Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

February 17, 2006
LIC-06-0014

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

Reference:
1. Docket No. 50-285
2. Letter from Harry J Faulhaber to Document Control Desk (NRC) dated November 18, 2005, Request for an Extension to the Completion Date for Corrective Actions Taken in Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" and Information Regarding Actions taken as a Result of Information Notice 2005-26 (LIC-05-0131)
3. NRC Information Notice 2005-26, "Results of Chemical Effects Head Loss Tests in a Simulated PWR Sump Pool Environment," dated September 16, 2005
4. Letter from Harry J Faulhaber to Document Control Desk (NRC) dated August 31, 2005, Follow-up Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (LIC-05-0101)
5. Letter from Harry J Faulhaber to Document Control Desk (NRC) dated January 17, 2006, Submittal of Engineering Analysis Supporting Compensatory Measures Implemented as a Result of GSI-191 (LIC-06-0004)

SUBJECT: Submittal of Revision 1 to Engineering Analysis Supporting Compensatory Measures Implemented as a Result of GSI-191

In Reference 5, the Omaha Public Power District (OPPD) provided an engineering analysis (EA-FC-04-010, Revision 0) that supports the compensatory measures implemented in response to potential blockage of the sump strainers. Attached is the revision to that engineering analysis (EA-FC-04-010, Revision 1) which addresses a number of questions raised during our phone call of January 13, 2006.

In Reference 2, OPPD committed to "Establishment of procedural guidance for throttling High Pressure Safety injection (HPSI) flow after the recirculation actuation signal to a value that is acceptable to the safety analysis, but less than full flow." Based on further analysis, OPPD has determined that a maximum flow reduction of only approximately 150 gpm could be achieved by pre-emptive throttling of HPSI before flow would fall below design limits if a HPSI pump was

4171

subsequently lost. The resultant increase in time to the Recirculation Actuation Signal (RAS) would be minimal, as would the improvement in net positive suction head (NPSH) margin and reduction in debris transport. In addition, these measures would require operator actions, increasing the possibility of operator error. Therefore, OPPD has decided not to implement this commitment.

I declare under penalty of perjury that the foregoing is true and correct. (Executed on February 17, 2006.)

If you have additional questions, or require further information, please contact Thomas R. Byrne at (402) 533-7368.

Sincerely,

Sudesh K. Gambhir
Division Manager
Nuclear Projects

SKG/TRB/trb

Attachment 1 - Engineering Analysis EA-FC-04-010, Revision 1: Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01

ATTACHMENT 1

Engineering Analysis EA-FC-04-010, Revision 1: Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01

EA COVER SHEET

EA-FC-04-010		Rev. No.: 1	EC#:37927		Page No.:1	Total Pages 205	
EA Title (include computer program designation): Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01							
QA Category				Report Type			
X	CQE		Fire Protection	X	Revision		Analytical Report
X	Non CQE		Limited CQE		Special		
Engineering Analysis Type:							
	Electrical Equipment Qualification (EEQ)				Safe Shutdown Analysis (SSA)		
	Seismic Equipment Qualification (SEQ)				Computer Code Error Analysis (CCE)		
	Core Reload Analysis (CRA)				Nuclear Mat'l Accountability (NMA)		
	Fire Hazards Analysis (FHA)			X	Operations Support Analysis (OSA)		
	Cable Separation Analysis (CSA)				USAR Justification (USJ)		
	Associated Circuits Analysis (ACA)				OTHER:		
Initiation: PED Department No.: 357						Initiation Date: 1/25/06	
Preparer: Gregory E. Guliani							
Review Assignment (name or group – by Preparer or Responsible Department Head)							
Reviewer: Janice Bostelman						Date: 2/16/06	
Independent Reviewer: Michael Friedman						Date: 2/16/06	
*Interdisciplinary Review: Scott Lindquist						Date: 2.16.06	
**Mgr-Station Eng./Mgr – DEN:						Date:	
* Operations review required if Operating Documents may be impacted (EOPs, AOPs, OIs, etc.). ** Signature required only when independent review authorization is required.							
Approval (signature when EA results are ready to implement)							
Responsible Department Head: Joseph Gasper J R Gasper						Date: 2/16/06	
Owner Assignment (by Department Head)							
Name: Carmen Ovici						Date: 2/16/06	
EA Close-Out (Document Changes listed on PED-QP-5.6) Completed PED QP-5.6 transmitted to Document Control							
Name:						Date:	
Condition Report (SO-R-2) written based on the results of this EA? [X] Yes CR: 200600619 [ ] No							

Preparation/Review (signatures):	
Preparer(s) [signature]	Date: 2/16/06
Reviewer(s) [signature]	Date: 2/16/06
Independent Reviewer(s) Michael Friedman	Date: 2/16/06
Interdisciplinary Reviewer(s)* Scott Lindquist	Date: 2.16.06
* Operations review required if Operating Documents may be impacted (EOPs, AOPs, OIs, Etc.)	
Affected Documents: For a list of affected documents see form PED-QP-5.6	

Affected System/Equipment	
System	Tag No.(s)
SI	SI-1A, SI-1B, SI-2A, SI-2B, SI-2C, SI-3A, SI-3B, SI-3C, SI-5, SI-12A, SI-12B
Containment	Containment Building
SFP	Spent Fuel Pool

Distribution					
Group	Name & Location	Copy Sent (X)	Group	Name & Location	Copy Sent (X)
[352]	Manager-System Eng.				
[840]	Manager-Operations				
[800]	Training Program Configuration Management				

RECORD OF REVISION

Rev. No.	Description/Reason for Change
0	Original Issue
1	General update to incorporate insights gained on GSI-191 since the original issue of this EA. It evaluates the adequacy of compensatory measures in response to Bulletin 2003-01 and IN 2005-26 and provides additional information to support the implementation of a strategy to respond to the loss of ECCS recirculation capability. Significant changes include: 1. Assessment of FCS interim compensatory measures against WCAP-16204, "Evaluation of Potential ERG and EPG Changes to Address NRC Bulletin 2003-01 Recommendations" [Ref. 3.38]. 2. Incorporation of temporary Tech. Spec. amendment allowing the securing of 2 CS pumps [Ref. 3.39]. Implementation of this amendment has already been incorporated into the EOPs. This revision acknowledges the amendment within the EA. 3. Improved assessment of the impact of securing containment spray and using containment fan coolers for containment pressure control. 4. Improved assessment of the effects of increased containment water level on containment hydraulic conditions. 5. Identification of mission critical components that may be submerged as containment water level rises and alternate means of accomplishing their functions. 6. Determination of the volume of water required over time to ensure adequate core cooling during the implementation of the strategy for responding to the loss of ECCS recirculation capabilities. 7. Identification of sources and flowpaths on site to provide adequate clean makeup water to the SIRWT to allow the implementation of the strategy for responding to the loss of ECCS recirculation capabilities. None of the above changes significantly alters the overall strategy for responding to a loss of ECCS recirculation capability due to the clogging of SI-12A/B (ECCS recirculation sump strainers) which is established in section 5.1 B of this EA. In addition to the EOP changes that were already implemented following the issuance of Revision 0 of this EA, this revision supports the development of a procedure to assist the TSC staff in evaluating plant conditions and providing recommendations to the control room staff in responding to a loss of ECCS recirculation capabilities.

EC#: 37927

EA - FC-04-010 Rev.: 1

Page No.: 4

EA AFFECTED DOCUMENTS

The EA Preparer is to identify documents affected by this Engineering Analysis. Markups are to be provided in an Attachment to the EA except those noted with an *. Changes not involving procedures should follow the associated change process. The Preparer is to indicate below how the EA is to be processed by Document Control.	
	Not Required, EA supports Engineering Change:
	Required, the need for an Engineering Change, LAR, Pre-approved NRC commitment change, or Condition Report identified. EA is closed on receipt of the completed QP-5.6 form.
	Change to a DBD, USAR, etc. without a change to plant procedures identified. EA is closed on receipt of the completed QP-5.6 form.
X	Change to a DBD, USAR, etc., and plant procedures (no hardware) identified. EA is closed on receipt of the completed QP-5.6 form.
	No documents changes or other changes are required. EA is closed on receipt of the completed QP-5.6 form.
NOTE: Markups are to include any inputs or assumptions which define plant configuration and/or operating practices that must be implemented to make the results of the EA valid. Reference Procedure PED-QP-5 Section 4.10 for a detailed discussion. The EA may provide the basis for a 10CFR50.59 and/or 10CFR72.48 review or substantiate a 10CFR50.59 and/or 10CFR72.48 review.	

Affected Documents		
Document Type	Document Number (NA if not applicable)	Procedure Change No, LAR No., etc.
Emergency Operating Procedure*	EOP-03, EOP-20, EOP/AOP Att.	EOP/AOP change suggestion
Abnormal Operating Procedure*	AOP-22	EOP/AOP change suggestion
Annunciator Response Procedure	N/A	
Technical Data Book	N/A	
Surveillance Test Procedure	N/A	
Calibration Procedure	N/A	
Operating Procedure	N/A	
Maintenance Procedure	N/A	
P.M. Procedure	N/A	
E.P/E.P.I.P/R.E.R.P.*	N/A	
Security Procedures * (Safeguards)*	N/A	
Operating Instruction	N/A	

EC#: 37927

EA - FC-04-010 Rev.: 1

Page No.: 5

Affected Documents		
Document Type	Document Number (NA if not applicable)	Procedure Change No, LAR No., etc.
System Training Manuals	N/A	
Technical Specification*	N/A	
Dry Fuel Storage Technical Specification	N/A	
U.S.A.R	N/A	
Dry Fuel Storage FSAR	N/A	
Licensing Commitments	N/A	
10 CFR 72.212 Report	N/A	
Standing Order	N/A	
Security Plan (Safeguards)	N/A	
CQE List	N/A	
Vendor Manual Changes	N/A	
Design Basis Documents	N/A	
Equipment Data Base	N/A	
Oil Spill Prevention, Control and Countermeasure (SPCC) Plan	N/A	
EEQ Manual	N/A	
SE-PM-EX-0600	N/A	
Updated Fire Hazard Analysis	N/A	
EPIX	N/A	
Electrical Load Distribution Listing (ELDL)	N/A	
Station Equipment Labeling (FC-Label-1)	N/A	
Engineering Analysis	N/A	
Calculations	N/A	
Drawing Number	N/A	
Other	TSC Guideline (New)	Submitted to Owner
Other	FCSG-39	Submitted to Owner
Completed by Owner (If Plant Procedure Changes Required or n/a) N/A		Date: N/A
Completed by (Preparer): Gregory Guliani Greg Guliani per telecon w/ M Friedman 2/16/06		Date: 2/16/06

EC#: 37927

EA -FC-04-010 Rev.: 1

Page No.: 6

EA PREPARER CHECKLIST	Yes	No	N/A
1. Are the ASSUMPTIONS necessary to perform the EA adequately described and verified as being valid and accurate? Reference PED-QP-5 Section 4.6.	X		
2. If applicable, has the use of Engineering Judgment been document per PED-QP-14? Reference PED-QP-5 Section 4.6.			X
3. If applicable, has operating experience been considered (e.g. for replacement parts/components, has EPIX, INPO, NRC, industry experience been used supporting the application)? Reference PED-QP-5 Section 4.6.	X		
4. Have applicable licensing commitments regarding the subject EA been reviewed and are met? Reference PED-QP-5 Section 4.6.	X		
5. Is the computer program identification number (Ref. PED-MEI-23, Section 5.3.1) on the cover sheet as part of the EAs description? **NOTE:** Only applies to DEN Mechanical and Electrical/I&C Departments.			X
6. Is the computer code title and version/level properly documented in the EA?	X		
7. Is the listing or file reference of the final computer input and output provided?			X
8. Does the computer run have page number and alphanumeric program number on every sheet?			X
9. Have updates been prepared or described for procedures as identified in form PED-QP-5.6 including any assumptions that impact procedures or design documents? This includes drafts of the associated 10CFR50.59 screen (FC-154A) where required. Reference PED-QP-5 Section 4.10. **NOTE:** The FC-154 forms cannot be signed by a qualified reviewer until the EA reviews are complete and the Responsible Department Head has approved the EA for implementation.	X		
10. Have modification to the facility as identified in Section 6.0 Results and Conclusions been identified and the appropriate documents (Design Change Notice) been drafted? Reference PED-QP-5 Section 5.2.1.			X
11. If required has a Condition Report been prepared and/or submitted in accordance with SO-R-02. Is the off normal condition summarized in EA Section 7.6?			X
12. If a Commitment to the NRC that is not part of the FCS Design Basis must be changed to implement this EA, has Licensing been notified of the proposed change? Certain Commitments require prior NRC approval before implementing the change. Has the necessary approval been obtained? See NOD-QP-34 for additional guidance.			X
13. Does Form QP-5.6 define the EA close-out requirements?	X		

EC#: 37927

EA -FC-04-010 Rev.: 1

Page No.: 7

EA PREPARER CHECKLIST	Yes	No	N/A
14. Where appropriate, have the necessary 10CFR50.59 (FC-154A or FC-155) evaluations been drafted to support changes to the DBDs, USAR, Operating documents, etc.? **NOTE:** The FC-154A forms cannot be signed by a qualified reviewer until the EA reviews are complete and the Responsible Department Head has approved the EA for implementation.		X	

Comments:

Regarding Item 14. Revisions to the EOPs will be screened as part of the procedure revision process.

Preparer: Gregory E. Guliani	Date: 2/16/06
Department: 357	Organization: Alion Science and Technology

EC#: 37927 EA -FC-04-010 Rev.: 1

Page No.: 8

EA REVIEWER CHECKLIST		Yes	No	N/A
1.	Does the PURPOSE section adequately and correctly state the reason: or the need to prepare the EA?	✓		
2.	Does the EA adequately and correctly address the concerns as stated in the PURPOSE section?	✓		
3.	Are the RESULTS AND CONCLUSIONS stated and reasonable and supportive of the PURPOSE and SCOPE?	✓		
4.	Were the methods used in the performance of the Analysis appropriately applied?	✓		
5.	Have adjustment factors, uncertainties and empirical correlations used in the analysis been correctly applied?	✓		
6.	Were the INPUTS correctly selected and incorporated into the EA?	✓		
7.	Are all INPUTS to the ANALYSIS correctly numbered and referenced such that the source document can be readily retrieved?	✓		
8.	Were the ASSUMPTIONS used to prepare the EA adequately documented?	✓		
9.	Have the appropriate REFERENCES and the latest revisions been identified?	✓		
10.	Have the REFERENCES been appropriately applied in the preparation of the EA?	✓		
11.	Is the information presented in the ANALYSIS accurate and clearly stated in a logical manner?	✓		
12.	If manual calculations are presented in the ANALYSIS are they:			
	a. free from mathematical error?	✓		
	b. appropriately documented commensurate with the scope of the analysis?	✓		
13.	Have the affected documents, identified on the PED-QP-5.6 form been accurately marked-up?	✓		
14.	Are 10 CFR 50.59 (FC-154A) screening forms included with the document changes as required?		✓	
15.	Is the EA free of unconfirmed references and assumptions?	✓		
16.	Have all crossouts or overstrikes been initialed and dated by the Preparer/Reviewer?	✓		
17.	Is the EA legible and suitable for reproduction and microfilming?	✓		
18.	Has the EA Cover Sheet been appropriately completed?	✓		
19.	For <u>Revisions</u> only, is the change identified and the reason for the change provided on the Record of Revision Sheet?	✓		
20.	Does the computer run have page number and alphanumeric program number on every sheet?			✓
21.	Is the listing or file reference of the final computer input and output provided?			✓
22.	Is the computer code title and version/level properly documented in the EA?			✓
23.	Is the identification number (Ref. PED-MEI-23, Section 5.3.1) on the cover sheet as part of the EAs description? **NOTE:** Only applies to DEN Mechanical and Electrical/I&C Departments.	✓		
	Are final computer runs correctly identified?			✓
	Is the computer program validated and verified in accordance with NCM-1?			✓

EC#: 37927

EA -FC-04-010 Rev.: 1

Page No.: 9

EA REVIEWER CHECKLIST		Yes	No	N/A
26.	If the computer program was developed for limited or onetime use and not validated and verified in accordance with NCM-1, has a functional description of the program, identification of the code (title, revision, manufacturer), identification of the software and brief user's instructions been documented in the EA?			✓
27.	Is the modeling correct in terms of geometry input and initial conditions?			✓
28.	If the analysis has identified a condition that may be outside the design basis of the plant, has a Condition Report been initiated?			✓
29.	Does Form QP-5.6 define the EA close-out requirements? **NOTE:** Applicable only to analysis of existing conditions.	✓		

NOTE: For all "No" responses, a written comment shall be documented on Comment Form PED-QP-5.5 briefly explaining the deficiency and, as appropriate, providing a suggested resolution.

Comments:

Reviewer: Janice L. Bostelman [signature]	Date: 2/16/06
Department: 357	Organization: Alion Science & Technology

EC#: 37927

EA -FC-04-010 Rev.: 1

Page No.: 10

EA INDEPENDENT REVIEWER CHECKLIST		Yes	No	N/A
1.	Were the INPUTS correctly selected and incorporated into the EA?	✓		
2.	Are the ASSUMPTIONS necessary to perform the EA adequately described and reasonable and appropriately documented?	✓		
3.	If applicable, have the appropriate QA requirements been specified?	✓		
4.	Are the applicable codes, standards and regulatory requirements including issue and addenda properly identified and the requirements correctly applied in the EA?			✓
5.	Is the approach used in the ANALYSIS section appropriate for the scope of the EA?	✓		
6.	Were the methods applied in the performance of the ANALYSIS appropriate?	✓		
7.	Has applicable operating experience been considered (e.g., for replacement parts/components, has EPIX, INPO, NRC, industry experience been used supporting the application)?	✓		
8.	Have any interface requirements been appropriately considered (e.g., between disciplines, Divisions, etc.)?	✓		
9.	Are the results and conclusions reasonable when compared to the purpose and scope?	✓		
10.	Has the impact on Design Basis Documents, the USAR, and Operating documents been correctly identified and considered (including 10CRF50.59 reviews where appropriate)? 50.59 Reviews will be performed as part of EOP/AOP CHANGES	~~✓~~ MF	✓	
11.	Have all applicable licensing commitments regarding the subject EA been considered?	✓		
12.	Does Form QP-5.6 define the EA close-out requirements?	✓		

NOTE: For all "No" responses, a written comment shall be documented on Comment Form PED-QP-5.5 briefly explaining the deficiency and, as appropriate, providing a suggested resolution.

Comments: EOP/AOP Revision suggestion forms are included. The 50.59 review will be included as part of the procedure change process.

Independent Reviewer: Michael Friedman *Michael Friedman*	Date: 2/16/06
Department: 357	Organization: DEN

PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

PED-QP-5.5
R9

EC#: 37927

Rev. No. 1

Page No. 11

COMMENT FORM

Reviewer: Janice L. Bostelman	Organization: Alion Science & Technology	Page 1 of 1
EA Title: Recommendations for Implementing of Compensatory Actions in Respon: Bulletin 2003-01		Date: 02/16/2006

COMMENT TYPE CODES* RORY**

*Editorial (ED) System Interaction/ 1:

*Technical (TC) Design Change (DCC) 2: mmendation

Comment Number	Comment Type Code*	Page	Comment	Resolution
1	ED		Only EOP / AOP mark-ups have been included in the EA. 50.59 screen will be included with the procedure changes.	on is provided the procedure roval process.

Engineering Analysis:

Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01

Revision 1

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLES:

FIGURES:

1.0 PURPOSE

This EA provides an evaluation of the actions needed to respond to a potential clogging of the Emergency Core Cooling Containment Sump Strainers (sump clogging) following a Loss of Coolant Accident (LOCA).

NRC Bulletin 2003-01 [3.1] required that operators of PWR Plants state that the ECCS and Containment Spray (CS) recirculation functions meet applicable regulatory requirements with respect to adverse post-accident debris blockage or describe interim compensatory measures to reduce risk associated with the potentially degraded or non-conforming ECCS and CS recirculation functions. NRC Information Notice 2005-06 [3.49] provided additional information concerning the potential for sump clogging due to chemical interactions between LOCA debris and the chemically treated water in containment post-LOCA.

Reference 3.2 provided the interim compensatory measures to be evaluated by OPPD for the FCS. The compensatory measures are intended to compensate for the increased risk associated with sump clogging. The interim actions and recommendations contained in this EA are not intended for plant operations following the resolution of GSI-191. However, if they are within the plant's design basis, some of these measures may remain in place after the issue is resolved if they provide a benefit to future plant operations. This EA provides technical justification and analysis for procedural changes to EOPs, AOPs and other instructions, to implement the interim compensatory measures.

Additionally, this EA provides the basis for development of a technical support document (such as an Emergency Response Organization guideline) that may be used to assist operations in implementing the mitigation strategy for a clogged sump strainer.

1.1 Format of Analysis

The analytical work in this document is divided into four sections:

- Section 5.0 evaluates the various actions associated with recognition of and response to a potential degradation or loss of ECCS recirculation capabilities due to LOCA generated debris clogging the ECCS recirculation strainers, SI-12A/B. Conclusions are made regarding the acceptability of implementing each action.
- Section 6.0 summarizes the conclusions from section 5.0 and recommends the specific actions that should be taken as interim compensatory measures to assure continued safe plant operation until the station has completed all activities in response to Generic Letter 2004-02 [3.48].
- Section 7.0 summarizes the actions that remain to be taken to implement the recommendations from section 6.0.

- Section 8.0 contains attachments that are used to support the activities of sections 5.0 and 7.0. These attachments provide additional detail for topics that would be too voluminous to incorporate directly into sections 5.0 and 7.0.

2.0 SCOPE

The Scope of this EA is limited to the following Reference 3.2 commitments:

Item 1b: OPPD will develop procedural guidance for responding to sump clogging.

Item 2a: OPPD will evaluate shutting off one HPSI Pump (SI-2C) pre-RAS if operator resources are available, or shortly after RAS.

Item 3: OPPD will develop procedural guidance for refilling the SIRWT immediately post-RAS.

Following the issuance of Revision 0 of this EA, reference 3.38 was provided by the Westinghouse Owners Group to assist member utilities in evaluating various activities - referred to as "Candidate Operator Actions" (COAs) - that may be implemented to satisfy these commitments. It is each utility's responsibility to evaluate these COAs to determine if they can be effectively incorporated into the plant's operating manual. In addition to the commitments listed above, this EA will evaluate the relevant COAs provided in reference 3.38 and provide justification as to whether or not they should be included in the Fort Calhoun Station EOPs and AOPs as part of the overall event mitigation strategy.

Not all sections of this EA are safety-related (CQE). The sections that evaluate preemptive compensatory actions that are taken to reduce the risk of sump clogging while the plant is within its design bases are CQE. Those sections that evaluate actions to be taken for plant conditions that are beyond design bases are non-safety-related (non-CQE).

The following EA sections are CQE:

- Sections 5.1.A and 6.1.A evaluating indications of sump clogging and recommendations for sump inoperability criteria.
- Sections 5.2 and 6.2 evaluating the preemptive compensatory actions to secure HPSI pumps not required for core cooling.
- Sections 5.3 and 6.3 evaluating the preemptive compensatory actions for early termination of CS pumps.

All other sections of this EA evaluate actions that occur during beyond design basis conditions, or after a system has completed its safety function and as such are non-CQE.

3.0 INPUTS/REFERENCES SUPPORTING THE ANALYSIS

3.1 NRC Bulletin 2003-01, Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors, June 9, 2003
3.2 LIC-03-0105, Fort Calhoun Station Unit 1, 60 Day Response to NRC Bulletin 2003-01, August 8, 2003
3.3 EOP-03, Loss of Coolant Accident, Rev. 30
3.4 EOP-20, Functional Recovery Procedure, Rev. 17
3.5 FCS Updated Safety Analysis Report, Revisions as of 3/4/2004
3.6 NRC Staff Responses to Industry Pre-Meeting Questions and Comments on Bulletin 2003-01 for June 30, 2003 NRC Public Meeting.
3.7 NRC Regulatory Guide 1.82, Revision 0, Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant-Accident.
3.8 SDBD-CONT-501, Containment Design Basis Document, Rev. 17
3.9 USAR Figure 14.16-7, Long-Term Pressure Response – Loss of Coolant Accident, File# 56380
3.10 FC06639 Rev. 1, Containment Spray Pump Minimum Performance Requirement.
3.11 PRA Summary Notebook, Revision 5
3.12 Passport Equipment Database
3.13 Letter NRC-01-034, Transmittal of License Amendment 198 for Revisions to Charcoal Adsorber Surveillance Requirements
3.14 FCS Station Technical Specifications, as of Amendment 233
3.15 Calculation ITS-REP-MERS02001-01, Rev. 0, Fort Calhoun Station Unit 1 Natural Deposition and Radiological Consequences Post LOCA Based on FCS Alternate Source Term.
3.16 Calculation FC06965, (Westinghouse DAR-OA-03-16) Evaluation of Emergency Core Cooling by Alternate Water Source in the Absence of Sump Recirculation, Rev. 0.
3.17 OSAR 85-33, Electrical Equipment Qualification Environment Determination, Appendix B, Containment Flood Level Calculations
3.18 Technical Data Book TDB-III.20, RCS Elevations vs. LI-106, LI-199, LI-197, and LIS-119, Rev. 15
3.19 Calculation FC06728, Rev. 1, Calculation of Containment Free Volume.
3.20 Drawing EM-387, Sheet 1, Instrument and Control Equipment List, Rev. 9, File # 20562
3.21 SAMG Calculation Aids, CA-11, Rev. 0, Containment Flooding Bases.
3.22 Crane Technical Paper No. 410, Flow of Fluids Through Valves, Fittings, and Pipe, 23rd Printing, 1986
3.23 FCS Equipment Environmental Qualification (EEQ) Database; EEQ Elevation Query
3.24 Drawing 11405-S-2, Containment Structure Steel Liner, Sheet 1 of 3
3.25 Fort Calhoun Automated Cable Tracking System (FACTS) Database

3.26 Drawing 11405-E-67, Cable Tray Sections, File # 46367 – 46385, Revisions as of 3/4/2004

3.27 FCS Equipment Environmental Qualification (EEQ) Reference Manual, Enclosure 4, Rev. 14, System Component Evaluation Worksheet

3.28 SDBD-CA-IA-105, Instrument Air Design Basis Document

3.29 Drawing 11405-S-61 Rev. 7, Auxiliary Building Spent Fuel Well Outline (File # 16446)

3.30 SDBD-AC-SFP-102 Rev. 12, Spent Fuel Storage and Fuel Pool Cooling

3.31 OI-FH-5, Rev. 1, Operating Instruction, Transferring Spent Fuel Pool Water to Transfer Canal.

3.32 Calculation FC05988, Rev. 2, Thermal Hydraulic Analysis of Fort Calhoun Station Spent Fuel Pool with Maximum Density Storage.

3.33 OI-ERFCS-1 Rev. 24, Emergency Response Facility Computer System

3.34 CR#200302218 – Bulletin Response Condition Report

3.35 Keenan, J., Keyes, F., Hill, P., & Moore, J. (1969), Steam Tables: Thermodynamic Properties of Water Including Vapor, Liquid, and Solid Phases; John Wiley & Sons, Inc.

3.36 OPPD Letter to NRC Responding to Request for Information Regarding Compliance With RG 1.82, Revision 0, May 1, 1978.

3.37 Calculation FC05777, Revision 0, The Development of a Hydraulic Computer Model of the Containment Spray System at the Fort Calhoun Station Using the "As-Built" Piping Isometrics and "FLO-SERIES" Hydraulic Analysis Computer Code.

3.38 WCAP 16204, R1, Evaluation of Potential ERG and EPG Changes to Address NRC Bulletin 2003-01 Recommendations (PA-SEE-0085).

3.39 Technical Specification Amendment No. 235, "Amendment to Facility Operating License No. DPR-40", May 20, 2005.

3.40 AOP-17, Loss of Instrument Air, Rev. 8.

3.41 FC07010, Rev. 0, Calculation of Design Basis Minimum Containment Post-RAS water level.

3.42 Technical Data Book Sections IV and VII, current as of 11/22/05

3.43 AOP-22, Reactor Coolant Leak, Rev. 24

3.44 NFPA Fire Protection Handbook, 15th Edition, Section 16, Chapter 7

3.45 LIC-05-131, Fort Calhoun Station Unit 1, Request for an Extension to the Completion Date for Corrective Actions Taken in Response to Generic Letter 2004-02 and Information Regarding Actions taken as a Result of Information Notice 2005-26, Nov. 18, 2005.

3.46 SDBD-CH-108, Chemical and Volume Control System Design Basis Document

3.47 Calculation FC07055 (Enercon Calculation OPP005-CALC-002) "Containment Response Study of a LOCA with GOTHIC", Rev. 0

3.48 NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors", Sept. 13, 2004.

3.49 NRC Information Notice 2005-06, "Results of Chemical Effects Head Loss Tests in a Simulated PWR Sump Pool Environment", Sept. 16, 2005.

3.50 FCS proposed modification EC27581, Remove Auto-Start of HPSI Pump SI-2C.

3.51 FCS modification EC27582, Remove Auto-Start Feature from SI-3C Containment Spray Pump.

3.52 FC06959, Revision 0, "Site Boundary and Control Room Doses following A Loss of Coolant Accident using Alternative Source Term", Feb.28, 2004

3.53 FC06063, Revision 0, "Blair Water to FCS Fire Protection System Flow Calculation, Sep. 24, 1994.

3.54 E-Mail from T. Heng to G. Guliani; Subject: "FW: Cycle 23 and 24 CBCs", Feb. 9, 2006 (see attachment 8.9).

3.55 Calc No. FC07078 (Draft), Recirculation Phase System Performance for Safety Injection and Containment Spray Systems.

4.0 ASSUMPTIONS

Assumptions are stated in the individual evaluation sections, where applicable.

5.0 ANALYSIS

The Emergency Operating Procedures (EOP) and Emergency Procedure Guidelines (EPG) did not originally include strategy or guidance to specifically address symptoms indicative of sump clogging. This condition is not considered within the current design basis. This EA evaluates interim compensatory measures that may be implemented to assure safe plant operation until the plant has completed its response to Generic Letter 2004-01 [3.48].

The compensatory measures that support the strategy for mitigating the effects of ECCS sump strainer blockage can be broken into three categories:

- Pre-emptive

  Pre-emptive measures are those that are intended to minimize the possibility of degraded strainer performance. These actions may be either institutional or operational. The plant remains within its design basis, and pre-emptive actions must conform to the plant's design basis.

- Responsive

  Responsive measures are those taken when degraded strainer performance no longer allows the ECCS to perform as designed while on recirculation. The event has gone beyond the plant's design basis. These operational actions are intended to allow the ECCS to remain operational in the recirculation mode.

- Alternative

  Alternative measures are those taken when strainer performance has degraded to the point where long term core cooling cannot be sustained using ECCS sump recirculation. The event is outside the plant's design basis and the

ECCS system must be re-aligned to provide decay heat removal by other means.

Section 5.1 will evaluate the responsive and alternative measures that could be used to mitigate the effects of degraded or blocked ECCS sump strainers. Specifically, section 5.1A establishes the transition point at which the plant has progressed beyond its design basis where responsive or alternative measures are to be implemented, and section 5.1B evaluates the effectiveness of those measures in supporting the overall response strategy and maintaining the plant in a safe and stable condition throughout the event. Sections 5.2 through 5.4 will evaluate various pre-emptive measures to determine if and how they can effectively be accomplished, given the current plant configuration and licensing basis.

The COAs provided in Reference 3.38 provide a framework for addressing potential ECCS sump strainer clogging. The underlying COA(s) will be identified in the associated sections of this analysis. Attachment 8.3 provides a table of the relevant COAs from Reference 3.38, a brief description of the purpose for each COA, and a brief discussion of where the COA is addressed in this analysis and whether it is being implemented at Fort Calhoun Station.

Following the issuance of Revision 0 of this EA, changes were made to the EOPs and AOPs to recognize and respond to sump clogging. Revision 1 of this EA expands the assessment to include insights gained from References 3.38 and 3.49. Section 7.0 of this EA documents the specific activities that have been recommended and how they will be incorporated into plant operation.

5.1 Response to Sump Clogging

This section evaluates:

- Establishing EOP/AOP Guidelines for symptoms of sump clogging and criteria for identifying sump inoperability.
- Contingency Actions in response to sump inoperability. The primary actions evaluated are:
    - Securing pumps not required for reactor core coverage and monitoring operating pumps for indication of cavitation.
    - Establishing the minimum required HPSI flow from the SIRWT, after it is refilled or during refill, to maintain reactor core coverage.
    - Establishing the maximum injection water volume.

A. Containment Sump Degradation and Inoperability

COA A8-CE provides recommendations on the establishment of procedural guidance for symptoms and identification of containment sump blockage [3.38]. If sump clogging were to occur, operators would transition from EOP-03 [3.3] to EOP-20 [3.4] and continue to monitor and restore safety functions. If the event progressed into a core damage scenario, the Severe Accident Management Guidelines (SAMG) provides recommendations.

Containment sump screens SI-12A and SI-12B are redundant passive devices that remove debris that may damage SI and CS components during the LOCA Recirculation phase. The sumps are designed to assure adequate NPSH to the operating pumps and to maintain their structural integrity. The sumps are currently in compliance with NRC Regulatory Guide 1.82 Revision 0 [3.7] with exceptions as stated in Reference 3.36. Clogging of a sump screen is a result of the failure of a passive device, and is therefore beyond design basis.

For purposes of this evaluation, containment sump inoperability is defined as the inability of a sump screen to perform any of the design basis functions of:

- Pass sufficient flow to ensure adequate NPSH to SI or CS pumps so that the pump capacity is not reduced to less than design basis flow rates
- Maintain structural integrity
- Prevent debris of >1/4" from passing through the strainers and damaging downstream components

When evaluating procedural guidance for recognition of sump screen clogging or inoperability, the following factors were considered:

- Accurate and timely identification of sump inoperability can potentially reduce the consequences associated with sump screen clogging.
- It is acceptable to use installed plant instrumentation that is not qualified to RG 1.97 standards. Sump inoperability is beyond the plant design basis. Any available means may be used to take risk reduction measures [3.6; Question 15].
- Additions to plant EOPs increase operator response times and may focus attention away from other more important tasks. The proposed guidance should use instrumentation readily available in the Control Room, and simplify diagnostic actions to the extent practicable to minimize the impact on operator response.
- No single parameter can provide adequate indication of sump blockage. Sump inoperability criteria must ensure that a failure of a single pump or train due to a problem not related to sump clogging is not interpreted as a sump failure.
- Diagnostic actions should be conservative with regard to RCS inventory control, core cooling, and containment spray control. At the same time, the actions should be proactive with respect to preserving SI and CS pump integrity.

- Incorrect diagnosis of sump blockage could lead to actions that may increase the consequences of the actual event in progress.
- The overall mitigating strategy should reduce the risk associated with sump screen clogging.

1. Indications of Sump Clogging

Direct indications of sump screen clogging would include visual evidence of buildup, increasing differential pressure across the sump screen, or loss of suction pressure due to inadequate $NPSH_{Available}$. There are no provisions in the FCS design for observation of any of these indications.

Consequently, diagnosis of sump screen clogging is limited to monitoring SI/CS pump performance for symptoms of pump distress. The pumps may cavitate if $NPSH_{Available}$ decreases below $NPSH_{Required}$. The CS pumps have the smallest NPSH margin and should experience distress before the HPSI pumps. [3.5; Section 6.2.1]

Symptoms of pump distress may include:

- Reduced/erratic flow
- Reduced/erratic discharge pressure
- Reduced/erratic pump motor current
- Low suction pressure indication
- Excessive pump vibration
- Cavitation noise
- Lowering pump differential pressure (failure to develop the required Total Dynamic Head (TDH) for the required flow)

It is important to note that sump screen clogging should not be diagnosed based on degradation of performance for a single pump.

FCS has limited instrumentation that can be used to monitor the above parameters. Suction pressure instrumentation is not installed for the SI or CS pumps or suction lines. Each SI and CS pump is equipped with a discharge pressure indicator; however, indication is local, normally isolated, and is not available without entry into the SI Pump Rooms. HPSI header pressure indication is available in the Control Room. The SI and CS pumps are not provided with installed vibration monitoring.

a. Diagnosis of Pump Distress Using Local Indications

High dose rates in the SI Pump Rooms may render local monitoring activities unavailable if core damage occurs. If SI Pump Room dose rates permit and resources are available, personnel can be dispatched to the SI Pump Rooms to monitor for excessive noise level that would indicate cavitation.

b. Diagnosis of Pump Distress Using Control Room Indicators

Diagnosis of pump distress using Control Room indicators is limited to observation of HPSI header pressure and loop flows, CS header flows, and pump motor amperes.

Fluctuation of CS or HPSI flow rates or header pressures may be an indication that pump distress is resulting in a lower delivered flow rate to the system. Erratic or unusually low pump motor amps can indicate that the pumps are delivering a lower flow or are experiencing pump or motor distress. Individually, these indications will not definitively indicate a clogged sump screen. These indications may also be indicative of pump failure, or component failures in the SI or CS System. When using these indications to diagnose sump screen clogging, it is important that the symptoms be observed on more than one of the operating pumps to minimize the risk of misdiagnosis of sump screen clogging.

Indications of sump screen clogging will vary depending on the rate of debris accumulation on the strainer. The following table summarizes the expected instrumentation response for 1) a slow buildup of debris with partial blockage, and 2) a fast buildup of debris and subsequent complete blockage of the sump screens.

