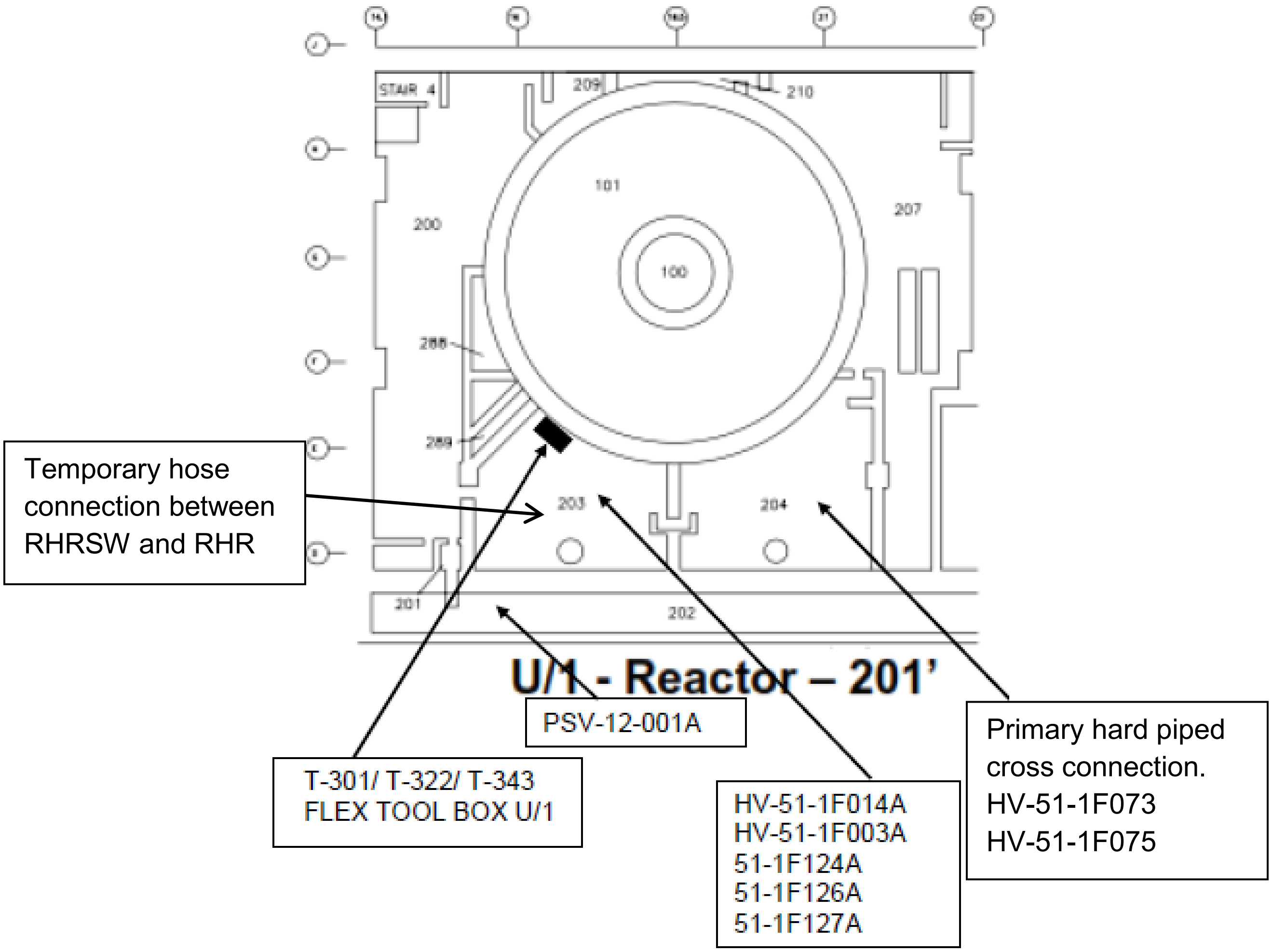

Figure 18 - RPV Makeup Strategy

7.4 Suppression Pool Cooling Strategy

The suppression pool temperatures are maintained by anticipatory venting of the suppression pool. By maintaining the lower suppression pool pressures, steam and hot gasses are vented to the atmosphere, maintaining the suppression pool at saturated conditions and limiting temperatures. Makeup to the suppression pool is controlled using procedure T-343, "Suppression Pool Makeup from Spray Pond" (Reference 69) to add water using the suppression pool spray line or through the RHR full flow test line.

7.5 Spent Fuel Pool Make-up Strategy

Section 7.2 described how the FLEX Pump supplies UHS water to the RHR system. New 3" valves were installed in the fuel pool heat exchanger room of each unit (Figure 18). This allows the operators to install a short hose jumper between the RHR system and a return line to the SFP and provide makeup water to the pool (Figure 19). This was selected as the primary strategy since the operator action is limited to installation of the hose jumper.

