ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT
UNIT 1

SEQUOYAH UNIT 2
STEAM GENERATOR REPLACEMENT RIGGING AND HEAVY LOAD HANDLING
TECHNICAL REPORT, SQN2-SGR-TR1, REVISION 3

QA Record B88 120315 800

APPROVED
This approval does not relieve the Contractor from any part of his responsibility for the correctness of design, details and dimensions.
Letter No. TVSGT-0759
Date: March 15, 2012
TENNESSEE VALLEY AUTHORITY
SQEP BY M. Gillman

SEQUOYAH UNIT 2 STEAM GENERATOR REPLACEMENT

RIGGING AND HEAVY LOAD HANDLING TECHNICAL REPORT

Document No: SQN2 - SGR - TR1

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The Steam Generating Team
SGT
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The Steam Generating Team
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A URS / AREVA Company

Document No.: SQN2-SGR-TR1

RIGGING AND HEAVY LOAD HANDLING TECHNICAL REPORT

Safety Related? ☒ YES ☐ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Signature Block

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Record of Revision

Revision No.	Date	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
0	22-Apr-2011	All	Initial Issue
1	20-Sep-2011	TOC, Section 7.1, Appendix B, General Editing throughout the document to address TVA Comments and reformat of document in accordance with TVA instructions.	Incorporation of TVA comments and changes made to reflect development of the License Amendment Request that will combine submittal of Technical Report SQN2-SGR-TR1 to the NRC with the proposed changes to the Unit 1 Operating License and Technical Specification 3.7.5, "Ultimate Heat Sink." This includes deleting the Appendix B No Significant Hazard Consideration Determination, since the No Significant Hazard Consideration will be presented only within the License Amendment Request. Section 7.1 is changed to include the results of data taken during the Unit 2 N-1 Outage (Unit 2 Cycle 17 Refueling Outage). General reformatting performed to reflect adding Unit 2 SGR Project responses to the NRC Requests for Additional Information (RAIs) that were made for the Unit 1 SGR Project rigging and handling. Due to the extensive nature of revisions between Revision 0 and Revision 1, revision bars are not shown.
2	23-Sep-2011	Figures 6-1 and 8-2 for valve number correction, and editorial clarifications in various sections.	Incorporation of SQN Plant Operations Review Committee (PORC) comments from PORC review meeting held September 22, 2011. Revision bars are not shown, because initial issue to the NRC needs to be without revision bars.
3	13-Mar-2012		Added valve numbers to Figures 6-1 and 8-2 as addressed in RAI Question 2 regarding these ERCW figures. RE: Letter from TVA to NRC, "Response to NRC Second Request for Additional Information Regarding the Heavy Load Lifts and UHS One Time Change in Support of Unit 2 SGRP (TAC NO. ME7225)," dated March 5, 2012 Other changes: 1) Manner of rigging attachment to OSGs is changed from using a rigging lug welded to the Main Steam nozzle to use of keeper plates and slings to the OSG secondary side manways (see revised figures 5-1 and 5-4). 2) Correcting the test weight from 275 tons (550 kips) to 265 tons (530 kips).

Revision No.	Date	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
			3) Changing Figure 5-3 to illustrate raising OLS foundation by 6 inches. 4) Changing reference to Liebherr 1400/1 crane to be "Liebherr 1400/1 or Liebherr 1400/2" to permit use of either crane. Calculation 39866-CALC-C-010 (Reference 24 in the Technical Report) has been revised to qualify both cranes. 5) Changes made to reflect updated RSG rigging weight.

SQN UNIT 2 SGR RIGGING AND HEAVY LOAD HANDLING TECHNICAL REPORT (No. SQN2-SGR-TR1)

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SEQUOYAH UNIT 2 SGR RIGGING AND HEAVY LOAD HANDLING TECHNICAL REPORT

1.0 Abstract

In response to NRC Generic Letters 80-113 (Reference 1) and 81-07 (Reference 2), TVA established a program for the control of heavy loads at Sequoyah. This program, which addresses the guidance provided in NUREG-0612 (Reference 3), was reviewed by the NRC and incorporated into plant Procedure 0-MI-MXX-000-026.0 (Reference 4). During the upcoming Steam Generator Replacement (SGR) at Sequoyah Unit 2, which will occur during the Unit 2 Cycle 18 refueling outage (Fall 2012), heavy loads exceeding those anticipated by plant administrative controls (Reference 17) will be handled using new safe load paths. In some cases, the load paths traverse over safety-related equipment supporting operation and safe shutdown capability for Unit 1, which will remain in operation during the Unit 2 Steam Generator Replacement (SGR) Outage. The rigging and handling evaluations used to prepare the similar rigging and handling report for the Unit 1 SGR that was performed during the Spring of 2003 (Topical Report No. 24370-TR-C-002-A, Reference 5) were researched in preparing Technical Report No. SQN2-SGR-TR1 for the Unit 2 SGR.

As defined in NRC Bulletin 96-02 (Reference 6), licensees planning to perform activities involving the handling of heavy loads over safety-related equipment while the reactor is at power and involving a potential load drop accident that has not previously been addressed in the UFSAR should submit a license amendment request to the NRC. Following revisions to 10 CFR 50.59 Regulation in 2000, the Bulletin's guidance was supplemented by NRC Regulatory Issue Summary 2001-03 (Reference 7), which states that, "The fact that the load is larger or is moving in a different load path than previously evaluated would enter into the risk assessment required by 10 CFR 50.65(a)(4) and determine under what plant conditions the load lift should occur."

This technical report documents the provisions made to ensure that heavy load handling activities associated with the Unit 2 SGR Outage can be accomplished without impacting the safe operation of Unit 1. These provisions support the risk assessment required by 10 CFR 50.65(a)(4) and an application for a one-time license amendment associated with the operability of the Essential Raw Cooling Water (ERCW) System. Actions required to support the conclusions of this technical report are detailed in Appendix A.

2.0 Introduction

This technical report provides a description of and technical justification for the use of cranes and rigging of heavy loads over safety-related structures, systems, and components (SSCs) in support of the Sequoyah Unit 2 SGR. The cranes and the heavy loads addressed in this technical report are:

- Outside Lift System (OLS) Mammoet Platform Twin-Ring Containerized (PTC) Heavy Lift Crane
- Use of a Liebherr LR 1400/1 or Liebherr LR 1400/2 crawler crane and other assist cranes

- Large crane components
- Old and replacement steam generators
- Reactor Shield Building dome and steam generator (SG) compartment roof concrete sections
- Steel Containment Vessel (SCV) dome steel cut sections

The activities addressed in this technical report are:

- Assembly, use, and disassembly of the OLS.
- Use of the mobile cranes for assembly/disassembly of the OLS.
- Rigging and handling to remove the Shield Building dome concrete sections that are cut to create openings in the Shield Building dome for access to the Unit 2 Containment.
- Rigging and handling to remove/reinstall the SCV steel sections that are cut to create openings for access to the Unit 2 Containment.
- Rigging and handling to remove/reinstall the SG compartment roof plugs, the removal of which is performed to provide access to the SG compartments for steam generator changeout.
- Rigging and handling to remove the Old Steam Generators (OSGs) and install the Replacement Steam Generators (RSGs).
- SSC protection from external events and postulated load drops.

The OLS is commercially designed and, therefore, is considered as non-quality related. The OLS was not specifically designed to withstand the external events addressed by 10 CFR 50, Appendix A, General Design Criterion (GDC) 2 that are a part of the Sequoyah design and licensing basis. However, because of the size of the OLS and because of the OLS location and proximity to the Unit 2 Containment, Auxiliary Building, Essential Raw Cooling Water (ERCW) piping, Unit 2 Refueling Water Storage Tank (RWST), Unit 2 Main Steam (MS) piping, and Unit 2 Feedwater (FW) piping, the OLS was evaluated as indicated below for those external events that might cause it to collapse when these SSCs are required to be operable.

The OLS was analyzed for both loaded and unloaded configurations for structural adequacy with design basis earthquake (DBE) loads imposed. Details of this seismic evaluation are provided in Section 5.1. As discussed in Section 5.1, administrative controls will be imposed to restrict crane use and orientation under high winds or severe weather conditions.

This technical report also documents the load path provisions, equipment protection techniques, operator training, and compensatory measures that will ensure that OLS assembly/disassembly and load handling with the OLS is performed safely.

3.0 Objectives

This technical report provides the technical basis for a one-time change to the Unit 1 Operating License (OL) and Technical Specification 3.7.5, "Ultimate Heat Sink," applicable to the Unit 2 Cycle 18 refueling outage. This technical report establishes that lifting of heavy loads will not affect ERCW system operability, provided that the load movements are performed in accordance with this technical report and prescribed compensatory measures.

4.0 Regulatory Requirements/Criteria for Handling of Heavy Loads

Detailed below are regulatory requirements/criteria that are relevant to the handling of heavy loads over safety-related equipment. Since the load handling activities described in this technical report do not involve handling of loads over or near spent fuel, requirements related specifically to load handling over fuel are not addressed. Following each requirement/criterion is an *italicized* reference to where the requirement/criterion is addressed within this technical report.

4.1 SRP Section 9.1.5 – Overhead Heavy Load Handling Systems

Standard Review Plan (SRP) Section 9.1.5 addresses the reviews of overhead heavy loads handling systems performed by the NRC to assure conformance with the requirements of 10 CFR 50, Appendix A, GDC 1, 2, 4, and 5 (Reference 8). The heavy load handling system is considered acceptable if the integrated design of the structural, mechanical, and electrical elements, the manual and automatic operating controls, the safety interlocks and devices, and the load handling instructions, inspections, maintenance and testing, provide adequate system control for the specific procedures of handling operations, if the redundancy and diversity needed to protect against malfunctions or failures are provided, and if the design conforms to the relevant requirements of the following regulations:

1) GDC 1 of Appendix A to 10 CFR Part 50 as related to the design, fabrication, and testing of SSCs important to safety to maintain quality standards.

   Qualification of the OLS for aspects associated with design, fabrication, and testing are addressed below in the discussion for compliance with NUREG-0612.

2) GDC 2, as related to the ability of structures, equipment, and mechanisms to withstand the effects of earthquakes. Acceptance is based in part on meeting position C.1 of Regulatory Guide 1.29 for safety-related equipment and position C.2 for non-safety related equipment, and positions C.1 and C.6 of Regulatory Guide 1.13.

   As detailed in Section 5.1, the OLS has been evaluated for seismic loads while unloaded and while loaded with its heaviest load (a steam generator). This seismic evaluation determined that the OLS will not collapse or result in a drop of the load during a seismic design basis safe shutdown earthquake event for the lift configurations to be used for the Sequoyah Unit 2 SGR.

   Per Section 5.2, use of the mobile cranes for OLS assembly/disassembly is limited to an area within the location shown on Figure 5-2. However, mobile crane usage beyond the OLS boom location may be allowed if engineering evaluation shows no adverse impact to nearby safety-related SSCs. Protection (see Figure 5-2) for safety-related SSCs is provided, as necessary, to ensure that Unit I and Unit 2 can be safely shut down and/or maintained in a safe condition while maintaining ERCW supply to essential SSCs in the unlikely event of a seismically induced load drop during use of these cranes for assembly/disassembly of the OLS.

3) GDC 4, as it relates to protection of safety-related equipment from the effects of internally generated missiles (i.e., dropped loads). Acceptance is based in part on meeting positions C.3 and C.5 of Regulatory Guide 1.13.

Safety-related SSCs that may be affected by a load drop from the OLS or mobile cranes are described in Section 6. As detailed in Section 8, these SSCs have been evaluated and where necessary, protective or compensatory measures have been determined to mitigate the effects of a load drop induced SSC failure.

4) GDC 5, as related to the sharing of equipment and components important to safety, between Units 1 and 2.

   Shared systems between Unit 1 and Unit 2 that could be affected by load drops from the OLS are discussed in Section 7.1, which also details the system isolation means employed to ensure that the capability to safely shut down the operating unit (Unit 1) is maintained during OLS heavy load handling (Unit 2 defueled). Section 8.3 details the cross-tie configuration that ERCW is placed in which ensures that the capabilities to safely shut down Unit 1 and service heat loads of essential equipment (e.g., Spent Fuel Pool Cooling System) are maintained. As indicated in Appendix A, plant procedures will be developed to delineate specific prerequisite actions to successfully maintain the function of ERCW and other shared systems (Component Cooling System (CSS) and Essential Air Distribution System) in the event of a postulated large heavy load drop.

Other specific criteria necessary to meet the relevant requirements of GDC 1, 2, 4, and 5 are detailed in NUREG-0612.

4.2 NUREG-0612 – Control of Heavy Loads at Nuclear Power Plants

Section 5.1 of NUREG-0612 provides guidelines for the control of heavy loads. The objectives of these guidelines, in part, are 1) to assure that the potential for a load drop is extremely small or 2) radioactive releases resulting from damage caused by the load drop are less than 1/4 of 10 CFR 100 limits (i.e., less than 75 rem thyroid and 6.25 rem whole body) and to ensure that damage to equipment in redundant safe shutdown paths is not sufficient to preclude safe shutdown.

The evaluation of the radiological consequences of dropping an OSG is described in Section 7.1.

NUREG-0612 reflects an overall philosophy that provides a defense-in-depth approach for controlling the handling of heavy loads; i.e., prevent as well as mitigate the consequences of postulated accidental drops. Part of this defense-in-depth approach involves 1) providing sufficient operator training, handling system design, load handling instructions, and equipment inspections to assure reliable operation of the handling system and 2) defining safe load paths through procedures and operator training so that to the extent practical heavy loads being carried over or near safe shutdown equipment are avoided. Where a load path that avoids safe shutdown equipment cannot be defined, alternative measures may be taken to compensate for this situation.

As detailed in Section 7, for the large equipment lifts discussed in this technical report, a safe load path has been chosen that minimizes potential interactions with critical equipment. For the lifts that must traverse safe shutdown equipment, compensatory measures will be implemented in the unlikely event of a load drop.

Section 5.1.1 of NUREG-0612 states that all plants should satisfy the following for handling heavy loads that could be brought in proximity to or over safe shutdown equipment:

1) Load paths should be defined for the movement of heavy loads to minimize the potential for heavy loads to impact safe shutdown equipment. These load paths should be defined in procedures, shown on equipment layout drawings, and clearly marked in the area where the load is to be handled.

   Safe load paths for the loads to be handled by the OLS have been identified as shown on Figure 5-2. Criteria for operation of mobile cranes used in the assembly/disassembly of the OLS have been developed as detailed in Section 5.2.

2) Procedures should be developed to cover load handling operations for heavy loads to be handled in proximity to safe shutdown equipment. These procedures should include identification of required equipment, inspections and acceptance criteria required before movement of the load, the steps and proper sequence to be followed in handling the load, the safe load path, and other special precautions.

   Rigging operations using the OLS and mobile cranes will be controlled and conducted by highly trained and qualified personnel in accordance with approved procedures. The entire operation has been evaluated by engineering personnel and documented by calculations, engineering drawings, and procedures.

   Drawings showing the safe load paths have been developed. Assembly and disassembly of the OLS will be performed in accordance with the crane manufacturer's procedures and drawings. Tornado initiated crane failures or load drops will be precluded through implementation of procedures to suspend load handling when high winds or severe weather/tornado conditions are anticipated. As indicated in Appendix A, procedures to implement compensatory measures required to mitigate the effects of a postulated load drop on ERCW system operation will be developed, and personnel will be trained in their use.

3) Crane operators should be trained, qualified, and conduct themselves in accordance with ANSI B30.2 Chapter 2-3 guidelines.

   The successor code to ANSI B30.2 (ASME B30.2)(Reference 9) is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ASME B30.5 (Reference 10). The operator training detailed in Sections 5.1 and 5.2 of this technical report conforms to the guidelines of ASME B30.5, Chapter 5-3.

4) Special lifting devices should satisfy the guidelines of ANSI N14.6, as modified by NUREG-0612.

   The rigging operations addressed in this technical report do not use special lifting devices as defined by ANSI N14.6.

   As described in Section 5.1, the OLS attachments and rigging meet the requirements of ASME NQA-1-1994, Subpart 2.15 (Reference 11) and the applicable ASME B30 series standards (References 9, 10, 12). The attachments and rigging used to attach the OLS *to the SGs have been previously load tested in accordance ASME NQA-1, Subpart 2.15 or have a previous load history that exceeds the loads to be lifted.*

5) Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9, as modified by NUREG-0612.

   As described in Section 5.1, the OLS attachments and rigging meet the requirements of ASME NQA-1-1997, Subpart 2.15 and the applicable ASME B30 series standards. This includes the successor code to ANSI B30.9 (ASME B30.9)(Reference 12), as modified by NUREG-0612.

6) The crane should be inspected, tested, and maintained in accordance with ANSI B30.2, as modified by NUREG-0612.

   The successor code to ANSI B30.2 (ASME B30.2) is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ASME B30.5. The crane inspections, testing, and maintenance detailed in Sections 5.1 and 5.2 of this technical report conform to the guidelines of ASME B30.5, as modified by NUREG-0612.

7) The crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2 and of CMAA-70.

   The successor code to ANSI B30.2 (ASME B30.2) is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ASME B30.5. The manufacturer's user manual for the OLS also refers to ASME B30.5. The crane designs detailed in Sections 5.1 and 5.2 of this technical report conform to the guidelines of ASME B30.5, which meets the intent of ASME B30.2 and CMAA-70 (Reference 13).

Section 5.1.5 of NUREG-0612 states that in addition to the above requirements from Section 5.1.1, the effects of load drops should be analyzed (in accordance with the guidelines of Appendix A to NUREG-0612), and the results should indicate that damage to safe shutdown equipment is not sufficient to preclude safe shutdown.

Appendix A of NUREG-0612 states, in part, that analyses of postulated load drops should as a minimum include the following considerations:

1) The load is dropped in an orientation that causes the most severe consequences.

   The consequences of a postulated load drop from the OLS or the mobile cranes are detailed in Section 7. Where it was not possible to protect SSCs in the vicinity of the load drop, the worst case failure of these SSCs was postulated.

2) The load may be dropped at any location in the crane travel area where movement is not restricted by mechanical stops or electrical interlocks.

   As detailed in Section 7.1, loads drops along the entire load path have been postulated and evaluated. The load path is maintained by strict administrative controls. These administrative controls will be in the form of notes on drawings and procedural steps contained in controlled work packages.

3) X/Q values for determining the radiological consequences of a heavy load drop should be derived from analysis of onsite meteorological measurements based on 5% worst meteorological conditions.

   The meteorological conditions and the X/Q values used to determine the doses resulting from a postulated drop of an OSG are detailed in Section 7.1.

4) Analyses should be based on an elastic-plastic curve that represents a true stress-strain relationship.

   As detailed in Sections 7 and 8, when appropriate, the analyses are based on the true material characteristics.

5) The analysis should postulate the "maximum damage" that could result (i.e., the analysis should consider that all energy is absorbed by the structure and/or equipment that is impacted).

   Where it was not possible to analytically show that a SSC would survive the impact of a postulated load drop, the SSC was assumed to fail to the point where it could no longer perform its design function. If this failure could result in an adverse impact on other SSCs, this impact was accounted for in assessing whether compensatory measures were required to restore the affected functions.

6) Credit may not be taken for equipment to operate that may mitigate the effects of the load drop if the equipment is not required to be operable by the Technical Specifications when the load could be dropped.

   No credit has been taken for equipment not required to be operable by the Technical Specifications.

4.3 NRC Bulletin 96-02 – Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment

This bulletin requires licensees planning to handle heavy loads over safety-related equipment while the reactor is at power that involve a potential load drop accident that has not been previously evaluated in the UFSAR or a change to the Technical Specifications, to submit a license amendment request in advance of the planned load movement so as to afford the NRC sufficient time for review and approval.

Since the postulated load drops could adversely affect safety-related components that are addressed in the Technical Specifications, this technical report has been prepared to support NRC review and approval of an amendment to the Unit 1 Operating License and to Technical Specification 3.7.5, "Ultimate Heat Sink" to add one-time conditions for conduct of heavy load lifts associated with the Unit 2 steam generator replacement (Reference Section 8.3).

4.4 NRC Regulatory Issue Summary 2001-03 – Changes, Tests, and Experiments

Attachment 1 to Regulatory Issue Summary 2001-03, Issue 7, states, "With respect to [Bulletin] 96-02, if a heavy load movement is part of a maintenance activity, there is no 10 CFR 50.59 evaluation needed. The fact that the load is larger or is moving in a different load path than previously evaluated would enter into the risk assessment required by 10 CFR 50.65(a)(4) and determine under what plant conditions the load lift should occur. If the heavy load lift is not maintenance related, and so requires a 10 CFR 50.59 evaluation, the licensee should follow the requirements of the revised rule to determine whether prior NRC approval is needed."

This technical report documents the provisions made to minimize and control the risks associated with the subject lifts. While the lifts are associated with a maintenance activity for Unit 2, it is TVA's intent that Unit 1 continues normal operation during the Unit 2 SGR Outage. Because of the potential interactions of the Unit 2 activities upon Unit 1 safety, and to clarify the operational issues associated with the plant Technical Specifications, an amendment to the Unit 1 Operating License and Technical Specification 3.7.5 based upon this technical report will be requested.

5.0 Description of Cranes and Heavy Loads

The cranes described herein are commercially available equipment and are not specifically designed as single failure proof, nor are they specifically designed to withstand the external events that are a part of the plant licensing basis. Since this rigging equipment will carry large and heavy loads in the vicinity of safety-related SSCs, it must be demonstrated that the installation, use, and removal of this rigging equipment does not adversely affect the safety function of these SSCs or that alternative means of performing the SSC safety function are available.

5.1 Outside Lift System

The OLS will consist of a Mammoet Platform Twin-Ring Containerized (PTC) Heavy Lift Crane (see Figure 5-1), which is a commercially designed crane. The maximum rated load for this crane defined in Reference 14 is 1763.2 tons (1600 metric tons), however this will vary with crane configuration and lift radius. From Reference 14, the rated load for the crane configuration proposed for the Sequoyah SGR ranges from 66 tons (60 metric tons) to 1227 tons (1113 metric tons), depending on the lift radius. The OLS meets or exceeds ASME NQA-1 Subpart 2.15 design requirements, and its load charts and operating restrictions consider applicable dead, live, wind, impact, and out-of-plumb lift loads (Reference 15). The OLS, supplied with standard load charts for its various boom configurations, has a rated load capacity certified by the manufacturer and has been load tested during its production; this meets the load test requirements of ASME NQA-1, 1994 Edition, Subpart 2.15, Section 601.2. In addition, after the OLS has been erected it will be load tested by lifting a 265 ton (530 kip) test load assembly with the OLS boomed out to a radius where the test load represents 110% of the OLS rated capacity at this radius. OLS lifts of the loads described in this technical report will be performed after Unit 2 is defueled and will be completed prior to the start of refueling. The OLS load test may be performed with Units 1 and 2 in any mode (Reference 16). The OLS will be located in an area between the Turbine Building, the Unit 2 RWST and the Unit 2 Containment, as shown on Figure 5-2.

The OLS is designed, built, and tested to criteria based on the following DIN standards:

- DIN 15018 Part 1, Cranes: Steel structures, verification and analyses
- DIN 15018 Part 3, Cranes: Principles relating to steel structures; Design of cranes on vehicles
- DIN 15019 Part 2, Cranes: Stability for non-rail mounted mobile cranes; test loading and calculation
- DIN 15020 Part 1, Lifting Appliances: Principles relating to rope drives; calculation and construction
- DIN 1055 Part 4, Design loads for buildings; Imposed loads - wind loads on structures unsusceptible to vibration

In addition, the following codes are also listed in the crane user manual: ASME B30.5-1994, SAE J987, SAE J765 and CE.

In order to obtain its certification, the prototype PTC was tested to 125 percent of its rated load after it was manufactured. The OLS has dual engines, dual hydraulic systems and dual computers. It is capable of performing its intended function with one of each system out of operation. In the event that all power and hydraulic systems fail, the load can be safely lowered using a 12-volt car battery and the manual controls.

Beyond the OLS's dual systems, an operational safety device called a redundant load moment safety system is integrated into the computer system, which progressively warns and then disables operations, subsequently allowing only operations, which improve the safety margins.

The OLS consists of a main A-frame boom, which is pinned to and rides on wheel trucks at its base, and has a jib boom and 2 stay beams pinned to its top end. The main boom is stabilized by a counterweight system including a backmast boom that also rides on wheel trucks. The OLS wheel trucks ride on the base ring supported by built-in outrigger support rings/plates, which enable the OLS to be self-leveling, as shown on Figure 5-3.

The OLS will be supported on top of an 8 ft wide, 70.5 ft diameter (centerline) concrete ring foundation that is supported by approximately 80 piles to bedrock and has an integral concrete cap that is a minimum of 4 ft thick. The crane base is supported on 24 independent jack stands, which are resting on top of the pile cap extension. Each jack stand is approximately 5 ft x 7.5 ft. Lateral loads are resisted by friction between the stands and the concrete.

Utilizing the Unit 1 SGR Project seismic II/I qualification for the OLS, the Unit 2 SGR Project evaluates for seismic II/I in Reference 15 for stability and stress under the minimum design basis earthquake event for the proposed SGR lift configurations in both the loaded and not-loaded conditions. Due to the very low natural frequency of the pendulum (~0.1 hz) with a SG as the lifted load, the lateral displacement response of the SG center-of-gravity relative to the boom tip is less than 0.25 ft. The corresponding lateral load applied to the boom tip is approximately 2 kips, which is negligible for crane stability and stress calculations. Therefore, lateral loading of the boom tip due to "swinging" was neglected in the stability and stress calculations.

A seismic analysis has been performed for the OLS which demonstrates that the OLS is capable of sustaining SSE loads without failure of the OLS foundation, the crane structural components or rigging devices. The seismic evaluation of the OLS was based on dynamic modal analysis by the response spectrum method using a GT-Strudl finite element model. The seismic response spectrum used in the analysis was derived as described below. Three critical OLS configurations (based on lift radius and load) that envelop all configurations of the OLS Crane for the Sequoyah Unit 2 SGR Project were analyzed separately. Each of these three configurations was analyzed in the not-loaded and loaded conditions. Responses were obtained for dead + lifted loads (D+L) load combination and under D+L+E load combination, where E is the seismic load. Based on the force and displacement responses from the finite element analyses, the OLS was evaluated for strength (stress) and stability.

For the stress analysis of critical crane components it was conservatively assumed that all the members and connections have an interaction of 1.0 for combined stresses at their maximum working allowable for dead + lifted loads (D+L). The interaction value of 1.0 under D+L load condition is a baseline number for quick evaluation under D+L+E load condition, where E is the seismic SSE load condition and acceptance was yield stress for seismic II/I qualification. The minimum factor of safety to yield strength available in the allowable stress design is 1.5. The ratio of the responses (D+L+E) / (D+E) was calculated and compared to 1.5. If the ratio was less than or equal to 1.5, the members were considered adequate without any further evaluation. If the ratio was greater than 1.5, a more detailed evaluation of stresses was performed to determine adequacy of the member. For some components like the base components, stresses were directly evaluated without using the ratioing approach. The stresses in all components that were evaluated further remained within AISC-ASD 9th Edition allowables. The maximum combined stress interaction ratio under the load combination including seismic load was 1.2 in comparison to the allowable of 1.5.

Stability (overturning, sliding of the crane was evaluated based on base reactions obtained from the analyses. The evaluation determined that the minimum factor-of-safety against overturning during a seismic event was 1.13 and the minimum factor of safety (FOS) against sliding during a seismic event was 1.55. The results of the evaluation showed that the critical failure mode of the OLS crane in a seismic event was by overturning (tipping).

The maximum lifted load of the SGs during the Unit 2 SGR Project is about 381 metric tons. The maximum lift radius with the full SG load is 54.8 meters. The rated chart capacity by interpolation (including effect of allowable operating wind speed) of the OLS based on 55 m lift radius is 408 metric tons. The worst case lifted load is therefore 93.3 percent of chart capacity. It is noted that this 93.3 % chart capacity occurs only for OSG 2-3 and RSG 2-3. For the other RSGs and the OSGs, the percentages of chart capacity at their maximum lift radii are around 91 percent or less. The rated chart capacities of the OLS have a factor of safety of at least 1.25. For the worst case lift of the SG corresponding to 93.3 percent chart capacity, the factor of safety against overturning is at least (1.25 / 0.933) = 1.34. As discussed in the previous paragraph, during a seismic event the minimum factor of safety against overturning for the OLS crane was 1.13. Further, the OLS is seated on a firm engineered pile foundation that is adequately designed for the design loads including seismic loads, ensuring that there will not be a collapse of the crane due to a foundation failure in a seismic event.

The guidance of Section 5.1.6 of NUREG-0612, which addresses single-failure-proof handling systems, has not been applied to the interfacing lift points (e.g., trunnions, keeper plates) for loads handled by the OLS, since a single-failure-proof lifting arrangement is not being provided. While the OLS incorporates many redundant and safety-enhancement features, it is not considered a single-failure-proof lifting system. Consequently, effects of postulated non-mechanistic load drops from the OLS have been evaluated, and heavy load handling provisions, including compensatory measures, have been made a part of the load handling plan to satisfy the evaluation criteria of Section 5.1 of NUREG-0612.

The OSG interfacing lift points are the secondary side manways, which will be fitted with keeper plates to enable slings to be utilized to rig out the OSGs. The keeper plates will be installed during the Unit 2 defueled condition. Slings for rigging the OSG will be attached to the manways during the Unit 2 defueled condition. With respect to the RSGs, the interfacing lift points (lifting trunnions) are attached outside of the Unit 2 Containment independent of Unit 2 and Unit 1 conditions. OSG and RSG rigging and handling are performed during the Unit 2 reactor defueled condition. The OSG and RSG interfacing lift points meet the design requirements of ASME NQA-1, Subpart 2.15 and the allowable stresses per the AISC Manual of Steel Construction, 9th Edition.

The lifting devices that are not specially designed (i.e., commercially available) are the synthetic slings used to lift the SGs, which will comply with ASME B30.9, "Slings." The slings used to attach the OLS to the SGs will have been previously proof load tested in accordance ASME B30.9, which meets the requirements for NQA-1, Subpart 2.15. Spreader beams used to attach the OLS to the SGs will have been previously load tested in accordance with ASME B30.20, which meets the requirements for NQA-1, Subpart 2.15. Rigging will be inspected prior to use in accordance with approved procedures, and rigging operations will be controlled and conducted by highly trained and qualified personnel in accordance with approved procedures.

The design load by which the sling is selected includes the static load plus all dynamic loads (e.g., impact and wind), and these loads are documented in calculations prepared by the rigging contractor and reviewed by SGT. The slings have been designed per the requirements of ASME B30.9, where the minimum FOS against ultimate capacity is required to be greater than or equal to 5. The minimum FOS for the SG lifts at Sequoyah Unit 2 is determined below for the slings, and is based on the maximum static and dynamic impact loads. The slings, therefore, meet the guidelines provided by ASME B30.9 and Section 5.1.1(5) of NUREG-0612.