Table 5.1-1: Expected Instrumentation Response for Debris Buildup and Blockage of Sump Screens

Parameter	Instrument	Case 1 (Slow)	Case 2 (Rapid)	Comments
HPSI Injection Flow	FI-313 FI-316 FI-319 FI-322	Gradual Decrease	Erratic; Drops to 0 on pump failure	EOP's require actions to maintain flow >50gpm/pump for pump protection
HPSI Pump Discharge Pressure	PI-323A PI-323B PI-323C	Erratic	Erratic; drops to 0 on pump failure	**Local Indication Only**; Indicator normally isolated
HPSI Header Pressure	PI-309 PI-310	Erratic	Erratic; drops to 0 on pump failure	
CS Pump Discharge Pressure	PI-303A PI-303B PI-303C	Erratic	Erratic; drops to 0 on pump failure	**Local Indication Only**; Indicator normally isolated

CS Header Flow	FT-342 FT-343	Gradual Decrease	Erratic; drops to 0 on pump failure	CS Flow must be maintained > 2,800 gpm to satisfy Alternate Source Term commitment
HPSI & CS Pump Motor Current	Meters on AI-30A & AI-30B	Erratic; Gradual Decrease	Erratic; drops to 0 on pump failure	
HPSI & CS Pump Trip	Alarm on AI-30A & AI-30B	Should see other indications prior to trip	Alarm received	

2. Recommendations for Sump Inoperability Criteria

Procedural guidance should be contained in the appropriate EOPs and AOPs to assist the operators in diagnosing sump screen clogging. This guidance should be provided to operators post-RAS. Below are the recommended criteria for diagnosing sump inoperability:

ANY of the following conditions existing on 2 or more operating, or previously operating pumps:

- Erratic indication or inability to maintain desired CS or HPSI flow
- Erratic or sudden decrease in HPSI Header Pressure
- Erratic or sudden decrease in HPSI or CS Pump Motor Amps
- CS or HPSI Pump Trip Annunciator
- Increased HPSI or CS Pump noise.

Following RAS, the above available indications should be monitored for signs of reduced pump performance. The criteria require that indications be observed on two or more pumps to ensure that individual pump degradation, or a failure in a single component, will not be interpreted as a failure of the sump screens.

The criteria include audible indications of pump cavitation as input to the diagnosis in the event that personnel are in the SI Pump room and observe the indication. However, audible indication of cavitation is not necessary to confirm an inoperable sump.

Note that this point is the transition from design basis to beyond design basis plant conditions.

B. Contingency Actions in Response to Sump Inoperability

Once sump inoperability is identified, it is important that actions be taken to ensure core cooling, protect operating CS and HPSI pumps from damage, and to reduce flow through the sump screens. Cavitation has the potential to cause permanent damage that may degrade pump performance. Taking actions to reduce flow through the sump screens may allow the HPSI pump, which has lower flow and NPSH requirements than the CS pumps, to operate for a longer period of time on the degraded sump to continue to cool the core. COA A9-CE provides recommendations on the establishment of procedural guidance for response to containment sump blockage, loss of suction, and cavitation [3.38].

The actions discussed in this section will be presented in the order that they would be undertaken in response to indications of degraded sump strainer performance. They will progress from responsive actions, which are intended to allow continued ECCS recirculation, to alternative actions if strainer blockage will not support ECCS recirculation via the normal flow path. In the event of total strainer blockage, the ultimate strategy will be to raise containment water level to point above the RCS cooling loops, allowing sump water to backfill the RCS through the break and develop adequate elevation head to establish Shutdown Cooling (SDC) as an alternate means of recirculation. As water level is raised, core cooling is accomplished by HPSI injection flow from a refilled SIRWT until SDC can be established.

When evaluating contingency actions for response to an inoperable sump, the following factors were considered:

- Core cooling takes precedence over other functions such as continued operation of containment spray and preventing damage to indications used to monitor the event [3.6; Question 38].
- It is not required that risk be quantified to demonstrate adequacy of the interim corrective measures [3.6; Questions 37, 54, 59]. The purpose of these evaluations is to gain a qualitative understanding of how the interim corrective measures will affect risk.
- The actions taken should be conservative with regard to avoiding or minimizing permanent damage to pumps operating on a degraded sump.

1. Securing Containment Spray Pumps

The CS system limits containment pressure rise, and reduces leakage of airborne radioactivity, following a LOCA. The system sprays cool, borated water, to cool the containment atmosphere, and strip radioactive particles from the atmosphere where they fall to a surface and are washed into the containment sump.

The CS System has three pumps, two of which are powered from the respective safeguards buses, and one (SI-3C) that is normally powered from one safeguards bus, but may be manually transferred to the other safeguards bus under certain circumstances. It is essentially an installed spare. A proposed modification is currently in process to remove the autostart feature from this pump [3.51]. The CS pumps take suction from the SIRWT during the LOCA injection phase. The RAS signal shifts the suction source to the containment sump.

Securing the CS pumps is a responsive action to reduce the consequences of a beyond design basis event [3.38, COA A9-CE]. This will reduce flow through the sump screens and reduce the potential for damage to the pumps. This reduction in flow may allow the HPSI pump(s) to continue operation on a degraded sump to provide core cooling because the HPSI pump flow rate is lower, and the NPSH margins are greater, than the CS pumps. If no action is taken, the result will be degradation of the operating pumps.

a. Containment Pressure and Temperature Considerations

The containment building and associated penetrations are designed to withstand an internal pressure of 60 psig at 305°F, including all thermal loads resulting from the temperature associated with this pressure, with a leakage rate of 0.1 percent by weight or less of the contained volume per 24 hours. [3.8; Section 5.1.1.2]

The containment pressure analysis performed in support of the Replacement Steam Generator (RSG) project is used in this evaluation because the mass and energy release values will increase slightly when the RSGs are installed. The long term pressure response analysis, which is representative of the conditions that would be seen during a sump clogging event shows that the peak containment pressure results are approximately 55 psig occurring at slightly less than 200 seconds, and peak containment temperature results are approximately 278°F [3.47]. The pressure decreases as the containment is cooled and at RAS initiation (approximately 20 minutes into the LOCA) containment pressure is approximately 40 psig and decreasing. At one hour into the event, containment pressure will decrease to approximately 30 psig [3.47, Fig.3].

The LOCA analysis assumes operation of one train of containment spray (one CS pump and one CS header, with one spray nozzle missing and five spray nozzles per header blocked) during ECCS injection mode. An assumed CS flow rate of 1885gpm takes into account pump degradation, instrument uncertainties and flow through the mini-recirculation lines [3.10]. The analysis does not credit cooling from the containment fan coolers (CFC).

Upon receipt of both a PPLS and a CPHS Signal, the CS pumps spray cool, borated water into the containment from the SIRWT to remove heat and limit the containment pressure rise. The heat removal capacity of each CS train pre-RAS is 140 X 10^6 BTU/hr [3.14; Section 4.2.3].

At RAS, the CS pump suctions are switched to the containment sump and water is recirculated and cooled by the Shutdown Cooling (SDC) heat exchangers. The SDC heat exchangers have a heat removal capacity of 58.9 X 10^6 BTU/hr for each heat exchanger [3.5; Table 6.3-1]. Flow through one SDC heat exchanger is sufficient post-RAS to remove heat and limit the containment pressure rise. [3.5; Section 14.16]

The CFCs operate independently from the CS system to remove heat from the containment atmosphere. The CFCs consist of two redundant trains; each train with one cooling unit with filtering capability, and one cooling unit without filtering capability. The CFC filtering units are brought into operation upon receipt of the SIAS signal. The CFC Cooling Units start on a CSAS Signal. If all normal power sources are lost and one diesel generator fails to function, one train of CFCs will operate.

The CFCs were designed to remove heat from moisture saturated air at 60 psig and 288°F, with a heat removal capacity of 140X10^6 BTU/hr for each cooling and filtering unit, and 70X10^6 BTU/hr for each cooling unit [3.5; Table 6.4-1]. Therefore, the heat removal capacity of one train of CFCs exceeds the heat removal capacity of a single train of CS during both ECCS injection and recirculation modes of operation.

The CFC fans and coolers are CQE [3.12] and are credited in the containment pressure analysis for a Main Steam Line Break (MSLB) with a total heat removal rate of 200 x 10^6 BTU/ hour [3.5; Section 14.16].

Although the CFC's are not credited for LOCA mitigation, the coolers will operate and the cooling capacity of one train of CFC's post-RAS exceeds the capacity of the SDC heat exchangers. In the event that all CS pumps are lost post-RAS, one train of CFC's will provide sufficient cooling to limit the pressure rise. Therefore, securing the CS pumps in response to an inoperable sump will not result in exceeding containment design pressure and temperature limits.

b. Radiological Considerations

The LOCA radiological consequences analysis credits CS operation for removal of particulates from the containment atmosphere during a LOCA. Credit for aerosol and elemental iodine removal via sprays is taken starting at T=185 seconds and continued to approximately T=5hrs. Assumed CS flow rates are 1885gpm prior to RAS, and 2,800gpm post-RAS for the remainder of the 5 hour period [3.52]. The analysis does not credit the containment charcoal filters for removal of iodine in the containment atmosphere. [3.13]

Two of the CFCs are equipped with HEPA Filters and Charcoal Adsorbers that will provide for some filtration of particulates and iodine during a LOCA. The filters are not CQE and the charcoal adsorbers are not required to be laboratory tested to demonstrate their Iodine removal capability. License Amendment 198 removed the requirement for charcoal adsorber laboratory testing and the CS system was credited for removal of radioactive material from the containment atmosphere [3.13]. The filters remain installed in the plant and are subject to surveillance testing to ensure no leakage paths around the filters and no adverse pressure drop [3.14; Section 3.6].

A calculation was performed to assess the impact of natural deposition on the quantity of radioiodine that is released to the FCS containment atmosphere during a LOCA, and quantified the radiological impact of the radioiodine using analytical models [3.15]. Although non-CQE, the calculation was performed with the same rigor as a safety related calculation, with respect to evaluating the consequences of not crediting containment spray for radioiodine removal.

The calculation used the Alternate Source Term as defined in NRC Regulatory Guide 1.183 to determine FCS Site Boundary and Control Room doses based on natural deposition only. Design basis values were used throughout the calculation, with the exception that experimental data sets published by other laboratories in public documents were used as basis for comparison and as source input for radioiodine natural deposition rates. No credit was taken for radioiodine removal via the containment spray system or the CFC charcoal and HEPA filters. The analyses showed a significant reduction in dose following a large LOCA just by crediting natural deposition.

Quantifying the radiological consequences of a loss of the CS pumps prior to T=5 hours requires additional safety related analysis. Therefore, it is not recommended that all CS pumps be secured prior to indication of sump clogging as a preventive compensatory action. However, from a qualitative perspective, removal of particulates and iodine by the CFC HEPA filters and charcoal adsorbers will continue if CS pumps are lost due to sump screen clogging. In addition, as discussed above, the evaluations performed show a reduction in dose for the scenarios of concern just by crediting natural deposition. Therefore, securing all CS pumps as a responsive action to a degraded sump to prevent damage to the pumps and maintain core cooling is recommended as a mitigative strategy to reduce the overall risk associated with sump clogging.

Conclusion:

The action to secure all operating CS Pumps upon confirmation of sump inoperability should be implemented based on the following considerations:

- Failure of a sump screen is a condition beyond the FCS design basis. Securing CS pumps is an action to reduce the consequences of a beyond design basis event.
- Taking no action upon indications of sump clogging may result in degradation or failure of the operating pump(s), making them unavailable for future mitigation strategies.
- Securing CS pumps may allow HPSI pump(s) to operate on a degraded sump; thereby, extending time until alternate injection sources are required, and allowing more time for operators to initiate shutdown cooling.
- The containment coolers, while not credited in the LOCA analysis, have the capacity to maintain the containment below the design pressure of 60 psig post-RAS. The CFC Coolers and Fans are maintained CQE.
- The CFC Charcoal and HEPA filters, although not credited in the radiological consequence analysis, will provide for some filtration of particulate and radioiodine.
- Preliminary analyses show a significant reduction in dose following the type of LOCA that could lead to sump clogging just by crediting natural deposition.

The following are factors to consider if the containment sump screens are inoperable:

- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging.
- Increased awareness of containment pressure is necessary due to the increased risk for challenging of containment design pressure limits.

- Increased awareness of HPSI pump operating parameters is necessary while the HPSI pump is operating on a degraded or inoperable sump due to the increased risk of pump damage.
- All available containment coolers should be verified operating to provide continued containment pressure reduction.
- Plant cooldown by all available methods will reduce the heat load inside containment.
- Increased awareness of radiological conditions in the Control Room is necessary because of the possibility of higher control room doses due to potentially higher particulate and iodine activity in the containment atmosphere.

2. Throttling HPSI Flow

The ECCS recirculation flow rate established via HPSI following RAS provides more heat removal than is necessary to account for decay heat. Providing the required heat removal ensures that the cooling water flowing through the core remains subcooled. In the event of sump clogging, a higher flow rate results in increased head loss across the debris bed and less $NPSH_{Available}$. Therefore, it is desirable to reduce the flow rate as much as possible to improve HPSI pump NPSH margin while still maintaining adequate heat removal capabilities. If recirculation capabilities are lost and the HPSI pumps must be returned to the injection mode of operation, throttling HPSI flow will maximize the time available for decay heat removal for a given volume of supply water. This section evaluates throttling HPSI flow following detection of sump strainer clogging as a responsive action to address a condition outside the design basis [3.38, COA A9-CE].

Following RAS, the HPSI pump recirculation isolation valves (HCV-385 and HCV-386) are closed. When throttling HPSI flow, the flow rate should not be reduced to the point where flow through a running HPSI pump falls below 50 gpm, which is the pump's minimum flow limit. If throttling HPSI flow cannot effectively restore adequate pump operation at a flow rate of greater than 50 gpm, the affected pump(s) must be secured to avoid permanent damage.

Throttling HPSI flow to the lowest value that will provide adequate decay heat removal will reduce flow through the sump screens and reduce the potential for damage to the pumps. This reduction in flow may allow the HPSI pump(s) to continue operation with a degraded sump strainer to provide core cooling by reducing the head loss across the debris bed to restore a positive NPSH margin for the HPSI pumps. If no action is taken, the result will be degradation of the operating pumps.

a. Minimum Required Flowrate to RCS

Minimum required flowrate to maintain RCS inventory and to prevent precipitation of boric acid within the reactor vessel was calculated [Ref. 3.16]. This calculation is non-CQE, and uses best estimate values for decay heat. The calculation was performed for the minimum time from SIAS until RAS and subsequent sump blockage, and for the minimum time when hot leg switchover requires simultaneous hot /cold leg injection.

The calculation determined that approximately 160gpm is required to remove core decay heat at T=30 minutes. Assuming a potential loss of 25% of the SI flow through the break, a HPSI flow of 215gpm is required at 30 minutes into the LOCA. This value decreases with time as decay heat diminishes over time. [3.16].

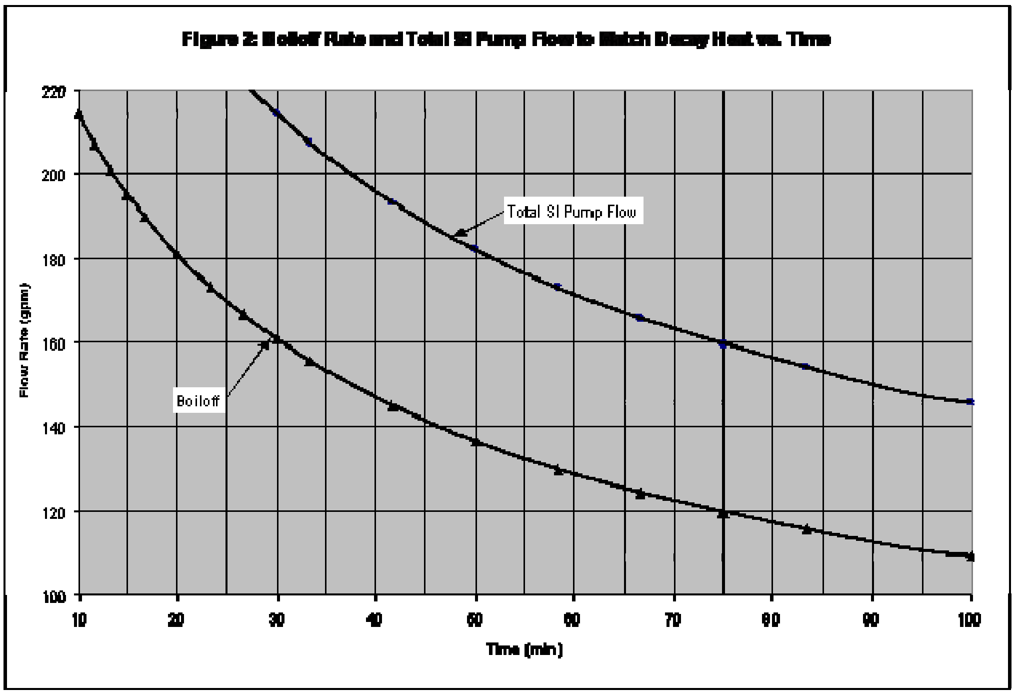


Figure 5.1-1, above, shows the boiloff rate and total SI pump flow to match decay heat vs. time to T = 100 minutes [3.16; Figure 2].

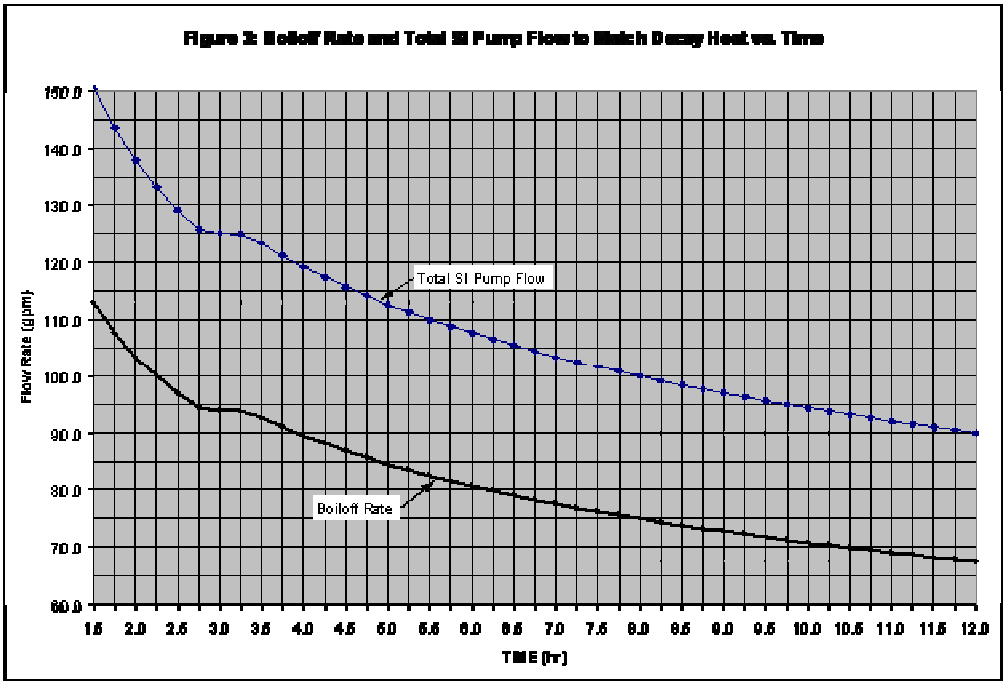


Figure 5.1-2, above, extends the Figure 5.1-1 graph out to T = 12 hours: [3.16; Figure 3].

In addition to the SI flow required to remove decay heat, flow to the hot legs is required to flush highly concentrated boric acid from the core to prevent precipitation of boron that could adversely impact core cooling.

The total hot leg/cold leg injection flow requirement as a function of time following a LOCA was evaluated. The additional flow to flush highly concentrated boric acid is based on a refilled SIRWT boron concentration of 965ppm and a maximum core boron concentration of 35,000ppm [3.16]. This boron concentration corresponds to boric acid precipitation at 180°F and provides some margin to reduce the likelihood of local precipitation.

The analysis assumes that:

- Boron concentration of a refilled SIRWT is 965ppm,
- Minimum required hot leg or cold leg SI flow is not less than ½ the total minimum required flow, and
- Maximum initial SIRWT boron concentration does not exceed 2,400ppm.

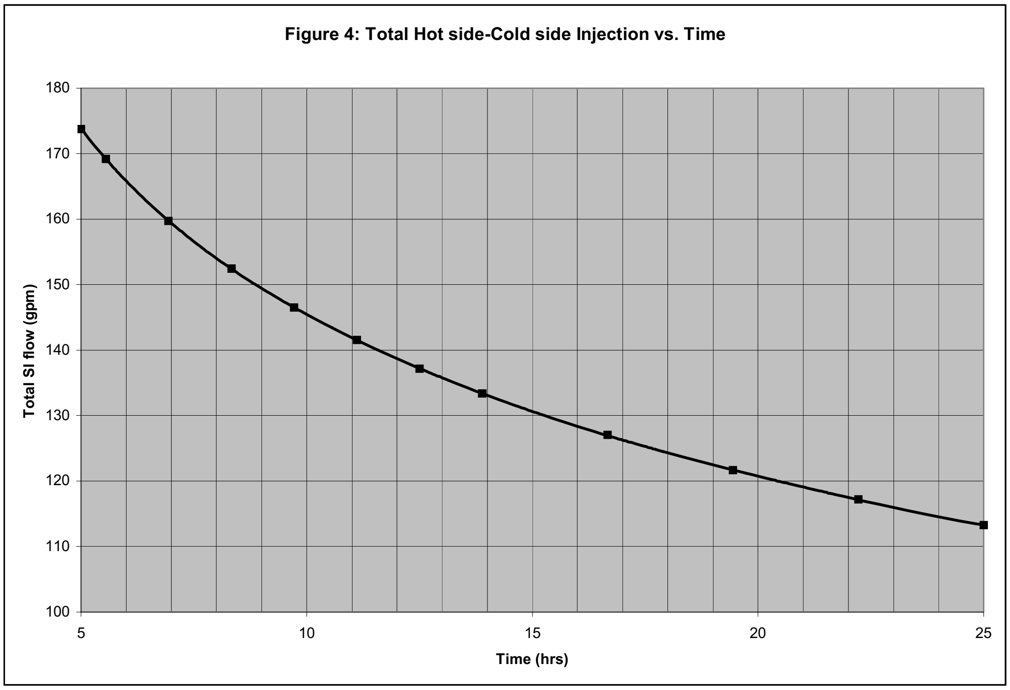


Figure 5.1-3 above, shows the total hot leg/cold leg injection flow required vs. time [3.16; Figure 4].

Conclusion:

Throttling of HPSI flow to less than design basis flow rate should only be used in the event that degraded ECCS sump strainer performance is evident.

The compensatory action to throttle HPSI flow post-RAS in response to sump performance degradation should be implemented based on the following considerations:

- The design configuration of the HPSI system post-RAS results in a recirculation flow rate that is greater than that required to remove decay heat and keep the core covered.
- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to improve ECCS sump strainer performance may result in core damage.

The following actions should be taken when throttling HPSI flow post-RAS in response to degraded ECCS sump strainer performance:

- HPSI flow should be throttled to establish just greater than the minimum flow necessary to maintain adequate decay heat removal, accounting for spillage of a portion of the injection water out the break prior to reaching the core.

- When simultaneous hot/cold leg injection is implemented, throttled HPSI flow must be adequate for decay heat removal and prevention of boron precipitation.
- If HPSI flow rate cannot be maintained greater than 50 gpm per pump, then the affected pump(s) should be secured to preserve them for later use.
- Increased monitoring of HPSI pump performance is necessary if evidence of degraded ECCS sump strainer performance is observed. Preservation of an operable pump is desirable for implementation of alternate long term cooling strategy.
- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging.

3. Establishing a More Rapid Cooldown Rate Using Steam Generators.

Reference 3.38, COA A7 recommends the establishment of a more aggressive cooldown rate following a small break LOCA. The maximum cooldown rate normally established post-LOCA is limited to 100°F/Hr and is governed by the Technical Specification pressure-temperature limits [3.3]. This limit is intended to ensure that the cooldown does not result in pressurized thermal shock, which could exacerbate the LOCA break size, and lead to more rapid initiation of RAS.

However, if degraded ECCS sump strainer performance is evident, the responsive action to establish a more aggressive cooldown is justified, as it reduces the reliance on safety injection recirculation for heat removal and lowers the fuel temperature more rapidly, thereby providing a greater margin to boiling and core uncovery.

Conclusion:

Exceeding a cooldown rate of 100°F/Hr, or exceeding T.S. pressure temperature limits should only be performed in the event that degraded ECCS sump strainer performance is evident.

Maximizing the cooldown rate post-RAS in response to sump performance degradation should be implemented based on the following considerations:

- The guidance for this action previously existed in the EOPs for situations where inventory control is threatened [3.4, section IC-2].

- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to improve ECCS sump strainer performance may result in core damage.

4. Establishing SI Flow from the Refilled SIRWT

In the event of sump clogging the primary priority is to maintain core cooling. The inability to operate the HPSI pumps from the containment sump results in the loss of long term core cooling via the normal flow path. Therefore, a mitigating strategy that establishes an alternative means of long term heat removal is required.

Reference 3.38, COA A6 establishes injection of more than one RWST (SIRWT) volume of water into the RCS. Injection of water from a refilled SIRWT is evaluated here as a compensatory measure [3.2] that maintains core cooling. While injection from the SIRWT is in progress, decay heat removal is accomplished via flow from the SI system through the core and out the break ("once through cooling").

COA A6 does not specify an end point for re-alignment and injection from the SIRWT, but there are obvious limitations in terms of containment design and equipment location that preclude indefinite operation in the injection mode. Therefore, in order for this measure to be considered a success path for long-term core cooling, it is necessary to establish a transition point at which injection of water from the SIRWT is secured and another means of long term cooling is initiated. This transition point can occur at FCS when the containment is filled to above the loop level. With the loops covered, there are several success path possibilities. The two most likely are: 1) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS, or 2) thermal convection via countercurrent flow through the break or ex-vessel cooling, with fan coolers providing the ultimate decay heat removal. If flooding is not performed to the loop level, then SIRWT injection to the RCS is only a temporary measure and will not ensure long-term core cooling.

Although there would be no strainer on the SDC suction line, it is reasonable to assume that the SDC system would remain capable of decay heat removal in this scenario because the elevation of the suction point from the recirculation pool (RCS loop at approximate El. 1,007 ft.) would limit debris transport, and the majority of debris would be lodged on the ECCS suction strainers or settled out by the time that SDC is initiated.

Section 5.4 provides recommendations for refilling of the SIRWT post-RAS, after the SIRWT Design Basis function is completed, to provide a volume of borated water for long-term core cooling.

This section evaluates the use of the refilled SIRWT for injection in the reactor in the event of sump inoperability. The primary factors considered in this evaluation:

- Concentration of boron required to ensure that the core does not return to criticality.
- Required flow rates to provide adequate core cooling to match decay heat and support hot side/cold side injection following hot leg switchover.
- Effect of injecting more than one SIRWT volume on containment sump pH and the need for additional neutralization of the containment sump water.
- Volume of water necessary to fill to above the hot legs.
- Impact of hydraulic effects of increased water level on containment pressure/structural limits.
- Effect of rising containment water level on plant equipment, components, and installed instrumentation.

a. <u>Reinjection Water Boron Requirement</u>

If the core becomes critical, heat production could be much greater than the decay heat and make it increasingly difficult to maintain long-term core cooling.

The FCS Cycle 22 BOC Critical Boron Concentration was calculated at the conditions of 50°F, ARI, no xenon, 0.0 MWD /MTU with no uncertainty [3.16]. The calculation determined the best estimate minimum SIRWT Boron Concentration upon refill should be at least 965 ppm to prevent localized re-criticality in the core. This does not account for the condition of a stuck CEA, which would raise the estimated concentration. The calculation does not account for initial boron concentration in the RCS and the remaining SIRWT and piping, which would lower the estimated concentration [3.16].

Cycle 23 and 24 BOC Critical Boron Concentrations for the same conditions are estimated to be within 10 ppm of the value assumed in the original calculation [3.54]. Using the same methodology as established in Ref. 3.16 for Revision 0 of this EA, SIRWT boron concentration should be at least 975 ppm to avoid local criticality. A reasonable target value for SIRWT boron concentration is therefore established as 1,000 ppm.

b. Minimum Required Flowrate from the SIRWT

Minimum required flowrate from the SIRWT to maintain RCS inventory and to prevent precipitation of boric acid within the reactor vessel was calculated [Ref. 3.16]. The minimum flow requirements for HPSI injection are consistent with those needed for recirculation, which was addressed earlier in this evaluation. Early strainer clogging was assumed to occur 10 minutes after the earliest time for RAS, or approximately 30 minutes after event initiation. At that time, minimum required flow rate will be approximately 215 gpm. As decay heat load reduces, the minimum required flow rate is reduced as well. Accounting for the additional flow required to maintain simultaneous hot leg/cold leg injection, the minimum flow rate required after 24 hours is approximately 120 gpm. Details of the minimum flow calculation are discussed; and figures 5.1-1 through 5.1-3, which define the minimum required HPSI flow rate before and after hot leg injection are presented in section 5.1 B 2, Throttling HPSI Flow.

Assuming that the RCS injection flow rate from the SIRWT is maintained in accordance with the curves shown in figures 5.1-1 through 5.1-3, the total volume of water required for makeup per unit time was calculated. This calculation is presented in attachment 8.5. The results of this calculation can be used to determine how much time a given volume of water in the SIRWT would provide for decay heat removal. It can also be used to determine the makeup flow rate requirements to the SIRWT for various times in the event.

If HPSI flow is throttled in accordance with figures 5.1-1 through 5.1-3, the volume of water required to provide adequate core cooling for the first 24 hours of the event is approximately 182,000 gallons. Section 5.4 of this EA shows that sufficient capacity exists in the Fuel Transfer Canal, Spent Fuel Pool and Primary water storage tank to deliver more than 182,000 gallons to the SIRWT at a rate greater than that required by figures 5.1-1 through 5.1-3. After 24 hours, the required flow rate from the SIRWT will be within the capacity of the CVCS makeup system, which ensures that adequate level will exist in the SIRWT to support HPSI flow requirements.

c. Neutralization of Containment Sump Water

Sump pH must be maintained above 7.0 so that iodine released from a damaged core and washed into the sump will remain in solution and not enter the gas phase [3.5; Section 14.15]. Post-accident sump pH is controlled by dissolution of Tri-Sodium Phosphate Dodecahydrate (TSP) pre-staged in baskets in the containment basement, El. 994'. Addition of water from a refilled SIRWT will result in additional boric acid being added to the containment sump and may adversely affect sump pH.

To support Revision 0 of this EA, the impact on sump pH of the addition of a 965ppm boron solution into the RCS at a rate of 250gpm was evaluated [3.16]. Although the boron concentration of the spent fuel pool and the water stored in the Fuel Transfer canal are maintained at approximately 2,000 ppm, it is reasonable to assume that the emergency response organization would make efforts to dilute the SIRWT to approximately 1,000 ppm to maximize the availability of borated water for injection. Additionally, over the first 24 hours of the event, the injection rate would be reduced to less than 150 gpm. And finally, the pH assessment performed assumed maximum volumes and concentrations of borated water sources and minimum TSP volume, meaning that initial sump pH would likely be greater than 7.0 at the initiation of SIRWT re-injection.

The pH assessment also did not credit any natural buffering that would occur post LOCA from release of Cesium radionuclides at the end of the early in vessel release phase that form Cesium Hydroxides. From alternate source term calculations, 30% of the core cesiums (Table 2 RG 1.183, alkalis) are released to the RCS and hence, the sump pool. These cesiums interact with the pool to formulate cesium hydroxides and cesium iodides. Cesium hydroxides have a strong chemical affinity to offset acidic conditions depending on the activity of cesium released and the sump pool volume. Historically, in Alternate Source Term evaluations for BWRs, cesium hydroxide formation is credited for pH control post LOCA, and does have an impact in offsetting potential acidic conditions short term until long term neutralization systems are operated. The natural buffering from cesium hydroxides that would be present has not been explicitly quantified for FCS. Therefore, under core damage circumstances, where pH control is most important, the time period within which pH would remain above 7.0 is likely longer than what is calculated in the pH assessment. In addition, Cesium Iodides can form which would suppress the tendency for radioiodines to revolatize from sump solution.

Assessing all of the factors described above, the analysis supporting Revision 0 of this EA can still be considered valid. Figure 5.1-4 shows that it is possible to re-inject boric acid solution for several days without neutralization, while maintaining sump pH of the uniformly mixed sump at or above 7.0 [3.16, Fig. 7]. It is expected that the maximum length of time for SIRWT re-injection would be less than 150 hours (see Attachment 8.5).

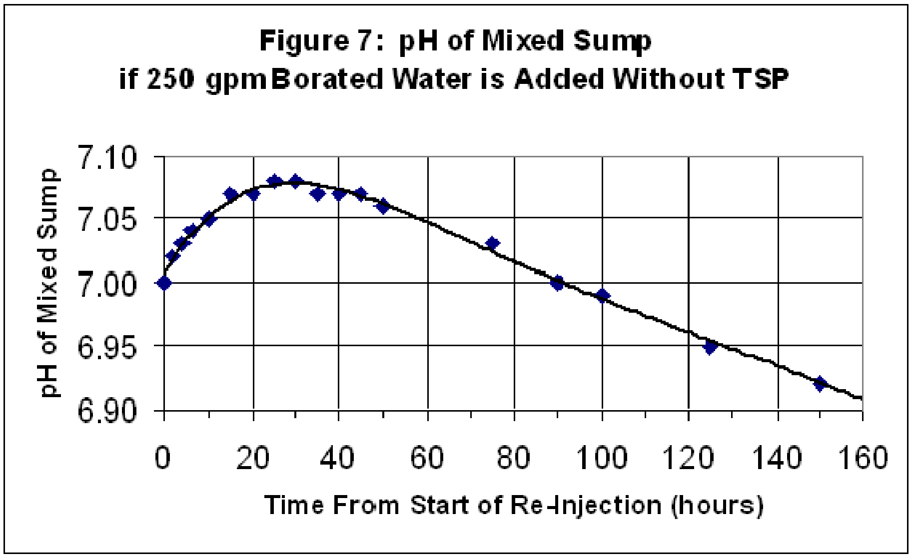


Figure 5.1-4: pH of a Mixed Sump if 250gpm Borated Water is Added without TSP [3.16; Figure 7]

Given that approximately 90 hours would elapse before sump pH falls below 7.0, adequate time exists to measure actual sump pH and develop a plan for adding a pH buffer to the SIRWT water, if necessary.

d. Evaluation of Required Water Volume

Transfer of greater than one SIRWT volume to the containment is outside the plant design basis. Existing analyses assume that the maximum containment water level at RAS is 1000.9 ft [3.17]. The Equipment Environmental Qualification (EEQ) Program limit for containment flood level is El. 1000.9ft.

Table 5.1-2 provides a summary of containment elevation vs. RCS and Vessel physical features [3.18].

Table 5.1-2: Reactor Vessel & RCS Physical Features vs. Containment Elevation	
Elevation (ft)	Physical Features
981	Bottom of Reactor Vessel
994 (Basement Floor, Sump Screen Elevation)	Approximately 4 ft above the bottom of the active core
1000.9 (EQ Flood Level)	Top of active core
1002.2	Top of core fuel assembly
1004.5 (top of instrument range)	Approximately 28 inches above the Fuel Alignment Plate
1005	Bottom of the hot leg ID
1006.4	Hot Leg Centerline
1007.7	Top of hot leg ID
1013	Reactor Vessel Flange; SG bottom head above the manholes
1018.3	Top ID Reactor Vessel Head
1019.5	Reactor Vessel Vent Centerline
1020.1	Instrument Flange
1020.6	Omega Seal

Flooding to the top of the hot legs (El. 1,008 ft.) should allow for makeup to the RCS via reverse break flow and the initiation of Shutdown Cooling (SDC). Flooding of containment to El. 1,013ft would ensure that the RCS loops and SG bottom heads including the primary side manholes are underwater.

Figure 5.1-5 provides a graph of containment water volume vs. indicated containment water level up to El. 1,006' [3.19]. The top of the range of level indicators LI-387-1/388-1 is 27.5ft, which corresponds to El. 1,004.5ft. [3.20]

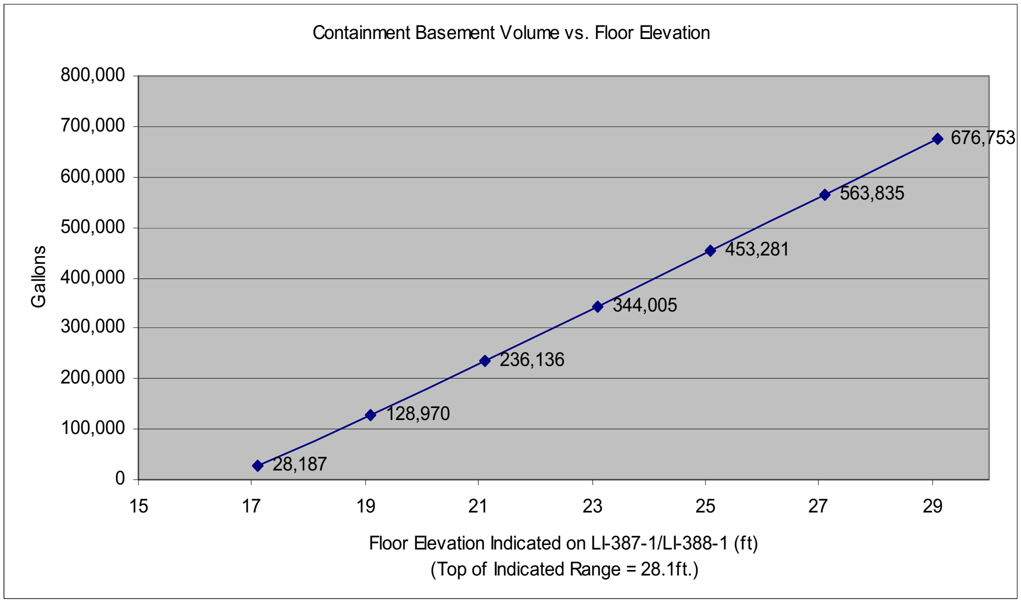


Figure 5.1-5 – Containment Basement Volume vs. Floor Elevation

Above elevation 1,004'6", containment water level monitoring is not available and water level must be estimated based on the volume of water sources injected during the accident. The calculation of containment free volume [3.19] that Figure 5.1-5 is based on does not address above El. 1,006 ft.

Figure 5.1-6 provides estimated containment water volume vs. elevation above the top of the containment level indicators to El. 1,014 ft. The curve is a linear extrapolation from the data used to develop Figure 5.1-5. The assumptions and equation used in developing this figure are discussed in Section 3 of attachment 8.5.