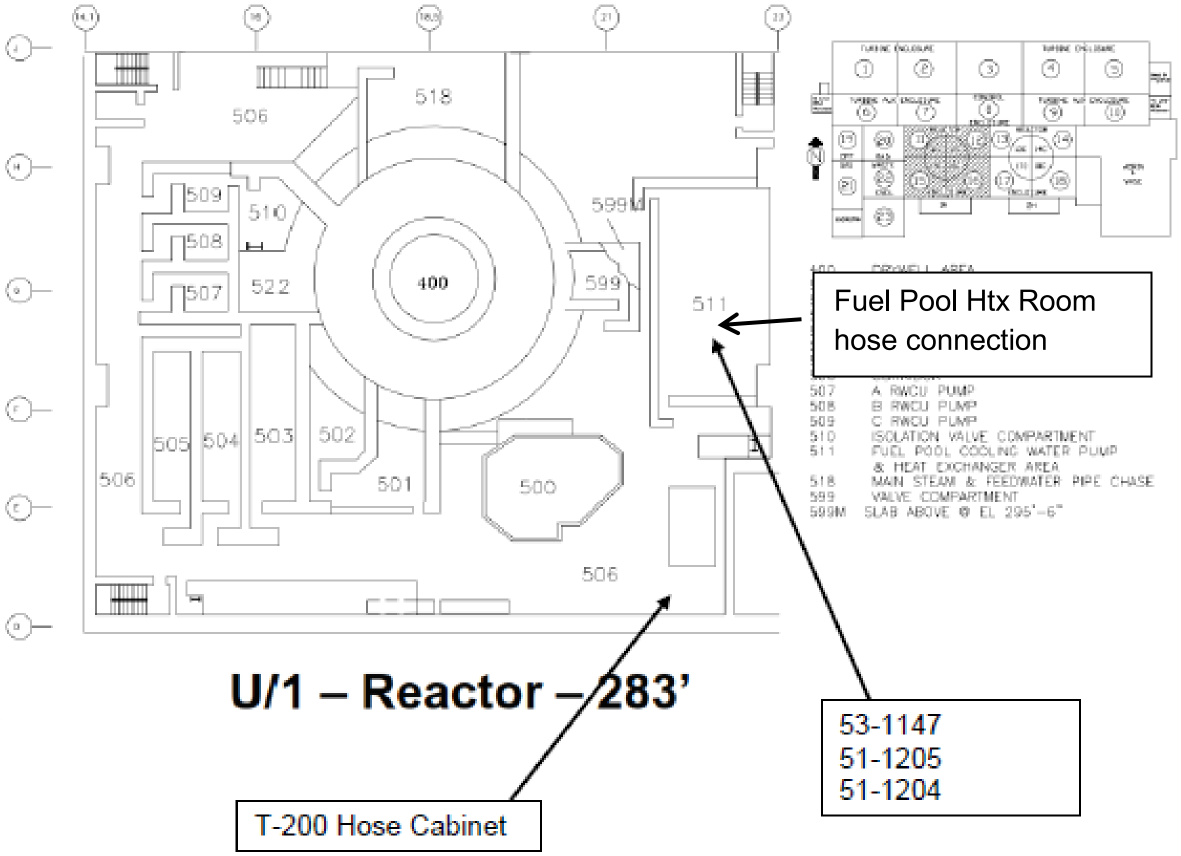

Figure 19 - SFP Makeup Strategy

Water from the other RHR loop can be also transferred to the spent fuel pool using a combination of hoses and standpipe to connect to the Unit 1 A RHR (Unit 2 B RHR) system at elevation 201 ft. in the RHR Heat Exchanger room and via the stair tower supply water to the SPF.

The required hoses are stored on the refuel floor near the stair towers along with oscillating monitor nozzles. This equipment is used for both FLEX and B.5.b strategies requiring fuel pool makeup or spray. As part of SAWA/SAWM during severe accident conditions, the use of the standpipe is procedurally directed as the spent fuel pool makeup water flow path. This allows adjustments in flow rates to be made with an entry into the stairway from the external building exit.

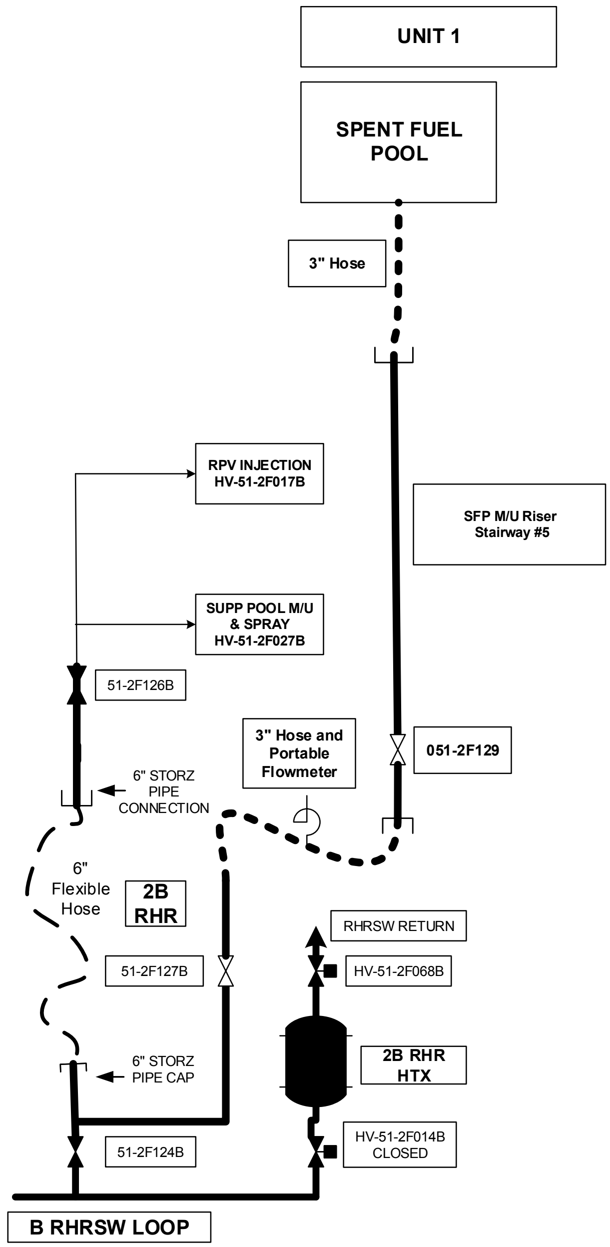

Figure 20 - SFP Makeup Strategy Using Standpipe

8 Offsite Resources

8.1 National SAFER Response Center

The industry has established two (2) National SAFER Response Centers (NSRCs) to support utilities during BDB events. Limerick has established contracts and issued purchase orders to Pooled Inventory Management for participation in the establishment and support of two (2) National SAFER Response Centers (NSRC) through the Strategic

