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References:

1. NRC Order Number EA-12-049, *Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events*, dated March 12, 2012
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 21, 2012
4. APS Letter 102-06670, APS 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

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 Docket Nos. STN 50-528, 50-529, and 50-530 APS Final 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)**

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued an order (Reference 1) to Arizona Public Service Company (APS). Reference 1 was immediately effective and directs APS 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 overall integrated plan (OIP) by February 28, 2013. The NRC Interim Staff Guidance (ISG) (Reference 2) was issued August 29, 2012 which endorses industry guidance document NEI 12-06, Revision 0 (Reference 3) with clarifications and exceptions. APS provided the OIP (Reference 4) pursuant to Section IV, Condition C.1, of Reference 1.

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The NRC staff subsequently requested that, within 60 days of the date for the final unit to achieve compliance at their plant, licensees submit a Final Integrated Plan (FIP), reflecting the strategies for their plants on that date. This letter transmits the FIP for PVNGS Units 1, 2, and 3. The information in the FIP supersedes the information provided in the OIP.

The NRC also requested that, within 60 days of the compliance date for the final unit at their plant, licensees submit responses to the NRC Open Items, Confirmatory Items, and Audit Items identified by the staff regarding the mitigation strategies implemented at their sites. The APS response for the Palo Verde Nuclear Generating Station (PVNGS) site was submitted by letter number 102-07157, dated December 17, 2015.

No commitments are being made to the NRC by this letter.

Should you have any questions concerning the content of this letter, please contact Thomas Weber, Department Leader, Regulatory Affairs, at (623) 393-5764.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 24, 2015
(Date)

Sincerely,

George W. A— FOR MARIA LACAL

MLL/TNW/PJH/af

Enclosure: Final Integrated Plan Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3

cc:	M. L. Dapas	NRC Region IV Regional Administrator
	M. M. Watford	NRC NRR Project Manager
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ENCLOSURE

FINAL INTEGRATED PLAN

PALO VERDE NUCLEAR GENERATING STATION
UNITS 1, 2 AND 3

FINAL

INTEGRATED

PLAN

PALO VERDE NUCLEAR GENERATING STATION
UNITS 1, 2 AND 3

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Acronyms

AC .... Alternating Current
ADAMS .... Agencywide Documents Access and Management System
ADV .... Atmospheric Dump Valve
AFAS .... Auxiliary Feedwater Actuation Signal
AFT .... Applied Flow Technology
AFW .... Auxiliary Feedwater
AHU .... Air Handling Unit
APS .... Arizona Public Service Company
AOP .... Abnormal Operating Procedures
ASCE .... American Society of Civil Engineers
ASHRAE ..... American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME .... American Society of Mechanical Engineers
ASTM .... American Society for Testing and Materials
BDB .... Beyond-Design-Basis
BDBEE .... Beyond-Design-Basis External Events
Btu .... British thermal unit
CE .... Combustion Engineering
CET .... Core Exit Thermocouples
CENTS .... Combustion Engineering Nuclear Transient Simulator
CRE .... Control Room Envelope
CST .... Condensate Storage Tank
CVCS .... Chemical and Volume Control System
DG .... Diesel Generator
DC .... Direct Current
EAL .... Emergency Action Level
EC .... Engineering Change
ECCS .... Emergency Core Cooling System
EDMG .... Extreme Damage Mitigation Guidelines
EESF .... Emergency Equipment Storage Facility
ELAP .... Extended Loss of Alternating Current Power
EOF .... Emergency Operations Facility

EOP .... Emergency Operating Procedure
EPRI .... Electric Power Research Institute
ERO .... Emergency Response Organization
ESF .... Engineered Safety Feature
ETAP .... Electrical Transient Analyzer Program
F .... Fahrenheit
FSG .... FLEX Support Guidelines
FLEX .... Diverse and Flexible Coping Strategies
FMEA .... Failure Modes Effects Analysis
gpm .... Gallons per Minute
GOTHIC .... Generation of Thermal-Hydraulic Information for Containments
HCLPF .... High Confidence of Low Probability of Failure
HDPE .... High Density Polyethylene
HELB .... High Energy Line Break
HPSI .... High Pressure Safety Injection
HVAC .... Heating, Ventilation, and Air Conditioning
IEEE .... Institute of Electrical and Electronics Engineers
INPO .... Institute of Nuclear Power Operations
ISG .... Interim Staff Guidance
K_{eff} .... $K_{effective}$, neutron multiplication, used as a measure of criticality safety
KSB .... Klein, Schanzlin & Becker
LCO .... Limiting Condition for Operation
LOCA .... Loss of Coolant Accident
LOP .... Loss of Power
LPSI .... Low Pressure Safety Injection
LUHS .... Loss of the Ultimate Heat Sink
MAAP .... Modular Accident Analysis Program
MCC .... Motor Control Center
MS .... Microsoft®
MSSS .... Main Steam Support Structure
MSSV .... Main Steam Safety Valve
NC .... Natural Circulation

NEI ..... Nuclear Energy Institute
NEMA ..... National Electrical Manufacturers Association
NRC ..... US Nuclear Regulatory Commission
NSRC ..... National SAFER Response Center
NSSS ..... Nuclear Steam Supply System
NTTF ..... Near-Term Task Force
OBE ..... Operating Basis Earthquake
OIP ..... Overall Integrated Plan
ORIGEN ..... Oak Ridge Isotope GENerator
PEICo ..... Pooled Equipment Inventory Company
PM ..... Preventative Maintenance
PMF ..... Probable Maximum Flood
PMP ..... Probable Maximum Precipitation
ppm ..... Parts per Million
psia ..... Pounds per Square Inch Absolute
psig ..... Pounds per Square Inch Gauge
PVNGS ..... Palo Verde Nuclear Generating Station
PWROG ..... Pressurized Water Reactor Owners Group
Q1E ..... Quality "Q" Class 1 Electrical Equipment
RAI ..... Request for Additional Information
RCP ..... Reactor Coolant Pump
RCS ..... Reactor Cooling System
RHR ..... Residual Heat Removal
RMWT ..... Reactor Makeup Water Tank
RPM ..... Revolutions per Minute
RVLMS ..... Reactor Vessel Level Monitoring System
RWT ..... Refueling Water Tank
SAFER ..... Strategic Alliance for FLEX Emergency Response
SAMG ..... Severe Accident Mitigation Guidelines
SAT ..... Systematic Approach to Training
SBCS ..... Steam Dump and Bypass Control System
SBO ..... Station Blackout

SBOG .... Station Blackout Generator
SER .... Safety Evaluation Report
SFP .... Spent Fuel Pool
SG .... Steam Generator
SIT .... Safety Injection Tank
SS .... Stainless Steel
SSC .... Structures, Systems, and Components
SSE .... Safe Shutdown Earthquake
TDAFW .... Turbine Driven Auxiliary Feedwater
UFSAR .... Updated Final Safety Analysis Report
UGS .... Upper Guide Structure
UHS .... Ultimate Heat Sink
USGS .... United States Geological Survey
VAC .... Volts - Alternating Current
VDC .... Volts - Direct Current
VFC .... Variable Frequency Control
WR .... Wide Range

Executive Summary

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-049, *Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,* to all licensees requiring implementation of mitigation strategies for beyond-design-basis external events (BDBEE), as identified in Near-Term Task Force (NTTF) Recommendation 4.2. Order EA-12-049 required submission of a Final Integrated Plan (FIP) to the NRC after full compliance with the referenced orders. In order to assist the industry in responding to the NRC order, the Nuclear Energy Institute (NEI) developed guidance in report number 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide." NRC interim staff guidance (ISG) JLD-ISG-2012-01 endorses, with clarifications, the methodologies described in NEI 12-06.

This submittal describes the Palo Verde Nuclear Generating Station (PVNGS) FIP, including key assumptions, implementing strategies, and operator action times for complying with the NRC order and implementing FLEX, as described by JLD-ISG-2012-01 and NEI 12-06. The PVNGS FIP contains a description of the general elements of the plan, followed by a discussion of the safety functions that are identified in the order, which are core cooling, containment integrity, and spent fuel pool cooling.

The NRC order requires that the underlying strategies for coping with BDBEE involve a three-phase approach:

- Phase 1 - Initially cope relying on installed equipment and on-site resources.
- Phase 2 - Transition from installed plant equipment to on-site FLEX 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.

These phases are discussed in the response in terms of how each phase addresses the identified safety functions. The first step of the FLEX strategy is establishment of the baseline coping capability to maintain or restore key plant safety functions under the conditions of an extended loss of alternating current (AC) power (ELAP) and loss of normal access to the ultimate heat sink (LUHS). These strategies are independent of a specific damage state or mechanistic assessment of external events. To meet the requirements of a FIP, the safety functions of core cooling, containment integrity, and spent fuel pool cooling need to be maintained indefinitely under ELAP and LUHS conditions. Using conservative operator action times and NEI 12-06 guidance, Arizona Public Service Company (APS) has determined that the long term coping and approach to shutdown cooling is achievable without loss of natural circulation flow. PVNGS procedures and processes address plant strategies for implementing the FIP.

PVNGS coping strategies can be utilized regardless of the initiating external event (as identified by NEI 12-06). These strategies were developed to mitigate the impact of an

ELAP and LUHS. However, based on NEI 12-06 screening guidance, the two external hazards that are applicable to PVNGS are seismic and extreme heat. Although station design for these external hazards are conservative with ample margin of safety, APS has evaluated the functional threats from each of these hazards and identified FLEX equipment and strategies that are expected to be effective in mitigating these events. Based on this evaluation, strategies that focus on the seismic hazard were selected, since extreme high temperatures for a prolonged duration and extreme drought are slowly progressing meteorological events which can be adequately addressed by existing plant procedures that will ensure the plant is shutdown, if required, and placed in a safe condition for these situations.

The information within this submittal is prepared solely to support beyond design bases operational procedures to mitigate the limiting external events applicable to PVNGS. It provides a description of the conceptual approach used by APS to implement the PVNGS FIP.

This FIP documents the completion of the commitments made in the OIP, and subsequent communication with the NRC, to comply with NRC Order EA-12-049.

1. Background

In 2011, an earthquake-induced tsunami caused beyond-design-basis (BDB) flooding at the Fukushima Dai-ichi Nuclear Power Station in Japan. The flooding caused the emergency power supplies and electrical distribution systems to be inoperable, resulting in an extended loss of alternating current power (ELAP) in five of the six units on the site. The ELAP led to (1) the loss of core cooling, (2) the loss of spent fuel pool cooling capabilities, and (3) the inability to maintain 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 (Reference 1) contained many recommendations to fulfill this charter, including assessing extreme external event hazards and strengthening station capabilities for responding to BDB external events.

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 2) on March 12, 2012, to implement mitigation strategies for Beyond-Design-Basis External Events (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 integrity, and spent fuel pool (SFP) cooling capabilities following a BDBEE.

2) These strategies must be capable of mitigating a simultaneous loss of all alternating current (AC) power and loss of normal access to the ultimate heat sink (UHS) and have adequate capacity to address challenges to core cooling, containment integrity 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 integrity, 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 FLEX 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 2) required licensees of operating reactors to submit an overall integrated plan (OIP), including a description of how compliance with the requirements would be achieved. The Order also required licensees to complete implementation of the requirements no later than two refueling cycles after submittal of the OIP or December 31, 2016, whichever came first.

The Nuclear Energy Institute (NEI) developed NEI 12-06 (Reference 75), which provides guidelines for nuclear stations to assess extreme external hazards and implement the mitigation strategies specified in NRC Order EA-12-049 (Reference 2). The NRC issued Interim Staff Guidance JLD-ISG-2012-01 (Reference 3), dated August 29, 2012, which endorsed NEI 12-06 (Reference 75) with clarifications on determining baseline coping capability and equipment quality. NRC staff reviews of the APS efforts to implement the order (Reference 2) are documented in References 5 and 6. References 12, 13 and 14 document the APS conclusion that PVNGS is in compliance with the Order for each of the PVNGS units.

2. General Integrated Plan Elements

APS has evaluated the PVNGS performance for applicable external hazards based on the requirements of NRC Order EA-12-049 (Reference 2) and the guidance provided in Nuclear Energy Institute (NEI) 12-06 (Reference 75). The PVNGS Overall Integrated Plan (OIP) (Reference 9) and subsequent communication provide additional details. PVNGS has determined that regardless of the initiating external event, the coping strategies address the impact to the station from an ELAP and LUHS. The basis for how the NEI 12-06 guidance was applied for each hazard is described in Section 7 of this report.

APS has evaluated the functional threats from each of the applicable hazards and identified equipment and strategies that are expected to be effective in the deployment of Diverse and Flexible Coping Strategies (FLEX) for these events. The FLEX portable equipment, storage, and deployment locations provide appropriate protection from these hazards using station procedures and processes.

2.1. Assumptions

The key assumptions used in the development of the PVNGS Diverse and Flexible Coping Strategies (FLEX) are stated below:

1) All stationary AC power sources (onsite and offsite) are lost at the time of the initiating event (t=0).

2) The initiating event is an extreme external event that results in an ELAP, which causes all three (3) reactors at PVNGS to trip.

3) All three (3) reactors (units) are initially operating at full power (see Assumption 4 below) or two (2) units are at full power with one (1) unit in normal refueling.

4) Prior to the initiating event the reactors (all units or 2 out of 3 units per Assumption 3 above) have been operating at 100 percent of licensed power (3990 MW_{th}) for at least 100 days and core decay heat is sufficient for secondary steam source to drive essential TDAFW to perform its design function.

5) Units are not in any Technical Specification, Limiting Condition for Operation (LCO).

6) All operating reactors are shutdown and all control rods are inserted at the time of the initiating event (t=0), per design.

7) The reactors and supporting plant equipment are operating within normal ranges at the time of the initiating event and function as they were designed during FLEX phase 1.

8) No independent events (e.g., active security threat, fire, or internal flooding) occur concurrently with the initiating event.

9) No fatality or injury of essential personnel occurs as a result of the applicable hazards.

10) No single failure or partial actuation of active or passive SSCs occurs during the initiating event.

11) All SSCs are available.

12) All seismic category 1 essential electrical, mechanical and control equipment (passive or active) will remain functional per design, except as identified in Assumption 1 above.

13) All essential DC power sources, systems, and components will function as designed.

14) Sources of water for cooling and makeup that are contained in systems or structures are robust, with respect to seismic events, and are available for use in phases 2 and 3 of FLEX.

15) Diesel fuel oil for FLEX equipment is stored in structures that are robust, with respect to seismic events, and is available for use in phases 2 and 3 of FLEX.

16) The Spent Fuel Pool structures and boundaries are seismically designed with significant design margin. These SSCs are seismically qualified and will not fail as a result of a seismic event.

17) Where applicable, the requirements of NTTF 9.3, NRC 10 CFR 50.54(f) letter (Reference 4) are implemented and functional.

18) Reactor coolant inventory loss, post event, consists of reactor coolant pump seal leakage at its prescribed leakage recommended by NUMARC 87-00 (Reference 76 and Reference 7).

19) Extreme Heat Hazard procedural requirements direct all units to shutdown due to the impending event; the ultimate heat sink (UHS) is not affected by this hazard.

20) PVNGS seismically qualified ultimate heat sink (UHS) is not credited for FLEX per the guidance provided in NEI 12-06 (Reference 75). However, the motive force for the UHS is designed for the limiting safe shutdown earthquake (SSE), with margin, and the system and water inventory are available during recovery from a FLEX event. Duration of coping at PVNGS is defined as the time period starting with an initiating event (Assumption 2 above) and ending with recovery of the UHS.

21) Relatively short duration evolutions during plant shutdown or startup (less than one shift) are not considered within the scope of FLEX strategies due to the low probability of an event (Reference 75 and Reference 18).

2.2. Analytical Methods and Computer Codes used in Key Analyses

RCS and Secondary Side Evaluation

(Reference 34, NM1000-A00002)

PVNGS specific NSSS analysis was performed using the Combustion Engineering Nuclear Transient Simulator (CENTS) Nuclear Steam Supply System (NSSS) simulation code, Version 11240 (Reference 84), to evaluate the ELAP transient response for a maximum of 80 hours or until the core becomes uncovered, which is considered to be the precursor for core damage.

The PVNGS plant specific analysis is consistent with WCAP-17601-P (Reference 78).

An ELAP is assumed to occur at normal RCS conditions. The model evaluates a transient instantaneous loss of all AC power at the initiating event. This results in a loss of forced reactor coolant flow, pressurizer heaters, pressurizer sprays, charging pumps, letdown flow, high pressure safety injection (HPSI) pumps, low pressure safety injection (LPSI) pumps, steam dump and bypass control system (SBCS), and electrically supplied feedwater flow. RCS flow is maintained by Natural Circulation (NC) and Steam Generator (SG) secondary side heat removal via the Main Steam Safety Valves (MSSVs) early in the event and then manual remote operation of the Atmospheric Dump Valves (ADVs) after one hour.

Secondary makeup inventory is supplied by the essential Turbine Driven Auxiliary Feedwater (TDAFW) pump. The cases analyzed assume that the two SGs are connected. Since one ADV per SG is available and is used to cool the plant, the plant operators steam both SGs to maintain approximately equal pressures. Thus, assuming that the two SGs are connected has little effect on the progress of the scenarios, and essentially no impact on the final plant conditions. Additionally, the CENTS site specific evaluations provided reactivity control profiles and time dependent mass and energy input for containment analysis.

The CENTS code is benchmarked to CEFLASH-4A (Reference 85); the code benchmark is accepted by the NRC (Reference 16) and is considered an acceptable code to determine the time of transition to reflux cooling during an ELAP event for the Combustion Engineering (CE) designed plants.

Decay Heat Evaluations
(Reference 35, NM1000-A00004)

The **O**ak **R**idge **I**sotope **GEN**erator (ORIGEN-S) computer code (Reference 87) was used for the calculation of decay heat for the core. Both fission product and actinide contributions were considered as well as activation products of the fuel assembly structural materials.

PVNGS specific best estimate decay heat was developed for use in NSSS analysis using ORIGEN-ARP libraries and the ORIGEN-S code. This analysis uses the plant specific ORIGEN-ARP library inputs generated in SCALE 6.1 (Reference 86).

The determination of core decay heat was calculated through modeling three fuel assembly regions (once, twice and thrice burned batches) in the core and summing the decay heat contributions for the various regions.

Electrical Analysis of AC Power Circuits
(Reference 46, NM1000-A000174, Reference 47, NM1000-A000176, Reference 48, NM1000-A000175, and Reference 49, NM1000-A000177)

Computer Code ETAP (Reference 88) was used to evaluate essential 480 VAC electrical circuits that are powered by two 800 kW generators. AC analysis included:

- Load flow and motor starting calculation
- Short circuit, arc flash hazard & protective device coordination

Single-line diagrams and inputs were developed from planned layouts of temporary cables, modification packages, and FLEX final delivered generator sets and loose cabling. These analyses were done in place of design verification testing and provide a high level of confidence that the integrated system is functional.

Electrical Analysis of DC Battery Loads
(Reference 50, NM1000-A000048)

Battery life cycle analyses were performed consistent with the NEI position paper endorsed by the NRC (Reference 17). Verified Microsoft® (MS) Excel worksheets were used for calculating the battery discharge durations (Reference 91). The battery life cycle analysis considered pre-selected loads as described in the FLEX Support Guidelines (FSGs) (Reference 68). It was assumed that the load shed sequence is completed within 2 hours of the initiating ELAP event, and an additional load is shed at 16 hours (e.g., Atmospheric Dump Valves - ADVs). Battery life was evaluated until the batteries were discharged to the minimum voltage, or until the battery reached 72 hours, whichever time was shorter.

An aging correction factor of 1.25 was used per IEEE 485-2010, which corresponds to the IEEE 450-2002 (Reference 92) recommendation for battery replacement when capacity drops to 80% of rated capacity. A temperature factor of 1.30 was used based on an assumed temperature of 40 degrees F in the battery compartment for the FLEX event.

Hydraulic Calculations
(Reference 39, NM1000-A00020 and Reference 42, NM1000-A00032)

Computer code AFT-FATHOM (Reference 89) was used to determine fluid system hydraulic performance and to validate that the FLEX portable pumps have adequate NPSH and discharge flow. System analyses (for full power and lower modes) included:

- Spent Fuel Pool FLEX makeup lineups and suction sources
- RCS FLEX makeup lineups and suction sources
- Steam Generator FLEX makeup lineups and suction sources

Piping takeoff diagrams and inputs were developed from planned layout of hoses, piping runs per modification packages, and FLEX final delivered diesel and electric motor driven pump skids. These analyses were done in place of design verification testing and provide a high level confidence that the integrated system is functional.

SFP Seismic Sloshing and Time to Boil Off Evaluation
(Reference 36, NM1000-A00010)

An analytical calculation method was used with MS Excel software to estimate sloshing using the Housner method and TID-7024 (Reference 90). The amount of water sloshed out of the SFP is dependent on the wave motion inside of the pool. It is assumed that wave motion is parallel to seismic motion in either the x or y-axis. In this two dimensional analysis, the depth of the pool (and the maximum height of the wave) is in the z-direction and the equations describing the wave travel are in the x or y-direction. Any secondary and/or reflected waves will be smaller due to inventory and momentum losses.

Time to boil was calculated conservatively using water inventory within the pool after a seismic event by using nominal pool elevation (excluding the volume occupied by the fuel rack), loss due to sloshing, and system/pool liner leakages. Decay heat used for this analysis was based on NRC Branch Technical Position APCSB 9-2 (Reference 22) and is discussed in more detail in Section 5 of this report.

Containment Evaluation
(Reference 44, NM1000-A00042)

A model of the PVNGS containment building was developed using GOTHIC (Reference 83) to evaluate the long term temperature and pressure during an extended loss of AC power event during power and refueling operation. Walls and other significant heat sinks were included using appropriate heat transfer coefficients and boundary conditions. Solar heating was also applied to appropriate surfaces using the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) sol-air method. In addition, energy sources were added based upon heat losses from major Nuclear Steam Supply System (NSSS) components and heat loads from main steam and feedwater system piping in containment were included.

Input for mass and energy values were provide by CENTS analysis (Reference 34) as describe above (RCS and Secondary Side Evaluation) for 25 gpm / Reactor Coolant Pump (RCP) leakage at the start of the event. For refueling modes, pool boil off rate mass and energy was calculated based on best estimate decay heat (per Reference 35) at 48 hours after reactor shutdown.

Essential Turbine Driven Auxiliary Feedwater Pump Compartment Environmental Analysis
(Reference 33, NM1000-A00001)

A GOTHIC (Reference 83) model of the essential TDAFW pump compartment was developed with a three dimensional control volume to ensure that spatial temperature gradients, especially buoyancy driven differences, were appropriately captured. Adjacent areas with the potential for hydraulic communication with the essential TDAFW pump compartment were modeled with lumped control volumes.

Walls and other significant piping heat sinks were modeled with thermal conductors using appropriate heat transfer coefficients and boundary conditions. Doors and openings between the essential TDAFW pump compartment and other areas were modeled using an appropriate number of flow paths to allow for natural circulation and establish operator action times. Heat sources such as steam supply and exhaust piping, condensate drain lines, and un-insulated components were modeled directly with thermal conductors. In addition, direct steam release into the compartment was included to account for turbine gland seal and steam trap bypass leakage.

Control Room Habitability
(Reference 56, 13-MS-C045)

A simplified one node model of the control room using GOTHIC (Reference 83) was modeled to predict a 24 hour room temperature. Internal and external walls, floors, and ceilings were modeled as thermal conductors using appropriate heat transfer coefficient and surface conditions. The doors were considered closed during the entire period; therefore, no mass transfer took place. The heat generated by the instrumentation, lighting components, and personnel in the Control Room Envelope (CRE) were added and modeled as a single heat generating component.

The event scenario was based upon the failure of the normal and essential Air Handling Units (AHUs) in the CRE during a loss of all AC power. Consistent with this event sequence, initial room temperatures and thermal conductor temperatures were established based upon the availability of normal ventilation prior to the event.

2.3. Procedural Controls

1) Initial operator response is the same as existing procedures for a Station Blackout at power (10 CFR 50.63) and Lower Mode Functional during refueling (Reference 66 and Reference 70). FLEX Support Guidelines (Reference 68 and Reference 69) are entered within an hour of the initiating event.

2) National SAFER Response Center (NSRC) will start implementation of the Palo Verde SAFER Response Plan and by 24 hours after notification the first NSRC equipment will arrive at the site (Reference 62 and Reference 80).

3. Strategies

The objective of the FLEX strategies is to establish a plant long term coping capability in order to:

1) Prevent damage to the fuel in the reactor and the spent fuel pool and

2) Maintain containment integrity

These strategies address long term station coping capability as a result of a beyond-design-basis external event (BDBEE) that would result in an ELAP.

The plant's long term coping capability is attained through the implementation of pre-determined strategies (FLEX) that are focused on maintaining or restoring key reactor core, containment, and spent fuel pool safety functions. The FLEX strategies are not tied to any specific damage state or mechanistic assessment of events. Rather, the strategies are developed to maintain the key plant safety functions based on the evaluation of plant response to the coincident ELAP event. A safety function-based approach provides consistency and allows coordination with existing plant emergency operating procedures (EOP). FLEX strategies are implemented using FLEX Support Guidelines (FSGs). FSGs, EOPs, and Severe Accident Management Guidelines (SAMGs), in conjunction with the NSRC, provide a comprehensive strategy to mitigate a BDBEE.

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

- Phase 1 - Initially cope relying on installed equipment and on-site resources.
- Phase 2 - Transition from installed plant equipment to on-site FLEX 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.

FLEX phase durations, as described above, are for units experiencing an initiating external event at 100% power. Phase duration for other plant modes are discussed in the applicable sections of this report.