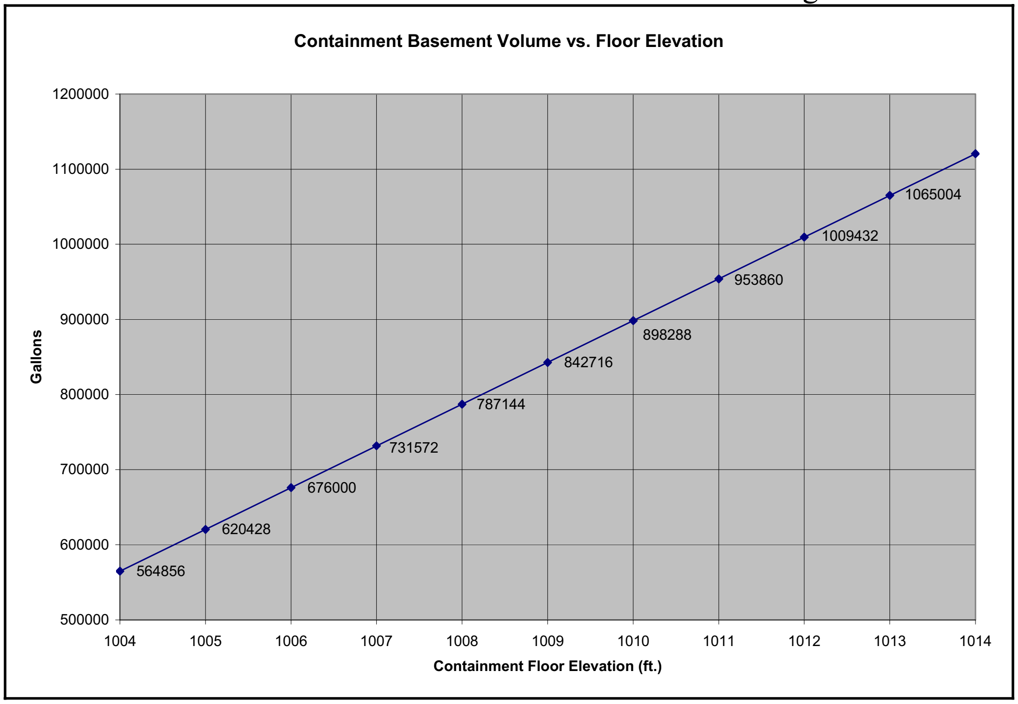


Figure 5.1-6 – Containment Basement Volume vs. Floor Elevation (Above El. 1004)

It will take approximately 787,200 gallons to reach El. 1,008 and 1,065,000 gallons to fill the containment to El. 1,013ft. This is consistent with Reference 3.21, which states that it requires injection of >790,000 gallons to fill to El. 1,008 ft, and >1,000,000 gallons to fill to El.1,013ft.

Borated water from the sources credited in the containment water level analysis [3.41] will contribute 308,490 gallons to containment (see attachment 8.4 for evaluation). Therefore, approximately 479,000 gallons of additional water will be necessary to bring containment water level to El. 1,008 ft. and 765,500 gallons to reach El. 1,013 ft. Section 5.4 of this EA shows that adequate clean water sources exist on site to replenish the SIRWT, and inject borated water to above El. 1,008 ft. If water level must be raised to greater than El. 1,008 ft., adequate time would exist (approximately 3 days) to obtain additional makeup water from additional sources, such as Blair water or tank trucks. Fire water, which has diverse pump capabilities and an essentially unlimited supply of water from the Missouri river, would provide a backup means of SIRWT replenishment if necessary.

e. <u>Hydraulic/Structural Effects of Rising Water Level</u>

The design basis assumes a maximum post-LOCA water level in containment of El. 1,000.9 ft. This level is based on injection of one SIRWT, four SITs, and the RCS volume with worst-case assumptions regarding maximum deliverable water inventory [3.17].

This evaluation considers two hydraulic effects of injecting water to El. 1013ft.; increased pressure due to submergence, and increased pressure due to the compression of the containment free air volume:

- Increased pressure on submerged areas of containment due to elevation head of water.

  Increasing water level will increase pressure on the containment liner and penetrations below the water level. The pressure exerted at any point in the containment below the sump water level is the sum of the vapor pressure inside the containment and the height of water above the given location.

  $P = P_{vapor} + P_{water}$

  $P_{water} = 0.4335\ lb/in^2$ per 1 ft of water at 50°F [3.22]

  P_{vapor} = Indicated Containment Pressure

  The water temperature of 50°F was chosen as a conservative valve that corresponds to the minimum design water temperature. [3.5; App. G]

  At the design basis water level of El. 1,000.9 ft, the hydraulic pressure exerted at containment floor level is:

  $P = P_{vapor} + P_{water}$

  $= 60psig + (1{,}000.9 – 994)(0.4335)$

  $= 63$ psig

  If design basis water level (El. 1,000.9ft) were assumed, the pressure on the reactor cavity floor at 60 psig is:

  $P = P_{vapor} + P_{water}$

  $= 60psig + (1{,}000.9 – 976.5)(0.4335)$

  $= 70.6psig$

  Table 5.1-3 shows the results of the calculation of water pressure at specific elevations inside containment for a containment water level of 1,013ft.

Table 5.1-3: Pressure With Height of Water at El. 1,013’			
El (ft)	Feature	Δ El. (ft)	P_{water} (psi)
976’6”	Reactor Cavity Floor	36.5	15.82
994’	Basement Floor Elevation	19	8.24
996’4”	Mechanical Penetrations M-1, M-2, M-3	16.67	7.23
996’7”	Mechanical Penetration M-4	16.42	7.12
998’8”	Mechanical Penetrations M-5 through M-15	14.33	6.21
1001’0”	Mechanical Penetrations M-16 through M-25	12	5.2
1002’5”	Mechanical Penetration M-26	10.58	4.59
1003’4”	Electrical Penetrations Group A	9.67	4.19
1007’10”	Electrical Penetrations Group B	5.17	2.24
1009’2”	Mechanical Penetrations M-27 through M-34	3.83	1.66
1011’ 6”	Bottom of Personnel Air Lock and Equipment Hatches	1.5	0.65

- Increased containment pressure due to compression of containment free air volume.

  Increasing water level will compress the free air space in containment. Although the rise in containment water level is slow, it is conservative to assume that there is no containment leakage. Therefore, the ideal gas law is applied to determine the maximum pressure increase that could be observed as containment is filled to the El. 1,013 ft.

Assuming that the temperature of the containment atmosphere remains constant (a reasonable assumption, given the very slow rise in water level and the capacity of the CFCs), the following equation is used to determine the effect on containment pressure:

$$P_2 = P_1 * V_1 / V_2$$

Where:

V_1 = Containment free volume at RAS 1.05 E6 ft^3.

$V_2 = V_1$ – Volume of water added to containment.

Using water volumes derived from figure 5.4-1, the water volume added over time is shown in table 5.1-4. The volume of water injected prior to RAS has conservatively been included in this table.

At El. 1,013 ft.:

$$P_2 = P_1 * 1.05 \text{ E6}/0.908 \text{ E6}$$

$$P_2 = P_1 * 1.16$$

Therefore, predicted containment pressure when the containment water level reaches 1,013 ft must be increased by a factor of 1.16 to account for the effects of free volume compression.

Table 5.1-4: Containment Free Volume Reduction

Time post-RAS (min.)	Water Volume (ft^3)	V_1 / V_2
0	41,239	1.04
490	49,413	1.05
1364	64,643	1.07
4469	105,226	1.11
8042	142,371	1.16

The containment building and associated penetrations are designed to withstand an internal containment pressure of 60 psig at 305°F [3.8]. At pressures near the design limit, containment integrity is virtually certain. Routine surveillance activities test the ability of the liner and penetrations to limit leakage to within design limits at the design pressure of 60 psig [3.14; Section 3.5]. Initial containment testing was performed at 1.15 X Design Pressure (69 psig) [3.8]. The containment has a high confidence of low probability of failure (HCLPF) up to pressures of 130 psig. The median failure pressure of the FCS containment structure is

190psig [3.11]. In other words, at 190 psig, the containment has a 50/50 probability of remaining intact.

The containment pressure calculation associated with the NSSS Refurbishment Project provides a long term containment pressure profile following a double ended cold leg guillotine break, using minimum safeguards equipment. This analysis assumes no containment cooling and a single failure resulting in a single containment spray pump providing containment pressure reduction. It is conservative to use the RSG analysis because the mass and energy release following S/G and pressurizer replacement will be larger than the current configuration. Under these worst case conditions, containment pressure at the time of RAS initiation (approximately 20 minutes) would be approximately 40 psig [3.47, Figure 3]. As discussed in this section, part B.1.a, the heat removal capability of a single train of containment fan coolers is at least equivalent to the heat removal capability of a single train of containment spray during the injection phase, and is well in excess of the capacity of a single train of containment spray in the recirculation phase. It is therefore reasonable to assume that under worst case circumstances, one train of containment fan coolers could maintain containment pressure at or below 40 psig for the remainder of the event.

Applying the effects of compression of the containment free air volume due to raising water level to El. 1,013 ft., general Containment atmosphere pressure would be increased by a factor of 1.16, to 46.4 psig, which remains below the peak analyzed pressure for the event and is well below the containment design pressure of 60 psig.

Combining the effects of increased pressure due to elevation head and increased pressure due to free volume compression, the worst case hydraulic pressure at the containment floor and all containment penetrations would be 54.7 psig, which is below the 60 psig design pressure. Hydraulic pressure at the reactor cavity floor resulting from raising containment water level to El. 1,013 ft. is 62.25 psig. While this value is greater than the 60 psig containment design pressure, it is approximately 8 psi less than the hydraulic pressure seen if design basis containment water level is applied at the design basis containment pressure of 60 psig, and is below the pressure applied to containment during design testing.

f. Effect of Rising Water Level on Components, Penetrations, and Cables

Electrical equipment located above the EQ flood level (El. 1,000.9 ft) is not qualified for submergence. Once containment water level is raised above this elevation, the performance and accuracy of this equipment is not assured. However, the equipment may continue to function. As containment water level is raised by injection of water from a refilled SIRWT, increased monitoring should be performed for instrumentation subjected to submergence and alternate methods should be determined for monitoring parameters lost as a result of the rising level. Attachment 8.2 provides detailed information about EQ equipment that may be submerged, and identifies those components that are critical to support the strategy of injection from the refilled SIRWT, followed by initiation of Shutdown Cooling.

The following tables summarize the components affected by rising containment water level up to El. 1,013ft. The tables are a compilation of the tables contained in Attachment 8.2, which show elevation vs. components, electrical penetrations, and cable trays.

The containment water level monitoring instrumentation (LI-387/388) has a range of 0-27.5ft. This corresponds to containment level of 976' 11" to 1,004'5". Above this elevation no level monitoring is available [3.20]. Alternate methods of measuring water level will be required above El. 1,004'5".

Table 5.1-5 summarizes components subjected to submergence as containment water level is raised to 27.5ft (El. 1,004.5ft). The indicated level is as indicated on LI-387-1/LI-388-1.

Table 5.1-5: Components Affected By Rising Containment Level EEQ Flood Level to Top of Containment Sump Level Instrumentation Range				
Ind. Level (ft)	El. (ft)	Tag #	Description/Service	Submerged Component
23.8	1,000.9	HCV-248	Charging to Loop 1B	Operator
24.1	1,001	A/PT-102	Pressurizer Pressure	Cable
		FT-316	HPSI Flow to Loop 1A	Cable
		FT-328	LPSI Flow to Loop 1B	Cable
		PCV-2909	Loop 1A Leakage Pressure Control	Cable
		A/LT-901/904	S/G Water Level	Cable
		A/PT-902/905	S/G Pressure	Cable
		A/PT-120	Pressurizer Pressure	Cable
		A/LT-911/912	S/G Level for AFW	Cable
		A/PT-913/914	S/G Pressure for AFW	Cable
24.4	1,001.3	PT-105	Pressurizer Pressure for A Sub-Cooled Margin	Cable

Table 5.1-5: Components Affected By Rising Containment Level EEQ Flood Level to Top of Containment Sump Level Instrumentation Range				
Ind. Level (ft)	El. (ft)	Tag #	Description/Service	Submerged Component
		B/PT-102	Pressurizer Pressure	Cable
		FT-313	HPSI Flow to Loop 1B	Cable
		FT-330	LPSI Flow to Loop 1A	Cable
		PCV-2929	Loop 1B Leakage Pressure Control	Cable
		B/LT-901/904	S/G Water Level	Cable
		B/PT-902/905	S/G Pressure	Cable
		YM-102-2	PORV Flow Monitor	Cable
		YM-141	RC-141 Flow Monitor	Cable
		B/PT-120	Pressurizer Pressure	Cable
		B/LT-911/912	S/G Level for AFW	Cable
		B/PT-913/914	S/G Pressure for AFW	Cable
24.6	1,001.5	TCV-202	Loop 2A Letdown TCV	Operator
25.1	1,002	HCV-247	Charging to Loop 1A	Operator
		FT-313 FT-316 FT-319 FT-322	HPSI Loop Flow Indicators	Transmitters
		FT-328 FT-330 FT-332 FT-334	LPSI Loop Flow Indicators	Transmitters
		HCV-545	SI Leakage to Waste Control Isolation Valve	Operator
		A/LT-911/912 B/LT-911/912 C/LT-911/912 D/LT-911/912	S/G Water Level for AFW	Transmitters
		A/PT-913/914 B/PT-913/914 C/PT-913/914 D/PT-913/914	S/G Pressure for AFW	Transmitters
26.1	1,003	PT-105	RC Pressure (WR) for A Sub Cooled Margin Mon.	Transmitter
		HCV-348	SDC Isolation Valve	Operator
26.4	1,003.3	YM-102-1	PORV Flow Monitor	Pen. A-4
		YM-141	RC-141 Flow Monitor	Pen. A-4
		B/TE-112C B/TE-112H B/TE-122C B/TE-122H	B Channel RC Loop Hot Leg and Cold Leg RTD’s	Pen. A-4
		B/PT-120	Pressurizer Pressure	Pen. A-4
		B/LT-911/912	S/G Water Level for AFW	Pen. A-4
		B/PT-913/914	S/G Pressure for AFW	Pen. A-4

Table 5.1-5: Components Affected By Rising Containment Level EEQ Flood Level to Top of Containment Sump Level Instrumentation Range				
Ind. Level (ft)	El. (ft)	Tag #	Description/Service	Submerged Component
		PT-105	RC Pressure (WR) for A Sub Cooled Margin Mon	Pen. A-4
		B/PT-102	Pressurizer Pressure	Pen. A-4
		FT-313	HPSI Flow to Loop 1B	Pen. A-4
		FT-330	LPSI Flow to Loop 1A	Pen. A-4
		B/LT-901 B/LT-904	S/G Level	Pen. A-4
		B/LT-902 B/LT-905	S/G Pressure	Pen. A-4
		YE-116A	HJTC-MI Cable System for RVLMS	Pen. A-10
		CET	Core Exit T/C Cables	Pen. A-10
		A/TE-112C A/TE-112H A/TE-122C A/TE-122H	A Channel RC Loop Hot Leg and Cold Leg RTD's	Pen. A-11
		A/PT-120	Pressurizer Pressure	Pen. A-11
		A/LT-911/912	S/G Water Level for AFW	Pen. A-11
		A/PT-913/914	S/G Pressure for AFW	Pen. A-11
		B/PT-102	Pressurizer Pressure	Pen. A-11
		FT-316	HPSI Flow to Loop 1A	Pen. A-11
		FT-330	LPSI Flow to Loop 1B	Pen. A-11
		A/LT-901 A/LT-904	S/G Level	Pen. A-11
		A/LT-902 A/LT-905	S/G Pressure	Pen. A-11

Table 5.1-6 summarizes components subjected to submergence as containment water level is raised from El. 1004.5ft to El. 1013 ft.

Table 5.1-6: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
1,005	LT-387A/B/C LT-388A/B/C	Containment Water Level	Transmitters
1,005.8	HCV-2914	SI-6A Outlet Valve Motor	Cable
	HCV-311	HPSI to Loop 1B Valve Motor	Cable
	HCV-327	LPSI to Loop 1B Valve Motor	Cable
	HCV-320	HPSI to Loop 2B Valve Motor	Cable
1,006	HCV-239	Charging to Loop 2A	Cable

Table 5.1-6: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
	HCV-151	Pressurizer Relief Valve	Cable
	PCV-102-2	PORV Control	Cable
	HCV-820B HCV-821B	Hydrogen Analyzer Isolation Valve	Cable
	HCV-883C HCV-883D HCV-883E HCV-883F HCV-883G HCV-883H	Hydrogen Analyzer Sample Valve	Cable
	HCV-315	HPSI to Loop 1A Valve	Cable
	HCV-318	HPSI to Loop 2A Valve	Cable
	HCV-329	LPSI to Loop 1A Valve	Cable
1,006.8	TCV-202	Loop 2A Letdown	Cable
	HCV-240	Pressurizer Aux Spray Inlet	Cable
	HCV-2916	SI-6A Drain Valve	Cable
	HCV-2504A	RC Sample Line Valve	Cable
	HCV-2629	SI-6A Supply Stop Valve	Cable
	HCV-425A HCV-425B	SI Leakage Cooler CCW Valves	Cable
	PCV-742A PCV-742C	Containment Purge Isolation Valves	Cable
	PCV-742E PCV-742G	RM-050/RM-051 Containment Radiation Monitor Isolation Valves	Cable
	HCV-746A	Containment Pressure Relief Isolation Valve	Cable
	PCV-1849A	Containment Instrument Air PCV	Cable
	HCV-881 HCV-882	Containment Purge Isolation Valves	Cable
	HCV-883A HCV-884A	Hydrogen Analyzer Isolation Valves	Cable
	HCV-820C HCV-820D HCV-820E HCV-820F HCV-820G HCV-820H	Hydrogen Analyzer Sample Valves	Cable
1,007	D/LT-911	S/G Wide Range Water Level	Cable
	D/PT-913	S/G Wide Range Pressure	Cable
1,007.9	HCV-151	PORV Isolation	Pen. B-1, B-2
	HCV-2934	SI-6B Outlet Valve	Pen. B-1, B-2
	HCV-315	HPSI to Loop 1A Isolation Valve	Pen. B-1, B-2
	HCV-318	HPSI to Loop 2A Isolation Valve	Pen. B-1, B-2
	HCV-329	LPSI to Loop 1A Isolation Valve	Pen. B-1, B-2
	PCV-2929	SI Leakage Cooler PCV	Pen. B-2

Table 5.1-6: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
	HCV-2936	SI-6B Fill/Drain Valve	Pen. B-2
	HCV-725A HCV-725B	CFC Inlet Dampers	Pen. B-2
	HCV-2603B	SI Tank Supply Isolation Valve	Pen. B-2
	HCV-2604B	RCDT/PQT Isolation Valve	Pen. B-2
	HCV-2631	SI-6B Supply Stop Valve	Pen. B-2
	HCV-820B HCV-821B	Hydrogen Analyzer Isolation Valve	Pen. B-2
	HCV-883C HCV-883D HCV-883E HCV-883F HCV-883G HCV-883H	Hydrogen Analyzer Sample Valve	Pen. B-2
	JB-15C	NT-002 Channel B Excore Detector	Pen. B-4
	RE-091B	Containment High Range Radiation Monitor	Pen. B-4
	PT-103X	Pressurizer Pressure	Pen. B-5
	LT-101Y	Pressurizer Level	Pen. B-5
	TE-601	Containment Sump Temperature	Pen. B-5
	JB-17C	NT-001 Channel A Excore Detector	Pen. B-11
1,008	A/TE-112C A/TE-112H A/TE-122C A/TE-122H	A Channel RC Loop Hot Leg and Cold Leg RTD’s	RTD Assemblies
	B/TE-112C B/TE-112H B/TE-122C B/TE-122H	B Channel RC Loop Hot Leg and Cold Leg RTD’s	RTD Assemblies
1,008.9	HCV-238	Charging to Loop 1A Isolation	Cable
	HCV-241	RCP Bleed to VC Isolation	Cable
	HCV-438A HCV-438C	CCW to RCP Isolation	Cable
	HCV-467A HCV-467C	CCW to VA-13A Isolation	Cable
	HCV-1108A	AFW Inlet Isolation Valve	Cable
	HCV-1387A HCV-1388A	S/G Blowdown Isolation Valve	Cable
	HCV-2506A HCV-2507A	S/G Sample Isolation Valves	Cable
1,009	HCV-239	Charging Loop 2A Isolation Valve	Operator
1,011	HCV-821B	Hydrogen Analyzer Isolation Valve	Operator
1,013	A/LT-901 B/LT-901	S/G Water Level Indication	Transmitters

Table 5.1-6: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
	A/LT-904 B/LT-904 C/LT-904	S/G Water Level Indication	Transmitters
1,013	A/PT-902 B/PT-902 C/PT-902	S/G Pressure Indication	Transmitters
	B/PT-905	S/G Pressure Indication	Transmitter
	HCV-2603B HCV-2604B	Nitrogen System Isolation	Operators
	HCV-820G HCV-883E HCV-883F HCV-883G HCV-883H	Hydrogen Analyzer Sample Isolation Valves	Operators
	HCV-820B	Hydrogen Analyzer Isolation Valve	Operator
	HCV-425A	SI Leakage Cooler Isolation Valve	Operator
	LT-101X LT-101Y	Pressurizer Level Indication	Transmitters
	A/PT-102 D/PT-102	Pressurizer Pressure Indication	Transmitters
	PT-115	RC Wide Range Pressure for Sub Cooled Margin Monitor B	Transmitter
	HCV-881 HCV-882	Hydrogen Purge Isolation Valves	Operators
	PT-103X PT-103Y	Pressurizer Pressure For Heater Control	Transmitters
	HCV-724A HCV-724B	CFC Inlet Dampers	Cable
	HCV-864	Spray Water to CFC Filter Valve	Cable
	HCV-1107A	AFW Inlet Isolation Valve	Cable

The preceding tables show that equipment required for monitoring of key parameters is affected as soon as water level is raised above El. 1,000.9 ft. This equipment is not qualified for submergence; therefore, the performance and accuracy of the equipment cannot be assured. Actions to ensure core cooling take precedence over monitoring functions; however, operators should be aware that raising containment water level above El. 1,000.9 ft. may cause erroneous reading or equipment failures.

Not all of the equipment listed in the tables above is critical to the mission of core cooling using injection from a refilled SIRWT, followed by initiation of Shutdown Cooling. In Attachment 8.2, mission critical components are identified, and coping strategies are provided to compensate for the potential failure of those components.

Conclusion:

Injection of water from a refilled SIRWT tank should only be used in the event that the containment sump strainers are no longer operable due to clogging.

In order for this measure to be considered a success path for long-term core cooling, it is necessary to permit filling the containment to at least the top of the hot legs at El. 1,008ft. This may allow for long-term cooling via: 1) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS, or 2) thermal convection via countercurrent flow through the break or ex-vessel cooling, with fan coolers providing the ultimate decay heat removal.

The compensatory action to inject water from a refilled SIRWT in response to sump inoperability should be implemented based on the following considerations:

- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to provide water to the core for cooling will result in core damage.
- Injection water from a refilled SIRWT must have a boron concentration of at least 1,000 ppm to prevent localized re-criticality in the core.
- A sufficient volume of clean makeup water is available on site to fill the SIRWT at flow rates sufficient to accommodate the HPSI injection rate required by figures 5.1-1 through 5.1-3.
- Re-injection of approximately 1,000 ppm boric acid solution at 250gpm for approximately three days would not result in the need for additional sump neutralization.
- The effects of compression of the containment free air volume due to raising water level to El. 1,013 ft. following RAS will not cause containment pressure to exceed its design limit.
- The combined effects of containment free air volume compression and increased elevation head due to raising water level to El. 1,013 ft. will result in a worst case hydraulic pressure at the containment floor and all penetrations that are below containment design pressure.

- The combined effects of containment free air volume compression and increased elevation head due to raising water level to El. 1,013 ft. will result in a worst case hydraulic pressure at the reactor cavity floor that is greater than 60 psig. However, it is below containment test pressure and below the hydraulic pressure that would be seen at containment design level and pressure in containment.
- Although cables and electrical equipment located above El. 1,000.9 ft. may continue to operate, the submergence may cause erroneous readings or equipment failure. Actions to ensure core cooling takes precedence over other functions such as preventing damage to indications used to monitor the event.

The following actions should be taken when injecting water from the refilled SIRWT:

- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging. Key issues associated with establishing injection flow from a re-filled SIRWT include prediction of make-up water needs and compensating for the effects of submerged equipment and instrumentation.
- Increased awareness of instrumentation response is necessary as water level is increased. ERO resources will be necessary to help monitor the effects of rising level on critical accident monitoring and mitigation equipment, and to estimate containment water level. Attachment 8.2 provides tables showing affected components. It also identifies affected components that are critical to the mission of raising containment water level above the hot legs and provides alternative means of accomplishing those components' functions.
- Makeup water boron concentration should be maintained at approximately 1,000 ppm if possible. This will ensure adequate margin to criticality, while maximizing the availability of borated water and minimizing the impact on sump pH. Addition of makeup water at higher boron concentrations is acceptable, but blending of makeup water should target 1,000 ppm in the SIRWT.
- As a minimum, SIRWT boron concentration should be estimated to ensure that it is greater than 1,000 ppm. The SIRWT should be sampled prior to injection.

5. Reestablishing HPSI Flow from the Containment Sump

Reestablishing flow from the containment sump may be used to delay containment water level rise. It is also a method to provide core cooling during SIRWT refill.

After the HPSI pumps' suctions are switched from the containment sump, debris collected on the sump screen vertical areas may fall off resulting in lower headloss across the screens and the ability to run a HPSI pump on the degraded sump. The increased water level in containment may raise the $NPSH_{Available}$ to a point that may allow HPSI pump operation from the sump.

In addition, throttling the HPSI pump discharge or isolating one injection loop will reduce NPSH required and allow for a larger DP across the strainers. With a higher strainer differential pressure, the debris bed may collapse and allow an adequate flow path.

The following factors should be considered when switching from the SIRWT back to the containment sump:

- Time should be allowed for the debris to settle in the containment basement area and for debris to drop from the vertical portions of the sump screen.
- The required SI flow at transfer to the SIRWT, assuming that transfer occurs at T=1hour from event start, is 170gpm based on Figure 5.1-1. The flow requirement drops to 138gpm after one hour from switchover.

Conclusion:

To allow sufficient time for settling of debris, and for the SI flow requirement to drop, reducing the $NPSH_{Required}$, it is recommended that the SI pumps aligned to the sump have been secured for a minimum of one hour before attempting to reestablish flow from the containment sump.

5.2 Securing SI Pumps Not Required For Core Cooling

WCAP-16204 [3.38] contains several COAs which suggest possible pre-emptive strategies for securing one or more safety injection pumps prior to the onset of degraded ECCS sump strainer performance. Because these actions are pre-emptive, they must allow the plant to remain within its design basis. This section evaluates the various COAs to secure SI pumps not required for core heat removal. The intent of these compensatory measures is to delay the initiation of RAS, reduce flow through the sump screens and to preserve operability of pumps that may be needed later in the event to provide core cooling.

Delaying RAS would result in lower decay heat removal requirements during recirculation, thereby reducing the recirculation flow rate required to maintain heat removal in recirculation. The amount of debris collected on the sump screens is a function of screen size, flow volume through the screens, and overall inflow of debris into the containment sump area. Greater flow is more likely to sweep debris into the sump screens, thereby increasing the risk of sump blockage.

Securing unneeded SI pumps will reduce the total flow to the sump screen and may delay or prevent sump clogging.

The design basis function of the SI System is to provide emergency core cooling to the reactor core in the event of a LOCA. The SI system injects borated water from the SIRWT via the HPSI and LPSI pumps into the reactor coolant system, which provides cooling, to prevent core damage and fission product release and assure adequate shutdown margin regardless of temperature. The system also provides long-term post accident cooling of the core by recirculation of borated water from the containment sump using the HPSI pumps.

The LPSI System has two pumps, each of which is powered from an independent safeguards bus. The HPSI System has three pumps, two of which are powered from the respective safeguards buses. The third HPSI pump (SI-2C) is normally powered from one safeguards bus, but may be manually transferred to the other safeguards bus under certain circumstances. It is essentially an installed spare. A proposed modification is currently in process to remove the autostart feature from this pump [3.50].

The SI pumps take suction from the SIRWT for initial injection of borated water. Once the SIRWT volume is depleted, the RAS signal secures the LPSI pumps, shifts the suction source to the containment sump and the HPSI pumps recirculate water from the sump through the reactor. One HPSI Pump, in conjunction with a Low Pressure Safety Injection (LPSI) Pump and 3 of 4 Safety Injection Tanks (SIT), is sufficient to meet core cooling requirements for a LOCA pre-RAS [3.5; Section 6.2.5]. One HPSI Pump is sufficient to maintain core water level at the start of recirculation and during long term core cooling. [3.5; Section 6.2.5]

A. Consideration of Securing a LPSI Pump Pre-RAS

COA A4 recommends consideration of securing one LPSI pump prior to RAS [3.38]. Since the LPSI pumps are secured by RAS, the only benefit of securing LPSI pumps is increasing the delay time to RAS. Because their relatively low total developed head results in a maximum discharge pressure of less than 200 psig, the LPSI pumps will only provide injection flow for large and medium break LOCAs. The following factors must be considered regarding the benefits of securing a LPSI pump prior to RAS:

- Delay time to RAS actuation

  The SIRWT depletion rate is a direct function of the flow rate through the HPSI, LPSI and CS Pumps. The maximum LPSI pump flow rate is approximately 2,950gpm [3.5; Section 6.2]. This would reduce total flowrate from approximately 16,000gpm to approximately 13,050 gpm). The operators would have to complete the standard post-trip actions and transition to the optimal recovery procedure for a LOCA (EOP-3) prior to securing the LPSI pump. They would also be required to verify that the other train of LPSI was operating properly before one LPSI pump could be secured. It is reasonable to assume that these actions would result in a time delay of at least 10 minutes prior the securing the LPSI pump. Thus, for large and medium break LOCA scenarios, securing a LPSI pump at T=10 minutes will increase in the time to RAS by approximately 2 minutes.

- Single Failure

  The LOCA safety analysis assumes that the worst case single active failure has resulted in a LPSI flow rate equivalent to the operation of one LPSI pump at the minimum acceptable flow rate. Securing a LPSI pump after verifying that two pumps are operating would not result in LPSI flow falling below analyzed limits. However, the safety analysis does not assume that a manual action would be taken to secure one of the LPSI pumps. If the worst case single failure occurs after one LPSI pump was manually secured, total SI flow rate would fall below the currently analyzed value until action was taken to restart the secured LPSI pump.

Conclusion:

Although securing a LPSI pump would result in a slightly longer time to RAS, adopting this action would place the plant outside of its design basis, and would require prior NRC review and approval. The small benefit achieved by adopting this action does not appear to justify the efforts of OPPD or NRC staff. Therefore, it is not recommended that this strategy be implemented. However, it should be noted that the current EOPs have criteria to secure LPSI pumps under SBLOCA conditions when they are operating above shutoff head [3.3, Floating Step B]. This will ensure that the SIRWT is not depleted unnecessarily during a cooldown following a SBLOCA.

B. Securing HPSI Pump SI-2C Pre-RAS

COA A10 recommends consideration of the strategy to secure one train of HPSI prior to RAS, with the intent being to reduce HPSI flow to a single pump flow rate [3.38]. The general considerations for securing one train of HPSI are similar to those associated with securing a LPSI pump, with the added consideration that this action would result in a lower recirculation flow rate post-RAS. Part C of this section will discuss the consideration of reduction to one train of HPSI post-RAS. Therefore, this discussion will focus in the action prior to RAS.

The HPSI system consists of two trains. Each train contains a dedicated HPSI pump (SI-2A and SI-2B), with SI-2C acting as an installed spare and available to replace either of the dedicated pumps. As with the securing of a LPSI pump, securing one train of HPSI is not recommended, because this action would place the plant outside its design basis. The increase in time to RAS will be even less than that for securing a LPSI pump, and is not significant enough to offset the potential for a single failure to result in the temporary loss of all HPSI flow until the operators can restore the secured train to operation.

However, all three HPSI pumps auto start on a safeguards signal, but only two of the three HPSI pumps are credited for operation by the safety analysis. Further, only two HPSI pumps (powered from independent safeguards buses) are required to be operable per Technical Specifications [3.14, T.S. 2.3]. Therefore, it is acceptable to secure one HPSI pump if all three have initially started. As noted earlier, a proposed modification is currently in process to remove the autostart feature from SI-2C [3.50].

The compensatory action to secure SI-2C prior to RAS provides the following benefits:

- Delay time to RAS actuation

  The SIRWT depletion rate is a direct function of the flow rate through the HPSI, LPSI and CS Pumps. The HPSI pump flow rate (approximately 400gpm at RCS pressure of <200psig) [3.3; Attachment 3] is a small fraction of total flowrate (approximately 16,000gpm). For large and medium break LOCA scenarios, securing SI-2C at T=10 minutes will increase in the time to RAS by less than 30 seconds. For a small break LOCA, time to RAS is longer and current guidance stops HPSI if SI termination criteria are met. This action provides a small benefit in delaying time to RAS actuation.

- Reduce debris transport

  Securing SI-2C will reduce the total flow to the sump screen. Assuming all CS and HPSI pumps running during recirculation, with containment pressure at 60psig and RCS pressure less than 200psig, securing SI-2C will reduce flow through sump screen SI-12B by approximately 14% from approximately 2800gpm to approximately 2400gpm [3.3; Attachment 3 and 3.37]. This reduced flow rate may reduce the risk of sump screen blockage, and thus provides a small benefit.

- Preserve an operable HPSI pump

  Securing SI-2C pre-RAS will ensure that the pump is not damaged due to debris ingestion or loss of NPSH. This ensures that SI-2C is available for injection of water from a refilled SIRWT should the sump screens become inoperable due to debris blockage, and constitutes a significant benefit.

Conclusion:

A modification is in process to remove the autostart feature on SI-2C (scheduled for the 2006 refueling outage). Until that modification is installed, the action to secure SI-2C should only be taken if all other HPSI pumps have started and are verified to be operating normally. This allows two full trains of HPSI to remain in operation. In the event of a failure of an operating HPSI pump or train following the action to secure SI-2C, one HPSI pump will still be operating and providing core cooling. The design function of the HPSI System can be met with only one HPSI Pump running for the entire duration of the LOCA event. SI-2C is not credited in the LOCA analysis [3.5; Section 14.15.5.3].

The action to secure SI-2C should only be taken upon verification of all of the following plant conditions:

- SI Flowrate is above the Attachment 3, Safety Injection Flow vs. Pressurizer Pressure Curve, indicating that SI flow is above the flow assumed in the LOCA Analysis for the HPSI and LPSI pumps.
- The Reactor Vessel Level Monitoring System (RVLMS) indicates vessel level greater than the top of active fuel and not lowering. This indicates that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

Securing SI-2C early in the event under the above analyzed conditions, provides a positive risk benefit and is an acceptable compensatory action to address sump screen clogging concerns.

In addition to securing SI-2C, securing one train of HPSI prior to RAS initiation as a pre-emptive measure was considered. This action is not acceptable because it places the plant outside its design basis prior to any indication of a beyond design basis event occurring.

C. Consideration of Operation with One HPSI Pump Post-RAS

COA A3 recommends consideration of securing one train of HPSI following initiation of RAS [3.38]. The intent of this compensatory action is to permit securing HPSI pumps so that one pump is in service if both trains of HPSI are not needed for core heat removal. This action would only be performed if 1) RAS has occurred, 2) both HPSI trains are operating normally and delivering design flow rate to the core, 3) representative CET temperatures are less than superheat; and 4) reactor vessel level is greater than the bottom of the hot leg. The above conditions would indicate that there may be more HPSI flow than is required to cool the core.

The compensatory action to secure HPSI pumps so that one train is operating may provide the following benefits:

- Reduce debris transport

  A reduced flow rate may reduce the rate of sump screen blockage. Operating with a single HPSI pump following RAS would reduce the total flow to the sump screen and reduce debris transport. This benefit can also be accomplished by two pump operation with flow throttled to approximately the flow required from a single pump.

- Preserve an operable HPSI pump

  Securing an additional HPSI pump following RAS would ensure that the pump is not damaged due to debris ingestion or loss of NPSH. This ensures that a train of HPSI is available for use in later mitigation strategies.

- Preserve one sump screen

  If one CS and one HPSI pump were operated on a common suction line and sump screen, then one sump screen would be available for use in the event that the operating screen becomes blocked.

The HPSI system is designed to perform the safety function of providing flow to the core for the entire duration of the LOCA event assuming a failure of a single active component [3.5; Appendix G, Criterion 21,38]. Failure of one HPSI pump will not limit the performance of the system [3.5; Appendix G, Criterion 41]. The limiting LOCA analysis credits operation of one HPSI train to provide core cooling for the entire duration of a LOCA event [3.5; Section 14.15]. The worst case single failure assumed is the loss of one train of HPSI due to loss of off-site power and failure of one diesel generator [3.5; Section 6.2].

Deliberate manual securing of a HPSI pump to reduce to one train of HPSI is not considered a failure. Therefore, the effect of a loss of the remaining HPSI pump must be considered. Failure of the operating pump results in a total interruption of HPSI flow to the core until operators recognize the failure, and take actions to restore flow. The current FCS licensing basis does not account for total interruption of HPSI flow in the accident analysis. Therefore, this action would require further analysis to show that no core damage occurs during the time that HPSI flow is lost, and NRC review and approval would be required prior to implementation.

The preemptive compensatory measure to reduce to one train of HPSI pump operation post-RAS is not recommended because:

- Due to the low flow rate of the HPSI pump, this action provides limited benefit in reducing the rate of sump plugging. Other evaluated actions, such as securing selected CS pumps, provide a significantly greater risk benefit with regard to sump clogging.
- Action to secure SI-2C Pre-RAS (evaluated in Section 5.2.B) will provide the benefit of preserving a HPSI pump for use in later mitigation strategies.
- Current analyses do not account for a total interruption of flow to the core due to loss of a HPSI pump. This would place the plant outside its design basis.