Alliance for FLEX Emergency Response (SAFER). Each NSRC will hold five (5) sets of equipment, four (4) of which will be able to be fully deployed when requested. The fifth set will have equipment in a maintenance cycle. In addition, on-site BDB/FLEX equipment hoses 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 will be moved from an NSRC to a local assembly area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team. For Limerick the local assembly area (staging Area 'C') is the Exelon Power Labs facility in Coatesville PA. From there, equipment can be transported by helicopter, if ground transportation is unavailable or inhibited by the area damage, to the Limerick site and staged at Staging Area 'B' (upper parking lot). Communications will be established between the Limerick site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The equipment is normally delivered to Staging Area 'C', but the site can request direct delivery of needed equipment directly to Staging Area 'B' as described in the Limerick SAFER Response Plan documented in procedure CC-LG-118-1001 (Reference 24).

8.2 Equipment List

The equipment stored and maintained at the NSRC for transportation to Limerick to support the response to a BDB external event is listed in Table 4. Table 4 identifies the equipment that is specifically credited as backup to the FLEX strategies for Limerick, that will be available for replacement should on-site equipment break down. Since all the equipment will be located at the Limerick Staging Area 'B', the time needed for the replacement of a failed component will be minimal.

9 Water Sources

Limerick uses the suppression pool as the primary water source for RPV makeup during Phase 1 as a water supply for RCIC. As the response transitions to Phase 2 the Spray Pond (UHS) is the primary water source for reactor makeup, suppression pool makeup and SFP makeup/spray throughout the ELAP/LUHS event.

9.1 Suppression Pool

The suppression pool offers a relatively clean source of makeup water to the RPV from RCIC. At the beginning of the event, the suppression pool is near reactor quality water. During Phase 2 as Spray Pond water is added to the reactor and steams off and is quenched in the suppression pool, the suppression pool water quality will degrade, but it will remain a favorable water source.

The Limerick core cooling strategy uses RCIC to the maximum extent for RPV injection. The temperature of the water supplied to the pump is maintained in a range that does not challenge its long-term availability. Once a FLEX pump is available at approximately 6 hours after the event, raw water from the Spray Pond is used to makeup to the reactor and later to the suppression pool if required to maintain level.

The RCIC pump takes suction from the suppression pool through the RCIC suction strainer that was designed to conform to Regulatory Guide 1.82 Rev. 2, Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident (Reference 55). The suction strainer will prevent debris from entering the RCIC system and being injected into the RPV.

9.2 Ultimate Heat Sink

The normal minimum surface elevation of Limerick Spray Pond is El 250’ 10" (9' 10" depth). The lowest Spray Pond design water surface elevation is El 243' 6", a surface area of 9.6 acres, with a design minimum volume of 29 million gallons. The FLEX pump takes suction on the Spray Pond using a 6" rigid hose with a floating suction strainer. This floating strainer design prevents the suction hose from reaching the Spray Pond clay floor and draws water from just below the surface.

The floating suction strainer, has an integral screen sized to preclude objects larger than the pump can handle from entering the pump. This screen size is similar to the screen size that is used for RHRSW suction at the spray pond pump house. If required the pump can be secured briefly, the suction hose can be pulled from the water and cleaned by hand if required.

With respect to RPV makeup directly from the Spray Pond, the A and B RHR connection points supply water to the RPV using the LPCI injection line which supplies water inside the shroud region. Adequate cooling is assured when the inside shroud region remains flooded because coolant can enter the fuel through the top of the fuel channels and maintain low fuel temperatures (Reference 56). This is based on BWROG report, BWROG-TP-14-006 (Reference 57). This report states “BWR fuel can be adequately cooled when the core inlet is postulated to be fully blocked from debris injected with the make-up coolant. The fuel is effectively cooled when the inside shroud is flooded, and this is accomplished by either injecting makeup coolant inside the shroud or by maintaining the water level above the steam separator return elevation if injecting make-up in the downcomer.”

9.3 Spent Fuel Pool

During Phase 1 makeup to the SFP is not required. During Phase 2, water for Spent Fuel Pool makeup comes from the Spray Pond by way of the RHRSW piping and the RHR systems as described above.

10 Shutdown and Refueling Analysis

LGS will abide by the Nuclear Energy Institute position paper entitled "Shutdown and Refueling" (Reference 18) addressing mitigating strategies in shutdown and refueling modes. This position paper is dated September 18, 2013 and has been endorsed by the NRC staff (Reference 19). These mitigating strategies are defined below.

Using the NEI position paper to further develop and clarify the guidance provided in NEI 12-06 related to industry's ability to meet the intent of Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events, during shutdown and refueling modes of operation, the following Exelon fleet strategy objectives are established:

1. A defense in depth approach will be used to support FLEX strategies during shutdown/refueling modes. The defense in depth approach is selected over development of mode specific FSGs and supporting analysis for the following reasons:

   - Outage conditions are highly diverse and will be a significant challenge to developing modifications, procedures and supporting analysis that will be valid under all shutdown/refueling conditions.

   - The time duration of shutdown/refueling conditions is small compared to the time at operating conditions such that the risk of external initiating events concurrent with shutdown/refueling conditions is very small. Additionally, due to the large and diverse scope of activities and configurations for any given nuclear plant outage (planned or forced), a systematic approach to shutdown safety risk identification and planning, such as that currently required to meet §50.65(a)(4) along with the availability of the FLEX equipment, is the most effective way of enhancing safety during shutdown.