BDBEE strategies are provided for specific plant conditions, when steam generators are available (100% power) or when steam generators are decoupled from the RCS and the RCS vent has been established (refer to the relevant sections of this report for the specific plant conditions for which the lower modes strategy are applicable). Discussion herein is focused on plant modes of operation with the highest decay heat in the Reactor Core or the Spent Fuel Pool. Non-limiting plant conditions such as start-up and Modes 2-4 shutdown sequence are bounded.

The above objectives establish strategies capable of mitigating a simultaneous loss of all AC resulting from a BDBEE by providing adequate capability to maintain or restore core cooling, containment integrity, and SFP cooling capabilities at all units on site simultaneously. Though specific strategies are proceduralized, due to the inability to anticipate all possible scenarios, the strategies are diverse and flexible to encompass a wide range of possible conditions. These pre-planned strategies were developed to protect the public health and safety. Their impacts to the design and licensing basis have been evaluated under 10 CFR 50.59, Changes, Tests, and Experiments.

The plant Technical Specifications contain the limiting conditions for normal unit operations to ensure that design safety features are available to respond to a design basis accident and direct the required actions to be taken when the limiting conditions are not met. The result of the BDBEE 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), Conditions of Licenses and/or 10 CFR 73.55(p), Suspension of Security Measures. This position is consistent with the Task Interface Agreement (TIA) 2004-04 (Reference 15).

4. Reactor Core Cooling and Heat Removal Strategy

4.1. Reactor Coolant System at power

The FLEX strategy selected to mitigate an event from 100% power, via borated makeup and Residual (decay) Heat Removal (RHR) from the PVNGS Combustion Engineering (CE) System 80 NSSS, is to establish natural circulation in the RCS using symmetric steam generator cool-down. This is accomplished via release of steam from the two Steam Generators and two of the four Atmospheric Dump Valves (ADVs), one on each steam generator.

Long term performance of secondary cooling is assured by selection of a conservative operating point for the essential Turbine Driven Auxiliary Feed Water (TDAFW) and maintaining the primary system above the required pressure and temperature by controlling the secondary steaming rate.

The RCS reactivity and inventory control is achieved initially by discharge of the Safety Injection Tanks (SITs) as a result of RCS depressurization. When SITs are emptied, the FLEX portable high pressure RCS injection pump will provide borated makeup from the Refueling Water Tank (RWT). RCS boration and long term mixing is achieved using a FLEX strategy consistent with the accepted methods as documented in NRC Acceptance of Boration Strategies (Reference 27).

The RHR function is achieved by the essential TDAFW pump. The source of water for the essential TDAFW system is the Condensate Storage Tank (CST) and Reactor Makeup Water Tank (RMWT).

Phase 1 Strategy

At the time of the BDBEE which results in an ELAP, reactors and supporting systems are operating normally and within Technical Specifications with no LCOs invoked. An initiating event results in an ELAP and reactor trip. Automatic plant systems which do not rely on AC power are actuated as designed, with the exception of the Emergency Diesel Generators (EDG). As shown in Table 5, *Sequence of Events Timeline, Modes 1 – 4*, operators will enter existing PVNGS emergency and/or abnormal operating procedures (Reference 66 and Reference 67). These procedures will direct the operators to proceed with predetermined actions. These actions include, but are not limited to, confirming control rods are inserted, containment is isolated, and the essential Turbine Driven Auxiliary Feedwater (TDAFW) Pump is actuated and operational.

These procedures will also direct operator action to confirm isolation of any reactor coolant system (RCS) controlled leakage paths. The Blackout procedure (Reference 66) provides direction to dispatch an operator to manually start the station blackout generators (SBOGs). The FSG will be entered when an SBOG is confirmed to be unavailable and it is confirmed that offsite power cannot be restored, by either communication with the load dispatcher or visual verification of physical damage to site infrastructure. Once the FSG procedure is entered operators will:

- Initiate an RCS symmetric cool-down at 70 degrees F/hr to a stand-by RCS temperature and pressure that would support performance of the essential TDAFW pump. TDAFW and ADV controls are available in the control room for remote operation. The RCS will reach target long term pressure and temperature approximately 3.5 hours after the start of cool-down.

- Perform area walk-downs to limit water inventory loss and open the essential TDAFW pump compartment door(s) to limit heat buildup within the pump compartment.

- Initiate the Class IE 125 VDC power system (A, B, C, and D banks) load shed sequence.

The ADV control system can be remotely operated for a minimum of 16 hours based on ADV accumulator nitrogen design (Reference 8, UFSAR Section 9.5.9). The ADVs can also be manually operated in the Main Steam Support Structure (MSSS) building. The SG pressure will be controlled above 155 psia by manipulating ADVs to maintain the desired RPM for continuous operation of the essential TDAFW pump.

The essential TDAFW pump delivers CST inventory to the SGs and SG level is maintained at the upper limit of narrow range, to provide additional operational margin for recovery should the essential TDAFW pump degrade due to unanticipated conditions (Reference 34). The CST has sufficient water inventory for phase 1 RHR without the need for additional makeup.

The strategy described here was simulated using site specific CENTS analyses (Reference 34) and is consistent with NRC approved industry generic position use of CENTS code for ELAP evaluation. These analyses show that approximately 6 hours into the event the RCS is cooled to long term standby pressure and temperature, two phase natural circulation is established, and the plant will be in a stable coping condition.

Reactivity management is minimal during this phase; reactivity margin in leakage scenarios (range of RCP leakage modeled 0-25 gpm / RCP) is dominated by the shutdown rods, which provide enough negative reactivity such that boron injection from the SITs can be ignored and the core will still remain at more than 2% delta ρ shutdown. Therefore, even if the SITs do not inject, the core will remain subcritical. Manual operator actions are limited for the reminder of phase 1 to minor ADVs adjustments after ADV accumulator nitrogen is depleted. Reference 34 and Reference 16 provide additional details.

Phase 2 Strategy
As shown in Table 5, Item 15, RCS inventory safety function will be challenged as a result of RCS volume contraction during cool-down, RCP seal leakage, SIT depletion and loss of natural circulation at approximately 35 hours into the event (if all RCP seals develop the maximum leakage of 25 gpm). Consequently, control room staff will initiate RCS borated makeup capability earlier by staging two (2) portable 480 V FLEX generators.

Connections to vital plant essential 480 V buses can be established using FLEX designed and installed primary or alternate connection boxes at external building locations that are easily accessible and require minimum operator action for breaker alignment at control building ground elevation. Capabilities are available to connect to either train of the Class 1E 480 V switchgear and align to the required equipment in that train.

RCS borated makeup can then be started via one of the two permanently installed charging pumps or by using the FLEX motor driven portable pump (high pressure RCS injection pump). The source of water for RCS injection is the RWT at 4,000-4,400 ppm boron. RCS inventory makeup from the RWT is sufficient to last for approximately 10 days.

FLEX portable 480 V generator sets will also provide power to critical electrical loads such as vital instrumentation, two of four trains of battery chargers and battery compartment exhaust ventilation fans, and to the safety related essential diesel fuel oil transfer pump. If required, portable generator sets are sized with additional capacity to provide power to non-critical loads such as unit essential lighting and control room air recirculation unit.

If required in the Phase 2 strategy diesel powered FLEX SG pumps can be used for reactor core cooling and heat removal when decay heat is not sufficient to drive the TDAFW pump. The source of the supply water for feeding the SGs is the seismically qualified CST and seismically robust RMWT to be used to supply water for feeding the SGs.

Mechanical and Electrical modifications required for the use of FLEX equipment are detailed in Section 4.4.

Phase 3 Strategy

Phase 2 strategies will continue for Phase 3 with the addition of secondary makeup to ensure coolant is available for the SGs to perform the core cooling safety function. To transport this water, a temporary pipeline will be installed from station reservoirs to the units. Equipment and components for the pipeline are strategically distributed and stored along the implementation route onsite and deployment will begin as soon as external resources have access to the site.

As the FLEX ELAP event proceeds, the decay heat produced by the nuclear fuel will decrease. Initially, ADVs will be closed to maintain SG pressure; however, eventually, the steam output will not be sufficient to run the essential TDAFW pump. Prior to loss of functionality of the essential TDAFW pump, the FLEX SG makeup pump will be staged and placed into operation.

During Phase 3, National SAFER Response Centers (NSRC) equipment for PVNGS will be staged, including generators, boration and water purification equipment, and other redundant capabilities. If required, NSRC equipment will be used to continue Phase 3 coping strategies or transition to recovery strategies. PVNGS will exit the FLEX ELAP event if, and when, the ultimate heat sink is re-established and the unit(s) achieves cold shutdown.

4.2. Reactor Coolant System at Lower Modes

The strategies for lower modes (RCS vented) are not engineered to the extent of strategies for the RCS at 100% power (Section 4.1); this is consistent with the NRC approved industry position (Reference 18). Due to the large and diverse scope of activities and configurations for any given nuclear plant outage (planned or forced), industry established guidance (Reference 81 and Reference 82) has concluded that a systematic approach to shutdown safety risk identification and planning, such as that currently required to meet the Maintenance Rule [10 CFR 50.65(a)(4)] along with the availability of the FLEX equipment, is the most effective way of enhancing safety during shutdown.

The term 'lower modes' in this report, is defined as the time that the RCS is open to the containment environment and steam generators are decoupled from the RCS; the SG system no longer provides a functional method to remove decay heat. Lower mode strategies are applicable to outages (planned or unplanned) during unit shutdown or start-up. Two strategies will be discussed herein:

- Condition 1: RCS is open to containment with restricted flow path (pressurizer manway open); core is fully loaded. Event starts at least 48 hours after outage start (reactor shutdown).
- Condition 2: RCS is open to containment with the reactor head lifted and UGS/internals removed; core is fully loaded. Event starts at least 72 hours after outage start (reactor shutdown).

Due to the small fraction of the operating cycle that is spent in an outage condition, the probability of a BDBEE occurring during any specific outage configuration is very small. A minimal set of higher level strategies have been developed and are incorporated into lower mode FSGs (Reference 69).

Additionally, in accordance with the NEI white paper endorsed by the NRC (Reference 18), APS has incorporated the supplemental guidance provided in the NEI position paper entitled "Shutdown / Refueling Modes" (Reference 97) into the shutdown risk process and procedures (Reference 71 and Reference 73). These procedures ensure that the lower mode FLEX strategies can be accomplished during outages.

APS will pre-stage critical FLEX equipment prior to each outage at designated seismically qualified pads to reduce deployment time and risk. Pre-staged equipment includes a generator set to energize the vital bus, diesel driven RCS lower mode makeup pump (also called the SG makeup pump, see Table

2), and SFP makeup pump. This equipment will be fueled but not attached to external FLEX connections. The staging location meets the seismic class 2 over seismic class 1 (2/1) interaction requirements.

Phase 1 Strategy
In condition 1, coping is achieved per station guidelines and procedures for loss of all power during lower modes (Reference 69 and Reference 70) which establishes lineups, initial conditions, and prerequisites for RCS inventory makeup. During this phase, gravity drain is established to the RCS from the RWT. The RCS inventory will be replenished and stabilized and fuel in the core is cooled by establishing a boiling regime (nucleate boiling).

In condition 2, the refueling pool is flooded by RWT inventory to a plant nominal elevation of 138 ft. Heat capacity of the refueling pool inventory is sufficient to delay the pool boiling to approximately 6 hours after the initiating event (Reference 45); thereafter core cooling is established by nucleate boiling.

Phase 2 Strategy
In condition 1, coping is achieved per station FSG procedure for loss of all AC power during lower modes (Reference 69) which establishes lineups, initial conditions, and prerequisites for RCS inventory makeup. During this phase, a FLEX pre-staged diesel driven RCS lower mode makeup pump is used to inject RWT borated water (at greater than 4,000 ppm) into RCS cold legs through High Pressure Safety Injection (HPSI) system headers. An analytical boil off rate is established as a guide for an initiating event at 48 hours after shutdown of a unit.

The flow requirement is equivalent to the boil off with consideration given to potential leakage. Also, guidance has been provided to minimize boron saturation / precipitation within the RCS by an additional flow requirement that will flush the system, if required (Reference 43). FSGs will maintain boron concentration below the saturated solubility concentration at the reactor coolant boiling point of 50,000 ppm boron (see Request for Additional Information [RAI] 34 in Reference 11). The borated water inventory in the seismically qualified RWT provides makeup to RCS for a minimum of 50 hours after initial ELAP. To prolong the coping time, the seismically qualified CST volume will be available for diluting the RWT. The governing procedure provides an option of diluting the RWT inventory by 50 percent prior to injection. These actions will double the coping time.

In condition 2, coping is achieved per station FSG procedures for loss of all power during lower modes (Reference 69) which will allow the refueling pool to boil down to approximately 12 inches above reactor vessel flange. Level is monitored in the control room using seismically designed pressurizer level instrumentation. The refueling pool water inventory is sufficient to keep fuel assemblies cool until injection is established at approximately 50 hours.

Phase 3 Strategy

For both condition 1 and 2, a unit in refueling would rely on the boration skid and purification unit from the NSRC or onsite equipment with alternative water sources from the other units. To achieve this, borated water inventory stored in the RWTs of the two non-outage units may be used.

UHS Restoration

The UHS restoration strategy could be to operate the UHS, via use of temporary power sources from onsite or offsite resources to power one of the essential Class 1E trains supporting one of the two redundant seismically qualified spray ponds (UFSAR Sections 2.4.11.6, 3.8.4.1.6, and 9.2.5, Reference 8). UHS inventory can be continuously replenished using the 85 or 45 acre water reservoir using the temporary pipeline built after ELAP (see Phase 3 in Section 4.1). It should be noted that the RCS boron concentration in the reactor vessel and refueling pool during phase 3 would be approaching 50,000 ppm boron. Since RCS injection can be achieved through HPSI cold leg nozzles, injection of non-borated water for a limited time will be permissible for conditions 1 and 2 as a final option to keep the fuel assemblies cool.

4.3. Systems, Structures, Components

Essential Turbine Driven Auxiliary Feedwater Pump

The essential TDAFW pump will automatically start on low SG level and provide AFW flow to the SGs following an ELAP. The essential Turbine Driven Auxiliary Feedwater Pump system is described in Sections 3.9.3.2.1.1.5 and 10.4.9.2 of the PVNGS UFSAR (Reference 8). The components supporting the essential TDAFW steam driven pump and flow path for this coping strategy are powered by the essential Class 1E battery system. Long term functionality during ELAP is evaluated by identification and selection of key attributes of the essential steam driven pump. A long term coping RCS pressure and temperature were selected based on actual pump testing to minimize the possibility of turbine or pump degradation, or trip.

The control system Failure Modes Effects Analysis (FMEA) was performed to identify key components in the control system that may be susceptible to failure as a result of higher than normal essential TDAFW pump compartment temperature conditions as result of HVAC loss due to ELAP. Using FMEA results a GOTHIC (Reference 83, refer to Section 2.2 for analysis discussion) *best estimate analysis was performed to predict a time dependent temperature* profile within the compartment. It was concluded that to mitigate the temperature rise, a time dependent operator action of opening the access doors or opening the access hatch at the 100 ft. elevation of the MSSS building at about 2 hours post ELAP will add margin to the environmental condition degradation within the essential TDAFW pump compartment. The compartment analysis shows that taking this mitigating action will limit the temperature rise to less than 130 degrees F for the remainder of the event (see RAI 22a in Reference 11 and Reference 33).

The FSGs require operator action to open an essential TDAFW pump compartment door (80 ft. and 100 ft. elevation) in 2 hours (see Table 5, Item 8 in this report). Therefore, the station essential TDAFW Pump is capable of mitigating ELAP through phases 1 and 2. The core cooling safety function may be transferred to a portable diesel driven SG makeup pump during phase 2 or 3 of ELAP during startup of the plant (early fuel cycle) if the residual core decay heat is not sufficient to generate required secondary steam pressure for the essential TDAFW Pump to function.

In the event that the essential TDAFW pump fails to start, procedures direct the operators to manually reset and start the pump (which does not require electrical power for motive force or control). The pump is only needed for plant operational modes 1-4 FSGs (Reference 68) and it is not utilized in lower modes.

Reactor Coolant Pump and Pump Seals

The PVNGS RCPs are CE-KSB (Klein, Schanzlin & Becker) pumps with modified three-stage hydrodynamic seals supplied by Sulzer.

PVNGS has performed a plant-specific evaluation (Reference 34), that considered RCS pump leakage rates ranging from 1-25 gpm per pump. It is assumed that leakage starts immediately after the initiating event. The leakage selected is consistent with NUMARC 87-00 Station Blackout (SBO) guidance (Reference 76), NRC guidance (Reference 7), and NRC safety evaluation for PVNGS regarding SBO (Reference 21). Using this leakage, analyses were performed to develop a set of critical operator actions to transition from FLEX phase 1 to phase 2 (refer to Table 5 for sequence of events).

Analyses using lower leakage rates support reactivity management and FSGs have operational margin. RCP seal leakage is expected to be insignificant if the initiating event occurs during lower mode operation; RCS system pressure would be at atmospheric pressure plus a water deferential head, which is dependent on the refueling evolution water level.

Atmospheric Dump Valves

Atmospheric Dump Valves (ADV) are described in Section 10.1 of the PVNGS UFSAR (Reference 8). ADVs are needed for plant operational modes 1 - 4 FSGs (Reference 68) and this equipment is not utilized in lower modes.

ADVs (there is one ADV per steam line for a total of four) are pneumatically driven with seismically qualified back up nitrogen accumulators. The control systems for ADVs are powered by a safety related essential Class 1E, DC power source. These valves will be operated from the control room during initial stages of an ELAP to achieve a rapid cool-down of the RCS. A symmetric RCS cool-down will establish natural circulation within the primary system. Remote functionality from the control room will be maintained as long as a backup nitrogen source is available. The nitrogen inventory may be depleted in as soon as 16 hours. Should nitrogen be depleted, the ADVs can be manually operated by trained operators in the Main Steam Support Structure (MSSS).

Unlimited access to the MSSS is possible since the building remains habitable during an ELAP event. Additionally, the nitrogen supply can be remotely replenished at an exterior location of the MSSS building. CENTS simulation (see Section 2.2 for analysis discussion) shows minimal manipulations of ADVs are required, post cool-down, to maintain the secondary side above the required pressure; therefore, operator burden is minimal.

Batteries

The essential Class 1E 125 Volt direct current (DC) systems are described in Section 8.3.2 of the PVNGS UFSAR (Reference 8). The four independent safety related battery banks and associated 125 VDC/120 VAC distribution systems are located within the control building, a safety related structure designed to meet design basis external hazards. These battery banks are used to power required instrumentation, control systems, and valve operators during the postulated event.

The Class 1E battery duty cycle life for ELAP strategies is calculated in accordance with the NEI position paper, which was endorsed by the NRC (Reference 17), using best available manufacturer discharge test data. A conservative battery discharge capacity analysis (Reference 50) provides the bases for FSG operator actions to complete the load shed sequence on the station battery Train "A" and "B" within 2 hrs. of the initiating event. This will ensure 125 VDC/120 VAC power is available for at least 34 hours after the initiating event. At this time, FLEX portable 480 VAC, 800 kW diesel generators are deployed to supply AC power and recharge the battery banks (see Table 1 for the generator load list). Actual validation exercises show generator deployment time could occur well within 24 hours of the initiating event. Therefore, ample operational margin exists in the strategy to provide an uninterrupted power source to maintain control room functionality.

Hydrogen generation is not a concern during the discharge cycle of batteries. When 480 VAC diesel generators are deployed and prior to the start of the battery charging cycle, station essential battery exhaust fans in the battery compartments are started to eliminate build-up of hydrogen in the area. Additionally, analytical evaluation shows the hydrogen concentration in a battery compartment will remain below 2 percent at 130 hours after the start of the charging cycle if no ventilation is provided. This concentration is below the

4 percent flammability limit and provides additional operating margin to take action should essential HVAC fail (Reference 55, RAI 8 in Reference 11 and Reference 57). Battery capacity as a result of an ELAP event during lower modes of operation is not a concern since the 480 VAC generators will be pre-staged and within 2 hours into the event external AC power will be established to charge essential batteries.

Plant Primary Side Source of Borated Water

The Refueling Water Tank (RWT) supplies borated water for the Emergency Core Cooling System (ECCS) and plant normal/refueling operation and it is described in UFSAR Sections 3.8.4.1.8 and 9.3.4.2.1 (Reference 8). The refueling water tank is a reinforced concrete structure (46.5 feet internal diameter, 68 feet in height) located near the seismically qualified fuel building. The RWT has cylindrical walls approximately 2 feet thick. This structure is designed to withstand design basis SSE and tornado events. A seismic category I stainless steel wall and base-mat liner provides the internal water tight barrier to the concrete structure.

RWT has a required boron concentration in the range of 4,000-4,400 ppm. The tank's contents are maintained above 60 degrees F by two, redundant 25 kW electric heaters which prevent the boron from precipitating. During operational modes 1-4 the normal volume available is approximately 675,000 gallons (Reference 52). Thirty (30) days prior to outages borated water volume in the tank is procedurally increased to at least 720,000 gallons (Reference 71).

Plant Secondary Side Sources of Cooling Water

The Condensate Storage Tank (CST) provides the main source water for plant cool-down at the initial onset of the BDBEE and into Phase 2. This tank is described in Sections 3.8.4.1.7 and 10.4.9.2 of the UFSAR (Reference 8). The condensate storage tank is a reinforced concrete structure (46.5 feet internal diameter, 52 feet in height). The CST is located approximately 175 feet plant north of the center of the containment structure. The condensate storage tank has concrete cylindrical walls approximately 2 feet thick. The structure is designed to withstand design basis SSE and tornado events. The condensate storage tank has a seismic category I stainless steel wall and base-mat liner.

CST has a normal volume of 508,000 gallons during operational modes 1-4 (Reference 59).

Additionally, 445,000 gallons of water is available in the RMWT (Reference 54), a designated Technical Specification backup source of water to the CST. RMWT inventory can be manually aligned to the essential TDAFW pump suction. The back–up function of RMWT, as a source of water to the CST, is described in Section 9.2.6.2 of the UFSAR (Reference 8).

The seismic category 2 RMWT is a flat bottom cylindrical stainless steel tank constructed out of American Society for Testing and Materials (ASTM) SA240-

304 material. The seismic capacity of the tank is calculated as High Confidence of Low Probability of Failure (HCLPF) following the EPRI NP-6041 Guidance (Reference 77) methodology for flat bottom tanks. The HCLPF seismic capacity of the RMWT is calculated as 0.36 g (Design Basis SSE = 0.25 g) (Reference 51). Therefore, it is concluded with high level of confidence that RMWT will be available post initiating event.

In the highly improbable event of RMWT failure, procedural direction is included in the FSGs for methods of transferring water from the seismically qualified RWT to CST during FLEX phase 2. A surplus of borated water will be available during operational modes in the RWT since boil off from the SFP and makeup to the RCS would be relatively small.

Additional seismic capacity calculations were performed to establish integrity of non-seismic piping attached to the CST. HCLPF values calculated using EPRI methodology concluded that all cases analyzed enveloped the design basis SSE (Reference 53). Further, FSGs establish priority operator actions including walk-down of high risk plant areas and isolation of possible leak paths from the described tanks.

4.4. FLEX Modifications in Support of Phases 2 and 3

Plant changes described in this section have been implemented and reviewed pursuant to 10 CFR 50.59 consistent with the current licensing basis. When applicable, the design requirements of 10 CFR 50 were applied instead of NEI 12-06 (Reference 75).

FLEX Primary Mechanical Connections, RCS Injection and Makeup
These modifications installed FLEX RCS pump suction (and RWT connections) and discharge tie-ins. Easily accessible primary and alternate locations in each unit were selected. Primary location including suction and discharge piping are protected against the applicable external event. An alternate location within the auxiliary building was selected to provide maximum separation and protection against possible high wind events, although high wind external events are not applicable to PVNGS (see Section 7). At least one of the two (primary and/or alternate) staging locations meets the seismic 2/1 interaction requirements. Schematics of these external connections are shown in Figure 1 and Figure 4. Piping and components are designed and installed to SSE + 10% margin (see Section 7.1).

Primary RCS Tie-in Connection (FLEX pump discharge)

Primary RCS connection piping and associated components are tied in to the existing 4 inch train A HPSI system header, between the outboard containment isolation valve and containment structures. This tie-in location is selected to provide a direct injection path to the reactor core and to minimize possible intermittent component failure that may obstruct flow. Redundant manual containment isolation valves are also installed as part of this modification. These valves are located as close as practical to the containment boundary and are easily accessible from the 87 ft. platform in the auxiliary building. The lower auxiliary building is habitable when operator access is needed, which is expected to be more than 24 hours after the initiating event.

The primary RCS tie-in piping is routed through the auxiliary building to an external location adjacent to the RWT, where the RCS pump would be deployed. At the deployment location two connection options are provided: 1 ½ inch NPT connect for the modes 1-4 electric motor driven high pressure RCS injection pumps (see Figure 1) and a 5-inch STORZ fitting connection for low pressure injection into the RCS (see Figure 4) during modes 5 & 6 using the diesel driven RCS lower mode makeup pump (also called the SG makeup pump, see Table 2). Refer to Figure 2 for the simplified routing.

Alternate RCS Tie-in Connection (FLEX pump discharge)

The alternate discharge connection ties into the existing 4 inch train B HPSI system header and has the same design as the primary discharge connection. The alternate RCS tie-in piping is routed to the ground elevation of auxiliary building east – west corridor, adjacent to plant charging pumps compartment, where the RCS pump may be deployed. This internal location was selected as an alternate deployment location due to its ease of access and communication with the yard area through the large roll up doors. Although PVNGS screens out for high wind requirement per NEI 12-06 (Reference 75) guidance (see Section 7), this alternate location provides a high wind protected tie-in. Refer to Figure 3 for the simplified routing.