An alternative strategy would be to retain the operation of two HPSI pumps post-RAS, but throttle the loop injection valves to reduce total SI flow. The benefits of this strategy are:

- $NPSH_{Available}$ is improved by reducing head loss across the debris bed.
- By throttling flow with two pumps running, the flow rate through each pump is reduced. Therefore, the NPSH margin for each pump is further improved by reducing the $NPSH_{Required}$.
- In the event of a single failure following the throttling operation, one pump would remain operating. Flow rate would be reduced, but not lost completely, until operator action could be taken to re-start SI-2C or open the loop injection valves.

To implement this strategy and remain within the plant's design basis, flow could only be throttled to the point where the subsequent failure of a pump would not result in flow through the remaining pump falling below the design limits. Runout flow through a HPSI pump is approximately 475 gpm, while the design flow rate is approximately 400 gpm. Under runout conditions, without accounting for instrument uncertainty, this means that a maximum flow reduction of only approximately 150 gpm could be achieved by pre-emptive throttling of HPSI before flow would fall below design limits if a HPSI pump was subsequently lost. The resultant increase in time to RAS would be minimal, as would the improvement in NPSH margin and reduction in debris transport.

Conversely, the introduction of an additional operator action affecting SI system performance at the time of RAS provides an increased possibility of operator error that could place the system outside of its design basis.

Given the above considerations, it is not recommended that SI flow be throttled without evidence of sump strainer clogging as a pre-emptive measure.

Conclusion:

> Securing one train of HPSI or throttling HPSI flow following RAS initiation without evidence of strainer clogging as a pre-emptive measure would not provide a significant benefit in preventing sump strainer clogging and it places the plant outside its design basis prior to any indication of a beyond design basis event occurring.
>
> Therefore, the adoption of this compensatory action is not recommended.

D. Consideration of Early Initiation of Recirculation with One HPSI Train

COA A2 suggests consideration of establishing one train of ECCS recirculation prior to automatic initiation of RAS [3.38]. The intent of this COA is to establish recirculation conditions early to allow assessment of the potential for strainer blockage while the train of ECCS remaining on the SIRWT continues to guarantee a source of heat removal. This would also prolong the time that water for cooling is available from the SIRWT.

This COA is not desirable at FCS for several reasons. Three of the most significant are:

- Due to the relatively small HPSI pump NPSH margin (which is dependent on recirculation pool water level) at initiation of RAS, the window in which this early actuation could occur is very small. Therefore the action is not likely to produce a significant delay in the time to full recirculation.
- RAS actuation is normally an automatic function. For those events likely to lead to strainer clogging (i.e., LBLOCAs) the time required to verify initiating conditions (to ensure adequate NPSH) and to perform the necessary manual actions would likely result in too short a time in the "early recirculation" mode to be effective.
- By directing manual operator action for a function that normally occurs automatically, the risk of operator error resulting in the disabling of that train of ECCS is increased.

Conclusion:

Placing one train of HPSI in the recirculation mode prior to RAS requires a manual operator action that would require considerable monitoring and confirmation prior to implementation of the step. Due to the relatively small window of time that would be available for this action to be completed before automatic RAS initiation. There is no significant benefit that could be gained. Additionally, the introduction of an additional operator action early in the event increases the probability of an error that could hinder system performance.

Therefore, the adoption of this compensatory action is not recommended.

5.3 Early Termination of CS Pumps

COA A1a-CE recommends consideration of securing one CS pump prior to initiation of RAS [3.38]. This section evaluates actions to secure CS pumps not required for containment pressure control. The intent of this compensatory measure is to reduce flow through the sump screens. The amount of debris collected on the sump screens is a function of screen size, flow volume through the screens, and overall inflow of debris into the containment sump area. Greater flow is more likely to sweep debris into the sump screens, thereby increasing the risk of sump blockage. Securing unneeded CS pumps will reduce the total flow to the sump screen and may delay or prevent sump clogging.

The CS system limits containment pressure rise, and reduces leakage of airborne radioactivity, following a LOCA. The system sprays cool, borated water, to cool the containment atmosphere, and strips radioactive particles from the atmosphere where they fall to surfaces and are washed into the containment sump.

The CS system has three pumps, two of which are powered from the respective safeguards buses, and one (SI-3C) that is normally powered from one safeguards bus, but may be manually transferred to the other safeguards bus under certain circumstances. It is essentially an installed spare. During recirculation, SI-3C takes suction from the "A" train ECCS recirculation strainer (SI-12A). A proposed modification is currently in process to remove the autostart feature from this pump [3.51].

Upon receipt of both a PPLS and a CPHS Signal, the CS pumps spray cool, borated water into the containment from the SIRWT to remove heat and limit the containment pressure rise. At RAS, the CS pump suctions are switched to the containment sump and water is recirculated and cooled by the Shutdown Cooling (SDC) heat exchangers. The LOCA containment pressure analysis assumes operation of one CS pump and one CS header, with one spray nozzle missing and five spray nozzles per header blocked [3.5; Section 14.16]. An assumed CS flow rate of 1885gpm takes into account pump degradation, instrument uncertainties and flow through the mini-recirculation lines [3.10].

The LOCA radiological consequences analysis credits CS operation for removal of iodine and particulates from the containment atmosphere during a LOCA. One CS pump and header is credited for aerosol and elemental iodine removal via sprays starting at T=185 seconds and continuing to approximately T=5hrs. Assumed CS flow rates are a minimum of 1,885gpm prior to RAS, and 2,800gpm post-RAS for the remainder of the 5 hour period [3.5; Section 14.15.8].

The following benefits are associated with the pre-emptive compensatory action of early termination of CS pumps:

- Delay time to RAS actuation

  The depletion rate of the SIRWT is a direct function of the flow rate through the HPSI, LPSI and CS Pumps. The CS pump flow rate is a significant contribution to the total flowrate from the SIRWT pre-RAS.

  When compared to the total flow rate being taken from the SIRWT (Approximately 16,000gpm), actions to secure one CS pump at T=10 minutes could increase the time to RAS by up to 2 minutes. Taking action to secure two CS pumps at T=10 minutes could increase the time to RAS by up to 4 minutes. This action provides benefit in delaying time to RAS actuation.

- Reduce debris transport

  The amount of debris collected on the sump screens is a function of screen size, flow through the screens, and overall inflow of debris into the containment sump area. Greater volumetric flow is more likely to sweep debris into the sump screens, thereby increasing the risk of sump blockage.

  Securing one CS pump will reduce the total flow to one of the sump screens up to a maximum of 3,200gpm depending on initial CS system configuration and containment pressure (i.e., non-degraded single pump, low containment pressure) [3.55]. Assuming all CS and HPSI pumps running post-RAS, with containment pressure at 60 psig and HPSI pump flow rates a nominal 400gpm, securing SI-3B or SI-3C will reduce flow through sump screen SI-12A by approximately 45% from 4500gpm to 2500gpm. Securing SI-3A will reduce flow through sump screen SI-12B by approximately 72% from approximately 2800gpm to 800gpm. Securing both SI-3B and SI-3C will reduce the total flow through sump screen SI-12A by approximately 92% from approximately 4500 to 400gpm [3.37]. This significant reduction in flow rate will reduce the rate of sump screen blockage and extend the time to strainer blockage.

- Preserve an operable CS pump

  Early termination of unneeded CS pumps will ensure that the pumps are not damaged due to debris ingestion or loss of NPSH post-RAS, and are available for future mitigation strategies.

A. Securing One CS Pump

Three CS pumps are available to supply two CS trains. This section assesses the securing of one CS pump while the remaining two remaining pumps are each aligned to an independent CS train.

In the event of a failure of an operating CS pump or train following the action to secure a CS pump, one CS pump and header will always remain operating and providing containment pressure reduction as assumed in the LOCA analysis. Securing one CS pump produces results that are less restrictive than the limiting containment pressure analysis that assumes one pump and header operation for the duration of the event. This is because all spray pumps function up to the time that one is stopped. Therefore, this action is acceptable as a pre-emptive measure because the plant remains within its design basis.

Conclusion:

A modification is in process to remove the autostart feature on SI-3C (scheduled for the 2006 refueling outage). Until that modification is installed, the action to secure one CS pump should only be taken if all other CS pumps have started and are verified to be operating normally, and upon verification of the following plant conditions:

- Containment pressure is <5psig and NOT increasing;
- All available CFC's are operating; and
- SI is actuated and flow is acceptable per Attachment 3, Safety Injection Flow vs. Pressurizer Pressure.

Following the action to secure one CS pump, operators should verify that containment pressure is being maintained below design. If containment pressure cannot be controlled, then operators should be directed to start all available CS pumps.

Based on the above evaluation, securing one CS pump early in the event under the above analyzed conditions, provides a positive risk benefit and is an acceptable compensatory action to address sump screen clogging concerns.

B. Securing Two CS Pumps

The intent of this compensatory action is to permit securing two CS pumps so that one pump and one header of CS is in service if both trains of CS are not needed for containment pressure and temperature control. This action would only be performed if 1) at least two CS pumps are operating normally and delivering design flow rate, 2) containment pressure has peaked and is less than containment pressure setpoint of 5 psig, 3) both trains of CFC's are operating, and 4) SI has actuated and is delivering design flow. The above conditions would indicate that there may be more CS flow than is required to maintain containment pressure. Verifying that SI flow has been maintained within the delivery curves ensures that significant core damage has not occurred and that a significant source term does not exist inside the containment.

One CS pump and header is credited for containment pressure control for a LOCA [3.5; Section 14.16]. Operation of one train of CS is credited in the radiological consequences analysis for removal of particulates and iodine for a period of five hours following a LOCA [3.5; Section 14.15]. Operation of one CS pump and header is within the existing accident analysis and will not adversely affect the containment pressure or LOCA radiological consequences analyses.

The CS system is designed to perform its safety functions assuming a failure of a single active component [3.5; Appendix G, Criterion 21, 38]. Failure of one CS pump will not limit the performance of the system [3.5; Appendix G, Criterion 41]. The worst case single failure assumed is the loss of one train of CS due to loss of off-site power and failure of one diesel generator [3.5; Section 6.3].

Deliberate manual securing of two CS pumps to reduce to one train of CS is not considered a failure. Therefore, the effect of a loss of the remaining CS pump must be considered. Failure of the operating pump results in a loss of containment spray until operators recognize the failure, and take actions to restore the system. As a result, securing 2 CS pumps places the plant outside its design basis. Consequently, prior NRC review and approval is required before the action can be instituted.

The LOCA analysis does not credit CFCs for containment temperature and pressure control. The current LOCA analysis of record shows peak containment pressure occurs at 290 seconds, and peak containment temperature occurs at 282 seconds [3.5; Section 14.16]. The RSG reanalysis shows the peaks to be at approximately 200 seconds [3.55]. The action to secure CS pumps occurs after the pressure and temperature peaks. The containment pressure analysis credits the CS system for the pressure and temperature reduction and no credit is taken for the CFC's. The CFC's will start due to LOCA conditions and have the capacity to continue the containment pressure and temperature reduction after the transient peak. With both trains of CFCs operating, no single failure will result in the loss of all CFCs. Therefore, loss of the remaining CS pump would not adversely affect containment pressure and temperature control, because at least one train of CFCs will remain operating. Based on this assessment, FCS applied for, and on May 20, 2005, received a temporary technical specification amendment to allow two CS pumps to be secured if all CFCs are operating [3.39]. This temporary amendment remains in effect until the completion of the 2008 refueling outage.

Conclusion:

The current FCS licensing basis does not account for interruption of CS flow in the LOCA radiological consequences analysis. However, FCS was granted a temporary technical specification amendment to allow two CS pumps to be secured if all CFCs are operating. This temporary amendment remains in effect until the completion of the 2008 refueling outage.

Based on the temporary license amendment, the preemptive compensatory measure to reduce to one train of CS when with all CFCs are operating. This strategy provides a positive risk benefit and is an acceptable compensatory action to address sump screen clogging concerns.

5.4 Refilling the SIRWT Post-RAS.

COA A5 provides the strategy of refilling the SIRWT after RAS initiation [3.38]. Refilling of the SIRWT post-RAS, after the SIRWT Design Basis function is completed, provides a source of water for injection in the reactor in the event of sump clogging without impacting the plant's design basis.

The SIRWT provides a minimum usable volume of 283,000 gallons of borated water at the Refueling Boron Concentration for injection to the core by the SI System, and for the CS system, during a LOCA. During refueling operations, SIRWT water is used to fill the Fuel Transfer Canal and Refueling Cavity, and to provide makeup water to the Spent Fuel Pool. Upon completion of refueling activities the water in the Fuel Transfer Canal and the Refueling Cavity can be transferred back to the SIRWT. [3.5; Section 6.2.3.1]

The SIRWT is designed to provide at least a 20 minute supply of water before the pump suctions are automatically shifted to the containment sump inlet. Once the initial SIRWT water volume is depleted the SIRWT Design Basis Accident Function is completed [3.5; Section 6.2].

By waiting to refill the SIRWT until after RAS initiation, the SIRWT has completed its design function. Any subsequent refill could then be reserved for the beyond design basis failure of both ECCS recirculation sump strainers and injected as outlined in section 5.1.

In this section, the total volume of required SIRWT makeup water and a hierarchy of preference will be established. Those sources that are at the refueling boron concentration and can be easily transferred to the SIRWT with limited personnel resources have the highest preference, followed by other sources of borated water. Unborated clean water sources would have a lower preference, and chemically contaminated or heavily sedimented sources, such as fire water would be least preferred.

If water is added at to the SIRWT at the refueling boron concentration, it can be diluted to approximately 1,000 ppm [3.16] by doubling the volume of water with demineralized or fire protection water.

The following water sources were evaluated in order of preference:

- Fuel Transfer Canal (FTC) (Borated, refueling boron concentration)
- Spent Fuel Pool (SFP) (Borated, refueling boron concentration)
- Chemical and Volume Control System (CVCS) (Borated, variable concentration)
- Demineralized Water or Fire Protection Water via fire hose (Non-borated)

This section of the EA does not analyze injection of the refilled SIRWT water; that evaluation is contained in Section 5.1.

A. <u>Makeup Water Requirements</u>:

Section 5.1 B 4 d identifies the total amount of water required to raise containment water level from elevation at RAS to El. 1,008 as approximately 479,000 gal. Although in a beyond design basis event, the use of any source of water is acceptable to maintain core cooling, it is highly desirable to avoid introducing unborated, highly contaminated or sedimented water into the post accident core and containment environment.

Section 5.1 B 4 of this EA establishes the minimum required flow rate post-RAS, and the minimum Boron Concentration to ensure that the core remains shutdown. The conclusions of that section are as follows:

- Target SIRWT Boron Concentration upon refill should be 1,000 ppm to prevent localized re-criticality in the core.
- Assuming a minimum time to sump blockage of 30 minutes after LOCA initiation, the required flow to the RCS should be at least 215gpm for the duration of the event. This 215gpm would be sufficient to cover both the SI flow required to match decay heat early in the transient with 35% spillage, and the SI flow required to support

simultaneous hot/cold leg injection following initiation of hot leg injection. As time progresses from event initiation, the required injection flow rate will be reduced. At 24 hours post-RAS, total required flow rate is approximately 120 gpm.

- Neutralization of the boric acid solution from the refilled SIRWT is not necessary for three to four days at these minimum flow and concentration values. The sump pH will remain at or above 7.0 during this period.

Based in the above, sources of water investigated for makeup to the SIRWT included those capable of immediately providing at least 250gpm early in the event, those capable of providing a long term source of water later in the event, and either the sources are already borated or able to be borated to a minimum of 1,000 ppm.

1. <u>Total Injected Water Volume over Time</u>

To assist in evaluating whether makeup sources to the SIRWT would be capable of supporting continuous injection at a rate consistent with the requirements of figures 5.1-1 through 5.1-3, an analysis was performed to integrate the total makeup water volume required for SIRWT refill over time, assuming injection flow rate is maintained as required by figures 5.1-1 through 5.1-3, to maintain core cooling while injecting from the SIRWT. This analysis is presented in attachment 8.5.

Figure 5.4-1 shows the result of that analysis.

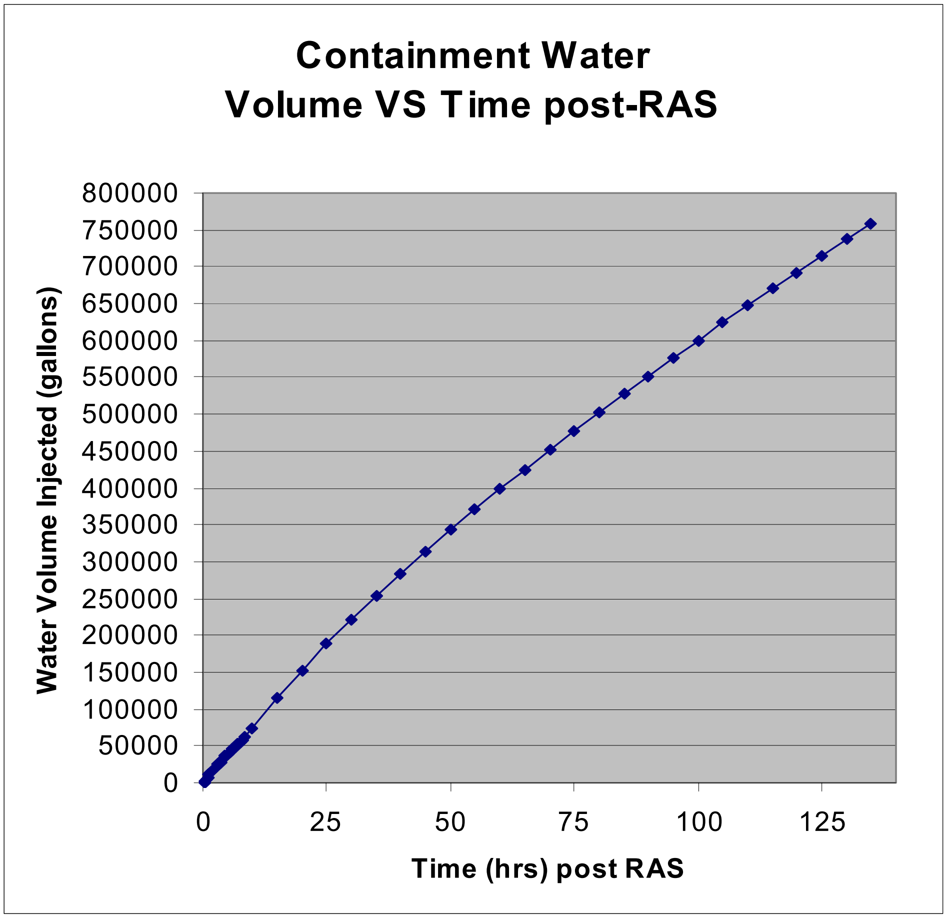


Figure 5.4-1: Containment Water Volume vs. Time post-RAS

B. <u>Short Term SIRWT Refill Water Sources</u>:

The SIRWT is normally filled with borated water at the Refueling Boron Concentration by blending the contents of the Boric Acid Storage Tanks (BAST) with demineralized water to the specified concentration.

This section evaluates water sources that have the capability to refill the SIRWT at the required flow rates (up to 215 gpm) for approximately the first 24 hours of the event.

1. Fuel Transfer Canal:

Historically, the FTC has normally been left drained; however, if left full following refueling operations, it is a source of borated water at refueling boron concentration. Revision 0 of this evaluation recommended that the canal remain full during plant operation. This recommendation was implemented, and the FTC is now normally maintained full until shortly before a refueling outage.

Available Volume: 45,669 gallons
(91,338 gallons if diluted to 1000ppm)

Assumptions: Water level at El. 1036' 9"
7.48052 gallons/ft^3 water
Volume of equipment in bottom of FTC negligible

The FTC dimensions are as follows: [3.29]

Length = 29.6 ft
Width = 5 ft
Height = 41.25 ft (1036' 9" – 995'6")

Available Volume = L x W x H
= 29.6ft x 5ft x 41.25ft
= 6,105 ft^3 x 7.48052 gal/ft^3
= 45,669 gallons

Methods:

a. Fuel Transfer Canal Drain Pumps (AC-13A/B)

The FTC Drain Pumps are centrifugal pumps with a nominal capacity of 250gpm. The pumps are load shed by the SIAS signal and would require restart to support this evolution. In the event of a Loss of Offsite Power (LOOP) concurrent with the LOCA, these pumps may not be available. The flow path is established using the normal transfer procedure in OI-SFP-1, Attachment 10.

b. Gravity Drain

The contents of the FTC can be gravity drained via AC-306 and AC-307. (Calculations contained in Attachment 8.6)

The estimated flow rate to the SIRWT via gravity drain is considerably higher than 250gpm initially due to the significant elevation difference (~ 47 feet), and short length (~10ft) of 4 inch piping between the FTC and the SIRWT. The flow rate will decrease rapidly as the level of the FTC decreases and the SIRWT level increases, reducing the elevation head. The flow rate decreases to less than 250gpm when the differential head between the refueling canal and the SIRWT is approximately 1.8 feet (approximately 2,000-3,000 gallons remaining in the canal).

Conclusion:

> The FTC will provide adequate volume at a high enough makeup flow rate to allow for over 5 hours of injection to the RCS at the flow rates specified in figures 5.1-1 through 5.1-3 (see attachment 8.5).

2. <u>Spent Fuel Pool</u>:

The Spent Fuel Pool (SFP) is a source of borated water at refueling boron concentration. The total volume of the SFP is 215,000gal. The approximate available volume from the SFP is as follows:

Assumptions: Water level at El. 1,036’ 9”
7.48052 gallons/ft^3 water
Gate Stop at El. 1,009’ 8 ½”
Lower SFP Cooling Suction at El. 1011’ 8
Upper SFP Cooling Suction at El. 1034’ 0”

The SFP dimensions are as follows: [3.29]

Length = 33.3 ft, Width = 20.7 ft, Height = 41.25 ft (1036’ 9” – 995’6”)

Available Volume - gate stop: = L x W x H
= 33.3ft x 20.7ft x 27.04ft
= 18,638.94 ft^3 x 7.48052 gal/ft^3
= 139,429 gallons
(278,858gal if diluted to 1000ppm)

Available Volume - lower suction: = L x W x H
= 33.3ft x 20.7ft x 25.08ft
= 17,287.89 ft^3 x 7.48052 gal/ft^3
= 129,403 gallons
(258,806gal if diluted to 1000ppm)

Available Volume – Upper suction: = L x W x H
= 33.3ft x 20.7ft x 2.75ft
= 1,895.6 ft^3 x 7.48052 gal/ft^3
= 14,180 gallons
(28,360gal if diluted to 1000ppm)

It is not possible to pump the contents of the pool to below the top of the stored fuel because all piping connections terminate above the top of the fuel storage racks. With the gate removed, draining the FTC will result in draining the SFP below the lower pump suction line. Draining of the SFP is limited by the gate stop installed at El. 1,009’ 81/2”. The gate stop level is above the top of the active fuel in a Westinghouse spent fuel assembly [3.30]. The top of the active fuel region for other vendors’ assemblies in the pool would be similar.

If SFP level is allowed to drop below the lower pump suction line, then inventory will have to be restored to the SFP, by either normal means if available or by addition of demineralized water using hoses, prior to restoring SFP cooling. In the event of a prolonged loss of cooling to the SFP, the water in the SFP would rise to the boiling point of 212°F within approximately 7.2 hours assuming worst case initial and decay heat conditions [3.5; Section 9.6.6]. The pool walls, liner, and fuel assemblies are designed to withstand boiling temperatures without a loss of integrity. [3.30]

Refill Methods:

a. Storage Pool Circulating Pumps (AC-5A/B)

The Storage Pool Circulating Pumps are rated at a nominal 900gpm. The pumps are load shed by the SIAS signal and would require restart to support this evolution. In the event of a LOOP concurrent with the LOCA, these pumps may not be immediately available, but can be restored if engineered safeguards are re-set. Given that over 5 hours of injection water would normally be available from the FTC, it is reasonable to assume that this can be accomplished prior to the need for transferring water to the SIRWT. Realistic flow rate to the SIRWT via this method is estimated at 300 gpm due to high headloss of the extended piping run (~355 feet).

The flow path is established from the SFP cooling suction valves, through the waste header, and into the SIRWT. This flow path will divert flow from the Storage Pool Heat Exchanger and leave the SFP without cooling while transferring water.

b. Gravity Drain

The estimated flow rate to the SIRWT via gravity drain from the SFP through the SFP Cooling lines is estimated to be less than 100gpm due to the high headloss of the extended piping run. This method is not further evaluated due to the low flow rate.

c. Transfer from SFP to FTC

Reference 3.31 provides a method of transferring SFP water to the FTC by either siphoning or using a Tri Nuclear Filtering Unit. The siphoning method was not further evaluated because of the low expected flowrate. The Tri Nuclear Filtering Unit has the capacity to deliver the required flowrate; however, the unit requires power from welding receptacles in the SFP area that are load shed and locked out by the SIAS signal. Therefore, reset of engineered safeguards would be required prior to use of this method.

3. <u>Storage Strategies</u>:

Two strategies are evaluated for providing a large volume of readily accessible borated water for addition to the SIRWT during a LOCA. One strategy involves maintaining the FTC filled with borated water, at refueling boron concentration, during plant operations. This provides a readily accessible volume of approximately 45,000 gallons for transfer to the SIRWT. The second strategy involves plant operation with the gate between the FTC and SFP removed. This would provide a readily accessible volume of approximately 185,000 gallons of water, at the refueling boron concentration, for transfer from the FTC/SFP to the SIRWT.

a. FTC Filled During Normal Plant Operation

The FTC is a reinforced concrete structure, with a stainless steel liner, located in the Auxiliary Building between the SFP and Containment. During refueling operations, the FTC is filled with water at the Refueling Boron Concentration, the gate between the FTC and the SFP is removed, and fuel assemblies are transferred between the SFP and the Refueling Cavity inside Containment.

During non-refueling periods the FTC is typically drained. It is isolated from the SFP by the gate and from the Containment by a blind flange and isolation valve. Fuel transfer equipment is located in the FTC. Note that as an interim measure, the FTC will normally be full of water as described in 5.4 B1, above, until the response to GL 2004-02 [3.48] is complete.

There are no FCS Design and Licensing Basis requirements to maintain the FTC drained during non-refueling periods. Following refueling, the FTC is drained to allow access to the transfer tube for installation of the blind flange and leak rate testing. It is then normally left dry until the end of the cycle when fuel transfer preparations begin. This facilitates maintenance on fuel transfer equipment located in the FTC, and it is preferred that transfer machine testing be performed dry to facilitate identification of problems prior to refueling activities. However, the fuel transfer equipment is designed for operation in a borated water environment and will not be adversely affected by maintaining the FTC full for this interim period.

Normal operations with the FTC filled will result in additional radioactive liquid waste processing. Once the transfer tube is tested, the FTC would be filled at the refueling boron concentration. This will result in the need to drain the FTC during preparations for the next refueling period and will require processing an additional 45,000 gallons of water through the radwaste system over an operating cycle.

b. Operation with the Gate removed between the SFP and FTC

A gate that is installed during non-refuelling periods separates the FTC and SFP volumes. During refuelling periods, the FTC is flooded and the gate removed allowing communication between the two volumes to facilitate transfer of fuel assemblies.

The design of the SFP is such that no active or passive failure can result in the pool being drained below the level of the top of the stored fuel when in its storage rack. With the gate removed, draining the FTC will also result in draining the SFP. Draining is limited by a plate installed across the bottom of the gate at elevation 1009' 8 1/2", which is above the top of the active fuel in a Westinghouse spent fuel assembly [3.30]. The top of the active fuel region for other vendors' assemblies in the pool would be similar.

The following issues would require further analysis before implementing this operational change:

- The SFP Cooling System is designed to cool the SFP water by recirculating its contents through the cooling loop once every two hours with both pumps operating. [3.5; Section 9.6.5]
- This statement assumes a pool volume of 215,000 gallons will be recirculated using the SFP Cooling Pumps at 900gpm each once every 2 hours. With the Gate removed, the total volume of the SFP and FTC canal is a combined 260,000 gallons (215,000 + 45,000). With this additional volume, the contents of the SFP and FTC will be recirculated once every 2.3 hours.
- Reference 3.32 provides a thermal-hydraulic analysis of the SFP with maximum density fuel storage. This provides the time to boil and boil-off rates in the event of a loss of SFP Cooling with the SFP at the worst case initial conditions. This calculation assumes that the Gate is installed.

Without further analysis of the above two issues, establishing a normal plant practice of operation with the Gate removed between the SFP and the FTC for the purposes of providing an available water volume for addition to the SIRWT is outside of the plants design basis. Given that the additional volume of water that could be obtained by leaving the gate open is relatively small, it is not recommended that this strategy is used as a compensatory action.

Conclusion:

The SFP will provide adequate volume at a high enough makeup flow rate to allow for approximately 18 hours of injection to the RCS at the flow rates specified in figures 5.1-1 through 5.1-3 if water level is lowered to approximately the lower suction elevation (see attachment 8.5).

When implementing the strategy of transferring a portion of the SFP water to the SIRWT, the following should be considered:

- Engineered Safeguards must be reset to allow the spent fuel pool cooling pumps to be restarted.
- The SFP provides a source of rapidly transferable water to the SIRWT, and is a preferred source. However, if normal methods of borated water makeup to the SIRWT are available, it would be

preferable to use those sources first and retain the contents of the SFP in the pool until needed.

The additional 10,000 gallons that could be transferred if the water level was brought down to the gate elevation would result in an additional 1-2 hours of injection time. Because additional volume obtained by leaving the SFP gate removed, and operation with the SFP gate removed is an un-analyzed condition, operation with the SFP gate removed is not recommended.

C. Long Term SIRWT Refill Water Sources:

The SIRWT is normally filled with borated water at refueling boron concentration by blending the contents of the Boric Acid Storage Tanks (BAST) with demineralized water to the specified concentration.

This section evaluates water sources available to refill the SIRWT at the required flow rates (up to 120 gpm) from approximately 24 hours into the event until injection mode operation is secured. Along with evaluating the SIRWT makeup water sources, it evaluates the supplies of water to those sources to ensure that an adequate volume of water is available at required flow rates to assure that there is no interruption to SIRWT makeup capabilities.

1. Chemical and Volume Control System:

The CVCS system can be used to blend the contents of the Boric Acid Storage Tanks (BAST) to the SIRWT using the normal method. Reference 3.33 provides the method to determine the Boric Acid and makeup water flow rates to give a blended flow at the Refueling Boron Concentration. This method will not provide the required flow rate at event initiation. However, it could be used to supplement other SIRWT fill methods early in the event. Combined with the immediate transfer of borated water from the FTC, this makeup source may be adequate to mitigate the need to transfer borated water from the SFP. CVCS is also the normal means of refilling the SIRWT and would be the preferred method of long term makeup to the SIRWT, because boric acid can be blended during the fill process to achieve the desired boron concentration. Availability of boric acid is discussed in section 5.4 B 5. The primary water storage tank (PWST, DW-45) is a 23,500 gallon tank. Its water level is normally maintained at approximately 75%. Therefore, approximately 17,500 gallons of water are available for SIRWT fill via the boric acid blending tee.

Thereafter, an additional supply of makeup water must be provided to the demineralized and primary makeup water systems to utilize this alignment. From figure 5.4-1, the combined capacity of the FTC, the SFP drawn to the lower suction and the primary water storage tank will provide adequate decay heat removal capability using injection from a refilled

SIRWT for approximately 25.5 hours. This would provide ample time for alignment of long term makeup water sources via demineralized water to the primary makeup water system.

In the event of a loss of offsite power, the normal source of supply water to the demineralized water system (treated water from the RO unit) may not be available. This would be the preferred source of makeup to the SIRWT via the PWST. Shown below are the other water sources that could be used to supply the demineralized water system at greater than 120 gpm, which is adequate to satisfy makeup flow requirements subsequent to depletion of the contents of the short term to the SIRWT makeup sources. Blair water, if available, would be the preferred source, as it is near demineralized water quality. Following Blair water, there is no specific order of preference for the use of the other sources. Plant conditions would dictate that at the time of the event.

- Blair Water, Bypassing the RO Unit. Unlimited volume, approximately 250 gpm.

  A loss of offsite power may not have affected the Blair water system. Use of this flow path would ensure that adequate makeup water is provided to raise containment water level above El. 1,008 ft.

- Water Plant Storage Tanks. Approximately 100,000 gallons.

  These tanks normally remain full and are used as a reserve for potable water. Spool pieces or fire hoses coupled to blank flanges are required to align the system to demineralized water. Demineralized water booster pumps (DW-8A/B) would provide motive force to demineralized water tank.

- Training Center/Admin Building Fire Water Head Tank. Approximately 135,000 gallons.

  The Blair water system supplies fire protection water to the training center and administrative buildings. A concrete head tank is located on a hill across highway 75. A bypass around the backflow preventer valve would allow the water in this tank to be aligned to the normal water supply into the station. Motive force would be elevation head.

- Condensate Storage Tank. Approximately 120,000 gallons.

  Capacity of the CST is 150,000 gallons of demineralized water. Water would be transferred to the demineralized water system via fire hoses coupled to blank flanges. The diesel engine driven AFW pump (FW-54) would provide motive force to the demineralized water tank. Care would be required to ensure that the high pressure pump does not overpressurize the transfer lines.

- Emergency Feedwater Storage Tank. Minimum 55,000 gallons [3.14, T.S. 2.5].

  In a LBLOCA, the EFWST volume is not required for heat removal. Therefore, this volume of demineralized water would become available for makeup water. Water would be transferred to the demineralized water system via fire hoses coupled to blank flanges. The motor driven AFW pump (FW-6) would provide motive force to the demineralized water tank. Care would be required to ensure that the high pressure pump does not overpressurize the transfer lines.

Per attachment 8.5, the total amount of additional water (beyond the design sources) necessary to raise containment water level to El. 1,008 ft. is approximately 480,000 gallons. Without crediting Blair water, the total amount of stored water on site that could be provided to the SIRWT via CVCS is approximately 410,000 gallons. Combined with the over 187,500 gallons that are available in the fuel transfer canal, spent fuel pool and primary water storage tank, the total available makeup capacity on-site is approximately 597,500 gallons. This exceeds the required volume to achieve a containment water level of El. 1,008 ft. by approximately 117,500 gallons.

Attachment 8.7 provides a description of the basic flow paths that would be used to supply the demineralized water system for each of the water sources identified above. Attachment 8.8 provides the flow paths from the demineralized water system to the CVCS for long term SIRWT makeup.

Conclusions:

CVCS makeup to the SIRWT via the boric acid blending tee provides a long term source of borated makeup water to the SIRWT.

- The availability of water from the FTC, SFP and PWST will allow at least 24 hours for alignment of makeup water to the demineralized water system, if necessary.
- Although the makeup capacity is not adequate to make up for immediate decay heat removal needs post-RAS, there are adequate

sources of water on site to meet decay heat removal makeup flow requirements until the CVCS can provide the necessary flow rate.

- Makeup to the SIRWT from the CVCS is considered a less preferred source than the SFP due to flow rate limitations. However, if makeup to the SIRWT from the CVCS is initiated early, it may not be necessary to transfer water from the SFP to satisfy SIRWT makeup needs.
- There is enough water available on site to ensure that the SIRWT can be supplied with clean (though not necessarily demineralized) water.
- Some makeup water sources to the demineralized water system would require the use of fire hoses. Some connections will attach to piping flanges. This equipment should be pre-staged to ensure availability if needed.
- Engineered safeguards must be reset to allow the primary water system to supply water to the CVCS blending tee. Given that over 5 hours of injection water would normally be available from the FTC, it is reasonable to assume that this can be accomplished prior to the need for transferring water to the SIRWT.

4. <u>Non-borated Sources of Makeup to the SIRWT</u>

The following non-borated sources of water are the least preferred SIRWT refill options because the water source contains a significant amount of impurities. In addition, mixing of boric acid at lower temperatures may result in poor dissolution.

The fire protection and demineralized water systems are both capable of providing makeup water either to the FTC or directly to the SIRWT via fire hoses.

The Fire Protection System can supply approximately 250gpm using a 2 ½ inch fire hose connection. Flow rate from the demineralized water system would be at a significantly lower rate, due to smaller bore supply piping and the need for longer runs of fire hose. Fire Protection or demineralized water can be added by:

a. Adding water into the FTC and manually dumping bags of boric acid into the FTC. Once desired level in the FTC is reached, the contents can be transferred to the SIRWT by one of the evaluated methods described above.

   This method would require that the contents of the FTC be at a boron concentration of >1,000 ppm prior to transferring to the SIRWT. The method of obtaining the required boron concentration is to add bags of boric acid to the canal while agitating the boric acid with the fire hose water to promote mixing.

The number of bags to achieve 1,000 ppm by this method:

1ppm = 1mg/liter
1gal = 3.785 liters
1lb = 453,592.4mg

$$\text{lbs Boron as B required} = \frac{(\text{Reqd Conc})(\text{gallons})(3.785\text{liter/gal})}{(453{,}592.4\text{mg/lb})}$$

$$= \frac{(1{,}000)(45{,}000)(3.785)}{453{,}592.4}$$

$$= 375.5 \text{ lbs}$$

To convert this to Boric acid (H_3BO_3): Boron is 17.48% by weight of boric acid; therefore

Lbs boric acid = 375.5lbs/ 0.1748 = 2148 lbs

Each bag is 50 lbs, therefore require 2148 lbs/50 or 43 bags Boric Acid for each fill of the FTC.

b. Adding water directly to the SIRWT through the vent. This method requires removal of the SIRWT access floor plug and emptying bags of boric acid into the SIRWT.

This method requires addition of bags of boric acid directly to the SIRWT to achieve a boron concentration of 1,000ppm. Boric acid bags would be emptied into the SIRWT through the access floor plug. Mixing would be provided using fire hoses for agitation.

The number of bags to achieve 1,000ppm by this method assuming volume of water is 250,000 gallons:

1ppm = 1mg/liter
1gal = 3.785 liters
1lb = 453,592.4mg

$$\text{Lbs Boron as B required} = \frac{(\text{Reqd Conc})(\text{gallons})(3.785\text{liter/gal})}{(453{,}592.4\text{mg/lb})}$$

$$= \frac{(1{,}000)(250{,}000)(3.785)}{453{,}592.4}$$

$$= 2086\text{lbs}$$

To convert this to Boric acid (H_3BO_3): Boron is 17.48% by weight of boric acid; therefore

Lbs boric acid = 2086lbs/ 0.1748 = 11934 lbs

Each bag is 50 lbs; therefore require 11934 lbs/50 or 239 bags Boric Acid for each fill of the SIRWT.