The discussion below provides the design criteria used for the design of the interface lifting points and rigging and a measure of "robustness" of the equipment with the calculated FOS. The design load considered for the design of the interfacing lift points and rigging includes maximum static and dynamic loads.

The interfacing lift points and rigging for the Sequoyah Unit 2 steam generator lifts are as follows:

(a) Replacement Steam Generators (RSGs)(Interfacing lift points are lifting trunnions that attach to the secondary manways):

i. Slings – The load per sling is derived from Drawing 0010037471-000-D-L02 (Reference 47). Since two slings will be used, each with a working load limit of 125 metric tonnes (Te), the load carried per sling is 0.5*340.2Te = 170.1Te. The configuration and dimensions of the spreader beam yield an angle to horizontal of the sling of approximately 58° (Reference 47). The increase in load from the horizontal component per sling due to the 58° angle is 170.1Te/sin(58°) = 201Te, which is the actual load per sling. As shown on Drawing 0010037471-000-D-L02 (Side View), the two slings have a total capacity of 435Te in the basket configuration they are used in. Therefore, a single sling is rated for 435Te/2 = 217.5Te. Slings are designed with a 5:1 Working Load Limit (ASME B30.9). Therefore, the Sling Ultimate Strength in this configuration is 217.5Te*5 = 1087.5Te. Thus, the factor of safety is 1087.5Te/201Te = 5.4, which is greater than 5, as required by ASME B30.9.

ii. Trunnions – The lifting trunnions meet the design requirements of ASME NQA-1, Subpart 2.15 and the allowable stress design of AISC Manual of Steel Construction, 9th Edition. The design loads used include a dynamic impact load. The stress interaction ratios for the trunnion base metal (ASTM SA 516 Gr 70 or A36) are 0.127 (shear), 0.334 (bearing), and 0.021 (bending) that is conservatively based on A36 material as calculated on Westinghouse Calculation CN-PEUS-10-32 (Reference 49).

Table 5-1A – Factor of Safety for RSG Rigging: Lifting Trunnion

	Allowable Stress (ksi)	Actual Stress (ksi)	Interaction Ratio (Actual/Allowable)	Factor of Safety (Yield Stress/Actual Stress)
Shear	14.4	1.83	0.127	19.67
Bearing	32.4	10.81	0.334	3.33
Bending	21.6	0.45	0.021	80.0

iii. Trunnion Bolts – The trunnion bolts are 1.25" diameter – 8UN, ASTM A193 Gr B7 (Reference 49). The interaction ratios are 0.81 (shear) and 0.246 (tension). The tensile stress of these bolts from the ASTM Standard for A193 bolts is 125ksi.

Table 5-1B – Factor of Safety for RSG Rigging: Trunnion Bolts

	Allowable Stress (ksi)	Actual Stress (ksi)	Interaction Ratio (Actual/Allowable)	Factor of Safety (Tensile Strength/Actual Stress)
Shear	21.0	17.0	0.810	7.35
Tension*	23.2	5.7	0.246	22.0

**Note – Calculated allowable tensile stress accounts for shear stress per AISC 9th Edition.*

(b) Old Steam Generators (OSGs) (Interfacing lift point is a Secondary Manway Keeper Plate):

i. Slings – The load per sling is derived from Drawing 0010037471-000-D-L10 (Reference 48). Since two slings will be used, each with a working load limit of 125 metric tonnes (Te), the load carried per sling is 0.5*340.2Te = 170.1Te. The configuration and dimensions of the spreader beam yield an angle to horizontal of the sling of approximately 58° (Reference 48). The increase in load from the horizontal component per sling due to the 58° angle is 170.1Te/sin(58°) = 201Te, which is the actual load per sling. As shown on Drawing 0010037471-000-D-L10 (Side View), the two slings have a total capacity of 410Te in the basket configuration they are used in. Therefore, a single sling is rated for 410Te/2 = 205Te. Slings are designed with a 5:1 Working Load Limit (ASME B30.9). Therefore, the Sling Ultimate Strength in this configuration is 205Te*5 = 1025Te. Thus, the factor of safety is 1025Te/201Te = 5.1, which is greater than 5, as required by ASME B30.9.

ii. OSG Keeper Plates – The keeper plate is a Grade 50 (Fy = 50 ksi [345 N/mm^2]) steel plate which attaches to the OSG secondary manways using bolts as shown on Drawing 0010037471-000-D-L10 (Reference 48). The intent of the keeper plate is to prevent the sling from slipping off of the secondary manway. As discussed in SGT Calculation 39866-CALC-C-057 (Reference 50), the keeper plate is designed in accordance with ASME BTH-1-2005 where a factor of safety of 2.0 is used. The stress interaction ratios for the keeper plate base metal (ASTM A572 Gr 50) are 0.04 (shear) and 0.35 (bending), which is shown on Calculation 39866-CALC-C-057 (Reference 50).

Table 5-2A – Factor of Safety for OSG Rigging: Keeper Plate

	Allowable Stress (N/mm^2)	Actual Stress (N/mm^2)	Interaction Ratio (Actual/Allowable)	Factor of Safety (Yield Stress/Actual Stress)
Shear	100.0	4.0	0.04	86.0
Bending	216.0	75.0	0.35	4.6

iii. Keeper Plate Bolts - The keeper plate bolts are 1.25" diameter – ASTM A490 (Reference 48). The interaction ratios are 0.07 (shear) and 0.05 (tension). The tensile stress of these bolts from the ASTM Standard for A490 bolts is 150ksi (1034N/mm^2).

5-2B – Factor of Safety for OSG Rigging: Keeper Plate Bolts

	Allowable Stress (N/mm^2)	Actual Stress (N/mm^2)	Interaction Ratio (Actual/Allowable)	Factor of Safety (Tensile Strength/Actual Stress)
Shear	267.0	19.0	0.07	54.4
Tension	431.0	22.5	0.05	46.0

Once the OLS is assembled, daily checks of the engine and hydraulic, pneumatic, electrical and mechanical systems will be performed during periods of use. These engine and system checks will verify areas such as proper fluid levels and operating pressure, and the working of components such as the air-dryer, control panel, and brakes. All limit switches and the load moment indicator will also be checked daily. Further, a visual inspection will be performed to look for possible malfunctions such as leakage, locking of pins/rods, rust formation, failure of welded joints, and damage to hoisting ropes.

The instrumentation on the OLS (PTC crane) was last calibrated in January 2011. Instrument calibration is normally performed once a year, or as required by clients. Calibration of the OLS load cell instrumentation will be performed as required in ASME NQA-1 Subpart 2.15. In addition, the OLS will be load tested prior to use. Since the load test will be performed with a test load of known weight, it will confirm the calibration of the OLS load cells. Additionally, the OLS boom radius indication readouts will be verified during the load test, which will also verify the incline meter readings. The safe load indicator, which stops crane operation unless the operation improves the safety margin, will also be tested during the load test.
After erection of the boom/jib and during the functional test and load test, the anti-two block switches, airplane warning lights, and boom stops will be checked.

Qualification of the operators for the Unit 2 SGR Project will include the requirements specified in ASME B30.5, as stated in Section 4.2(3). The operators will successfully pass a complete physical, which covers all aspects of the standard prior to obtaining approval for crane operation and site access. The testing will include a complete physical, a MMPI psychological test, and training and testing to site procedures.

All OLS operators are being supplied by the manufacturer and have many years experience operating this crane.

Mammoet will have four dedicated operators for the OLS, two per shift.

The person-in-charge (PIC) monitors the signal men controlling the lift and directs them as necessary. The physical location of the PIC during a lift with the OLS will vary depending on the load being lifted. The PIC and signal men will position themselves as field conditions dictate in order to have the best vantage point to observe the lift. For example, there will be three separate signal men controlling the various steps of an OSG lift; one signal man inside the Unit 2 Containment and two signal men outside the Unit 2 Containment. Only one of these three signal men will be in control of the lift at a time. The OLS operator will be instructed, prior to commencement of a lift, as to who the signal man in control is and when the signal man will be transferring this control responsibility to another signal man. It will be made clear to the operator which signal man has control of the lift at all steps along the way. The operator will also be told that anyone can stop the lift at any time if they see an interference or any item which is out of place. The signal man will control the lift by being the only individual that the operator will listen to, via a dedicated radio channel or dedicated line, to start any operation involving the OLS.

During removal of an OSG, three signal men will control the lift as described below:

- The Mammoet signal man (located inside the Unit 2 Containment) will have control of the lift from the start of the lift until the OSG is completely above the top of the steam generator compartment roof inside the Unit 2 Containment. At this point he/she will inform the operator that the Mammoet signal man on the Containment dome has control.

- The Mammoet signal man on the Unit 2 Containment dome will be positioned where he can see the OSG and direct the lift from the time the OSG is above the steam generator compartment roof until the OSG is in position to be lowered to the ground. Note that the signal man will position workmen as needed to help him watch the lift. Once the OSG is in position to be lowered to the ground, the Mammoet signal man on the Unit 2 Containment dome will turn over the lift to another Mammoet signal man positioned on the ground close to the lowering area. The operator will be informed by the signal man on the Unit 2 Containment dome that he/she is turning over responsibility to the signal man on the ground.

- The Mammoet signal man on the ground will control the lift until the OSG is downended onto the transporter.

The signal men utilized will be experienced in heavy load handling and qualified by experience to direct these lifts.

At all times, the OLS operator is in control of load movement. The OLS software prevents load movement outside of specified limits. This is accomplished through the use of limit switches and load cells. Examples of movements that are limited in this manner are:

- Anti two-block switch – prevents raising the lifting block into the boom tip
- Boom back stop switch – prevents the boom from being boomed back too far
- Jib preventer switch – prevents the jib from being boomed up too far
- Minimum and maximum radius switches – will be set during erection based on load path for loads to be moved
- Load cells to indicate the lifted load – these will be tested during the load test
- Safe load indicator (SLI) system – is tied into the load cell and the min/max radius switches

The OLS SLI software was designed by Krüger Systemtechnik, a leading specialist in designing crane SLI software.

The qualification of the software is verified through functional testing during initial commissioning of the prototype crane. This functional test is developed to validate the anticipated logic of the control system. Any changes implemented in the system control logic are validated through additional functional testing to ensure proper operation

For the Unit 2 SGR Project rigging and heavy load handling, the safe load paths can be followed by the OLS instrumentation. The instrumentation accurately indicates the radius of the load. The slewing of the OLS will be directed by the Mammoet superintendents under the direction of the person in charge (PIC). For the initial pick, the boom will be located over the load using a total station surveying system. The load path is designed as being at a certain radius for which there is instrumentation in the cab that accurately locates the load. In addition to the instrumentation the load path will be marked on the ground. The rigging operation will be directed by the PIC who will be in constant radio communication with the crane operators and load tenders inside the Unit 2 Containment. A field engineer will be with the PIC who will be in constant communication with the operator in the plant control room. Figure 5-2 provides a schematic designed to illustrate the load path in a general way. The actual implementation drawing precisely defines each segment of the load path.

Personnel involved in operating the OLS will receive the following instruction:

- Operators will receive the applicable Sequoyah site-specific training specified in:
  - TVA Safety Manual Procedure 721, "Rigging" (Reference 17).
  - TVA Safety Manual Procedure 721A, "TVA Rigging Manual" (Reference 18)
  - TVA Safety Manual Procedure 721B, "Rigging Equipment – Standard Procurement Specifications" (Reference 19)
  - TVA Safety Manual Procedure 802, "Requirements for the Safe Operation of Cranes" (Reference 20)
- Personnel will undergo hands on training with the equipment before a load is attached to the equipment.
- Prior to a lift, detailed pre-lift meetings will be conducted by the SGR rigging specialist or designee. Operation of the crane shall be in accordance with approved provisions provided by the crane manufacturer in addition to the crane operator's manual, and crane operators will be trained in accordance with subcontractor ES&H procedures.
- Coordination with Plant Operations is required prior to commencement of heavy load movement activities.

During the lifting operation, the exact location of boom tip will be monitored by two independent methods. Instrumentation internal to the crane provides continuous readout of crane and boom orientation and the location of the boom tip. In addition, the boom tip will be continuously monitored from a remote survey station independent from the crane instrumentation. This survey station will have the necessary data input to monitor and calculate the boom tip location relative to the interfacing structures and components. The individual directing the rigging operations will be in constant communication with both the crane operator and the surveyor manning the remote survey station. These controls will be utilized to ensure that the exact location of the load is known and compliance with design requirements is maintained.

Assembly and disassembly of the OLS will be performed in accordance with the crane manufacturer's procedures and drawings and may be performed with Unit 1 and Unit 2 in Modes 1-6 or defueled. The assembly/disassembly process will require the use of mobile cranes and other equipment as detailed in Section 5.2. During assembly and disassembly of the OLS, the main boom will lay in an area to the south of the Unit 2 Containment as shown on Figure 5-2. The orientation of the main boom during assembly/disassembly along with the restrictions on mobile crane usage and SSC protection provisions in Section 5.2 ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a load drop during assembly/disassembly of the OLS.

The OLS has been evaluated for seismic loads while unloaded and while loaded with a steam generator (SG) as detailed in Reference 15. A SG is the heaviest load that will be handled by the OLS. This seismic evaluation determined that the OLS will not collapse or result in a drop of the load during a seismic design basis Safe Shutdown Earthquake (SSE) event for the lift configurations to be used during the Sequoyah Unit 2 SGR. Therefore, use of the crane for the Sequoyah Unit 2 SGR will not result in Seismic II/I interaction issues on the SSCs located in the vicinity of the OLS.

Reference 15 qualifies the applicability of the calculation performed for the Unit 1 SGR Project. Reference 15 compares different types of input data specific to Unit 2 and compares it to the input data used for evaluation for Unit 1. This calculation (Reference 15) justified the existing evaluation (Reference 21) as acceptable for use for the Unit 2 SGRP by determining that the Unit 1 qualification and conditions enveloped that for Unit 2.

The Unit 1 calculation, Reference 21, qualified a GT-STRUDL 3-D lumped mass finite element model using beam/truss elements to analyze the critical lift configurations of the OLS for SSE loads. NRC Regulatory Guide (RG) 1.61 allows 7% damping for bolted steel structures for the SSE. However, this analysis conservatively used 5%, which is consistent with Table 3.7.1-3 of the UFSAR. The OLS seismic analysis was performed using the response spectrum method in both the loaded and unloaded conditions.

The seismic analysis of the OLS is based on an appropriate ground spectrum corresponding to the plant's minimum SSE design basis spectra. The OLS will be supported on a concrete ring foundation seated on a large number of battered piles anchored to bedrock. Based on soil borings the average depth of soil deposit at the location of the OLS is 30 ft. The input spectrum used for the horizontal direction is an amplified response spectrum at ground surface for an average soil depth to bedrock of 30 ft under the crane foundation. These amplified spectra were obtained by interpolation for a 30 ft soil deposit and reduced to correspond to the minimum design basis from Reference 22 which provides 5% damped free field top of soil response spectra curves for the Sequoyah Nuclear Plant for soil depths of 40 ft and 20 ft. It is noted that the amplified ground spectra documented in Reference 22 are an average based on the four artificially generated time histories used to develop the more conservative actual design spectra (see Section 2.5.2.4 and Figure 2.5.2-14 of the UFSAR). A 10% broadened amplified SSE horizontal ground response spectrum for 5% damping for 30 ft depth of soil corresponding to the "minimum design basis spectra" in Figure 2.5.2-14 of the UFSAR was thus developed from the 20 ft and 40 ft curves in Reference 22 and used as the input horizontal spectrum. Since the OLS will be supported on a concrete ring foundation seated on a large number of battered piles that are supported well into bedrock, the vertical response spectrum used for the crane seismic analysis was the minimum design basis vertical spectrum for 5% damping from Figure 2.5.2-14 of the UFSAR. The vertical response spectrum used is 2/3rds (per UFSAR Section 2.5.2.4) of the horizontal minimum design spectrum.

Section 2.5.2.4 of the UFSAR provides discussion on the chronological sequence of development of the Sequoyah seismic design basis spectra at top of bedrock. The seismic safe shutdown earthquake (SSE) "minimum design basis spectrum" at top of bedrock for

Sequoyah Nuclear Plant, as stated in Section 2.5.2.4 (p 2.5-21) of the UFSAR, is the modified Housner spectrum based on a peak acceleration (ZPA) of 0.18g and are indicated as "Minimum Design Spectra" in Figures 2.5.2-11 through 2.5.2-14 of the UFSAR. Further from Section 2.5.2.4 of the UFSAR, it is noted that TVA used a more conservative arithmetically averaged response spectra generated by four artificial records as the SSE design response spectrum. These spectra are indicated as "Actual Design Spectra" in UFSAR Figures 2.5.2-11 through 2.5.2-14. Figures 2.5.2-11 through 2.5.2-14 of the UFSAR thus illustrate the relationship between the minimum design response spectra and the actual design spectra for different damping ratios.

The seismic evaluation of the OLS (PTC Crane) is based on an appropriate ground spectrum corresponding to the minimum SSE design basis spectra. It is also noted that since the OLS is a temporary system that will be in service for a short period of time and will be loaded for a much smaller period of time, the use of a spectrum based on the minimum seismic design basis of the plant is very conservative. Table 3.7.1-1 of the Sequoyah UFSAR specifies a maximum damping of 5% for Category I bolted steel structures for SSE. Regulatory Guide 1.61 allows 7% for bolted steel structures for SSE. In order to keep the analysis conservative, the OLS seismic analysis is based on 5% damping response spectra.

The OLS is supported on a concrete ring foundation seated on a large number of piles anchored to bedrock. Based on borehole data taken during soil investigation for the SGR Project, the average depth of soil deposit above bedrock at the location of the OLS is approximately 30 ft. Since the OLS will be supported on top of a ~ 30 ft thick soil deposit above bedrock, the response spectra used in the analysis is an amplified spectrum at ground surface corresponding to the "minimum design basis" spectrum (see Section 2.5.2.4 and Figure 2.5.2-14 of UFSAR) for SSE at top of bed rock, as explained below.

The input spectrum used for the horizontal direction is an amplified response spectrum at ground surface. For a given soil deposit, the amplified ground spectrum is essentially a function of the depth of soil deposit. Reference 22 provides 5 percent damped free field top of soil operational basis earthquake (OBE) response spectra curves for Sequoyah Nuclear Plant for soil depths of 40 ft and 20 ft. It is noted that the ground spectra developed in Reference 22 are an average based on the four artificially generated time histories used to develop the more conservative "actual design spectra" (see Section 2-5.2.4 and Figure 2.5.2-14 of UFSAR). Reference 22 further makes reference to TVA Report CEB-80-15, Rev. R0, "Preliminary Response Spectra for Ground Motion in Area of Diesel Generator Building and Cooling Towers." A 10 percent broadened SSE ground response spectrum for 5 percent damping for 30 ft depth of soil corresponding to the "minimum design basis spectra" in Figure 2.5.2-14 of the UFSAR was developed from the 20 feet and 40 feet curves in Reference 22 as follows:

(i) The OBE ground spectra for 30 ft depth of soil were approximated by averaging the 20 ft and 40 ft response spectra curves on sheet 2 of Reference 22. It is noted that this is conservative.

(ii) The SSE ground spectra for 30 ft depth of soil was obtained by multiplying the OBE curve obtained in step (i) above by 2 (see Section 2.5.2.4 of UFSAR).

(iii) The SSE ground spectrum obtained in step (ii) above is further reduced to correspond to a time history corresponding to the "minimum design basis" spectrum for a given frequency by multiplying by a factor given by the ratio of acceleration value from the minimum design spectra to the corresponding acceleration value from the actual response spectra for that frequency.

(iv) The frequency axis is broadened by ±10 percent to obtain a 10 percent broadened SSE ground horizontal response spectra for use in the seismic evaluation of the OLS.

The amplified input horizontal spectra for the OLS analysis, developed as explained above, were input at ground surface. Since the OLS is supported on a concrete ring foundation seated on a large number of piles that are supported well into bedrock, the vertical response spectrum used for the crane seismic analysis was the minimum design basis vertical spectrum for 5 percent damping from Figure 2.5.2-14 of the UFSAR. The vertical response spectrum used is 2/3rd (per Section 2.5.2.4 of UFSAR) the horizontal minimum design spectrum.

The bedrock motion was amplified upward through the soil in Reference 22 and TVA Report CEB-80-15. The amplified spectra from these references, used for developing the response spectrum for the OLS analysis, were developed based on a soil structure interaction evaluation methodology described in Section 3.7.1.6 of the UFSAR:

> For Category I structures (see Table 3.7.1-1) founded upon soils the rock motion was amplified to obtain the ground surface motion by considering the soil deposit as an elastic medium and making a dynamic analysis of a slice of unit thickness using only the horizontal shearing resistance of the soil. A damping ratio of 10 percent is used for the soil. The four artificial earthquakes mentioned in Section 2.5.2.4 were considered as the input motion at the top of rock. Once the time history of surface accelerations was known, a response spectrum was produced for the analysis of the soil-supported structure.

Regarding the above, the ground surface response spectrum determined by a linear amplification of the bedrock motion was broadened by ±10 percent in order to obtain a design response spectra. The broadened curve was used as input to the dynamic seismic analysis.

Soil springs were calculated to simulate soil-structure interaction at the foundation. The response spectra loadings were applied simultaneously in two horizontal directions and the vertical direction. Modal responses were combined using the NRC Ten-Percent Method. Co-directional responses were combined using the Square Root of the Sum of the Squares (SRSS) method.

The seismic evaluation of the OLS determined that the calculated stresses are less than the maximum allowable stresses (0.9 F_y) and the minimum safety factor against overturning is 1.1 (Reference 15).

To further demonstrate the capability of the OLS, Reference 21 also determined the "whip-lash" effect a loss of lifted load would have on the OLS. Reference 21 determined that the whip-lash effect resulting from a postulated drop of a load from the OLS will not cause instability of the boom masts in the reverse direction, i.e. the masts will not flip over backwards and impact

SSCs (e.g., Auxiliary Building, Independent Spent Fuel Storage Installation (ISFSI), etc.) behind the OLS (Reference 15).

Rigging operations will not be performed when wind speeds exceed the maximum operating wind speed for the OLS. This wind speed will be measured using an anemometer on the crane boom tip. The OLS has two anemometers for measuring wind speed, one anemometer is located in the boom tip and a duplicate anemometer is located at the top of the back stay. The anemometers are verified to be operational prior to the boom/back stay being erected. If wind speeds increase during a rigging operation such that the wind speed may exceed the maximum operating speed, rigging operations will be suspended and the unloaded OLS will be secured by implementing administrative controls specified by the manufacturer in Reference 23. These administrative controls define the allowable mainmast and jib angles, and the slew drive and load block configurations, and are dependent on the wind speed.

The stability analysis for the crane does not consider wind effects, since these are considered separately as part of the crane manufacturer's limitations on OLS crane operation. To comply with the crane manufacturer's limitations, the maximum wind speed allowed during operation of the OLS (PTC Crane) when the lifted load is more than 3 ft off the ground is 10 m/s (22 mph) in any direction measured at the boom tip. The maximum wind speed allowed during operation of the OLS when the lifted load is at 3 ft or less off the ground is 15 m/s (33 mph) in any direction measured at the boom tip.

The maximum wind speed allowed during operation of the OLS (PTC Crane) when the lifted load is more than 3 ft off the ground and outside the Unit 2 Containment is 10 m/s (22 mph) in any direction measured at the boom tip. This operating wind speed is specified in the PTC Crane Manual and the load capacity charts. The wind load due to this maximum wind speed has been accounted for by the manufacturer in the crane structural and stability calculations based on which the safe working load specified in the load capacity table was arrived at with safety margins specified in the lifting codes. The maximum wind speed allowed during operation of the OLS when the lifted load is less than or equal to 3 ft off the ground or inside the Unit 2 Containment is 14.75 m/s (33 mph) in any direction measured at the boom tip, as directed by the crane manufacturer. The lifting capacity of the OLS was determined by the manufacturer in accordance with the following codes (lifting codes): DIN 15018 Parts 1 & 3, DIN 15019 Part 2, DIN 15020 Part 1 and DIN 1055 Part 4, ASME B30.5-1994, SAE J987, SAE J765 and CE. It is noted that the OLS comes instrumented with a wind speed anemometer mounted at the boom tip.

The rigging contractor's calculation provides a comparison between the actual calculated wind force on the steam generator, using a wind speed of 50 mph, and the allowable lateral load on the steam generator, per the OLS manufacturers requirements. This comparison indicates that even with a wind speed of 50 mph the wind force on the steam generator will be approximately 55 percent of the allowable wind force. Keeping in mind that the allowable wind speed will be limited to 22 mph (10 m/s) in the high lift position (with the load outside the Unit 2 Containment) and 33 mph (15 m/s) in the lowered position (or with the load inside the Unit 2 Containment) one can see that sufficient margin remains to maintain the OLS in a safe condition.

In case the wind at the tip is expected to exceed the specified 10 (15*) m/s (22 (33*) mph), the crane will be secured in the configurations in the table below as specified in the PTC Crane Manual and the rigging contractor's calculation:

Table 5-3 – PTC Crane Operation for Range of Wind Speeds

Wind Speed at Tip	Mainmast Angle	Jib Offset Angle	Slew Drive	Load
10 (15*) -22 m/s (22 (33*) -49 mph)	All angles allowed 0° - 85°	Minimum 10°	Braked	Lower Block (**) Suspended
22-30 m/s (49-67 mph)	80°	10°	Braked	Lower Block (**) Suspended
30-46 m/s (67-103 mph)	80°	10°	Braked + Park Brake	Lower Block (**) Secured with 200 ton (440 kip) pretension to 250 ton (550 kip) ballast on the ground
>46 m/s (>103 mph)	Boom Lowered	Jib Lowered	Free	Not Applicable

(*) Only when lifted load is carried not more than 3 ft above grade.

(**) Lower Block is the terminology used by the crane manufacturer for the main hook block or load block.

The above table shows that the load may remain suspended from the lower block (main hook block) for wind speeds up to 67 mph with the slew drive braked and the mainmast and jib offset angles configured as specified in the table. The maximum time required to bring the OLS from the operating configuration to the specified configuration is less than 15 minutes. For wind speeds anticipated in the 67-103 mph range, the OLS shall be configured with regard to mainmast and jib offset angles as specified in the above table and the following cases apply with regard to the load: (1) If the load on the hook is equal to or greater than 550 kips, the load will be partially lowered to the ground so as to maintain a pretension of 440 kips; (2) If the load on the hook is less than 550 kips or there is no load on the hook, the load will be lowered and removed from the hook and the lower block tied off to a 550 kip ballast on the ground with a 440 kip pretension. The maximum time required to bring the crane from the operating configuration to the specified configuration is less than 30 minutes.

When wind speeds could exceed 103 mph (this would be expected to occur only during tornadoes), the boom and the jib will be lowered. The time required to accomplish this is about 2 hours (if no load is on the hook). Should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be place in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration. The time to accomplish this will vary depending on the load being lifted and the stage of the lift.

The OLS manufacturer has qualified the crane for wind effects, including side load effects, for wind speeds up to 103 mph, with the lower block secured to a 550 kip load and pretensioned to 440 kips. Thus, the OLS will not tip over from side load effects for wind speeds up to 103 mph. The design basis wind speed for Sequoyah Nuclear Plant is 95 mph (UFSAR Section 3.3.1.1). Wind speeds exceeding 103 mph can be expected only during a tornado. However, for the Sequoyah SGR Project, all heavy lift operations using the OLS will commence only after confirming, based on weather forecasts and reports, that no severe weather conditions are expected for the duration of the lift. In the event a tornado watch or warning is announced in accordance with Procedure AOP-N.02, crane operations shall cease and the boom and jib will be lowered and oriented in a Southwest direction as indicated on Figure 5-2.

Lateral Capability of the OLS Compared to a Lampson Crane

Lampson Transi-Lift Crane: The boom and jib of the Lampson Crane are of single lattice frame construction. The crane is mounted at the base on crawlers with a relatively smaller footprint, which induces relatively higher pressures on the base of foundation. The Lampson Crane used on the Miller Park Project was seated on the ground, not on an engineered foundation. The ground on which it was seated was not a level surface and it is reported that at the time of failure there were apparent cracks in the ground on which the crane was seated.

OLS: In comparison, the main mast (main boom) and back mast are of a significantly more robust A-Frame Construction with the two legs of the A-Frame connected by a horizontal cross beam/frame. The two pivots at the base of the A-Frame masts are 33 ft apart laterally for both the main mast and the back mast. Further, the jib of the crane is a double frame construction with the two parallel frames connected by cross beams at three levels. The two jib pivots at the base of the double frame are 13 ft apart laterally. The OLS has a 70.5 ft diameter (centerline) ringer base mounted on 24 jacks seated on top of an engineered foundation using outrigger plates. The OLS ringer design with 24 jacks enables good distribution of bearing pressure under the jack pads. The OLS will be seated on the reinforced concrete pile cap extension of an engineered battered pile foundation consisting of approximately 80 piles anchored into bedrock. The battered pile foundation is designed for lateral loads (seismic and wind) in addition to gravity loads of the crane and load.

The above structural features and configuration of the OLS provides it with a significantly higher lateral load carrying capability in comparison to the Lampson Crane.

Correlation of Operating Wind Speeds of OLS and Other Cranes

- The permissible operating wind speed (measured at the tip of the jib) specified for the OLS (Mammoet PTC Crane) for the Sequoyah Unit 2 SGR Project is 22 mph (for all wind directions) when the load is more than 3 ft off the ground and outside the Unit 2 Containment and 33 mph (for all wind directions) when the load is 3 ft or less off the ground or inside the Unit 2 Containment. The maximum permissible wind load at the load is 0.75% of the safe working load (SWL) specified in the load capacity chart. For the worst case lift of the SG for the Unit 2 Sequoyah SGR Project, this lateral wind force will occur on the load at a wind speed of 50 mph. The OLS has been load tested for side load on a steam generator that is 2.9 times that from a 50 mph wind. This comparison indicates the substantial safety factor for wind load even at 50 mph for the use of the OLS for the Sequoyah Unit 2 SGR Project.

- For the Lampson Transi-lift Crane used in the Miller Park Project, the specified operating wind speed was 20 mph. The wind anemometer was mounted on the boom at an elevation of ~175 ft from the ground, not at the jib tip. Based on reports of the accident, winds were gusting in the 28-30 mph range during the afternoon of the accident.

It is noted that in the cases of crane failures that have occurred at low wind speeds (e.g., the Lampson Crane at Miller Park), the wind, in and of itself, has not been the ultimate factor for failure, but a contributing factor among others, the combination of which resulted in the final collapse. Some of these factors are included in the discussion below.

- For the OLS, wind loads have been accounted for by the manufacturer both on the crane structure as well as the load in developing the rated load capacity tables. The maximum permissible lateral wind load at the load is 0.75% of the safe working load (SWL) specified in the load capacity chart. For the worst case lift of the steam generator for the Sequoyah Unit 2 SGR Project, this lateral wind force will occur on the load at a wind speed of 50 mph. The OLS has been load tested for side loads corresponding to 2% of SWL, which corresponds to a side load on a steam generator that is 2.9 times that from a 50 mph wind. This comparison indicates the substantial safety factor for wind load even at 50 mph for the use of the OLS for the Sequoyah Unit 2 SGR Project. The actual permissible operating wind speed at the tip of the jib specified for the crane for the Unit 2 SGR is 22 mph (for all wind directions) when the load is more than 3 ft off the ground and outside the Unit 2 Containment and 33 mph (for all wind directions) when the load is 3 ft or less off the ground or inside the Unit 2 Containment. Thus, there is significant margin available with regard to wind load on the OLS.