Primary RCS Suction Piping (FLEX pump suction)

A permanent connection to the existing RWT drain line is selected as the primary RCS pump suction location. A section of pipe and an isolation valve (ASME Section III Class 2), with 5-inch STORZ connector, are installed (see Figure 1 and Figure 4). This piping extension is located in a FLEX added valve pit below grade and fitted with a 3 inch carbon steel missile barrier for protection against postulated tornado borne missile hazards. Refer to Figure 2 for the simplified routing.

Alternate RCS Suction Piping (FLEX pump suction)

To tie-in to the existing essential charging pump suction piping to enable RCS pump alternate suction, 4 inch piping and valves are installed at the existing hydrostatic test connection flange immediately adjacent to valve 1,2,3PCHAV314, hydro-connection isolation valve. The FLEX line runs from the hydrostatic test flange in the charging pump compartment to the adjacent hallway at the ground elevation where a FLEX added isolation valve and 5-inch STORZ fitting are located. Refer to Figure 3 for the simplified routing.

FLEX Secondary Plant Mechanical Connections, SG Makeup

These modifications installed secondary plant tie-ins for steam generator makeup and FLEX SG makeup pump suction piping (including CST connections) to support FSG strategies. These tie-in locations are selected to provide a direct injection path to the steam generators and to minimize possible intermittent component failure that may obstruct flow. Additionally, the selected location provides the capability of symmetric natural cool-down, should it be needed, by manually opening additional valves.

Redundant manual containment isolation valves are provided as part of this plant modification. These valves are located as close as practical to the containment boundary and are easily accessible in the train B AFW pump compartment. Access to this compartment is provided through the 100 ft. elevation hatch and, at the point in time when access may be required, the valve location is habitable.

The primary and alternate tie-in and deployment locations in each unit are similar and have been selected for ease of access. Locations of suction and discharge piping are protected against the applicable external event. At least one of the two staging locations meets the seismic 2/1 interaction requirements. A schematic of these external connections is shown in Figure 5. Piping and components are designed and installed to SSE + 10% margin.

Although provisions are made for attachment of the secondary makeup pump (SG makeup pump), FSGs do not require deployment of these pumps until core decay heat is reduced such that steam generator pressure is no longer sufficient to support the requirements of the essential TDAFW pump.

Primary SG Tie-in Connection (FLEX pump discharge)

Secondary plant connection piping and associated components tie-in to the train B electrical auxiliary feedwater discharge piping to steam generator number 2, in the train B AFW pump compartment downstream of existing AFW isolation valve (1,2,3JAFBUV35) and containment penetration (see Figure 5). The FLEX added line runs from the train B AFW pump compartment to condensate pipe tunnel and exits the plant permanent structure adjacent to CST. A 5-inch STORZ connection is provided at deployment location to tie-in the diesel driven FLEX SG makeup pump.

Alternate SG Tie-in Connection (FLEX pump discharge)

Configuration of Alternate connection is similar design as the primary connection. The connection for alternate is made to the train B auxiliary feedwater discharge piping to the steam generator number one in the train B AFW pump compartment downstream of existing AFW isolation valve (1,2,3JAFBUV34). Alternate pipe runs parallel with the primary to the location of deployment, refer to Figure 6.

Primary Secondary Plant Tie–in Piping (FLEX pump suction)

A permanent connection to the existing 6 inch CST drain line provides the primary suction source to the FLEX diesel driven SG makeup pump. Specifically, a new section of pipe and redundant isolation valves are installed (ASME Section III Class 3), and the piping is terminated at a 5-inch STORZ connector (see Figure 5). The existing CST valve pit is extended to accommodate the FLEX installed piping and valves. The equipment is located beneath grade and fitted with a 3-inch carbon steel missile barrier for protection from postulated tornado missile hazards.

Alternate Secondary Plant Tie–in Piping (FLEX pump suction)

Alternate secondary plant makeup is composed of new 6 inch piping, new inboard and outboard manual isolation valves, and a 5-inch STORZ standard connection at the location of diesel driven SG makeup pump deployment (see Figure 5). The FLEX added line runs from a connection point at the FLEX SG makeup pump staging area on the north wall of the Condensate Transfer Pump House (adjacent to the CST) through a new penetration in the Condensate Transfer Pump House north wall. It then proceeds south in the CST pipe tunnel to an existing penetration through the Main Steam Support Structure (MSSS) (train B AFW Pump compartment) wall.

Once inside the pump compartment the piping will tie-in to existing 8 inch line downstream of CST and RMWT suction check valves 1,2,3PAFBV022 and 1,2,3PAFBV009. The inboard isolation valve is located in the train B AFW pump compartment and the outboard valve is located outside at the north wall of the Condensate Transfer Pump House, refer to Figure 6.

Hatch Alteration 80-100 ft. of Auxiliary Building

A new (FLEX added) manway hatch in the MSSS 100 ft. elevation floor to access the 80 ft. elevation train A essential TDAFW compartment will provide backup ventilation capability for the essential TDAFW pump compartment during an ELAP event. Additionally, this hatch (and added access ladder) provides a new ingress and egress path, if the existing access door is not functional and/or obstructed. The new manway hatch is fitted in the existing equipment hatch area.

Gravity Flow Diesel Fuel Oil Day Tank FLEX Supply Line

This modification provides the capability to gravity drain from the essential diesel day tank drain line (~elevation 130 ft.) to the 104 ft. elevation of the Diesel Building near the missile doors (inside) using 1 ½ inch piping. The modification provides initial "first fill" of fuel oil for portable equipment needed for phase 2. Once the 480 VAC diesel generators are started and aligned with station electrical system, the essential day tanks will be filled as needed from the station seismically qualified 7-day tank by the installed essential station fuel oil transfer pumps. This will provide a sufficient source of diesel fuel for FLEX mitigation strategy.

Electrical Modifications

FLEX Primary and Alternate 480 VAC Electrical Connections

This electrical modification provides AC power to the high pressure RCS injection pump, capability to charge batteries, and power to ventilation fans, if needed, following entry to FLEX phase 2.
This modification installed FLEX electrical offshore tie-ins to station train "A" and "B" essential 1E Class 480 VAC load centers.

Primary and alternate locations to make connections to generators in each unit were chosen for ease of access. The primary location connection boxes are protected against the applicable external event. The alternate location was selected outside the diesel building (plant east) to provide maximum practical separation and protection against possible high wind events, although high wind external event is not applicable to PVNGS. At least one of the two staging locations meets the seismic 2/1 interaction requirements.

Physical layout and schematic of these external connections are shown in Figure 7 and Figure 8. Conduit routing and components are designed and installed to SSE + 10% margin. The external cable connections are color coded and use a standard molded locking connector per NSRC recommendation. Manual operator actions are required in the control building at the 100 ft. elevation (ground) to align the portable generators to the breakers in the Class 1E load centers. This location is expected to be at ambient conditions, since no equipment is energized in the area prior to this action.

The eight 800 kW FLEX generators, as required for N+1 stipulations, will be stored onsite. Two FLEX generators are deployed per unit and staged plant south of the diesel building. FLEX generators are trailer mounted and easy to deploy. A set of dedicated color coded cables will be stored with each generator. Generators and FLEX permanently installed boxes are color coded to insure correct phase rotation during the deployment.

Each FLEX generator will be grounded via a flexible cable to a ground test well which will provide an accessible ground in the staging area. These generators, cables, and protection devices are sized to repower key 480 VAC Class 1E load centers (load centers are normally isolated from FLEX connections by use of mechanically locked open breakers). The FLEX generators are to power essential loads identified in Table 1. These loads are energized manually per FSGs.

<u>FLEX electrical connections for the primary and alternate AC motor driven high pressure RCS injection pump</u>

Essential 480 VAC power for the motor driven high pressure RCS injection pumps are provided at two locations. The primary location is near the RWT (ground elevation, yard area just outside the western wall of the auxiliary building). The alternate location is located between the charging pump compartments and the east penetration wrap (ground elevation, auxiliary building east corridor). Two new (FLEX added) redundant circuits (Train "A" and "B") are routed from existing spare cubicles in the Class 1E MCCs. A FLEX added breaker provides power to 100A receptacles (Blue Bell DR100) as source of power for the motor driven high pressure RCS injection pumps.

Train isolation is achieved by new Class 1E qualified disconnect switches installed adjacent to the corresponding MCC. At least one of the two staging locations meets the seismic 2/1 interaction requirements.

Physical layout and schematic of these connections are shown in Figure 9 and Figure 10. Conduit routing and components are designed and installed to SSE + 10% margin.

Defense-in-Depth Primary and Alternate 4.16 kV AC Electrical Connections

The 4.16 kV modifications are not required for FLEX mitigation strategies at PVNGS. The unique stand-alone seismic UHS and sources of water at PVNGS, in combination with Section 2.1, Assumptions 19 and 20, enable restoring the UHS by energizing an essential train of shutdown cooling, which is an effective method for mitigation at PVNGS. Electrical modifications for this defense-in-depth option provide AC power to a Train “A” or “B” ECCS system and its auxiliary components needed to cool the plant from an RCS shutdown entry condition to cold shutdown; in addition it would cool the Spent Fuel Pool via the UHS. This defense-in-depth system is also a 100 percent back up to 480 VAC FLEX, described above.

These modifications installed FLEX electrical tie-ins to station Train “A” and “B”, 1E Class 4.16 kV busses sized for receiving power from 4.16 kV generators (synchronized generators). Similar to the 480 VAC modification, primary and alternate locations in each unit were chosen for ease of access. At the primary location, connection boxes are protected against the applicable external event. An alternate location was selected outside the diesel building (plant west) to provide maximum practical separation and protection against possible high wind events, although high wind external event is not applicable to PVNGS (per Section 7.3). At least one of the two staging locations meets the seismic 2/1 interaction requirements.

Physical layout and schematic of these connections are shown in Figure 11 and Figure 12. Conduit routing and components, including transfers switches, are designed and installed to SSE + 10% margin. The external cable connections use a standard NEMA connector.

Sufficient generation capacity (gross 4 MWe) for 1 of the 3 units are stored in the EESF (refer to Section 8.1). The remainder of 4.16 kV generators will be delivered to site, when needed, by the NSRC. Generators are staged plant south of the diesel building. 4.16 kV generators are trailer mounted and easy to deploy. Dedicated cables are stored at the site for the generators, including NSRC generators.

4.5. Key Reactor Parameters

Mode 1 Instrumentation:
One single instrument channel train ("A" or "B", as a result of load shed) of listed safety instrumentation is required for PWRs in Phase 1 for reactor core cooling and heat removal strategy:

- SG Level/Pressure(*)
- RCS Pressure/Temperature
- Containment Pressure

At PVNGS the list of instrumentation below will be powered by essential station batteries at the start of the initiating event. When an ELAP is declared, DC electrical load shedding will begin. One train of instruments is maintained. Once the onsite portable 480 V diesel generator set is staged and functional, batteries will be recharged to maintain a supply of power to this instrumentation.

SG Level:

- Steam Generator Level (wide range (WR))

SG Pressure:

- Steam Generator Pressure

RCS Temperature:

- Core Exit Thermocouples (CETs)
- T_{hot}, T_{cold} (two Hot Leg and two Cold Leg on the same loop)
- Subcooling/Saturation Margin (RCS and CET)

RCS Pressure:

- RCS Pressure (WR)

As a result of load shed and breaker alignments the following additional instrumentation is also available to the operator for monitoring:

- Safety Injection Tanks 1A and 1B Level and Pressure

* Parameters can be read out locally, when required, using a portable instrument, as required by Section 5.3.3 of NEI 12-06. Portable FLEX hand-held instruments are available at pre-designated locations. The use of these instruments is detailed in the FSGs.

- Pressurizer Level instruments
- Reactor Vessel Level Monitoring System (RVLMS)
- ADV Positions
- Essential TDAFW Pump flow to each SG (A train power)
- Pressurizer Level
- CST and RWT level

Mode 5 and 6 Instrumentation:

- Core Exit Thermocouples
- T_{hot}, T_{cold} (two Hot Leg and two Cold Leg on the same loop)
- Pressurizer level instruments
- CST and RWT level
- RCS Pressure (WR)

5. Spent Fuel Pool (SFP) Cooling/Inventory Strategy

Strategies are developed for an ELAP following BDBEE (Section 2.1, Assumption 2). Two distinct bounding scenarios are considered:

- Power Operation – Initial bounding condition is a limiting SFP decay heat during power operations (e.g., at start of power operation after a scheduled refueling outage)
- Full core off-load – Initial bounding condition is the maximum SFP decay heat following full core off-load (beginning of refueling outage, 100 hours after reactor shutdown)

The PVNGS Spent Fuel Pool is designed to the guidelines of Regulatory Guide 1.13, Revision 0 (Reference 26). The fuel building, pool and liner, and fuel rack are seismically designed. As applicable, surrounding SSCs are also designed to eliminate seismic 2/1 interactions. The seismically qualified physical boundary of the SFP is defined as the inner gate located between the spent fuel pool and the cask loading pit, the boundary valve on the transfer tube on the fuel building side, drain valve and the spent fuel pool liner.

The Palo Verde SFP design incorporates passive safety features such as physical arrangements and siphon holes in piping to eliminate the probability of uncovering spent fuel due to system failures. Since the SFP boundary cannot be breached as a result of a seismic event or other mechanistic failures, fuel remains covered at all times; inventory losses are negligible as a result of sloshing and minimal boundary leakages. However, PVNGS has the capability to remotely spray spent fuel stored in the pool by deploying B.5.b equipment (monitor nozzles) if a SFP failure event were to occur. The capability of B.5.b equipment was reviewed and accepted by NRC under security order (Reference 32).

The engineered capacity of the FLEX SFP system (makeup pump, nozzles, and piping) exceeds the flow needed to match the boil off rate in the considered scenarios. The time to boil and boiling rate are based on decay heat calculated using the guidance of NRC Branch Technical Position APCSB 9-2 (Reference 22) and as described in UFSAR Section 9.1.3 and Table 9.1-2 (Reference 8). The two bounding scenarios analyzed are: (1) maximum normal operation in which the heat load in the pool is administratively controlled to less than 12.6E+6 Btu/hr. and (2) the maximum normal/emergency refueling heat load of 4.7E+7 Btu/hr.

The time to boil calculations are based on the SFP normal elevation of water and initial SFP bulk water temperature of 125 degrees F (Reference 36) and includes inventory losses due to seismic sloshing, loss of non-seismically qualified piping entering the SFP, and SFP boundary leakages. Evaluations were performed in accordance with the NRC endorsed boron mixing position paper (Reference 19) to validate that SFP fuel measure of criticality (K_{eff}) remains less than one (<1) at zero (0) ppm boron when bulk water in the SFP is boiling (Reference 58).

5.1. Spent Fuel Pool Cooling Strategy, ELAP During Power Operation

Phase 1 Strategy

In Phase 1, as a result of ELAP, cooling to the SFP will be lost and SFP boiling will occur approximately 11.5 hours after the initiating event. Boiling will result in SFP water level decreasing to 10 ft. above the active fuel stored in the fuel rack approximately 39 hours after the initiating event. An operator action is conservatively taken to open the Fuel Building rollup door to keep the building at atmospheric pressure and temperature.

Phase 2 Strategy

In preparation for Phase 2 portable diesel powered SFP makeup pumps are deployed at pre-designated external locations to supply RWT water to the SFP (see Figure 13, Figure 14, and Figure 15). This pump provides inventory makeup sufficient for SFP leakages (31 gpm) and boil off (27 gpm) (Reference 36). Therefore, a SFP makeup flow rate of 58 gpm will maintain adequate SFP level at 10 ft. above the fuel during power operation in the core not off-loaded scenario.

FSGs (Reference 68 and Reference 69) direct operators to fill the SFP using a batch process. FLEX SFP makeup pump would be operated at 150 to 200 gpm to fill the SFP to a predesignated elevation. This strategy reduces the possibility of water losses and assures discharge nozzles are operated at optimum conditions.

The normal RWT water level is sufficient to provided makeup to the SFP beyond 72 hours.

Phase 3 Strategy
In Phase 3 PVNGS will continue the Phase 2 strategies to provide makeup to the SFP. Makeup will be provided to the RWT from the station reservoirs using a pipeline and pumps sized to match the decay heat.

5.2. Loss of Power with a Full Core Off-Load (at least 100 hours into refueling)

The FLEX actions during a full core off-load are nearly identical to those described above in Section 5.1, with only the timing for those actions and the flow requirement for the FLEX SFP makeup pump being dissimilar. The differences are described below:

Phase 1 Strategy
SFP boiling will occur approximately 3.3 hours after the initiating event. The focus of Phase 1 actions is establishing the fuel building vent path at 2 hours, similar to Section 5.1.

Phase 2 Strategy
In Phase 2, based on fuel core decay heat load as described in Section 5, time to boil is estimated at 3.3 hours after an ELAP. As a result of boiling, SFP level will reach 10 ft. of water above the irradiated fuel assemblies in approximately 17 hours after the initiating event. This would result in entry to FLEX phase 2 in 17 hours verses the 39 hours in the scenario described in Section 5.1.

The SFP makeup flow rate for the full core off-load case is 131 gpm (100 gpm boil off and 31 gpm for system leakage) (Reference 36). The source of water for makeup to the SFP in lower modes is the CST, which does not contain borated water. As stated in Section 5, the SFP criticality evaluation shows that the pool will remain in a sub-critical configuration during the event.

FSGs direct operators to deploy the FLEX SFP makeup pump and establish suction from CST and initiate SFP makeup prior to inventory of pool reaching 10 feet above the active fuel (Reference 69).

Phase 3 Strategy
Phase 3 includes (similar to Section 5.1) the use of additional water and resources at 72 hours.

5.3. Systems, Structures, Components

Refueling Water Tank - Source of water during power operation
The Refueling Water Tank (RWT) is described in Section 4.3 of this report. The RWT is the primary source of water to replenish inventory loss and boil off from the SFP during an ELAP at power operation. Other sources of water may be used if RWT, or its associated SSCs, needs to be maintained.

Condensate Storage Tank - Source of water during a full core off-load
The Condensate Storage Tank (CST) is described in Section 4.3 of this report. The CST is the primary source of water for replenishment flow to makeup for inventory losses and boil off from the SFP during an ELAP coincident with a full core off-load. Other sources of water may be used if CST, or its associated SSCs, needs to be maintained.

5.4. SFP Cooling Modifications

FLEX Mechanical and Electrical Design
This FLEX modification establishes coping capability to prevent damage to fuel in the Spent Fuel Pool (SFP) for an extended loss of AC power (ELAP) as a result of a Beyond Design Basis Event (BDBE). A primary hose connection at an outdoor location (outside plant north wall of the Fuel Building) and an alternate indoor hose connection (Fuel Building truck bay) are provided to supply makeup water to the Spent Fuel Pool (refer to Figure 13, 14 and 15 for schematic and simplified piping).

A portable diesel driven pump skid will be connected to one of these hose connections to provide makeup water from the CST if the event occurs during a full core off-load and / or the Refueling Water Tank (RWT) if the event occurs during modes 1-4 (refer to Figure 14 and Figure 15 for schematic and simplified piping). Modifications to provide suction from the RWT or CST are described Section 4.4 this report. Additionally, "Y" connections are stored with portable pumps to establish multi-suction header if required.

The design modification installed redundant headers of 4 inch seismically qualified stainless steel pipe and supports on the inside of the Fuel Building truck bay (east of the roll-up door) on the ground elevation to a location on the plant north wall of the Fuel Building, near the middle of the SFP on the 140 ft. elevation in the Fuel Building (refer to Figure 13, Figure 15, and Figure 16).

5-inch STORZ adapters are used at the pipe connection to the portable pump connection.

Flow directing nozzles are located along the length of the spent fuel pool plant north wall; the height of these headers was selected for optimum stream trajectory. A redundant header for each of the FLEX added makeup water pathways will be utilized to eliminate the need for isolation valves or check valves in each of the pathways (Figure 16).

5.5. Key Spent Fuel Pool Parameters

The key parameter for the SFP cooling/inventory strategy is the SFP water level. The SFP water level is monitored by newly installed, redundant, DC powered Spent Fuel Pool Level Instrumentation that meets the requirements set by Order EA-12-051 (Reference 9, APS Letter 102-06669 for Order EA-12-051 Overall Integrated Plan). RWT and CST level instrumentation are available.

6. Containment Integrity Strategy

6.1. Containment Integrity at Power

All Three Phases of FLEX

At the time of an ELAP event containment will be isolated as a result of ESF actuation and this condition will be verified by control room personal using existing plant procedures. A containment evaluation has been performed based on the boundary conditions described in Section 2 of NEI 12-06 (Reference 75). Computer code GOTHIC (Reference 83) was used to predict the environmental conditions (pressure and temperature) within the Containment. The 72 hour post ELAP pressure and temperature in the containment (Reference 44) is estimated to be less than 20 psia and 200 degrees F based on a total RCP seal leakage of 100 gpm at the start of the event (refer to Section 4.3 of this report).

A conservative, long term 30 day containment pressure GOTHIC model predicts that containment will remain well below the 60 psig design pressure. Therefore, no operator action is required; however, the FSGs (Reference 68) provide guidance for monitoring containment pressures as a trending tool for RCS leakage, in addition to continuing assessment of the containment integrity.

6.2. Containment Integrity during Modes 5 and 6 (fuel in reactor vessel and in the containment with no fuel movement)

All Three Phases of FLEX

An ELAP event during modes 5 and 6 would result in possible over pressurization of the containment. As described in Section 4.2 of this report, refueling pool / RCS will start to boil as a result of decay heat and containment pressure will increase. To eliminate possible challenge to containment integrity a passive vent path is provided through the 42 inch refueling purge system (see Figure 17). Station administrative procedure 40OP-9ZZ23 (Reference 71) will implement a refueling purge (CP) system alignment before establishing a hot leg vent during Mode 5 in each outage to provide an open path through the 42 inch containment refueling purge system to the outside environment. Additionally (not required by FLEX), the plant vent radiation monitors (RU-143/144) are powered after ELAP using a 480 V 800 kW generator to monitor fuel conditions and radioactive releases.

The containment will be vented through the 42 inch purge for the duration of the event and the control room will have the capability to isolate containment, should fuel failure occur, using one of the containment isolation valves.

6.3. Systems, Structures, Components

Containment integrity is maintained beyond 72 hours without reliance on plant SSCs during ELAP at power conditions. Containment integrity in lower modes is described below.

Containment Purge System (CP) (Modes 5&6 only)
Containment purge system is described in section 9.4.6 of the UFSAR (Reference 8). The normal purge system for the containment consists of a refueling purge and a power access purge. The refueling purge train is used for high flowrate purge during refueling and is closed during normal power generation. It consists of a supply air handling unit and an exhaust fan as shown in Figure 17. Although the majority of the system is non-quality, containment isolation dampers are seismically qualified. In addition, many of the components that are installed inside containment are designed to seismic 2/1 interaction requirements.

To mitigate an ELAP during refueling and eliminate containment pressurization, the system is opened to the environment prior to establishing a hot leg vent (RCS is open –SG is decoupled). The system alignment will be such that valves 1,2,3CPA-UV-2B and 1,2,3CPB-UV-3B are open (these dampers are designed to "fail as is" and they will not change position as a result of ELAP). Additionally, administratively in each outage, damper 1,2,3CPN-M05A will be temporarily modified by physical restraint ("gag") of the damper blade to eliminate the possibility of path closure, should the flow conduits survive the initiating event (Reference 63).

6.4. Key Containment Parameters

One train (A or B train) of listed instrumentation is recommended for all modes for containment integrity:

- Containment Pressure

6.5. FLEX Modifications

No permanent modifications were needed to maintain containment integrity.

7. Characterization of External Hazards

APS has evaluated PVNGS for external hazards based on the screening guidance in NEI 12-06 (Reference 75) and determined that the seismic and extreme heat hazards are applicable to PVNGS. External flooding, high wind, and extreme cold hazards were found not to be applicable to the PVNGS site.

Flood and seismic re-evaluations pursuant to the 10 CFR 50.54(f) letters of March 12, 2012, are completed and it has been concluded that the original design and licensing bases remain bounding. It has been concluded, using "state of the art" methodologies, that the PVNGS site remains a "dry site" as a result of an extreme flooding event and the original Safe Shutdown Earthquake (SSE) hazard curve remains bounding at 0.25g Peak Ground Acceleration. These conclusions are documented in the respective APS and NRC letters (References 24 and 25).

7.1. Seismic

The NEI 12-06 guidance (Reference 75) requires that all plants consider the impact of a seismic event. As described in the PVNGS UFSAR (Reference 8, UFSAR Section 3.7), the seismic criteria include two design basis earthquake spectra: Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE). The site seismic design response spectra define the vibratory ground motion of the SSE. For additional conservatism, FLEX permanent plant modifications (electrical and mechanical) are designed to the SSE plus 10 percent.

For FLEX strategies, the earthquake is assumed and results in damage to non-seismically designed structures and equipment. Non-seismic structures and equipment may fail in a manner that they would challenge accomplishment of FLEX related activities (normal access to plant equipment, functionality of non-seismic plant equipment, deployment of Beyond-Design-Basis (BDB) equipment, restoration of normal plant services, etc.). The diverse nature (e.g., alternate deployment locations, connections, and pathways, and a variety of equipment, including both electric and diesel driven motors) of the PVNGS FLEX strategies is discussed throughout this report and PVNGS has the ability to clear debris from hauling routes to facilitate the deployment of FLEX Phase 2.

7.2. High Temperatures

NEI 12-06 (Reference 75, Section 9.2) requires all plants to consider high temperature conditions for the site in storing and deploying the FLEX equipment. PVNGS addresses the effect of extreme heat on continued plant operation with current administrative controls if the temperature exceeds design basis values.

PVNGS may experience extreme high temperatures for a prolonged duration. However, the extreme drought and high temperature meteorological events progress slowly such that existing plant administrative and operational procedures are adequate to ensure that the plant is shutdown and placed in a safe condition.