Conclusion:

The capability exists to add water to the FTC or the SIRWT directly from fire hoses. Boric acid can be batched directly to either location from bags available on site. However, this is the least preferred method of makeup, because fire water is not chemically controlled and may contain contaminants and sediment.

5. Availability of Boric Acid

As shown in 4, above, 239 bags of boric acid are required to borate a refilled SIRWT to 1,000 ppm. The warehouse stock for Boric acid is 13,800 lbs (276 bags) minimum to 39,200 lbs (784 bags) maximum. A check of warehouse inventory performed on 2/3/2006 found 318 bags of boric acid. Additional bags of boric acid are usually present near the boric acid batch tank as well. Therefore, the FCS Site currently has sufficient inventory of boric acid to perform at least one refill of the SIRWT with 250,000 gallons of water to a concentration of 1,000 ppm, and the minimum warehouse inventory will ensure that adequate volume is maintained.

The total volume of borated water available from the FTC and SFP is approximately 165,000 gallons. If the inventory of the FTC and SFP are diluted to 1,000 ppm boron, a total of 330,000 gallons of borated water is available before additional boric acid is required. Combined with an assumed 250,000 gallons from one refill of the SIRWT, FCS has the ability to provide a minimum of 580,000 gallons of water borated to at least 965 ppm to the SIRWT. Approximately 480,000 gallons will be required to raise containment water level to greater than El. 1,008 ft. Per figure 5.4-1, it would take nearly 4 days to inject 550,000 gallons of water at the minimum necessary flow rate.

a. Preferred method of addition

The preferred method of adding boric acid to the SIRWT would be via the boric acid batching tank. Boric acid can be added to the SIRWT via the boric acid blending tee or directly to the RCS via the charging system.

b. Alternate method of addition

Mixing of the boric acid will be difficult if direct addition to the FTC or SFP with demineralized or fire protection water must be used, since the boric acid will precipitate out at approximately 40°F. Fire protection water is likely to be at a lower temperature and mixing will become more difficult as temperatures approach 40°F. Due to the amount of agitation required, and the possibility of no power source for mechanical agitation, it is preferred to mix small quantities at a time. If makeup must be accomplished using fire hoses, boration would be best accomplished by dumping just enough boric acid in the transfer canal to mix one bag of boric acid into a volume of approximately 1000 gallons (less than one foot in the canal). The canal should be empty first, so that a combination of the fire hose and bottom of the canal will provide the agitation.

Conclusion:

Sufficient boric acid is available on site to ensure that containment can be filled to greater than El. 1,008 ft. with water borated to at least 965 ppm. Sufficient boric acid is available on site for approximately 90 hours of continuous injection at the minimum flow rate necessary for heat removal.

When implementing the strategy of providing boric acid to the SIRWT, the following should be considered:

- Replenishing the boric acid storage tanks is the preferred method of supplying makeup water sources with boric acid.
- The boric acid storage tanks should be maintained as full as practical during normal plant operations.
- When possible, attempts should be made to preserve available boric acid by securing emergency boration, and actions to begin refill of the BASTs should be undertaken in a timely manner.
- Due to solubility and mixing concerns, direct addition of boric acid to a water source should only be used if the BASTs are not available.
- If direct addition of boric acid must be performed, small amounts should be added at a time, and lower tank levels will promote better mixing.

D. Leakage of SIRWT Valves

During refill of the SIRWT, the supply valves to the SI and CS Pumps (LCV-383-1/383-2) are shut and the pump suctions are aligned to the containment sump. In the event of a failure of the SIRWT isolation to fully shut, or excessive seat leakage were to occur, water could potentially leak into the containment sump. Significant leakage would be observed by operations by lowering SIRWT level, or the SIRWT level not increasing during fill activities. Any leakage into the sump is bounded by the analysis in Section 5.1 of this evaluation for minimum injection water volume.

The HPSI pump recirculation valves to the SIRWT (HCV-385 and HCV-386) are normally open to provide pump mini flow back to the SIRWT. Upon RAS initiation, these valves close to prevent the contaminated water from the containment sump from being recirculated into the SIRWT. Valves HCV-385 and HCV-386 are air-operated valves that fail open on a loss of air supply. The air accumulator is designed to maintain the valves open for a period of 13 hours following a loss of the air supply [3.28; Attachment 5]. If instrument air is lost, these valves would be manually shut prior to 13 hours to ensure that they will not drift open [3.40]. This would avoid potential contamination of the SIRWT water with containment sump water. HCV-385/386 should also be verified closed prior to re-initiation of SI flow from the SIRWT if the sump strainers become clogged, to prevent potential contamination.

As long as the HPSI throttle valves can be throttled further open to compensate, opening HCV-385 and HCV-386 will not result in a reduction in injection flow rate. If boric acid crystals must be mixed directly in the FTC or SIRWT, it may be beneficial to open HCV-385/386 to provide better mixing in the SIRWT. This decision would be made on a case basis, depending on how completely the boric acid is dissolving, and the expected increase in dose rate near the SIRWT if the recirculation line is opened.

Conclusion:

Regarding the potential for leakage of SIRWT valves, the following should be considered:

- Potential leakage from the SIRWT through the SI/CS suction isolation valves to containment would be bounded by the analysis in section 5.1 of this EA.
- Adequate procedural guidance is already in place to ensure that HCV-385/386 will not fail open on loss of instrument air. However, these valves should be verified closed when re-aligning HPSI to the SIRWT to avoid contamination of the SIRWT and attendant high dose rates if direct access to the SIRWT is required for filling purposes.
- If increased agitation is required for mixing of boric acid crystals in the SIRWT, it may be beneficial to open HCV-385/386.

6.0 RESULTS AND CONCLUSIONS

6.1 Response to Degraded ECCS Sump Performance and Sump Clogging

A. Sump Inoperability Criteria:

It is recommended that procedural guidance be contained in the appropriate EOPs and AOPs to assist the operators in diagnosing sump screen clogging. This guidance should be provided to the operators post-RAS. Below are the recommended criteria for diagnosing sump inoperability:

ANY of the following conditions existing on 2 or more operating, or previously operating pumps:

- Erratic indication or inability to maintain desired CS or HPSI flow
- Erratic or sudden decrease in HPSI Header Pressure
- Erratic or sudden decrease in HPSI or CS Pump Motor Amps
- CS or HPSI Pump Trip Annunciator
- Increased HPSI or CS Pump noise.

Following RAS, the above available indications should be monitored for signs of reduced pump performance. The criteria require that indications be observed on two or more pumps to ensure that individual pump degradation, or a failure in a single component in the CS or SI train, will not be interpreted as a failure of the sump screens.

The criteria include audible indications of pump cavitation as input to the diagnosis in the event that personnel are in the SI Pump room and observe the indication. Audible indication of cavitation is not necessary to confirm an inoperable sump.

Status:

The recommended actions have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4]. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A8. No further action is required.

B. Contingency Actions for Sump Inoperability.

The following is a summary of the strategy that should be employed if indications of degraded ECCS sump strainer performance are evident:

1. Securing all CS Pumps:

The action to secure all operating CS Pumps upon confirmation of sump inoperability should be implemented based on the following considerations:

- Failure of a sump screen is a condition beyond the FCS design basis. Securing CS pumps is an action to reduce the consequences of a beyond design basis event.
- Taking no action upon indications of sump inoperability may result in the degradation or failure of the operating pump(s), making them unavailable for future mitigation strategies.
- Securing CS pumps may allow HPSI pump(s) to operate on a degraded sump; thereby, extending time until alternate injection sources are required, and allowing more time for operators to initiate shutdown cooling.
- The containment coolers, while not credited in the LOCA analysis, have the capacity to maintain the containment below the design pressure of 60 psig post-RAS. The CFC Coolers and Fans are maintained CQE.
- The CFC Charcoal and HEPA filters, although not credited in the radiological consequence analysis, will provide for some filtration of particulate and radioiodine.
- Preliminary analyses show a significant reduction in dose following the type of LOCA that could lead to sump clogging by crediting natural deposition.

The following are factors to consider if the containment sump screens are inoperable:

- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging.
- Increased awareness of containment pressure is necessary due to the increased risk for challenging of containment design pressure limits.
- Increased awareness of HPSI pump operating parameters is necessary while the HPSI pump is operating on a degraded or inoperable sump due to the increased risk of pump damage.

- All available containment coolers should be verified operating to provide continued containment pressure reduction.
- Plant cooldown by all available methods will reduce the heat load inside containment.
- Increased awareness of radiological conditions inside the Control Room is necessary due to the possibility of higher control room doses as a result of potentially higher particulate and iodine activity in the containment atmosphere.

Status:

Ensuring ERO awareness of potential challenges to core cooling and radiological conditions (first and last bullets) is being addressed by the development of a TSC Guideline. See section 7.4 B for details. All other considerations described above have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4], and require no further actions. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A9-CE.

2. Throttling HPSI Flow

Throttling of HPSI flow to less than design basis flow rate should only be used in the event that degraded ECCS sump strainer performance is evident.

The compensatory action to throttle HPSI flow post-RAS in response to sump performance degradation should be implemented based on the following considerations:

- The design configuration of the HPSI system post-RAS results in a recirculation flow rate that is greater than that required to remove decay heat and keep the core covered.
- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to improve ECCS sump strainer performance may result in core damage.

The following actions should be taken when throttling HPSI flow post-RAS in response to degraded ECCS sump strainer performance:

- HPSI flow should be throttled to establish the minimum flow necessary to maintain adequate decay heat removal, accounting for spillage of a portion of the injection water out the break prior to reaching the core.

- When simultaneous hot/cold leg injection is implemented, throttled HPSI flow must be adequate for decay heat removal and prevention of boron precipitation.
- If HPSI flow rate cannot be maintained greater than 50 gpm per pump, then the affected pump(s) should be secured to preserve them for later use.
- Increased monitoring of HPSI pump performance is necessary if evidence of degraded ECCS sump strainer performance is observed, as preservation of operable pumps is desirable for implementation of alternate long term cooling strategy.
- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging.

Status:

Ensuring ERO awareness of potential challenges to core cooling (last bullet) is being addressed by the development of TSC Guideline. See section 7.4 B for details. All other considerations described above have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4], and require no further actions. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A9-CE.

3. Establishing a More Aggressive Cooldown Rate

Exceeding a cooldown rate of 100°F/Hr, or exceeding T.S. pressure temperature limits should only be performed in the event that degraded ECCS sump strainer performance is evident.

Maximizing the cooldown rate post-RAS in response to sump performance degradation should be implemented based on the following considerations:

- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to improve ECCS sump strainer performance may result in core damage.

Status:

The recommended action is already present in EOP-20, IC-2 [3.4]. A detailed discussion of the action taken can be found in Attachment 8.3, COA A7. No further action is required.

4. Establishing SI Flow from the Refilled SIRWT

Injection of water from a refilled SIRWT tank should only be used in the event that the containment sumps are no longer operable due to clogging.

In order for this measure to be considered a success path for long-term core cooling, it is necessary to permit filling the containment to at least the top of the hot legs at El. 1008 ft. This may allow for long-term cooling via: 1) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS, or 2) thermal convection via countercurrent flow through the break or ex-vessel cooling, with fan coolers providing the ultimate decay heat removal.

The compensatory action to inject water from a refilled SIRWT in response to sump inoperability should be implemented based on the following considerations:

- Failure of passive devices post-LOCA is a condition beyond the FCS design basis. Providing core cooling by this method is an action to reduce the consequences of a beyond design basis event.
- The primary priority for response to an inoperable sump is to maintain core cooling. Taking no action to provide water to the core for cooling will result in core damage.
- A sufficient volume of clean makeup water is available on site to fill the SIRWT at flow rates sufficient to accommodate the HPSI injection rate required by figures 5.1-1 through 5.1-3.
- Injection water from a refilled SIRWT must have a boron concentration of at least 1,000 ppm to prevent localized re-criticality in the core.
- Re-injection of approximately 1,000 ppm boric acid solution at 250gpm for approximately three days would not result in the need additional sump neutralization.
- The effects of compression of the containment free air volume due to raising water level to El. 1,013 ft. following RAS will not cause containment pressure to exceed its design limit.
- The combined effects of containment free air volume compression and increased elevation head due to raising water level to El. 1,013 ft. will result in a worst case hydraulic pressure at the containment floor and all penetrations that are below containment design pressure.

- The combined effects of containment free air volume compression and increased elevation head due to raising water level to El. 1,013 ft. will result in a worst case hydraulic pressure at the reactor cavity floor that is greater than 60 psig. However, it is below containment test pressure and below the hydraulic pressure that would be seen at containment design level and pressure in containment.
- Although cables and electrical equipment located above El. 1000.9 ft. may continue to operate, the submergence may cause erroneous readings or equipment failure. Actions to ensure core cooling takes precedence over other functions such as preventing damage to indications used to monitor the event.

The following are factors to consider when injecting water from the refilled SIRWT:

- The ERO should be notified to provide for increased awareness of potential challenges to core cooling. Guidance should be developed to help the TSC staff focus on key issues associated with sump clogging. Key issues associated with establishing injection flow from a re-filled SIRWT include prediction of make-up water needs and compensating for the effects of submerged equipment and instrumentation.
- Increased awareness of instrumentation response is necessary as water level is increased. ERO resources will be necessary to help monitor the effects of rising level on critical accident monitoring and mitigation equipment, and to estimate containment water level if level is above the top of the sump level monitoring instrumentation. Attachment 8.2 provides tables showing affected components. It also identifies affected components that are critical to the mission of raising containment water level above the hot legs and provides alternative means of accomplishing those components' functions.
- Makeup water boron concentration should be maintained at approximately 1,000 ppm if possible. This will ensure adequate margin to criticality, while maximizing the availability of borated water and minimizing the impact on sump pH. Addition of makeup water at higher boron concentrations is acceptable, but blending of makeup water should target 1,000 ppm in the SIRWT.
- As a minimum, SIRWT boron concentration should be estimated to ensure that it is greater than 1,000 ppm. The SIRWT should be sampled prior to injection, if practical.

Status:

Ensuring ERO awareness of potential challenges to core cooling (last four bullets) is being addressed by the development of TSC Guideline, which includes coping strategies for the various aspects of raising containment water level above design elevation. See section 7.4 B for details. All other considerations described above have been incorporated into EOP-20, IC-2 [3.4]. Enhancements are being made to EOP-20 and EOP/AOP Attachment 26 to ensure SDC is available and to notify the operations staff of the EROs role in assessing beyond design basis effects of this strategy. A detailed discussion of the actions taken can be found in Attachment 8.3, COAs A6 and A9-CE.

5. Reestablishing HPSI Flow from the Containment Sump

Reestablishing HPSI flow from the containment sump may delay the rise in containment water level to delay submergence of critical instrumentation. It may also be a method to provide cooling while refilling the SIRWT.

To allow sufficient time for settling of debris, and for the SI flow requirement to drop, reducing the $NPSH_{Required}$, it is recommended that the SI pumps aligned to the sump have been secured for a minimum of one hour before attempting to reestablish flow from the containment sump.

Status:

The recommended action has been incorporated into EOP-20, IC-2 [3.4]. A detailed discussion of the action taken can be found in Attachment 8.3, COA A9. No further action is required.

6.2 Securing SI Pumps Not Required for Core Cooling

A. Consideration of Securing a LPSI Pump Pre-RAS

- Adopting the action to secure a LPSI pump prior to RAS would place the plant outside of its design basis, and would require prior NRC review and approval. The benefits of this action are minimal at FCS. Therefore, it is not recommended that this strategy be implemented.
- Plant procedures do allow for securing of LPSI pumps pre-RAS under certain small break LOCA conditions.

Status:

LPSI pumps will not be secured prior to RAS, except in small break scenarios where RCS pressure remains above the LPSI Stop/Throttle criteria. The criteria and actions for securing LPSI pumps under these conditions are located in AOP-22 [3.43], EOP-03 [3.3] and EOP-20 [3.4]. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A4. No further action is required.

B. Securing SI-2C Pre-RAS

Securing SI-2C prior to RAS will reduce debris transport to the sump screens and preserve an operable HPSI pump.

A modification is in process to remove the autostart feature on the swing HPSI pump, SI-2C (scheduled for the 2006 refueling outage). Securing SI-2C prior to RAS is acceptable based on:

- The HPSI function can be accomplished with one HPSI Pump running for the entire duration of the LOCA event.
- SI-2C is not credited in the LOCA analysis
- In the event of a failure of an operating HPSI pump or train following the action to secure SI-2C, one HPSI pump will still be operating and providing core cooling.

Until the modification to remove the SI-2C autostart is installed, the action to secure SI-2C should only be taken upon verification of all of the following plant conditions:

- All other HPSI pumps have started and are verified to be operating normally.
- SI Flowrate is above the Attachment 3, Safety Injection Flow vs. Pressurizer Pressure Curve, indicating that SI flow is above the flow assumed in the LOCA Analysis for the HPSI and LPSI pumps.
- The Reactor Vessel Level Monitoring System (RVLMS) indicates vessel level greater than the top of active fuel and not lowering. This indicates that that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

In addition to securing SI-2C, securing one train of HPSI prior to RAS initiation as a pre-emptive measure was considered. This action would place the plant outside its design basis prior to any indication of a beyond design basis event occurring. The benefits of this action are minimal at FCS. Therefore, it is not recommended that this strategy be implemented.

Status:

The recommended actions to secure SI-2C prior to RAS have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4]. A detailed discussion of the actions taken can be found in Attachment 8.3, COAs A3-CE and A10. The modification to remove the autostart feature from SI-2C [3.50] is to be accomplished during the 2006 refueling outage. No actions will be taken to restrict HPSI operation to a single train before RAS initiation.

C. Consideration of Operation with One HPSI Pump Post-RAS

Securing one train of HPSI or throttling HPSI flow following RAS initiation without evidence of strainer clogging as a pre-emptive measure would not provide a significant benefit in preventing sump strainer clogging and it places the plant outside its design basis prior to any indication of a beyond design basis event occurring.

Therefore, the adoption of this compensatory action is not recommended.

Status:

No actions will be taken to restrict HPSI operation to a single train following RAS initiation.

D. Consideration of Early Initiation of Recirculation with One HPSI Train

Placing one train of HPSI in the recirculation mode prior to RAS requires a manual operator action that would require considerable monitoring and confirmation prior to implementation of the step. Due to the relatively small window of time that would be available for this action to be completed before automatic RAS initiation. There is no significant benefit that could be gained. Additionally, the introduction of an additional operator action early in the event increases the probability of an error that could hinder system performance.

Therefore, the adoption of this compensatory action is not recommended.

Status:

No actions will be taken to place one train of HPSI in recirculation prior to RAS initiation.

6.3 Early Termination of CS Pumps

A. Securing One CS Pump

Securing one CS pump early in the event is an acceptable compensatory action to address sump screen clogging concerns. A modification is in process to remove the autostart feature on the swing CS pump, SI-3C (scheduled for the 2006 refueling outage). Securing one CS pump prior to RAS is acceptable based on:

- The LOCA containment pressure and radiological consequences analyses assume operation of one CS pump and header.
- Securing one CS pump produces results that are less restrictive than the limiting containment pressure analysis that assumes one pump and header operation for the duration of the event. This is because all spray pumps function up to the time that one is stopped.
- In the event of a failure of an operating CS pump or train following the action to secure one CS pump, one CS pump and header will still be operating and providing containment cooling and source term removal.

Until the modification to remove the SI-3C autostart is installed, the action to secure a CS pump should only be taken if all other CS pumps have started and are verified to be operating normally, and upon verification of the following plant conditions:

- Containment pressure is <5psig and NOT increasing;
- All available CFC's are operating; and
- SI is actuated and flow is acceptable per Attachment 3, Safety Injection Flow vs. Pressurizer Pressure.

Following the action to secure one CS pump, operators should verify that containment pressure is being maintained below design. If containment pressure cannot be controlled, then EOP's should direct that all available CS pumps be started.

Status:

The recommended actions to secure SI-3C prior to RAS have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4]. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A1a-CE. The modification to remove the autostart feature from SI-3C [3.51] is to be accomplished during the 2006 refueling outage.

B. Securing Two CS Pumps

The preemptive compensatory measure to reduce to one train of CS under the conditions above (all CFCs operating), provides a positive risk benefit as a compensatory action to address sump screen clogging concerns. On May 20, 2005, FCS was granted a temporary technical specification amendment to allow two CS pumps to be secured if all CFCs are operating [3.39].

Status:

The recommended action to reduce CS operation to a single train prior to RAS has been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4]. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A1a-CE.

6.4 Refilling the SIRWT Post-RAS.

The action to refill the SIRWT post-RAS is acceptable based on:

- The design function of the SIRWT to deliver borated water to the core during a LOCA is complete once the CS and SI Pump Suctions are switched to the recirculation mode
- The action occurs after the SIRWT design basis function is complete
- Leakage of valves upon refilling of the SIRWT will not result in adverse radiological consequences

Table 6.3-1 summarizes the acceptable sources, methods, and capacities for use in refilling of the SIRWT post-RAS. Priority should be given to those sources and methods that are borated. If water at the refueling boron concentration is added to the SIRWT, it is acceptable to add non-borated water to dilute the SIRWT contents to 1,000ppm prior to injection into the RCS.

Table 6.4-1: Summary of SIRWT Refill Water Sources and Methods

Source	Capacity (gal)	Borating Required?	Comments
Full FTC at Refueling Boron Concentration by gravity drain	45,000 (>250gpm)	No	Requires change to normal operating practice to leave the canal full
Full FTC at Refueling Boron Concentration using FTC Drain Pumps	45,000 (>250gpm)	No	Requires change to normal operating practice to leave the canal full; Requires pump restart due to load shed.
SFP via circulating pumps using lower suction line	120,000 (~300gpm)	No	Requires pump restart after load shed
SFP via gravity drain	120,000	No	Not recommended due to low flow rate
Transfer from SFP to FTC using Tri Nuclear Unit	120,000 (250gpm)	No	Not recommended due to unavailability of power
Gate removed between the SFP and FTC and transfer to SIRWT from FTC	140,000 (>250gpm)	No	Not recommended due to SFP cooling issues; Requires further evaluation of SFP cooling system design and time to boil calculation.
CVCS to blend contents of	Dependent	Blended	Will not provide the

Table 6.4-1: Summary of SIRWT Refill Water Sources and Methods			
demineralized water and/or the BAST(s) to the SIRWT using the normal method. See attachment 8.8 for flow paths.	on BAST content (>120gpm)	as required for makeup needs.	required flow rates early in event; can be used to supplement other methods. Can be used for long term SIRWT makeup. Makeup water sources are described in attachment 8.7.
Demineralized Water or Fire Protection fill of the FTC via fire hoses and dumping bags of boric acid into the FTC	Up to 250gpm	Yes	Least preferred method. Water contains impurities; Requires addition of 43 bags of boric acid for each FTC volume; Poor mixing at low water temperatures.
Demineralized Water or Fire Protection fill of SIRWT via fire hoses through the vent and dumping bags of boric acid through the floor plug	Up to 250gpm	Yes	Least preferred method. Water contains impurities; requires adding 239 bags of boric acid to achieve 1,000 ppm; poor mixing at lower temperatures; requires floor plug removal

The following is a summary of Engineering recommendations regarding refilling of the SIRWT:

1) The action to refill the SIRWT should be directed by the EOP Procedures, and procedures should contain detailed guidance regarding water sources as shown in the above table.

2) Any action to refill the SIRWT should not be commenced until after RAS has occurred.

3) Borated sources of water from the Fuel Transfer Canal and Spent Fuel Pool are the priority sources for initial fill activities. These sources will provide adequate volume to support approximately 24 hours of RCS injection at the minimum rate necessary for core cooling. CVCS fill of the SIRWT can be used to supplement initial fill activities, and may prevent the need for transferring water from the SFP to the SIRWT.

4) CVCS blended makeup (blending boric acid and demineralized water via FCV-269X/Y) is the preferred method for long term makeup to the SIRWT. Adequate sources of clean water are available on-site to

replenish demineralized water if Blair water via the RO unit is not available.

5) When possible, attempts should be made to preserve available boric acid by securing emergency boration, and actions to begin refill of the BASTs should be undertaken in a timely manner.

6) Mixing of Boron in the fuel transfer canal or the SIRWT may result in inadequate mixing and should be used only if all other sources of borated water are depleted or unavailable.

7) The boric acid storage tanks should be maintained as full as practical during normal plant operations.

8) The Fuel Transfer Canal (FTC) should be maintained full of borated water at the refueling boron concentration during normal plant operations to provide a large initial volume of water for addition to the SIRWT. This does not preclude draining of the FTC for maintenance activities, and is not intended to be a long-term operating strategy.

9) As a minimum, SIRWT boron concentration should be estimated to ensure that it is greater than 1,000 ppm. The SIRWT should be sampled prior to injection, if practical.

10) Reset of engineered safeguards may be necessary to successfully establish makeup flow paths from the SFP and CVCS. However, flowpaths from the FTC exist that do not require ES reset. Therefore at least 5 hours will normally be available for performing reset activities.

11) Adequate procedural guidance is already in place to ensure that HCV-385/386 will not fail open on loss of instrument air. However, these valves should be verified closed when re-aligning HPSI to the SIRWT to avoid contamination of the SIRWT and attendant high dose rates if direct access to the SIRWT is required for filling purposes.

12) If increased agitatation is required for mixing of boric acid crystals in the SIRWT, it may be beneficial to open HCV-385/386. This should be assessed by the ERO as necessary on a case basis.

13) This EA does <u>not</u> advocate or justify changing plant operational strategy to operate with the Spent Fuel Pool Gate removed during normal operation for the purpose of providing a source of borated water to refill the SIRWT. The preferred method of using the Spent Fuel Pool water is pumping to the SIRWT via the SFP Cooling Circulating Pumps, using the lower suction line. Extended operation with the gate removed requires further evaluation of the effect of the additional volume of water in the FTC on:

- Performance of the SFP Cooling system function
- Time to boil calculations in the event of a loss of SFP cooling function.

Status:

Items 1 – 6 described above have been incorporated into AOP-22 [3.43], EOP-03 [3.3] and EOP-20, IC-2 [3.4], using EOP/AOP attachment 25. Enhancements are being made to EOP/AOP Attachment 25 to help prioritize available borated water supplies, and to notify the operations staff of the EROs role in providing guidance on makeup water sources. Additional operator training is being conducted to clarify the priorities for borated water sources. A detailed discussion of the actions taken can be found in Attachment 8.3, COA A5.

Item 7 is being institutionalized by establishing operating bands within the appropriate operations logs to maintain BAST levels/concentrations at the high end of the band. See section 7.6 for details.

Item 8 has been institutionalized by adding a requirement to the EONA logs (FC-143) to maintain the FTC full.

The actions recommended by item 9 & 10 have been incorporated into EOP/AOP attachment 25. Additional guidance on the monitoring of makeup water boron concentration and establishment of makeup flow paths is being incorporated in the development of a TSC Guideline. See section 7.4 B for details.

The actions recommended by item 11 are located in AOP-17 [3.40], which is referenced by EOP-20, MVA-AC. No further action is required.

As discussed in item 12, the SFP gate will not be removed. The Auxiliary Building Operator (EONA) logs (FC-143) have been revised to reflect that the SFP gate should be in place with the FTC full of water.

7.0 DESIGN BASIS, LICENSING BASIS, AND/OR OPERATING DOCUMENT CHANGES

Document change markups associated with Revision 1 of this EA are included in attachment 8.9.

7.1 DBD Updates

A. The following DBDs are being updated:

1) SDBD-SI-CS-131, Containment Spray System.

2) SDBD-SI-HP-132, High Pressure Safety Injection System.

7.2 USAR Changes

No USAR Changes are required by this EA.

7.3 License Amendment Request

This EA does not require submittal of any License Amendment Request.

7.4 Description of Changes Required to Implement the Results of the EA

The results of this EA are used as inputs for the development of EOP and AOP steps for compensatory actions in response to a potential sump clogging event. AOP-22 [3.43] EOP-03 [3.3] and EOP-20 [3.4] currently provide guidance to implement the strategy established in Revision 1 of this EA see attachment 8.3 for a detailed description of the current procedural steps and how they relate to the COAs adopted by FCS. Additional changes as a result of revision 1 of this EA are discussed below.

A. EOPs and AOPs will be revised as follows:

1) EOP/AOP attachment 25 will provide additional guidance concerning the length of time that cooling can be provided using a SIRWT refilled from the FTC and SFP, and the availability of resources in the TSC to support identification of long term makeup flow paths.

2) EOP/AOP attachment 26 is being revised to clarify when the curves associated with figures 5.1-1, 5.1-2 and 5.1-3 are to be used.

3) A note is being added to EOP-20, IC-2 to provide additional guidance on the effects of raising containment water level above design flood elevation, and the availability of guidance from the TSC to evaluate the effects.

4) EOP-20, IC-2 is being revised to ensure HCV-348 is deenergized after opening, and to include HCV-327 and HCV-329 in the step requiring alignment of the SDC system prior to submergence of the components.

5) AOP-22, EOP-03 and EOP-20 are being revised to direct that emergency boration is stopped after ½ hour to preserve BAST inventory.

B. A new TSC Guideline is being developed to assist the TSC staff in assessing plant status and providing technical support for:

1) Monitoring ECCS performance if there is evidence of degraded recirculation strainer performance.

2) Emphasis on monitoring of plant radiological conditions due to the securing of containment sprays.

3) Establishing long term makeup water alignments.

4) Assessing and adjusting SIRWT and RCS pH and boron concentration.

5) Coping with the effects of raising containment water level above design flood elevation on components and instrumentation.

6) Monitoring the performance of the SDC system when operating.

7) Transition to SAMGs if alternate strategies fail to work.

C. Fort Calhoun Station Guidelines will be revised as follows:

1) FCSG-39 will be revised to include the contingency equipment necessary to support the makeup water flow paths identified in attachment 8.7.

7.5 Change to an NRC Commitment

This EA supports implementation of commitments made to the NRC in References 3.2 and 3.45.

One commitment will be changed as a result of Revision 1 to this EA. In Reference 3.45, Attachment 2, Commitment 2 states, "OPPD will implement the following enhancements by April 30, 2006":

- Establishment of procedural guidance for throttling HPSI flow after the recirculation actuation signal to a value that is acceptable to the safety analysis, but less than full flow.

Further assessment of this action has revealed that only a small reduction in flow rate can be gained within the current safety analysis, and that the benefits of this action would be offset by the increased likelihood of operator error introduced by performing this action. See section 5.2 C for details

7.6 Condition Report Determination

A. 200600619 was written to document the need for the following actions:

1) Establish bands in the appropriate operations log(s) that ensure that the BASTs will be maintained at the high end of allowable level and boron concentration.

2) Ensure that the hose connections identified in attachment 8.7 are capable of attachment to 2 ½" fire hoses.

3) Establish work orders to construct two (2) blank flange adapters capable of attachment to 2 ½" fire hoses.

8.0 LIST OF ATTACHMENTS

8.1 Accident Sequence Flowcharts for Evaluating Compensatory Actions

8.2 Components Affected by Rising Containment Water Level

8.3 Summary of Relevant Candidate Operator Actions Identified in WCAP-16204 [3.38]

8.4 Determination of Containment Sump Contribution from Design Water Sources

8.5 Volume and Time Requirements for SIRWT Injection to RCS

8.6 Calculation of Flow Rate by Gravity Drain from the FTC to the SIRWT

8.7 Summary of Emergency Makeup Water Flowpaths to the Demineralized Water System.

8.8 Summary of Emergency Makeup Water Flowpaths from the Demineralized Water System via CVCS to the SIRWT.

8.9 Record of E-mail Correspondence.

8.10 Document Change Markups.

ATTACHMENT 8.1: ACCIDENT SEQUENCE FLOWCHARTS FOR EVALUATING COMPENSATORY ACTIONS

The following flowcharts were developed as an aid to evaluate the expected response to strainer clogging, with and without compensatory measures. The compensatory actions evaluated are: 1) Securing SI-2C prior to RAS, and 2) Reducing to one operating CS pump prior to RAS.

Case 1: No Compensatory Actions; All ECCS Functions; No LOOP
Case 2: Compensatory Actions; All ECCS Functions; No LOOP
Case 3: No Compensatory Actions; LOOP with Failure of DG-1
Case 4: Compensatory Actions; LOOP with Failure of DG-1
Case 5: No Compensatory Actions; LOOP with Failure of DG-2
Case 6: Compensatory Actions; LOOP with Failure of DG-2

Sump Screens SI-12A and 12B are located in the containment basement El. 994 ft. The screens supply the following Engineered Safeguards functions:

<u>SI-12A</u>	<u>SI-12B</u>
SI-1B – LPSI Pump	SI-1A – LPSI Pump
SI-2B – HPSI Pump	SI-2A, SI-2C – HPSI Pumps
SI-3B, SI-3C – CS Pumps	SI-3A – CS Pump

In the event of a LOOP, power is supplied from the DG-1 and DG-2 Diesels as shown below. Either Diesel Generator can supply SI-2C and SI-3C.

<u>DG-2 Diesel</u>	<u>DG-1 Diesel</u>
SI-1B – LPSI Pump	SI-1A – LPSI Pump
SI-2B – HPSI Pump	SI-2A – HPSI Pump
SI-3B – CS Pump	SI-2C – HPSI Pump (Normal)
SI-3C – CS Pump (Normal)	SI-3A - CS Pump

Maximum pump flows for the above pumps are as follows:

LPSI = 2,850gpm HPSI = 450gpm CS = 3,200gpm

The following assumptions were made in the development of the attached flowcharts:

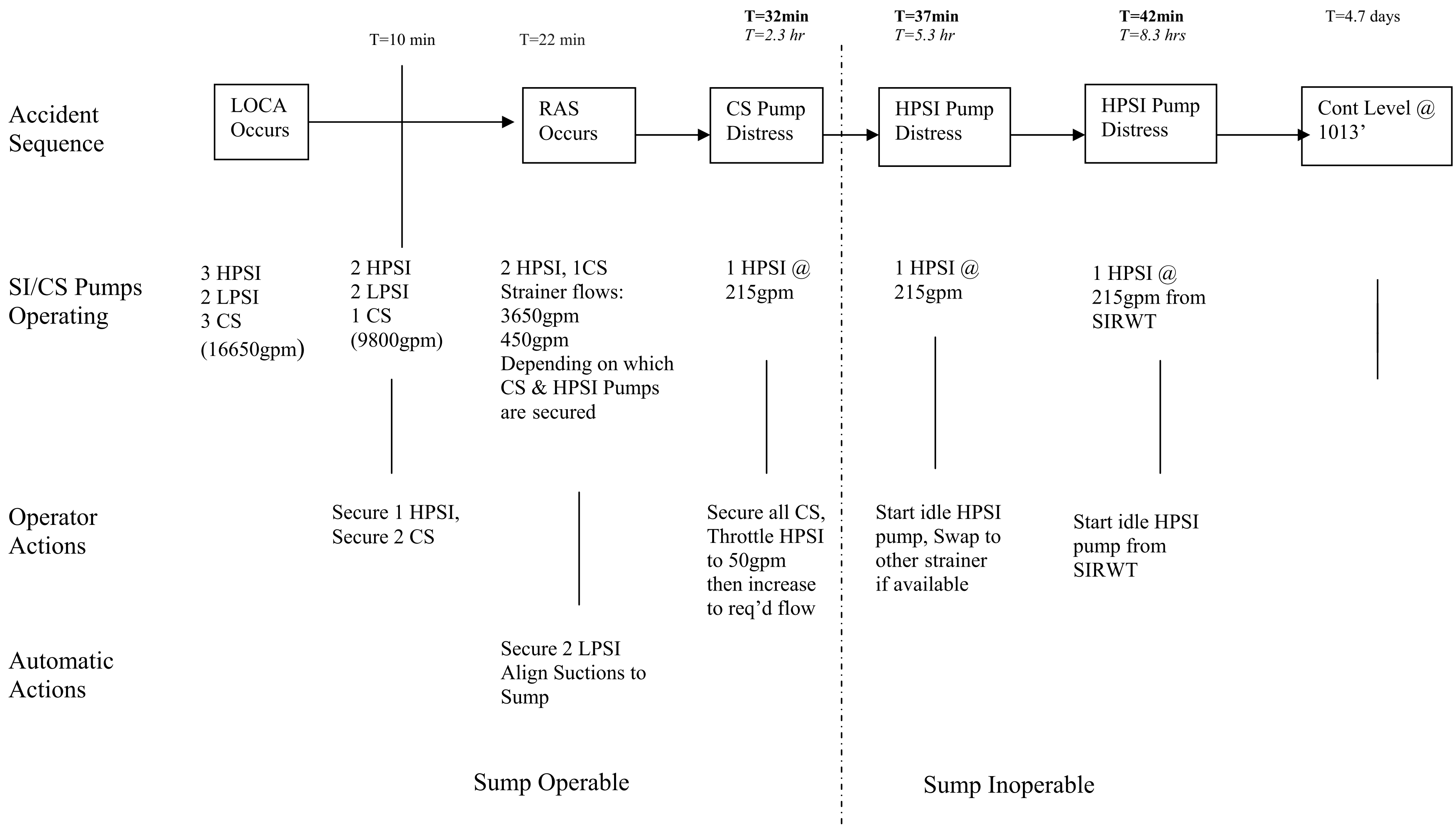
1) Compensatory actions occur at T=10 minutes.
2) Time to RAS assumes a large break LOCA with all water sources injecting at maximum capacity.
3) The initial SIRWT volume is assumed at 283,000gal.
4) Rapidly Clogging Sump (bold font): Sump clogged at T=10 minutes following RAS; loss of HPSI pump 5 minutes following alignment to the strainer.
5) Slowly Clogging Sump (italic font): Sump clogged at T=2 hours following RAS; Loss of HPSI pump in 3 hours following alignment to the strainer.