- For the Lampson Crane at Miller Park that failed, the manufacturer's recommendation with regard to permissible wind speeds was 20 mph. Based on reports of the accident, winds were gusting in the 28-30 mph range during the afternoon of the accident. Also, the wind anemometers were placed at a lower elevation relative to the tip of the jib and therefore, were not measuring the wind speed at the jib tip. Wind loads were not accounted for on the 180 ft x 100 ft load. In addition, the actual lifted load was ~105% of that allowed by the Lampson Crane's rated load capacity chart. Further, the rated loads for the Lampson Crane were 85% of its tipping load in comparison to less than 80% for the OLS.

- All calculations/tests performed by crane manufacturers with regard to stability of crane under wind loads in developing their rated load capacity charts assume that the crane base is seated on a firm level surface and the foundation is capable of carrying the bearing pressures. The OLS crane to be used for the Sequoyah Unit 2 SGR Project has a 70.5 ft diameter ringer base mounted on 24 jacks seated on top of an engineered foundation using outrigger plates. The OLS ringer design with 24 jacks enables good distribution of bearing pressure under the jack pads. The OLS will be seated on the reinforced concrete pile cap extension of an engineered battered pile foundation consisting of approximately 80 piles anchored to bedrock. The battered pile foundation is designed for lateral loads (seismic and wind) in addition to gravity loads of the crane and load. Thus, the OLS will be seated on a firm level foundation designed to carry all the expected loads.

- The Lampson Crane at Miller Park was not seated on a firm level surface. There was no engineered foundation designed especially considering heavy loads of the order of 450 tons that were lifted. Also, the crane was mounted on crawlers with relatively smaller footprint in comparison to the ringer base of the OLS. In addition, it is reported that at the time of failure there were apparent cracks in the ground on which the Lampson Crane was seated.

- Due to the structural (A-Frame/double-frame construction and ringer base) configuration of the OLS discussed under the "Lateral Capability of the OLS Compared to a Lampson Crane" section above, the OLS has significantly higher lateral load carrying capability in comparison to other cranes available. In comparison, the Lampson Crane mast components are of single lattice frame construction.

To eliminate the effects of wind conditions beyond the maximum operating wind speed, a lift will not commence if analysis of weather data for the expected duration of the lift indicates the potential for wind conditions in excess of the maximum operating wind speed. Further, should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be placed in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration.

Based on the above discussion, the conditions that could result in credible crane failure modes or load drops (i.e., operator errors, use of improper rigging or inappropriate slings, and crane component failures) have been minimized or eliminated through the training of rigging personnel, use of engineer-developed procedures for the load lifts, performance of engineering evaluations of the OLS and rigging components, and inspection and testing of the OLS. In addition, an OLS failure or load drop due to a tornado or seismic event has been eliminated. The tornado initiated OLS failure or load drop will be eliminated through implementation of procedures to preclude load handling when high winds or severe weather/tornado conditions are anticipated. The seismic induced crane failure or load drop has been eliminated by showing that the OLS will not collapse or drop a load while loaded or unloaded during the SSE. Given the training, procedures, evaluations, inspections, and testing involved in use of the OLS, it is highly unlikely that the OLS will fail or drop a load. However, as required by NUREG-0612, load drops from the OLS have been postulated and the potential consequences of these postulated drops evaluated as detailed in Sections 7 and 8.

5.2 Other Cranes Supporting the SGR Project

In addition to the OLS, mobile cranes will be used to perform a variety of other SGR Project rigging activities. Assist cranes will be used in the assembly/disassembly of the OLS, and a Liebherr LR 1400/1 or Liebherr LR 1400/2 crawler crane will be erected prior to the SGR Outage to rig and handle miscellaneous loads, principally between grade elevation and the dome of the Unit 2 Shield Building. The Liebherr LR 1400/1 or Liebherr LR 1400/2 crawler crane will be erected in the area immediately east of the Unit 2 Shield Building and west of the Independent Spent Fuel Storage Installation (ISFSI) (Figure 5-5). This crane will be operated prior to, during, and immediately after the SGR Outage to perform lifts of various equipment and items supporting SGR Project activities. These lifts are independent of the operational status of Unit 1, and will be performed during the Unit 2 conditions specified below:

- Structural steel components of the Construction Platform Support Truss System that will be erected on the dome of the Shield Building – lifts performed during any Unit 2 condition.
- Equipment for concrete cutting and repair (hydro-lasers, restoration formwork) – lifts performed during any Unit 2 condition on the front end of the SGR Outage. On the back end of the SGR Outage, concrete restoration activities are completed before Unit 2 exiting Mode 5 (Shield Building Operability required).
- Cut sections of main steam piping with venturi which are removed from each of the OSGs. The Replacement Steam Generators (RSGs) come equipped with main steam piping/venturi integrally installed on the RSG components. These lifts are performed during the Unit 2 defueled condition.
- Steel Containment Vessel (SCV) steel cut sections during the Unit 2 defueled condition. Note that the SCV cut sections may also be rigged by use of the OLS.
- Concrete handling buckets for placing concrete in the restored Shield Building openings – lifts performed on the back end of the SGR Outage with concrete restoration activities required to be complete before Unit 2 exits Mode 5 (Shield Building Operability required).

The mobile cranes are commercially designed, ruggedly constructed, cranes with a main boom, each crane utilizing a counterweight stabilization system. The designs of the cranes meet ASME B30.5-2004 design requirements (Reference 10), and the cranes' rated capacities consider applicable loadings. The cranes will have been load tested during their production and will have a current certification in accordance with ASME B30.5-2004.

Use of the mobile cranes for OLS assembly/disassembly is limited to an area within that shown on Figure 5-2. Mobile crane usage beyond the OLS boom location may be allowed if engineering evaluation shows no adverse impact to nearby safety-related SSCs. Restrictions on the use of these cranes will also be imposed to specify the weather conditions under which they may be operated and how and when to secure the mobile cranes in case of inclement weather. These restrictions are designed to preclude adverse interactions with safety-related SSCs, as well as the ISFSI, for adverse conditions, including seismic events.

Use of the mobile cranes for OLS assembly/disassembly will be governed by the following restrictions:

1. Load handling with the mobile cranes is limited to an approved area around the OLS boom location shown on Figure 5-2.

2. The load imposed on the ground by the mobile crane is limited to the calculated allowable ground bearing pressure of 4 ksf.

3. Physical protection measures (e.g., timber mats and steel plates) will be placed as shown on Figure 5-2 for identified commodities requiring protection. As demonstrated in Section 7.5, the RWST and ERCW piping require no protection during OLS assembly/disassembly, since they are located outside the OLS erection area. There are no Safety-Related SSCs located within the OLS assembly boundaries. Therefore, no load lifting elevation restrictions need to be considered.

Load handling operations with the Manitowoc 2250 crane that will be used for OLS assembly/disassembly will cease and the cranes will be put in a safe configuration when winds exceed the wind speed limits of 35 mph. This wind speed is based on the crane manufacturer's manual for the Manitowoc 2250. In performing the OLS assembly/disassembly, the OLS crane components to be lifted have a small sail area in comparison to the weight. If other mobile cranes are used during the assembly/disassembly of the OLS, load handling operations will cease when winds exceed the manufacturer's maximum recommended wind speed for safe operation.

Mobile crane operations will cease and the cranes will be put in a safe configuration if a tornado watch or warning has been announced in accordance with Procedure AOP-N.02, "Tornado Watch/Warning."

The rationale for allowing higher allowable operating wind speeds for the mobile cranes relative to those for the OLS is provided below.

The OLS supplier has determined that the safe operating wind speed while lifting a SG is 33 mph, which includes a safety factor. The Unit 2 SGR Project has made the decision to limit the maximum operating wind speed while the generators are greater than 3 feet above the ground and while outside the Unit 2 containment to further increase the margin of safety. As previously stated, the maximum operating wind speed allowed for the OLS is 22 mph when the lifted load is more than 3 ft off the ground and outside the Unit 2 Containment and 33 mph when the lifted load is less than or equal to 3 ft off the ground or inside the Unit 2 Containment. In addition, the SG lifts will be performed at between 90 percent and ~94 percent of rated crane capacity, thus justifying a reduced wind speed.

The maximum operating wind speed will be relayed to the operator during the pre-job briefing, and they are also included on the operating load path drawings. The crane operator has actual wind speed indication in the cab of the crane from an anemometer located on the crane boom. As a backup, a field engineer who accompanies the person-in-charge (PIC) will monitor weather forecasts and wind speed information from the site meteorological tower and will notify the PIC, as required, as wind/weather conditions change. Typically, lifts will commence only after reasonable assurance is obtained with regard to favorable weather and wind conditions at least for the duration of the lift, thereby precluding any limiting conditions. However, in the event that winds increase to near or at the limiting conditions, further actions will proceed to place the crane in a safe and optimum configuration in accordance with the drawings, crane operating manual and site procedures, which will be implemented through the work package for the activity.

Protection (see Figure 5-2) for safety-related SSCs is provided, as necessary, to ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a load drop during use of these cranes for assembly/disassembly of the OLS. The SSCs in the vicinity of where the OLS will be assembled/disassembled are the essential raw cooling water (ERCW) system piping, the Unit 2 refueling water storage tank (RWST), and fire protection piping. The approved area around the OLS boom location shown on Figure 5-2 is a safe load path provided that the mobile cranes are operated in accordance with Figure 5-2, the ground loadings by the mobile crane do not exceed the calculated allowable ground bearing pressure of 4 ksf, and the protection listed in Section 7.5 is in place.

Personnel involved in operating the mobile cranes will receive the following instruction:

- Operators and riggers will receive the applicable Sequoyah site-specific training specified in:
  - TVA Safety Manual Procedure 721, "Rigging" (Reference 17).
  - TVA Safety Manual Procedure 721A, "TVA Rigging Manual" (Reference 18)
  - TVA Safety Manual Procedure 721B, "Rigging Equipment – Standard Procurement Specifications" (Reference 19)
  - TVA Safety Manual Procedure 802, "Requirements for the Safe Operation of Cranes" (Reference 20)
- Personnel will undergo hands on training with the equipment before a load is attached to the equipment.
- Prior to lifts over safety-related SSCs, detailed pre-lift meetings will be conducted by the SGR rigging specialist or designee. Operation of the crane shall be in accordance with crane operator's manual, and crane operators will be trained in accordance with subcontractor ES&H procedures.
- Coordination with Plant Operations is required prior to commencement of heavy load movement activities.

The mobile cranes will not be operated in high winds or weather conducive to tornados and will be relocated away from safety-related SSCs under these conditions. The mobile cranes are not designed to withstand seismic events, however, as evaluated in Reference 24, the Liebherr LR 1400/1 or Liebherr LR 1400/2 crawler crane will remain stable and preclude any impact interactions with safety related SSCs in a seismic event. Reference 24 describes the location, safe load path requirements, and administrative controls for operation to prevent any damage to important-to-safety SSCs. Load height and weight restrictions will be imposed to preclude nearby safety-related SSCs from being adversely affected by a postulated load drop.

The mobile cranes are generally not equipped with wind speed monitoring capabilities. To ensure that any restrictions on the wind speeds are implemented, the mobile cranes will rely on site wind speed readings that are recorded at the site meteorological tower. In general, the mobile cranes have restrictions on their operational wind speed, as well as other operational limitations. To ensure that the crane manufacturer's operational limitations are being followed, there are job-specific construction procedures in place for the work associated with assembly/disassembly of the OLS. These controls regulate the construction activities. In addition, there is a work package specifically written for each work activity that invokes the requirements dictated by engineering, including wind speed limitations on crane operation. Meteorological forecasts will also be used to monitor wind speeds

Based on the above discussion, it is highly unlikely that a load will be dropped from a mobile crane. However, as required by NUREG-0612, load drops from a mobile crane have been postulated and the potential consequences of a postulated drop evaluated as described in Sections 7 and 8. None of these consequences leads to the need to invoke the one-time Unit 1 Operating License change / change to Technical Specification 3.7.5 or impose the ERCW compensatory measures during lifts by the mobile cranes. With regard to rigging of the SCV steel cut sections by either the Liebherr LR 1400/1 / Liebherr LR 1400/2 crawler crane or by the OLS, postulated drops of these steel sections from crane failures have been evaluated in Reference 24 to result in no failure of the ERCW lines over which these loads will travel because of load handling limitations for these lifts and the physical protection of the ERCW lines provided to them by their soil depth and the concrete protection features of the Unit 2 pipe tunnel containing these ERCW lines.

Operational crane tests are performed at the time of production of the crane and the crane manufacturer maintains records of these tests. During the assembly/disassembly of the OLS and prior to each shift usage of the mobile cranes, a preoperational checklist of the crane features will be conducted by that shift operating team and signed off. If a load sustaining part of a crane (other than the wire rope) is altered, replaced, or repaired, ASME B30.5 requires that the crane be load tested using a maximum of 110% of the manufacturer's load rating. For wire rope replacement, a functional test is performed using normal operating loads. The mobile cranes used in the assembly/disassembly of the OLS will follow these ASME requirements.

5.3 Outside Lift System Components

The OLS will arrive at the Sequoyah site in standard containers. These containers will be moved to the OLS assembly/disassembly area (see Figure 5-2) on tractor-trailers. The OLS will be assembled/disassembled in accordance with Reference 23 while both units are in Modes 1-6 or defueled. As described in References 23 and 51, the heaviest individual component is the lower counterweight tray at 27.8 metric tonnes (61.3 kips). The heaviest assembled component lifted during the erection process is the main mast at 104.7 metric tonnes (230.1 kips). The largest ballast blocks used are 10.9 metric tonnes (24 kips).

The crane components will be off-loaded from the tractor-trailers using the mobile cranes discussed in Section 5.2, and forklifts. During the offload process, the components will be lifted slightly higher than the trailer bed and lowered to the ground. Offloading locations will be chosen to minimize the potential for impacting ERCW piping. In addition, physical protection in the forms of timber mats, steel mats, and steel plate will be provided to ERCW piping and other underground commodities as necessary to distribute the impact from a load drop such that the ERCW piping/other underground commodities will not be affected. None of these consequences leads to the need to invoke the one-time Unit 1 Operating License change / change to Technical Specification 3.7.5 or impose the ERCW compensatory measures during lifts by the mobile cranes.

5.4 Old and Replacement Steam Generators

The existing Westinghouse Model 51 OSGs will be removed and new RSGs furnished by Westinghouse will be installed. The RSGs are form, fit and function replacements of the OSGs and are similar in orientation and overall physical dimensions to the OSGs. The enveloping weight for the steam generator lifts has been determined to be 375 tons (750 kips). This enveloping weight includes the steam generator, rigging, attached upper lateral restraint, and attached insulation.

Movement of the OSGs/RSGs out of and into the Unit 2 Containment will be performed with Unit 2 in the defueled condition with Unit 1 assumed to be at power. Coordination with Plant Operations is required prior to commencement of SG movement activities.

Once lifted clear of the Shield Building dome, the OSGs will follow designated load paths over the top of the Shield Building dome, as shown on Figure 5-2. Rigging and lifting of the OSGs will be performed by trained personnel, will be strictly controlled and conducted in accordance with approved procedures, and will be restricted to the load paths described by Figure 5-2. After clearing the edge of the Shield Building dome, the OSG will be lowered. Once the bottom of the OSG reaches a suitable height above the ground, the OLS will rotate and move the OSG to the downending area for attachment of the lower end of the OSG to the downending device, as shown on Figure 5-4. As illustrated in Figure 5-4, the OSG will be lowered and downended to the horizontal position for placement on the transporter. Downending equipment and the downending foundation area have been designed for the applicable loads in accordance with ASME NQA-1, Subpart 2.15. Reference 25 determined that the loads on the downending foundation are less than 278.5 tons (557 kips) and the soil bearing pressure from the foundation is less than the allowable pressure. Each OSG will be handled in an identical manner (but with slightly different load paths over the Shield Building dome), and the RSGs will be handled in a similar manner, but reverse order. However, the OLS attachments and saddles will differ as required for adaptation to the RSGs.

For the Unit 2 SGR Project, it is estimated that from the time an OSG clears the Unit 2 Containment dome until it is positioned to start downending on to the transporter will be approximately two hours. This time is also valid for a RSG once it is upended and ready to start towards the Unit 2 Containment until it is ready to pass through the Unit 2 Containment dome opening. Safety-related SSCs (e.g., ERCW piping) could potentially be impacted by a SG drop for a duration of approximately 30 minutes during this portion of the lift. Protection and compensatory measures will be in place during this portion of the lift to prevent damage to and/or mitigate the consequences of damage to these SSCs.

The time to downend or upend a SG is anticipated to be approximately two hours. No safety-related SSCs could be impacted during this portion of the lift by a SG drop.

The anticipated time to haul an OSG once it is ready for transport until it is outside the Unit 2 OSG storage facility (OSGSF), is approximately four hours. Although there are safety-related SSCs (ERCW piping) buried adjacent to the haul route, protection will be provided prior to movement of the SGs along the haul route such that these SSCs will not be damaged as a result of a load drop from the transporter.

The SG haul route is shown on Figure 5-6. The distance from the Unit 2 SGR downending/upending (laydown) area to the Unit 2 OSG Storage Facility/replacement steam generator storage area (RSGSA) is approximately 4,090 ft. A review of SSCs in the vicinity of this portion of the haul route identified several safety-related and non-safety related buried and above-ground interferences. Interferences include ERCW pipes, valve boxes, fire protection piping, sanitary water system, lighting systems, electrical duct banks, manholes, catch basins, and drain pipes. Non-safety related interferences were evaluated in Calculation 39866-CALC-C-003 (Reference 42) and determined to be capable of withstanding the normal surcharge loads that will be experienced during SG transport by use of a self-propelled modular transporter (SPMT). Calculation 39866-CALC-C-005 (Reference 43) documents the continued availability of safety-related ERCW piping and duct banks in consideration of a postulated drop of a steam generator being transported by the SPMT with the application of the following protection measures detailed in the calculation:

- 36" ERCW pipe Southwest of Perimeter Road approximately between STA 5+88.10 and STA 9+92.10: 1.0 ft of sand/fill protection
- 30" ERCW pipes Northeast of Perimeter Road approximately between the centerline of the Reactors and STA 9+92.10: 1.0 ft of sand/fill protection
- 36" ECRW pipes running parallel to the ERCW Pumping Station Access Road between STA 0+40' and STA 0-25': 2.5 ft of sand/fill protection
- Handhole 29: 2.5 ft of wood cribbing along the perimeter of two sides
- Manhole Groups 31 & 32, and Handhole group 52: 2.5 ft of wood cribbing along the perimeter of three sides

The potential for a load drop in the vicinity of the safety-related SSCs will be minimized by operating the transporter at less than 5 mph, provision of a stable road surface with limited grades, and use of a stable single-wide transporter. Additionally, the height of the transporter will be restricted in the vicinity of safety-related SSCs.

Although the SG transporter is considered rugged equipment, it is not specifically designed to withstand external events addressed by 10 CFR 50, Appendix A, GDC 2, which are part of the Sequoyah design basis. The probability of an external event occurring when the transporter is near a safety-related SSC, and which causes a heavy load drop that results in loss of the adjacent SSC is extremely low. However, to conservatively address the worse case consequences, a test weight or SG drop off the transporter was postulated to occur anywhere along the haul route in conjunction with a plant external event.

In lieu of performing the haul route load test with a fully loaded transporter, the test will be performed by loading the test vehicle with enough test weights to produce a subgrade bearing pressure equivalent to or greater than that caused by a loaded transporter. The purpose of the load test is to develop a test pressure that will identify any soft spots in the surface course/subgrade requiring repairs. The entire haul route will be either load tested or evaluated against equivalent previously performed load tests prior to the SG transport. With respect to load tests performed as part of the SGR Project, the complete haul route designated for testing need not be tested all at one time; individual segments may be tested at different times. Load drop protection need only be present immediately prior to and during passage of the load (test load or SG).

The generators will be lifted with rigging devices attached as well as any equipment (nozzle closure plates, insulation, upper lateral support, etc.) that will be attached during movement.

The lifted weight for the OSGs includes the following components:

- Generator (calculated)
- Lifting device (calculated)
- Internal water and sludge (conservatively estimated based on past projects)
- Nozzle cover plates (calculated)
- Lower lateral bumper blocks (calculated)
- Upper lateral support (calculated)
- Rings and Insulation (calculated)
- Rigging (calculated)

The lifted weight of the new SGs includes the following components:

- Generator (375 tons)
- Lifting trunnions (calculated – will be confirmed upon delivery to site)
- Lower lateral bumper blocks (calculated – will be confirmed after removal)
- Upper lateral support (calculated – will be confirmed upon delivery to site)
- Insulation support rings (calculated – will be confirmed upon delivery to site)
- Rigging (calculated)

The OLS has a load cell incorporated into the crane that will be able to confirm the weight as each lift is performed. The OLS will lift the generators a few inches off their support and then hold. At this point the weight of the load will be confirmed and a systems check will be performed on the OLS prior to movement.

5.5 Reactor Shield Building Concrete, Steam Generator Enclosure Concrete, and Containment Vessel Steel

Two approximately 20 ft by 45 ft openings will be cut into the Shield Building dome, as illustrated in Figure 5-2. Similar geometry openings will also be made in the Steel Containment Vessel (SCV) dome, and the concrete roof plugs of each of the four SG compartments will be removed in order to create the rigging paths into the steam generator cubicles to allow removal of the OSGs and installation of the RSGs. Rigging of the Shield Building concrete sections, SCV steel sections, and SG compartment roofs will occur only during the defueled condition.

The OLS will be used to remove the cut concrete sections of the Shield Building dome, which based on engineering are expected to weigh less than 170 tons (340 kips) (Reference 26). Because the SCV steel sections have been evaluated to weigh no more than 15.5 tons (~31 kips), either the OLS or the Liebherr LR 1400/1 / Liebherr LR 1400/2 crane may be used for rigging these loads (Reference 24).

The SG compartment roof and the Main Steam whip restraint beams below the roof will be cut and removed and reinstalled by the OLS as one piece for each of the four compartments. The weight of an individually-rigged SG compartment roof has been determined to be no greater than 67.25 tons (134.5 kips) (Reference 27).

Movement of the above loads will be performed with Unit 2 in the defueled condition and with Unit 1 assumed to be at power. Coordination with Plant Operations is required prior to commencement of heavy load movement activities.

5.6 Lift Plan

The heavy lift plan for the various loads to be lifted during the SQN, Unit 2, SGR Project is detailed in engineering packages, which define the requirements for the safe rigging of the heavy loads associated with the Unit 2 SGR Project. These engineering packages were developed under the direction of registered professional engineers having special knowledge of critical lift operations with many years of experience performing this type of work. The engineering packages associated with the rigging plan include the following details:

- Calculations to determine the critical aspects (e.g., lifted weight, center of gravity, size, etc.) of items to be rigged
- Qualification of rigging components
- Qualification of rigging equipment
- Comparison of lifted load with crane capacity
- Allowable load paths and allowable locations of cranes with respect to the load paths
- Crane foundation design and construction details
- Relocation details for underground utilities in the OLS foundation area
- Qualification and design of SG rigging attachment points
- Load test requirements
- Evaluation of safety-related buried commodities in the vicinity of heavy lift load path for a postulated load drop from the OLS
- Evaluation of the OLS for seismic and wind/tornado loads
- Evaluation of the response from a postulated drop onto the Unit 2 Shield Building
- Load path restrictions (path, height)
- Operating weather restrictions and associated work instructions
- Protection details for safety-related SSCs if a load drop occurs
- Contingency measures for the realignment of plant systems if a load drop occurs

Incorporated into these engineering products are the load limitations derived from the crane manufacturer's load charts. For lifting of the SGs, calculated weights will be confirmed by load cell measurements upon initial lift operations. The potential for winds to influence the safety of the lift operations will be controlled administratively. As noted above, cranes performing heavy lift operations will be limited to locations where ground conditions have been examined and evaluated; more specifically, the OLS will be supported on an engineered pile foundation.

A specific work package is written for each work activity associated with the above rigging plan that invokes the necessary requirements dictated by the engineering packages. These work packages are prepared by construction personnel who plan the overall SGR construction/maintenance program. Each work package is reviewed by design engineering personnel to confirm that the planned activities are within the limits established by the engineering evaluations and analyses.

During the Unit 2 SGR Project heavy load lifts, personnel observing the load lift will be in direct communication with the main control room to relay status information of the lift to the operating crew. In addition, personnel will be in direct communication with the main control room to monitor for Auxiliary Building flooding should a heavy load drop occur.