   - Resource availability is much greater and more diverse during outages, particularly during high risk evolutions such as shutdown and refueling mode operations and reduced inventory conditions (e.g., RPV water level below the vessel flange with irradiated fuel seated in the reactor vessel (BWR), mid-loop operation with fuel seated in the reactor vessel or reactor vessel head installed with Reactor Coolant System loops isolated (PWR)). This includes command and control structures to support event mitigation and recovery.

   - Shutdown Safety Management Program procedures require availability of a greater number of systems than required by plant Technical Specifications to ensure capability of key safety functions. Contingency plans are developed as required when the defense in depth is reduced below a specified minimum value. A defense in depth strategy is recognized by previous NRC and industry initiatives to improve shutdown safety.

2. Exelon has incorporated the supplemental guidance provided in the NEI position paper into OU-AA-103, "Shutdown Safety Management Program" (Reference 38) to provide this additional guidance.

3. For planned outages and early in an unplanned outage, an outage risk profile is developed as described in OU-LG-104, "Limerick Generating Station Shutdown Safety Management Program." (Reference 39) This risk assessment is updated daily and as changes are made to the outage schedule. Contingency actions are developed for high risk evolutions and the time needed for such evolutions is minimized. During an outage, additional resources are available on site and during the high- risk evolutions individuals are assigned specific response actions (e.g. response team assigned to close the containment equipment hatch). The risk assessment accounts for environmental conditions and the condition of the grid, among other variables. In order to effectively manage risk and maintain safety during outages, LGS develops contingencies to address the precautions and response actions for a loss of core cooling. These contingencies not only direct actions to minimize the likelihood for a loss of core cooling but also direct the actions to be taken to respond to such an event. For the worst-case conditions (reduced inventory at the start of a refuel outage with high decay heat load) an Engineering Eval (Reference 20) was performed to determine and document the time to boil off enough water to reduce level to TAF. This time to boil off this quantity of water is greater than FLEX pump deployment times, therefore pre-deployment of FLEX pumps is not required. No modifications, analyses, or additional engineering evaluations need to be performed to support shutdown/refueling FLEX strategy implementation. This approach is fully consistent with the NEI position paper on shutdown/refueling modes and the NRC endorsement letter of the NEI position paper.

11 Sequence of Events

The Table 1 below presents a Sequence of Events (SOE) Timeline for an ELAP/LUHS event at Limerick. Validation of each of the FLEX time constraint actions has been completed in accordance the FLEX Validation Process document issued by NEI and includes consideration for staffing.

Table 1 Sequence of Events Timeline

Action item	Elapsed Time	Action	Time Constraint Y/N [1]	Remarks / Applicability
N/A	0	Event Starts	NA	Plant @100% power
1	0	Enter TRIPS	N	Operator Response
2	0	Enter SBO Procedure (E-1).	N	Operator Response
3	< 10 minutes	Manually operate MSRV, stabilize Reactor Pressure, initiate cooldown.	N	E-1, SBO Procedure
4	< 10 minutes	If HPCI automatically initiated, shutdown HPCI.	Y	E-1, SBO Procedure
5	< 10 minutes	Maintain RCIC with suction from the Suppression Pool.	N	E-1, SBO Procedure
6	< 10 minutes	Attempts to start EDGs from MCR unsuccessful.	N	E-1, SBO Procedure
7	< 10 minutes	Dispatch operators to attempt to start EDGs locally.	N	E-1, SBO Procedure
8	~ 20 minutes	Commence cooldown of RPV.	N	E-1, SBO Procedure
9	~ 45 minutes	DC load shedding initiated.	N	E-1, SBO Procedure
10	1 hour	Attempts to start EDGs locally unsuccessful.	N	E-1, SBO Procedure
11	1 hour	Control Room crew has assessed SBO and plant conditions and declares an Extended Loss of AC Power (ELAP) event.	Y	Time constraint because decision drives timeline for additional load shedding and setup of FLEX equipment.

[1] Instructions: Provide justification if No or NA is selected in the remark column
If yes include technical basis discussion as required by NEI 12-06 section 3.2.1.7

Action item	Elapsed Time	Action	Time Constraint Y/N [1]	Remarks / Applicability
12	1 hour	Dispatch Operators to begin setup/connection of FLEX equipment.	N	DC analysis shows the batteries have a minimum of 7:25 hours coping capability with initial and deep load shedding completed.
13	< 1.5 hours	Complete actions to establish natural ventilation to RCIC Rooms.	Y	Limit heatup of RCIC Room to allow prolonged RCIC operation.
14	2 hours	Complete initial SBO DC Load Shed.	Y	Prolong battery life. E-1 SBO Procedure requires that this is completed in 2 hours.
15	3 hours	Complete additional load sheds (ELAP) identified for battery life extension.	Y	Prolong battery life beyond current SBO guidance.
16	4 hours	Heat Capacity Temperature Limit (HCTL) curve exceeded, RPV depressurization to ~ 200 psig required. RPV pressure maintained at 150 to 200 psig to support RCIC Operation.	N	Analysis indicates that the HCTL curve will be exceeded at ~4 hrs based on this strategy. RPV depressurization stops at ~200 psig (pressure band of 150-250 psig used) in RPV to preserve RCIC operation.
17	6 hours	Initiate early containment venting to preserve RCIC and portable pumps connected to RHRSW for Reactor inventory makeup.	Y	

Action item	Elapsed Time	Action	Time Constraint Y/N [1]	Remarks / Applicability
18	< 7 hours	Portable Generators providing power to battery chargers.	Y	Analysis indicates that battery life to support RCIC operation is limited to approximately 7.5 hours. Restore power to battery chargers prior to reaching 7 hours.
19	12 hours	Water available for Spent fuel pool cooling.	Y	
20	~ 20 hours	Provide Suppression Pool makeup via portable pumps to RHRSW/RHR.	Y	Analysis indicates that Suppression Pool makeup will be required at approximately 65 hrs per LG-MISC-012.
21	24 hours	Initial equipment from Regional Response Center (RRC) becomes available.	N	Not time critical since RRC equip. is not needed at 24 hrs to support actions.