Case 1: No Compensatory Actions, No LOOP, Normal ECCS Operation

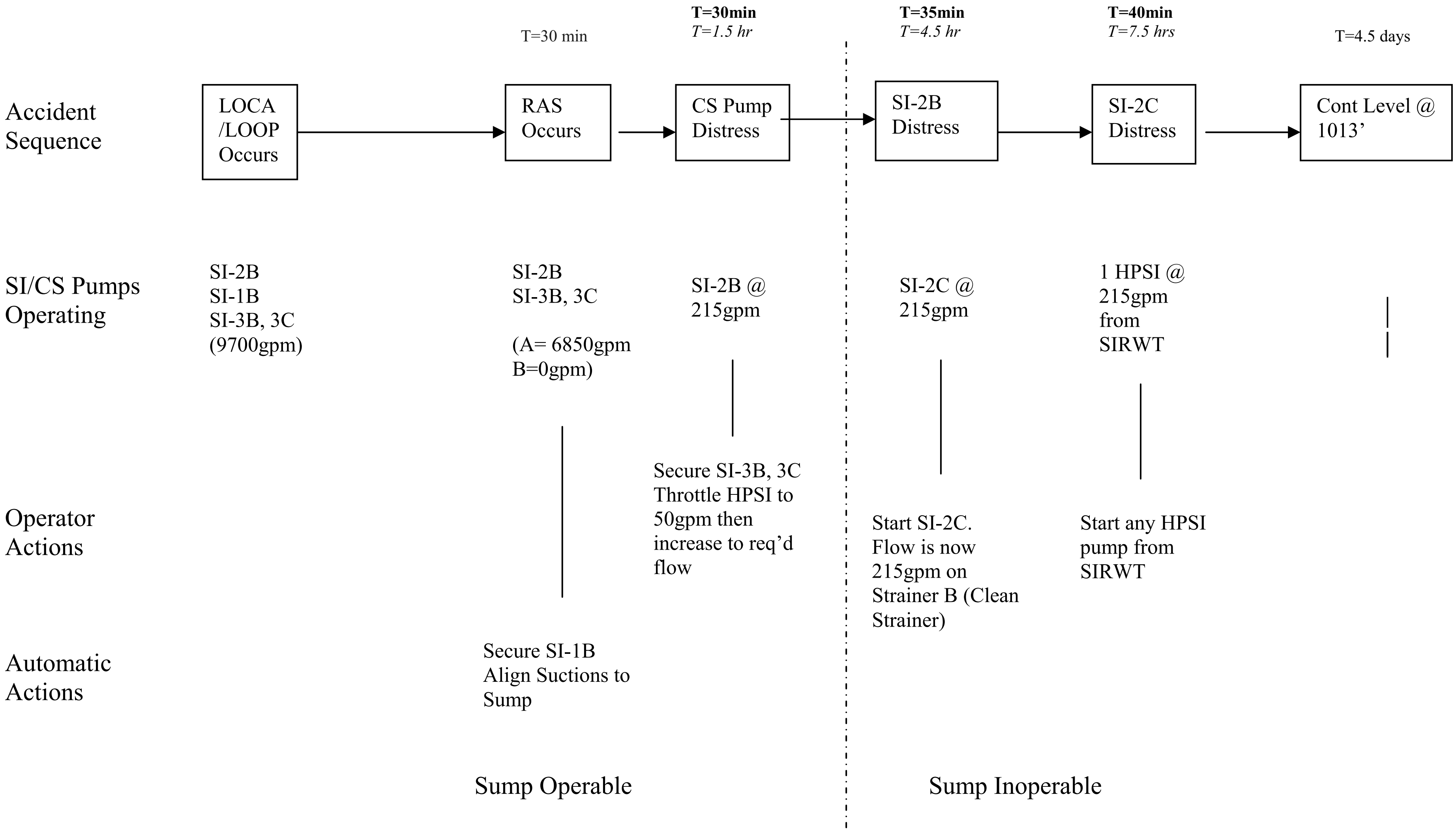
		T=17 min	**T=27min** *T=2.25 hr*	**T=32min** *T=5.25 hr*	**T=37 min** *T=8.25 hrs*	T=4.7 days
Accident Sequence	LOCA Occurs →	RAS Occurs →	CS Pump Distress →	HPSI Pump Distress →	HPSI Pump Distress →	Cont Level @ 1013’
SI/CS Pumps Operating	3 HPSI 2 LPSI 3 CS (16650gpm)	3 HPSI 3 CS SI-12A=6850 SI-12B=4100	1 HPSI @ 215gpm	1 HPSI @ 215gpm	1 HPSI @ 215gpm from SIRWT	
Operator Actions			Secure all CS, Throttle HPSI to 50gpm then increase to req’d flow	Start HPSI pump @ ~ 215gpm, Swap to other strainer if available	Start HPSI pump from SIRWT	
Automatic Actions		Secure 2 LPSI Align Suctions to Sump				

Sump Operable (up to the CS Pump Distress stage) | Sump Inoperable (from the first HPSI Pump Distress stage)

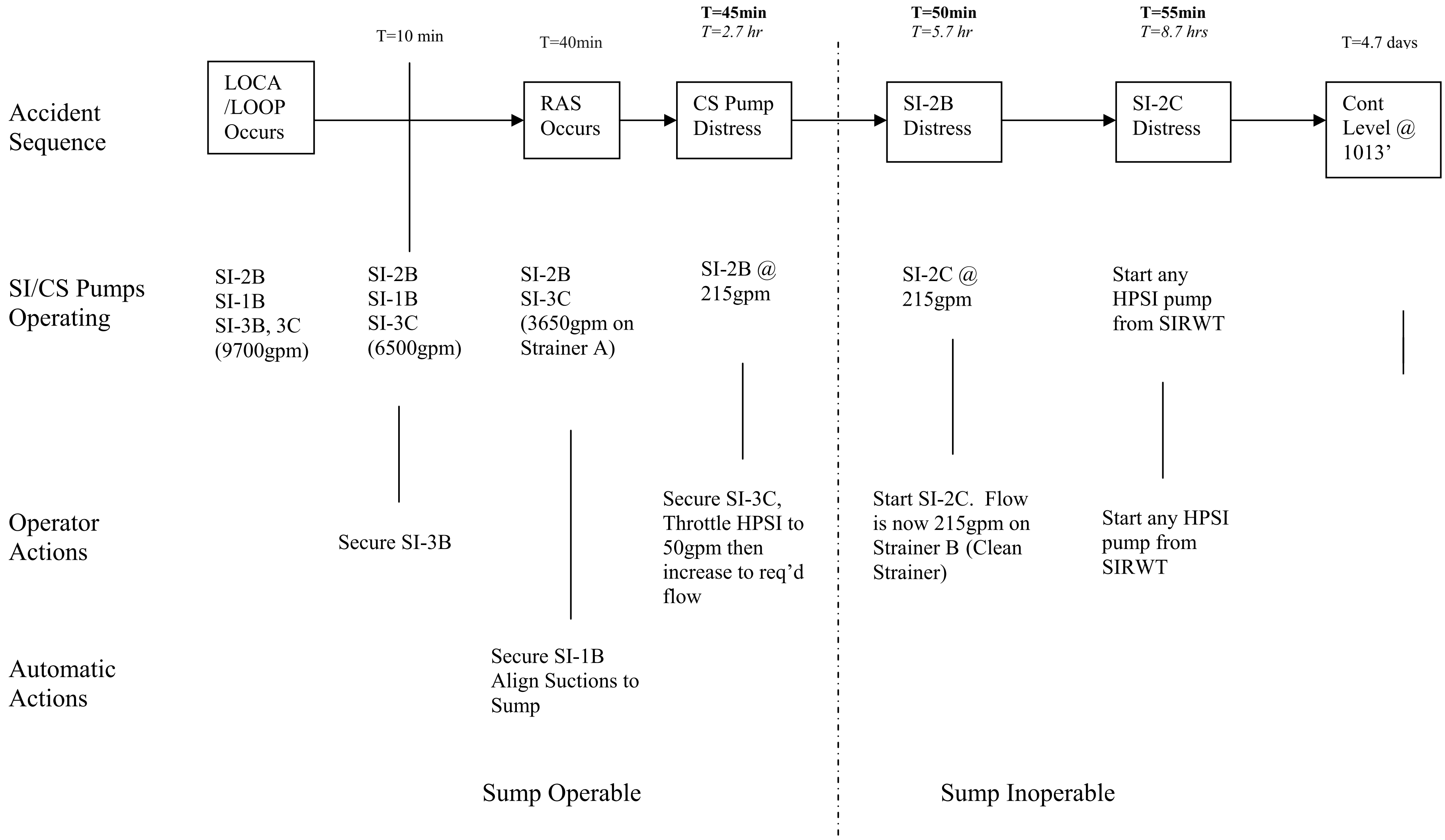
Case 2: Compensatory Actions, No LOOP, Normal ECCS Operation



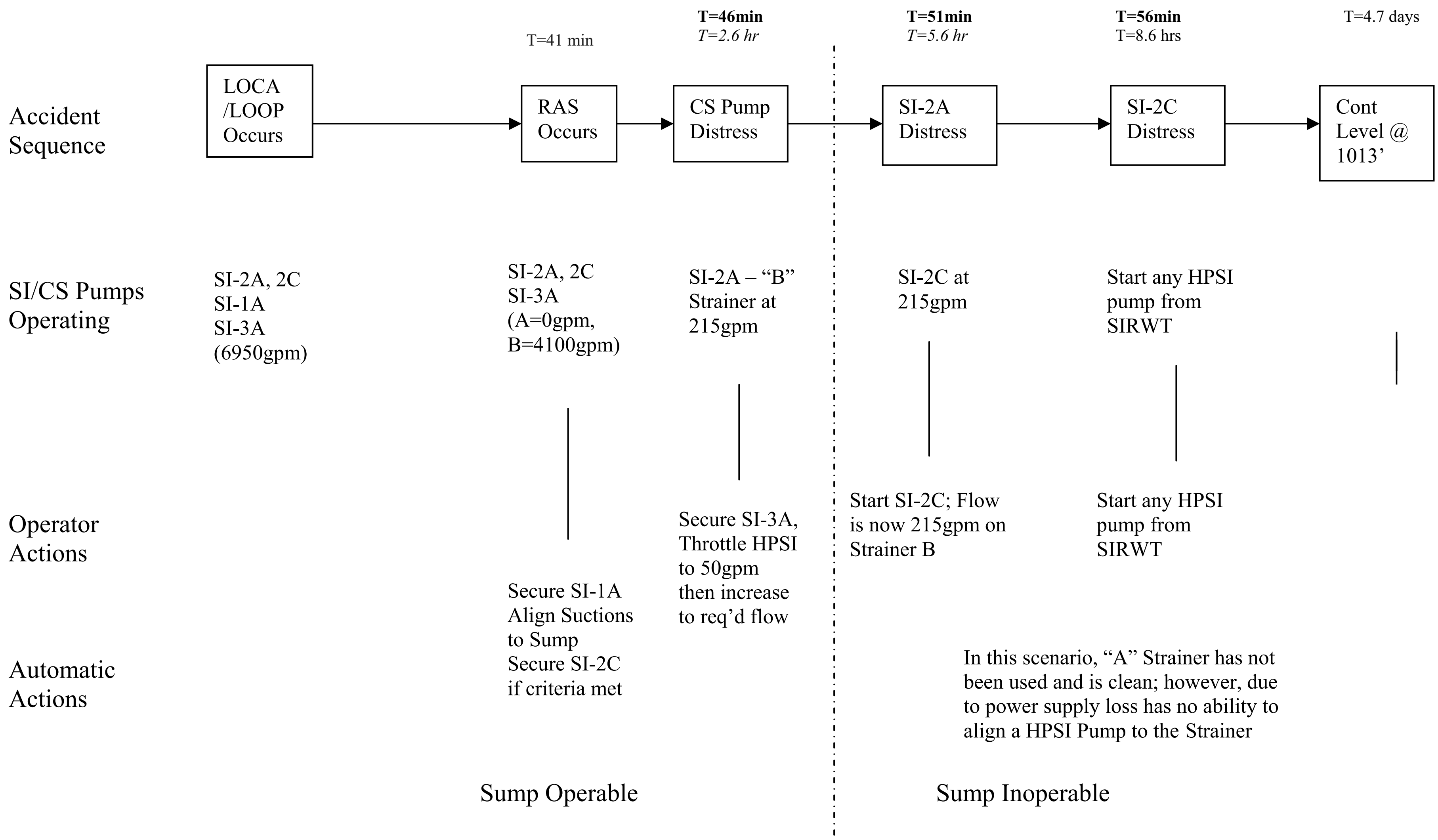
Case 3: No Compensatory Actions LOOP with failure of D-1 Diesel



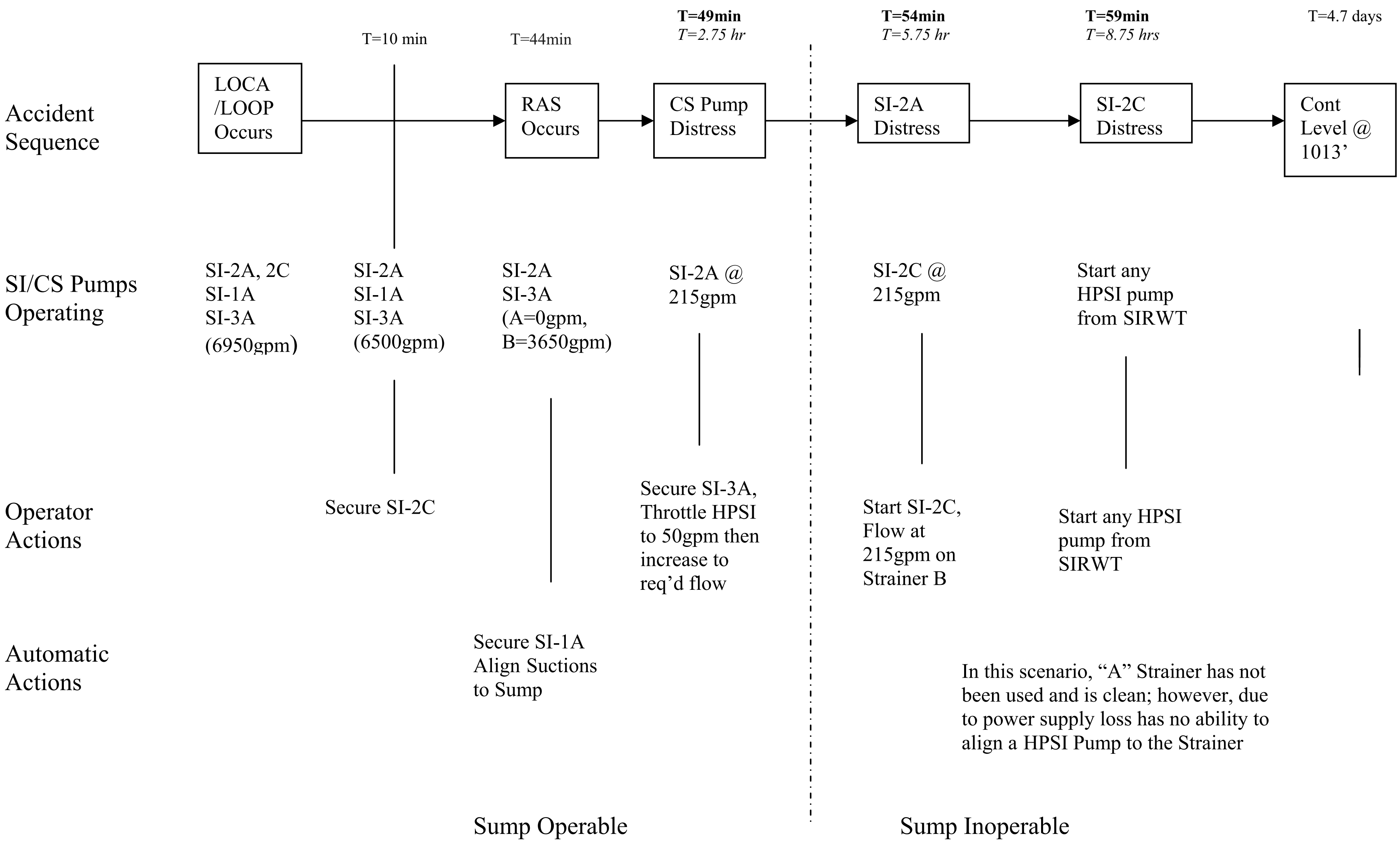
Case 4: Compensatory Actions LOOP with failure of D-1 Diesel



Case 5: No Compensatory Actions LOOP with failure of D-2 Diesel



Case 6: Compensatory Actions LOOP with failure of D-2 Diesel



ATTACHMENT 8.2
Components Affected by Rising Containment Water Level

The following tables summarize the components, electrical penetrations, and cable trays vs. containment elevation up to El. 1013ft. Indicated water level for the Tables is as indicated on LI-387-1/LI-388-1. Mission critical components and suggested coping strategies are shown in table 8.2-4.

Table 8.2-1 summarizes the EEQ components and a description of their service/function. Only components below El. 1013ft and not EEQ qualified for submergence are listed. Elevations in the table are approximations with a +/- one foot margin. [3.23]

Table 8.2-1 – EEQ Components vs. Containment Elevation			
El. (Ft)	Ind. Level	Tag #	Description / Service
1000.9	23.8	HCV-248	Charging to Loop 1B Isolation
1001.5	24.6	TCV-202	Loop 2A Letdown Flow Isolation Valve
1002	25.1	HCV-247	Charging to Loop 1A
		FT-313/316/319/322	HPSI Loop Flow Indication
		FT-328/330/332/334	LPSI Loop Flow Indication
		HCV-545	Safety Leakage Cooler Diversion to RCDT
		A/B/C/D LT-911/912	S/G Wide Range Level Indication for AFW
		A/B/C/D PT-913/914	S/G Pressure Indication for AFW
1003	26.1	PT-105	RC Pressure (WR) – Used for Sub Cooled Margin Monitor A
		HCV-348	SDC Isolation Valve Operator
1005	28.1	LT-387A/B/C LT-388A/B/C	Containment Water Level
1008	N/A	A/TE-112C / 112H B/TE-112C / 112H A & B/TE-122C	Primary System Temperature RTD Assemblies
1009	N/A	HCV-239	Charging Loop 2A Isolation
1011	N/A	HCV-821B	H2 Analyzer Isolation
1013	N/A	A/B LT-901 A/B/C LT-904	S/G Level Indication
		A/B/C PT-902 B/ PT-905	S/G Pressure Indication
		HCV-2603B/2604B	N2 System Isolation

Table 8.2-1 – EEQ Components vs. Containment Elevation			
El. (Ft)	Ind. Level	Tag #	Description / Service
		HCV-883E/F/G/H HCV-820G	H2 Analyzer Sample Isolation
		HCV-820B	H2 Analyzer Isolation
		HCV-425A	SI Tank Leakage Cooler Isolation
		LT-101X/101Y	PZR Level
		A & D/PT–102	PZR Pressure
		PT-115	RC Pressure (WR) – Used for Sub Cooled Margin Monitor B
		HCV-881/882	H2 Purge Isolation
		PT-103X/103Y	PZR Pressure Heater Control

Table 8.2-2 below summarizes electrical penetrations below El. 1013 ft that will be affected by rising containment water level. Only the penetrations that affect EEQ components or EOP functions are summarized. [3.24, 3.25]

Table 8.2-2: Electrical Penetrations vs. Containment Elevation			
El. (Ft)	Ind. Level	Pen. #	Description/Service
1003.3	26.4	A-1	Pressurizer Heaters
		A-2	Pressurizer Heaters
		A-4	YM-102-2: Pressurizer PORV Flow Monitor YM-141: Pressurizer Relief Valve Flow Monitor B Channel RC Loop Hot Leg and Cold Leg RTD PT-120: Pressurizer Pressure B/LT-911/912: SG Level Transmitter for AFW B/PT-913/914: SG Pressure Transmitter for AFW PT-105: RC Pressure to Sub Cooled Margin Monitor A B/PT-102: Pressurizer Pressure FT-313: HPSI Flow FT-330: LPSI Flow B/LT-901/904: SG Level B/LT-902/905: SG Pressure PCV-2929: SI Leakage Cooler PCV Solenoid
		A-10	YE-116A: HJTC-MI Cable System for Transmission of RVLMS Signals Core Exit T/C Wiring

Table 8.2-2: Electrical Penetrations vs. Containment Elevation			
El. (Ft)	Ind. Level	Pen. #	Description/Service
		A-11	A Channel RC Loop Hot Leg and Cold Leg RTD's A/LT-911/912: SG Level Transmitter for AFW A/PT-913/914: SG Pressure Transmitter for AFW A/PT-102: Pressurizer Pressure A/PT-120: Pressurizer Pressure FT-316: HPSI Flow FT-328: LPSI Flow A/LT-901/904: SG Level A/LT-902/905: SG Pressure PCV-2909: SI Leakage Cooler PCV Solenoid
1007.9	N/A	B-1	HCV-151: Pressurizer Relief Isolation Power HCV-2934: SI-6B Outlet Power HCV-315: HPSI to RC Loop 1A Isolation Power HCV-318: HPSI to RC Loop 2A Isolation Power HCV-329: LPSI to RC Loop 1A Isolation Power
		B-2	HCV-151: Pressurizer Relief Isolation Control HCV-239: Loop 2A Charging Line Isolation Power HCV-315: HPSI to RC Loop 1A Isolation Control HCV-318: HPSI to RC Loop 2A Isolation Control HCV-329: LPSI to RC Loop 1A Isolation Control PCV-2929: SI Leakage Cooler Control Valve Control HCV-2934: SI-6B Outlet Control HCV-2936: SI-6B Fill/Drain Control HCV-725A: CFC VA-15A Inlet Damper Control HCV-725B: CFC VA-15B Inlet Damper Control HCV-2603B: SI Tank Supply Isolation Control HCV-2604B: RCDT/PQT Inboard Isolation Control HCV-2631: SI-6B Supply Stop Valve Control HCV-820B/821B: H2 Analyzer Isolation Control HCV-883C – 883H: H2 Analyzer Sample Valve Control
		B-4	JB-15C: NT-002 Channel B Excore Detector Pre-amp RE-091B: Containment High Range Radiation Monitor
		B-5	PT-103X: Pressurizer Pressure for Heater Control LT-101Y: Pressurizer Level TE-601: Containment Sump Temperature
		B-11	JB-17C: NT-001 Channel A Excore Detector Pre-amp

Table 8.2-3 below lists the cable tray sections affected by rising containment water level up to El. 1013 ft. Cables common to several elevations are only listed once, in the entry for the lowest elevation. [3.25, 3.26, 3.27]

Table 8.2-3: Cable Trays vs. Containment Level			
El. (ft.)	Ind. Lvl	Cable Section	Affected Equipment
1001	24.1	48C(I2)	A/PT-102: Pressurizer Pressure
			FT-316: HPSI Flow to Loop 1A
			FT-328: LPSI Flow to Loop 1B
			PCV-2909: Loop 1A Leakage Pressure Control
			A/LT-901/904: A SG Level
			A/PT-902/905: A SG Pressure
			A/PT-120: Pressurizer Pressure
			A/LT-911/912: A SG Level for AFW
			A/PT-913/914: A SG Pressure for AFW
1001.3	24.4	61C(I1A)	PT-105: Pressurizer Pressure for A Sub Cooled Margin Monitor
			B/PT-102: Pressurizer Pressure
			FT-313: HPSI Flow to Loop 1B
			FT-330: LPSI Flow to Loop 1A
			PCV-2929: Loop 1B Leakage Pressure Control
			B/LT-901/904: B SG Level
			B/PT-902/905: B SG Pressure
			YM-102-2: PCV-102-2 Flow Monitor
			YM-141: RC-141 Flow Monitor
			B/PT-120: Pressurizer Pressure
			B/LT-911/912: B SG Level for AFW
			B/PT-913/914: B SG Pressure for AFW
1005.9	N/A	6C(P3A) 4C(P3A)	HCV-2914: SI-6A Outlet Valve Motor
			HCV-311: HPSI to Loop 1B Valve Motor
			HCV-327: LPSI to Loop 1B Valve Motor
1005.9	N/A	5C(P3A)	HCV-320: HPSI to Loop 2B Valve Motor
1006	N/A	12C(C2)	HCV-239: Charging Isolation to Loop 2A Cont
1006	N/A	10C(C2)	HCV-151: Pressurizer Relief Valve Control

Table 8.2-3: Cable Trays vs. Containment Level			
El. (ft.)	Ind. Lvl	Cable Section	Affected Equipment
1006	N/A	67C(C2)	PCV-102-2: Pressurizer Relief Valve
			HCV-820B/821B: Hydrogen Analyzer Isolation Valve Control & Indication
			HCV-883C/883D/883E/883F/883G/883H: H2 Analyzer Sample Valve Control
1006	N/A	67C(P2)	HCV-151: Pressurizer Relief Motor
			HCV-318: HPSI to Loop 2A Motor
			HCV-315: HPSI to Loop 1A Motor
			HCV-329: LPSI to Loop 1A Motor
1006	N/A	9C(C2)	HCV-239: Charging to Loop 2A Control
1006.9	N/A	4C(C2)	TCV-202: Loop 2A Letdown TCV Control
			HCV-240: Pressurizer Aux Spray Inlet Control
			HCV-311: HPSI to Loop 1B Control
			HCV-327: LPSI to Loop 1B Control
			HCV-2914: SI-6A Outlet Valve Control
			HCV-2916: SI-6A Drain Control
			HCV-2504A: RC Sample Line Valve Control
			HCV-2629: SI-6A Supply Stop Valve Control
1006.9	N/A	3C(C2)	HCV-320: HPSI to Loop 2B Control
			HCV-425A/C: SI Leakage Cooler CCW Valves
			PCV-742A/C: Cont. Purge Isolations Control
			PCV-742E/G: RM Cabinet Isolations Control
			HCV-746A: Cont. Pressure Relief Isol. Control
			PCV-1849A: Cont. IA Supply Inbd. PCV Cont
			HCV-881/882: Cont. Purge Isolation Control
			HCV-883A/884A: H2 Analyzer Isolation Cont.
			HCV-820C/820D/820E/820F/820G/820H: H2 Analyzer Sample Valve Control
1007	N/A	15C(I1)	D/LT-911: SG A WR Level
			D/PT-913: SG A WR Pressure

Table 8.2-3: Cable Trays vs. Containment Level			
El. (ft.)	Ind. Lvl	Cable Section	Affected Equipment
1008.9	N/A	1C(C1)	HCV-238: Charging to Loop 1A
			HCV-241: RCP Cont Bleed to VC Control
			HCV-438A/C: CCW to RCP Isolation Control
			HCV-467A/C: CCW to VA-13A Isolation Cont.
			HCV-1108A: AFW Inlet Valve Control
			HCV-1387A/1388A: SG B/D Isolation Control
			HCV-2506A/2507A: SG Sample Valve Control
1013	N/A	54C(C2)	HCV-724A/B: CFC Inlet Damper Control
			HCV-864: Spray Water to CFC Filter Control
			HCV-1107A: AFW Inlet Valve Control

Table 8.2-4 below summarizes mission critical components below El. 1013 ft that may be affected by rising containment water level, their purpose and alternate methods of performing that component's function.

Table 8.2-4: Mission Critical Components and Coping Strategy for Submergence		
Tag #	Description/Purpose	Coping Strategy
FT-313 FT-316 FT-319 FT-322	HPSI Flow Transmitters. Used for determination of effect of throttling HPSI.	Estimate flow rate based on the following: 1. HPSI pump discharge pressure. 2. HPSI pump amps. 3. Rate of change of SIRWT level.
HCV-348	SDC Suction Valve. Used to establish SDC.	Open valve and de-energize before submergence.
B/TE-112C B/TE-112H B/TE-122C B/TE-122H A/TE-112C A/TE-112H A/TE-122C A/TE-122H	RCS Loop Temperatures. Used to verify effectiveness of recirculation/once-through cooling/SDC.	1. Use C or D channel temperature indications. 2. Sample RCS hot legs via HCV-2500/2501 through HCV-2504A/B (TE-2513, outlet of sample cooler)

Table 8.2-4: Mission Critical Components and Coping Strategy for Submergence		
Tag #	Description/Purpose	Coping Strategy
CET	Core Exit Thermocouples. Used to verify effectiveness of recirculation/once-through cooling/SDC.	Sample RCS hot legs via HCV-2500/2501 through HCV-2504A/B (TE-2513, outlet of sample cooler)
YE-116A	HJTC-MI Cable System for RVLMS. Used to determine when water level is above hot leg.	1. Estimate water level based on total volume added to containment. 2. Use PI-303A/B/C on the idle CS pump(s) to estimate level based on elevation head.
LT-387A/B/C LT-388A/B/C	Containment Water Level. Used to monitor approach to covering hot leg. This instrument is out of range high at El. 1004.5 ft.	1. Estimate water level based on total volume added to containment. 2. Use PI-303A/B/C on the idle CS pump(s) to estimate level based on elevation head.
HCV-311 HCV-315 HCV-318 HCV-320	HPSI Loop Injection Valves. Throttled to minimize injection rate.	1. Utilize HCV-312/314/317/321 for throttling HPSI flow. 2. De-energize valves in desired position prior to submergence. 3. If necessary, hand jack HCV-308 & HCV-307 to further throttle flow. This would only be necessary if makeup flow to the RCS was exceeding makeup capabilities to the SIRWT.
HCV-327 HCV-329	LPSI Loop Injection Valves. Needed to align SDC.	Open valves and de-energize before submergence.
HCV-725A HCV-725B	CFC Inlet Dampers. CFCs are primary means of removing decay heat from containment.	De-energize dampers in open position before submergence.

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A1a-CE	Operator Action to Secure One Spray Pump. Evaluated in section 5.3 of this EA.	Y	**EOP-03, Step 17; EOP-20 IC-2, Step 5.** Steps are located prior to initiation of RAS. Procedure instruction directs securing of 2 CS pumps if: 1. Containment pressure < 60 psig, and 2. All containment fan coolers (CFCs) (VA-3A/B, VA-7A/B) are operating. Procedure contingency action directs securing of 1 CS pump if: 1. Containment pressure < 60 psig, and 2. All containment CFCs (VA-3A/B, VA-7A/B) are operating. The objective of this COA is to delay the time to RAS, thereby reducing the decay heat removal requirements of ECCS in recirculation. This action will delay RAS by 2 to 4 minutes or more, depending on containment pressure. This also sets up the system for lower recirculation flow rate through one of the sump strainers (COA A10 accomplishes the same goal for the opposite strainer by securing a HPSI pump). The autostart feature of SI-3C will be removed during the 2006 refueling outage [3.51]

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A2	Manually Establish one Train of Containment Sump Recirculation Prior to Automatic Actuation Evaluated in section 5.2 of this EA.	N	This COA has not been implemented by FCS and it is not recommended that this COA be adopted. The intent of this COA is to establish recirculation conditions early to allow assessment of the potential for strainer blockage while the train of ECCS remaining on the SIRWT continues to guarantee a source of heat removal. This would also prolong the time that water for cooling is available from the SIRWT. This COA is not desirable at FCS for several reasons. Three of the most significant are: 1. Due to the relatively small HPSI pump NPSH margin (which is dependent on recirculation pool water level) at initiation of RAS, the window in which this early actuation could occur is very small. Therefore the action is not likely to produce a significant delay in the time to full recirculation. 2. RAS actuation is normally an automatic function. The time required to verify initiating conditions and to perform the necessary manual actions would likely result in too short a time in the "early recirculation" mode to be effective. 3. By directing manual operator action for a function that normally occurs automatically, the risk of operator error resulting in the disabling of that train of ECCS is increased.

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A3-CE	Terminate One Train of HPSI/High – Head Injection After Recirculation Alignment. Evaluated in section 5.2 of this EA.	N	The intent of this COA is twofold: 1. Preserve one train of HPSI for recirculation in the event that the strainer for the operating train becomes degraded or clogged. Additionally, this configuration would ostensibly allow the first strainer to become preferentially loaded (i.e., act as a "sacrificial anode"), thus reducing the debris available for loading on the other strainer. 2. Reduce overall recirculation pool flow rate by ½, thereby reducing the debris transport potential. While the termination of one train of SI, either before or after RAS, would not result in flow rates that are below analyzed values (single train is assumed for analysis), securing one train after RAS would place the plant outside of its safety analysis, because a subsequent single failure would result in a loss of core cooling flow until the operators restarted one of the secured HPSI pumps. Further, the configuration of the FCS recirculation system, with the two strainers located adjacent to each other in close proximity make it likely that most debris transported to the vicinity of the "sacrificial" strainer would also be available to clog the "preserved" strainer. (continued on next page)

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A3-CE (continued)	Terminate One Train of HPSI/High – Head Injection After Recirculation Alignment	N	(continued) The potential reduction in flow from securing a train of HPSI is relatively small. And because FCS has a strategy that will compensate for the complete blockage of the strainers, the potential for a loss of core cooling due to component failure does not justify operation of the system outside its design basis. As a result, this COA is not recommended for implementation at FCS. An alternative approach was also considered. Rather than secure one train of HPSI following RAS, throttling HPSI flow post-RAS to a value that is acceptable to the safety analysis, but less than full flow was considered. This action would have accomplished the same intent as COA A3-CE. However, it was determined that the flow reduction that could be accomplished within the design basis was not significant enough to warrant the additional operator action. Therefore, throttling of HPSI post-RAS is also not recommended.

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A4	Early Termination of One LPSI/RHR pump Prior to Recirculation Alignment. Evaluated in section 5.2 of this EA.	Alt.	**EOP-03, Floating Step B; EOP-20, Floating Step B.** Steps are performed any time initial conditions are met. Instruction directs securing of LPSI pump if RCS pressure is > 200 psia. The intent of this COA is to reduce the draw-down rate of the SIRWT to prolong the time to RAS. Floating step B will secure LPSI, but only if RCS pressure is above the point where LPSI is needed. This will help ensure that LPSI does not contribute to SIRWT draw-down as the plant is cooled down and depressurized during a SBLOCA. However, it will not reduce drawdown under LBLOCA conditions, which is ostensibly where this action would be of greatest benefit. As with termination of a HPSI train, any additional action would place the plant outside its design basis. Further, given the length of time it would take to accomplish this action (it would have to be directed following completion of EOP-00, entry into EOP-03 and verification of adequate safeguards response) and the relatively short timeframe available for operator action before RAS on a LBLOCA, it is doubtful that a significant benefit could be obtained. Therefore adoption of this COA is not recommended.

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A5	Refill of Refueling Water Storage Tank (SIRWT). Evaluated in section 5.4 of this EA.	Y	**EOP-03, Step 38; EOP-20 IC-2, Step 8; EOP Attachment 25; SAMG Phase 3 BD/CC, Step 4.1.4 E.** Steps are performed immediately following RAS. Instruction directs operators to Attachment 25, which provides a comprehensive list of options for refilling the SIRWT. The list includes: 1. Fuel transfer canal via • Gravity Drain • Canal Drain Pumps • Waste Disposal 2. Spent Fuel Pool via • Spent Fuel Pool Cooling • Fuel transfer canal 3. Normal makeup via • BASTs • Demineralized Water 4. Addition of fire water directly to SIRWT Attachment 25 also provides guidance for long term makeup by: 1. Refilling the BASTs (to provide additional boration capabilities) 2. Refilling the fuel transfer canal 3. Refilling the Spent Fuel Pool (continued on next page)

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A5 (continued)	Refill of Refueling Water Storage Tank (SIRWT)	Y	(continued) Attachment 25 also provides notes to inform the operators of key considerations for refilling the SIRWT, including: 1. Reactivity Management 2. Spent Fuel Pool level management 3. Key level indications The use of fire water ensures that an essentially unlimited source of water is available. However, it would be beneficial from several aspects to avoid the use of river water if at all possible. The availability of the water from the fuel transfer canal affords FCS staff the time for logistical activities to ensure the continued supply of water to the demineralized water system. Therefore, it is recommended that additional guidance should be provided in TSC/SAMG procedures to assist in establishing a long term source of clean water, probably via the demineralized water system. Although sufficient clean water should be available on site, if additional water is needed, ample time would be available to truck additional water in from other locations.

ATTACHMENT 8.3 SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38] (NOTE: Only COAs applicable to C-E plants are listed in this table)			
COA	**Description**	**Implemented? Y/N/Alt.**	**Comments**
A6	Inject More than One RWST (SIRWT) Volume from a Refilled RWST or Bypassing the RWST. Evaluated in section 5.1 of this EA.	Y	**EOP-20 IC-2, Step 19; SAMG Phase 3 BD/CC, Step 4.1.4 E.** Operations Instruction is only located in EOP-20 because the functional recovery procedure is the normal procedure to be used when safety functions cannot be recovered by normal "design" methods. Guidance in SAMGs supports operator actions. This is consistent with standard operating philosophy at FCS.
A7	Provide More Aggressive Cooldown and Depressurization Following a Small LOCA. Evaluated in section 5.1 of this EA.	Y	**EOP-20 IC-2, Step 13; SAMG Phase 3 BD/CC, Steps 4.3 & 4.4.** Step is located after determination that sump strainer is clogged. Instruction directs operators to maximize steam generator cooldown. The action is not directed unless the recirculation function is threatened to avoid the possibility of overcooling induced thermal stresses under other circumstances. SAMG steps provide additional means of ensuring that S/Gs are available for RCS cooling following SBLOCAs.

ATTACHMENT 8.3
SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38]
(NOTE: Only COAs applicable to C-E plants are listed in this table)

COA	Description	Implemented? Y/N/Alt.	Comments
A8-CE	Provide Guidance on Symptoms and Identification of Containment Sump Blockage. Evaluated in section 5.1 of this EA.	Y	**EOP-03, Step 38; EOP-20 IC-2, Step 9.** Steps are located immediately after verification of RAS actuation. Symptoms include: 1. Erratic indication of HPSI or CS flow, discharge pressure or motor current. 2. HPSI or CS pump trip alarms 3. Audible cavitation noise Symptoms must be present on more than one pump.