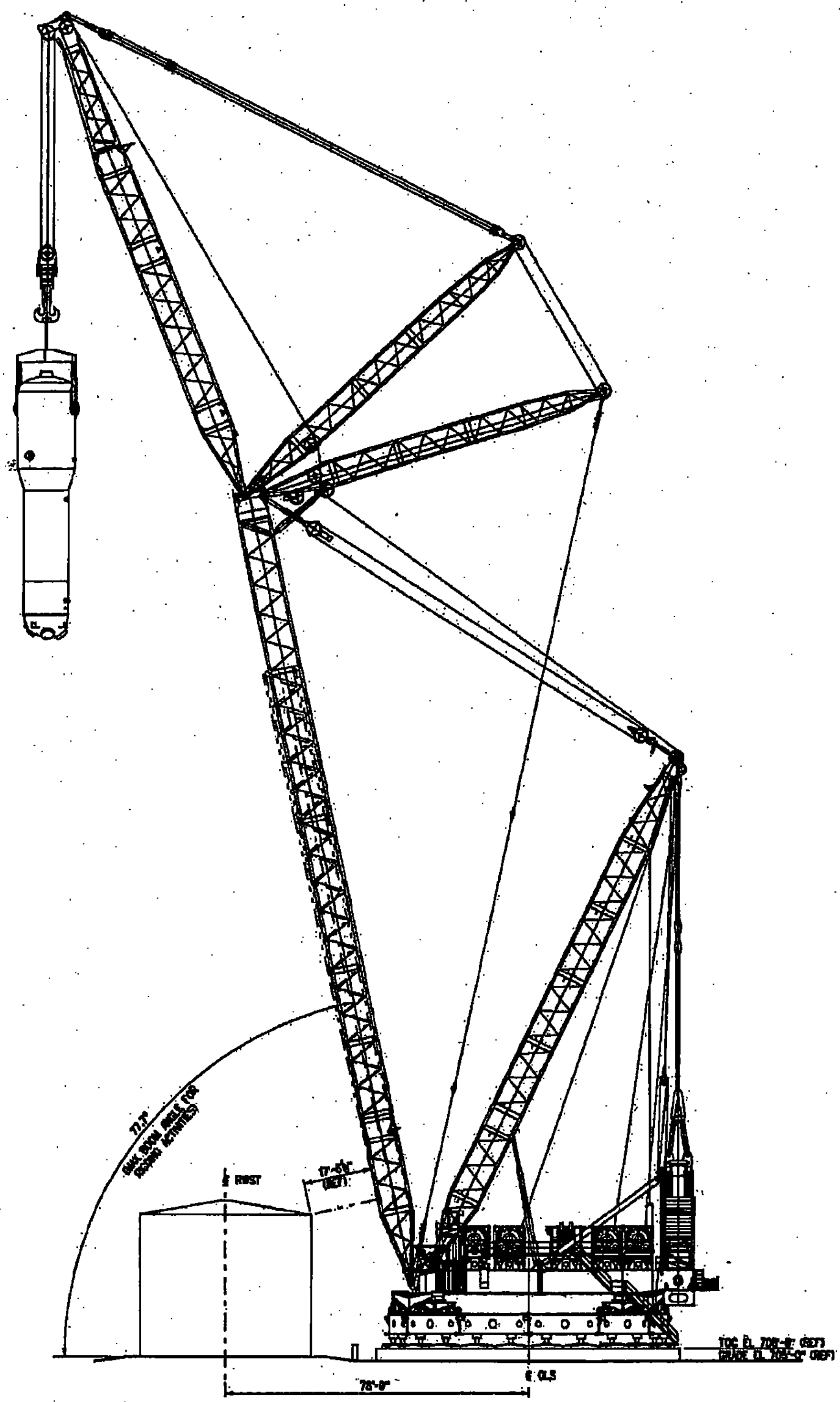

Figure 5-1 – Outside Lift System Elevation

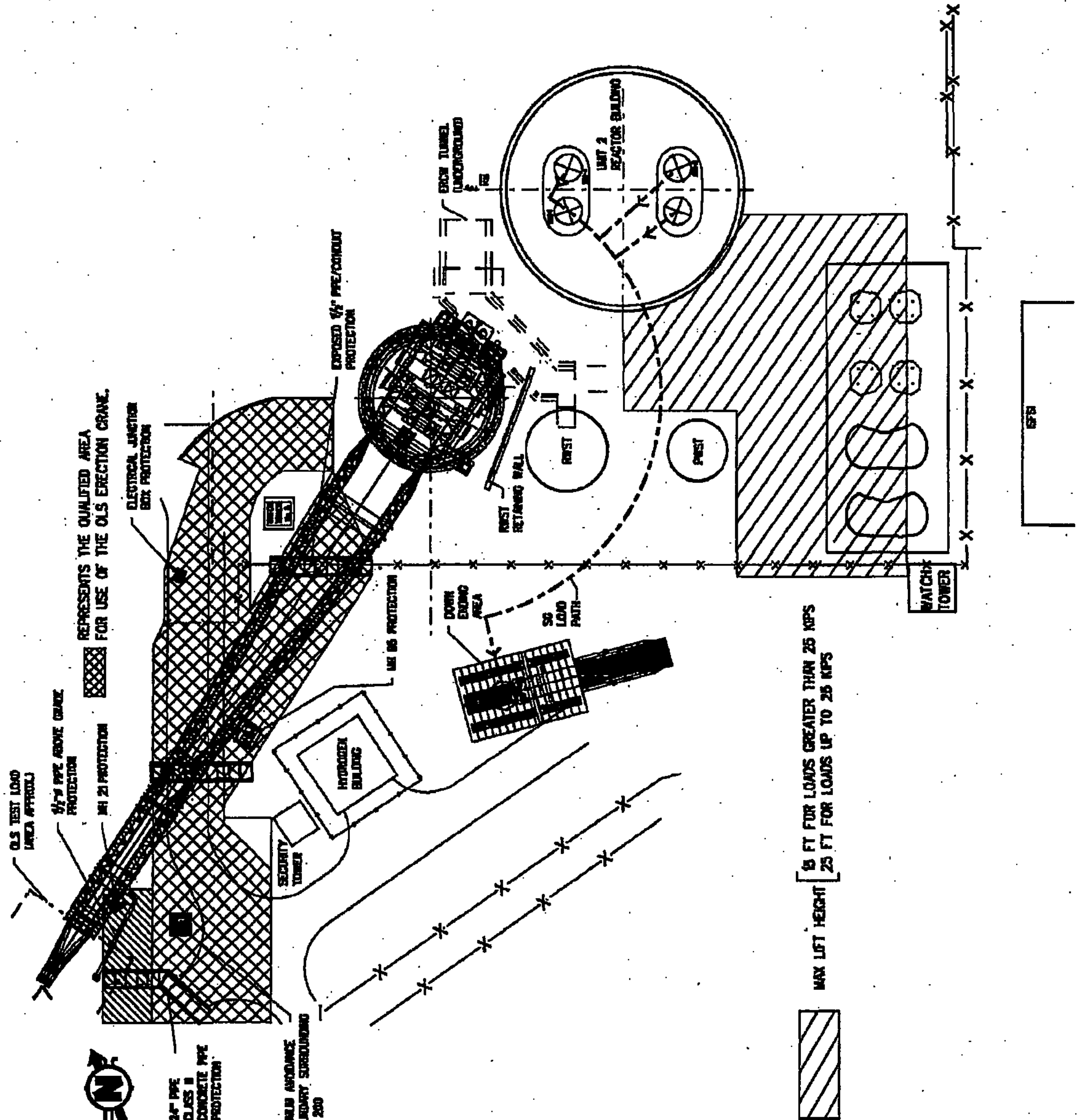

Figure 5-2 – Outside Lift System General Assembly and Load Paths

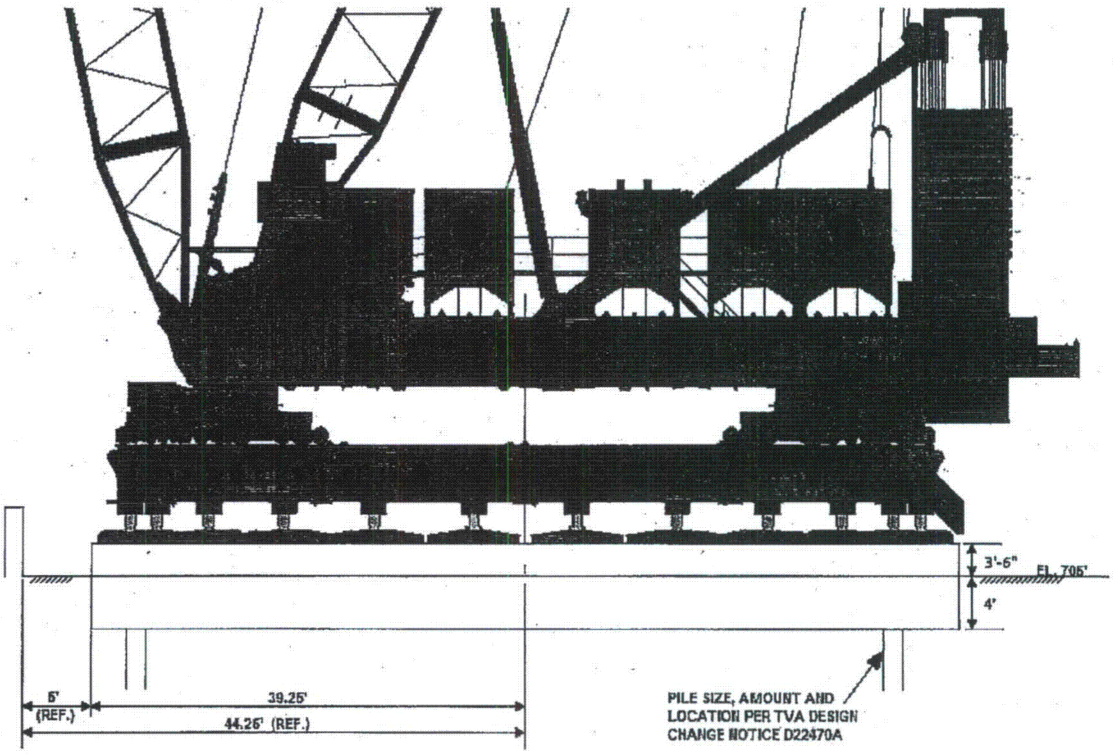

Figure 5-3 – Outside Lift System Base Elevation

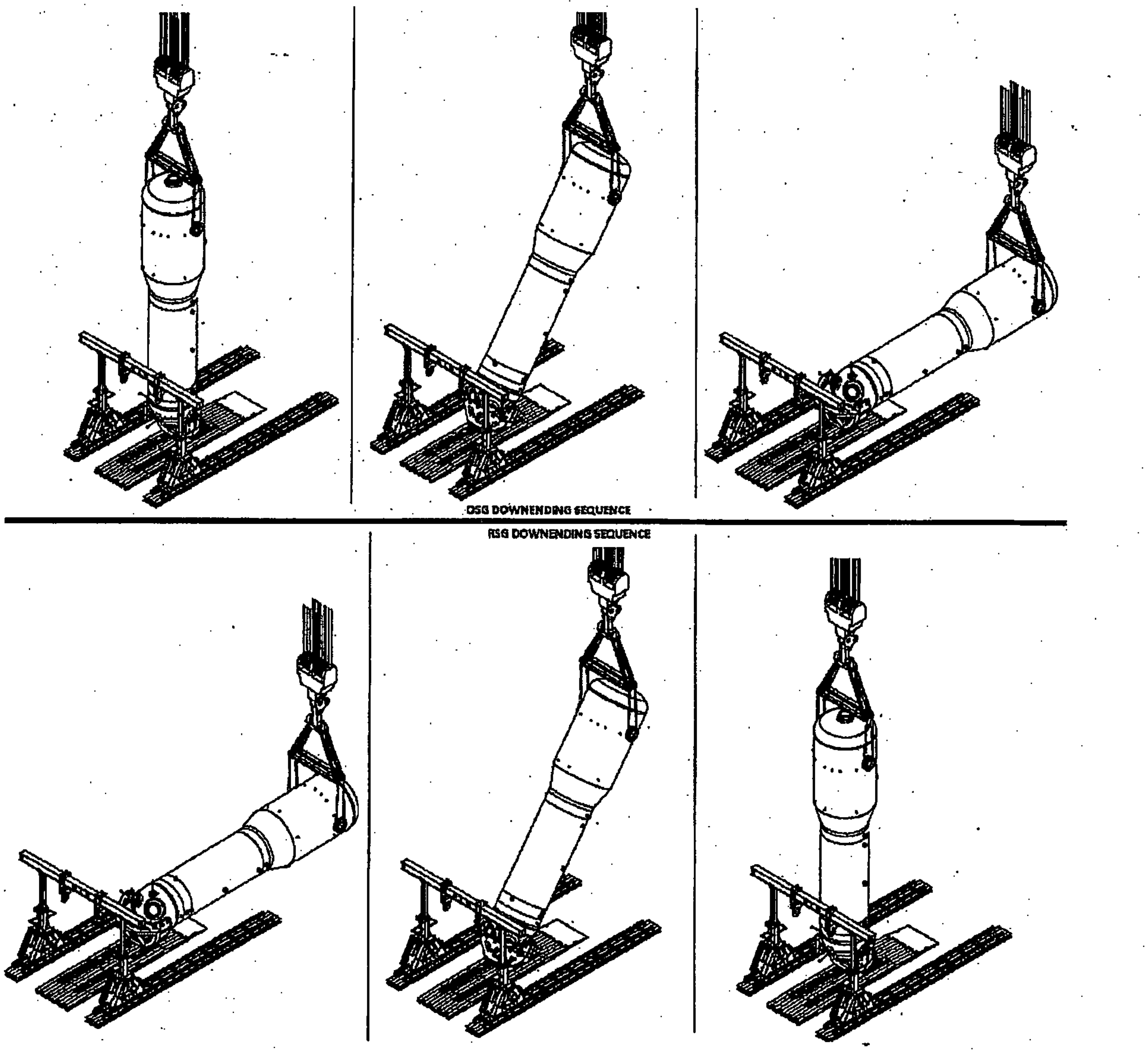

Figure 5-4 – Downending Device

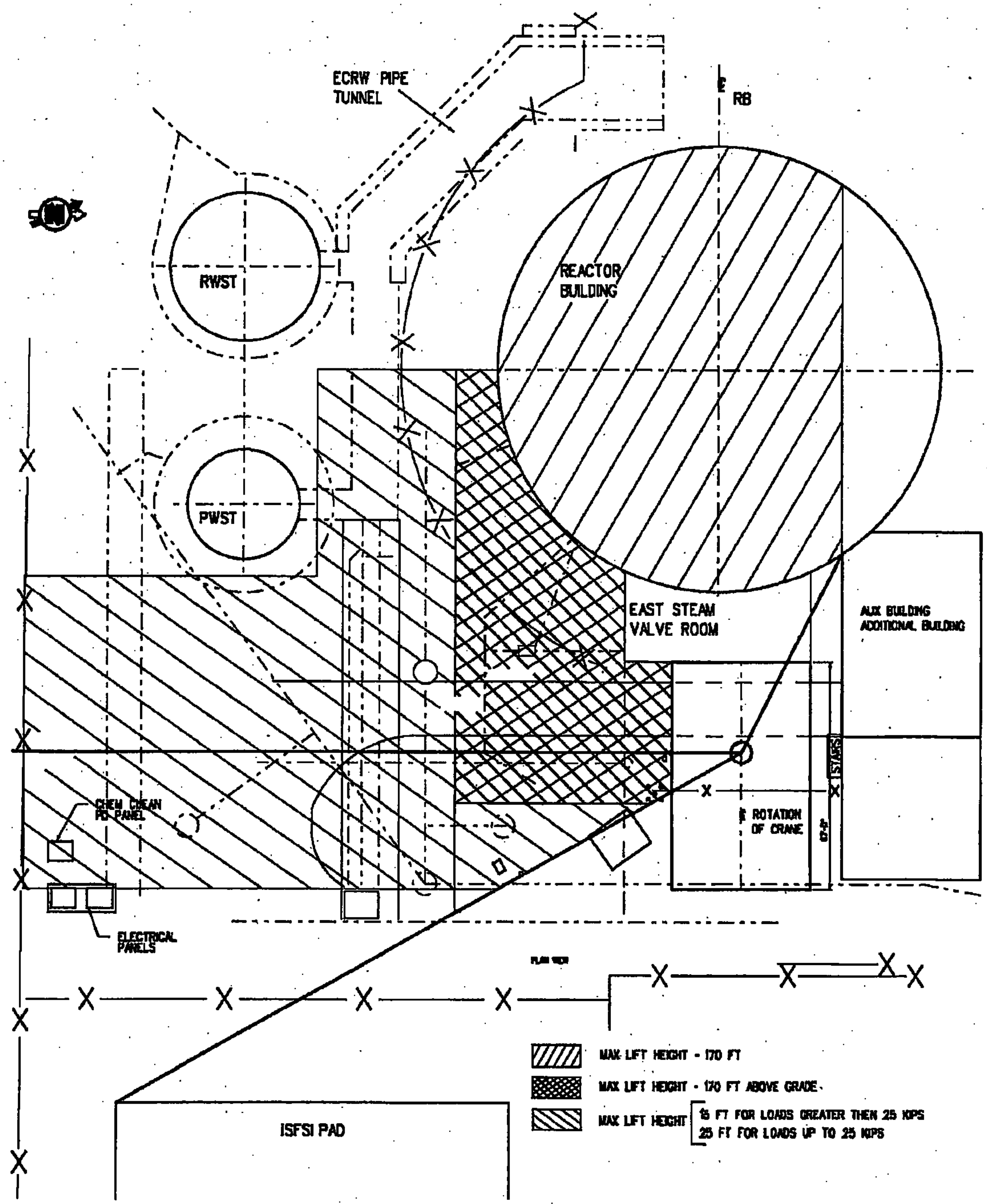

Figure 5-5 – Supplementary Crane General Assembly and Load Paths

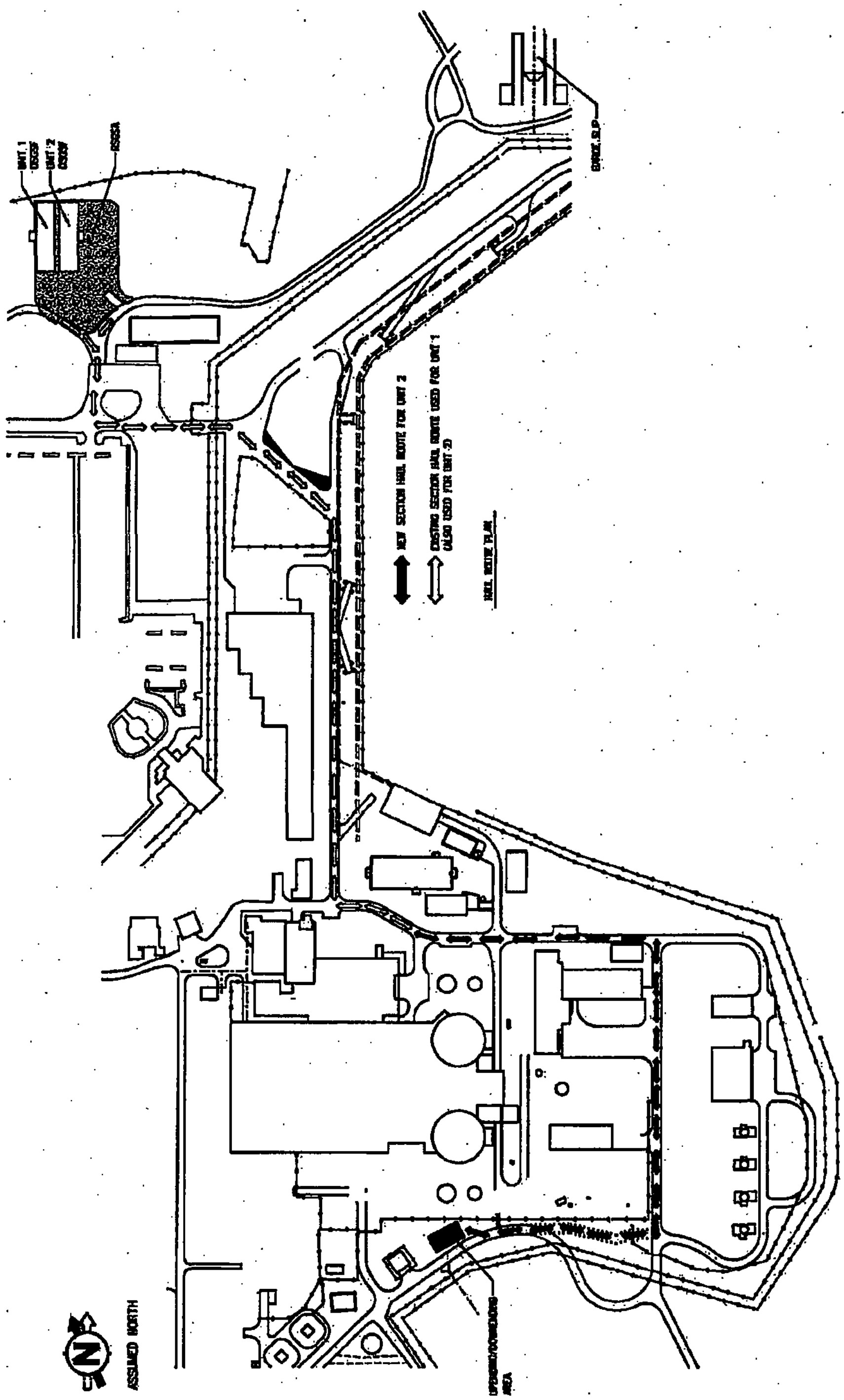

Figure 5-6 - Unit 2 SGR Project Steam Generator Haul Route With Unit 1 SGR Project Haul Route Overlay

6.0 Description of SSCs Potentially Affected by a Postulated Load Drop

To support the Unit 2 SGR, there will be movements of heavy loads in the vicinity of, and over, safety-related equipment that is required to support operation of both units while Unit 2 is in Modes 1 through 6 and defueled. The SSCs that are potentially affected from either equipment impact or a heavy load drop impact are identified in this section. The potentially affected design functions and operability requirements of these SSCs are also addressed. As detailed in Sections 7 and 8, the movements of loads in the vicinity of and over these SSCs have been evaluated and found to be acceptable based on the capability of the SSC to withstand the impact, protection being provided, and/or compensatory measures being implemented.

6.1 Unit 2 Containment

The Sequoyah Unit 2 Containment consists of a free-standing Steel Containment Vessel (SCV) surrounded by a free-standing concrete Unit 2 Shield Building. The SCV and Shield Building are designed to Seismic Category I standards to remain functional during and after a SSE. The design function of the SCV, as indicated in UFSAR Sections 3.8.2.1, 6.1 and 6.2.1.1.1, is to provide an essentially leak-tight barrier to the release of fission products to the environment. As described in UFSAR Section 3.8.1.1, the Shield Building is a reinforced concrete structure. The design functions of the Shield Building are to protect the SCV from external events and to act as the principal structure that limits doses from radioactivity inside the Containment. These design functions are not required while the reactor is defueled.

Unit 2 Technical Specifications 3/4.6.1.1, 3/4.6.1.6, and 3/4.6.1.7 specify the integrity requirements for the Unit 2 SCV and Unit 2 Shield Building during Modes 1-4. The Bases for Technical Specifications 3/4.6.1.1, 3/4.6.1.6, and 3/4.6.1.7 indicate that the safety design basis for Primary Containment is that the Containment must withstand the pressures and temperatures of the limiting design basis accident without exceeding design leakage rates.

Unit 2 Technical Specification 3/4.6.2.2 requires that two independent trains of lower Containment vent coolers be operable with two coolers in each train in Modes 1-4. The Bases for Technical Specification 3/4.6.2.2 indicate that the operability of the lower Containment vent coolers ensures that adequate heat removal capacity is available to provide long-term cooling following a non-LOCA event.

Unit 2 Technical Specification 3/4.6.3 requires that each Containment isolation valve be operable in Modes 1-4. The Bases for Technical Specification 3/4.6.3 indicate that operability of the Containment isolation valves ensures that the Containment atmosphere will be isolated from the outside environment in the event of a release of radioactive material to the Containment or pressurization of the Containment.

Unit 2 Technical Specification 3/4.9.4 defines the required status of Containment Building penetrations during movement of irradiated fuel within the Containment. The Bases of Technical Specification 3/4.9.4 indicate that the requirements on Containment Building penetration closure and operability ensure that a release of radioactive material within Containment will be restricted from leakage to the environment.

6.2 Auxiliary Building

The Auxiliary Building will not be directly impacted by the evaluated load drops. However, a potential effect from the postulated load drops is flooding of the Auxiliary Building through the ERCW tunnel. The impact of potential flooding on the Auxiliary Building is addressed in Section 7.1. Measures that mitigate this flooding are detailed in Section 8.2.

As described in UFSAR Section 3.8.4.1.1, the Auxiliary Building is a part of the Auxiliary Control Building. It is a multi-story reinforced concrete structure that houses Unit 1 and 2 Engineered Safety Features equipment. The Spent Fuel Pit and Fuel Transfer Canal are also housed in the Auxiliary Building. The Auxiliary Building is designed to Seismic Category I standards and will remain functional during and after a SSE. The exterior concrete walls above grade are designed to resist the design basis tornado missiles. Since the Auxiliary Building is shared between Unit 1 and Unit 2, these design bases are required whenever either unit is in Modes 1-4 or fuel is stored in the Spent Fuel Pool.

6.3 Essential Raw Cooling Water System

As described in UFSAR Section 9.2.2.2, the ERCW system consists of eight pumps, four traveling water screens, four screen wash pumps, and four strainers located within the ERCW pumping station, and associated piping and valves. The safety-related portion of the ERCW system is designed to Seismic Category I standards and will remain functional following the SSE. Water is supplied to the Auxiliary Building from the ERCW pumping station through four independent sectionalized supply headers designated as 1A, 1B, 2A, and 2B. Four ERCW pumps are assigned to Train A, and four are assigned to Train B. The two headers associated with the same train (i.e., 1A/2A or 1B/2B) may be cross-tied to provide greater flexibility. This allows one supply header to be out of service (e.g., for strainer maintenance), subject to the Ultimate Heat Sink limitations of Technical Specification 3/4.7.5. Section 9.2.2 of the UFSAR indicates that the ERCW system design function is to supply cooling water to various heat loads in both the primary and secondary portions of each unit. A simplified flow diagram of the ERCW system is provided as Figure 6-1. Figure 6-1 also depicts the impact locations of the postulated load drop of an SG based on the load path indicated on Figure 5-2. Note that as illustrated in Figure 6-2, there are three (3) ERCW lines which run adjacent to each other under the load path resulting in three impact locations on Figure 6-1.

The ERCW system piping is arranged in four headers (1A, 1B, 2A, and 2B) each serving certain components in each unit as follows:

1. Each header supplies ERCW to one of the two Containment Spray heat exchangers associated with each unit.
2. The primary cooling source for each of the Diesel Generator heat exchangers is from the Unit 1 headers. Each diesel also has an alternate supply from the Unit 2 headers of the opposite train.

3. The normal cooling water supply to Component Cooling System (CCS) heat exchangers 1A1 and 1A2, 2A1 and 2A2, and 0B1 and 0B2, is from ERCW headers 2A, 2A, and 2B, respectively.
4. Each A and B supply header in each unit header provides a backup source of Feedwater for the turbine-driven Auxiliary Feed Pumps in the respective unit.
5. Each of the two discharge headers provides a backup source of Feedwater for the motor-driven Auxiliary Feedwater Pumps in each unit.
6. Headers 1A and 1B provide ERCW cooling water to the control room and Control Building electrical board room air-condition systems.
7. Each A and B header in each unit supplies ERCW cooling water to the Auxiliary Building ventilation coolers for safeguard equipment, the Containment ventilation system coolers, the Reactor Coolant Pump (RCP) motor coolers, the control rod drive vent coolers, and the Containment instrument room cooler's water chillers in the respective unit.
8. Headers 1A and 1B provide a backup source of cooling water for the Station Air Compressors.
9. Headers 1A and 2B provide ERCW cooling water for the Shutdown Board room air conditioners and Auxiliary Control Air Compressors.
10. Headers 2A and 2B provide ERCW cooling water for the Emergency Gas Treatment room coolers and boric acid transfer and Unit 2 Auxiliary Feedwater Pump space coolers.
11. Headers 1A and 1B provide ERCW cooling water for the CCS pumps and Unit 1 Auxiliary Feedwater Pump space coolers.
12. Under flood conditions, ERCW provides water to the Spent Fuel Pit heat exchangers, Reactor Coolant Pump thermal barriers, ice machine refrigeration condensers, and sample heat exchangers, and the Residual Heat Removal heat exchangers as needed.

Technical Specification 3/4.7.4 (both units have the same Technical Specification requirements) requires that at least two independent ERCW loops be operable in Modes 1-4. The Bases of Technical Specification 3/4.7.4 indicate that the operability of the ERCW system ensures that sufficient cooling capacity is available for continued operation of safety-related equipment during normal and accident conditions. The Unit 2 systems that require ERCW are not required to be operable while the reactor is defueled.

6.4 Unit 2 Refueling Water Storage Tank

As discussed in UFSAR Section 3.8.4.1.4, the Unit 2 Refueling Water Storage Tank (RWST) is a Seismic Category I structure, but is not tornado missile protected. Pipes from the Unit 2 RWST to the Auxiliary Building are housed in reinforced concrete tunnels. A storage basin is provided around the Unit 2 RWST to retain a quantity of borated water in the event the RWST is ruptured by a tornado missile or other initiating event.

The design function of the Unit 2 RWST, as indicated in UFSAR Sections 5.5.7.2.2, 6.3.2.2 and 6.3.3.12, is to provide borated water for (1) filling the Refueling Canal during refueling and (2) the Safety Injection, Residual Heat Removal, and Containment Spray pumps during the Emergency Core Cooling System (ECCS) function. These design functions are not required while the Reactor is defueled.

UFSAR Table 6.3.2-3 provides the minimum storage volume for the accumulators and RWST. As indicated in UFSAR Section 6.3.2.6, this minimum storage volume is sufficient to ensure that after a RCS break, sufficient water is injected and is available within the Containment to permit recirculation flow to the core, and to meet the net positive suction head requirements of the RHR pumps.

Unit 2 Technical Specification 3/4.5.5 requires the Unit 2 RWST to be operable in Modes 1-4. The Bases for Technical Specification 3/4.5.5 indicate that the operability of the Unit 2 RWST as part of the ECCS ensures that a sufficient supply of borated water is available for injection by the ECCS in the event of a LOCA.

6.5 Unit 2 Primary Water Storage Tank

As indicated in UFSAR Section 11.2.2, the Unit 2 Primary Water Storage Tank (PWST) is one of the outside tanks used to store low-level radioactive liquids. Based on UFSAR Section 3.8.4.1.4, the PWST is not a Category I tank (i.e., the PWST is non-seismic, non-tornado missile protected, and non-safety related). Section 11.2.3 of the UFSAR indicates that the Unit 2 PWST has a high level alarm and an overflow line that discharges to the ERCW pipe tunnel.

6.6 Unit 2 Main Steam Piping

UFSAR Section 10.3 describes the Main Steam supply system. The system is designed to conduct steam from the steam generator outlets to the High Pressure Turbine, the Condenser Steam Dump System, and to other components. Downstream of the Main Steam Isolation Valves (MSIVs), the steam lines follow the outside perimeter of the Unit 2 Shield Building until they enter the Turbine Building.

As described in UFSAR Section 10.3.2.1, the MSIVs and Main Steam Bypass Isolation Valves are provided to protect the plant following a break in the steam header downstream of the MSIVs, as well as to protect the plant from the effects of a break in the steam line from on steam generator inside the Unit 2 Containment or upstream of MSIV, and from the effects of a steam generator tube rupture. UFSAR Section 3.5.5 states that tornado missile protection is not required for the portion of the Main Steam piping downstream of the MSIVs.

Unit 2 Technical Specification 3/4.7.1.5 requires that four MSIVs be operable in Modes 1-3. The Bases for Technical Specification 3/4.7.1.5 indicate that the operability of the MSIVs ensures that no more than one steam generator will blow down in the event of a steam line rupture.

6.7 Unit 2 Feedwater Piping

As described in UFSAR Section 10.4.7.1, the Condensate Feedwater System is designed to supply a sufficient quantity of feedwater to the steam generator secondary side inlet during normal operating conditions and to guarantee that feedwater will not be delivered to the steam generators when feedwater isolation is required. The portion of the system from the steam generators back through the check valve and isolation valve is designed as TVA Class B.

Unit 2 Technical Specification 3/4.7.1.6 requires that four Main Feedwater Isolation Valves (MFIVs), four Main Feedwater Regulating Valves (MFRVs), and four MFRV Bypass Valves be operable in Modes 1-3. The Bases for Technical Specification 3/4.7.1.6 indicate that isolation of the Main Feedwater System is provided when required to mitigate the consequences of a steam line break, feedwater line break, excessive feedwater flow, and loss of normal feedwater (and station blackout) accident.

6.8 Fire Protection System Piping

Section 12.1 of Part II of the Sequoyah Fire Protection Report (FPR) indicates that the High Pressure Fire Protection (HPFP) system water supply is common to both units and consists of one electric motor driven fire pump and one diesel engine driven fire pump. Each pump takes suction from its own 300,000 gallon potable water storage tank which is supplied by the local municipal utility. Each pump is connected to the HPFP system looped yard main by a separate supply line that can be isolated.

A fire protection water distribution system is provided to serve both units and is cross-tied between the units. Sectional isolation valves are provided so that maintenance may be performed on portions of the loop while maintaining fire fighting capability. The sectional isolation valves in the underground loop are locked or sealed in position and surveillance is performed to ensure proper system alignment.

The HPFP system is also connected to the two fire/flood mode pumps (old fire pumps) which can be utilized by opening the normally closed valves which isolate them from the system.