Action item	Elapsed Time	Action	Time Constraint Y/N [1]	Remarks / Applicability
22	24 -72 hours	Continue to maintain critical functions of core cooling (via RCIC), containment (via hardened vent opening and FLEX pump injection to suppression pool) and SFP cooling (FLEX pump injection to SFP). Utilize initial RRC equipment in spare capacity and begin setup for suppression pool cooling via the additional RRC equipment to be delivered (4160 VAC generator to power RHR pump and large FLEX pump to provide cooling water flow from Spray Pond to the RHR Heat Exchanger).	N	Not time critical since Phase 2 actions result in indefinite coping times for all safety functions.
23	72+ hours	Establish suppression pool cooling via RRC equipment and continue to maintain critical functions.	N	Not time critical since Phase 2 actions result in indefinite coping times for all safety functions.

12 Programmatic Elements

12.1 Overall Program Document

Limerick procedure CC-LG-118 (Reference 43) provides a description of the FLEX Program for Limerick Station. This procedure implements Exelon fleet program document CC-AA-118 (Reference 44) which contains governing criteria and detailed requirements. The key elements of the program include:

- Summary of the Limerick FLEX strategies
- Maintenance of the FSGs including any impacts on the interfacing procedures (EOPs, Operational Transient (OT), Off-Normal (ON), etc.)
- Maintenance and testing of FLEX equipment (i.e., SFP level instrumentation, emergency communications equipment, portable FLEX equipment, FLEX support equipment, and FLEX support vehicles)
- Portable equipment deployment routes, staging areas, and connections to existing mechanical and electrical systems
- Validation of time critical operator actions

- The FLEX storage buildings and the Regional Response Center
- Supporting evaluations, calculations, and FLEX drawings
- Tracking of commitments and FLEX equipment unavailability
- Staffing and training
- Configuration management
- Program maintenance

The instructions required to implement the various elements of the FLEX program at Limerick and thereby ensure readiness of in the event of a BDBEE are contained in Exelon fleet program document CC-AA-118, Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Document.

Design control procedure CC-AA-102, Design Input and Configuration Impact Screening (Reference 45) has been revised to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will be reviewed to ensure they do not adversely impact the approved FLEX strategies or the strategies will be modified if required.

Design control procedure CC-AA-309-101, Engineering Technical Evaluations (Reference 46) has been revised to ensure technical evaluations are performed when new information is received that potentially challenges the conservatism of current external event design assumptions.

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 or a previously approved alternate approach, and 2) an engineering basis is documented that ensures that the change in FLEX strategies continues to ensure the key safety functions (core and SFP cooling, containment integrity) are met.

12.2 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 FSGs (T-300 procedures) will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDB external event conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to accomplish FLEX strategies or supplement EOPs, the EOP or Severe Accident Mitigation Guidelines (SAMPs), will direct the entry into and exit from the appropriate FSG procedure.

FLEX strategy support guidelines have been developed in accordance with BWROG guidelines. FSGs will provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs. FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

Procedural interfaces have been incorporated into Limerick E-1 Station Blackout procedure (Reference 11) to the extent necessary to include appropriate reference to T-300 procedures and provide command and control for the ELAP.

Changes to FSGs (T-300 series) procedures are controlled by OP-LG-101-100, Transient Response Implementation Plan (TRIP) and Severe Accident Management Plan (SAMP) Procedures (Reference 47). Changes to any other non-EOP procedures are governed by Exelon fleet procedure AD-AA-101, Processing of Procedures and T&RMs (Reference 48). FSG changes will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy remains feasible. Validation for existing FSGs has been accomplished in accordance with the guidelines provided in NEI APC14-17, FLEX Validation Process, issued July 18, 2014 (Reference 49) and OP-LG-101-102, Transient Response Implementation Plan (TRIP) and Severe Accident Management Plan (SAMP) Procedures Verification and Validation (V&V) Program (Reference 50).

12.3 Staffing

Using the methodology of NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities (Reference 7), an assessment of the capability of Limerick on-shift staff and augmented Emergency Response Organization (ERO) to respond to a BDBEE was performed (Reference 53).

The assumptions for the NEI 12-01 Phase 2 scenario postulate that the BDBEE involves a large-scale external event that results in:

1) ELAP conditions
2) an extended loss of access to UHS
3) impact on units (the unit is in operation at the time of the event)
4) impeded access to the unit by off-site 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.

Limerick Operations personnel conducted a table-top review of the on-shift response to the postulated BDBEE and extended loss of AC power for the Initial and Transition Phases using the FLEX mitigating strategies. Resources needed to perform initial event response actions were identified from the EOPs and SBO/ELAP Procedure E-1 (Reference 11). 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 analyses of NEI 10-05, Assessment of On-Shift Emergency Response Organization Staffing and Capabilities (Reference 51) .

This Phase 2 staffing assessment concluded that the current minimum on-shift staffing as defined in the Emergency Response Plan for Limerick, as augmented by site auxiliary personnel, is sufficient to support the implementation of the FLEX strategies, as well as the required Emergency Plan actions, with no unacceptable collateral duties.

The Phase 2 staffing assessment also identified the staffing necessary to support the Expanded Response Capability for the BDBEE as defined for the Phase 2 staffing assessment. This staffing will be provided by the current Limerick site resources, supplemented by Exelon fleet resources, as necessary.