The extreme heat event considered herein is a loss of AC power as a result of high temperatures coincident with high electrical grid demands, resulting in a regional black out. During this type of event, the equipment conditions and water inventories at the station are expected to be within design limits such that no additional limitations on initial conditions/failures/abnormalities are expected (also see Section 2.1, assumptions 19 and 20).

7.3. Not Applicable External events

Using guidance and screening processes provided by NEI 12-06 (Reference 75), the following external hazards are not applicable to PVNGS site.

External Flooding
PVNGS is a dry site (Reference 8, UFSAR Section 2.4.2.2) and does not rely on a permanently installed seawall or levee for flood protection. Therefore, PVNGS does not need to consider external flooding as a hazard defined in NEI 12-06 (Reference 75), Section 6.2.1, and Reference 24, the PVNGS Flood Hazard Reevaluation.

High Wind
NEI 12-06 (Reference 75) Section 7.2.1, *Applicability of High Wind Conditions*, contains a screening process to identify whether sites should address high wind hazards as a result of hurricanes and tornadoes. Based upon the location of the site at 33°23'N and 112°52'W and the information provided in Figures 7-1 and 7-2 of NEI 12-06 (Reference 75), PVNGS is not expected to experience winds exceeding 130 mph. Therefore, the high wind hazard is not applicable to PVNGS.

Ice, Snow and Extreme Cold

NEI 12-06 (Reference 75) Section 8.2.1, *Applicability of Snow, Ice and Extreme Cold*, clarifies that snow, ice and extreme cold are not expected at sites in Southern California, Arizona, the Gulf Coast, and Florida. Because the site is located in Arizona and below the 35th parallel (33°23'N), ice, snow, and extreme cold hazard is not applicable to PVNGS.

8. Protection of FLEX Equipment

8.1. FLEX Emergency Equipment Storage Facility and Deployment

The FLEX Emergency Equipment Storage Facility (EESF) that houses equipment for FLEX is constructed to be seismically robust using the requirements of ASCE 7-10 (consistent with NEI 12-06, Section 5, Reference 75 and Reference 3). Trailer mounted equipment within buildings will be restrained to tie down hooks using nylon strap winches at twice the calculated load to eliminate seismic interaction.

The EESF (shown as part of Figure 18) is comprised of four individually seismically isolated buildings, a separate stand-alone climate controlled building, and a canopy structure. The four seismically isolated buildings house FLEX equipment for each of the units and an additional set of "N+1" equipment. These buildings are not temperature controlled. The separate climate controlled building is used for housing equipment, parts, and miscellaneous items which are susceptible to the outside environment. This climate controlled building will also serve as the command control center for NSRC delivered equipment post event.

Lastly, the canopy area has been provided as a parking location for FLEX vehicles and debris removal equipment, such as front end loader, transportation trucks and yard truck. The vehicles are parked with at least a 6 foot separation to avoid seismic interaction (Reference 60). Therefore, the equipment will remain functional and deployable, to clear obstructions from the pathway between the EESF location and deployment location(s). Deployment of the debris removal equipment and the Phase 2 FLEX equipment from the EESF is not dependent on offsite power. The building equipment doors may be manually opened.

The FLEX EESF is designed to withstand EF-3 tornado wind speeds (excluding roofing material) and the finished floor is 1 foot above the predicted site flood elevation as a result of PMP. Additionally, located directly northwest of the EESF, a seismic pad was built to aide with future facility maintenance issues, should there be a need to store equipment outside to maximize the availability of FLEX equipment. The seismic pad will be maintained indefinitely.

The EESF is located west of the Protected Area (PA) warehouse and is inside of the owner controlled area, but outside of the PA (see Figure 18).

8.2. FLEX Deployment Pads

If equipment with safety function(s) is pre-deployed, it would be deployed in a pre-designated, seismically designed, concrete pad location and restrained in 8 directions to tie-down anchors. These locations are evaluated for seismic interaction with non-seismic SSCs (see Figure 19 for location deployment locations) and at least one staging location for each strategy is free of seismic interaction.

9. Planned Deployment of FLEX Equipment

9.1. Deployment Routes

Figure 20 shows the paths for transportation of FLEX equipment to deployment areas. The deployment routes within PVNGS are engineered roads. They were evaluated for the seismic interaction and soil liquefaction hazards and determined to remain passable following a seismic event (Reference 61). Deployment routes are surveyed following an event and an appropriate route will be selected. An administrative program (Reference 65) is in place to maintain the routes clear during normal site activities in all modes of plant operation.

9.2. 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 essential as part of the immediate activities required during Phase 1.

Doors and gates serve a variety of barrier functions on the site. One primary function, security, is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line breaks (HELB). These doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDBEE and subsequent ELAP event, FLEX coping strategies only require operator walk-downs for damage assessment at PVNGS, no routing of hoses and cables through barriers are required to achieve established FSG strategies.

However, ability to open doors for ingress, egress, and ventilation is necessary. Security doors and gates that rely on electric power to operate opening and/or locking mechanisms are barriers of concern. The Security force will initiate an access contingency upon loss of the Security Diesel and all AC/DC power as part of the Security Plan. Access to the Owner Controlled Area, site Protected Area, and areas within the plant structures will be controlled under this access contingency as implemented by Security personnel. Access authorization lists are prepared daily and copies are protected from the BDBEE for use post-ELAP. The plant main control room contains a duplicate set of security keys for use by plant Operations personnel in implementing the FLEX strategies.

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

9.3. On-Site Fuel Storage Tanks and Qualifications

During Phase 2, unit essential diesel generator fuel oil seismically qualified day tanks in each diesel building are used for initial fueling of FLEX diesel powered makeup pumps and 480 VAC 800 kW generators. These essential tanks (one per train, two per Unit) have a capacity of 1,100 gallons. The drain portion of this tank has been permanently modified (see Section 4.4) to provide a gravity drain at ground elevation, such that a self-contained 500 gallon fuel trailer (2 available on site) can be filled with no AC power available. These fuel oil tank trailers will provide sufficient fuel to SFP makeup pumps and 480 VAC 800 kW generators to start. Once the 480 VAC 800 kW generators are started, the essential fuel oil transfer pumps are powered and fuel oil can be delivered continuously from the 7-day underground seismically qualified tanks (nominal capacity is 83,000 gallons per tank) to the essential day tanks for distribution to the diesel driven engines on portable FLEX equipment and vehicles. A procedure is developed to ensure fueling strategies are successful (Reference 72).

10. Deployment of Major FLEX Equipment and Strategies

10.1. Reactor Core Cooling and Heat Removal Equipment Deployment and Associated Water Inventory Sources

The Condensate Storage Tank (CST) and Reactor Makeup Water Tank (RMWT) provide primary sources of water to the essential Turbine Driven Auxiliary Feedwater (TDAFW) pump or directly to the suction of the portable diesel driven FLEX SG makeup pump. Additionally, the seismic category I, Refueling Water Tank (RWT) could be used as a source of inventory. Using this source of water would require a portable pump and hoses between RWT and CST.

Two FLEX suction connections (5-inch STORZ) are provided at easy to access locations, one at the external wall of condensate tank pump house and second at drain connection to CST. A flexible hose will be routed from the pump suction to the water source.

Both of the FLEX SG makeup pump discharge connections also are located at the Condensate Pump House, external to the MSSS building.

Figure 19 depicts deployment pad location of the SG makeup pump and Figure 21 depicts the approximate location of the primary and alternate suction, the flow path, and equipment utilized to facilitate this FLEX strategy.

Two egress/ingress paths are available to the essential TDAFW pump compartment (train A). Access can be achieved using the 80 ft. qualified water tight door or through an access hatch at the 100 ft. elevation of the MSSS building. As stated in Section 4.3, the entrance door also provides a ventilation path to control the environment temperature within the essential TDAFW pump compartment. Should the door at 80 ft. not be operational or blocked by debris or water accumulation as a result of non-seismic turbine building structures and/or systems failure, the FLEX installed hatch at the 100 ft. elevation of the MSSS can be also used for ventilation and access (see Section 4.4).

The FLEX SG boundary valves (interface between Q1E and ASME B31.1 piping), interconnecting the FLEX modification to the plant permanent AFW system, are located in the electric motor driven AFW pump compartment (train B) (Figure 21). Access to this location is via the existing hatch at the 100 ft. elevation. Both hatch openings are equipped with access ladders.

10.2. RCS Injection Skid Deployment and Associated Water Inventory Sources

The primary RCS pump deployment and connection is located plant south west of the fuel building, adjacent to the RWT. This location includes a 5-inch STORZ fitting for low pressure, high flow deployment during modes 5 & 6 and a 1 ½ inch NPT threaded connection for high pressure injection during operational modes. To power the high pressure electric motor driven RCS injection pump, redundant Class 1E train essential 480 V receptacles are also at this location, in the yard area and easily accessible after any external events. The suction source for RCS injection and makeup is the RWT. The drain of the RWT was modified at ground elevation with a 5-inch STORZ fitting to provide easy access to attach the suction for these pumps.

An alternate location for the high pressure RCS injection pump is within the auxiliary building entrance east west corridor at ground elevation. This area was selected due to ease of access via the large rollup door which opens to the outside. Access is credited for LOCA portable hydrogen recombiner deployment. This location is equipped with an identical set of electrical and mechanical equipment/connections as described above for the primary location; however, no tie downs are provided at this location since this location will not be used for pre-staging. Suction for the alternate location is established at the suction to the permanent essential charging pump in the chemical and volume control system (CVCS). Refer to Figure 22 for primary deployment location arraignment using the electric motor driven RCS injection pump and Figure 23 for the alternate deployment location arrangement.

After deployment of the FLEX RCS pump, an operator needs to access the auxiliary building, east or west mechanical penetration room at 70 ft. elevation, to open FLEX to high pressure safety injection (HPSI) boundary valves (interface between Q1E and ASME B31.1 piping). Additionally, during a Modes 1 - 4 FLEX event, operator action is also needed to access the auxiliary building 120 ft. west or 100 ft. (ground) east electrical penetration rooms to align the disconnect switches to FLEX power source aligned to A or B, Class 1E train of the essential 480 VAC system (see Figure 3 and Figure 9).

10.3. SFP Makeup Pump Deployment and Associated Water Inventory Sources

The SFP makeup strategy will initiate makeup by deploying the FLEX diesel driven SFP makeup pump at a pre-designated pad (Figure 19). The discharge and suction of the SFP makeup pump will be connected to 5-inch STORZ connection. The primary discharge is located outside of the fuel building. The alternate location for discharge is just inside the fuel building, adjacent to the rollup door.

The FLEX SFP makeup pump suction will be attached to RWT, if the initiating event occurs during operational modes, as shown in Figure 22. Since RWT inventory is not available to be used for SFP makeup during a lower mode FLEX event, the CST primary FLEX drain connection will be used as primary source of makeup if the initiating event occurs during an outage.

Makeup to the SFP will be coordinated between a local and control room staff. Using the newly installed SFP level instrumentation (Reference 23) the pool is batch filled to a nominal level and then it will be cooled by boil off to an elevation 10 ft. above active fuel. This process will allow multiple suction sources (RCS injection and SFP makeup) from a single drain of the RWT.

10.4. FLEX 480 VAC Electrical Generator Deployment

In phase 2, or as part of pre-outage deployment, two 480 VAC 800 kW generators will be moved onto a pre-designated seismically qualified pad south of each unit (approximately 200 ft. from receptors). The generators may be connected to external primary or alternate receptacle connection boxes (see Figure 24). After the generators sets are connected, isolation breakers can be closed and loads added, as required by the FSGs. Isolation breakers are located at the ground elevation of the control building, and are easily accessible from the deployment location or control room.

Each 480 VAC 800 kW diesel driven generator set is equipped with a set of color coded cables which connect from the deployed generators to a panel located in the south yard as shown in Figure 24. A cable set consists of 2 x 3 x 250 MCM – 100 ft. cables per phase, plus two grounds, neutral, and spare. 100 ft. segments of cables are stored on easy to move carts. Two individual trailers house the cables for these generators. Each cable is color coded per NSRC standard. Wall mounted receptacles are also color coded and verified as part of design modification configuration for conductivity and phase rotation.

For each 1E cabinet, a new 600 amp breaker is installed. These breakers are locked in the open position and proceduralized to provide isolation between the 1E and non1E circuits.

10.5. Defense-in-Depth 4.16 kV 4 MW Electrical Generator Deployment

Medium voltage Defense-in-depth generators provide the station with vast flexibility to mitigate an unexpected event. Although not credited (or required) for FLEX, a combination of plant modification and onsite availability of 4 MWe, at 4.16 kV, adds a significant safety margin to overall FLEX philosophy. The 2 X 2 MWe generator set is stored in the FLEX EESF (an additional 8 MWe can be supplied by NSRC) and is sufficient for supply power to one train of the UHS for events that would not result in damage to the seismically designed PVNGS redundant spray ponds, such as an extreme heat event. Operationally, initiating shutdown and spent fuel pool cooling and by using these generators, early in the event, will eliminate the need for a significant amount of Phase 2 FLEX equipment and manpower.

Defense-in-depth 4.16 kV AC generators can be moved onto pre-designated seismic pad south of each unit (approximately 200 ft. from switch gear receptacle boxes) and they can be connected to external primary or alternate switch gear receptacle boxes (see Figure 24). After generators sets are connected, Isolation switch can be closed and loads can be added as required by FSGs. 4.16 kV seismically qualified isolation manual switches are located at the ground elevation of the control building, and are easy to access from generator pad location or unit control room. Two (2) sets of cables plus spare per unit (total 6) are available in easy to deploy trailers with diesel driven cable deployment mechanism.

10.6. Fueling of Equipment

All non-electric driven FLEX equipment, including vehicles and debris removal equipment and FLEX supporting machines, have their motive force powered by low sulfur diesel fuel oil. Two (2) 500 gallon mounted fuel tanker trailers and two (2) fuel delivery systems using diesel fuel tank trailers and trucks will be used to fuel each unit's FLEX equipment, as needed, with high priority given to FLEX equipment that provides critical safety functions. Once deployed during an ELAP BDBEE, a fuel transfer trailer will refuel equipment per a proceduralized sequence, as required (Reference 72). Site fuel capacity and sources are described in Section 9 of this report. The NSRC and external state and national resources will provide diesel fuel oil once site inventory is exhausted.

All vehicles and debris removal equipment will be maintained with sufficient fuel to achieve initial implementation of the 480 VAC generators so they can provide motive force for fuel distribution (see Section 9.3).

11. Offsite Resources

11.1. National SAFER Response Center

The industry has established two (2) National Strategic Alliance for FLEX Emergency Response (SAFER) Response Centers (NSRCs) to support utilities during BDB events and these resources have been accepted by the USNRC (Reference 28). APS, the operator of PVNGS, has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs as required. 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, onsite BDB equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

In the event of a BDBEE and subsequent ELAP condition, equipment will be moved from an NSRC to a local staging area "C" established by the SAFER team. For the PVNGS, the NSRC-Phoenix is designated as staging area "C". From there, equipment can be taken to the PVNGS site and staged at the onsite Staging Area near the FLEX EESF and close to helicopter pad (see Figure 18), or by helicopter if ground transportation routes are unavailable. Twenty four (24) hours after notification the first piece of offsite equipment is delivered to the onsite staging area. The equipment is delivered as identified in the PVNGS SAFER Response Plan (Reference 62).

12. Equipment List

Table 2, Table 3, and Table 4 provide a summary overview of the types and quantities of equipment needed to support the PVNGS FLEX integrated plan. Equipment selection considered NEI 12-06 (Reference 75), Sections 9.3.2 and 9.3.3 recommendations.

Specifications for FLEX equipment include applicable environmental parameters. The FLEX equipment required to provide safety functions are procured for continuous operation at a limiting extreme temperature of 130 degrees F.

The equipment stored and maintained at the NSRC for transportation to support phase 3 of ELAP strategies are listed in the PVNGS SAFER Response Plan (Reference 62).

13. Habitability and Operations

13.1. Equipment Operating Conditions

As described previously in this report, a minimum set of instrumentation has been selected to provide control room operators with key safety-function information. Instruments identified are safety related, seismically qualified, meet the environmental qualification requirements of 10 CFR 50.49, and are verified qualified consistent with the criteria in NEI 12-06, Section 3.2.1.12 (Reference 75). The PVNGS ELAP analysis does not credit automatic actuation beyond the SBO scenarios, and such actions would occur within the first hour of the event. The SBO response strategies were reviewed and approved by the NRC in Reference 21. Operator actions directed by the FSGs are manual actions after the first hour. Instrumentation and components credited are qualified to 10 CFR 50.49 for loss of coolant accident (LOCA) and steam line break; therefore, they will remain accurate and reliable for the duration of the beyond-design-bases event. Additionally, the maximum temperature expected within containment during an ELAP remains below the threshold of the equipment qualification harsh limit of 230 degrees F. Additional extensive analysis was performed to evaluate the essential TDAFW compartment and it was concluded that the system will not be adversely impacted if the access door or hatch is opened at about 2 hours, refer to Section 4.3 and discussion in Section 2 on analytical methods.

13.2. Personnel Habitability

Long term habitability will be assured by monitoring control room conditions, heat stress countermeasures, and rotation of personnel to the extent feasible. PVNGS procedure "Heat Stress Prevention Program" (Reference 64) outlines the issues and the actions to take when working in a higher temperature environment and provides various measures to mitigate the effects of working in elevated temperatures for extended periods.

The control room staff is trained on the expected conditions, the need for self and team monitoring, and the countermeasures available. The staffing analysis (see Section 13.6 of this report) addresses the availability of replacement personnel, both long term and in the event of medical emergency.

The Control Room Envelope (CRE) was analyzed using simplified a GOTHIC computer code model and it was concluded that the CRE will not exceed 115 degrees F.

All others portions of the plant that may require personnel entry will remain habitable at times when strategies necessitate operator actions. During preliminary walk-downs, it is possible that non-seismic SSC failure within the safety related buildings, such as the Auxiliary and MSSS buildings, may impede the normal access paths. Alternative egress/ingress pathways are available at each structure. Internal flooding as a result of seismic failure of non-quality systems is not a concern since areas that require access will remain above the most limiting flood levels. Although there is a possibility of steam leakage from the Auxiliary Steam System within the auxiliary and MSSS buildings, the source of steam is quickly eliminated once Main Steam Isolation occurs as result of reactor trip and AFW actuation. The buildings will return to ambient conditions within a few hours and before access is required for FLEX implementation. PVNGS fuel building is vented by opening the large rollup door and, although no operator action is required within the building as to comply with NRC Order EA-12-051 (Reference 2), ventilation will aid to cool the lower elevation building should entry be needed.

13.3. Lighting

PVNGS emergency lighting is described in UFSAR Sections 9.5.3.2.2.3 (Reference 8). In the control room emergency lighting is designed to provide sufficient illumination for the operator to perform the required actions in the event of a loss of essential power. The emergency lighting system has minimum of eight hour battery-backed power. It is expected that the power source for these batteries will realistically provide illumination for a longer duration.

This lighting illuminates automatically upon a loss of AC power. The Train "A" essential lighting is powered by the FLEX 480 VAC, 800 kW generators to provided illumination for FSGs critical operator actions. Diesel driven temporary FLEX equipment (pumps and generator) are designed to have self-illumination and will not require an external source.

Should emergency lighting fail, the standard gear/equipment for operators includes flashlights and portable lanterns and light stands (Reference 68).

13.4. Communications

Communications strategies, following the guidelines of NEI 12-01 (Reference 74), for BDBEE are described in the PVNGS response to NRC 50.54(f) letter on NTTF 9.3 (Reference 4 and Reference 29) and NRC acceptance documented in Reference 30.

13.5. Additional Water Sources

FSG strategy long term sources of water after 72 hours are provided by two state certified, seismically designed, below ground reservoirs with a minimum 500 million gallon capacity. These reservoirs normally supply cooling water to the cooling towers and are described section of 2.4.8.2.2 of the PVNGS UFSAR (Reference 8). This water will be available at each unit before other water sources are exhausted (refer to Section 4.3 of this report). The equipment and components for the delivery system to the units are stored in secure shelters strategically placed along the path of the pipe line for ease of implementation. This equipment, in addition to complementary equipment provided by NSRC for phase 3, will provide sufficient water to continue coping strategies indefinitely.

13.6. Staffing

Staffing strategies, following the guidelines of NEI 12-01 (Reference 74), for BDBEE are described in the PVNGS response to NRC 50.54(f) letter on NTTF 9.3 (Reference 4 and Reference 10) and NRC acceptance documented in Reference 31.

Human resources begin arriving at the Palo Verde site starting at six hours after the event occurs (Reference 80). The Palo Verde site is fully staffed by 24 hours (Reference 10).

14. Sequence of Events

The Sequence of Events Timeline for an ELAP as a result of a BDBEE at PVNGS is presented in Table 5.

No sequence of events is provided for the lower modes since plant condition and availability of SSCs are variable. Per NEI Guidance (Reference 18) shutdown risk assessment will be performed for each outage and evaluate if lower mode FSG (Reference 69) strategies are implementable or additional action is need. Strategies for lower modes are discussed in Sections 4.2, 5, and 6.2 of this report.

Validation of each of the FLEX time constraint actions has been completed in accordance with NEI 14-01 (Reference 93) and includes consideration for staffing.

15. Programmatic Elements

15.1. Overall Program Document

The Palo Verde Nuclear Generating Station Diverse and Flexible Coping Strategies (FLEX) Program Plan (Reference 65) is implemented to comply with the requirement of the Nuclear Regulatory Commission Order EA-12-049 (Reference 2) and NEI 12-06 (Reference 75), which states:

> "The FLEX strategies and basis will be maintained in an overall program document. This program document will also contain a historical record of previous strategies and the basis for changes. The document will also contain the basis for the ongoing maintenance and testing programs chosen for the FLEX equipment."

The key elements of the program include:

- Maintenance of the FSGs including impacts on the interfacing procedures (EOPs, Abnormal Operating Procedures (AOPs), Severe Accident Mitigation Guidelines (SAMGs), or Extreme Damage Mitigation Guidelines (EDMGs), 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 sensitive operator actions
- The FLEX EESF and the NSRC
- Hazards Considerations (See Section 7)
- Supporting evaluations, calculations and drawings
- Tracking of commitments and equipment unavailability
- Staffing, Training, and Emergency Drills
- Configuration Management
- Program Maintenance

The instructions required to implement the various elements of the FLEX Program and thereby ensure readiness in the event of a BDBEE are contained in station procedures.

Existing design control and fuel cycle procedures have been revised to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will not adversely impact the approved FLEX strategies. Changes for the FLEX strategies will be reviewed with respect to operations critical documents to ensure no adverse effect.

Limited configuration and quality assurance control for portable equipment supporting the FLEX coping safety function is implemented. Only documents establishing performance basis for critical safety function which are used as the basis for maintenance testing will be maintained in the PVNGS document control system. These include engineering and manufacturing reports establishing critical attribute for tests recommended by EPRI (Reference 94 and Reference 20).

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 (Reference 75) and supporting documents, 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.

15.2. Procedural Guidance

The inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FSGs (Reference 68 and Reference 69) provide guidance that can be employed for a variety of conditions.

The FSGs have been developed in accordance with plant specific analysis and industry guidance accepted by the NRC. FLEX Support Guidelines provide available, pre-planned FLEX strategies. 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 exiting procedures such as "Blackout" (Reference 66) to the extent necessary to include appropriate reference to FSGs and provide command and control for the BDBEE ELAP.

FSG updates will be performed as necessary; site administrative processes, NEI 96-07 (Reference 79), and NEI 97-04 (Reference 95) are used to evaluate changes to procedures.

FSGs are reviewed and validated by the site stakeholders to the extent possible and practical to ensure the strategies are implementable. Validation is accomplished by use of desktop discussion, simulator practices, walk-throughs, hands-on simulation of implementation, and drills.

FLEX mitigation equipment is subject to initial acceptance testing and subsequent periodic maintenance and testing to verify proper function (See Section 15.5).

15.3. Organizational responsibilities

The following is a description of the roles and responsibilities of those associated with the FLEX Program:

FLEX Program Owner – The Program Owner has the following responsibilities:

- Coordination of overall station BDBEE strategies and trending the health of the program.
- Compliance with regulatory requirements
- Maintenance of program manual
- Maintain operational margin
- SAFER Site Specific response plan

Department Leader, Fire Protection – The Fire Protection Department has the following responsibilities:

- Development of FLEX equipment surveillance and maintenance procedures
- Surveillance/Maintenance of Fire Department FLEX equipment
- Equipment Inventory
- FLEX equipment deployment Incident Command
- Training of Fire Department personnel on the aspects of the FLEX program

Department Leader, Operations – The Operations Department has the following responsibilities:

- Overall responsibility of the management and direction of the PVNGS post-Fukushima response
- Implementing the operational strategies as required during a BDB event.
- Coordinating the activities of on-site affected departmental entities, as well as communication with nuclear industry counterparts for information sharing
- Training of Operations personnel on the aspects of the FLEX program

Department Leader, Site Procedure Standards – The Procedure Standards Department is responsible for the revision of operational and administrative procedures that interface with the FLEX program.

Manager, Emergency Preparedness – Emergency Preparedness has the following responsibilities:

- FLEX Program site drills and exercise planning/implementation

15.4. Training

The PVNGS Nuclear Training Program is updated to include training on the mitigation of BDB external events. These programs and controls are developed and have been implemented in accordance with the Systematic Approach to Training (SAT) process.

Initial training has been provided and periodic training will be provided to site emergency response leaders on FLEX 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.