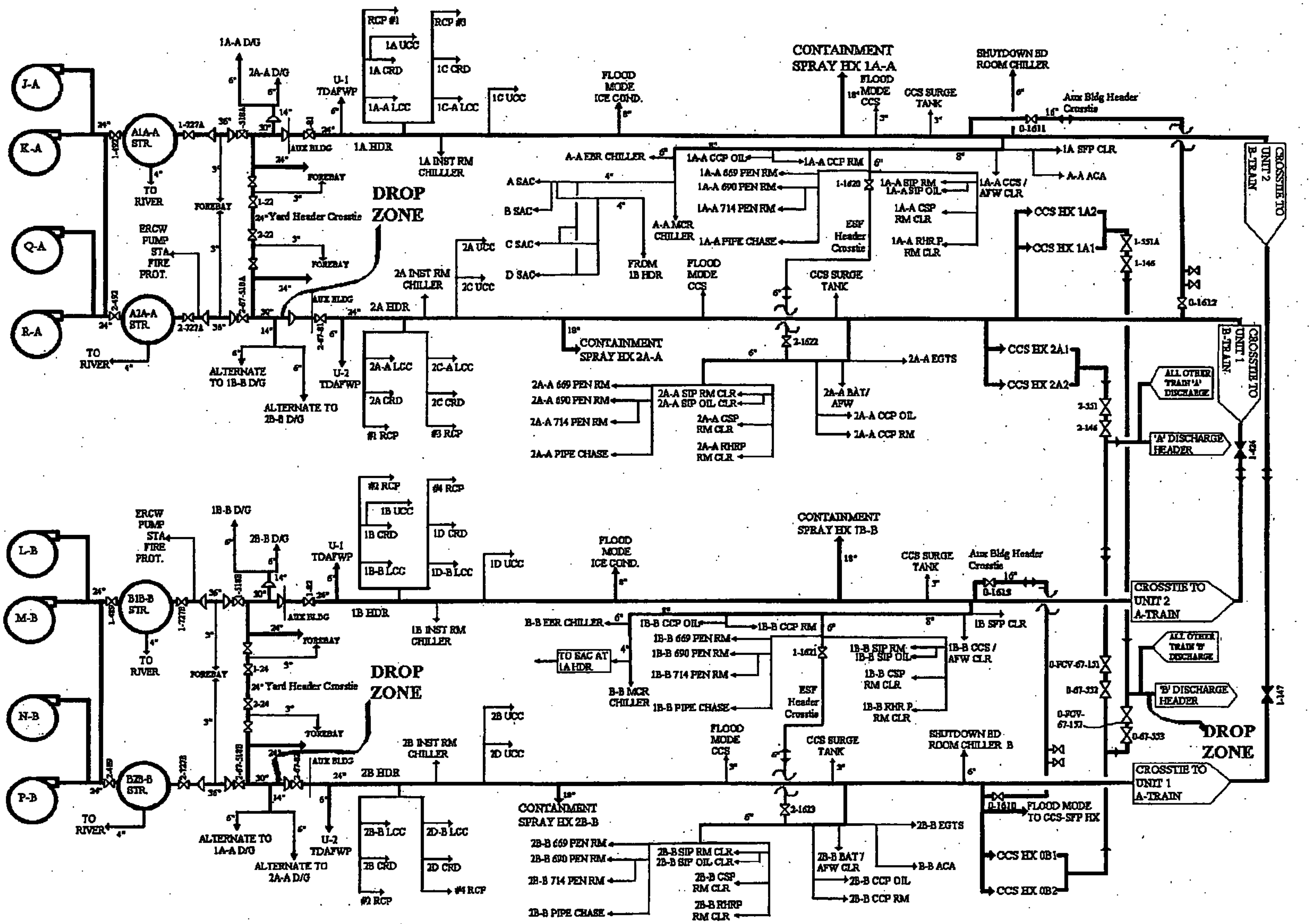

Figure 6-1 – Simplified ERCW System Diagram Showing OLS Drop Zones

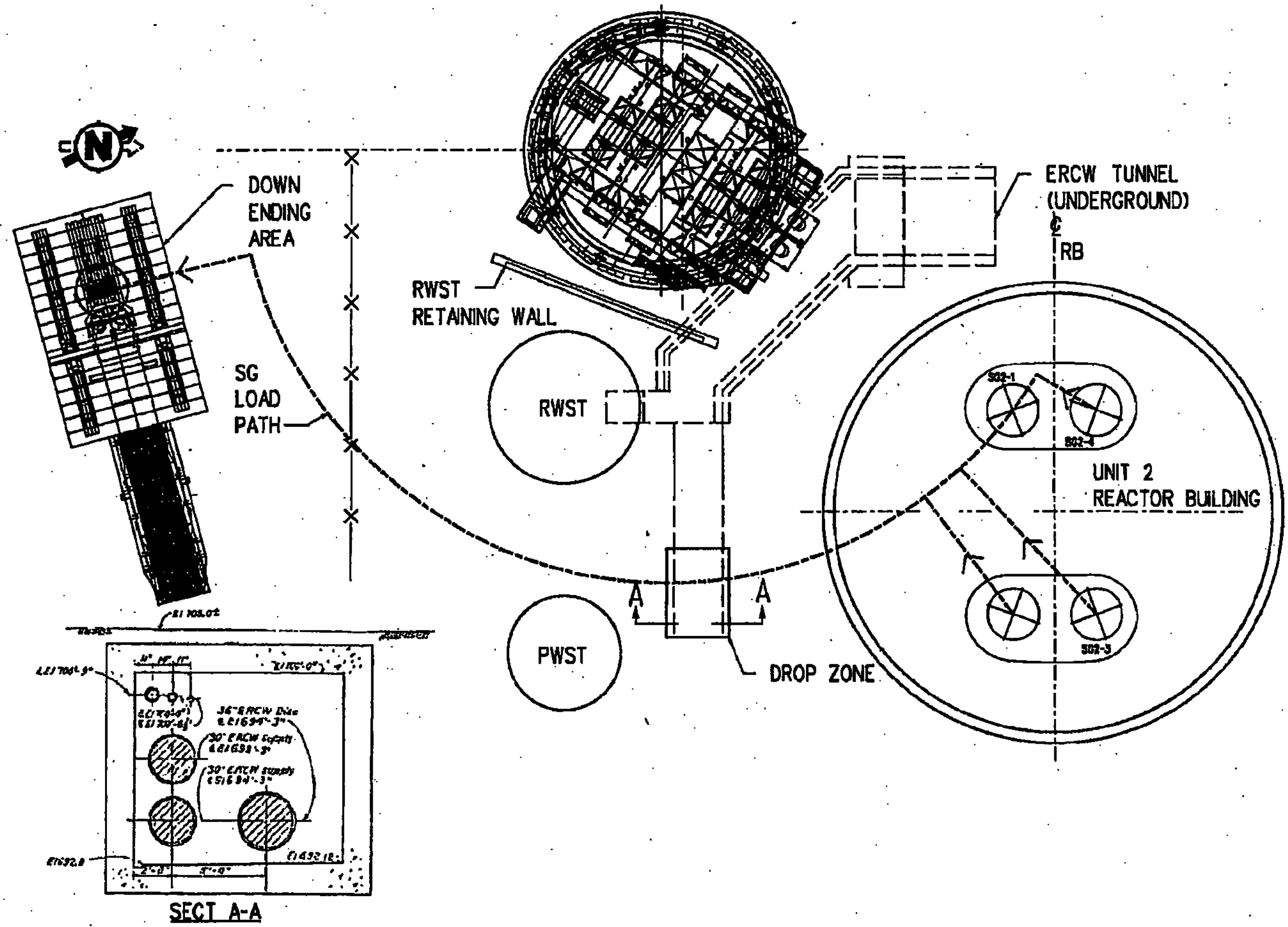

Figure 6-2 – Heavy Load Lifting Postulated Drop Zone

7.0 Postulated Load Drops

Details of the design of the cranes being used (including their seismic capability), inspections and load testing performed on these cranes, restrictions on operation of the cranes, operator training, and procedural controls have been provided in the previous sections. Given these considerations, it is highly unlikely that a load will be dropped from these cranes. However, as required by NUREG-0612, load drops from each of these cranes have been postulated and the potential consequences of these postulated drops evaluated.

Rigging of the heavy loads described in Section 5 will be performed within the load paths defined on Figure 5-2. In the event of a non-mechanistic failure of a crane or rigging equipment resulting in a load handling accident, the load is assumed to impact within the evaluated load path. Reference 16 evaluated safety-related buried commodities in the vicinity of heavy lift load path for postulated load drops from OLS and other cranes to be utilized for the Unit 2 SGR Project.

As detailed in Section 5, the heaviest loads being handled are the Steam Generators. Other significant loads include Shield Building concrete sections, SCV steel sections, Steam Generator Compartment roof concrete sections, and OLS components during assembly/disassembly.

7.1 Steam Generator Load Drops

Accidental dropping of a SG inside the Unit 2 Containment has been evaluated as part of the rigging engineering package and its associated 10 CFR 50.59 evaluation. Lifting of heavy loads inside or above the Unit 2 Containment with the OLS (PTC Crane) will not commence prior to completion of defueling. Since all fuel will be removed from the Unit 2 Containment and the spent fuel pit (SFP) will be isolated from the Unit 2 Containment, a load drop from the OLS inside or above the Unit 2 Containment will not result in: 1) releases of radioactive material due to damage to spent fuel, 2) damage to fuel or fuel storage racks, or 3) damage to the reactor vessel or spent fuel pool that causes a loss of water and the fuel to be uncovered.

Equipment required for safe shutdown of Unit 1 may be affected by a load drop from the OLS inside or above the Unit 2 Shield Building. Common systems involved are the ERCW System, Component Cooling System (CCS), and Essential Air Distribution System. To ensure that a load drop from the OLS inside or above the Unit 2 Shield Building will not affect the ability to shut down Unit 1, valves located outside of the Unit 2 Shield Building for the ERCW System, CCS, and Essential Air Distribution System will be closed prior to lifting heavy loads with the OLS. Therefore, a load drop from the OLS inside or above the Unit 2 Containment will not affect the ability to shut down the operating unit (Unit 1).

If a SG drop is postulated to occur while the SG is above the Unit 2 Shield Building dome, it is assumed to fall vertically onto the dome directly below where it is suspended at the time. If the SG were to roll off of the dome it could potentially hit the auxiliary or control buildings and impact the spent fuel pool and/or equipment required to safely shutdown Unit 1. As noted above, with the reactor defueled, outside Unit 2 Containment isolation valves for ERCW and CCS closed, and the Spent Fuel Pit isolated from the Unit 2 Containment, and the capability to manually isolate control air to the Unit 2 Containment, a load drop inside the Unit 2

Containment will not impact fuel or prevent the safe shutdown of Unit 1. Given the consequences of a SG impacting the Auxiliary or Control Buildings, handling of the SGs must be done in a manner that assures that if a SG drop occurs above the Shield Building dome, it penetrates the dome rather than rolling off of it.

<u>SG Drop Above the Unit 2 Shield Building/Containment</u>

Two SG load drop situations above the temporary truss structure/Shield Building/Containment have been considered; those within a radial distance from the center of the Unit 2 Containment of about 55 ft (remote from Shield Building ~131 ft diameter cylindrical shell wall) and those between this region and the parapet (near the cylindrical shell wall). Since the Unit 2 reactor will be defueled while the SGs are being moved, the primary concern with a SG drop is the SG trajectory following impact with the Shield Building dome and its subsequent impact location.

SG Drop Above the Unit 2 Shield Building - Away From Unit 2 Shield Building Wall

The SG drop trajectory following vertical impact from an arbitrary height onto the dome is difficult to predict. Since the lift height of the SG is only limited by the capability of the OLS, a substantial clearance between the SG and the Shield Building dome will be maintained by lifting the SGs vertically through the Unit 2 Containment and Shield Building openings until a defined minimum clearance is attained. The SGs will then be translated horizontally to the outer edge of the Shield Building, as shown on Figure 5-2. Applying an energy balance methodology to a rigid-plastic shell model, it was analytically determined (Reference 16) that a SG drop from a height of 12.75 ft or greater will perforate the concrete Unit 2 Shield Building dome and the SCV. A drop from this height ensures complete penetration of the SG through the temporary truss structure located above the Unit 2 Shield Building dome, through the Unit 2 Shield Building dome itself, and into the Containment, as opposed to a response characterized by impact with and deflection off the Shield Building dome. A minimum clearance from the Shield Building dome of 20 ft will be used when lifting the SGs. This 20 ft clearance is within the lifting limit and operational capability of the OLS. Some substantial conservatisms support the conclusion that perforation and entry will occur. These conservatisms are: 1) neglect of energies associated with local deformations, 2) consideration of the "laminar" concrete dome as a contiguous or single layer, 3) neglect of the weakening effect of the openings, and 4) use of a lift height (20 ft) that is over 50% greater than that calculated for perforating the dome.

SG Drop Above the Unit 2 Shield Building – Near the Unit 2 Shield Building Wall

As the SGs near the edge of the Unit 2 Shield Building dome, it no longer becomes possible to analytically show that the SG penetrates the Unit 2 Shield Building dome and SCV dome. At this point, a dropped SG is assumed to tumble over the edge of the Containment and impact the ground somewhere near the Shield Building wall along the load path. It may also impact the side of the Shield Building as it falls. Since it is difficult to predict exactly where the SG will impact, SSCs within and near the load path were assumed to be affected. The potentially affected SSCs in the vicinity of this postulated drop location are the Unit 2 Shield Building, ERCW tunnel and pipes, Unit 2 RWST, Unit 2 PWST, Unit 2 MS piping, Unit 2 FW piping, and Fire Protection System piping.

SG Drop Along the Unit 2 Shield Building Wall

The SGs will be lowered/raised by the OLS near the Unit 2 Shield Building wall above the load path shown on Figure 5-2. A SG drop in this area is assumed to impact directly below where the SG is being lowered/raised. Since the impact area is bounded by the area assumed for the postulated SG drop above the Shield Building near the Shield Building wall, the consequences of the drop along the Shield Building wall are also bounded.

SG Drop Between the Lowering/Raising Area and the Downending/Upending Area

A SG drop along the load path between the lowering/raising area and the downending/upending area is assumed to impact SSCs within the flopover distance (approximately 70 ft from the impact point on the load path) of the SG. Those SSCs potentially affected by a SG drop between the lowering/raising area and the downending/upending area are the same SSCs identified as potentially affected by a SG drop above the Unit 2 Shield Building near the Unit 2 Shield Building wall.

OSG Drop Dose Consequences

For the Unit 1 SGR, the radiological consequences of the drop of a transported OSG were concluded to be more conservative from a dose standpoint than those associated with OSG failures within Containment. Specifically, Reference 30 determined that the radiological consequences of an OSG drop outside the Unit 1 Shield Building along the haul route between the Unit 1 Shield Building and the Unit 1 OSG Storage Facility (OSGSF) were more conservative due to the close proximity of the failed OSG to the Exclusion Area Boundary (EAB) where, as described below, the acceptance values for dose consequences to the public are regulatorily defined.

Within Reference 30, the acceptability of the offsite dose consequences associated with a postulated drop of an OSG was evaluated and compared to the consequences of postulated design basis accidents for a gaseous release. For assessing offsite dose consequences, the drop of an OSG was considered to most closely resemble a rupture of a tank containing radioactive material. Failure of the Waste Gas Decay Tank (WGDT) (Reference UFSAR Section 15.3.5) is the limiting event evaluated in the UFSAR for accidental gaseous release from a tank. As indicated in UFSAR Section 15.5.2, the respective dose limits for Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) for the WGDT rupture accident are 1.8 Rem and 0.22 Rem, respectively. From UFSAR Section 15.5.3, the dose limit given for control room operators is 5 Rem.

Reference 30 conservatively assumed that 10% of the OSG activity would be released due to the impact of the drop during OSG transport and that 1% of this release amount would be in the form of particulates small enough to become airborne. Confirmatory NRC analyses of the early SGRs also used this percentage of activity release. Based on an isotopic survey of the CVCS, the prime contributors to the offsite dose due to a SG drop were determined to be Ni-63, Co-60, Cs-134 and Cs-137. Using these conservative assumptions, the maximum calculated control room dose was determined to be 3.76×10^{-2} Rem whole body. The offsite doses from a postulated drop at the limiting location along the haul route (Reference 30, Table 14) were:

At the EAB

4.86 x 10^{-2} Rem whole body (which correlated to the WGDT gamma dose)

3.02 x 10^{-4} Rem to the skin (which correlated to the WGDT beta dose)

At the LPZ

1.07 x 10^{-3} Rem whole body (which correlated to the WGDT gamma dose)

3.00 x 10^{-4} Rem to the skin (which correlated to the WGDT beta dose)

For the Unit 1 SGR, the resultant radiation dose values that were calculated for an OSG drop and postulated rupture were well within the above-described UFSAR dose limits for the comparative WGDT rupture.

UFSAR Section 15.5.2 presents the radiological consequences of a WGDT rupture in the context of 10 CFR 100. The Basis for Technical Specification 3/4.11.2.6 describes the SQN site's compliance with NRC Standard Review Plan Section 15.7.1 (Reference 31) for limiting the Curie content in waste gas systems such that any single failure of a component will not result in a whole body dose at the nearest exclusion area boundary in excess of 0.5 Rem. This limit on dose is greater than the calculated dose for an OSG drop. For the Unit 1 SGR, the evaluated consequences of an OSG drop were within the applicable regulatory criteria of NRC Standard Review Plan Section 15.7.1 and were much less than the limiting licensing design basis accidents evaluated in Chapter 15 of the UFSAR.

During the Spring 2011 Unit 2 refueling outage, radiological sampling data was obtained from the Unit 2 OSGs in order to make a comparison between the radiological and radiation dose characteristics of the Unit 1 and Unit 2 OSGs. This comparison includes factors such as approach distances of transported OSGs to the EAB for the Unit 1 and Unit 2 SGRs, the location of the Unit 2 OSGSF immediately adjacent to the Unit 1 OSGSF, and comparison of isotopic survey data between the Unit 1/Unit 2 OSGs. The conclusion of this comparison, as documented in Reference 32, is that the dose consequences of a postulated drop of an OSG during Unit 2 SGR transport are bounded by the dose consequences described above for the Unit 1 SGR (Reference 30), and therefore would be acceptable.

Summary of OSG Drop Dose Calculation for the SQN Unit 2 SGR Project

Calculation NDQ00200020100242, *Old Steam Generator Storage Facility Dose Assessment and OSG Drop Dose Considerations*, (Reference 32) was performed for the Unit 2 SGR Project. This calculation determines the radiological impacts at the exclusion area boundary (EAB), the low population zone (LPZ), and the control room (CR) due to a postulated load drop of an OSG during the steam generator replacement. The scenario postulated to cause the failure was a drop of an OSG from the outside lift system (OLS) crane or from the transporter at the most conservative location for occurrence along the haul route between the Unit 2 Containment and the Unit 2 OSG Storage Facility (OSGSF). The assumptions, inputs and methodologies used to determine the dose consequences, are stated below.

Input for OSG Drop Dose Calculation

1. Based on surveys taken during the Unit 2 Spring 2011 refueling outage, the highest dose rate at a radial distance of 3 feet from the outside surface of the shell in the vicinity of the tube region (at elevation 722 ft) was 60 mR/hr. This dose rate was lower than the value obtained during a survey performed between February 25, 2000 and March 1, 2000 on the Unit 1 OSGs which found a dose rate of 85 mR/hr for the same general area. Additional surveys taken during the November 2001 outage show the maximum dose rate at 3 ft from steam generator No. 3 was 85 mR/hr at elevation 722 ft with the primary side full and the secondary side drained. This calculation conservatively used a dose rate of 85 mR/hr at 10 ft to conservatively bound the collected data from all radiological surveys.

2. Isotopic surveys for a number of components in the reactor cleanup and radwaste systems during full power operation were also performed to develop Calculation NDQ00200020100242. Chemical and Volume Control System (CVCS) resin and drain tank residue represent the worst case distributions since they have the highest fractions of Co-60, the most dominant contributor to organ and whole body doses. The CVCS distribution was selected because it has higher amounts of Cs-134 and Cs-137 than the drain tank residue; these isotopes are also important dose contributors. Since the isotopic surveys were taken while Unit 2 was at power and the SG external dose rate survey was only a few days after shutdown, the two surveys were well matched in time and thus no adjustment was necessary.

3. Dimensions of the tubes within the OSGs and of the tube region of the OSG were as reported in UFSAR Table 5.5.2-1.

4. For Calculation NDQ00200020100242, the maximum accident atmospheric dispersion factors (X/Qs) utilized were as presented in the table below:

Table 7-1 – Atmospheric Dispersion Factors (X/Qs)

Release Point	Dose Point	X/Q (sec/m^3)	Reference
Containment	EAB	1.64E-3	UFSAR, Table 15A-2
Containment	LPZ	1.96E-4	UFSAR, Table 15A-2
Containment	CR	1.59E-3	UFSAR, Table 15.5.3-6
Haul Route or OSGSF	EAB	2.71E-3	See X/Q Calc Summary Below
Haul Route or OSGSF	LPZ	4.51E-5	See X/Q Calc Summary Below

5. For Calculation NDQ00200020100242, the maximum breathing rate of persons offsite and in the control room is 3.74E-4 m^3/sec (Regulatory Guide 1.4, Sheet 2). This rate was conservatively assumed for the duration of the accident.

6. Doses are calculated using the inhalation, air submersion, and ground deposition dose conversion factors (DCFs) in Federal Guidance Reports 11 and 12 (EPA-520/1-88-020 and EPA-402-R-93-081).

7. Based on experimental data and NRC recommendation, the structural shielding factor used for 0.75 for submersion and 0.33 for ground deposition (NUREG/CR-5164, Sheet 18; NUREG/CR-4551, Volume 2, Part 7 Sheet 3-28). These factors account for the shielding provided by buildings and other structures during normal activities.

8. Based on experimental data for various aerosol compositions and sizes and various deposition surfaces, the mean ground deposition velocity used was 0.3 cm/sec (NUREG/CR-4551, Volume 2, Part 7, Sheet 2-21).

Assumptions for OSG Drop Dose Calculation

1. It was assumed that 90 percent of the total SG isotopic inventory was in the tube region and that this activity corresponds to the dose rates measured in the vicinity of the tube region. Of the three regions of the generator (steam dome, tube region, channel head), it was assumed that most of the activity was in the tube region because the channel head is much smaller than the tube region and the steam dome, by design, is expected to have negligible levels of activity. The isotopic inventory inside the tube region was calculated based on this dose rate and the known isotopic distribution and physical dimensions. The inventory for the entire SG was then estimated by dividing the tube region activity by 90 percent.

2. It was assumed that 10 percent of the SG activity was released due to the impact of the drop and that 1 percent of this release amount was in the form of particulates small enough to become airborne. Hence, the fraction of the total SG activity that gets released to the environment is 0.001. The use of the 0.1 percent of the isotopes for dose assessments has been used historically on other steam generator replacements (SGRs). The early SGRs were not performed under the requirements of 10 CFR 50.59. Instead, a repair report was prepared and submitted to the NRC for review and concurrence. As part of its review, the NRC performed confirmatory analyses that used this percentage of isotopes being released. Recent SGRs performed under 10 CFR 50.59 have continued to use this isotopic release percentage.

3. All activity releases were assumed to occur within the first two hours of the accident. This is conservative as it minimizes the dispersion of activity released to the environment, thereby maximizing the doses.

4. The inhalation dose to the control room operator was calculated using the atmospheric dispersion factor for the control room, but without taking credit for the control room structure.

5. LPZ doses due to ground deposition are conservatively calculated assuming no evacuation or remediation during the 30-day exposure period.

6. The control room is closer to the Containment than to any point on the haul route. It was therefore assumed that the control room dose from a SG rupture at the Containment bounds the dose from a rupture at any point along the haul route or at the OSGSF.

Methodology for OSG Drop Dose Calculation

The Calculation NDQ00200020100242 dose analysis was performed using the following steps:

1. Using the worst case measured isotopic distribution for the activity inside the OSG, a characteristic energy spectrum was calculated in the units of MeV/sec by energy group. See Table 7-2 below (Table 1 of Attachment A of Calculation NDQ00200020100242).

2. The energy spectrum (Step 1) was used in a point-kernal computer program to calculate a dose rate 10 ft from the outside of the OSG.

   As the dose measurement was taken with the primary side of the generators filled with water and the secondary side drained, the internal medium of the tube region was modeled as a homogenized mixture of steel and water. The homogeneous density of the tube region was calculated by dividing the total mass of the steel and water by the volume of the region.

3. By ratioing the calculated dose rate (Step 2) to the measured dose rate 10 ft from the outside of the OSG, a source adjustment factor was determined. Dividing this ratio by 90% (Assumption 1) yielded an adjustment factor of 9.0. The assumed initial isotopic inventory (Input 2) was multiplied by 9.0 to obtain the estimated total activity inside the generator.

4. The isotopic distribution (Step 1) was multiplied by the source adjustment factor (Step 3) to obtain the isotopic activities inside the OSG corresponding to the measured dose rate of 85 mR/hr at 10 ft from the outside of the OSG.

5. It was assumed that a certain fraction (Assumption 2) of the isotopic activity in the OSG (Step 4) is released to the environment as a result of the rupture. For a given isotope and organ, the inhalation, submersion, and deposition doses were calculated based on the guidance in NUREG/CR-5164. Doses were calculated for the Containment to EAB pathway. The doses for the other pathways were obtained by applying X/Q ratios to the total EAB doses. The doses from all isotopes and pathways were summed to arrive at the total dose.

The total activity in the SG was calculated by Calculation NDQ00200020100242 to be 777 Ci, with approximately 8 percent being from Fe-55, 6 percent from Co-58, 18 percent from Co-60, 38 percent from Ni-63, 12 percent from Cs-134, and 15 percent from Cs-137. The rupture of each SG was postulated to release 0.777 Ci to the atmosphere.

Table 7-2 – Isotopic Survey Data from CVCS Resin Tank*

Isotope	µCi/g	Isotope	µCi/g	Isotope	µCi/g	Isotope	µCi/g
H-3	3.99E-03	Ni-59	2.79E-01	Sn-113	2.90E-02	Pu-239	2.30E-04
C-14	6.72E-01	Ni-63	3.26E+01	Sb-125	4.94E-01	Pu-240	2.30E-04
Mn-54	1.11E+00	Zn-65	3.65E-02	I-129	5.60E-05	Pu-241	3.13E-02
Fe-55	6.71E+00	Sr-89	7.49E-03	Cs-134	1.01E+01	Am-241	1.00E-04
Co-57	1.94E-01	Sr-90	1.07E-01	Cs-137	1.30+01	Cm-242	2.59E-04
Co-58	4.98E+00	Tc-99	1.08E-04	Ce-144	1.25E-02	Cm-243	2.66E-04
Co-60	1.59E+01	Ag-110m	7.87E-02	Pu-238	6.51E-04	Cm-244	2.66E-04
						TOTAL	**8.63E+01**

*These values were specified for the Unit 1 evaluation and were determined to be bounding for the Unit 2 evaluation.

Table 7-3 – Summary of Doses from OSG Rupture*

Event	Release Point	Dose Point	Dose (Rem)			
			Whole Body	Lung	Bone	Skin
Drop from Crane	Containment	EAB	2.94E-02	1.28E-01	9.55E-02	1.83E-04
		LPZ	4.63E-03	1.62E-02	1.27E-02	1.30E-03
		CR	3.76E-02	1.31E-01	1.03E-01	1.06E-02
Drop During Transport	Haul Route	EAB	4.86E-02	2.11E-01	1.58E-01	3.02E-04
		LPZ	1.07E-03	3.73E-03	2.93E-03	3.00E-04
		CR	3.76E-02	1.31E-01	1.03E-01	1.06E-02

*These values were specified for the Unit 1 evaluation and were determined to be bounding for the Unit 2 evaluation.

<u>Summary of X/Q Calculation</u>

Bechtel Calculation 24370-M-001, *Steam Generator Replacement X/Q Analysis* was performed for Unit 1 in support of the dose calculation to estimate the worst-case atmospheric dispersion factors (X/Qs) at the EAB and at the LPZ for a hypothetical steam generator drop accident occurring at any point along the steam generator haul route (Figure 1) during the SGR. The results of Calculation 24370-M-001 are contained in Calculation NDQ00200020100242 as Attachment A and are applicable to Unit 2. A summary of the calculation is as follows.

Input

1. The representative meteorological data used were as reported in UFSAR Section 2.3 and Tables 2.3.2-23 through 29, "Joint Percentage Frequencies of Wind Speed by Wind Direction" for the 10-meter level (1/1/72-12/31/75).

2. Distance/location information for the EAB and LPZ were as reported in UFSAR Table 2.3.4-1 and Section 2.3.4.2, respectively. Centered on the Unit 1 Containment vent, a radius of 4828 m was used for the outer boundary of the LPZ.

3. The Containment Building cross-sectional area (1800 m^2) used in estimating the atmospheric dispersion factors were as reported in UFSAR Section 2.3.5.2.

4. A haul route drawing (see Figure 5-6) shows the locations of the steam generator haul route and the old steam generator storage facility (OSGSF).

5. The elevation at the top of the Containment Building is 856.04 ft with a grade elevation of 705 ft. Therefore, the physical height above ground level of the Containment Building is 151 ft (46 m).

Assumptions

1. It was assumed that a postulated steam generator drop could occur at any point along the identified haul route from the Unit 1 Containment to the OSGSF.

2. To account for the reduction in vertical cross-sectional area due to the sloping roof of the Containment Building, the top of the Containment was assumed to be about 45 m for modeling purposes.

Methodology

1. The primary methodology used was based on information contained in the following guidance documents:

   a. NRC Regulatory Guide 1.145 - "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Rev. 1.

   b. NUREG/CR-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations."

2. Since for a nonbuoyant ground-level release, ground-level pollutant concentrations decrease with increasing downwind distance, the shortest distance from the haul route to the EAB and LPZ for points corresponding to the 16 wind direction sectors was determined.

Based on guidance provided in Section 1.2 of Regulatory Guide 1.145, the assumed release points for each of the 16 directions were determined from Figure 5-6 as the minimum distance between any point on the haul route and the EAB for each direction. The shortest distances between each direction specific release point on the haul route and the EAB are presented in Table 7-4. The LPZ is the area within a 4828 m (15840 ft) radius measured from the Unit 1 Shield Building vent. The shortest distance from the haul route to the LPZ was found to be 4196 m measured from the OSGSF (located near the north end of the haul road) in the north direction. Since shorter distances are generally associated with less dispersion, this minimum distance was conservatively used in all directions to calculate the X/Q values at the LPZ (see Table 7-5).

3. UFSAR Section 2.3.2.4 indicates that terrain variations in the site region are minimal. Therefore, site-specific terrain adjustment factors (TAFs) were not used in the model.

4. The PAVAN model was configured to calculate X/Q values assuming both wake-credit allowed and wake-credit not allowed. The closest EAB is located 666 feet (203 m) from the haul road in the N and NNW directions (Table 7-4). The Containment Buildings are 151 feet (46 m) above grade. The maximum wake-influence distance between a wake-producing structure and a release point was assumed to be 10 "building heights" downwind of the structure. This distance was based on guidance contained in Regulatory Guide 1.23, Proposed Rev. 1, for the siting of meteorological instruments away from wake-producing objects/structures. The shortest distances from the haul road to the EAB are less than 10 building heights away in the NW, NNW, N, NNE, NE, and ENE directions. Receptors at these sectors are therefore located within the building wake influence zone induced by the Containment Building. Thus, the PAVAN "wake-credit allowed" scenario results were used for the X/Q analysis at these sectors. However, the entire LPZ, which at its shortest distance from the haul route is 13765 feet (4196 m), is located beyond this wake influence zone. Thus, the PAVAN "wake-credit not allowed" scenario results were used for the X/Q analysis at the LPZ.

5. As described in Section 1.4 of Regulatory Guide 1.145, the 0-2 hour and annual average 5% site limit X/Q values were used to determine the X/Q values for the intermediate time periods by the logarithmic interpolation approach described in the PAVAN computer code.

6. Based on Regulatory Guide 1.145, the 0.5% sector X/Q or the 5% overall site X/Q, whichever was higher, was selected. Summarized below (Table 7-5) are the maximum X/Q values for the EAB and LPZ.

Table 7-4 – Shortest Distances from the Haul Route to the EAB and LPZ

Sector	Distance from Unit 1 Shield Bldg Vent to EAB		Shortest Distance from Haul Road to EAB		Shortest Distance from Haul Road to LPZ	
	feet	meters	feet	meters	feet	meters
N	3100	945	666	203.0	13756	4195.6
NNE	2402	732	800	243.8	13756	4195.6
NE	2300	701	1200	365.8	13756	4195.6
ENE	1824	556	1450	442.0	13756	4195.6
E	1850	564	1760	536.4	13758	4195.6
ESE	2001	610	1900	579.1	13756	4195.6
SE	2100	640	2065	629.4	13756	4195.6
SSE	2300	701	2167	660.5	13756	4195.6
S	2851	869	2500	762.0	13756	4195.6
SSW	3225	983	2967	904.3	13756	4195.6
SW	4199	1280	3556	1083.9	13756	4195.6
WSW	2999	914	2560	780.3	13756	4195.6
W	2201	671	1940	591.3	13756	4195.6
WNW	2149	655	1690	515.1	13756	4195.6
NW	2175	663	1045	318.5	13756	4195.6
NNW	2402	732	666	203.0	13756	4195.6

Table 7-5 – EAB and LPZ X/Q Values

Time Period	Exclusion Area Boundary		Low Population Zone	
	Sector/Distance (m)	Max. X/Q Value (sec/m^3)	Sector/Distance (m)	Max. X/Q Value (sec/m^3)
0 to 2 Hours	N / 203 m	2.71E-03	N/A	N/A
0 to 8 Hours	N / 203 m	1.84E-03	SSW / 4196 m	4.51E-05
8 to 24 Hours	N / 203 m	1.52E-03	SSW / 4196 m	3.39E-05
1 to 4 Days	N / 203 m	1.00E-03	SSW / 4196 m	1.82E-05
4 to 30 Days	N / 203 m	5.50E-04	SSW / 4196 m	7.42E-06

Auxiliary Building Flooding

As indicated above, a postulated OLS load drop could affect the ERCW tunnel and pipes, Unit 2 RWST, Unit 2 PWST, and Fire Protection System piping. The failure of any of these tanks and pipes could result in flooding of the Auxiliary Building via the ERCW pipe tunnel. UFSAR Section 9.3.3.7 states that the Auxiliary Building has a passive sump that collects water from annulus drain sumps, and blowout panels located in the floors of the pipe chases and the Containment Spray and RHR pump rooms. Per Reference 33, the passive sump has a capacity of 210,862 gallons, and a water level sensor in the passive sump alarms in the Main control room. Compensatory measures to preclude flooding of safety-related equipment in the Auxiliary Building following a postulated large heavy load drop are described in Section 8.2.