12.4 Training

Limerick's Nuclear Training Program has been revised to assure personnel proficiency in 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.

Using the SAT process, job and task analyses were completed for the new tasks identified applicable to the FLEX mitigation strategies. Based on the analysis, training for operations was designed, developed and implemented for operations continuing training. "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" (Reverence 52) certification of simulator fidelity is considered to be sufficient for the initial stages of the BDB external event scenario training. Full scope simulator models have not been explicitly upgraded to accommodate FLEX training or drills. Overview training on FLEX Phase 3 and associated equipment from the SAFER NSRCs was also provided to Limerick operators. Upon SAFER equipment deployment and connection in an event, turnover and familiarization training on each piece of SAFER equipment will be provided to station operators by the SAFER deployment/operating staff.

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

Where appropriate, integrated FLEX drills will be conducted periodically; with all time-sensitive actions evaluated over a period of not more than eight years. It is not required to connect/operate temporary/permanently installed equipment during these drills.

13 FLEX Equipment

13.1 Equipment List

The equipment stored and maintained at the Limerick FLEX storage buildings and various pre-staged locations at Limerick necessary for the implementation of the FLEX strategies in response to a BDB external event are listed in Table 3. Table 3 identifies the quantity, applicable strategy, and capacity/rating for the major BDB/FLEX equipment components only, as well as, various clarifying notes. Details regarding fittings, tools, hose lengths, consumable supplies, etc., are not in Table 3 but are detailed in the Limerick FLEX inventory routine tests:

RT-6-000-914-0, Inspection of FLEX Pump Storage Building Equipment (Reference 58)
RT-6-000-915-0, Inspection of FLEX Generator Storage Building Equipment (Reference 59)
RT-6-000-913-0, Inspection of B.5.b Security Order Equipment (Reference 60)
RT-6-100-905-1, Routine Inspection of T-200 Hose Storage Locker (Reference 61)
RT-6-100-905-2, Routine Inspection of T-200 Hose Storage Locker (Reference 62)

13.2 N+1 Equipment Requirement

NEI 12-06 invokes an N+1 requirement for the major 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 all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where “N” is the number of equipment required by FLEX strategies for all units on-site. The existing 50.54(hh)(2) pump is counted toward the N+1 requirement, since it meets the functional and storage requirements outlined in NEI 12-06. The original 50.54(hh)(2) pump was replaced with a larger pump to meet both sets of requirements (Reference 76) and relocated from its previous storage locations to the nearby robust FLEX Pump storage building to ensure it is protected from all hazards.

The N+1 capability applies to the portable FLEX equipment that directly supports FLEX strategies required to maintain the key safety functions identified in Table 3-2 of NEI 12-06. Other 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.

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 being 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 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. This approach is now endorsed by NEI 12-06 Rev 2 and not considered an alternate approach.

The N+1 requirement does not apply to FLEX support equipment, vehicles, and tools. However, these items are covered by administrative procedures and are subject to inventory checks, unavailability requirements, and any maintenance and testing that are needed to ensure they can perform their required functions. FLEX Support equipment unavailability is tracked in accordance with Exelon Position Paper EXC-WP-12 (Reference 64).

13.3 Equipment Maintenance and Testing

Periodic testing and preventative maintenance of the FLEX equipment conforms to the guidance provided in INPO AP-913 (Reference 63). A fleet procedure has been developed to address Preventative Maintenance (PM) using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment.

EPRI has completed and has issued “Preventive Maintenance Basis for FLEX Equipment – Project Overview Report” (Reference 54). 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
- Fluid analysis
- Periodic operational verifications
- Periodic functional verifications with performance tests

The EPRI PM Templates for FLEX equipment conform to the guidance of NEI 12-06 providing assurance that stored or pre-staged FLEX equipment are being properly maintained and tested. EPRI templates are used for equipment where applicable. However, in those cases where EPRI templates were not available, Preventative Maintenance (PM) actions were developed using manufacturer provided information/recommendations, Exelon fleet procedure ER-AA-200, Preventive Maintenance Program (Reference 70), CC-AA-118 guidance and fleet Operating Experience. Refer to Table 2 for an overview. Detailed information on FLEX and FLEX support equipment PM's is contained in FLEX program document CC-LG-118 (Reference 43).

Table 2 Limerick FLEX Equipment Test and Maintenance Overview

Equipment	Quantity	Weekly	Quarterly	6 Month	Annual	3 Year	Notes
Diesel Portable Pump	3	Walk down		Functional Test and Inspection	Performance Test, Inspection & PM (Wet Run)	Battery and Fuel replacement	
Diesel Generator (480 volt 500 kW)	3	Walk down		Functional Test and Inspection (Unloaded Run)	Performance Test, Inspection and PM and Loaded Run	Filters, Battery and fuel replacement	
Cables	Stored in FLEX Generator Building						Replace every 10 years or test and justify extension/life
Hoses (for both pumps and permanent connections hoses)	Stored in Plant and FLEX Pump Building						Replace every 10 years
Communications (hand-held radios, bullhorns)	3 – Bullhorns 19 - radios			Functional test & inspection (Radios), phones)			
120VAC diesel generators	8				Inspection & Run		12 volt batteries not credited, use pull cord

Note: This schedule is typical PMs based on current fleet and industry recommendations, the site Program document (CC-LG-118) contains full list of PMs and scope that evolves over time based on Operating Experience.

13.4 Equipment Unavailability

The unavailability of FLEX equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP is controlled and managed per CC-LG-118 such that risk to mitigating strategy capability is minimized. The guidance in this procedure 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.