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

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

15.5. Equipment Maintenance and Testing

Periodic testing and preventative maintenance of the FLEX equipment conforms to the guidance provided in the Institute of Nuclear Power Operations' AP-913 (Reference 96). Site procedures have been developed to address preventative maintenance (PM) using the Electric Power Research Institute (EPRI) templates manufacturer provided information/recommendations, and equipment testing criteria.

Using the EPRI Preventive Maintenance guidance (Reference 94), Preventative Maintenance (PM) tasks are issued for major FLEX equipment including the portable diesel and electric motor driven pumps and generators.

The PM Templates include activities such as:

- Periodic static inspections – Monthly walk-down
- Periodic operational verifications – Quarterly starts
- Periodic functional verifications with performance tests – Annual 1 hour run with pump flow and head verifications

The unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment integrity, and SFP cooling will be managed such that risk to mitigating strategy capability is minimized by using the following guidance:

- Portable FLEX equipment or a portion of the FLEX Emergency Equipment Storage Facility (EESF) may be unavailable for 90 days provided that the site FLEX capability (N) is available.
- If portable equipment or a portion of the FLEX EESF becomes unavailable such that the site FLEX capability (N) is not maintained, actions will be initiated 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.

Work Management procedures are revised to reflect allowed outage times as outlined above.

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Regulatory

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66. Palo Verde Administrative Procedure 40EP-9EO08, "Blackout"
67. Palo Verde Administrative Procedure 40AO-9ZZ21, "Acts of Nature"
68. Palo Verde Administrative Procedure 79IS-9ZZ07, "PVNGS Extended Loss of All Site AC Guidelines"
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71. Palo Verde Administrative Procedure 40OP-9ZZ23, "Outage GOP"
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External to APS

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94. The Electric Power Research Institute (EPRI) Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." [ADAMS Accession Number ML 13276A573]
95. NEI 97-04, Revision 1, "Design Bases Program Guidelines," November 2000. [ADAMS Accession Number ML003679532]
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Tables and Figures

Table 1: 480 VAC FLEX Generators Essential Load List

Train A Load Centers	Train B Load Centers	Essential[1] Load
L31	L32	PKC/D-H13/H14 (58kVA) "C/D" Battery Charger
L31	L32	HJA/B-J01A/B (1hp) "A/B" Battery Compartment Exhaust Fan
L31	L32	HJA/B-J01B/A (1hp) "C/D" Battery Compartment Exhaust Fan
L31	L32	DFA/B-P01 (3hp) Diesel Fuel Oil Transfer Pump
L35	L36	PKA/B-H11/12 (80/92kVA) "A/B" Battery Charger
L35	L36	CHE-P01 (100hp) Swing Charging Pump "E" or 30hp electrical portable RCS injection pump.
L35	L36	HJA/B-F04 (125hp) Control Room Air Recirculation

Note(s):

[1] Generators have additional capacity to power non-essential loads such as station emergency or normal lighting, HVAC, and communication, if needed. Generators may also be used for non-seismic systems that survive the initiating event.

Table 2: PVNGS FLEX Phase 2 Equipment Providing Safety Function(s)

Portable equipment	Total (N+1)	Core	Containment	SFP	Instrumentation	Accessibility	Specification	Operating point	Design
SG Makeup Pumps	4	X			X	X	300 gpm @ < 300 psig (Reference 38)	300 gpm @ 200 psig, engine @ 3100 RPM	Diesel driven engine, SS -Centrifugal pump with dual 5-inch STORZ inlet and one 5-inch STORZ outlet
High Pressure RCS Injection Pumps	4	X			X	X	< 60 gpm @ 600 psig (Reference 37)	5 - 40 gpm @ 650 psig, engine @ 100-1200 RPM	Electric motor driven engine, positive displacement VFC pump with single STORZ 5-inch suction and single discharge with 1½ inch NPT connection
SFP Makeup Pumps	4			X	X	X	200 gpm, 100 psig (Reference 38)	< 200 gpm @ < 80 psig	Diesel driven engine, SS -Centrifugal pump with dual 5-inch STORZ inlet and one 5-inch STORZ outlet
RCS Lower Mode Makeup Pumps[1]	4	X			X	X	NA	250 gpm @ 50 psig, engine @ > 2100 RPM	Diesel driven engine, SS -Centrifugal pump with dual 5-inch STORZ inlet and one 5-inch STORZ outlet
Electrical Generators	8	X			X	X	800 kW, 480V (Reference 40)	500 kW, 480 V	Diesel driven, trailer mounted, 750A 3-phase
Cable Trailers	8	X			X	X	250 MCM (Reference 41)	250 MCM	3 per phase, plus ground, neutral, and spare, color coded to NSRC requirement

Note(s):

[1] Same equipment as SG makeup, the SG makeup pump is dual function

Table 3: PVNGS Other FLEX Equipment Available on Site

List of key equipment[1] and associated items	Total available	Key Parameter(s)	Design
Transfer Pumps (low flow)	4	150 gpm	Diesel driven engine, SS -Centrifugal pump with dual 5-inch STORZ inlet and one 5-inch STORZ outlet
Pumps (high flow)	2	1500 gpm	Electric motor driven submersible pump
Pipe	> 7,000 ft		12 inch, 20 ft. long High Density Polyethylene (HDPE) segments
Electrical Generators	2	4.16 kV, 2 MW	Diesel driven
2 cable trailer/unit for 4.16 kV Generators	6	4/0 / 2/0	4 x 4/0 cables per phase plus ground, neutral (2/0) cables, and spares
Electrical Generators and cables	2	150 kW	Diesel driven

Note(s):

[1] NSRC provided equipment list is available in the PVNGS SAFER Response Plan (Reference 62)

[2]

Table 4: PVNGS FLEX Miscellaneous Equipment/Commodities

Item	Notes
Portable Fuel Oil Refueling System • **Diesel Fuel Oil Delivery Tank Trailers** • **Pumps**	Three (3) 500 gallon trailers Three (3) diesel driven pumps (60 gpm)
Heavy Equipment • **Transportation Equipment** • **Debris Clearing Equipment** • **Communication Vehicles**	Two (2) commercial trucks for hauling trailers Two (2) yard trucks for generators Three (3) ATV 4 wheel + tow bars Two (2) mid-size debris removal loaders w/forks Four (4) communication vehicles
Misc • **Sani-Privy**	12 Sani-Privy (Portable)

Table 5: Sequence of Events Timeline, Modes 1 - 4

Item No.	Analytical Elapsed Time (hours)	Action / Description	Required Operator Action Time (hours)	FLEX Time Constraint Y/N/NA	Automated Action Y/N	Remarks / Applicability
	0	Initiating Event ELAP		NA	N	Reactor at 100% power, assumed RCS pump seal leakage is 25 gpm/pump
1	<0.001	Control Rods Insert		NA	Y	10 CFR 50.63 assumption for the designed plant response to a loss of offsite power, turbine trip result in reactor trip
2	0.184	AFAS generated		NA	Y	Low SG level
3	0.220	TDAFW flow to both SGs begins		NA	Y	Conservative assumption, time to AFAS generation + 60 second delay for TDAFW pump to start
4	0.25	SBO condition is realized		N	N	Estimated time for operator to recognize station black out (SBO). Procedural requirements are adhered to. Emergency Action Level (EAL) is exceeded and a Site Area Emergency is declared; SBO procedures instruct the operator to start the station blackout generators (SBOGs).
5		SBOG Fails to Start	1	N	N	Current design bases for SBO dictates operator action within 1 hr. to start the alternate source of power for the station black out scenario. Therefore, the latest time to enter FSGs (see item 6) will be 1 hr. after initial event. EAL is exceeded and a General Emergency is declared.
6		Enter FSG Guidelines	~1	Y	N	FLEX coping starts: RCS cool-down @ 70 degrees F / hr., symmetric cool-down using 1 ADV per train and DC load shed sequence starts.
7	2	Complete DC Load Shed	2	Y	N	DC load shed sequence completed

Item No.	Analytical Elapsed Time (hours)	Action / Description	Required Operator Action Time (hours)	FLEX Time Constraint Y/N/NA	Automated Action Y/N	Remarks / Applicability
8	2	Open the TDAFW pump Compartment (train A) Door and /or Hatch	2	Y	N	Action limits environmental temperature rise within the essential TDAFW pump compartment and reduces possibility of AF system component failure.
9	3	SITs begin to inject		N	Y	RCS borated makeup starts. RCS depressurizes to a lower pressure than the SIT nitrogen blanket. Operators will trend RCS pressure and vent SIT N_2 when SIT level reaches 10%.
10	4	Cool-down achieved, RCS above shutdown cooling entry P/T condition		N	N	Cool-down / depressurization of the RCS will result in reduced loss of RCS inventory due to RCP seal leakage. The RCS cool-down will stop at P/T near shutdown cooling entry condition. FSGs provide guidance to maintain secondary pressure (steam generator dome pressure) such that essential TDAFW steam supply will remain above the TDAFW required pressure for efficient operation.
11		Assessment Walk-downs	4	Y	N	Completion of Primary and Secondary side equipment status walk-downs. Specific tasks within the walk-downs have time constraints. During the four hours of walk-downs additional unknown actions may be required depending on the severity of the BDBEE. Entry into SAMGs may be evaluated based on level of damage.
12		Establishing Fuel Building Vent Path	4	N	N	Roll up door to the Fuel Building truck bay is opened prior to earliest predicted spent fuel pool time to boil. This action would provide ventilation and maintain accessibility to alternate SFP makeup pump connection point. This is not a required action since access is not required to the building and there is no permanent equipment within the building that is used for coping strategies.

Item No.	Analytical Elapsed Time (hours)	Action / Description	Required Operator Action Time (hours)	FLEX Time Constraint Y/N/NA	Automated Action Y/N	Remarks / Applicability
13	16	Begin Manually Operating ADVs	16	Y	N	Minimum time to exhaust seismic nitrogen supply to ADVs (per design). Manual operation of ADVs will be initiated if needed. Minimal adjustment will be needed since manipulation is only needed to maintain SG pressure. Auxiliary Operators are trained for this task. Area is habitable since upper MSSS is open to the environment. Additionally, power sources to ADVs would be load shed at this time.
14		480 VAC Generators Implemented	30	Y	N	AC power source is in place and available for loads identified in Table 1 of this report.
15	35.5[1]	Start Charging Pump or FLEX RCS injection pump	34.5	Y	N	Loads in Table 1 of report are aligned to 2 x 800 kW generators per FSG direction. RCS borated makeup is established as a top priority load.
16		Stage SG Makeup Pump	35	N	N	SG makeup pump is staged and operational. This is a contingency action to limit essential TDAFW pump trip impact should the suction be lost as a result of action item 18.
17	39	Establish SFP Makeup	39	Y	N	Approximate time SFP inventory is 10 feet above the irradiated fuel in the spent fuel pool storage rack. Batch makeup to SFP is established to maintain water level between normal (138 ft.) and 10 ft. above rack per NRC Order EA-12-051 (Reference 2).
18	40	Switchover to RMWT	37	Y	N	TDAFW pump suction is realigned to the RMWT by manipulation of manual valves. See Figure 5.

Item No.	Analytical Elapsed Time (hours)	Action / Description	Required Operator Action Time (hours)	FLEX Time Constraint Y/N/NA	Automated Action Y/N	Remarks / Applicability
19	104	Water from long term sources of water is available.	72	N	N	At 104 hours the water within the power block in the CST and RMWT is depleted; long term source of water will be available (see Section 10 of report).

Note(s):

[1] Analytically determined using CENTS code (Internal Document and Calculation Reference 34); *a one hour time averaged flow through the top of the SG U-tubes exceeds a value of 0.1.* This provides a reasonable transition point to the onset of reflux cooling and provides the guidance for initiating RCS forced injection to maintain natural circulation (Reference 16).