7.2 Unit 2 Shield Building Concrete Section Load Drops

As indicated in Section 5.5, the Shield Building concrete sections will be approximately 20 ft by 45 ft and will weigh less than 132.5 tons (265 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the steam generators, they will only be raised a maximum of twelve feet above the top of the Unit 2 Shield Building dome in order to clear construction-related interferences during rigging. This lift height and the inherent shape of the concrete sections will eliminate the potential for them to rebound from the Unit 2 Containment in an unanticipated direction. Given that the size and mass of these concrete sections are bounded by those of the steam generators, the consequences of a Unit 2 Shield Building concrete section load drop are bounded by the steam generator drops described in Section 7.1.

7.3 Unit 2 Containment Vessel Steel Section Load Drops

As indicated in Section 5.5, the Unit 2 SCV steel sections will be approximately 20 ft by 45 ft and weigh no more than 15.5 tons (31 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the steam generators, they will only be raised a maximum of twelve feet above the top of the Unit 2 Shield Building dome in order to clear construction-related interferences during rigging. This lift height and the inherent shape of the Unit 2 SCV sections will eliminate the potential for them to rebound from the Containment in an unanticipated direction. With regard to rigging of the Unit 2 SCV steel cut sections by either the Liebherr LR 1400/1 / Liebherr LR 1400/2 crawler crane or by the OLS, postulated drops of these steel sections from crane failures have been evaluated in Reference 24 to result in no failure of the ERCW lines over which these loads will travel because of load handling limitations for these lifts and the physical protection of the ERCW lines provided to them by their soil depth and the concrete protection features of the Unit 2 pipe tunnel containing these ERCW lines.

7.4 Unit 2 Steam Generator Compartment Roof Plug Load Drops

As indicated in Section 5.5, the Steam Generator Compartment roof concrete sections will be 18-20 ft in diameter and will weigh less than 65 tons (130 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the steam generators, they will only be raised a maximum of twelve feet above the top of the Unit 2 Shield Building dome in order to clear construction-related interferences during rigging. This lift height and the inherent shape of the concrete sections will eliminate the potential for them to rebound from the Shield Building in an unanticipated direction. Given that the size and mass of these concrete sections are bounded by those of the steam generators, the consequences of a SG compartment roof plug concrete section load drop are bounded by the SG drops described in Section 7.1.

7.5 OLS Component Load Drops During OLS Assembly/Disassembly

As indicated in Section 5.3, the OLS components vary in size and weight. These components will be handled in the OLS assembly/disassembly area shown on Figure 5-2. The crane components will be off-loaded from the tractor-trailers using mobile cranes and forklifts. During the offload process, the components will be lifted slightly higher than the trailer bed and lowered to the ground. Offloading locations used will minimize the potential for impacting the Unit 2 RWST and ERCW piping, and use of the safe load handling paths defined in Figure 5-2 precludes any adverse effect upon these SSCs. During assembly/disassembly of the OLS, when it is not possible to eliminate a potential impact with identified interferences, timber mats, steel mats, or steel plate will be used to distribute the impact from a load drop. The consequences of OLS component load drops have been evaluated to be acceptable based on provision of this protection.

8.0 Heavy Load Drop Protection Plans/Compensatory Measures

Section 4 details the regulatory requirements/criteria that are relevant to the handling of heavy loads over safety-related equipment and summarizes conformance with these requirements/criteria. As discussed in Section 4.2, Section 5.1.5 of NUREG-0612 indicates that the effects of load drops should be analyzed (in accordance with the guidelines of Appendix A to NUREG-0612) and the results should indicate that damage to safe shutdown equipment is not sufficient to preclude safe shutdown.

Each of the potentially affected SSCs identified in Section 6 has been analyzed in accordance with the NUREG-0612 guidance to determine the effects of a load drop. Summarized below is the protection required to preclude an adverse effect and/or the actions or compensatory measures required to mitigate these effects should a load drop occur. Provision of the identified protection and taking the specified actions and compensatory measures assures that safe shutdown can be achieved following a load drop. In addition, it will be confirmed that the assumptions made within this technical report regarding the status of the station are valid prior to heavy load handling activities.

8.1 Unit 2 Containment

The heavy loads of concern that will be handled above the Containment will only be moved while the Unit 2 reactor is defueled. With fuel removed from the Containment, the only other safety issue is whether a load drop into the Unit 2 Containment will affect systems common to both units that pass through the Unit 2 Containment. To preclude a SG drop inside the Unit 2 Containment from affecting Unit 1, the ERCW system, Component Cooling System (CCS), and the Essential Air Distribution System will be isolated with valves outside of Containment prior to performing heavy lifts with the OLS. In addition, the Spent Fuel Pit (SFP) shall be isolated from the Unit 2 Containment to preclude adverse effects to the SFP and the Spent Fuel Pool Cooling System.

8.2 Auxiliary Building

Heavy loads will not be handled over the Auxiliary Building and, as discussed in Sections 7.1, 7.2, 7.3, and 7.4, will not roll off the Shield Building dome and onto the Auxiliary Building. Therefore, no additional protection of the Auxiliary Building roof is required.

In the event a large heavy load drop results in the failure of Unit 2 RWST, Unit 2 PWST, and/or ERCW piping in the pipe tunnel (e.g., the "2A" and "2B" ERCW supply headers could fail such that this supply header piping is severed or leaks), the associated pipe tunnel could fill with water. To preclude flooding of the Auxiliary Building resulting from a large heavy load drop, a temporary wall (see Figure 8-1) will be installed in the ERCW pipe tunnel near the Auxiliary Building interface to separate the ERCW pipe tunnel from the Auxiliary Building prior to handling of heavy loads using the OLS. A door will be provided as part of the wall to allow access to the tunnel, if required. This wall will be installed prior to movement of heavy loads with the OLS and will be capable of withstanding the hydrostatic and velocity head of water from the postulated piping failures and loads created by the nearby drop of a steam generator or other large heavy load. It will also meet Sequoyah Seismic I (L) requirements, so that an earthquake would not cause a failure of nearby safety-related SSCs as a result of a seismically-induced failure of the wall (Reference 34). In the event of a heavy load drop, Operations will monitor the amount of water collecting behind the temporary pipe tunnel wall separating the SQN Unit 2 pipe tunnel from the Auxiliary Building and will determine the leak rate. Based on the leak rate and the accumulated volume of water, pre-established methods (e.g., temporary pumps to remove the water that collects in the Auxiliary Building passive sump from pipe tunnel wall leakage) will be utilized to remove water from the Auxiliary Building that leaks past the temporary pipe tunnel wall in order to maintain the Operability of required components in the Auxiliary Building.

UFSAR Section 9.3.3.7 states that the Auxiliary Building has a passive sump that collects water from annulus drain sumps, and blowout panels located in the floors of the pipe chases and the Containment Spray and RHR pump rooms. Any leakage through the temporary pipe tunnel wall will eventually drain to the passive sump. Reference 33 calculates the passive sump as having a capacity of 210,862 gallons. As described in UFSAR Section 6.3.2.11, the passive sump has a water level sensor in the passive sump that alarms in the main control room. In addition, TVA plans to have temporary pumping equipment available onsite to remove excess water from the Auxiliary Building passive sump. Prior to the commencement of heavy load lifts with the OLS, the passive sump water level will be verified to be less than 12 inches.

8.3 Essential Raw Cooling Water System

In the event of a large heavy load drop that would negatively impact the Essential Raw Cooling Water (ERCW) System pipe tunnel, analysis has been performed to demonstrate that, assuming worst case damage of the ERCW System piping running through the pipe tunnel, adequate heat removal capability will be maintained to required equipment serviced by the ERCW System. Large heavy loads with the potential to negatively impact the ERCW System pipe tunnel, if dropped, are a steam generator (SG), Shield Building concrete cut section, or SG compartment roof plug. Each of these large heavy loads would be handled using the Outside Lift System (OLS). The three affected sections of ERCW piping which are postulated to fail from a drop of a rigged SG, Shield Building concrete cut section, or SG compartment roof plug (i.e., those sections of ERCW piping that are located in the pipe tunnel which runs through the drop zone depicted in Figure 6-2) are the "2A" and "2B" ERCW supply headers and the "B" ERCW discharge header. The worst case damage of the ERCW System piping running through the pipe tunnel, in the event of a large heavy load drop, is assumed to be severing each of the "2A" and "2B" ERCW supply headers and crushing the "B" ERCW discharge header piping such that no flow is possible through the discharge header (References 28 and 29). In order to ensure that adequate heat removal capability is maintained if this event were to occur, the ERCW System is required to be pre-aligned before commencement of large heavy load handling that could potentially damage the piping running through this pipe tunnel. Prior to commencement of any heavy load movement with the OLS, the portions of the "2A" and "2B" ERCW supply headers in the drop zone will be isolated from the remaining ERCW piping, the "1A" and "2A" ERCW supply headers will be cross-tied together, and the "1B" and "2B" ERCW supply headers will be cross-tied together, the "1A" and "2A" ERCW Engineered Safety

Features (ESF) headers will be cross-tied together, and the "1B" and "2B" ESF headers will be cross-tied together. Valve 0-67-546C will be throttled, the ERCW supplies to the Unit 2 Reactor Building, the Unit 2 Containment Spray Heat Exchangers, and the Unit 2 Turbine Driven Auxiliary Feedwater Pump will be isolated. In addition, prior to commencement of any heavy load movement with the OLS, the "A" and "B" ERCW discharge headers will be aligned (i.e., cross-tied) such that ERCW discharge flow normally passing through the portion of the "B" ERCW discharge header that is located in the drop zone would flow through the "A" ERCW discharge header in the event of a large heavy load drop that crushed the "B" ERCW discharge header piping resulting in isolation of this discharge flow path. These isolations and alignments are shown on Figure 8-2.

To establish a minimum boundary for isolation of the "2A" ERCW supply header piping in the drop zone from the remaining ERCW piping, valves 2-FCV-67-81, 2-VLV-67-505A and 2-VLV-67-518A, are to be closed and ERCW alternate supply lines to the 1B-B Diesel Generator and the 2B-B Diesel Generator are to be isolated. To establish a minimum boundary for isolation of the "2B" ERCW supply header piping in the drop zone from the remaining ERCW piping, valves 2-FCV-67-82, 2-VLV-67-505B and 2-VLV-67-518B, are to be closed and ERCW alternate supply lines to the 1A-A Diesel Generator and the 2A-A Diesel Generator are to be isolated. Other valves that isolate larger segments of the ERCW piping may be isolated in lieu of the listed valves. To compensate for these isolations, the "1A" and "2A" ERCW supply headers will be cross-tied together by fully opening 0-VLV-067-1611 and 0-VLV-067-1612 and the "1B" and "2B" ERCW supply headers will be cross-tied together by fully opening 0-VLV-067-1610 and 0-VLV-067-1613. Also to help compensate for these isolations, the "1A" and "2A" ESF headers will be cross-tied together by fully opening 1-VLV-067-1620 and 2-VLV-067-1622 and the "1B" and "2B" ESF headers will be cross-tied together by fully opening 1-VLV-067-1621 and 2-VLV-067-1623. To ensure a flow path for ERCW discharge in the event a large heavy load drop crushes the portion of the "B" ERCW discharge header in the drop zone, discharge valves 0-VLV-67-552, 0-VLV-67-553, 0-FCV-67-151 and 0-FCV-67-152 are to be fully opened. Valve 0-67-546C will be throttled to an intermediate position to ensure that required flow rates are met and to minimize cavitation potential in certain areas. As a difference from the Unit 1 SGR Project ERCW alignment, the evaluated heavy load drop zones for the Unit 2 SGR Project ERCW alignment are located well away from ERCW piping that is required to remain intact following a postulated drop of a SG, Shield Building concrete section, or SG enclosure concrete roof plug. Therefore, the analysis for the effects of wave propagation that were performed for the Unit 1 SGR Project are not required to be performed for the Unit 2 SGR Project.

The ERCW System was analyzed using the alignment/configuration described above in order to demonstrate that adequate heat removal capability would be maintained to all required equipment serviced by the ERCW System. With the ERCW System in this alignment/configuration, it has been demonstrated by flow and water temperature modeling performed in References 28 and 29, that the ERCW System is capable of servicing required heat loads to ensure continued operation/safe shutdown of SQN Unit 1 (such as motor-driven auxiliary feedwater pumps), in addition to supplying ERCW to all other essential equipment (such as spent fuel pool cooling), provided that the ERCW System supply header average water temperature is maintained less than or equal to 74°F.

The ERCW System flow model used for this analysis utilized the same methodology as that used to support the SQN License Amendments regarding increased temperature and level limits of the Ultimate Heat Sink (i.e., Amendments 317 and 307 for SQN Units 1 and 2, respectively, dated September 28, 2007 (Reference 35)). This computer flow model was developed to perform a steady-state hydraulic analysis of the ERCW System and has been used to analytically determine the flow rates in the ERCW System needed for meeting plant design basis conditions. The ERCW System flow model is periodically validated by system flow balance testing and continuing inspections that assure that no degraded or non-conforming conditions exist that would invalidate the conclusions of the analyses. A physical ERCW System flow balance was performed in May 1997, an extensive data gathering test was performed in 2002, physical changes to the ERCW System have been incorporated into the flow model and validated, and the flow model is maintained current through continued updates and validation following ERCW System modifications that are made.

Therefore, with pre-alignment of the ERCW System as described above prior to the movement of any heavy load using the OLS, no operator action would be required, after a large heavy load drop, to ensure that the ERCW System maintains adequate heat removal capability for all required SQN Unit 1 equipment (such as motor-driven auxiliary feedwater pumps) and all other essential equipment (such as spent fuel pool cooling) serviced by the ERCW System.

Due to the potential to adversely affect both trains of ERCW, an amendment to the Unit 1 Operating License and Technical Specification 3.7.5, "Ultimate Heat Sink," is proposed. Using the NRC commitments presented in Appendix A of this technical report, the amendment to the Unit 1 Operating License amendment and Technical Specification 3.7.5 will include the specific compensatory actions to address large heavy load handling above the ERCW lines which could challenge the integrity of these lines in the unlikely event of a postulated load drop, and will include other conditions regarding rigging of these large heavy loads that are derived from the assumptions and analyses described above. Additionally, the conclusion of the acceptability of the ERCW alignment described above is predicated on the results of ERCW System sensitivity review performed in Reference 29, which limits the average maximum water temperature for the ERCW supply header at 74°F. This 74°F ERCW supply header average water temperature limitation has been captured as a prerequisite action to large heavy load movement involving the steam generators, the Shield Building concrete cut sections, and the SG compartment roof plugs that is stated in the NRC Commitments in Appendix A of this technical report that will form part of the amendment to the Unit 1 Operating License and will also be defined in the proposed change to Technical Specification 3.7.5.

8.4 Unit 2 Refueling Water Storage Tank

As noted in Section 6.4, the Unit 2 RWST is a Seismic Category I structure, but is not tornado missile protected. Pipes from the Unit 2 RWST to the Auxiliary Building are housed in reinforced concrete tunnels. A storage basin is provided around the tank to retain a quantity of borated water in the event the tank is ruptured by a tornado missile or other initiating event.

As shown on Figure 5-2, no heavy loads will be carried over the Unit 2 RWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 2 is defueled, loss of the Unit 2 RWST function has no safety impact. However, a failure of the Unit 2 RWST piping in the pipe tunnel between the Unit 2 RWST and the Auxiliary Building could result in flooding in the Auxiliary Building from OLS failure during lifts of the steam generators, the Shield Building concrete cut sections, and the SG compartment roof plugs. Measures to address the potential for flooding of the Auxiliary Building during this OLS rigging are described in Section 8.2.

The mobile cranes used for assembly/disassembly of the OLS will be positioned such that a load drop will not impact the Unit 2 RWST. Since the mobile cranes will be used while Unit 2 is in Modes 1-6, the positioning of these cranes away from the Unit 2 RWST assures that the Unit 2 RWST function will be available, if required.

8.5 Unit 2 Primary Water Storage Tank

As noted in Section 6.5 and shown on Figure 5-2, heavy loads will be carried over the Unit 2 PWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 2 is defueled, loss of the Unit 2 PWST function has no safety impact. However, a failure of the Unit 2 PWST piping in the pipe tunnel between the Unit 2 PWST and the Auxiliary Building could result in flooding in the Auxiliary Building from OLS failure during lifts of the steam generators, the Shield Building concrete cut sections, and the SG compartment roof plugs. Measures to address the potential for flooding of the Auxiliary Building during this OLS rigging are described in Section 8.2.

8.6 Unit 2 Main Steam Piping

As noted in Section 6.6, the MS piping outside the Unit 2 Shield Building is a potentially affected SSC for the postulated load drops described in Section 7. Because during Unit 2 operation a heavy load drop induced failure of the MS piping will be isolated by closure of the MSIVs (refer to UFSAR Section 15.4.2.1, "Rupture of a Main Steam Line"), no protective measures are required to be applied to this piping for this plant condition. During Unit 2 shutdown when the MS system is out-of-service, isolation of this piping is administratively controlled by plant procedures.

8.7 Unit 2 Feedwater Piping

As noted in Section 6.7, the Unit 2 FW piping outside the Shield Building is a potentially affected SSC for the postulated load drops described in Section 7. Because during Unit 2 operation a heavy load drop induced failure of the FW piping will be isolated by closure of the FW isolation valves (refer to UFSAR Section 15.4.2.2, "Major Rupture of a Main Feedwater Pipe"), no protective measures are required to be applied to this piping for this plant condition. During Unit 2 shutdown when the FW system is out-of-service, isolation of this piping is administratively controlled by plant procedures.

8.8 Fire Protection System Piping

As noted in Section 6.8, the high-pressure fire pump and flood mode pump piping in the pipe tunnel are potentially affected SSCs for the postulated load drops described in Section 7. To minimize the impact of a rupture of this piping on flooding of the pipe tunnel, valves 2-26-575 and 2-26-653 will be closed prior to OLS movement of the steam generators, the Shield Building concrete cut sections, and the SG compartment roof plugs. Closure of these valves minimizes the actions that need to be taken to isolate a break. Closing these valves will not affect plant operation.

With respect to the impact of closing Unit 2 valves 2-26-575 and 2-26-653 of the High Pressure Fire Protection (HPFP) System, the piping from valve 2-26-575 to valve 2-26-653 comprises one of the four feeders to the auxiliary building fire protection ring header. The auxiliary building ring header design requirements are that no more than one of the feeders be out of service. Normal plant processes will be used to document the isolation of the feeder. Therefore, there is no impact on Operability of the HPFP System from the isolation of this piping segment. The only action required from the isolation of this piping segment is to prevent the isolation of a second feeder to the auxiliary building ring header. Current plant administrative processes address these controls and will be used to control this activity during the SGR heavy load lift compensatory measures.

As indicated in Appendix A, the fire protection piping inside the ERCW pipe tunnel will be isolated prior to commencement of load movements with the OLS. The purpose of this action is to minimize the potential contribution of water from fire protection piping on flooding of the ERCW tunnel due to failure of the fire protection piping inside the ERCW tunnel as a result of a load drop from the OLS. Isolation of this piping segment will also eliminate any possibility of depressurizing the HPFP System due to the postulated load drop, thus reducing the actions that must be performed following a load drop. As indicated above, isolation of this portion of the fire protection piping will not affect the Operability of the fire protection system.

Underground fire protection piping in the yard areas where the mobile cranes are operating has been evaluated for the surcharge loads created by the mobile cranes. This piping is not adversely affected by these surcharge loads. Sectionalizing valves are provided to isolate potential faults. A fault in the fire protection piping due to a mobile crane load drop is no different in its consequences than a fault created by other means. Therefore, the consequences of a load drop from a mobile crane would be mitigated by closure of the appropriate sectionalizing valve(s). An evaluation of the adequacy of soil cover over the fire protection piping was not performed, since the consequences of a mobile crane failure or a load drop from a mobile crane were no different than other fire protection piping faults.

8.9 Outline for Compensatory Measures for Heavy Load Drop Protection

Due to physical proximity, several piping segments are in jeopardy of being broken or crushed by a postulated heavy load drop from the outside lift system (OLS) that will be performed during the Unit 2 shutdown and defueled condition. These lines include the essential raw cooling water (ERCW) 2A and 2B Supply Headers, the B ERCW Return Header, the Unit 2 primary water storage tank (PWST), the Unit 2 refueling water storage tank (RWST), and the associated piping for these two tanks. A postulated pipe break of the ERCW system could occur in the yard (i.e., underground) or in a pipe tunnel. A postulated rupture of the RWST and PWST could occur such that the water also goes into the pipe tunnel or onto the ground in the yard. Additionally, a fire protection supply line is present in the tunnel. Of these, the lines that have potential consequences for safe operation of Unit 1 are the ERCW supply and return headers. Since the consequences of ERCW pipe ruptures are potentially serious for Unit 1, compensatory measures will be instituted to place the ERCW system in a cross-tied alignment that has been demonstrated by analysis to maintain the capability of Unit 1 to be safely shut down with no reliance upon the ERCW piping that can be potentially damaged from a heavy load drop during OLS operation. This analysis is described in further detail in Section 8.3.

General Operating Instructions will be modified to proceduralize the alignments and other plant operations-related activities that must be in place before OLS heavy lifting activities commence. Compensatory measures in the unlikely event of a heavy load drop during OLS operation will be implemented using an abnormal operating procedure (AOP).

The zone where the potential for damage to the ERCW supply and return headers exists is the load path between the reactor building openings and the upending/downending area for the SGs starting at ~7 feet from the inside of the parapet wall until the upending/downending area is reached. For the Shield Building concrete sections and steam generator compartment roof concrete plug, the zone is between the Reactor Building openings starting at ~7 feet from the inside of the parapet wall and until the load is 3 ft above grade. Refer to Figure 5-2 for details on the load paths. In the event of a load drop of any of these loads (SG, Shield Building concrete section, SG compartment roof plug) in the zone potential for piping damage exists, the ERCW system will be inspected immediately. In addition, preparations will immediately commence for an orderly shutdown of Unit 1.

The principle attributes of the plant procedures to mitigate the consequences of a heavy load drop during the Unit 2 steam generator replacement outage are as follows.

- A specific operating procedure will be developed as a subsection (or attachment) to the General Operating Instructions that will address the required configuration of key common systems and structures prior to the start of large heavy load lifts. The operating procedure will ensure systems structures are aligned as required in approved design documentation associated with the U2 steam generator replacement outage before any large heavy load lift activities. The key common systems and structures that could be affected from a heavy load lift accident would be the ERCW System, Component Cooling Water System (CCS), Essential Air Distribution System, High Pressure Fire Protection System, Auxiliary Building including pipe tunnel, and the Spent Fuel Pit and the Spent Fuel Pool Cooling System. The system and structure configurations described below (Refer to Actions Prior to Commencement of OLS Large Heavy Load Lift) will be performed prior to conducting large heavy load handling using the crane (OLS), which includes lifts of the OSGs and RSGs, sections of concrete removed from the Unit 2 Shield Building dome, and the SG compartment concrete roof plugs. For the ERCW System, an alignment will be utilized, as described in Section 8.3 which will ensure that in the event of a heavy load drop, the ERCW System is maintained Operable.

- An AOP will be developed to initiate actions associated with a large heavy load drop. The AOP will initiate appropriate Operator actions to identify and mitigate consequences associated with a large heavy load drop.

The above procedures will be approved and in-place before heavy load lifts begin. Operating crews (licensed and non-licensed Operating personnel as applicable) will receive training for these procedures during a cycle of operator requalification training that will be conducted prior to the Unit 2 steam generator replacement outage. In addition, "just-in-time" refresher training will be conducted to specific applicable crew(s) prior to each heavy lift. Drafts or procedures will be available to support training as part of Operator requalification training.

In recognition of the plant consequences of a postulated load drop event, Sequoyah plant staff will also be closely examining other scheduled maintenance-tasks, as well as any failures that may arise, in accordance with the requirements of 10 CFR 50.65(a)(4).

The actions contained in these compensatory measures will ensure that Unit 1 can be safely brought to cold shutdown and maintained in cold shutdown in the unlikely event of a large heavy load drop.

Actions Prior to Commencement of OLS Large Heavy Load Lift

Prerequisite Actions to Heavy Load Movement with the Outside Lift System (OLS)

1. Install a wall in the Sequoyah Nuclear Plant (SQN), Unit 2, pipe tunnel to seal the tunnel from the Auxiliary Building. Ensure this temporary wall is intact and all openings are sealed. Ensure this temporary wall is fitted with a sight glass and instrument connection with a pressure gauge, which will allow detection and quantification of water accumulating behind the temporary wall. Means will be provided to quantify any leakage through the wall. Measures will be in place to suitably handle significant leakage through the temporary SQN Unit 2 pipe tunnel wall.

2. Develop and issue plant procedure(s) to delineate specific actions required in case of a large heavy load drop from the OLS to address monitoring any leakage through the temporary SQN Unit 2 pipe tunnel wall and the actions to be taken to respond to detected leakage into the Auxiliary Building. Concerning Plant Operations training, Operations crews (licensed and non-licensed Operating personnel as applicable) will receive training for these procedures during a cycle of requalification training, and "just-in-time" refresher training will be conducted to specific crew(s) prior to each heavy lift.

3. When erecting the OLS, utilize the safe load paths defined in procedures. During assembly of the OLS, when it is not possible to eliminate a potential impact with the Essential Raw Cooling Water (ERCW) System piping and where protection is necessary for other buried commodities, utilize timber mats, steel mats, or steel plate to distribute the impact from a load drop.

4. Ensure that ERCW System supply header average water temperature is less than or equal to 74°F.

5. Place the ERCW System in the alignment to support large heavy load lifts prior to the heavy load lifts occurring with the OLS. This alignment is as follows:

   a. Isolation of the portions of the "2A" and "2B" ERCW supply headers in the drop zone from the remaining ERCW piping.

      To establish a minimum boundary for isolation of the "2A" ERCW supply header piping in the drop zone from the remaining ERCW piping, valves 2-FCV-67-81, 2-VLV-67-505A and 2-VLV-67-518A, are to be closed and ERCW alternate supply lines to the 1B-B Diesel Generator and the 2B-B Diesel Generator are to be isolated. To establish a minimum boundary for isolation of the "2B" ERCW supply header piping in the drop zone from the remaining ERCW piping, valves 2-FCV-67-82, 2-VLV-67-505B and 2-VLV-67-518B, are to be closed and ERCW alternate supply lines to the 1A-A Diesel Generator and the 2A-A Diesel Generator are to be isolated.

b. Cross-tie of the "1A" and "2A" ERCW supply headers and cross-tie of the "1B" and "2B" ERCW supply headers.

   To compensate for the isolations of the "2A" and "2B" ERCW supply headers, the "1A" and "2A" ERCW supply headers will be cross-tied together by fully opening 0-VLV-067-1611 and 0-VLV-067-1612 and the "1B" and "2B" ERCW supply headers will be cross-tied together by fully opening 0-VLV-067-1610 and 0-VLV-067-1613.

c. Cross-tie of the "1A" and "2A" ERCW Engineered Safety Features (ESF) headers and cross-tie of the "1B" and "2B" ESF headers.

   Also to help compensate for the isolations of the "2A" and "2B" ERCW supply headers, the "1A" and "2A" ESF headers will be cross-tied together by fully opening 1-VLV-067-1620 and 2-VLV-067-1622 and the "1B" and "2B" ESF headers will be cross-tied together by fully opening 1-VLV-067-1621 and 2-VLV-067-1623.

d. Throttling valve 0-67-546C to reduce flow through CCS heat exchangers "0B1" and "0B2."

   Valve 0-67-546C will be throttled to an intermediate position to ensure that required flow rates are met and to minimize cavitation potential in certain areas.

e. Isolation of the ERCW supplies to the Unit 2 Reactor Building, the Unit 2 Containment Spray Heat Exchangers, and the Unit 2 Turbine Driven Auxiliary Feedwater Pump.

f. Alignment (i.e., cross-tie) of the "A" and "B" ERCW discharge headers.

   To ensure a flow path for ERCW discharge in the event a large heavy load drop the crushes the portion of the "B" ERCW discharge header in the drop zone, discharge valves 0-VLV-67-552, 0-VLV-67-553, 0-FCV-67-151 and 0-FCV-67-152 are to be fully opened.

6. Isolate the high-pressure fire protection pump and the flood mode pump piping in the SQN Unit 2 pipe tunnel to the Auxiliary Building by closing valves 2-26-575 and 2-26-653.

7. Isolate the ERCW System, Component Cooling System, and Essential Air Distribution System to the SQN Unit 2 Containment using valves outside of the SQN Unit 2 Containment to ensure no adverse effects upon SQN Unit 1 from a postulated heavy

load drop of a load handled by the OLS. Ensure that the Spent Fuel Pit and Spent Fuel Pool Cooling System are isolated from the SQN Unit 2 Containment.

Active Monitoring Actions During OLS Operation

Specific monitoring actions required to be performed prior to commencement of, and during, an OLS large heavy load lift are as follows.

1. Ensure that ERCW System supply header average water temperature is less than or equal to 74°F.

2. Ensure the auxiliary building passive sump level is less than 12".

3. Station Operations personnel to visually monitor the crane activities. These personnel observing the load lift will be in direct communication with the main control room to relay status information of the lift to the operating crew.

4. Station Operations personnel to monitor temporary gauges in the Auxiliary Building and to observe for leakage through the temporary wall. These personnel will be in direct communication with the main control room to relay status information regarding potential Auxiliary Building flooding should a large heavy load drop occur.

Actions Following a Load Drop

Specific actions to be accomplished after a heavy load drop from the OLS are as follows.

Immediate Actions

1. Following any load drop in the zone where the potential for piping damage exists, commence an orderly shutdown of Unit 1.

2. Monitor level of water behind the temporary wall using the installed temporary gauges.

3. Monitor for leakage through the temporary wall.

4. Monitor Auxiliary Building passive sump level.

5. Monitor Unit 2 RWST level and Unit 2 PWST level.

Other Actions

Based on a pre-determined leak rate and accumulated volume of water from the temporary wall into the Auxiliary Building, implement pre-established methods (e.g., temporary pumps to remove the water that collects in the Auxiliary Building passive sump from pipe tunnel wall leakage) to remove water from the Auxiliary Building that leaks past the temporary pipe tunnel wall in order to maintain the Operability of required components in the Auxiliary Building.