FLEX support equipment is defined as equipment not required to directly support maintenance of the key safety functions. There are no requirements specified in NEI 12-06 for unavailability time for any of the FLEX support equipment. This equipment is important to the successful Implementation of the Limerick FLEX strategy and Exelon requires establishment of an unavailability time (Reference 71).

- One or more pieces of FLEX support equipment available but not in its evaluated configuration for protection restore protection within 90 days.
- One or more pieces of FLEX support equipment is unavailable, restore the equipment to available within 90 days AND implement compensatory measures for the lost function within 14 days.

When FLEX equipment deficiencies are identified the following action will be taken:

1. Identified equipment deficiencies shall be entered into the corrective action program.
2. Equipment deficiencies that would prevent FLEX equipment from performing the intended function shall be worked under the station priority list in accordance with the work management process.
3. Equipment that cannot perform its intended functions shall be declared unavailable. Unavailability shall be tracked per CC-LG-118, utilizing the electronic Shift Operations Management System (eSOMS).

Table 3 Portable Equipment Stored On-Site

Use and (Potential / Flexibility) Diverse Uses						*Performance Criteria*
List Portable Equipment	**Core**	**Containment**	**SFP**	**Instrumentation**	**Accessibility**	
FLEX diesel-driven pump (3) and assoc. hoses and fittings	X	X	X			1200 gpm @ 227 psig, Supports core, containment and SFP cooling
FLEX generators (3) and associated cables, connectors	X	X	X	X		500 kW, 480 VAC, Supports core, containment and SFP cooling, instrumentation and controls
Tow vehicles with plows for debris removal (2)	X	X	X		X	Support large FLEX equipment deployment and debris removal
1000 gal Fuel tank with electric pump and backup hand pump in FLEX Pump bldg	X	X	X	X	X	Support adding fuel to diesel engine driven FLEX pump
Portable fuel transfer hoses (2) portable spare transfer pump)[1]	X	X	X	X	X	Support adding fuel to diesel engine driven FLEX equipment
Skidsteer loaders					X	Not credited for FLEX strategies, but increases debris removal capabilities

Table 3 Portable Equipment Stored On-Site (cont.)

Use and (Potential / Flexibility) Diverse Uses						
List Portable Equipment	***Core***	***Containment***	***SFP***	***Instrumentation***	***Accessibility***	***Performance Criteria***
Communications equipment [1] (radios, spare radio batteries and chargers, bullhorns and handheld satellite phones)	X	X	X	X	X	Support on-site and off-site communications
Communications small portable generators. (8)[1]	X	X	X	X	X	5.5 kW, 120 VAC, Support communication equipment, ventilation and lighting
Misc. debris removal equipment[1] (large bolt cutters, chain saws, sawzalls, proximity voltage detector)					X	Support FLEX deployment
Misc. Support Equipment[1] (hand tools, flashlights & batteries, lanterns, extension cords, rope)					X	Support FLEX deployment
NOTE 1: Support equipment. Not required to meet N+1.						

Table 4 BWR Portable Equipment from NSRC

Use and (Potential / Flexibility) Diverse Uses									Performance Criteria		Notes
List Portable Equipment	**Quantity Req'd /Unit**	**Quantity Provided / Unit**	**Power**	**Core Cooling**	**Cont. Cooling/ Integrity**	**Access**	**Instrumentation.**	**SFP Cooling**			
Medium Voltage Generators and cable sets	0	2	Jet Turb.	X	X		X		4.16 kV	1 MW	(1)
Low Voltage Generators and cable sets	0	1	Jet Turb	X	X		X		480VAC	1100 KW	(1)
High Pressure Injection Pump and hoses	0	1	Diesel						2000psi	60 gpm	(1)
S/G RPV Makeup Pump and hoses	0	1	Diesel	X	X				500 psi	500 gpm	(1)
Low Pressure / Medium Flow Pump and hoses	0	1	Diesel	X	X				300 psi	2500 gpm	(1)
Low Pressure / High Flow Pump and hoses	0	1	Diesel	X	X			X	150 psi	5000 gpm	(1)

Table 4 BWR Portable Equipment from NSRC (cont.)

Use and (Potential / Flexibility) Diverse Uses									Performance Criteria	Notes
List Portable Equipment	Quantity Req'd /Unit	Quantity Provided / Unit	Power	Core Cooling	Cont. Cooling/ Integrity	Access	Instrumentation.	SFP Cooling		
Lighting Towers	0	3	Diesel			X			440,000 Lumens	(1)
Diesel Fuel Transfer	0	1	AC/DC	X	X	X	X	X	500 gallon air-lift container	(1)
Diesel Fuel Transfer Tank	0	1							264 gallon tank, with mounted AC/DC pumps	(1)
Portable Fuel Transfer Pump	0	1							60 gpm after filtration	(1)
4.1 KV Electrical Distribution System	0	1							4160 V 250 MVA, 1200 A	(1)
Suction Booster Lift Pump	0	2	Diesel	X	X			X	26 Feet Lift 5000 gpm	(2)

Note 1 NSRC Generic Equipment – Not required for Phase 2 FLEX Strategy – Provided as Defense-in-Depth.
Note 2 NSRC Non-Generic Equipment needed to support use of NSRC Generic Pumps due to suction lift requirements as source of make-up water. – Not required for Phase 2 FLEX Strategy – Provided as Defense-in-Depth

14 References

1) NRC Order EA-12-049, Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, March 12, 2012

2) NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 0, August 2012

3) NRC 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

4) NRC Order EA-12-051, Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation, March 12, 2012

5) NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", Revision 1, August 2012

6) NRC JLD-ISG-2012-03, Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation, Revision 0, August 29, 2012

7) NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, Revision 0, April 2012

8) Task Interface Agreement (TIA) 2004-04, "Acceptability of Proceduralized Departures from Technical Specification (TSs) Requirements at the Surry Power Station"