ATTACHMENT 8.3
SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38]
(NOTE: Only COAs applicable to C-E plants are listed in this table)

COA	Description	Implemented? Y/N/Alt.	Comments
A9-CE	Develop Contingency Actions in Response to: Containment Sump Blockage, Loss of Suction, and Cavitation. Evaluated in section 5.1 of this EA.	Y	**EOP-03, Step 39; EOP-20 IC-2, Step 9. Attachment 26 provides minimum decay heat removal flow rates.** Steps are located subsequent to initiation of RAS. Procedure instruction directs: 1. Securing of 2 CS pumps, and 2. Throttling of SI flow to minimum necessary for decay heat removal. Procedure contingency action, if strainer performance still degraded, directs: 1. Throttle SI flow to as low as 50 gpm, and 2. If strainer performance still degraded, stop affected HPSI pump(s). **EOP-20 IC-2 continuing actions, Steps 13 thru 21; SAMG Phase 3 BD/CC, Step 4.1.4 E.** Steps provide long term recovery actions to address persistent strainer blockage: 1. Utilize S/Gs to assist in cooldown/heat removal (see COA A7). 2. Depressurize RCS to enhance SI flow. 3. Maximize containment cooling (using CFCs, not CS) 4. Use charging supplied from BASTs 5. Open HCV-348 to allow for subsequent initiation of SDC if valve becomes flooded. 6. Dump SITs. (continued on next page)

ATTACHMENT 8.3
SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38]
(NOTE: Only COAs applicable to C-E plants are listed in this table)

COA	Description	Implemented? Y/N/Alt.	Comments
A9-CE (continued)	Develop Contingency Actions in Response to: Containment Sump Blockage, Loss of Suction, and Cavitation.	Y	**EOP-20 IC-2 continuing actions, Steps 13 thru 21.** (continued) 7. Re-align to SIRWT (see COA A6) 8. Fill containment to cover hot legs and establish SDC. 9. While using alternate cooling from sources described above, attempt to re-establish recirculation to account for improved $NPSH_A$ and possible settling. One improvement is recommended for EOP-20 IC-2, Step 17: After HCV-348 is opened, it should be de-energized to ensure that flooding of the motor operator does not result in spurious closure of the valve, and HCV-327 and 329 should be opened and de-energized to ensure SDC is available to all four cold legs. It is also recommended that further guidance be provided to the TSC staff in the TSC/SAMG procedures on the effects of submergence of critical components.

ATTACHMENT 8.3
SUMMARY OF RELEVANT CANDIDATE OPERATOR ACTIONS IDENTIFIED IN WCAP-16204 [3.38]
(NOTE: Only COAs applicable to C-E plants are listed in this table)

COA	Description	Implemented? Y/N/Alt.	Comments
A10	Early Termination of One Train of HPSI/High – Head Injection Prior to Recirculation Alignment (RAS). Evaluated in section 5.2 of this EA.	Alt.	**EOP-03, Step 15.** Step is located following verification of proper ECCS initiation. Instruction directs operator to secure SI-2C if: 1. All HPSI pumps are operating 2. SI flow rate is adequate for given RCS pressure 3. Representative CET temperature < superheat 4. RVLMS shows core covered The intent of this COA is to delay the onset of RAS by lowering the SIRWT draw-down rate. It also preserves a HPSI pump for later use. However, as discussed in COAs A3-CE and A4, securing a train of HPSI would place the plant outside its design basis. SI-2C is a redundant “spare” HPSI pump, and securing that pump is within the plant’s design basis. Therefore, this action partially addresses the intent of the COA without affecting the SI system design basis. The autostart feature for SI-2C will be removed during the 2006 refueling outage [3.50]. This step is not provided in EOP-20 IC-2. It is recommended that a step similar to EOP-03 Step 15 is placed in EOP-20 IC-2, preceding step 5.

ATTACHMENT 8.4
DETERMINATION OF CONTAINMENT SUMP CONTRIBUTION FROM DESIGN WATER SOURCES

NOTE: This is a non-CQE estimate of water contributions. It is based on design inputs and conservatisms are included, but is intended only to provide input for compensatory measures for a beyond design basis event.

Problem: Determine the volume of water contributed by design water sources that can be credited for containment fill during events that could require injection from a refilled SIRWT.

Inputs: Volume contributions from design sources are taken from Ref. 3.41, Case 6.

Assumptions: The following assumptions are used when calculating sump volume contributions.

1. 1 ft^3 = 7.48 gallons.
2. RCS sump contribution is conservatively corrected for temperature to account for volume reduction.
3. Case 6 of Reference 3.41 may be used as baseline. It is acceptable to credit RCS volume to containment floor because if the break was high in RCS, hot legs would be full and SDC could be established without filling containment above the hot legs.
4. In response to the strainer clogging, the operators would secure the remaining CS pump(s) prior to returning to the RCS injection mode of core cooling. This would allow the drainage of some of the holdup water back to the sump. Also, when using direct injection of SIRWT water for decay heat removal, more than 24 hours will elapse before containment fill would culminate in establishing SDC. During this time, the amount of water retained in holdup volumes will decrease due to a decrease in the mass and energy released from the RCS as decay heat diminishes.
5. Despite the reduction in Mass & Energy that would be released to containment over the 24 hours following a RAS, it will conservatively be assumed that the following holdup volumes remain at their RAS initiation values:
   - Atmospheric steam vapor.
   - Holdup on higher elevations.
   - Condensation on heat sinks.
   - Filling risers to establish CS flow.
   - SI and CS system leakage.

6. Holdup volumes identified in Reference 3.41 that will be returned to sump in containment fill scenario:
   - CS pumps are off. Therefore, no spray mist.
   - With no CS flow, the source of water flow to refueling cavity is removed. Elevation head will not be required to drive water from the refueling cavity to the sump. Therefore, refueling cavity level will equalize with the sump.
   - With no CS flow, the source of water flow to the reactor cavity is removed. Therefore water level in the reactor cavity will equalize with the rest of the containment pool.
7. Volume expansion from heatup of injected SIRWT and SIT water is conservatively ignored.

Solution: **Determine the volume of water provided by design water sources that contributes to containment water level during the process of injecting more than one SIRWT volume into containment.**

From Reference 3.41, Case 6: LBLOCA – Worst Case Hot Leg Break; Minimum Safeguards; Future Gap

The design basis LOCA assumes a 32-inch double-ended break of RCS piping [USAR; Section 14.15].

For this case, the inventory in the hot and cold legs above the bottom of the hot leg nozzle is assumed to be released. The inventory remaining in the reactor vessel below the bottom of the hot leg nozzle, and a portion of the cold legs below the hot leg bottom elevation is assumed to remain in the RCS. The portion of reactor coolant that does not flash to steam spills to the floor as a saturated liquid.

Table 8.4-1: Containment Basement Volume Contributions and Water Holdup or Loss Values from Case 6 of Reference 3.41	
Water Source	Volume
RCS Volume	2,932 ft^3
SIRWT Volume	37,127 ft^3
SIT Volume (4 SIT's)	3,256 ft^3
Total Water Sources:	43,315 ft^3
Water Holdup or Loss:	
Vapor	500 ft^3
Holdup on Higher Elevations	462 ft^3
Condensation on Heat Sinks	750 ft^3
Mist (Droplets) in Atmosphere: Minimum Safeguards:	Returned to sump. See Ref. 3.41, assumption #6.
Filling Risers to Establish CS Flow	351 ft^3
SI and CS System Leakage	10 ft^3
Refueling Cavity	Returned to sump. See assumption #6.
Reactor Cavity	Returned to sump. See assumption #6.
Total Water Holdup or Loss	2,073 ft^3 (15,506 gallons)

Sump Volume = Water Sources – Water Holdup or Loss
= 43,315 ft^3 – 2,073 ft^3
= 41,242 ft^3

Convert Sump Volume to gallons:

41,242 ft^3 X 7.48 gal./ ft^3 = 308,490 gallons

ATTACHMENT 8.5
VOLUME AND TIME REQUIREMENTS FOR SIRWT INJECTION TO RCS

NOTE: This is a non-CQE estimate of volume and time requirements. It is based on design inputs, and conservatisms are included, but is intended only to provide input for compensatory measures for a beyond design basis event.

Problem:

To support the strategy of utilizing a refilled SIRWT in a beyond-design-basis event to raise containment water level until long term cooling can be accomplished by either SDC initiation or counter current pool circulation, several factors must be determined. Overall, it is desirable to maximize refill time, as this provides for lower decay heat load at the time of entry onto shutdown cooling, and allows technical staff a longer time to respond to potential problems. The following factors must be determined:

1. The minimum Containment Flooding Elevation at RAS, adjusted to account for securing of containment spray.
2. The time post RAS at which the inventory of the fuel transfer canal (FTC) and the available spent fuel pool (SFP) inventory are depleted.
3. The containment flooding elevation at the time the FTC and SFP are depleted.
4. The total amount of borated water that must be added to the SIRWT to raise containment water level to El. 1,008 ft. and 1,013 ft.
5. The time post RAS at which the containment flooding elevation reaches El. 1,008 and 1,013 ft.
6. The required average makeup flow to SIRWT following the depletion of the FTC and SFP available water inventories to continue containment fill to El. 1,008 ft and 1,013 ft.
7. The volume of borated water injected as a function of time post RAS.
8. The rate of change of the SIRWT level as a function of safety injection flow rate.
9. The relationship between the injection flow rate and change in containment water level.
10. The decay heat in BTUs/hr as a function of time following the initiation of the event

Inputs:

1. Figures 5.1-1, 5.1-2, 5.1-3 of this EA (same as Figures 2, 3, 4 of calculation FC06965 [3.16])
2. FTC and SFP water inventories from Section 5.4 of this EA
3. Figure 5.1-5 (derived from the figure on page 6 of calculation FC06728 Rev. 1 [3.19])
4. TDB VII Tank Curves [3.42].

Assumptions:

1. The inputs from EA-FC-04-010 Rev. 0 and calculation FC06728 Rev. 1 [3.19] remain valid and are acceptable for use in this calculation.
2. A LBLOCA event has occurred and RAS is reached approximately 20 minutes after the initiation of the event. This is conservative because it results in the highest heat load and largest required volume flow rate, which minimizes the heat removal capability of a given volume of water.
3. Because this event is beyond design basis, SI flow is throttled as shown in Figures 5.1-1, 5.1-2 and 5.1-3 of this EA.
4. Containment free volumes above El. 1,006 ft. are approximately the same as the region from El. 999.4 to El. 1,006 ft. It is conservatively assumed that RCS loop piping and S/G lower channel heads do not reduce containment free volume, since more water will then be required to fill containment.

Solution:

1. Determine the Containment Flooding Elevation at RAS.

   The containment water volume at RAS was determined in Attachment 8.4 of this EA to be 308,490 gallons. Based on this water volume, the containment flooding elevation at RAS is determined from Figure 5.1-5. The containment elevation post RAS, adjusted to account for securing CS in response to sumps strainer clogging is 999.4 ft.

2. Determine the time post-RAS at which the Available FTC and SFP Water Inventories are depleted. Volume increases due to adding dilution water after transfer will be conservatively ignored.

   Section 5.4 of this EA states that the FTC available water volume is 45,669 gallons. The SFP available water volume to the lower suction is 129,403 gallons and to the bottom of the stop gate is 139,429 gallons. This calculation will determine the time post RAS that:

   i. The available FTC water volume of 45,669 gallons will be depleted.
   ii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the lower suction of 129,403 gallons for a total of 175,072 gallons will be depleted.
   iii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the bottom of the stop gate of 139,429 gallons for a total of 185,098 gallons will be depleted.

Figures 5.1-1 and 5.1-2 of this EA show the safety injection flow (including a 25 % loss through the break) that matches the decay heat as a function of time. Figure 5.1-3 shows the hot side/cold side safety injection flow as a function of time (includes the additional flow to flush highly concentrated boric acid based on a refilled SIRWT boron concentration of 965 ppm and a maximum core boron concentration of 35,000 ppm). It should be noted that per TDB-EOP/AOP Attachments, simultaneous hot side/cold side injection is required to be initiated 8.5 -11 hours after the event, if shutdown cooling conditions can not be achieved. It is conservative to use the shorter time, as this increases the required flow rate.

Based on the above, the water volume injected to remove decay heat post RAS was determined based on Figures 5.1-1, 5.1-2 and 5.1-3 of this EA as follows:

Using an Excel Spreadsheet, each of the Figures was fitted with an equation of flow rate as a function of time:

Equation 1:

Figure 5.1-1 $f = 634.95\ t^{-0.3202}$
(f - flow rate in gpm, t - time in minutes)

Equation 2:

Figure 5.1-2 $f = 162.86\ t^{-0.2327}$
(f - flow rate in gpm, t - time in hours)

Equation 3:

Figure 5.1-3 $f = 266.61\ t^{-0.2642}$
(f - flow rate in gpm, t - time in hours)

Equations 1, 2 and 3 were integrated to determine the total volume of water injected in the respective post RAS time interval.

Equation 4:

Figure 5.1-1 $V = 934.024713\ (t^{0.6798} – 7.6637299)$
(V – volume in gallons, t – time in the range of 20 to 90 minutes)

Equation 5:

Figure 5.1-2 $V = 12735.04496 (t^{0.7673} – 1.36494379)$
(V – volume in gallons, t – time in the range of 1.5 to 8.5 hours)

Equation 6:

Figure 5.1-3 $V = 21740.41859 (t^{0.7358} – 4.8291074)$
(V – volume in gallons, t – time in the range of 8.5 to 135 hours. This equation was extrapolated beyond the 25 hours of injection time shown in Figure 5.1-3 with acceptable results)

Equations 4 and 5 will be used to determine the water volume injected in the respective time intervals up to the time at which the FTC is depleted (the FTC is depleted at the post RAS time when the sum of the water volume injected from Equations 4 and 5 is equal to 45,669 gallons). In addition, Equations 4, 5 and 6 will be used to determine the time at which the additional available water volume of the SFP is depleted (the SFP is depleted, following the FTC depletion, at the post RAS time when the sum of the water volume injected from Equations 4, 5 and 6 is equal to 175,072 gallons (lower suction) and 185,098 gallons (stop gate)).

It is determined that the following water volumes are injected:

<u>FTC</u>

- From 20 minutes to 90 minutes, Equation 4 determines
  $V = 934.024713 (90^{0.6798} – 7.6637299)$ 12,742 gallons
- From 1.5 hours to 5.99 hours, Equation 5 determines
  $V = 12735.04496 (5.992^{0.7673} – 1.36494379)$ 32,927 gallons
- Total water volume from 20 min to 5.99 hrs 45,669 gallons

<u>FTC + SFP to Lower Suction</u>

- From 20 minutes to 90 minutes, Equation 4 determines
  $V = 934.024713 (90^{0.6798} – 7.6637299)$ 12,742 gallons
- From 1.5 hours to 8.5 hours, Equation 5 determines
  $V = 12735.04496 (8.5^{0.7673} – 1.36494379)$ 48,405 gallons
- From 8.5 hours to 23.075 hours, Equation 6 determines
  $V = 21740.41859 (23.075^{0.7358} – 4.8291074)$ 113,925 gallons
- Total water volume from 20 min to 23.075 hrs 175,072 gallons

FTC + SFP to Bottom of Stop Gate

- From 20 minutes to 90 minutes, Equation 4 determines
  $V = 934.024713\ (90^{0.6798} - 7.6637299)$ 12,742 gallons
- From 1.5 hours to 8.5 hours, Equation 5 determines
  $V = 12735.04496\ (8.5^{0.7673} - 1.36494379)$ 48,405 gallons
- From 8.5 hours to 24.523 hours, Equation 6 determines
  $V = 21740.41859\ (24.523^{0.7358} - 4.8291074)$ 123,951 gallons
- Total water volume from 20 min to 24.523 hrs 185,098 gallons

Summary:

i. The available FTC water volume of 45,669 gallons will be depleted approximately 6 hours after RAS.
ii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the lower suction of 129,403 gallons for the total of 175,072 gallons will be depleted in approximately 23 hours.
iii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the stop gate of 139,429 gallons for the total of 185,098 gallons will be depleted in approximately 24.5 hours.

3. Determine the Containment Flooding Elevation at the time the available water inventories of the FTC and SFP are depleted.

   Figure 5.1-5 of this EA shows the containment volume as a function of containment elevation. This figure was derived from the figure on page 6 of calculation FC06728 Rev. 1 [3.19], which equates containment level to containment free volume. The line of this Figure was fitted with a linear equation that correlates containment volume as a function of containment elevation for elevations greater than 999.4 ft (post-RAS water level) as follows:

   Equation 7:

   $$V_c = 55572\ (L - 999.4) + 309225$$

   Where V_c is the containment volume in gallons and L is the containment elevation in feet

   From section 2 above, the water volumes injected post - RAS are 45,669 gallons (FTC), 175,072 gallons (FTC + SFP to lower suction) and 185,098 gallons (FTC + SFP to bottom of gate stop) respectively. Adding the containment water volume at RAS of 308,490 gallons results in containment water volume of 354,159 gallons 483,562 and 493,588 gallons respectively.

Therefore, from Equation 7 it is determined that the minimum containment water elevation at the time the FTC and the SFP available water inventories deplete are as follows (values rounded to nearest .1 ft.):

i. The FTC water volume of 45,669 gallons will raise containment water level to a minimum elevation of
$L = (V_c – 309225)/55572 + 999.4 = (354159-309225)/55572 + 999.4 =$ 1,000.2 ft.

ii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the lower suction of 129,403 gallons for the total of 175,072 gallons will raise containment water level to a minimum elevation of
$L = (V_c – 309225)/55572 + 999.4 = (483562-309225)/55572 + 999.4 =$ 1,002.5 ft.

iii. The available FTC water volume of 45,669 gallons plus the available SFP water volume to the stop gate of 139,429 gallons for the total of 185,098 gallons will raise containment water level to a minimum elevation of
$L = (V_c – 309225)/55572 + 999.4 = (493588-309225)/55572 + 999.4 =$ 1,002.7 ft.

4. Determine the total amount of borated water that must be added to the SIRWT to raise containment water level to El. 1,008 ft. and 1,013 ft.

   As discussed in section 5.1 of this EA, the containment free volume is only calculated in FC06728 Rev. 1 [3.19] to El. 1,006 ft. Equation 7 allows for extrapolation of the containment free volume curve above El. 1,006 ft. From equation 7, the containment water volume for elevations 1008 and 1013 are
   $V_{1008} = 55572\ (1008 – 999.4) + 309225 = 787{,}144$ gallons and
   $V_{1013} = 55572\ (1013 – 999.4) + 309225 = 1{,}065{,}004$ gallons respectively.

5. Determine the time at which the containment flooding level reaches 1008 ft and 1013 ft.

   Based on the containment water volumes shown above, the times at which the flooding will reach elevations 1008 ft and 1013 ft are determined from equations 4, 5 and 6 as follows:

   <u>Elevation 1008 ft.</u>

   - Pre RAS water volume injected 308,490 gallons

Volumes injected post RAS

- From 20 minutes to 90 minutes, Equation 4 determines
  $V = 934.024713 (90^{0.6798} – 7.6637299)$ 12,742 gallons
- From 1.5 hours to 8.5 hours, Equation 5 determines
  $V = 12735.04496 (8.5^{0.7673} – 1.36494379)$ 48,405 gallons
- From 8.5 hours to 75.269 hours, Equation 6 determines
  $V = 21740.41859 (75.269^{0.7358} – 4.8291074)$ 417,507 gallons
- Total water volume up to 1008' elevation 787,144 gallons

<u>Elevation 1013 ft.</u>

- Pre RAS water volume injected 308,490 gallons

Volumes injected post RAS

- From 20 minutes to 90 minutes, Equation 4 determines
  $V = 934.024713 (90^{0.6798} – 7.6637299)$ 12,742 gallons
- From 1.5 hours to 8.5 hours, Equation 5 determines
  $V = 12735.04496 (8.5^{0.7673} – 1.36494379)$ 48,405 gallons
- From 8.5 hours to 134.375 hours, Equation 6 determines
  $V = 21740.41859 (134.375^{0.7358} – 4.8291074)$ 695,367 gallons
- Total water volume up to 1013' elevation 1,065,004 gallons

Summary:

i. The time to reach 1008 ft elevation is approximately 75 hours.
ii. The time to reach 1013 ft elevation is approximately 134 hours.

6. Determine the average makeup flow rate to the SIRWT following the depletion of both the FTC and the SFP up to the time the containment flooding elevation reaches 1008 ft and the average makeup flow rate up to the time the containment flooding elevation reaches 1013 ft from 1008 ft.

   The time interval for the water level in containment to reach 1008 ft following the depletion of the FTC and SFP is 75.269 hrs – 24.523 hrs = 50.8 hrs.

Using equation 6, the average injection flow rate in gpm is calculated as follows:

Average flow rate = (volume injected from 8.5 hrs to 75.269 hrs - volume injected from 8.5 hrs to 24.523 hrs) / (50.746 hrs * 60 min/hr)

Average flow rate = (21740.41859 ($75.269^{0.7358}$ – 4.8291074) - 21740.41859 ($24.523^{0.7358}$ – 4.8291074)) gallons/3,044.76 min = (417,508–123,950) gallons/3,044.76 min = 96.4 gpm

The time interval for the water level in containment to rise from 1008 ft to 1013 ft (rounded to nearest hour) is 134.375 hrs – 75.269 hrs = 59 hrs.

Using equation 6, the average injection flow rate in gpm (rounded to nearest gpm) is calculated as follows:

Average flow rate = (volume injected from 8.5 hrs to 134.375 hrs - volume injected from 8.5 hrs to 75.269 hrs) / (59.106 hrs * 60 min/hr)

Average flow rate = (21740.41859 ($134.375^{0.7358}$ – 4.8291074) - 21740.41859 ($75.269^{0.7358}$ – 4.8291074)) gallons/3,546.36 min = (695,372–417,508) gallons/3,546.4 min = 78 gpm

7. Determine the volume of borated water injected over time from a refilled SIRWT.

The purpose of this section is to establish a curve that shows the volume of water injected into containment as a function of time post RAS. This will allow for estimating the time that a given volume of makeup water would provide for once-through core cooling from a re-filled SIRWT, assuming that flow rates are consistent with figures 5.1-1 through 5.1-3 of this EA. It would also provide a method for estimating containment water level, based on the length of time SIRWT re-injection has been occurring.

The volume of borated water injected as a function of time post RAS has been determined from Equations 4, 5 and 6 and is shown in Figure 8.5-1.

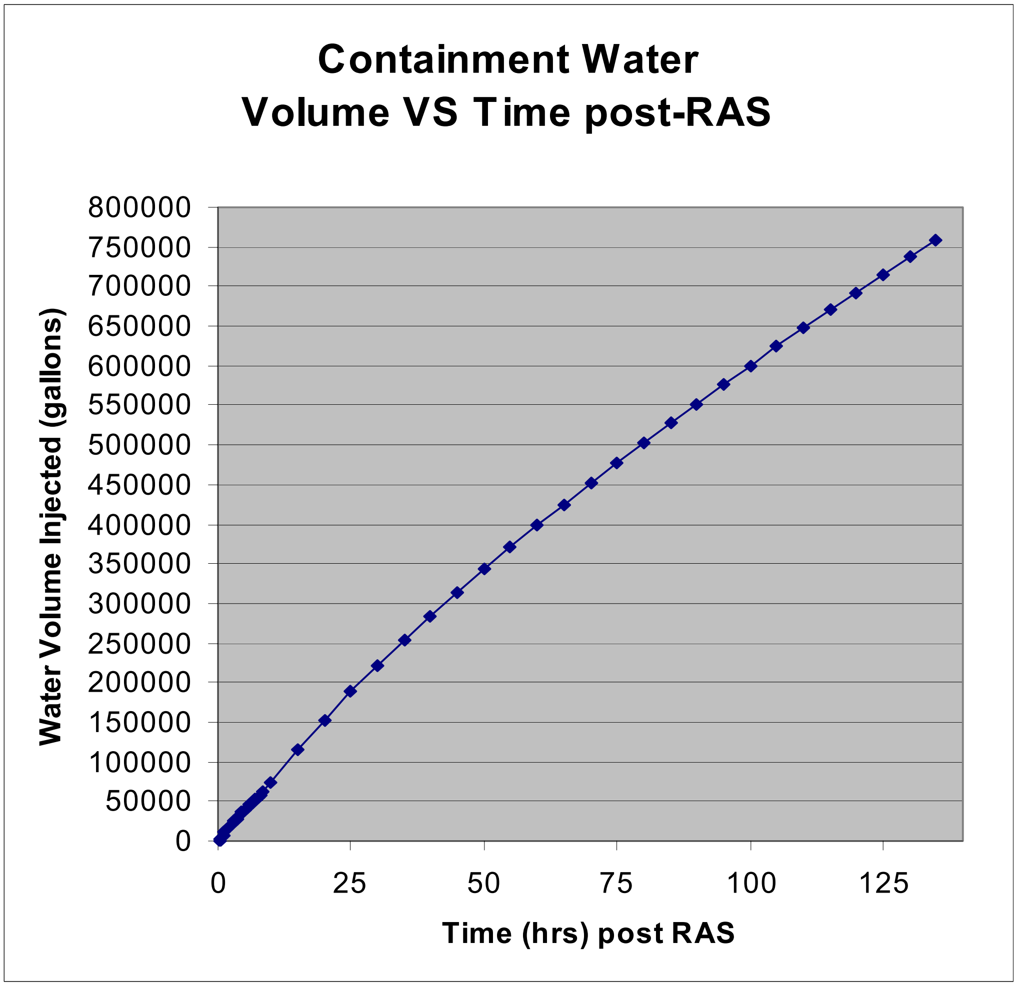


Figure 8.5-1: Containment Water Volume vs. Time, post-RAS

8. Determine the rate of change of the SIRWT level as a function of safety injection flow rate.

   The purpose of this section is to establish a curve that can be used to estimate flow rate as a function of the rate of change of SIRWT level.

The rate of change in SIRWT level as a function of safety injection flow rate was determined as follows:

- The SIRWT curve of TDB-VII shows the SIRWT water volume in gallons as a function of SIRWT level in inches. Using an excel spreadsheet, this curve was fitted with the following linear equation:

  Equation 8:

  $V_{SIRWT} = 1781.7L - 328.84$

  where: V_{SIRWT} is the SIRWT water volume in gallons and
  L is the SIRWT level in inches.

- Equation 8 was differentiated yielding:

  Equation 9:
  $dV_{SIRWT}/dt = 29.695\ dL/dt$
  where: dV_{SIRWT}/dt is the safety injection flow rate in gpm and
  dL/dt is the rate of change of SIRWT level in in/hr.

Equation 9 was solved for several injection flow rates using an excel spreadsheet and plotted on a curve. Figure 8.5-2 shows the rate of change of the SIRWT level as a function of safety injection flow rate.

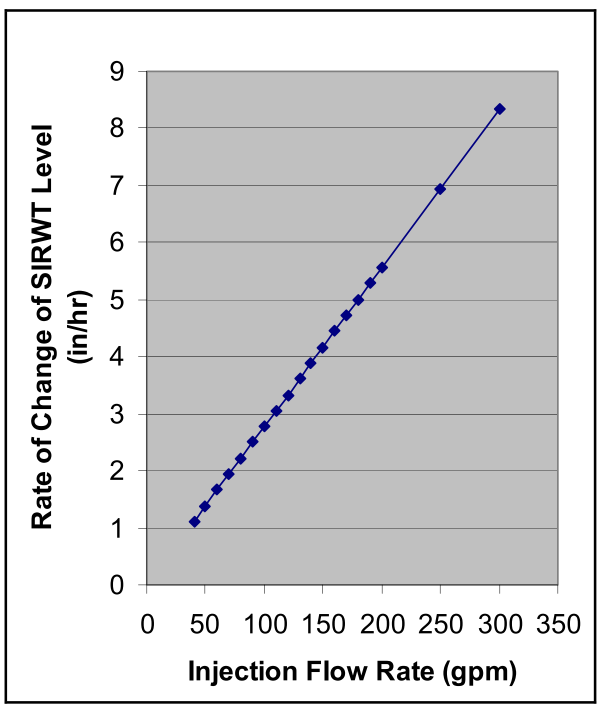


Figure 8.5-2: Rate of Change of SIRWT Level vs. Injection Flow Rate

9. Determine the relationship between injection flow rate and containment water level.

   The purpose of this section is to establish a curve relating injection flow rate and containment water level. This relationship could be used to estimate the containment water level based on the injection flow rate (if the containment flooding level indication is lost but the injection flow rate is known).

   This relationship is valid provided that the post RAS decay heat removal is accomplished by the safety injection flow rates of Figures 5.1-1, 5.1-2 and 5.1-3 of this EA.

   This relationship was established from equations 1, 2, 3, 4, 5, 6 and 7 as follows:

   - The injection flow rate was determined as a function of post RAS time from equations 1, 2 and 3.
   - The volume of water injected was determined as a function of post RAS time (up to 135 hours) from equations 4, 5 and 6. To this volume the pre-RAS water volume in containment was added to determine the total water volume in containment as a function of time.
   - Based on the total water volume in containment as a function of time, the containment flooding elevation as a function of time was determined based on equation 7.
   - The relationship between the injection flow rate and containment water level is then established by correlating these parameters for each of the three post RAS time intervals in an excel spreadsheet.

     The results are shown on Figures 8.5-3, 8.5-4 and 8.5-5 below for the time intervals of (20 to 90) min, (1.5 to 8.5) hours, (8.5 to 135) hours respectively.

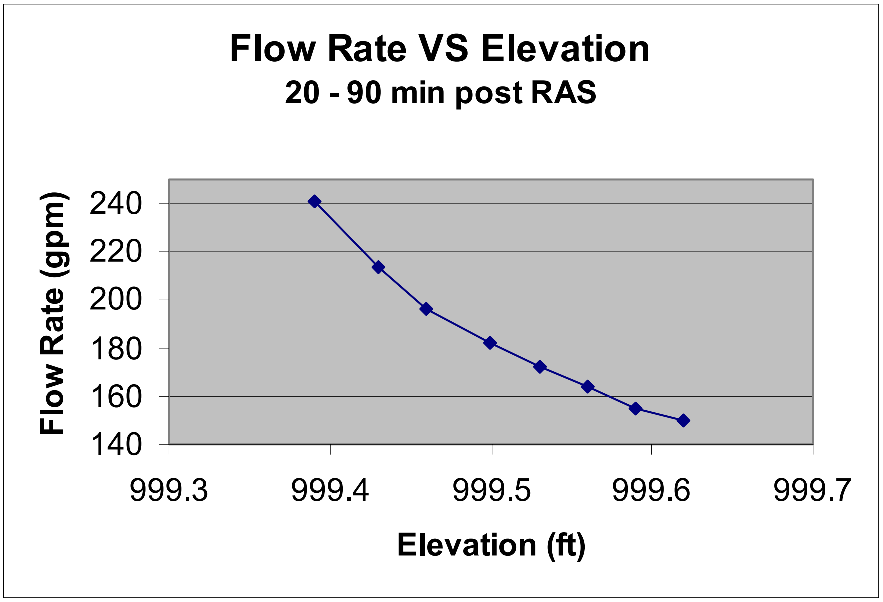


Figure 8.5-3: Containment Water Level vs. Injection Flow Rate, 20-90 Minutes.

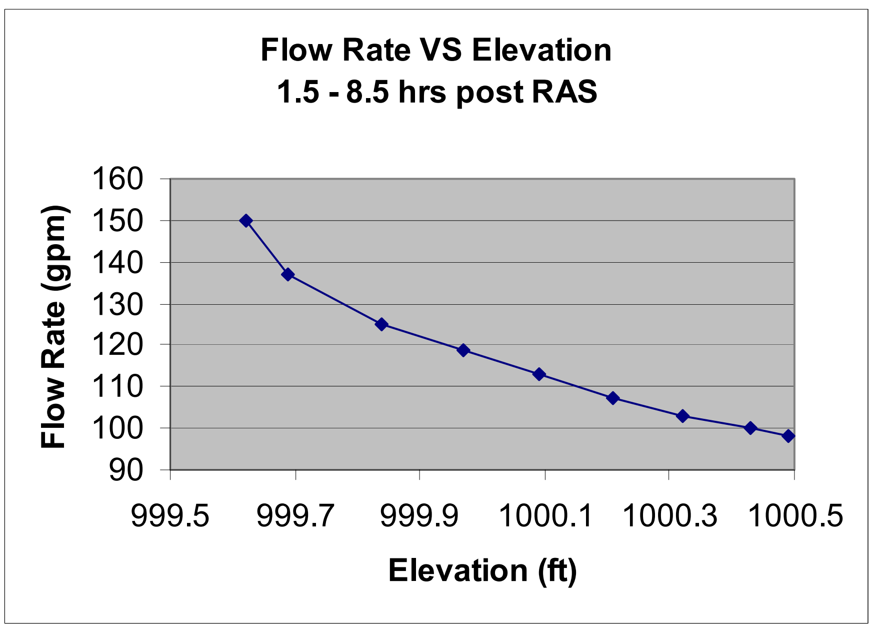


Figure 8.5-4: Containment Water Level vs. Injection Flow Rate, 1.5 – 8.5 Hours.

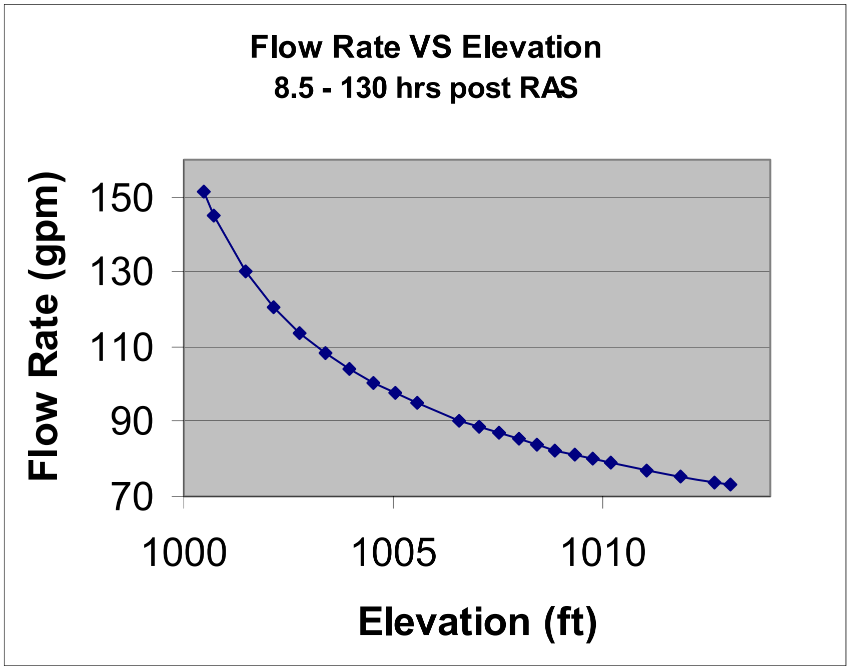


Figure 8.5-5: Containment Water Level vs. Injection Flow Rate, 8.5 – 130 Hours.

10. Determine the decay heat in BTUs/hr as a function of time following the initiation of the event.

    The purpose of this section is to establish a curve relating decay heat in BTU/Hr. to time after trip. This relationship can be used to determine if containment heat removal is adequate to account for decay heat generated by the core.

    The decay heat in BTUs/hr as a function of time was derived from Figure 1 of calculation FC06965 [3.16] and is shown in Figure 8.5-6.

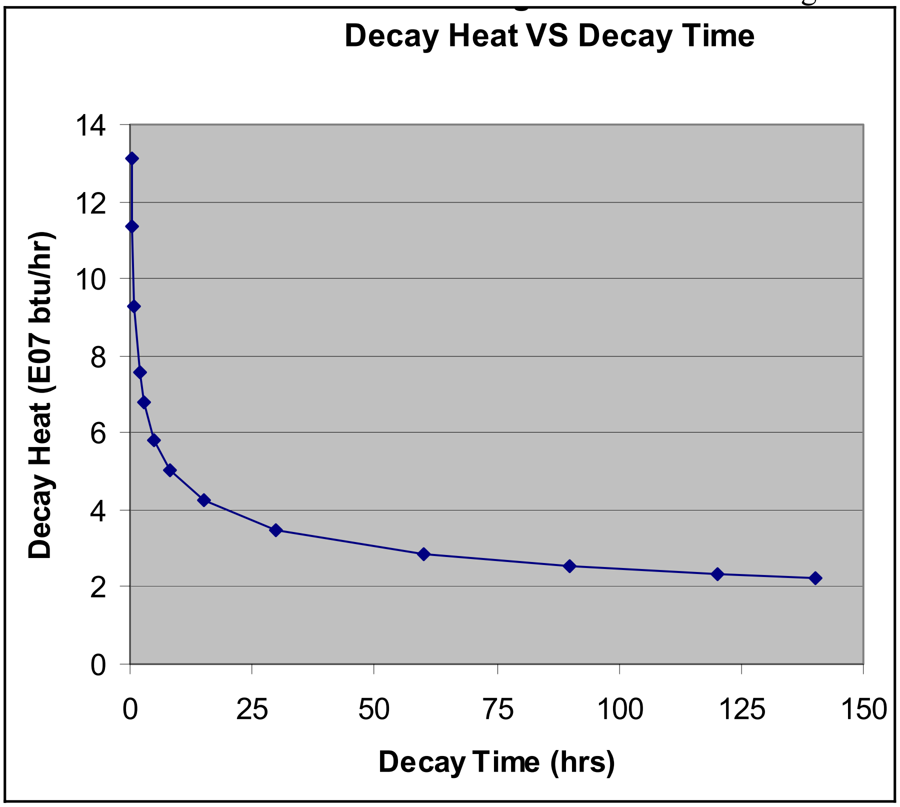


Figure 8.5-6: Decay Heat vs. Decay Time

ATTACHMENT 8.6
CALCULATION OF FLOW RATE BY GRAVITY DRAIN FROM THE FUEL TRANSFER CANAL TO THE SIRWT

Problem: Determine the flow rate by gravity drain from a full Fuel Transfer Canal (FTC) to the SIRWT.