Figure 1: FLEX Primary and Alternate RCS Injection Schematic for Modes 1 - 4

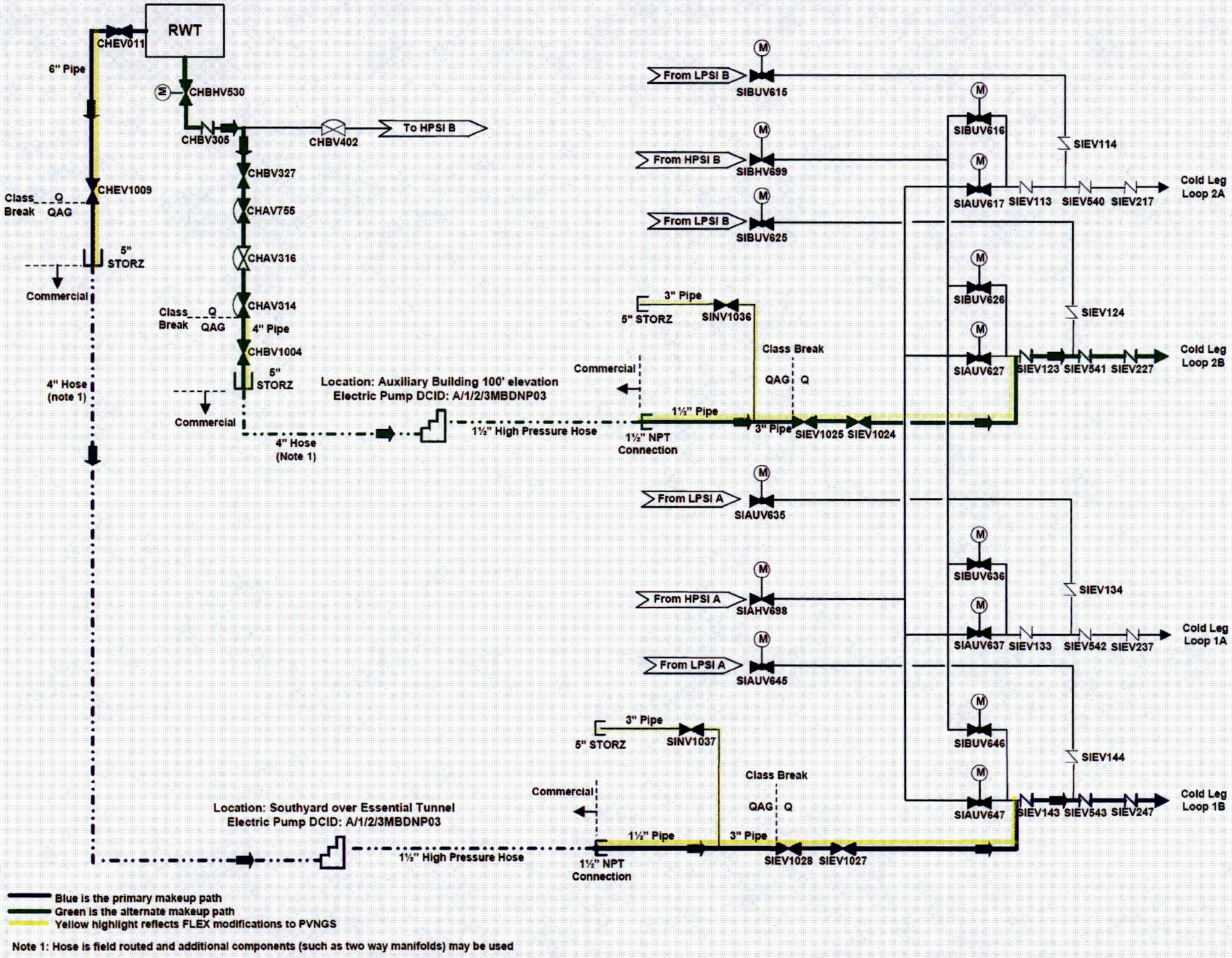


Figure 2: FLEX Primary RCS Injection Tie-in Simplified Piping

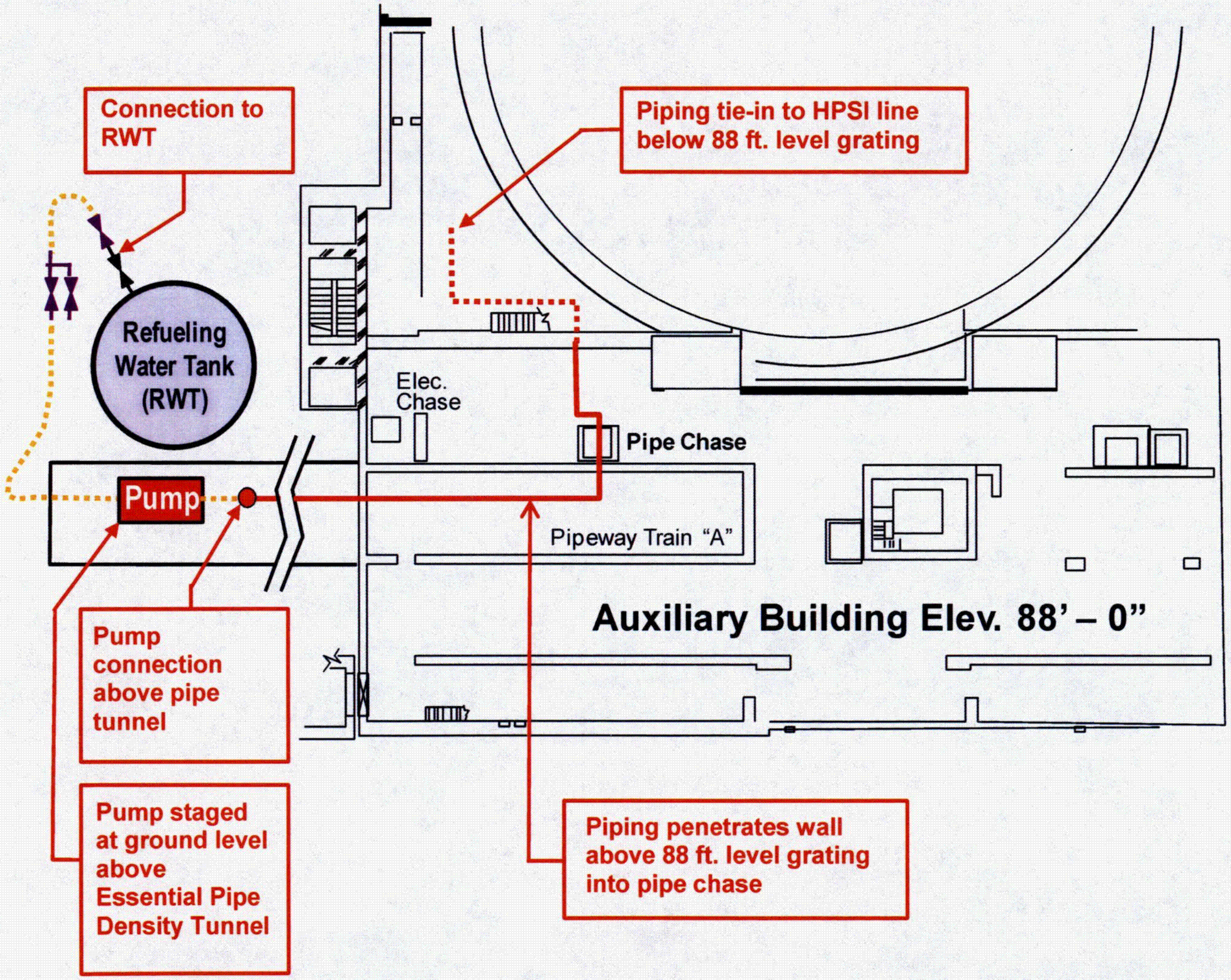


Figure 3: FLEX Alternate RCS Injection Tie-in Simplified Piping

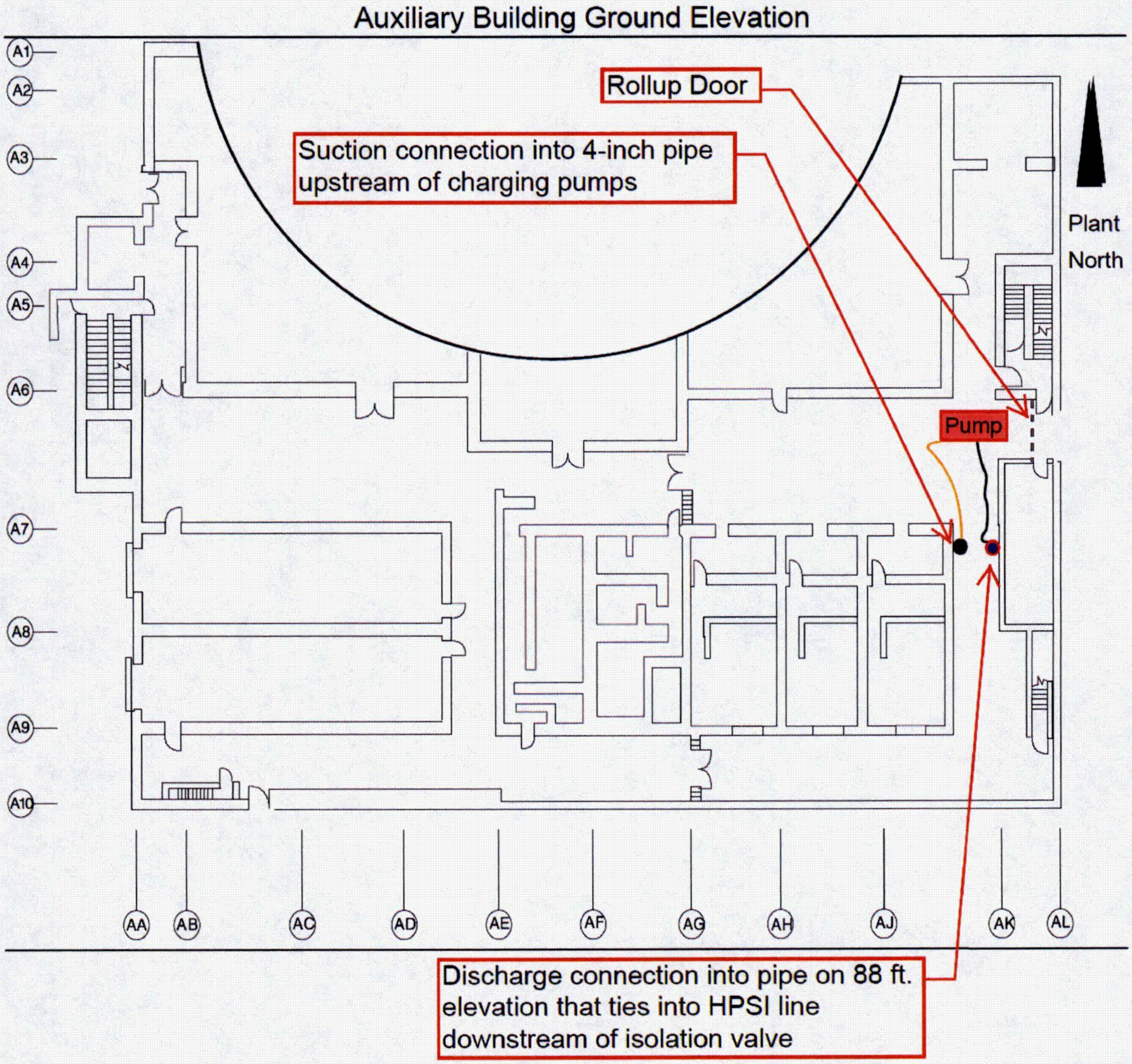


Figure 4: FLEX RCS Makeup Schematic for Modes 5 and 6

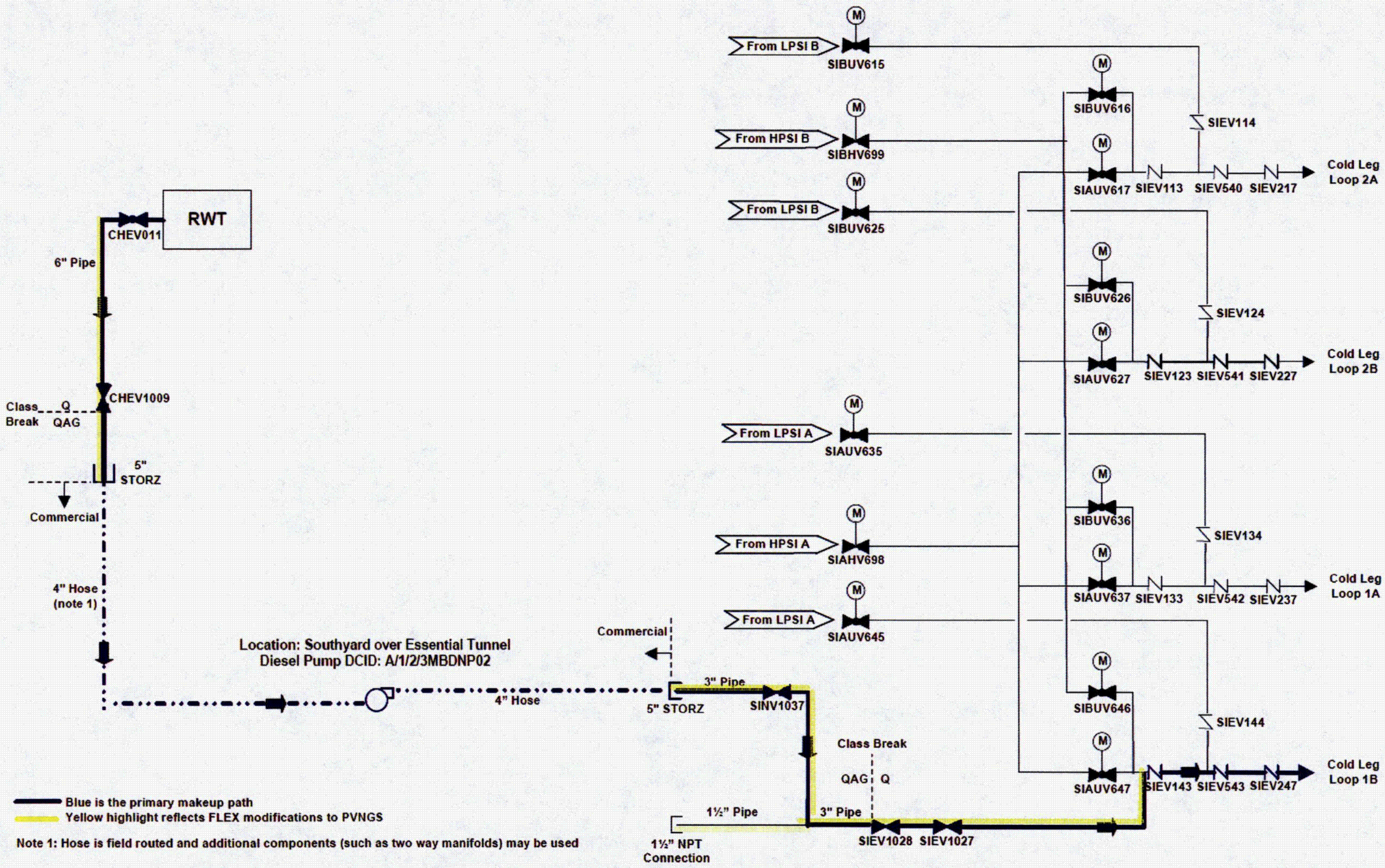
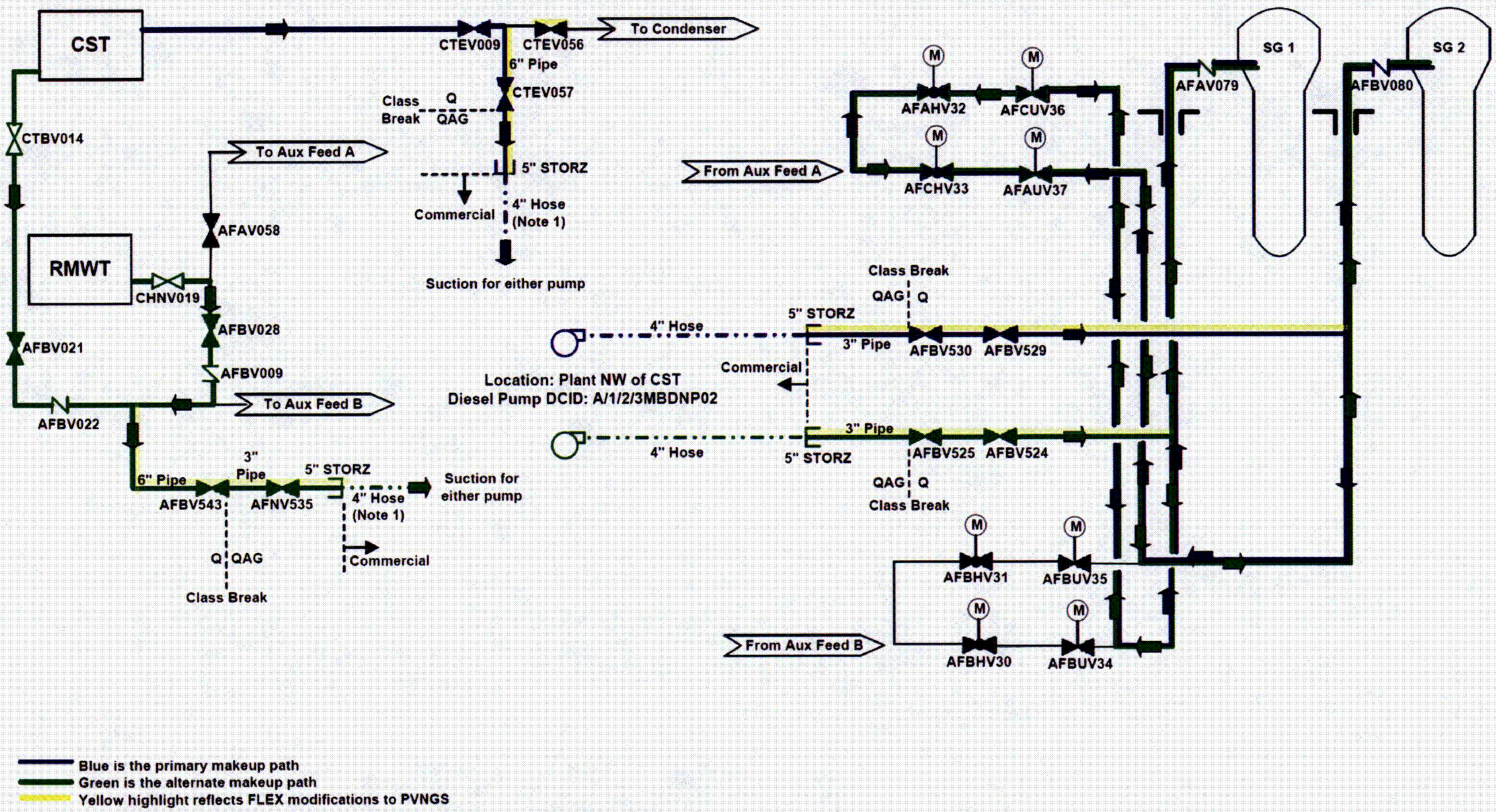


Figure 5: FLEX Primary and Alternate Secondary Makeup Schematic



Note 1: Hose is field routed and additional components (such as two way manifolds) may be used

Figure 6: FLEX Secondary Plant Makeup Simplified Piping

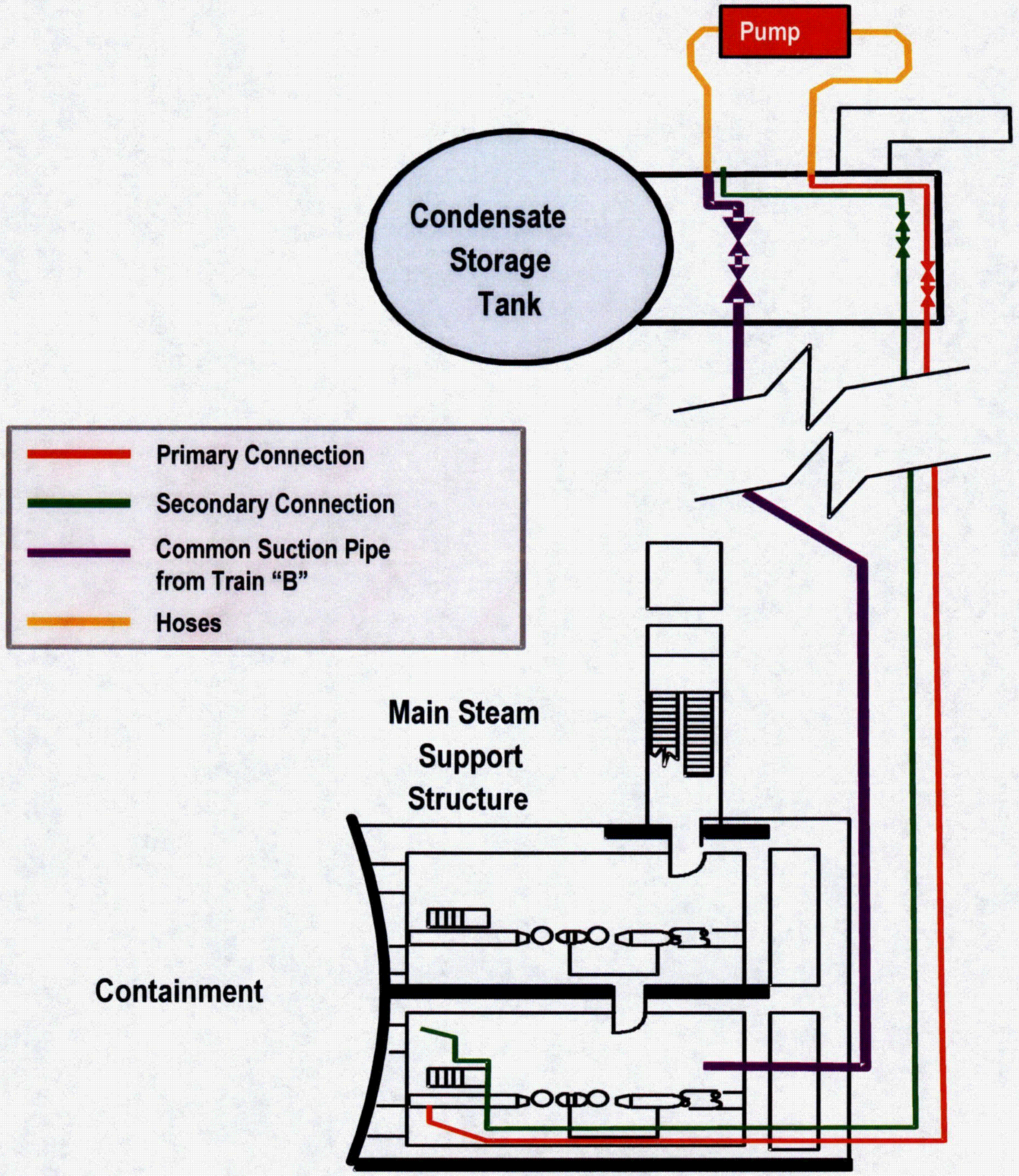
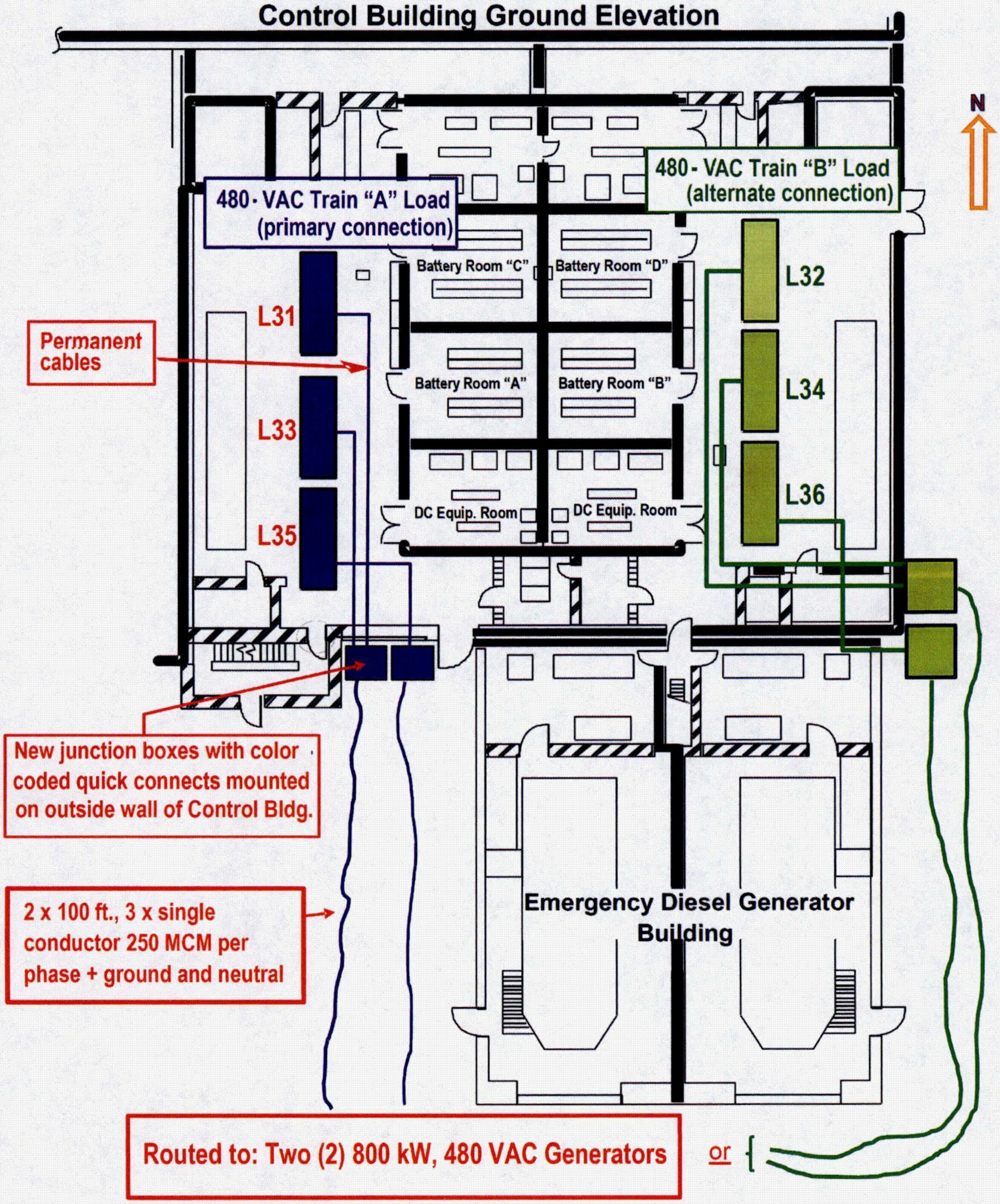


Figure 7: FLEX 480 VAC Physical Layout



(Not to scale)

Figure 8: FLEX 480 VAC Electrical Schematic

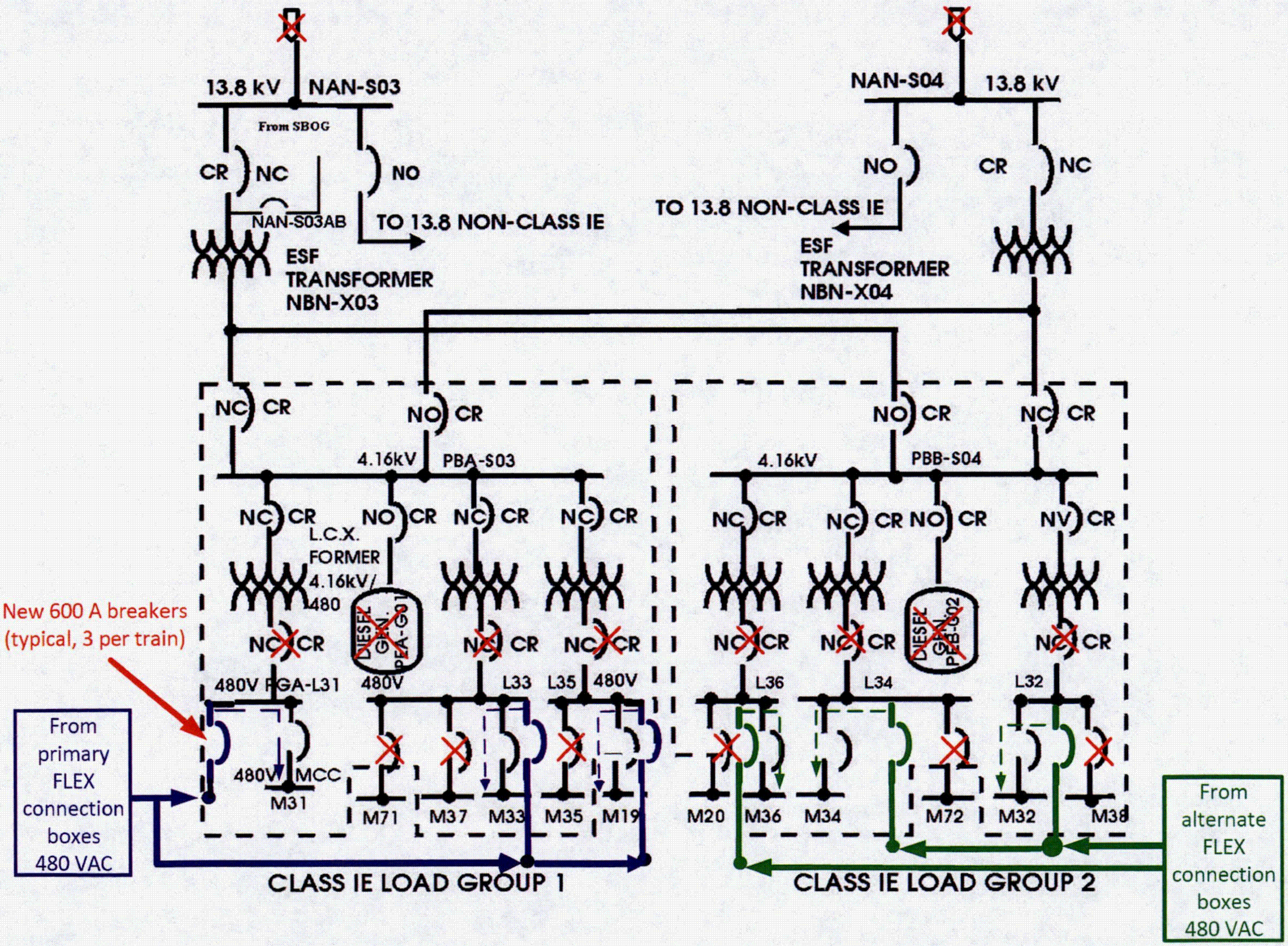
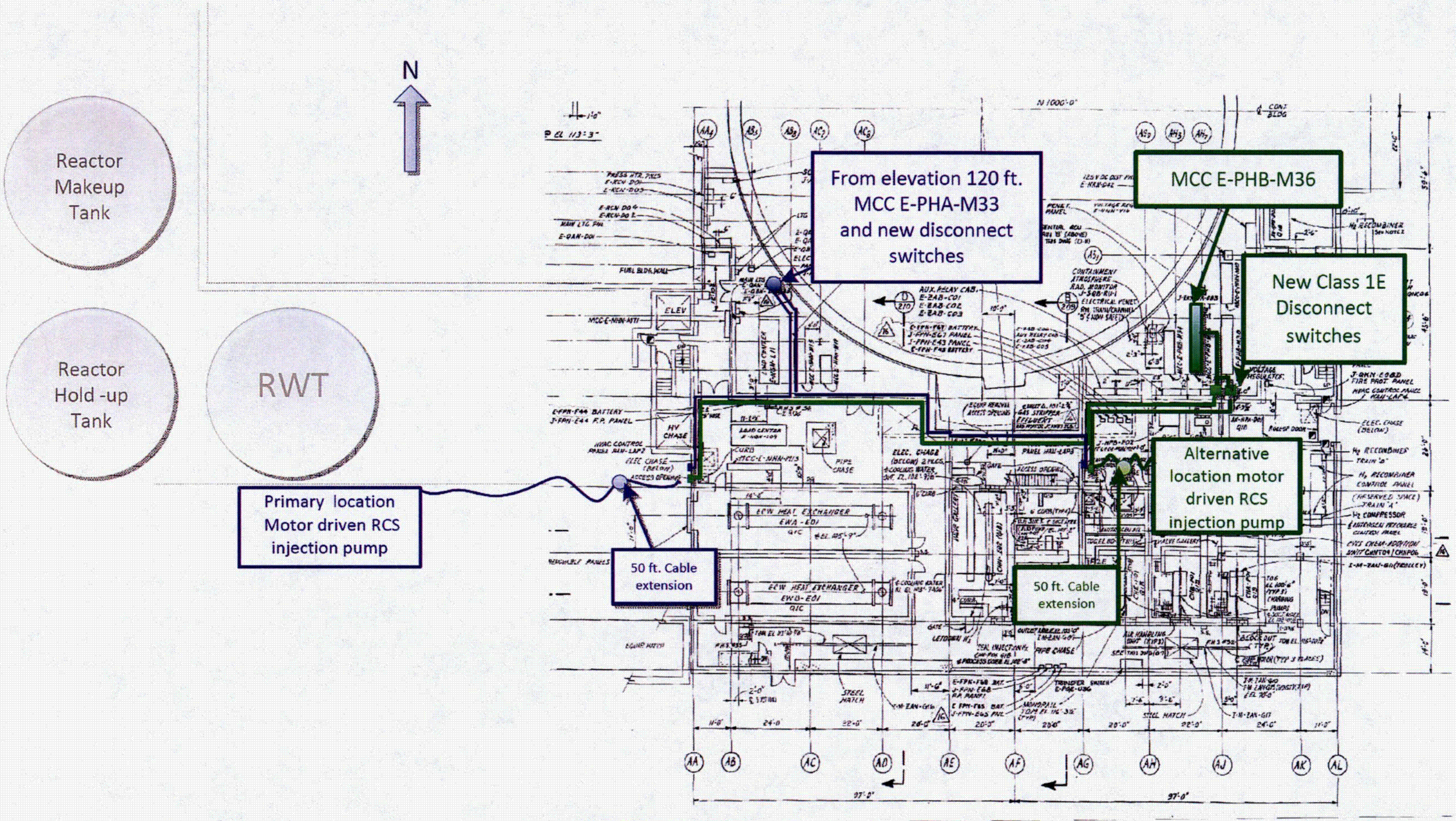


Figure 9: FLEX Motor Driven RCS Injection Physical Cable Layout (Ground Elevation)



(Not to Scale)

Figure 10: FLEX Electrical Modifications Schematic

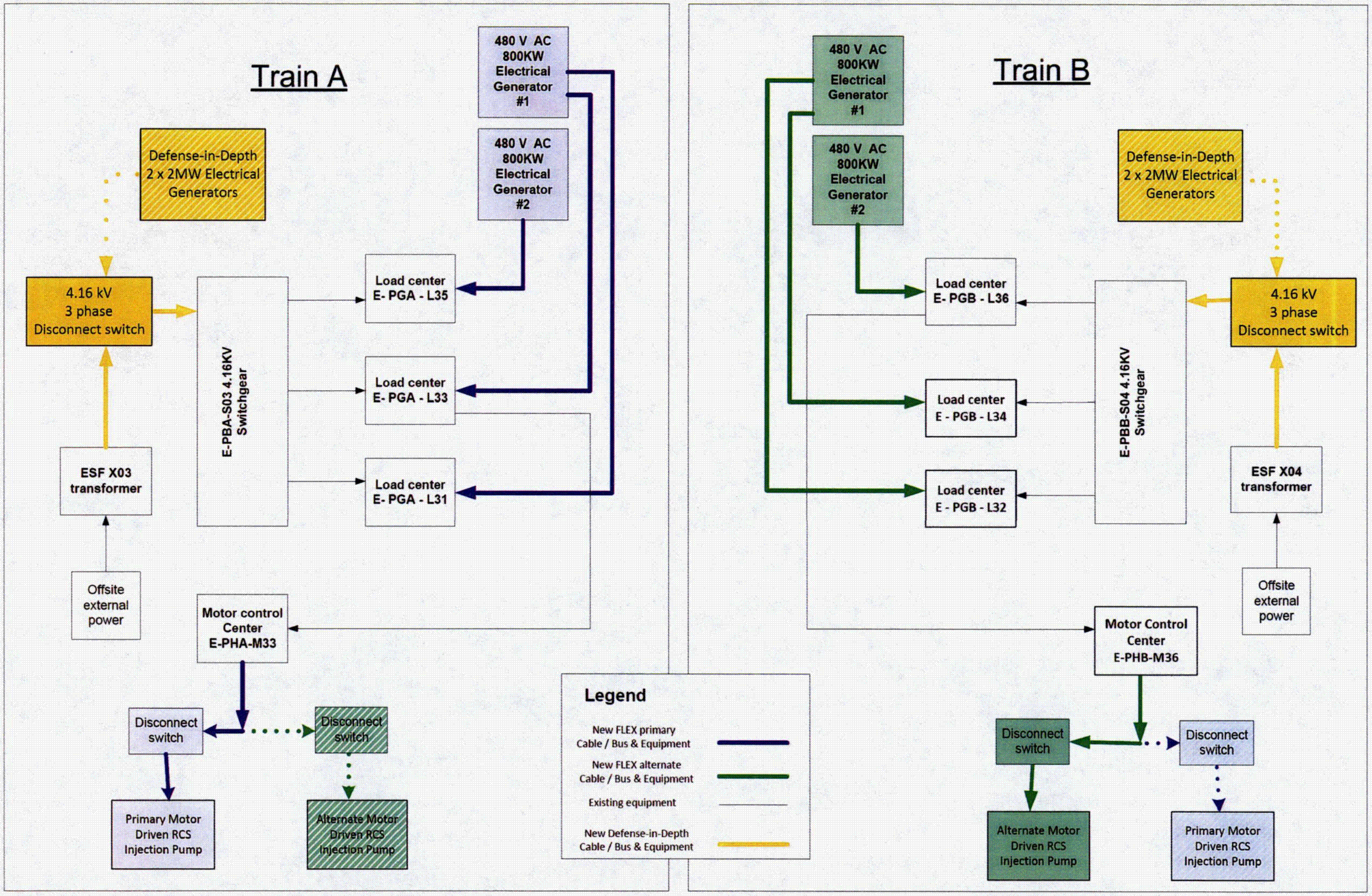
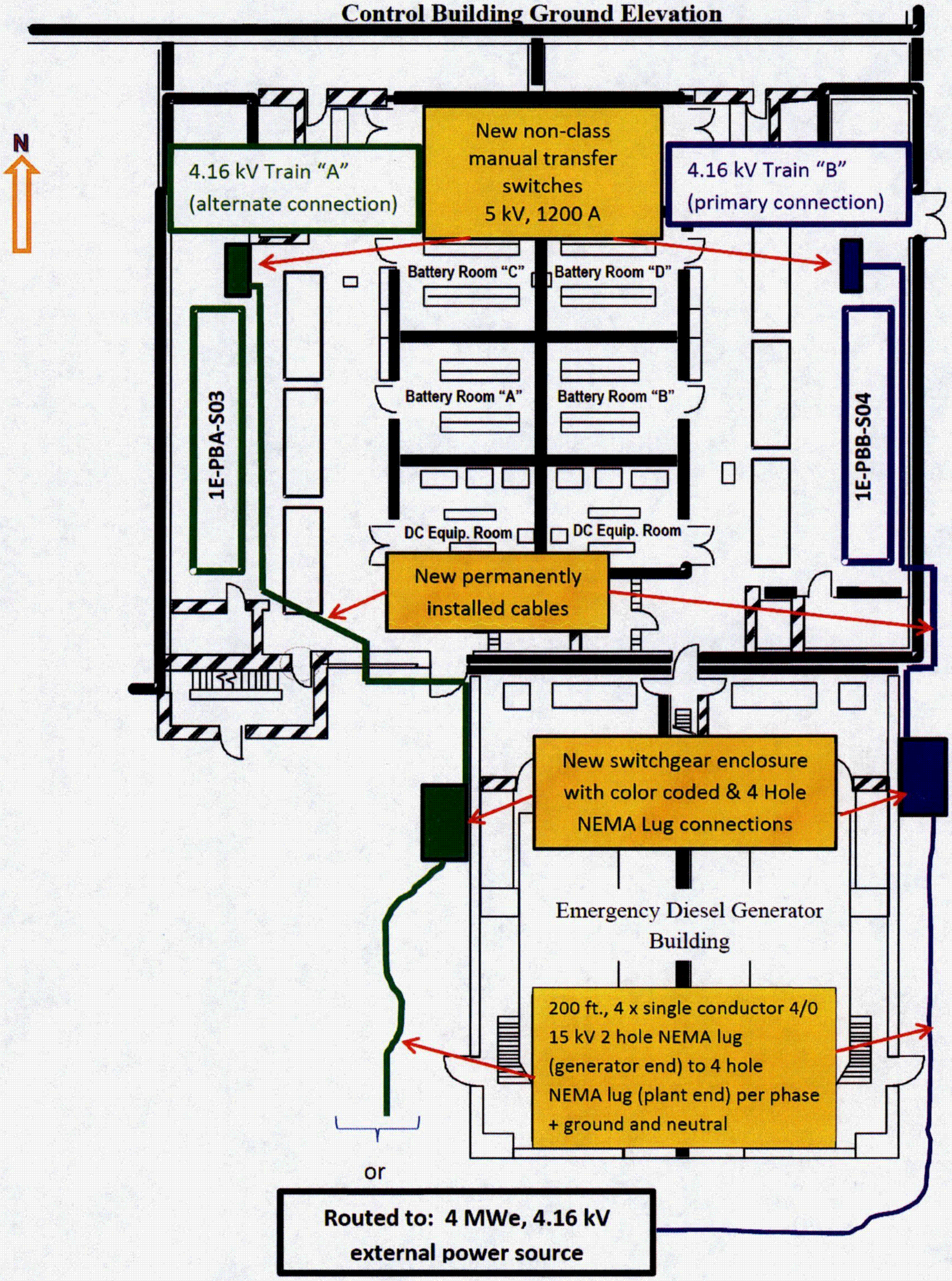