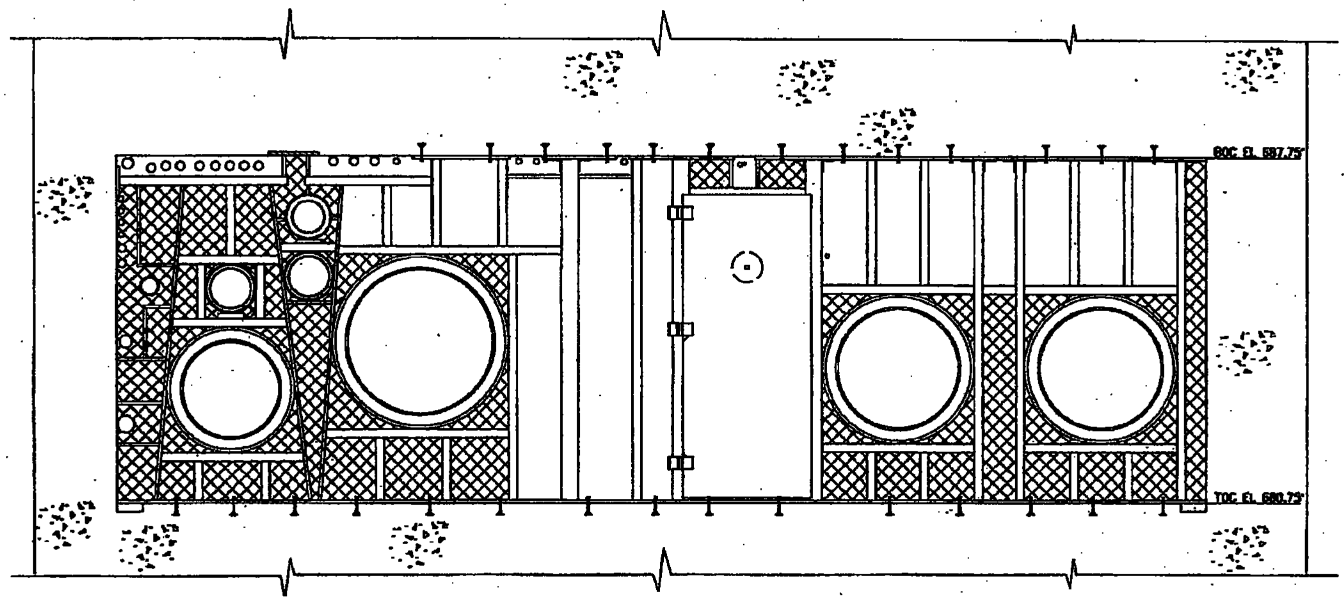

Figure 8-1 - ERCW Tunnel Wall

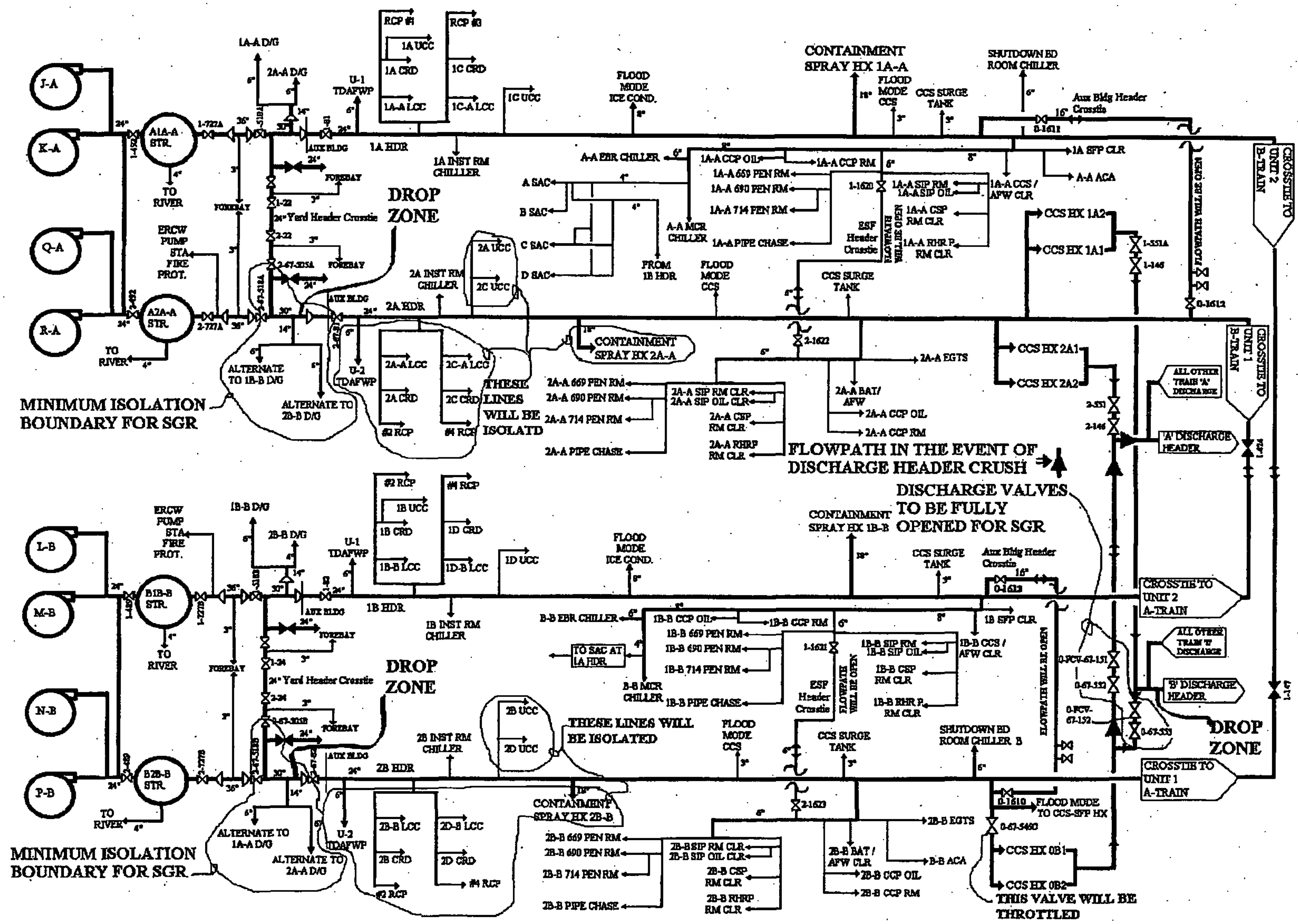

Figure 8-2 - ERCW System Alignment/Configuration for Heavy Load Handling with OLS

9.0 Probabilistic Risk Assessment (PRA) Insights

9.1 PRA General Discussion

The discussions included in this technical report for Unit 2 SGR heavy load handling represent an integrated program by TVA to assess and manage the risks to an operating Unit 1 during the Unit 2 SGR lift operations. The approach was based on a philosophy similar to that provided in NUREG-0612 (Section 5.3, Safety Evaluation) in that years of design, planning, and training have gone into adequate measures to reduce the potential for accidental dropping of heavy loads. While it was not possible to find a practical load path that avoided travel over all safe shutdown equipment, the proposed path has been chosen and planned for to reduce the potential for impact on safe shutdown equipment should a drop occur. Lastly, compensatory measures have been proposed so as not to result in the loss of required Unit 1 safe shutdown functions.

Beyond those provisions, TVA has made additional provisions to decouple certain events as load drop initiators. As was described in Section 5.1, the OLS has been evaluated for seismic loads while unloaded and while loaded with a steam generator. In addition, the OLS has mandatory wind speed restrictions for operation and includes the necessary monitoring instruments to ensure these restrictions are implemented. The OLS is not dependent upon offsite power, so the OLS is already decoupled from loss of offsite power as a load drop initiator.

As noted in Section 5.2 of this technical report, mobile cranes used in the OLS assembly/disassembly have limitations on the areas in which they can operate. Their usage has been evaluated and shown to have no adverse interactions with safety-related SSCs when operated in accordance with these limitations and the weather imposed restrictions.

The OLS will be used for 18 lifts that may result in damage to safety-related SSCs if the load were to be dropped while over or near these SSCs. These lifts and times for which the lifted component is in the zone for postulated damage to safety-related SSCs are described as:

- 2 Shield Building Concrete Cut Sections Removed from the Shield Building Dome (45 minutes each)
- 4 SG Compartment Roof Concrete Plugs Removed from Containment (45 minutes each)
- 4 Old Steam Generators Removed from Containment (30 minutes each)
- 4 Replacement Steam Generators Placed in Containment (30 minutes each)
- 4 SG Compartment Roof Concrete Plugs Rigged Back into Containment (45 minutes each)

Of the safety-related SSCs that may be affected, the only one required to be Operable during these lifts is the ERCW System. Lifts of the above-listed items can only be performed by the OLS. However, lifts of the Unit 2 steel containment vessel (SCV) steel cut sections may be performed by either the Liebherr LR 1400/1 / Liebherr LR 1400/2 crawler crane or by the OLS. As described in Section 7.3, postulated drops of these steel sections from crane failures have been evaluated to result in no failure of the ERCW lines over which these loads will travel because of load handling limitations for these lifts and the physical protection of the ERCW lines provided to them by their soil depth and the concrete protection features of the Unit 2 pipe tunnel containing these ERCW lines.

Concerning the above-listed items (Shield Building concrete cut sections, SG compartment roof concrete plugs, OSGs, RSGs), because of the alignment that ERCW System will be placed in as a prerequisite to conducting these large heavy load lifts, damage can be sustained to the potentially affected ERCW piping without affecting the ability to safely shut down Unit 1, as demonstrated in References 28 and 29.

Transport of the SGs along the haul route is discussed above. As discussed above, with the protection described in place, there will be no impact on safety-related SSCs as a result of a load drop from a transporter.

In addition, a numeric estimate of the impact of the SGR outage lifts on core damage frequency and large early release frequency has been performed and the following summary is provided.

9.2 Technical Adequacy of the Probabilistic Risk Assessment (PRA) Model

The current PRA model for SQN was issued on May 27, 2011. The previous model was updated from RISKMAN to CAFTA, which included a detailed internal flooding analysis, and a more in depth analysis of all plant systems to represent the as built, as operated plant. A peer review of the model was performed in January 2011 on the internal events and internal flooding supporting requirements of the American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) PRA Standard (i.e., ASME/ANS RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications"). The peer review team endorsed the model as being compliant with the ASME/ANS PRA standard with 77 Facts and Observations identified. All of the Facts and Observations were resolved to meet capability category II prior to issue of the model of record.

For the SGR, all the postulated accidents and system alignments are covered in the PRA model. The PRA model is based on the as built, as operated plant design and can be used to evaluate a possible load drop event by applying specific modeling changes. A detailed analysis of where a load drop can occur and what systems can be affected is documented in Sections 6.0 through 8.0. The PRA model was adjusted according to preventative measures listed in Table 5.2A of Reference 45.

9.3 PRA Assumptions

1. The frequency used for the load drop initiator is the industry average value of 5.6E-05 from the BWROG Integrated Risk-Informed Regulation Committee Guidance Document (Reference 44).
2. The new alignment of the ERCW valves is assumed to be in place for sixty days.
3. Each lift of a heavy load is assumed to take one hour, and will occur eighteen times for a total exposure window of eighteen hours.

4. A load drop severs all ERCW lines in the Unit 2 pipe tunnel and the Unit 2 RWST supply line.
5. The probability of dam failure (i.e, failure of the wall installed in the SQN, Unit 2, pipe tunnel that seals the tunnel from the Auxiliary Building) is assumed to be 1.0.
6. There are no operator actions which could isolate the flooding event caused by the load drop prior to impacting the RHR and CS pumps on elevation 653.
7. Mitigation of flooding events that occur on the 2A ERCW header was modeled by requiring isolation of the 1A ERCW header. Similarly, mitigation of flooding events that occur on the 2B ERCW header was modeled by requiring isolation of the 1B ERCW header.

9.4 PRA Modeling

For the steam generator replacement (SGR), the postulated changes in the model concern the change in alignment of the ERCW/CCS discharge headers and the potential load drops that could occur during the crane lifts in support of the SGR. The SQN model of record models all of the valves that are being realigned as part of the changes to support the steam generator replacement.

Initiating Events

<u>Existing Initiating Events Changes</u>

For this analysis the Unit 1 initiating event, %1ERCWDB loss of ERCW discharge header B, was removed from the model. Due to the realignment of the valves in the ERCW discharge headers, if the B header were to become blocked the A header would still be available to provide a sufficient flow path for successful operation of the CCS heat exchangers.

<u>New Initiating Event</u>

As discussed in Sections 6.3 and 8.3 of this technical report, the postulated location of a load drop event is above the B discharge header of ERCW. Therefore a new initiating event called %LOAD_DROP was added to the PRA under Top Event HE, the failure of the ERCW B Discharge Header (i.e., ERCW B Discharge Header is damaged such that no flow is possible through the discharge header pipe). Inserting the new initiator under top event HE ensures the initiator is properly populated throughout the model where the B discharge header is needed, ensuring all the appropriate effects on systems and components are included in the analysis. An industry average per-lift drop frequency of 5.6E-05 was used for this initiator (Reference 44).

Changes to Plant Alignments

The following changes are going to be implemented during the Steam Generator Replacement (Reference 45):

- Isolate the potential heavy load drop zone for the 2A ERCW supply header by isolating 2-FCV-067-0081, 2-VLV-067-0505A and 2-VLV-067-0518A.

- Isolate the potential heavy load drop zone for the 2B ERCW supply header by isolating 2-FCV-067-0082, 2-VLV-067-0505B and 2-VLV-06700518B.

- Cross-tie the A and B discharge headers by fully opening 0-VLV-067-0552, 0-VLV-067-0553, 0-FCV-067-0151 and 0-FCV-067-0152.

- Cross-tie the 1A and 2A ERCW supply headers by fully opening 0-VLV-067-1611 and 0-VLV-067-1612, and by opening 1-VLV-067-1620 and 2-VLV-067-1622.

- Cross-tie the 1B and 2B ERCW supply headers by fully opening 0-VLV-067-1610 and 0-VLV-067-1613, and by opening 1-VLV-067-1621 and 2-VLV-067-1623.

New logic was added to the PRA to represent the ERCW alignment changes during the SGR.

- An AND gate, U0_CCS_SGR_CROSSTIE, was added under gates U0_CCS_CCSTL_G56 and U0_CCS_BC1_G5621 to represent the discharge header cross-tie alignments. The new cross-tie alignment allows both the A and B Train CCS heat exchangers to discharge into the ERCW A discharge header as well the B discharge header.

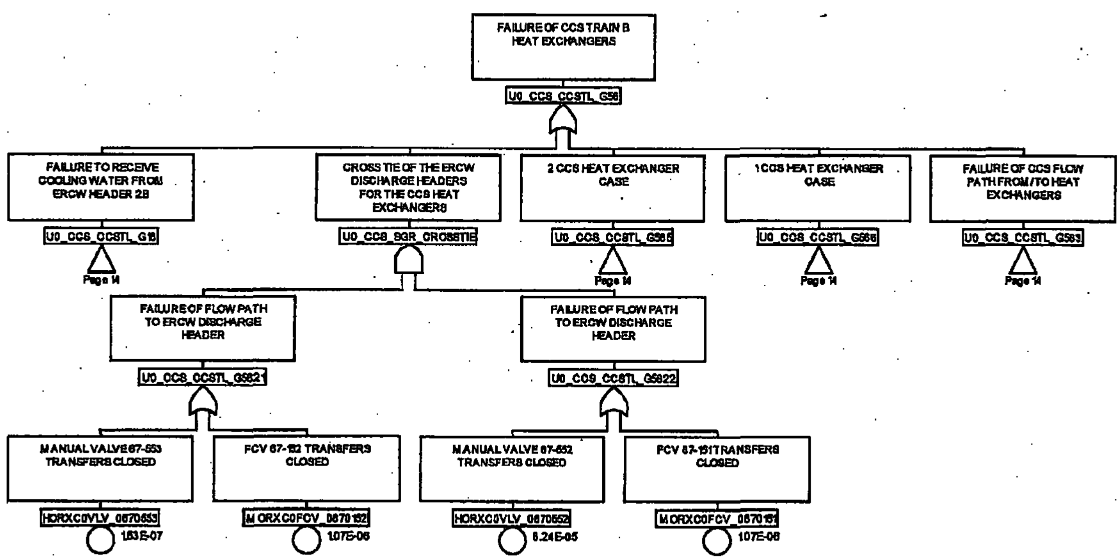

Figure 9-1 – PRA Figure Illustrating Failure of CCS Train B Heat Exchangers

- Gate U1_CCS_SGR_SUPCROSSTIE was added under U1_CCS_AC1_G56 for the A train CCS heat exchangers to represent the supply header cross-tie alignments. This alignment allows for the 1A ERCW supply header to provide cooling to the 1A1, 1A2, 2A1, and 2A2 CCS heat exchangers.

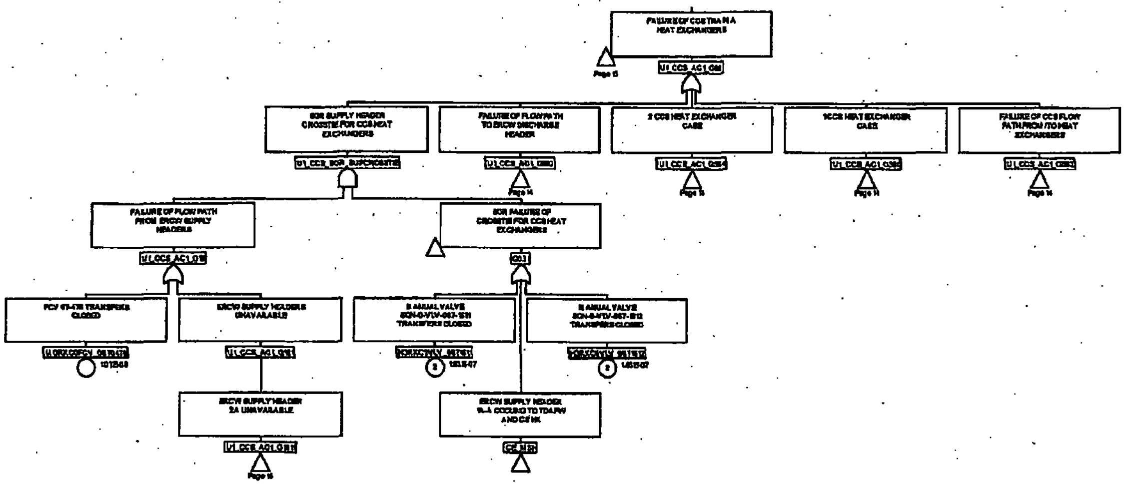

Figure 9-2 – PRA Figure Illustrating Failure of CCS Train A Heat Exchangers

- To address the second crosstie of the A ERCW headers, the current logic for gate EE_ACE, logic was added to account for the opening of the crosstie valves (1-VLV-067-1620 and 2-VLV-067-1622). This lineup allows for an additional flow path to the 1A ESF header equipment supplied by the 2A ERCW header.

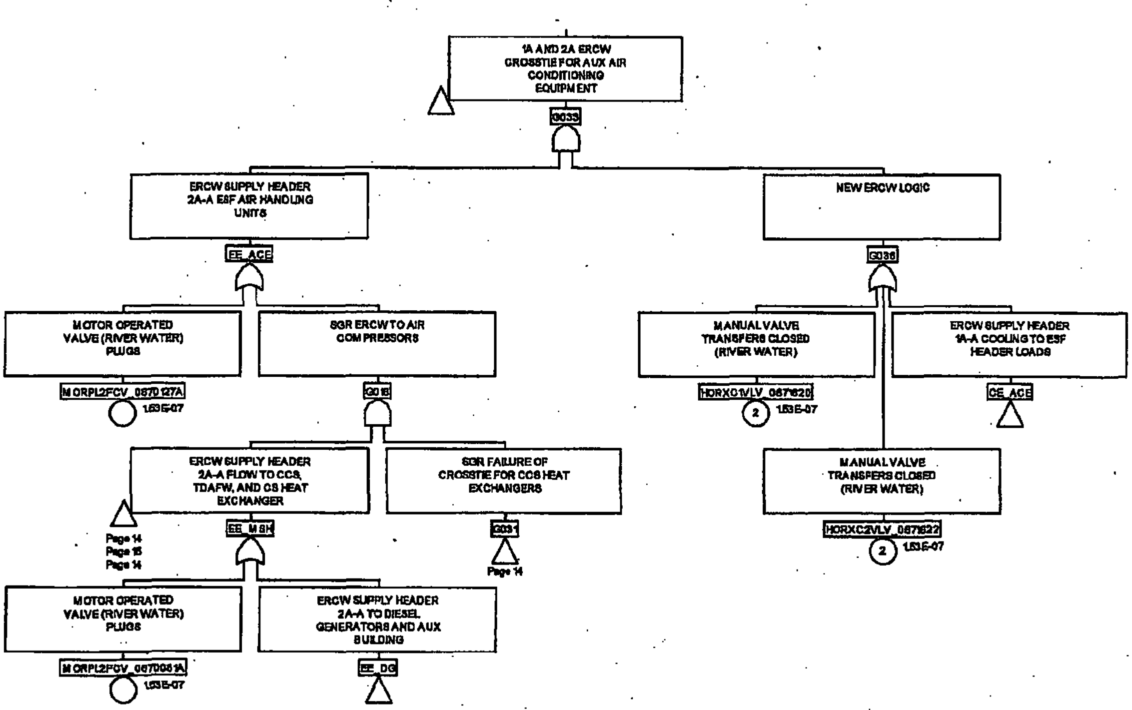

Figure 9-3 – PRA Figure Illustrating 1A and 2A ERCW Crosstie for Aux Air Conditioning Equipment

- To address the second crosstie of the B ERCW headers, the current logic for gate FE_ACE, logic was added to account for the opening of the crosstie valves (1-VLV-067-1621 and 2-VLV-067-1623). This lineup allows for an additional flow path to the 1B ESF header equipment supplied by the 2B ERCW header.

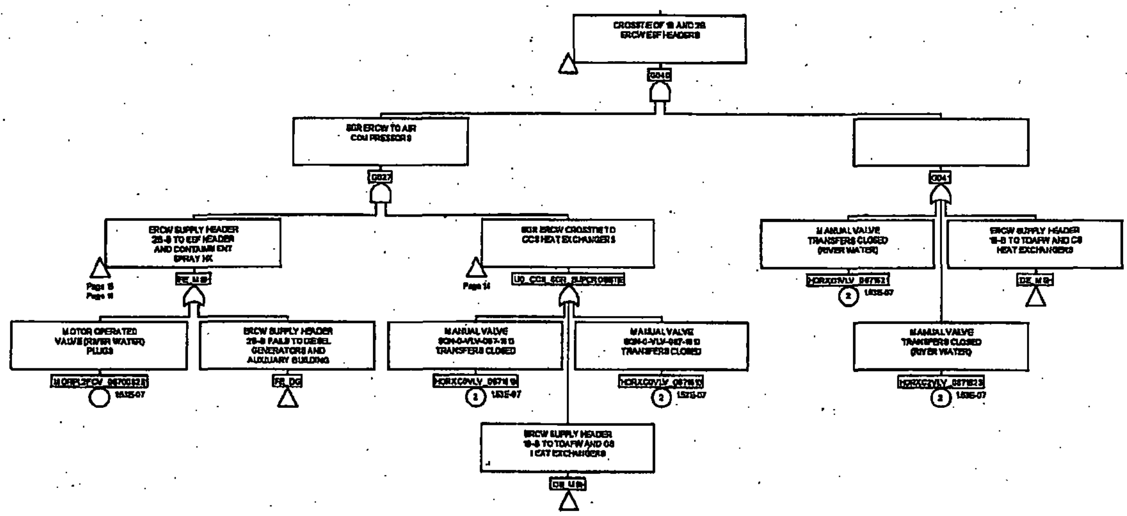

Figure 9-4 – PRA Figure Illustrating Crosstie of 1B and 2B ERCW ESF Headers

- Gate U0_CCS_SGR_SUPCROSSTIE was added under U0_CCS_BC1_G181 for the B train CCS heat exchangers. This alignment allows for the 1B ERCW supply header to provide cooling to the 0B1 and 0B2 CCS heat exchangers.

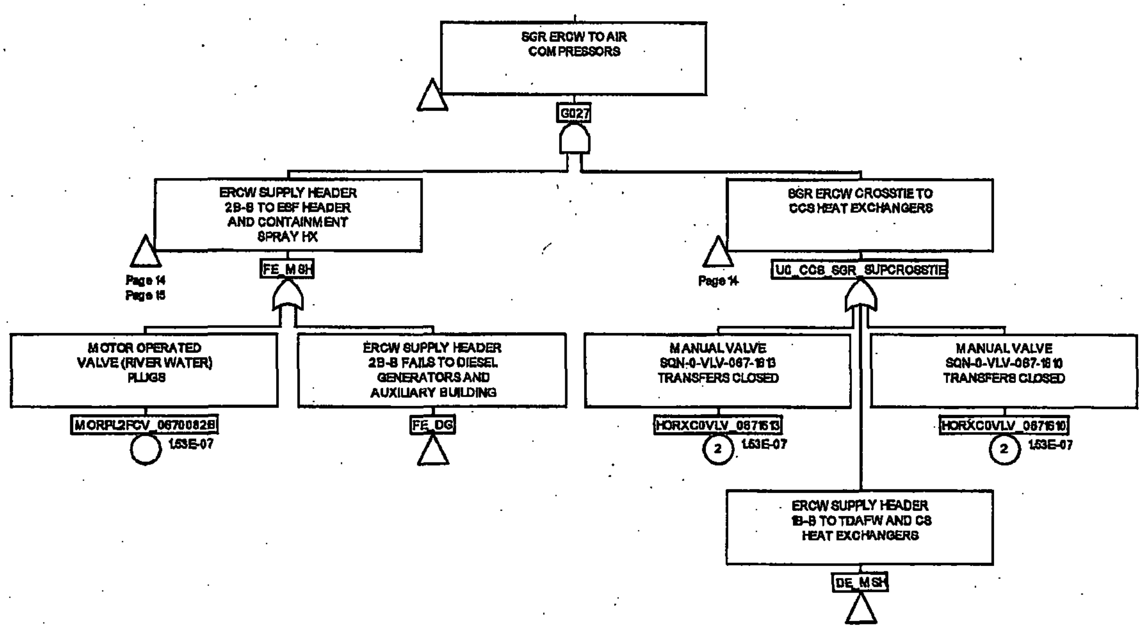

Figure 9-5 – PRA Figure Illustrating SGR to ERCW Air Compressors

- A transfer gate for Top Event GE, the A discharge header, was added under Top Event HE, the B discharge header, to represent the cross-tie. Due to the discharge header cross-tie mentioned above, the B discharge header is cross-tied to the A discharge header. This is established in the model by inserting a transfer gate to Top Event GE under Top Event HE.

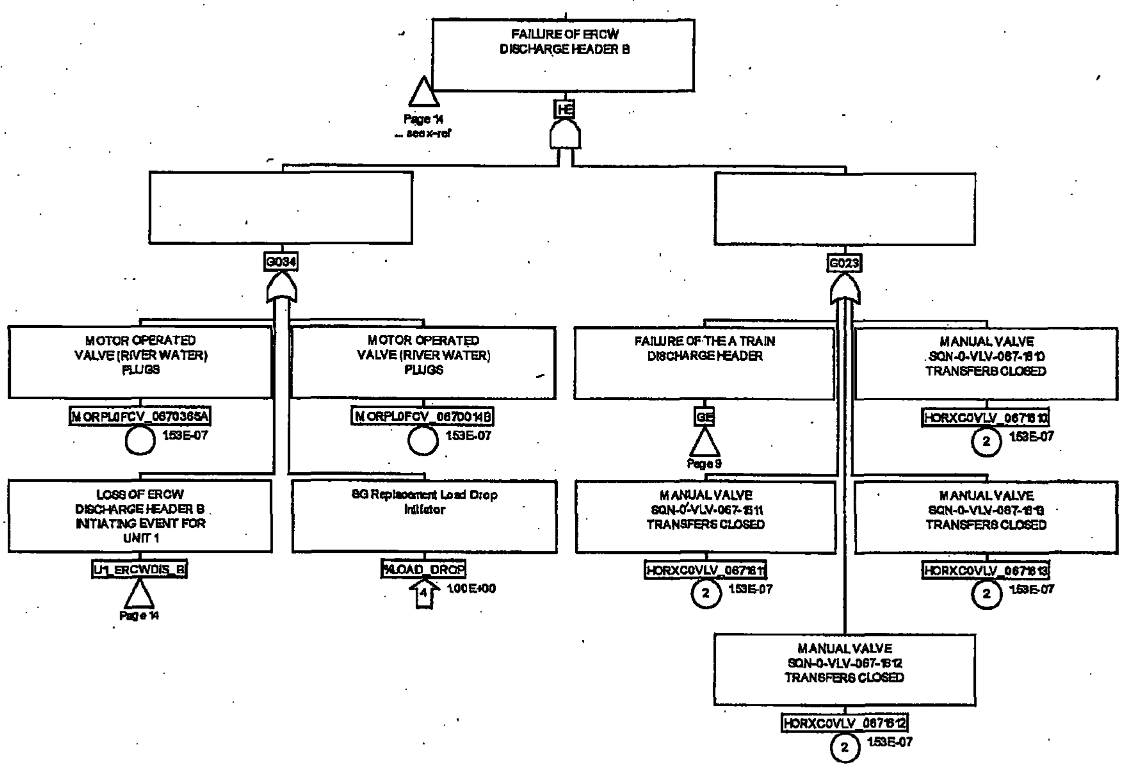

Figure 9-6 – PRA Figure Illustrating Failure of ERCW Discharge Header B

- Basic event values for the 2-FCV-067-0081/82, 2-VLV-067-0505A/B and 2-VLV-067-0518A/B transferring closed or plugging were set to TRUE due to the valves being closed. For the SGR, these valves are isolated as described in Section 8.3. By setting these basic events to TRUE, these valves will never fail to the isolated position.

- Due to the 2-FCV-067-0081, 2-VLV-067-0505A and 2-VLV-067-0518A being isolated, the initiating event (loss of ERCW header 2A-A) could not occur. Due to the valves being isolated, an initiating event being caused from the valves transferring closed or plugging cannot occur. The initiating events with the valves 2-FCV-067-0081, 2-VLV-067-0505A and 2-VLV-067-0518A transferring closed or plugging were set to FALSE.

Changes to Flooding Analysis

Additional Flood Initiating Event

The load drop initiating event discussed in the Section "New Initiating Event" above will cause the internal flooding event therefore no new initiating event for the flooding analysis was created. However, to address the probability of failure of the water retention dam, the basic event DAM_FAILURE was added to the model. Figure 9-7 shows how the logic was added to the model to account for the internal flooding effects.