9) ECR 14-00019 (EC 422939), Fukushima FLEX – Electrical Engineering Modification

10) LE-0125, Class 1E Battery Load Duty Cycle Determination ELAP Scenario

11) E-1, "Station Blackout"

12) Tech Eval 1550669-05, Battery Room Heat-up and H2 Generation

13) ECR 14-00013 (EC 422934), RHRSW Connections in the SPPH

14) ECR 14-00012 (EC 422933), Fukushima FLEX Mod Lead Unit (2) – Spray Pond

15) LM-0706, Fukushima FLEX Hydraulic Analysis

16) LG-MISC-012, MAAP Analysis to Support Initial FLEX Strategy

17) NEDC 33771P R2, GEH Evaluation of FLEX Implementation Guidelines

18) NEI Position Paper Shutdown and Refueling: ADAMS Accession No. ML13273A514

19) NRC Endorsement of NEI Shutdown and Refueling paper: ADAMS Accession No. ML13267A382

20) EC Eval 617968, "Determine Time to top Of Active Fuel During Low Inventory/ High Heat Load Conditions"

21) RCIC Pump and Turbine Durability Evaluation – Pinch Point Study, February 2013, 0000-0155-1545-R0, DRF 0000-0155-1541, Revision 07.2

22) BWROG Fukushima Response Committee, BWROG-TP-14-018, Beyond Design Basis RCIC Elevated Temperature Functionality Assessment, December 2014, Rev. 0
23) T-101, RPV Control
24) CC-LG-118-1001 Limerick SAFER Response Plan
25) NUMARC 87-00 Rev 1, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors
26) EA-13-109, Issuance of Order to Modify Licenses with Regard to Hardened Containment Vents Capable of Operation Under Severe Accident Conditions
27) T-102, Primary Containment Control
28) EXC-WP-10 RCIC Operation at Elevated Temperatures Rev. 1
29) USAR Section 9.1.3
30) LM-0708, Spent Fuel Pool Heat-up - FLEX
31) LM-0710, Refueling Floor Air Space Transient Temperature Profile following ELAP
32) LM-0689, RCIC Pump Rm Temps for Extended Loss AC Power-Post Fukushima Scenario
33) AR 1340416-46-35, FLEX Lighting Review
34) T-334, FLEX Generator Connection for Repowering Div 2 Battery Charger
35) T-333, FLEX Generator Connection for Repowering Div 1 Battery Charger
36) LM-0157, Control Heatup Analysis in an Event of Station Blackout
37) Tech Eval 1550669-04 ELAP MCR Temperatures
38) OU-AA-103, Shutdown Safety Management Program
39) OU-AA-104, Limerick Generating Station Shutdown Safety Management Program
40) T-362, Main Control Room Potable Ventilation and Lighting
41) Tech Eval 1550669-08, Haul Path Evaluation
42) AR 1560443-06, Site Specific Debris Removal Whitepaper
43) CC-LG-118, Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program
44) CC-AA-118, Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Document
45) CC-AA-102, Design Input and Configuration Impact Screening
46) CC-AA-309-101, Engineering Technical Evaluations
47) OP-LG-101-100, Transient Response Implementation Plan (TRIP) and Severe Accident Management Plan (SAMP) Procedures
48) AD-AA-101, Processing of Procedures and T&RMs
49) NEI APC 14-17, FLEX Validation Process
50) OP-LG-101-102, Transient Response Implementation Plan (TRIP) and Severe Accident Management Plan (SAMP) Procedures Verification and Validation (V&V) Program

51) NEI 10-05, Assessment of On-Shift Emergency Response Organizations Staffing and Capabilities
52) ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training
53) RS-14-325, LGS Response to the Phase 2 Staffing assessment, dated December 5, 2014
54) EPRI: Preventive Maintenance Basis for FLEX Equipment – Project Overview Report
55) Regulatory Guide 1.82 Rev 2, Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident
56) Eval 1550669-23, Track industry issue for Raw Water Effects on Reactor
57) BWROG-TP-14-006, Revision 0, March 2014, Fukushima Response Committee Raw Water Issue: Fuel inlet blockage from debris
58) RT-6-000-914-0, Inspection of FLEX Pump Storage Building Equipment
59) RT-6-000-915-0, Inspection of FLEX Generator Storage Building Equipment
60) RT-6-000-913-0, Inspection of B.5.b Security Order Equipment
61) RT-6-100-905-1, Routine Inspection of T-200 Hose Storage Locker
62) RT-6-100-905-2, Routine Inspection of T-200 Hose Storage Locker
63) INPO AP-913, Equipment Reliability Process Description
64) EXC-WP-12 Exelon Position Paper - Required Actions for FLEX Support Equipment
65) T-346, Refuel Floor Alignment for SFP Makeup, Spray and Ventilation
66) T-322, SFP Makeup and spray From Spray Pond
67) EC 623249, FLEX Fuel requirements
68) T-370, Primary and Alternate Instrumentation During ELAP
69) T-343, Suppression Pool Makeup from Spray Pond
70) ER-AA-200, Preventive Maintenance Program
71) EXC-WP-12 Exelon Position Paper – Required Actions for FLEX Support Equipment
72) ECs 4228314, 423281, 423331, 423332, 423333, 423440 - Unit 2 Hardened Containment Vent System
73) ECs 423381 and 423382 - Unit 1 Hardened Containment Vent System
74) Tech Eval 1550669-11, Pipe Stress Review for RCIC at Elevated Temperatures
75) NPB-117, Potential Flooding of Plant Area PMP, CT Dike Failure CW Pipe Break
76) Tech Eval 567707-35, Evaluation of Godwin HL110 and HL130 pumps to demonstrate that the HL130 pump can be used in place of the HL110 B.5.b