Figure 11: Defense-in-Depth 4.16 kV AC Physical Layout



(Not to scale)

Figure 12: Defense-in-Depth 4.16 kV AC Electrical Schematic

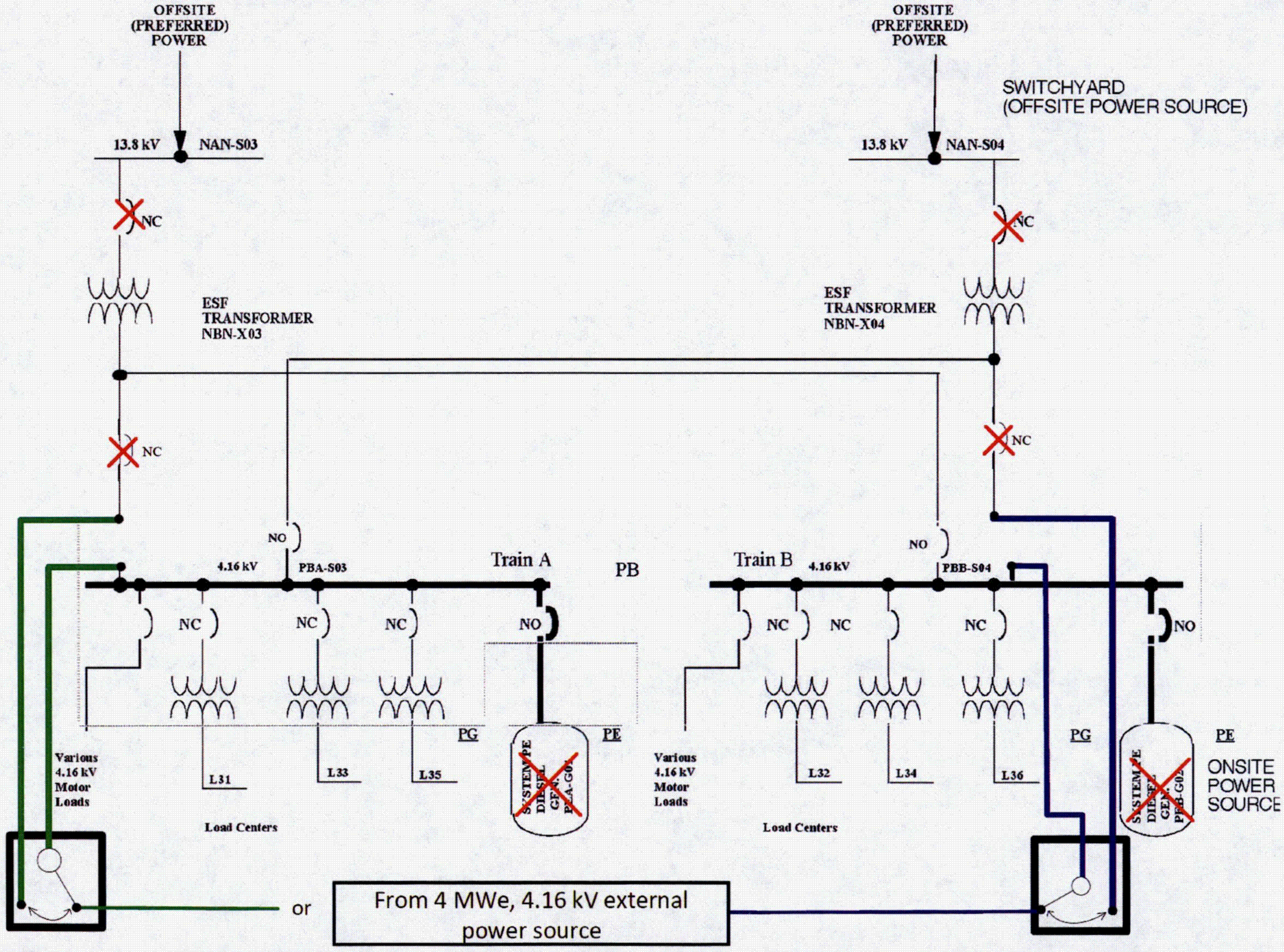
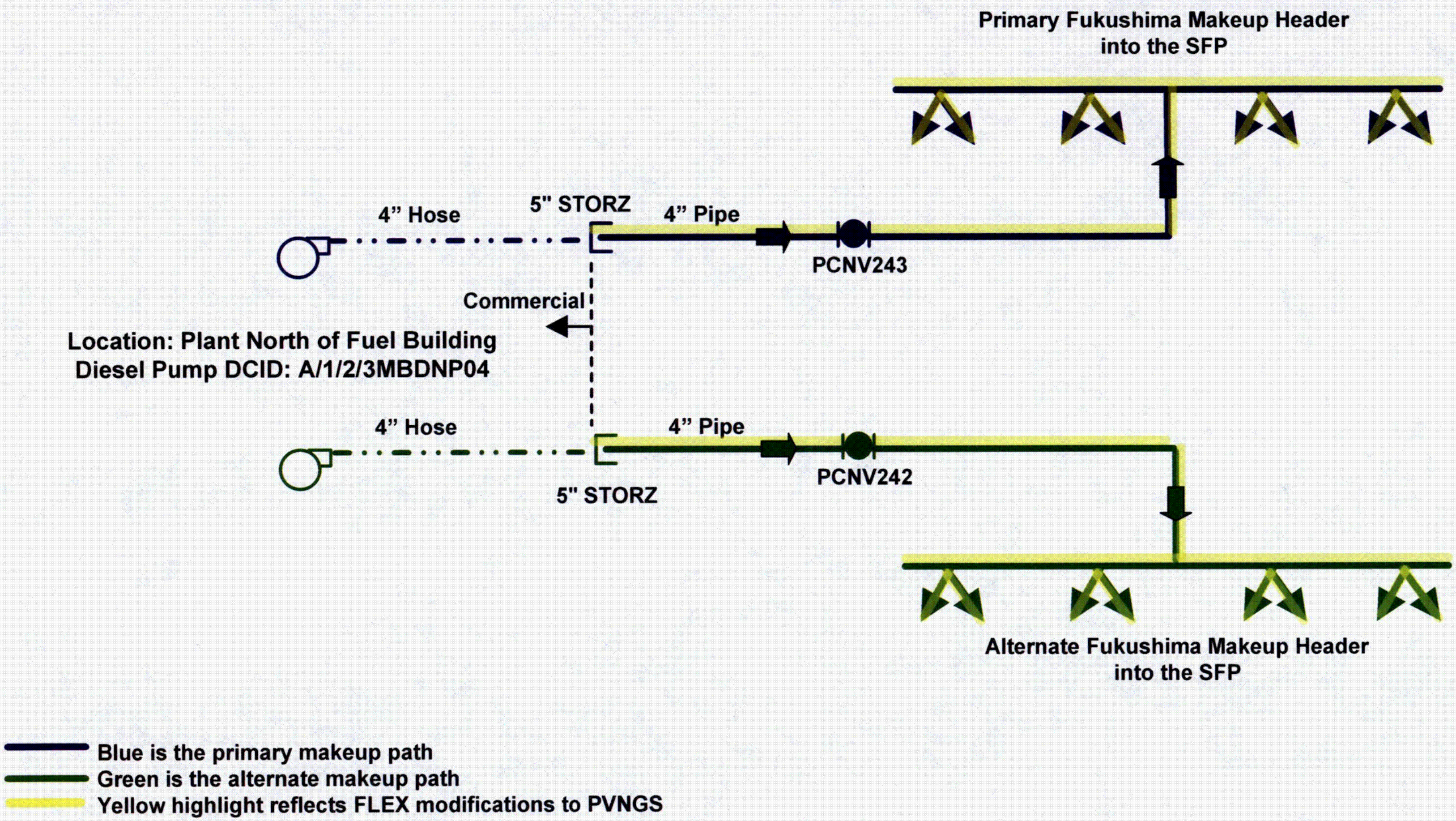
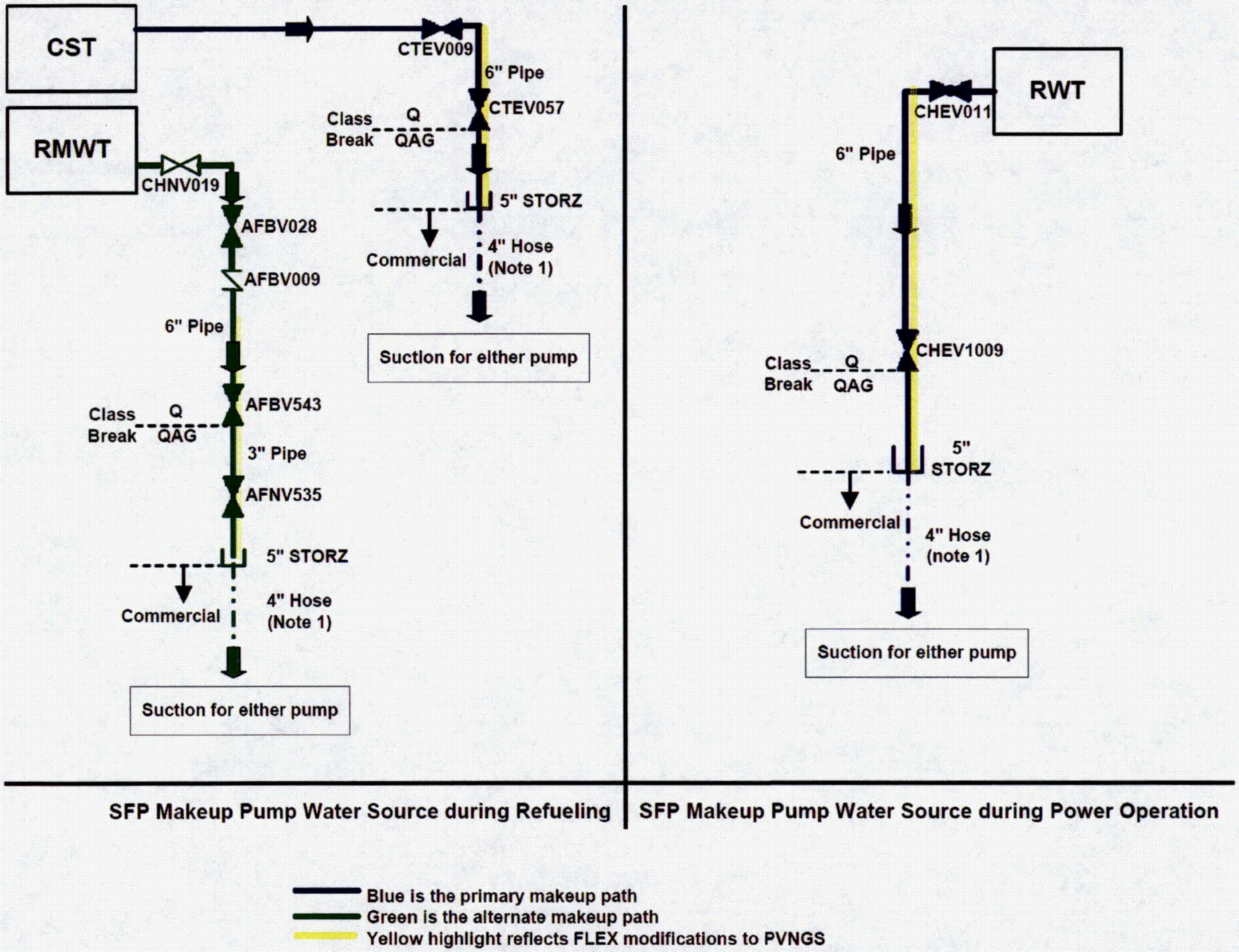


Figure 13: FLEX Primary and Alternate SFP Makeup Schematic for All Modes (FLEX SFP Pump Discharge)



Note 1: Hose is field routed and additional components (such as two way manifolds) may be used

Figure 14: FLEX Primary and Alternate SFP Makeup Schematic (FLEX SFP Pump Suction)



Note 1: Hose is field routed and additional components (such as two way manifolds) may be used

Figure 15: FLEX Primary and Alternate SFP Makeup Simplified Piping

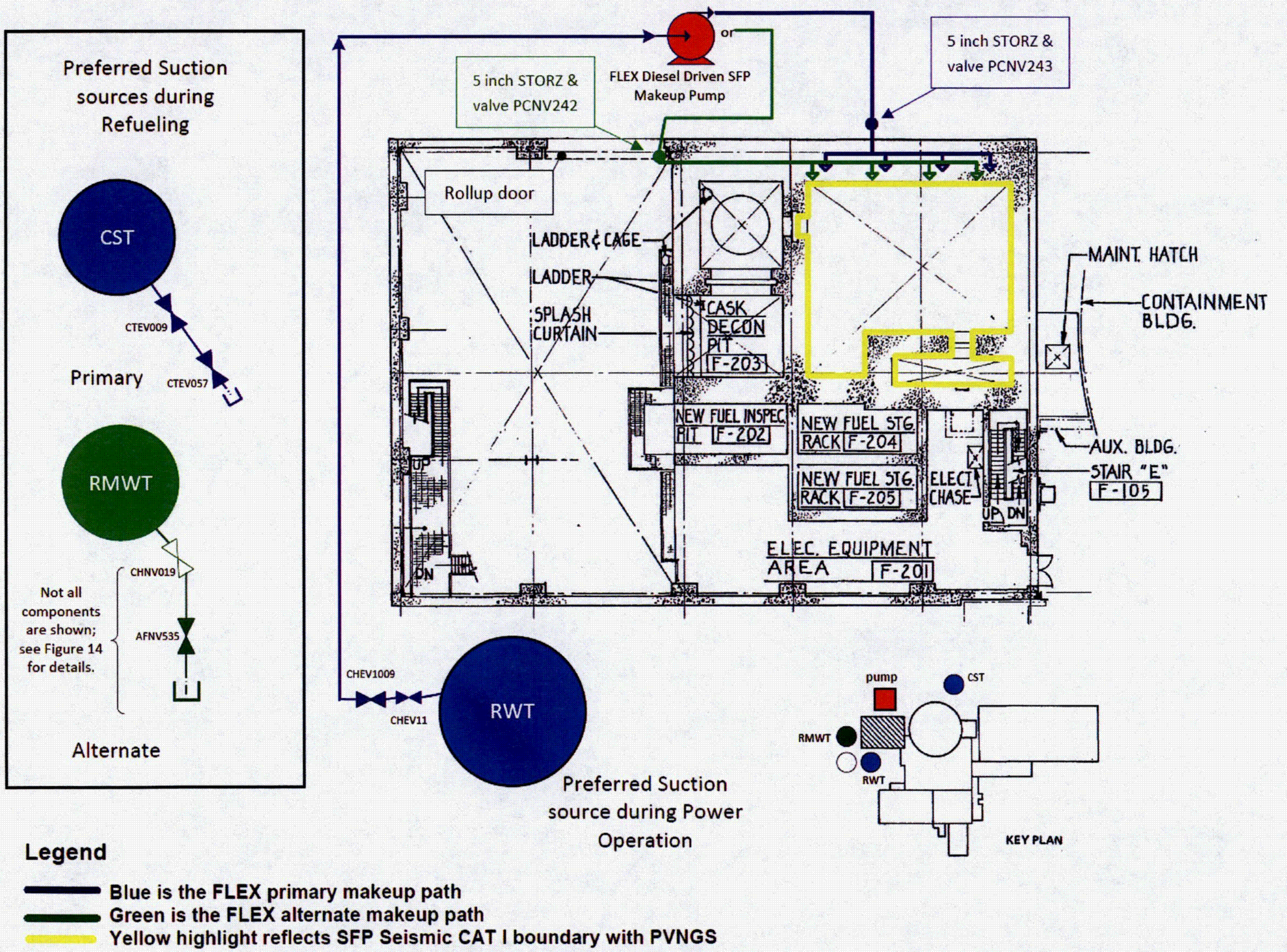
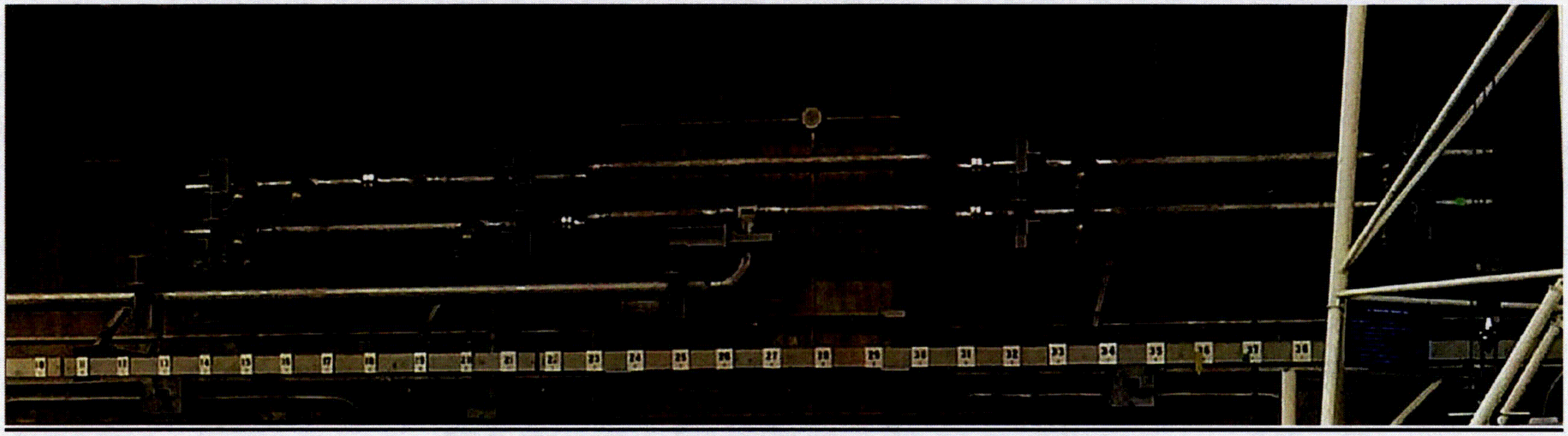


Figure 16: Photograph of Primary and Alternate SFP Makeup Piping and Nozzles within the Fuel Building



FLEX SFP Makeup Piping (including Nozzles)