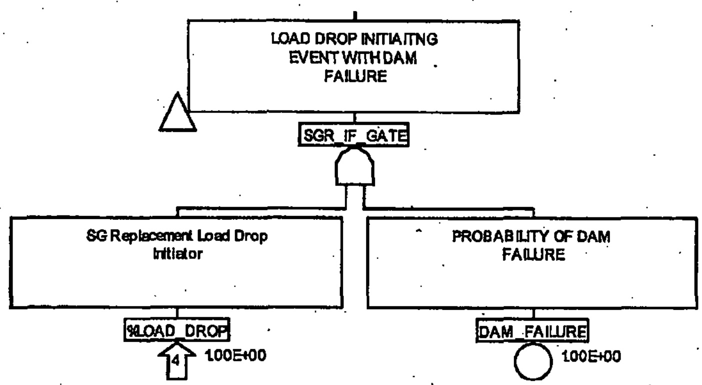

Figure 9-7 – Added Fault Tree Logic for Flooding Initiating Event

Flooding Impact

To address the flooding impact the indirect and direct effects of the flood must be accounted for. Direct effects are the SSCs that are impacted by the flood waters directly, i.e. submergence or spray damage, indirect effects are loss of system function based on either system characteristics after the pipe break or operator actions to disable the system to mitigate the flood.

The direct effects of this flooding event are that all components on elevation 653 will be failed due to submergence of from the RWST and ERCW combined flood waters.

The indirect effects of this flooding event are that the ERCW supply header 1B will be failed due to operator action to mitigate the flood, and the B discharge header will be failed due to the load drop.

Fault Tree Changes for Internal Flooding Events

The flooding event shown in Figure 9-7 was added to the following fault tree gates.

Table 9-1 – Flooding Consequences Logic Injection

Fault Tree Gate	Reason
U1_RAR	This gate will fail all RHR A train functions in the model
U1_RBR	This gate will fail all RHR B train functions in the model
U1_CSS_INJ_G02	This gate will fail CS A train injection mode
U1_CSS_INJ_G13	This gate will fail CS B train injection mode
U1_CSS_REC_G04	This gate will fail the CS A train recirculation mode
U1_CSS_REC_G23	This gate will fail the CS B train recirculation mode
DE_MSH	This will disable the ERCW supply header 1B-B to the Auxiliary Building
U1_CCS_CCSA_G1	This will disable the CCS heat exchangers 1A1 and 1A2 from being able to supply cooling.

Other Internal Flooding Impacts

Due to the crosstie of the ERCW headers flood events in the 2A and the 2B headers now might require isolation of the flood at the 1-FCV-067-0081 or 1-FCV-067-0082 valve. For this reason the initiating events that correspond to either 2A or 2B floods must impact the 1A or 1B header. Those events that were added to the 1A ERCW model are presented in Table 9-2. These events were added under the gate CE_ACE in the PRA model. Those events that were added to the 1B ERCW model are presented in Table 9-3 and were added under the gate DE_ACE.

Table 9-2 – 2A ERCW Internal Flooding Events that Impact 1A Header

Initiating Event	*Description*
%653.0-A01_067_F_2A	ERCW FLOOD EVENT IN 653.0-A1 FROM ERCW SUPPLY HEADER 2A-A
%653.0-A12_067_F_2A	ERCW FLOOD EVENT IN 653.0-A12 FROM 2A-A SUPPLY HEADER
%653.0-A14_067_F_2A	ERCW FLOOD EVENT IN 653.0-A14 FROM 2A-A HEADER
%669.0-A01_067_F_2A	ERCW FLOOD EVENT IN 669.0-A1 FROM 2A-A HEADER
%669.0-A01_067_M_2A	ERCW MAJOR FLOOD EVENT IN 669.0-A1 FROM 2A-A HEADER
%669.0-A24_067_F_2A	ERCW FLOOD EVENT IN 669.0-A24 FROM 2A-A HEADER
%669.0-A24_067_M_2A	ERCW MAJOR FLOOD EVENT IN 669.0-A24 FROM 2A-A HEADER
%669.0-A25_067_F_2A	ERCW FLOOD EVENT IN 669.0-A25 FROM 2A-A HEADER
%669.0-A25_067_M_2A	ERCW MAJOR FLOOD EVENT IN 669.0-A25 FROM 2A-A HEADER
%669.0-A26_067_F_2A	ERCW FLOOD EVENT IN 669.0-A26 FROM 2A-A HEADER
%690.0-A01-1_067_F_2A	ERCW FLOOD EVENT IN 690.0-A1-1 FROM 2A-A HEADER
%690.0-A01-1_067_M_2A	ERCW FLOOD EVENT IN 690.0-A1-1 FROM 2A-A HEADER
%690.0-A01-2_067_F_2A	ERCW FLOOD EVENT IN 690.0-A01-2 FROM THE 2A-A HEADER
%690.0-A01-2_067_M_2A	ERCW MAJOR FLOOD EVENT IN 690.0-A01-2 FROM THE 2A-A HEADER
%690.0-A01-4_067_F_2A	ERCW FLOOD EVEN IN 690.0-A01-4 FROM 2A-A HEADER
%690.0-A01-4_067_M_2A	ERCW MAJOR FLOOD EVEN IN 690.0-A01-4 FROM 2A-A HEADER
%690.0-A19_067_F_2A	ERCW FLOOD EVENT IN 690.0-A19 FROM 2A-A HEADER
%690.0-A19_067_M_2A	ERCW MAJOR FLOOD EVENT IN 690.0-A19 FROM 2A-A HEADER
%690.0-A29_067_F_2A	ERCW FLOOD EVENT IN 690.0-A29 FROM 2A-A HEADER
%690.0-A29_067_M_2A	ERCW MAJOR FLOOD EVENT IN 690.0-A29 FROM 2A-A HEADER
%714.0-A01-1_067_F_2A	ERCW FLOOD EVENT IN 714.0-A1-1 FROM HEADER 2A-A
%714.0-A01-1_067_M_2A	ERCW MAJOR FLOOD EVENT IN 714.0-A1-1 FROM 2A-A HEADER
%714.0-A01-2_067_F_2A	ERCW FLOOD EVENT IN 714.0-A1-2 FROM HEADER 2A-A
%714.0-A01-2_067_M_2A	ERCW MAJOR FLOOD EVENT IN 714.0-A1-2 FROM 2A-A HEADER
%714.0-A09_067_F_2A	ERCW FLOOD EVENT IN 714.0-A9 FROM 2A-A HEADER
%714.0-A09_067_M_2A	ERCW MAJOR FLOOD EVENT IN 714.0-A9 FROM 2A-A HEADER
%734.0-A13-1_067_F_2A	ERCW FLOOD EVENT IN 734.0-A13-1 FROM 2A-A HEADER
%734.0-A13-1_067_M_2A	ERCW MAJOR FLOOD EVENT IN 734.0-A13-1 FROM 2A-A HEADER
%734.0-A13-2_067_F_2A	ERCW FLOOD EVENT IN 734.0-A13-2 FROM HEADER 2A-A
%734.0-A13-2_067_M_2A	ERCW MAJOR FLOOD EVENT IN 734.0-A13-2 FROM 2A-A HEADER

Table 9-3 – 2B ERCW Internal Flooding Events that Impact 1B Header

Initiating Event	*Description*
%653.0-A01_067_F_2B	ERCW FLOOD EVENT IN 653.0-A1 FROM 2B-B ERCW SUPPLY HEADER
%653.0-A13_067_F_2B	ERCW FLOOD EVENT IN 653.0-A13 FROM 2B-B SUPPLY HEADER
%653.0-A15_067_F_2B	ERCW FLOOD EVENT IN 653.0-A15 FROM 2B-B HEADER
%669.0-A01_067_F_2B	ERCW FLOOD EVENT IN 669.0-A1 FROM 2B-B HEADER
%669.0-A01_067_M_2B	ERCW MAJOR FLOOD EVENT IN 669.0-A1 FROM 2B-B HEADER
%669.0-A24_067_F_2B	ERCW FLOOD EVENT IN 669.0-A24 FROM 2B-B HEADER
%669.0-A24_067_M_2B	ERCW MAJOR FLOOD EVENT IN 669.0-A24 FROM 2B-B HEADER
%669.0-A25_067_F_2B	ERCW FLOOD EVENT IN 669.0-A25 FROM 2B-B HEADER
%669.0-A25_067_M_2B	ERCW FLOOD EVENT IN 669.0-A25
%669.0-A26_067_F_2B	ERCW FLOOD EVENT IN 669.0-A26 FROM 2B-B HEADER
%669.0-A26_067_M_2B	ERCW MAJOR FLOOD EVENT IN 669.0-A26 FROM 2B-B HEADER
%690.0-A01-1_067_F_2B	ERCW FLOOD EVENT IN 690.0-A1-1 FROM 2B-B HEADER
%690.0-A01-1_067_M_2B	ERCW MAJOR FLOOD EVENT IN 690.0-A1-1 FROM 2B-B HEADER
%690.0-A01-2_067_F_2B	ERCW FLOOD EVENT IN 690.0-A01-2 FROM THE 2B-B HEADER
%690.0-A01-2_067_M_2B	ERCW MAJOR FLOOD EVENT IN 690.0-A01-2 FROM THE 2B-B HEADER
%690.0-A01-3_067_F_2B	ERCW FLOOD EVENT IN 690.0-A01-3 FROM 2B-B HEADER
%690.0-A01-3_067_M_2B	ERCW MAJOR FLOOD EVENT IN 690.0-A01-3 FROM 2B-B HEADER
%690.0-A01-4_067_F_2B	ERCW FLOOD EVEN IN 690.0-A01-4 FROM 2B-B HEADER
%690.0-A01-4_067_M_2B	ERCW MAJOR FLOOD EVEN IN 690.0-A01-4 FROM 2B-B HEADER
%690.0-A19_067_F_2B	ERCW FLOOD EVENT IN 690.0-A19 FROM 2B-B HEADER
%690.0-A19_067_M_2B	ERCW MAJOR FLOOD EVENT IN 690.0-A19 FROM 2B-B HEADER
%690.0-A29_067_F_2B	ERCW FLOOD EVENT IN 690.0-A29 FROM 2B-B HEADER
%690.0-A29_067_M_2B	ERCW MAJOR FLOOD EVENT IN 690.0-A29 FROM 2B-B HEADER
%714.0-A01-1_067_F_2B	ERCW FLOOD EVENT IN 714.0-A1-1 FROM 2B-B HEADER
%714.0-A01-1_067_M_2B	ERCW MAJOR FLOOD EVENT IN 714.0-A1-1 FROM 2B-B HEADER
%714.0-A01-2_067_F_2B	ERCW FLOOD EVENT IN 714.0-A1-2 FROM 2B-B HEADER
%714.0-A01-2_067_M_2B	ERCW MAJOR FLOOD EVENT IN 714.0-A1-2 FROM 2B-B HEADER
%714.0-A09_067_F_2B	ERCW FLOOD EVENT IN 714.0-A9 FROM 2B-B HEADER
%714.0-A09_067_M_2B	ERCW FLOOD EVENT IN 714.0-A9
%734.0-A13-1_067_F_2B	ERCW FLOOD EVENT IN 734.0-A13 FROM HEADER 2B-B
%734.0-A13-1_067_M_2B	ERCW MAJOR FLOOD EVENT IN 734.0-A13 FROM HEADER 2B-B
%734.0-A13-2_067_F_2B	ERCW FLOOD EVENT IN 734.0-A13-2 FROM 2B-B HEADER
%734.0-A13-2_067_M_2B	ERCW FLOOD EVENT IN 734.0-A13 FROM HEADER 2B-B

PRA Truncation Analysis

The model results were truncated at the limits specified in the Summary Document (Reference 46) 1E-12 from CDF and 1E-13 for LERF.

9.5 PRA Results

Without Load Drop

<u>Change in Risk Metric Value</u>

Table 9-4 – Plant Alignment Change in Risk Metric Frequency Change

Risk Metric	*Model of Record Value*	*Alignment Change Value*	*Change in Value*
CDF	3.0231E-05	3.0951E-05	7.2000E-07
LERF	4.3899E-06	4.4304E-06	4.0500E-08

The overall change in risk metric value is a combination of two effects, by cross tying the discharge headers an additional flow path is provided for successful operation of the ERCW system. However, the other crossties, on the supply headers, were conservatively assumed to require mitigation of the flood event via the 1-FCV-067-0081 or 82 valves. These additional floods increased the risk associated with this condition. The combination of both changes has yielded the results as presented in Table 9-4.

<u>Change in Risk Metric Probability</u>

Table 9-5 – Plant Alignment Change in Risk Metric Conditional Probability

Risk Metric	*Alignment Change*	*Model of Record Value*	*Exposure*	*Conditional Risk*
CDF	3.0951E-05	3.0231E-05	60 Days	1.1828E-07
LERF	4.4304E-06	4.3899E-06	60 Days	6.6530E-09

The ICCDP and ICLERP values reported in Table 9-5 reflect a small increase in risk due to the change in the CDF and LERF values being small and the duration of the configuration change being much less than one year.

With Load Drop

For this analysis the risk increase is assumed to be from the new alignment results presented in the Section "Without Load Drop."

Change in Risk Metric Value

Table 9-6 – Load Drop Change in Risk Metric Frequency

Risk Metric	*Alignment Change Value*	*SG Load Drop Value*	*Change in Value*
CDF	3.0951E-05	3.0958E-05	7.0000E-09
LERF	4.4304E-06	4.4309E-06	5.0000E-10

The risk increase that comes from the load drop is based on the loss of function of the CCS heat exchangers. Following the drop of the heavy load, the ERCW flow that was being sent out of the discharge headers would begin to enter the Auxiliary Building. To alleviate the flooding all loads that can only flow out the B discharge header would be isolated upstream of the break. This would isolate the B train safety system room cooling as well as the 1A1 and 1A2 CCS heat exchangers.

Change in Risk Metric Probability

Table 9-7 – Load Drop Change in Risk Metric Conditional Probability

Risk Metric	*SG Load Drop Value*	*Alignment Change Value*	*Exposure*	*Conditional Risk*
CDF	3.0958E-05	3.0951E-05	18 hours	1.4384E-11
LERF	4.4309E-06	4.4304E-06	18 hours	1.0274E-12

The ICCDP and ICLERP values reported in Table 9-7 reflect a small increase in risk due to the change in the CDF and LERF values being small and the duration of the configuration change being much less than one year.

9.6 PRA Uncertainties

Evaluation of Assumptions

Assumption 1

The frequency of the load drop that is used in the analysis comes from an industry consensus number for load drops. However, Reference 44 does provide bounding frequencies of load drops. To address the uncertainty associated with these events and their frequencies a sensitivity analysis was performed to show the overall model impact.

Assumption 2

The time frame in which the plant configuration has been changed to support the isolation of the 2A-A and 2B-B ERCW supply headers. However, the risk metrics declined during this configuration so there was no actual increase in the risk metric probability values.

Assumption 3

The time frame during which a load drop could occur influences the calculation of the conditional core damage/large early release probability. Due to the extremely small increase in CDF and LERF the model impact of this assumption is small.

Assumption 4

This is a conservative assumption that is based on the worst case scenario load drop within the pipe tunnel. By failing both the RWST and ERCW lines the volume of water entering the Aux Building would be such as to fail all components in the base elevation (653).

Assumption 5

This is a conservative assumption to simplify the modeling of the dam failing. There are limited sources of probability for failure of a dam, and as such to bound the potential consequences of a failure, the probability of 1.0 was used. Due to the small incremental increase in both CDF and LERF, this assumption has a small conservative impact on the overall results.

Assumption 6

This is a conservative assumption concerning the ability to mitigate a flood event. Based on the potential of a load drop failing both the RWST lines and the ERCW lines, some finite time frame exists by which actions could be taken to stop the propagation of flood waters into the RHR and CS pump rooms. Since the RWST line is upstream from the 63-1 valve, there is no existing way to isolate the flood waters from the Unit 2 RWST; therefore, the entire volume would enter the basement of the Auxiliary Building. Combined with the flow rate of ERCW from the ruptured header it was conservatively chosen to assume that no actions could be performed prior to submergence of these RHR and CS pumps. Based on the minimal risk increase from a load drop in the new plant configuration, this assumption has a small conservative impact on the overall results.

Assumption 7

This is a conservative assumption as the normal actions following a flood would be to isolate as near the break as possible. There are many isolation valves within the ERCW system headers that would allow for a break to be isolated and retain portions of the ERCW headers for normal operation.

Sensitivity Analysis

Sensitivity 1: Frequency of Load Drops

The BWROG guidance document (Reference 44) about heavy load drops gives both an average load drop frequency and the upper and lower bounds. To evaluate the impact of this frequency on the overall risk model, this sensitivity analysis evaluates the change in CDF and LERF for the upper and lower frequencies. Reference 44 states that the lower bound of the drop frequency is 1.0E-05 per year and the upper bound of the drop frequency is 1.5E-04 per year.

Table 9-8 – Lower Bound Drop Frequency Results

Risk Metric	*Lower Bound*	*Average*	*Change in Value*
CDF	3.0952E-05	3.0958E-05	-6.0000E-09
LERF	4.4305E-06	4.4309E-06	-4.0000E-10

Table 9-9 – Upper Bound Drop Frequency Results

Risk Metric	*Upper Bound*	*Average*	*Change in Value*
CDF	3.09705E-05	3.0958E-05	1.2500E-08
LERF	4.4317E-06	4.4309E-06	8.0000E-10

Based on these results the frequency of load drop has a small impact on the overall risk values calculated as part of this analysis.

9.7 PRA Conclusion

For the proposed ERCW alignment change only, the change in CDF and LERF values are 7.2000E-07 and 4.0500E-08 respectively. The added redundancy on the ERCW discharge headers removes a potential failure mode from the baseline analysis, and the new internal flooding events create only a small increase in overall risk. Based on these results, the proposed ERCW alignment change during the heavy lift phase of the steam generator replacement is acceptable.

For the analysis of a postulated heavy load drop, the change in CDF and LERF values are 7.000E-09 and 5.000E-10, respectively. The calculated increase in CDF and LERF are very small with respect to Regulatory Guide 1.174. The Regulatory Guide states that the changes in CDF and LERF are considered very small if less than a 10^{-6} change for CDF and 10^{-7} change for LERF. Both changes in CDF and LERF are well below the Regulatory Guide 1.174 limits for a very small change. The ICCDP and ICLERP values were calculated to be 1.4384E-11 and 1.0274E-12, respectively, are well under the Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications," limits of 5.0E-07 for ICCDP and 5.0E-08 for ICLERP. Based on these results the postulated load drop analysis during the steam generator replacement does not increase risk beyond Regulatory Guides 1.174 or 1.177 limits and, therefore, is acceptable.

10.0 Summary and Conclusions

The Steam Generator Replacement at Sequoyah Unit 2 will involve the handling of heavy loads that are larger and must travel along load paths different from those evaluated during the original licensing of the plant. Paralleling the guidelines of NUREG-0612, a safe load path has been selected which generally moves the loads away from the plant and away from sensitive SSCs supporting the continued safe operation of the station. In a few cases, handling over equipment supporting safe shutdown could not be avoided. Therefore, the continued safety of the plant will be assured by:

- Equipment selection,
- Equipment evaluation for certain external events,
- Operator training, and
- Procedural controls, including lift heights, load paths, and limitations related to weather conditions.

Due to the potential to adversely affect both trains of ERCW, an operability issue has been identified that requires an amendment to the Unit 1 Operating License and Technical Specification 3.7.5.

Based upon these considerations and the relatively short periods of time that loads will be suspended over safe shutdown equipment, the risk associated with the drop of a large heavy load as discussed in this technical report is considered to be small. However, as further protection from the postulated load drop: 1) placement of ERCW into an evaluated cross-tied alignment that isolates portions of that system vulnerable to a postulated drop of a rigged steam generator or other large heavy load (i.e., Shield Building concrete cut sections, SG compartment roof plugs). This alignment precludes adverse effects upon the function of ERCW to ensure the capability of Unit 1 to continue to operate / safely shut down and for ERCW to be supplied to all essential heat loads. 2) Protection will be provided from secondary flooding effects that could occur as a result of the postulated load drop, and 3) compensatory measures that will be implemented in the event of a load drop have been developed and will be proceduralized for use during the SGR Outage. These measures provide assurance that the operating unit (Unit 1) can continue to operate/be safely shut down and that ERCW supply to essential SSCs can be maintained in the event of a large heavy load drop.

11.0 References

1. NRC Generic Letter 80-113, Control of Heavy Loads, December 22, 1980
2. NRC Generic Letter 81-07, Control of Heavy Loads, February 3, 1981
3. NUREG-0612, Control of Heavy Loads at Nuclear Power Plants, July 1980
4. Maintenance Instruction 0-MI-MXX-000-026.0, Control of Heavy Loads in Critical Lifting Zones, NUREG-0612 [C.1], Revision 22
5. Topical Report No. 24370-TR-C-002-A, Sequoyah Unit 1 Steam Generator Replacement Rigging and Heavy Load Handling Topical Report, Revision 3
6. NRC Bulletin 96-02, Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment, April 11, 1996
7. NRC Regulatory Issue Summary 2001-03, Changes, Tests, and Experiments, January 23, 2001
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9. ASME B30.2, Overhead and Gantry Cranes (Multiple Girder), 2005 Edition
10. ASME B30.5, Mobile and Locomotive Cranes, 2004 Edition
11. ASME NQA-1-1994, Subpart 2.15, Quality Assurance Requirements for Hoisting, Rigging, and Transporting of Items for Nuclear Power Plants
12. ASME B30.9, Slings, 2003 Edition
13. Crane Manufacturers Association of America (CMAA) Specification #70, Specification for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes, dated 2000
14. Mammoet PTC (SSL) Load Chart, © 2006 by Mammoet Holding B.V., 2006
15. Calculation 39866-CALC-C-007, Evaluation of PTC Crane for Seismic and Wind/Tornado Loads, Revision 1
16. Calculation 39866-CALC-C-009, Evaluation of Safety-Related Buried Commodities in the Vicinity of Heavy Lift Load Path for Postulated Load Drop from OLS, Revision 0
17. TVA Safety Manual Procedure 721, Rigging, Revision 8
18. TVA Safety Manual Procedure 721A, TVA Rigging Manual, Revision 2

19. TVA Safety Manual Procedure 721B, Rigging Equipment – Standard Procurement Specifications, Revision 0

20. TVA Safety Manual Procedure 802, Requirements for the Safe Operation of Cranes, Revision 5

21. Bechtel Calculation 24370-C-026, Evaluation of PTC Crane for Seismic and Wind/Tornado Loads, Revision 0

22. Calculation CSG-87-018, 5% Damped Free Field Top of Soil Response Spectra, SQN Units 1 & 2, Revision 0

23. SQN2 SGR Project Document No. 0010037471-V01, PTC User Manual, Revision 0

24. Calculation 39866-CALC-C-010, Evaluation of Liebherr LR 1400/1 and LR 1400/2 Crawler Crane, Revision 1 (CCN 39866-CALC-C-010-1)

25. Calculation 39866-CALC-C-045, Qualification of Down Ender Foundation, Revision 0

26. Specification 39866-SPEC-C-001, Rigging and Handling of Steam Generators, Revision 0

27. Calculation 39866-CALC-C-039, Evaluation of SG Enclosure Concrete Plug Removal Jacking/Lifting Device, Revision 1

28. TVA Calculation No. MDQ000-067-2000-0095, ERCW Flow Balanced Hydraulic Model, Revision 11

29. TVA Calculation No. and MDQ00006720020109, ERCW System Sensitivity Review for 87°F, ESF & HVAC Equipment, Revision 7

30. Bechtel Calculation 24370-M-002, Old Steam Generator Drop Dose Analysis, Revision 0

31. NUREG-75-087, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants LWR Edition, dated May 1980, Section 15.7.1, "Waste Gas System Failure"

32. TVA Calculation NDQ00200020100242, Old Steam Generator Storage Facility Dose Assessment and OSG Drop Dose Considerations, Revision 1

33. TVA Calculation MDQ-0-077-00-0087, Passive Sump and Auxiliary Building Floor and Equipment Drain Sump Incremental Value, Revision 0

34. TVA Calculation SSG-1S-648, RWST Pipe Tunnel Dam, Revision 2

35. Letter from NRC to TVA, dated September 28, 2007, "Sequoyah Nuclear Plant, Units 1 and 2 – Issuance of Amendments Regarding Increased Temperature and Level Limits of Ultimate Heat Sink (TAC Nos. MD2621 and MD2622)"

36. Sequoyah Updated Final Safety Analysis Report, Amendment 23

37. Sequoyah Nuclear Plant Unit 1 Technical Specifications

38. Sequoyah Nuclear Plant Unit 2 Technical Specifications

39. Design Criteria Document No. SQN-DC-V-7.4, Essential Raw Cooling Water System, Revision 28

40. System Operating Instruction No. 0-SO-67-1, Essential Raw Cooling Water, Revision 88

41. Abnormal Operating Procedure AOP-N.02, Tornado Watch/Warning, Revision 28

42. Calculation 39866-CALC-C-003, "Evaluation of Underground Commodities Along the Haul Route," Revision 5

43. Calculation 39866-CALC-C-005, "Evaluation of Safety-Related Commodities Along Haul Route for Postulated Steam Generator Drop," Revision 0

44. BWROG-TP-10-0XX, "BWROG Integrated Risk-Informed Regulation Committee Guidance Document, Configuration Risk Management - Heavy Loads", Revision C, April 2010

45. MDQ000-067-2000-0095, "Evaluation of ERCW System Effects from a Unit 2 Steam Generator Replacement Heavy Load Drop", Revision 10

46. MDN-000-000-2010-0200, "SQN Probabilistic Risk Assessment – Summary Notebook"

47. Mammoet Drawing 0010037471-000-D-L02, Rev. 3, "Lifting (L) Rigging RSG"

48. Mammoet Drawing 0010037471-000-D-L10, Rev. 2, "Lifting (L) OSG Lifting (Secondary Manways)"

49. Westinghouse Calculation CN-PEUS-10-32, Rev. 1, "Sequoyah Unit 2 – Secondary Manway Trunnions"

50. SGT Calculation 39866-CALC-C-057, Rev. 0, "OSG Keeper Plate Design [0010037471-000-W-C15]"

51. Mammoet Drawing 0010037471-000-D-L04, "Lifting (L) Crane Assembly Plan"

Appendix A – NRC Commitments

There are a number of actions required to support the conclusions of technical report SQN2-SGR-TR1. These actions are required to be performed prior to and during movement of large heavy loads involving use of the OLS to rig the Shield Building concrete cut sections, the SG compartment roof plugs, the OSGs, and the RSGs. These actions are as follows.

Prerequisite Actions to Heavy Load Movement with the Outside Lift System (OLS)

1. Install a wall in the Sequoyah Nuclear Plant (SQN) Unit 2 pipe tunnel to seal the tunnel from the Auxiliary Building. Ensure that measures are in place to suitably handle significant leakage through the temporary SQN Unit 2 pipe tunnel wall. Develop criteria to quantify the amount of water behind the temporary pipe tunnel wall.

2. Develop and issue plant procedure(s) to delineate specific actions required in case of a large heavy load drop from the OLS to address monitoring any leakage through the temporary SQN Unit 2 pipe tunnel wall and the actions to be taken to respond to detected leakage into the Auxiliary Building. Concerning Plant Operations training, Operations crews (licensed and non-licensed Operating personnel as applicable) will receive training for these procedures during a cycle of requalification training, and "just-in-time" refresher training will be conducted to specific crew(s) prior to each heavy lift.

3. When erecting the OLS, utilize the safe load paths defined in procedures. During assembly of the OLS, when it is not possible to eliminate a potential impact with the Essential Raw Cooling Water (ERCW) System piping and where protection is necessary for other buried commodities, utilize timber mats, steel mats, or steel plate to distribute the impact from a load drop.

4. Ensure that ERCW System supply header average water temperature is less than or equal to 74°F.

5. Place the ERCW System in the alignment to support large heavy load lifts prior to the heavy load lifts occurring with the OLS. This alignment is as follows:

    a. Isolation of the portions of the "2A" and "2B" ERCW supply headers in the drop zone from the remaining ERCW piping,

    b. Cross-tie of the "1A" and "2A" ERCW supply headers and Cross-tie of the "1B" and "2B" ERCW supply headers,

    c. Cross-tie of the "1A" and "2A" ERCW Engineered Safety Features (ESF) headers and Cross-tie of the "1B" and "2B" ESF headers,

    d. Throttling valve 0-67-546C to reduce flow through CCS heat exchangers "0B1" and "0B2."

    e. Isolation of the ERCW supplies to the Unit 2 Reactor Building, the Unit 2 Containment Spray Heat Exchangers, and the Unit 2 Turbine Driven Auxiliary Feedwater Pump, and

f. Alignment (i.e., cross-tie) of the "A" and "B" ERCW discharge headers such that ERCW discharge flow normally passing through the portion of the "B" ERCW discharge header that is located in the drop zone would flow through the "A" ERCW discharge header in the event of a large heavy load drop that crushed the "B" ERCW discharge header piping resulting in isolation of this discharge flow path.

6. Isolate the high-pressure fire pump and the flood mode pump piping in the SQN Unit 2 pipe tunnel to the Auxiliary Building.

7. Isolate the ERCW System, Component Cooling System, and Essential Air Distribution System to the SQN Unit 2 Containment using valves outside of the SQN Unit 2 Containment. Ensure that the Spent Fuel Pit and Spent Fuel Pool Cooling System are isolated from the SQN Unit 2 Containment.

Active Monitoring Actions During OLS Operation

1. Monitor weather conditions, for the expected duration of the lift, to ensure conditions are acceptable for OLS operation.

2. If weather conditions exceed operational limits of OLS and heavy loads are in the vicinity of safety-related structures, systems and components that are required to be operable, then take actions to terminate heavy load operation and place loads in a safe condition.

3. Utilize safe load paths defined in procedures during OLS operation.

4. Monitor OLS operation to ensure a minimum clearance of 20 feet exists between the Shield Building dome and the bottom of the steam generator when a steam generator is being moved over the Shield Building.

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT
UNIT 1

SQN2-SGR-TR1
REVISION 3 AFFECTED PAGE LIST

Affected Page(s)	Brief Description / Change Authorization
52, 77	Added valve numbers to Figures 6-1 and 8-2 as addressed in RAI Question 2 regarding these ERCW figures. RE: Letter from TVA to NRC, "Response to NRC Second Request for Additional Information Regarding the Heavy Load Lifts and UHS One Time Change in Support of Unit 2 SGRP (TAC NO. ME7225)," dated March 5, 2012.
6, 18, 20 35, 41, 44, 96	Manner of rigging attachment to OSGs is changed from using a rigging lug welded to the Main Steam nozzle to use of keeper plates and slings to the OSG secondary side manways (see revised Figures 5-1 and 5-4).
15	Correcting the test weight from 275 tons (550 kips) to 265 tons (530 kips).
43	Changing Figure 5-3 to illustrate raising OLS foundation by 6 inches.
8, 32, 34, 35 39, 65, 78, 95	Changing reference to "Liebherr *1400/1*" crane to be "Liebherr *1400/1* or Liebherr *1400/2*" to permit use of either crane. Calculation 39866-CALC-C-010 (Reference 24 in the Technical Report) has been revised to qualify both cranes.
19	Changes made to reflect updated RSG rigging weight.