Nozzle

Figure 17: FLEX Containment Vent Path Configuration in Lower Modes

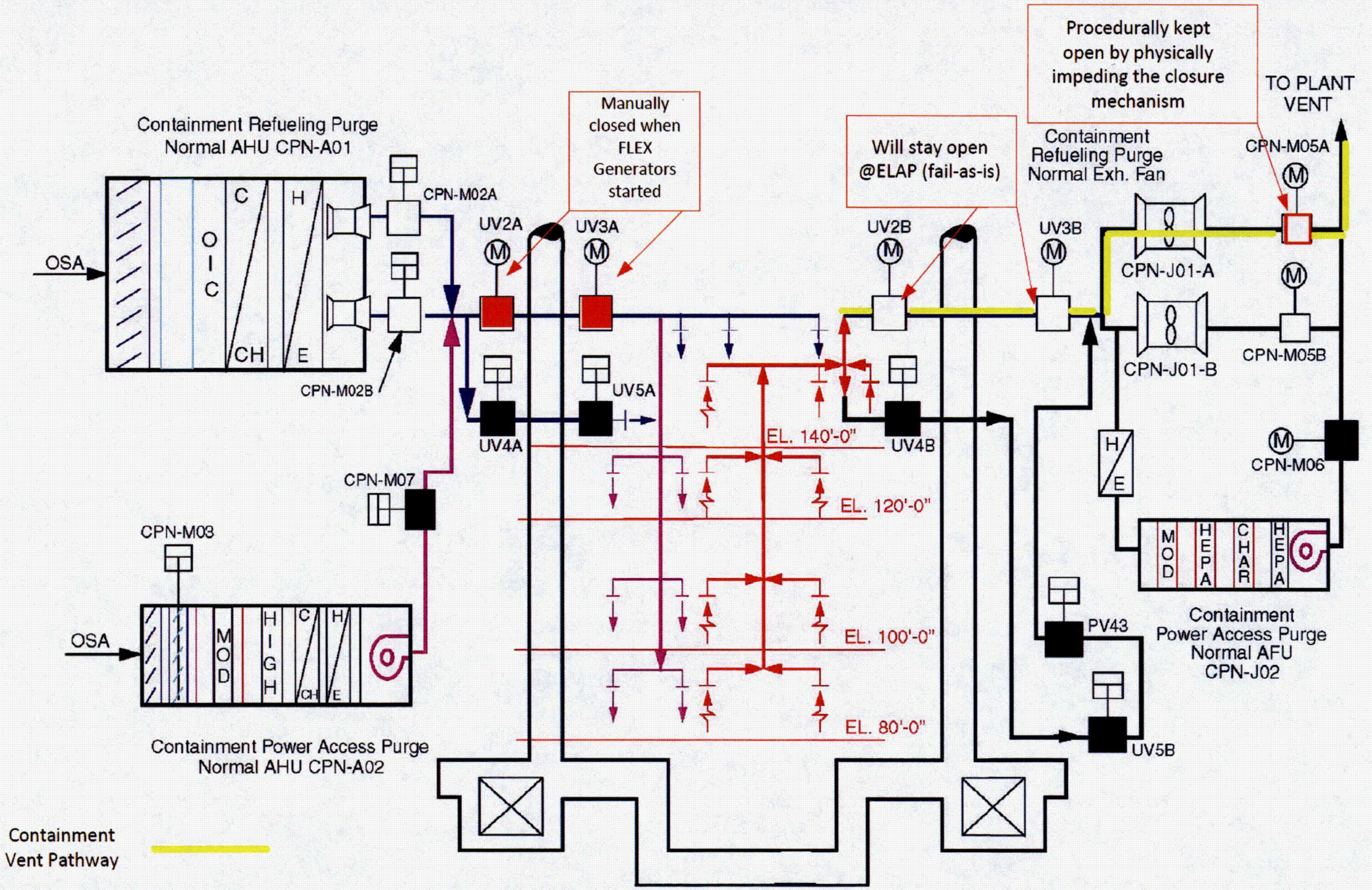


Figure 18: FLEX EESF and Vicinity

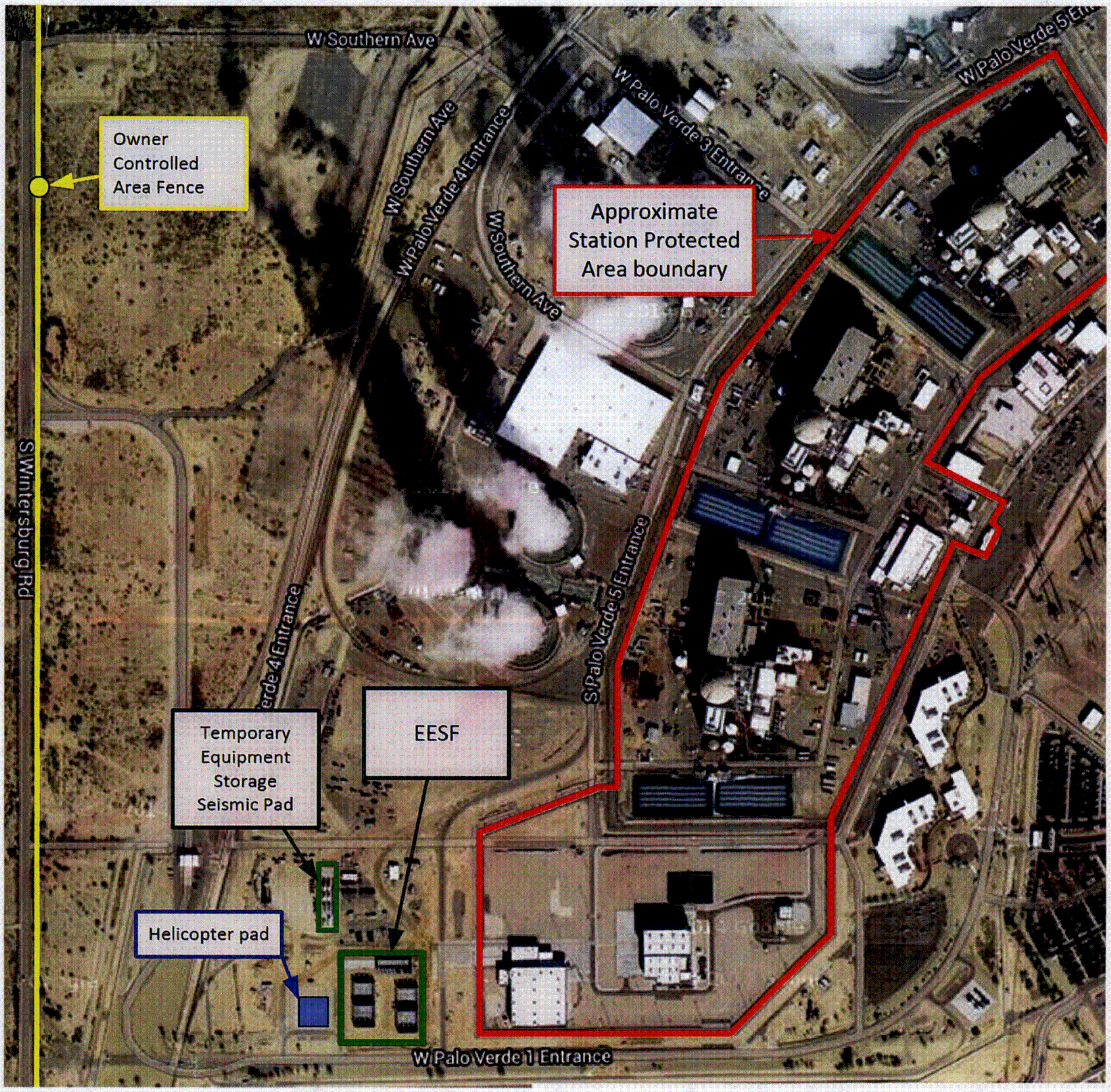
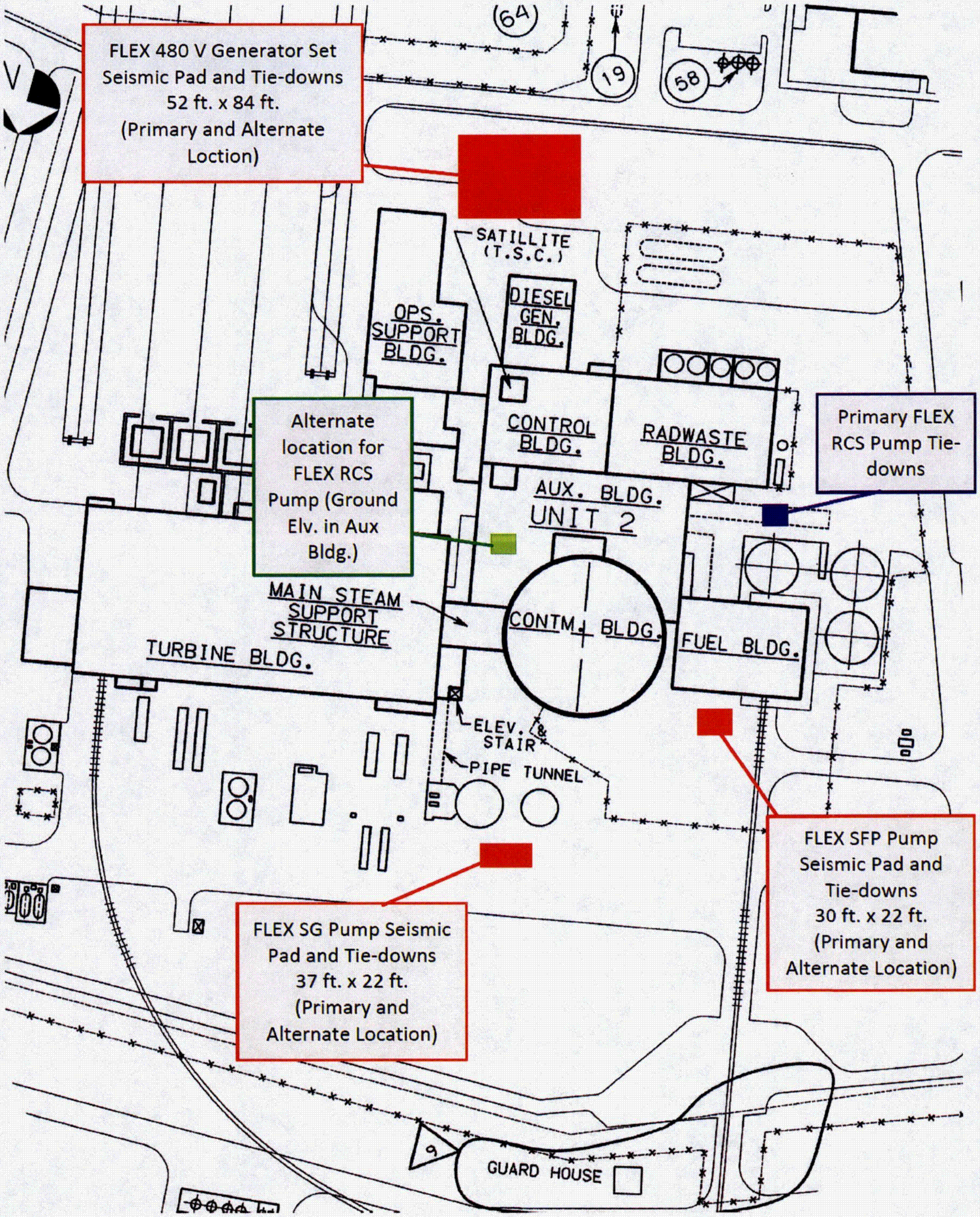


Figure 19: FLEX Deployment Locations (Seismic Pads and Tie-downs for Pumps and Generators)



Not to Scale
Unit 2 is shown; Units 1 & 3 are similar

Figure 20: FLEX Deployment Routes

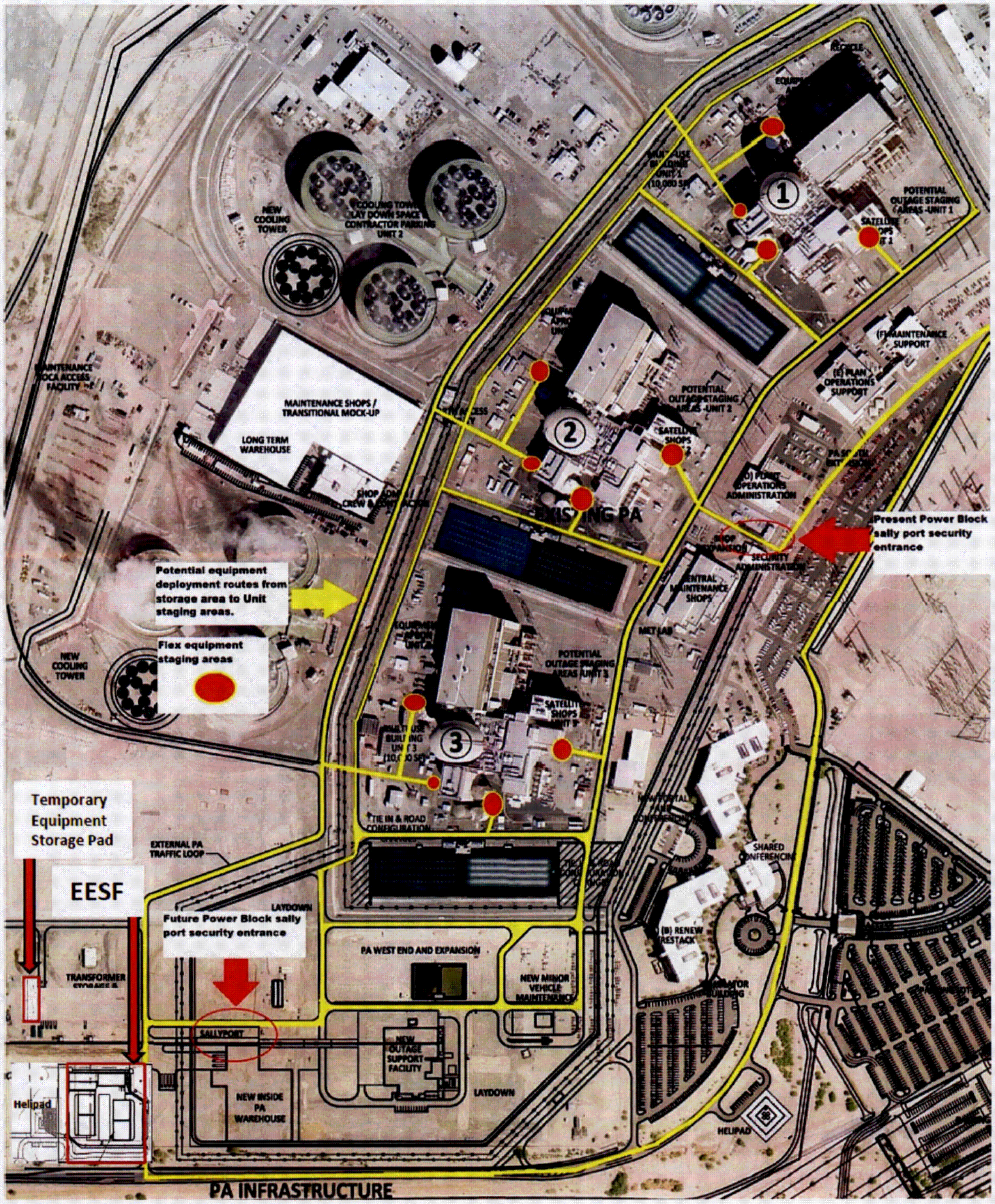


Figure 21: FLEX Primary and Alternate SG Makeup Pump Deployment Arrangement

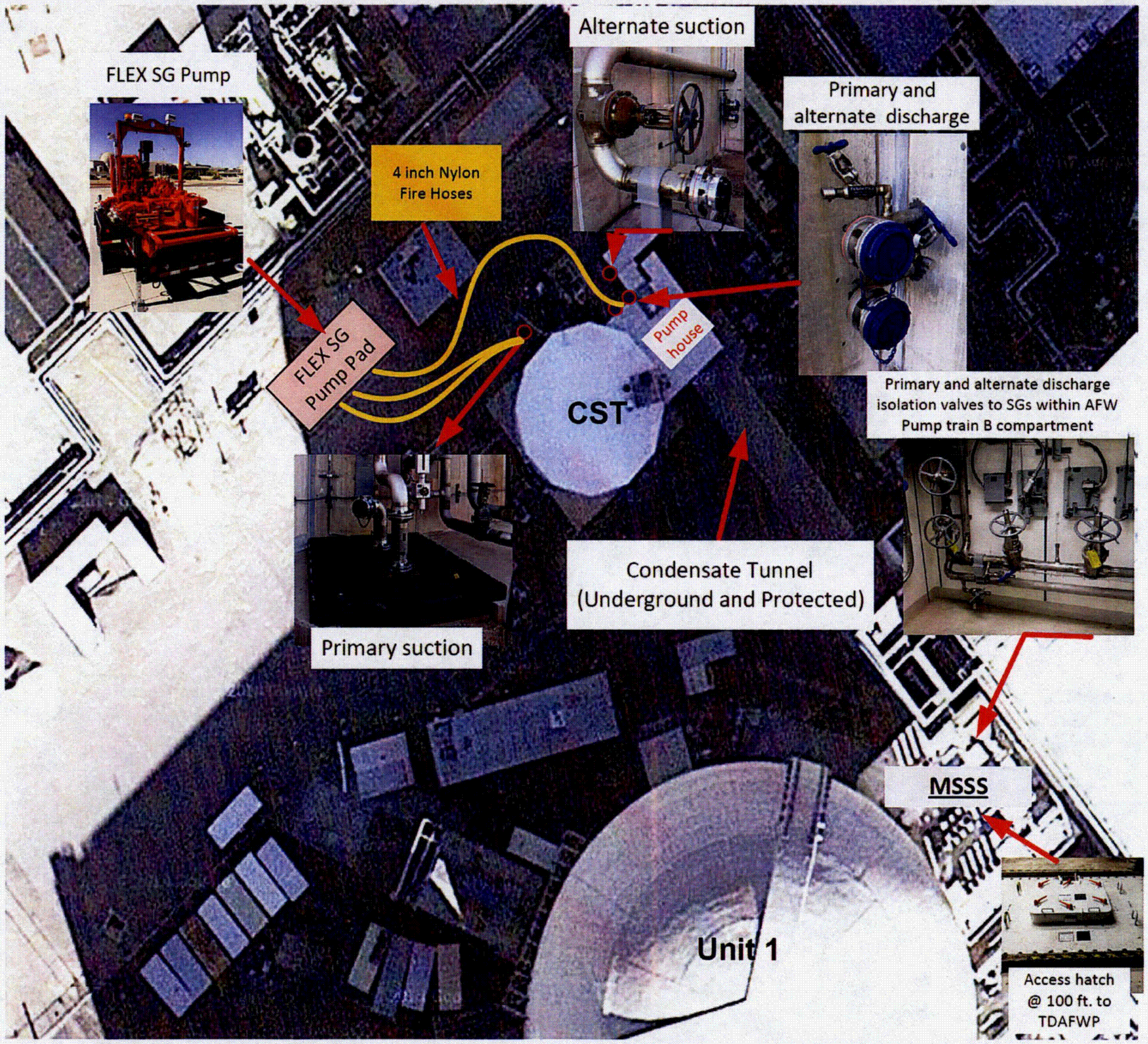


Figure 22: FLEX Primary and Alternate SFP Makeup Pump and Primary RCS Injection Pump Deployment Arrangements

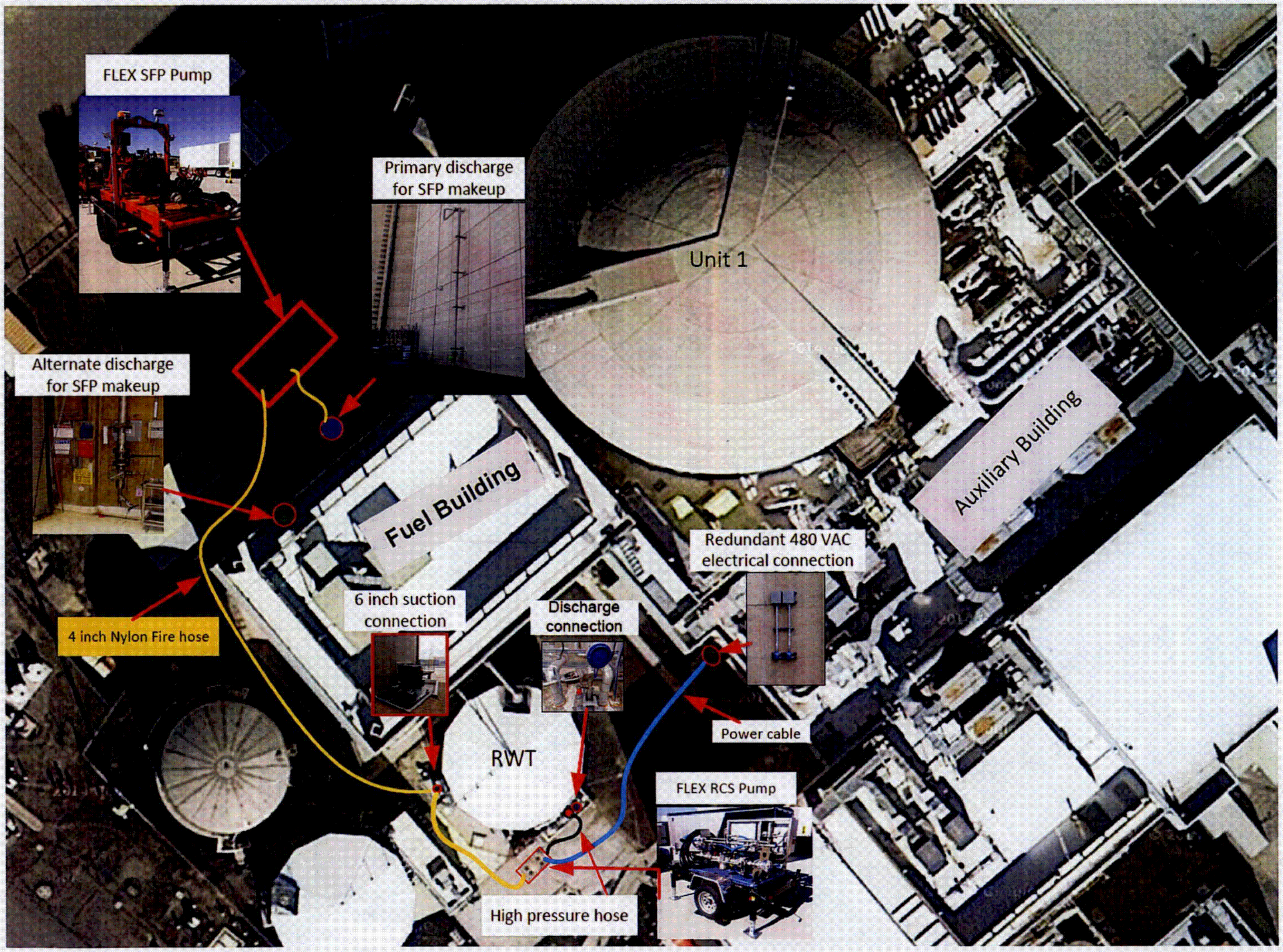
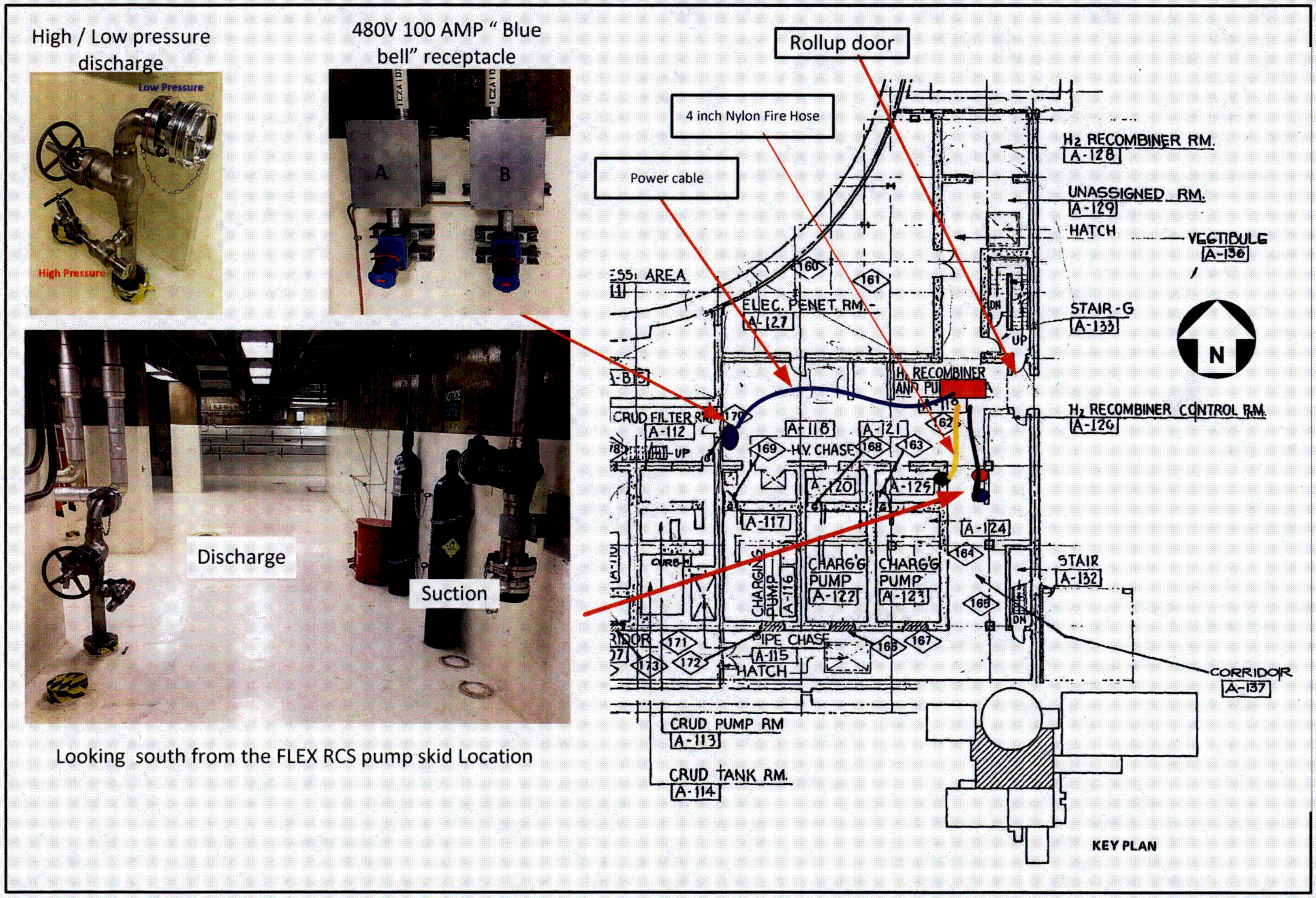
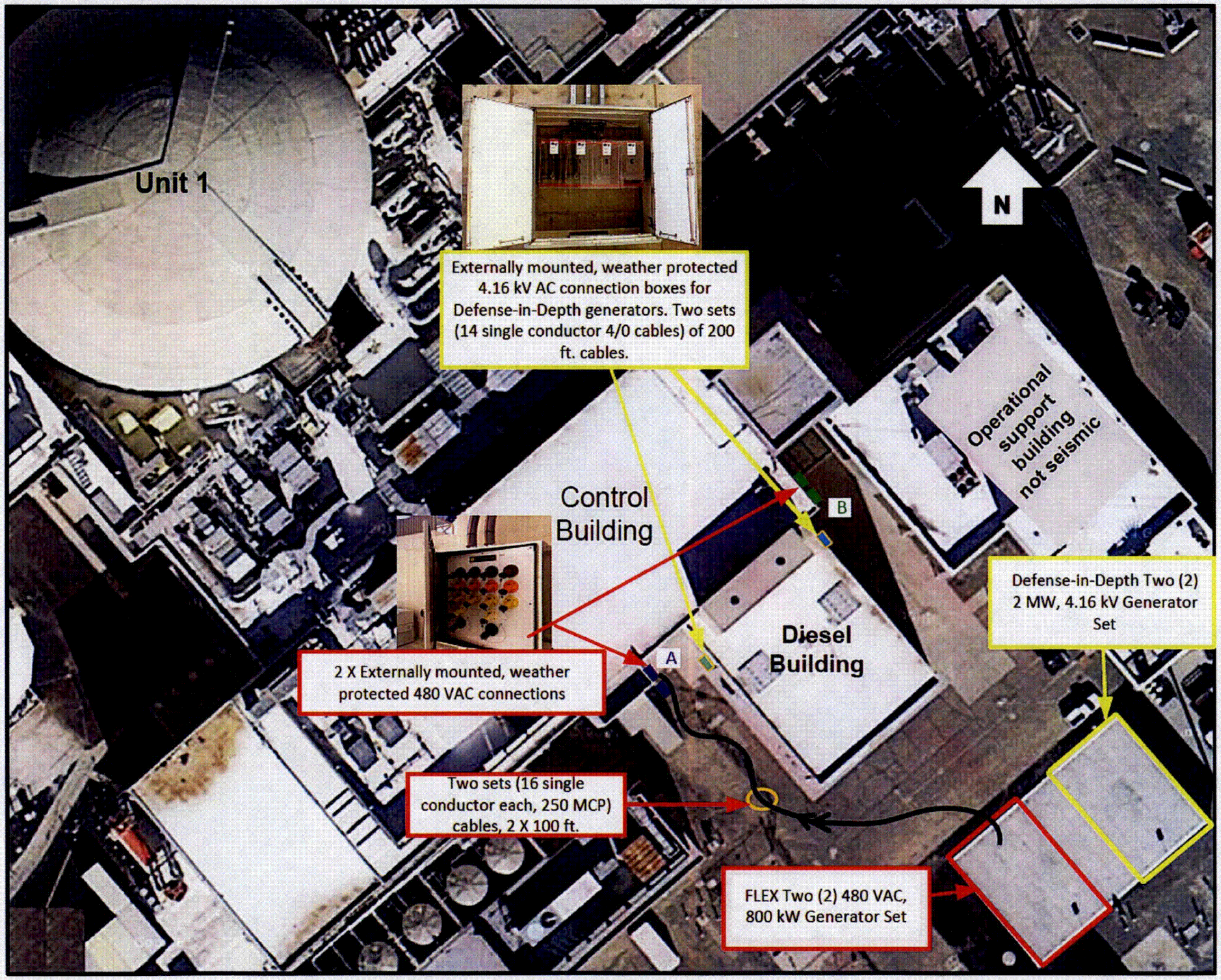


Figure 23: FLEX Alternate RCS Injection Pump Deployment Arrangement at Ground Level in the Auxiliary Building



Looking south from the FLEX RCS pump skid Location

Figure 24: FLEX Deployment Arrangement for 480 V, 800 kW Generators and Defense-In-Depth 4.16 kV, 4 MW (Total) Generators



Not to Scale
Unit 1 is shown; Units 2 & 3 are similar