References:
1) Crane Technical Paper No. 410, Flow of Fluids Through Valves, Fittings, and Pipe, 23rd Printing Dated 1986
2) Dravo Piping Isometric Drawing IC-274, Revision 8, File # 35824
3) Fuel Handling Equipment Arrangement Drawing I-09539-B, Revision 2, File # 17272
4) Calculation FC06731, Containment Basement Water Level, Rev. 1
5) Drawing 11405-A-13, Revision 11, Primary Plant Section A-A P&ID, File #12170

Assumptions:
1) Water Level in FTC = El. 1037’ 6” [Reference 3]
2) Bottom of the SIRWT at El. 989’ 0” [Reference 5]
3) SIRWT water level at RAS = 16” above the bottom of the tank [Reference 4]
4) Piping is 4” Nominal Schedule 105 [Reference 2]

Solution: From Reference 1, flow rate in gpm for a gravity system:

$$Q = 19.65d^2\sqrt{h_l/k}$$

Calculation of K:

Assumptions:

Entrance	k=0.5 (Assume inward projecting)
Straight Pipe	$k=f_t\ L/D$
Gate Valve	$k=8f_t$
Elbow	$k=30f_t$ (Assume 90 degree bend)
Tee	$k=60f_t$ (Assume standard tee with flow through branch)
Exit	k=1.0 (Assume Projecting)

$f_t= 0.017$, assumes clean commercial steel pipe with turbulent flow

Calculation:

1)	Entrance	k=	0.5
2)	~110 inches of Straight Pipe		
	k=0.017(110/4.26)	k=	0.44
3)	(2) 4” gate valves fully open		
	k=8(0.017)(2)	k=	0.272
4)	Elbow		
	k=30(0.017)	k=	0.51
5)	Tee		
	K=60(0.017)	k=	1.02
6)	Exit		
	Assume projecting	k=	1.0
		Total k =	3.742

Calculate Discharge Flow Rate:

h = height of water in canal – height of water in SIRWT

= El. 1037.5 ft – (989 ft + 1.33 ft)

= 47.2 ft

Q $= 19.65d^2\sqrt{h_l/k}$

$= 19.65(4.26)^2\sqrt{47.2/3.742}$

= 1266gpm

Calculate R_e:

$R_e = 50.6Q\rho/d\mu$ $\mu = 0.5$ @ 120°F;

$\rho = 61.71$ @ 120°F

$R_e = 50.6(1266)(61.71)/(4.26)(0.5)$

$= 1.86 \times 10^6$ $f_t = 0.017$

Calculate FTC Level where flow rate drops below 250gpm:

$250 = 19.65(4.26)^2\sqrt{h_l/3.742}$

$h_l = \sim 1.8$ ft.

ATTACHMENT 8.7
SUMMARY OF EMERGENCY MAKEUP WATER FLOWPATHS TO THE DEMINERALIZED WATER SYSTEM

Additional Clean Water Sources and Flowpaths to Demin Water Tank
(Note: See attachment 8.8 for flowpaths from Demineralized water to SIRWT)

1. **Blair Water (Unlimited Volume):**
   a. **Option 1 - Via RO Unit:** Normal flow path.
   b. **Option 2 - Bypassing RO unit:** Alternate flow path
   c. **Notes:**
      i. Blair Water is the preferred clean water source, if available.
      ii. Based on discussions with equipment operators, approximate maximum flow through RO unit is 125 – 150 gpm.
      iii. Conversations with several equipment operators has established that Bypassing RO unit allows higher volume flow (estimated greater than 250 gpm with 40 psi header pressure) and negates need for electric power to RO unit (LOOP where Blair water is still available).
2. **Water Plant Storage Tanks (DW-1, DW-5, DW-6 – Approx. 100,000 gal.):**
   a. **Common section - Tanks to Booster Pumps:** Presedimentation Tank → DW-279 → Clarifier/Softener → DW-280 → Surge Tank → DW-8a or 8b
   b. **Option 1 - Booster Pumps to Demin Water Tank (DW-39):** DW-8a or 8b → Blind flange on 6” line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 <u>or</u> DW-MV-132 <u>or</u> DW-367 → LCV-1515 to demin water tank.
   c. **Option 2 - Booster Pumps to Demin Water Tank (DW-39):** DW-8a or 8b → Spool piece → DW-288 → DW-289 → Normal RO flow path, bypassing RO unit to demin water tank.
   d. **Notes:**
      i. Water in water plant storage tanks is clean, but not demineralized. Tanks are flushed periodically to maintain acceptable quality.
      ii. Option 1 provides a more direct path with potential for higher flow rates (if large diameter fire hose can be used)
      iii. Option 2 provides a path that can be established using already available equipment (spool piece), but at potentially reduced flow rate due to smaller diameter piping and longer piping runs. However, this path could supply the RO unit if demineralization is more important than high flow rate, and power is available to the RO unit.

3. **Condensate Storage Tank (DW-48 – Approx. 125,000 gal):**
   a. **Common section – CST to Condensate Clean-up Hose Connection:** CST → FW-684 → FW-1016 → FW-54 → FW-1513 → FW-1230 → hose connection
   b. **Option 1 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to hose connection on demin water tank recirculation line → DW-245 → DW-164 to demin water tank.
   c. **Option 2 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to blind flange on 6" line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-367 → LCV-1515 to demineralized water tank.
   d. **Notes:**
      i. Water from this source is high quality demineralized water.
      ii. Water from this source is supplied via a pump capable of very high discharge pressure (approx. 1,100 psi). Care must be taken to avoid overpressurization of some portions of the flow paths.
      iii. Option 1 provides the most direct path but through a smaller (2" diameter) pipe.
      iv. Option 2 provides a less restrictive flow path, but will require more adapters to establish the proper hose connections.
4. **Emergency Feedwater Storage Tank (FW-19 – Minimum 55,000 gal.):**
   a. **Common section – EFWST to Condensate Clean-up Hose Connection:** EFWST → FW-6 → HCV-1384 → FW-1513 → FW-1230 → hose connection.
   b. **Option 1 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to hose connection on demin water tank recirculation line → DW-245 → DW-164 to demin water tank.
   c. **Option 2 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to blind flange on 6" line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-367 → LCV-1515 to demin water tank.
   d. **Notes:**
      i. Water from this source is high quality demineralized water.
      ii. Water from this source is supplied via a pump capable of very high discharge pressure (approx. 1,100 psi). Care must be taken to avoid overpressurization of some portions of the flow paths.
      iii. Option 1 provides the most direct path but through a smaller (2" diameter) pipe.

iv. Option 2 provides a less restrictive flow path, but will require more adapters to establish the proper hose connections.

5. **Condenser Hotwell (FW-1A/B – Approx. 60,000 gal.):**

   a. **Common section – Condenser to Condensate Clean-up Hose Connection:** Hotwell → FW-675 or FW-677 or FW-679 → FW-683 → FW-1016 → FW-54 → FW-1513 → FW-1230 → hose connection.

   b. **Option 1 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to hose connection on demin water tank recirculation line → DW-245 → DW-164 to demin water tank.

   c. **Option 2 – Condensate Clean-up Hose Connection to Demin Water Tank:** Hose from condensate clean-up connection to blind flange on 6" line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-367 → LCV-1515 to demin water tank.

   d. **Notes:**

      i. This source is not included in the EA assessment, because it may require a portable booster pump to ensure adequate NPSH to FW-54. However, it is provided here as an emergency alternative.

      ii. Water from this source is will contain some secondary system chemicals.

      iii. Water from this source is supplied via a pump capable of very high discharge pressure (approx. 1,100 psi). Care must be taken to avoid overpressurization of some portions of the flow paths.

      iv. Option 1 provides the most direct path but through a smaller (2" diameter) pipe.

      v. Option 2 provides a less restrictive flow path, but will require more adapters to establish the proper hose connections.

6. **Training Center/Admin Building Fire Water Head Tank (135,000 gal.):**

   a. **Common Section - Head Tank to RO Unit/Water Plant:** Head Tank (on hill across Hwy. 75) → DW-534 →DW-648 →DW-531 →DW-542

   b. **Option 1 – RO Unit:** DW-538 → DW-549 → RO Unit or Bypass → Normal flow path to demin water tank.

   c. **Option 2 – Water Plant:** DW-277 → DW-278 → DW-MV-1 → LCV-1506 → Presed tank (DW-1) → Flowpath #2 (described above).

   d. **Alternative approach:** Large fire hoses from TC/Admin hydrant to RO Unit.

   e. **Note:**

      i. The top of the demin water tank is approx. El. 1015 ft. The bottom of the fire water head tank is approx. El. 1242 ft. With a supply water temperature of 50°F, this would provide a supply pressure of approximately 100 psig. At a static pressure of 42 psig, the flow rate through the Blair water supply line to the FCS supply header was shown to be 790 gpm [3.53], so the capacity of the supply line is well in excess of the 120 gpm makeup needs after 24 hours.

General Notes:

1. The numbering scheme provided above does not reflect an order of preference, other than the normal flowpath from Blair water via the RO unit is the preferred flowpath. Order of preference for these makeup flow paths will depend on the event in progress, required flow rate, water quality and equipment availability.
2. The DW booster pumps (DW-8A/B) and the DW pumps (DW-40A/B) are powered from MCC-3C4C-2, which is load shed on SIAS, but not locked out. Therefore, MCC-3C4C2 can be re-energized and the pumps can be restarted.
3. DW-534, which is the bypass around the backflow preventer for the TC/Admin fire water head tank, may be held in its closed position by a semi-permanent locking method Such as a tack weld or locking collar.
4. Total volume of stored clean water on-site (including the TC/Admin fire water head tank) is approximately 475,000 gallons.
5. Each of the above flow paths (except the condenser hotwell, since it is for information only) that require the use of fire hoses were assessed for the ability to pass 150 GPM flow. 150 gpm exceeds the flow rate required after 24 hours to account for decay heat removal in the once-through-cooling mode during injection from a refilled SIRWT. The fire hoses are rated for >175 psig. All motive sources for these flow paths (DW-8A/B, FW-6, FW-54) are capable of providing 100 psig or better. All hoses are assumed to be 2.5” linen hoses (rubber lined will yield better performance, if available). From Ref. 3.44:
   - The following formula determines the maximum capacity of a 2.5” diameter nozzle:

     $Q=30d^2\sqrt{p}$

     Where:

     Q=flow rate, d=diameter (in.), p=pressure (psi)

     This yields a maximum flow rate of approximately 1,875 gpm @ 100 psig
   - The following formula determines the head loss through a 100 ft. length of 2.5” linen hose:

     $FL=4.26q^2L$

     Where:

     FL=friction loss (head loss), q=flow rate (x100 gpm), L=length (x100 ft)

     Assuming 500 ft. of fire hose (twice the length of the turbine building), the head loss through the fire hose would be approximately 50 psig.

Given that the elevation head of the demineralized water tank would be less than 10 psig, this leaves at least 40 psi at the exit of the hose, which is more than adequate to sustain 150 gpm.

ATTACHMENT 8.8
SUMMARY OF EMERGENCY MAKEUP WATER FLOWPATHS FROM THE DEMINERALIZED WATER SYSTEM VIA CVCS TO THE SIRWT
(Note: See attachment 8.7 for makeup water flowpaths to the Demin. Water system)

Flowpaths from Demin Water to SIRWT

This list does not include initial transfer of water from the fuel transfer canal or the SFP to the SIRWT, because those flow paths are already evaluated in section 5.4 of this EA. In all cases shown below, water is transferred from the demineralized water tank to the primary water storage tank via the demineralized water pumps DW-40A/B.

1. **Primary Water Storage Tank (DW-45) to Boric Acid Blending Tee. Boric acid is supplied from BAST(s) via FCV-269Y:**
    a. **Normal flow path:** PWST → Primary Water booster pumps (DW-41A/B) → Vacuum De-aerator (DW-42) → De-aerator Booster Pumps (DW-43A/B) → De-aerated water header → FCV-269X → FCV-269 → CH-152 →SIRWT.
    b. **Alternate flow path:** PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119→ DW-127 → DW-128 → De-aerated water header → FCV-269X → CH-152 →SIRWT.
    c. **Notes:**
        i. Approximate flow through normal flow path is 125 gpm. (Per Ref. 3.46, design flow rate is 150 gpm for demineralized water through FCV-269X).
        ii. Higher flow rates may be achieved by bypassing PCV-1553.
2. **Primary Water Storage Tank (DW-45) to Fuel Transfer Canal or SIRWT. Boric acid is supplied by adding bags directly to FTC:**
    a. **Common section – Primary Water Storage Tank to Booster Pumps:** PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119→ DW-127 → DW-128 → De-aerated demin water header → Hose bibs in Room 27 or Corridor 26 → Hoses dump to fuel transfer canal or SIRWT.
    b. **Room 27:** Three hose connectors – DW-281, DW-282, WD-566
    c. **Corridor 26:** Two hose connectors – DW-251a, DW-252.
    d. **Notes:**
        i. Multiple hoses may increase flow rate. However, total flow will be restricted due to all connections being supplied by the same 1 ½" supply line.
        ii. Boric acid would be added directly to the canal, with hose flow acting to mix the crystals into solution.

3. **Primary Water Storage Tank (DW-45) to SIRWT via Boric Acid Storage Tanks (CH-11A/B). Boric acid is added via batch tank as part of fill process:**
   a. **PWST to Boric Acid Batch Tank:** PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119 → DW-147 → CH-278 → Boric Acid Batch Tank → CH-104 or CH-105 → BAST(s).
   b. **BAST to SIRWT:** CH-4A/B → FCV-269Y → FCV-269 → CH-152 → SIRWT.
   c. **Notes:**
      i. Flow rate through this path will be limited to the capacity of FCV-269Y.
4. **Primary Water Storage Tank (DW-45) to RCS via Boric Acid Storage Tanks Boric acid is added via batch tank as part of fill process:**
   a. **PWST to Boric Acid Batch Tank:** PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119 → DW-147 → CH-278 → Boric Acid Batch Tank → CH-104 or CH-105 → BAST(s).
   b. **BAST to RCS:** CH-4A/B → HCV-268 → Charging pump(s) (CH-1A/B/C) → Normal charging flow path → RCS.
   c. **Notes:**
      i. This flow path will allow for direct RCS injection at a maximum of 120 gpm. Sustained flow rate will be limited to the rate at which demin water can be supplied to the BAST via the 2" boric acid batch tank transfer piping. This flow rate has historically been quite small.
      ii. The alternate hot leg injection flow path is not presented here because the core cooling capability of this flow path has not been established. However, the alternate hot leg injection flow path can be used to make up the difference between minimum flow required for boil-off (with spillage) and minimum combined hot/cold leg flow.
      iii. CH-202 will allow for a charging flow path to RCS loop 1A even if charging loop injection valves fail closed.

General Notes:

1. The primary water booster pumps (DW-41A/B) and the De-aerator booster pumps (DW-43A/B) are load shed on SIAS and locked out. Therefore, engineered safeguards must be reset before the pumps can be restarted.
2. As noted earlier, the flow path from the SFP to the SIRWT is not described here, because it is already proceduralized in EOP Attachment 25. It should be noted, however, that the SFP cooling pumps (AC-5A/B) which are part of the transfer path will be load shed on SIAS and locked out. Therefore, engineered safeguards must be reset before SFP transfer to the SIRWT can be accomplished.

ATTACHMENT 8.9
RECORD OF E-MAIL CORRESPONDENCE

From: HENG, THOMAS A

Sent: Thursday, February 09, 2006 3:37 PM

To: 'gguliani@alioniscience.com'

Cc: HOLTHAUS, KEVIN C; BAUGHN, SUSAN E

Subject: FW; Cycle 23 and 24 CBCs

Greg,

I ran a special SIMULATE-3 case to get these numbers so they are not reviewed. We typically put 100 ppm uncertainty on any borons calculated at low temperature like this.

Cycle 24, No XE, 50 Deg. F, 14.7 psia, ARI CBC = 881.2 ppm ← This was performed at Early Window which is conservative high.
Cycle 23, No XE, 50 Deg. F, 14.7 psia, ARI CBC = 899.6 ppm

I understand that this is only for checking the applicability of previous values and these values are not going to be used in safety related calculations.

Thomas A. Heng P.E.

ATTACHMENT 8.10
DOCUMENT CHANGE MARKUPS

Markups for changes to the following documents are included in this attachment:

1) AOP-22, RCS Leak
2) EOP-03, Loss of Coolant Accident
3) EOP-20, Functional Recovery Procedure
4) EOP/AOP Attachment 25, Methods for Filling the SIRWT Post RAS
5) EOP/AOP Attachment 26, Total SI Pump Flow to Match Decay Heat vs Time
6) TSC Guideline (New Document), ECCS Recirculation Failure
7) FCSG-39, Operational Contingency Action Guideline

EOP/AOP REVISION SUGGESTION FORM

EOP- AOP- EOP Coord use only	EOP-	AOP- 22
	Revision: 24	Date: ~~12/26/05~~ 8-15-05

Suggested Change (attach copy of marked up EOP/AOP and supporting documentation):

REDUCE TIME REQUIREMENT FOR SECURING EMERGENCY BORATION FOLLOWING A LEAK/LOCA FROM 1 HOUR TO 30 MINUTES.

Reason for Change:

EMERGENCY BORATION IS NOT CREDITED FOR REACTIVITY OR INVENTORY CONTROL IN LOCA ANALYSES. BY SECURING EMERGENCY BORATION EARLIER, THE BAST CONTENTS ARE RESERVED FOR USE IN SIRWT OR RCS MAKE-UP IN THE EVENT OF COMPLETE BLOCKAGE OF ECCS RECIRCULATION STRAINERS SI-12A/12B.

Originator: G.E. GUIANI / [signature]	Ext: 939-775-9259	Date: 12-26-05

The following is to be completed by the EOP Coordinator

	Accepted for incorporation, expected incorporation date:
	Forward copy of accepted for incorporation changes to Reliability Engineering for Maintenance Rule review
	Accepted for further evaluation, type of evaluation:
	Returned for clarification:
	Rejected: justification below
	Priority (if accepted)

Comments:

EOP Coordinator:	Date:

Section II - Reactor Coolant Leak in Excess of 40 gpm

INSTRUCTIONS | CONTINGENCY ACTIONS

31. **IF ANY** of the following criteria are satisfied:

- Emergency Boration has occurred for ~~one hour~~
- Both "CONC BORIC ACID TANK CH-11A/B LEVEL LO-LO" alarms (CB-1,2,3; A2) have annunciated

THEN terminate emergency boration by performing the following steps:

a. **IF** SIRWT level is greater than or equal to 74 inches, **THEN** align Charging Pump suction to the SIRWT by performing the following steps:

1) Open LCV-218-3, Charging Pump Suction SIRWT Isolation Valve.

2) Ensure LCV-218-2, VCT Outlet Valve, is closed.

(continue)

a.1 **IF** SIRWT level is less than 74 inches, **THEN** ensure the Charging Pump outlet piping is pressurized by performing the following steps:

1) Place the Charging Pump Control Switches in "PULL-TO-LOCK".

(continue)

Summary of Comments on Attachment 10. pdf

Page: 2

Author: Greg
Subject: Note
Date: 11/17/2005 9:38:34 AM
Insert Note:

Securing Emergency Boration with contents remaining in the Boric Acid Storage Tanks will enhance the ability to refill the SIRWT following RAS.

Author: Greg
Subject: Note
Date: 11/17/2005 9:36:46 AM
Change to: 30 minutes

Author: Greg
Subject: Cross-Out
Date: 11/17/2005 9:36:15 AM

EOP/AOP REVISION SUGGESTION FORM

EOP- AOP- EOP Coord use only	EOP- 03	AOP-
	Revision: 30	Date: 9/27/05

Suggested Change (attach copy of marked up EOP/AOP and supporting documentation):

REDUCE TIME REQUIREMENT FOR SECURING EMERGENCY BORATION FOLLOWING A LOCA FROM 1 HOUR TO 30 MINUTES

Reason for Change:

EMERGENCY BORATION IS NOT CREDITED FOR REACTIVITY OR INVENTORY CONTROL IN LOCA ANALYSES. BY SECURING EMERGENCY BORATION EARLIER, THE BAST CONTENTS ARE PRESERVED FOR USE IN SIRWT OR RCS MAKE-UP IN THE EVENT OF COMPLETE BLOCKAGE OF ECCS RECIRCULATION STRAINERS SI-12A/B.

Originator: G.E. GULIANI [signature]	Ext: 239-775-9259	Date: 12-26-05

The following is to be completed by the EOP Coordinator

	Accepted for incorporation, expected incorporation date:
	Forward copy of accepted for incorporation changes to Reliability Engineering for Maintenance Rule review
	Accepted for further evaluation, type of evaluation:
	Returned for clarification:
	Rejected: justification below
	Priority (if accepted)

Comments:

EOP Coordinator:	Date:

INSTRUCTIONS	CONTINGENCY ACTIONS
✖ 34. **IF ANY** of the following criteria are satisfied: • Emergency Boration has occurred for ~~one hour~~ • Both "CONC BORIC ACID TANK CH-11A/B LEVEL LO-LO" Alarms have annunciated (CB-1,2,3; A2) **THEN** terminate emergency boration by performing the following steps:	
a. **IF** SIRWT level is greater than or equal to 74 inches, **THEN** align Charging Pump suction to the SIRWT by performing the following steps: 1) Open LCV-218-3, Charging Pump Suction SIRWT Isolation Valve. 2) Ensure LCV-218-2, VCT Outlet Valve, is closed. (continue)	a.1 **IF** SIRWT level is less than 74 inches, **THEN** ensure the Charging Pump outlet piping is pressurized by performing the following steps: 1) Place all of the Control Switches for Charging Pumps, CH-1A/B/C, in "PULL-TO-LOCK". (continue)

Page: 4

Author: Greg
Subject: Note
Date: 11/16/2005 3:31:19 PM
Insert Note:

Securing Emergency Boration with contents remaining in the Boric Acid Storage Tanks will enhance the ability to refill the SIRWT following RAS.

Author: Greg
Subject: Note
Date: 11/16/2005 3:33:33 PM
Change to: 30 minutes

Author: Greg
Subject: Cross-Out
Date: 11/16/2005 3:32:58 PM

EOP/AOP REVISION SUGGESTION FORM

EOP- AOP- EOP Coord use only	EOP- 20, IC-2	AOP-
	Revision: 17	Date: 8-15-05

Suggested Change (attach copy of marked up EOP/AOP and supporting documentation):

1. REPLACE PLACEKEEPER TABLE
2. INSERT NEW STEP 5 SO THAT IC-2 ACTIONS ARE CONSISTENT WITH EOP-03 ACTIONS
3. INSERT NOTE PRIOR TO STEP 17 EXPLAINING THE IMPACT ON EQ INSTRUMENTATION / EQUIPMENT
4. REVISE STEP 18 TO INCLUDE HCV-327/329

Reason for Change:

CHANGE 1 - UPDATES PLACEKEEPER TO INCLUDE STEPS ADDED IN RESPONSE TO THE GSI-191 ISSUE

CHANGE 2 - ADDS STEP TO SECURE SI-2C, WHICH IS PART OF THE GSI-191 STRATEGY, AND LOCATES IT IN A SIMILAR POSITION TO THE SAME STEP IN EOP-03.

CHANGE 3 - THE GSI-191 MITIGATION STRATEGY INCLUDES PROVISIONS FOR FLOODING CONTAINMENT TO ALLOW FOR ESTABLISHMENT OF SDC. THIS NOTE INFORMS THE OPERATORS OF THE NEED TO COPE WITH THE EFFECTS OF THAT STRATEGY

CHANGE 4 - ADDS HCV-327/329, WHICH ARE NEEDED TO ESTABLISH SDC AND WHOSE CONTROL CABLES MAY BE SUBMERGED

Originator: G.E. GIULIANI / [signature]	Ext: 239-775-9359	Date: 12-26-05

The following is to be completed by the EOP Coordinator

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	Returned for clarification:
	Rejected: justification below
	Priority (if accepted)

Comments:

EOP Coordinator:	Date:

14.0 PLACEKEEPER

IC-2

Number	Step	time/√	Page
1	Check PPLS initiated		167
2	Check CPHS initiated		168
3	Maximize SI flow		170
4	Depressurize RCS		171
5	Reduce CS flow		172
6	Restart CS		173
7	Minimize leakage		173
8	Refill SIRWT		173
9	Monitor for sump blockage		174
10, 11	Check acceptance criteria		177

COMMENTS:

Page: 6

Author: Greg
Subject: Note
Date: 11/17/2005 9:07:52 AM
Replace placekeeper table with new table shown on next page.

Insert new placekeeper table

EA-FC-04-010
Attachment 8.10
Page 161 of 205

Number	Step	time/√	Page
1	Check PPLS initiated		167
2	Check CPHS initiated		168
3	Maximize SI flow		170
4	Depressurize RCS		171
5	Secure SI-2C		*
6	Reduce CS flow		*
7	Restart CS		*
8	Minimize Leakage		*
9	Refill SIRWT		*
10	Monitor for sump blockage		*
11,12	Check Acceptance Criteria		*
13	Isolate leakage		*
14	Maximize S/G cooldown		*
15	Depressurize RCS		*
16	Ensure all CFCs operating		*
17	Add water to RCS via charging		*
18	Open SDC valves inside containment		*
19	Inject SI tanks		*
20	Re-align for SI from SIRWT		*
21	Initiate SDC		*
22,23	Attempt to re-establish recirculation		*
24	Check Acceptance Criteria		*

*** NOTE TO TYPIST: Establish page #s based in new step locations.**

Page: 7

Author: Greg
Subject: Text Box
Date: 2/15/2006 10:04:40 PM
Insert new placekeeper table

14.0 RCS INVENTORY CONTROL

IC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
3. (continued)	3.1 (continued)
	c. Start **ALL** of the following idle pumps: ● HPSI Pumps, SI-2A/B/C ● LPSI Pumps, SI-1A/B ● Charging Pumps, CH-1A/B/C
	d. Verify SI flow is acceptable PER Attachment 3, Safety Injection Flow vs. Pressurizer Pressure.
✖4. **IF** high RCS pressure is preventing adequate SI flow, **THEN** depressurize the RCS to less than 1200 psia by performing the following steps: a. Deenergize PZR Heaters. b. Maximize PZR Main or Auxiliary Spray.	

Page: 8

Author: Greg
Subject: Note
Date: 11/16/2005 3:41:07 PM
Insert new step 5, see next page.
Re-number all subsequent steps.

Insert New step 5

INSTRUCTIONS | CONTINGENCY ACTIONS

✖5. **IF ALL** of the following conditions exist:

- **ALL** HPSI pumps are operating
- SI flowrate greater than Attachment 3, Safety Injection Flow vs. Pressurizer Pressure
- Representative CET temperature less than superheat
- RVLMS indicates greater than the top of active fuel and not lowering

THEN place SI-2C Control Switch in "PULL-TO-LOCK"

Page: 9

Author: Greg
Subject: Text Box
Date: 2/15/2006 10:04:28 PM
Insert New step 5

EA-FC-04-010 Attachment 8.10 Page 163 of 205

14.0 INVENTORY CONTROL

IC-2

CONTINUING ACTIONS FOR SUCCESS PATH: IC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
✖15. Ensure **ALL** available Containment Vent Fans are in operation with maximum cooling supplied.	
✖16. **IF** RAS is present, **AND BOTH** of the following conditions exist: • SI/CS pump suction from the Containment Sump appears to be blocked • Inventory is available in the BASTs **THEN** commence adding water to the RCS via the Charging Pumps at a ratio of three gallons of demineralized water for every one gallon of borated water.	
✖17. ~~**IF** RAS has actuated, **THEN** ensure HCV-348, SDC Inboard Isolation Valve, is open prior to exceeding a containment water level of 26.1 ft. (LI-387-1 or 388-1).~~	

Page: 10

Author: Greg
Subject: Note
Date: 1/25/2006 10:16:53 AM
(Recall that steps have been renumbered. This note will be in front of what is now step 17)

Insert Note :

The actions specified in steps 17 - 21 will raise containment water level above the analyzed range. The TSC can provide assistance in evaluating the effects on components and indications as water level rises.

Author: Greg
Subject: Note
Date: 11/16/2005 3:51:33 PM
Replace with new step 18. See next page.

Author: Greg
Subject: Cross-Out
Date: 11/16/2005 3:50:42 PM

Replace old step 17 (renumbered to 18) with this step

EA-FC-04-010
Attachment 8.10
Page 165 of 205

INSTRUCTIONS | CONTINGENCY ACTIONS

✖18. **IF** RAS has actuated,
THEN perform the following steps:

a. Ensure HCV-348, SDC Inboard Isolation Valve, is open **AND** de-energized at BKR MCC-3B1-F04 prior to exceeding a containment water level of 26.1 ft. (LI-387-1 or 388-1)

b. Ensure the following valves are open **AND** de-energized at their respective breakers prior to exceeding a containment water level of 27.5 ft. (LI-387-1 or 388-1):

- HCV-327 (BKR MCC-3B1-F03)
- HCV-329 (BKR MCC-4A1-F04)

Page: 11

Author: Greg
Subject: Text Box
Date: 2/15/2006 11:16:45 PM
Replace old step 17 (renumbered to 18) with this step

EOP/AOP REVISION SUGGESTION FORM

EOP- AOP- EOP Coord use only	EOP- ATTACHMENT 25	AOP-
	Revision: 19	Date: 10-25-05

Suggested Change (attach copy of marked up EOP/AOP and supporting documentation):

1. REVISE NOTES SECTION AND ADD NOTES IN FRONT OF STEPS 5 & 6 TO CLARIFY THE STRATEGY FOR FILLING THE SIRWT AND RETURNING TO SI INJECTION MODE IN THE EVENT OF STRAINER BLOCKAGE

2. RE-LOCATE STEP 1

Reason for Change:

CHANGE 1 - PROVIDES INFORMATION ABOUT THE DECAY HEAT REMOVAL TIMEFRAME AFFORDED BY TRANSFERRING VARIOUS VOLUMES OF WATER TO THE SIRWT, AND THAT INFORMATION CONCERNING LONG-TERM MAKE-UP WATER SOURCES IS AVAILABLE IN THE TSC.

CHANGE 2 - CORRECTS A FORMAT ERROR

Originator: G.E. GULIANI / [signature]	Ext: 239-775-4259	Date: 10/26/05

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	Accepted for further evaluation, type of evaluation:
	Returned for clarification:
	Rejected: justification below
	Priority (if accepted)

Comments:

EOP Coordinator:	Date:

Attachment 25

Methods For Refilling The SIRWT Post RAS

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTES

1. The following guidance is for refilling the SIRWT following RAS to minimize the impact of Containment Sump strainer plugging if it occurs. Multiple methods of filling the SIRWT are provided and any one or more of these methods may be used.

2. The following Level indications should be closely monitored while transferring water from the Spent Fuel Pool /Fuel Transfer Canal to the SIRWT:
   - Transfer Canal level (visually from above)
   - LI-2846 (Rm 69), SFP Level, and visually
   - LI-381 and 382 (AI-30A/B), SIRWT Level

3. The minimum boron concentration to ensure adequate Shutdown Margin and to prevent boron precipitation in the core is 965 ppm. Most sources of borated makeup to the SIRWT, with the exception of the Boric Acid Storage Tanks, would require equal amounts from the source and demineralized water to be added to obtain this concentration. (For example; the Fuel Transfer Canal holds ~45,000 gallons of roughly 2000 ppm borated water. Adding 45,000 gallons of demineralized water would result in ~90,000 gallons at a concentration of ~1000 ppm.)

4. By design, the Spent Fuel Pool can not be drained below a safe level with the gate between the pool and the canal removed. This additional amount of borated water will provide much needed volume to the SIRWT to maintain the core cooled and covered.

1. Consider batching boric acid to the Boric Acid Storage Tanks.

Page: 13

Author: Greg
Subject: Note
Date: 11/16/2005 4:40:07 PM
Insert the following: by steps 3-7

Author: Greg
Subject: Note
Date: 1/25/2006 10:18:57 AM
(Click on the balloon to see the entire content of this note)

Insert the following notes:

5. The volume of water in the Fuel Transfer Canal will increase the level in the SIRWT enough to provide for approximately 4 hours of SI flow if HPSI flow rate is maintained as shown in Attachment 26. The combined volumes of the Fuel Transfer Canal and the Spent Fuel Pool drawn down to the lower suction elevation will provide for approximately 24 hours of SI flow if maintained as specified in attachment 26.

6. The TSC can provide assistance in establishing a makeup water flow path to the demineralized water system if steps 5 or 6 will be used to blend borated water to the SIRWT.

Author: Greg
Subject: Note
Date: 11/16/2005 4:38:56 PM
This step should be located under the header for INSTRUCTIONS/CONTINGENCY ACTIONS.

Attachment 25

Methods For Refilling The SIRWT Post RAS

INSTRUCTIONS | CONTINGENCY ACTIONS

~~NOTE~~

The Boric Acid Storage Tank volume and concentration should be used to determine the amount of demineralized water necessary to reduce the boron concentration to approximately 965 ppm.

5. Transfer the contents of the Boric Acid Storage Tanks to the SIRWT by performing the following steps:

   a. Ensure FCV-269, Makeup Water Control Valve, is in CLOSE.

   b. Place HC-269, Makeup Water Mode Selector Switch, in MANUAL.

   c. Ensure **BOTH** Boric Acid Pump Recirculation Valves are closed:

      - HCV-264
      - HCV-257

(continue)

Page: 14

Author: Greg
Subject: Note
Date: 12/22/2005 1:41:11 PM
Change to: NOTES

Author: Greg
Subject: Cross-Out
Date: 12/22/2005 1:40:36 PM

Author: Greg
Subject: Note
Date: 12/22/2005 1:42:42 PM
Insert the following note:

Contact the TSC for assistance in establishing a makeup water flow path to the demineralized water system if steps 5 or 6 will be used to blend borated water to the SIRWT.

Attachment 25

Methods For Refilling The SIRWT Post RAS

INSTRUCTIONS | CONTINGENCY ACTIONS

~~**NOTE**~~

To assure adequate mixing of the borated water from the Fuel Transfer Canal/Spent Fuel Pool and the unborated water to reduce the boron concentration, the borated water should be added to the SIRWT at a rate approximately equal to the capacity of the unborated source.

6. Add Makeup Water to the SIRWT to achieve a boron concentration of approximately 965 ppm by performing the following steps:

   a. Open CH-152, Charg Pumps CH-1A, B & C Suct Hdr SI and Refueling Water Tank SI-5 Blended Boric Acid Supply Valve (Corridor 4).

   b. Ensure **BOTH** Primary Water Booster Pumps, DW-41A/B, are running (Room 69).

   c. Place HC-269, Makeup Water Mode Selector Switch, in "MANUAL".

(continue)

Page: 15

Author: Greg
Subject: Note
Date: 12/22/2005 1:43:37 PM
Change to: NOTES

Author: Greg
Subject: Cross-Out
Date: 12/22/2005 1:42:58 PM

Author: Greg
Subject: Note
Date: 12/22/2005 1:44:03 PM
Insert the following note:
Contact the TSC for assistance in establishing a makeup water flow path to the demineralized water system if steps 5 or 6 will be used to blend borated water to the SIRWT.

EOP/AOP REVISION SUGGESTION FORM

EOP- AOP- EOP Coord use only	EOP- ATTACHMENT 26	AOP-
	Revision: 19	Date: 10/25/05

Suggested Change (attach copy of marked up EOP/AOP and supporting documentation):

CHANGE TITLES AND ADD NOTES TO CURVES IN ATTACHMENT 26.

Reason for Change:

THIS CHANGE CLARIFIES THE PURPOSE FOR AND USE OF THE INJECTION CURVES FOR DECAY HEAT REMOVAL.

Originator: G.E. GUILIANI [signature]	Ext: 239-775-9059	Date: 10-26-05

The following is to be completed by the EOP Coordinator

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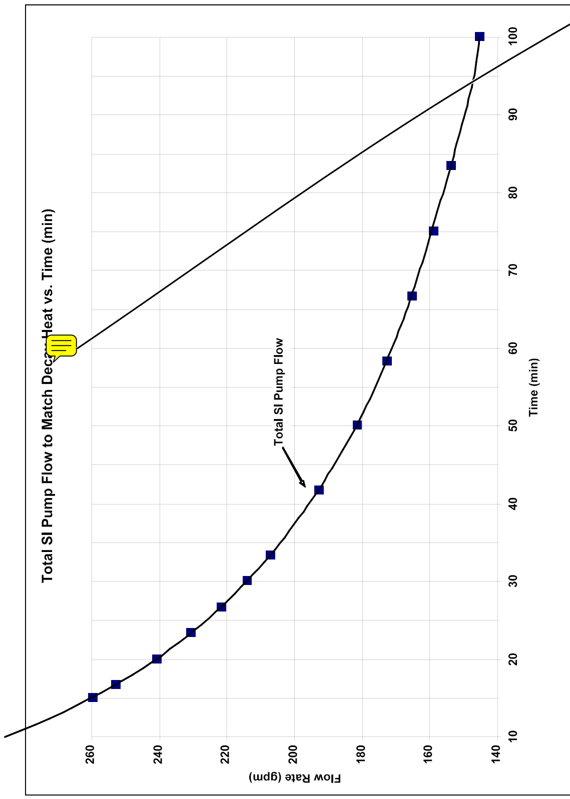
	Returned for clarification:
	Rejected: justification below
	Priority (if accepted)

Comments:

EOP Coordinator:	Date:

Attachment 26

Total SI Pump Flow to Match Decay Heat vs. Time



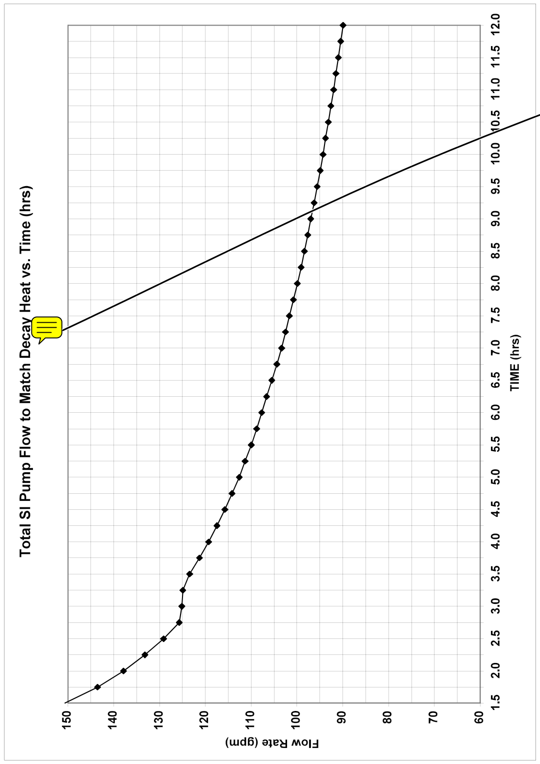
Page: 17

Author: Greg
Subject: Note
Date: 11/16/2005 4:42:52 PM
Change title to:

Curve 1 - Total SI Pump Flow to Match Decay Heat vs. Time (min.)

Attachment 26

Total SI Pump Flow to Match Decay Heat vs. Time



Page: 18

Author: Greg
Subject: Note
Date: 11/16/2005 4:46:26 PM
Insert Note:

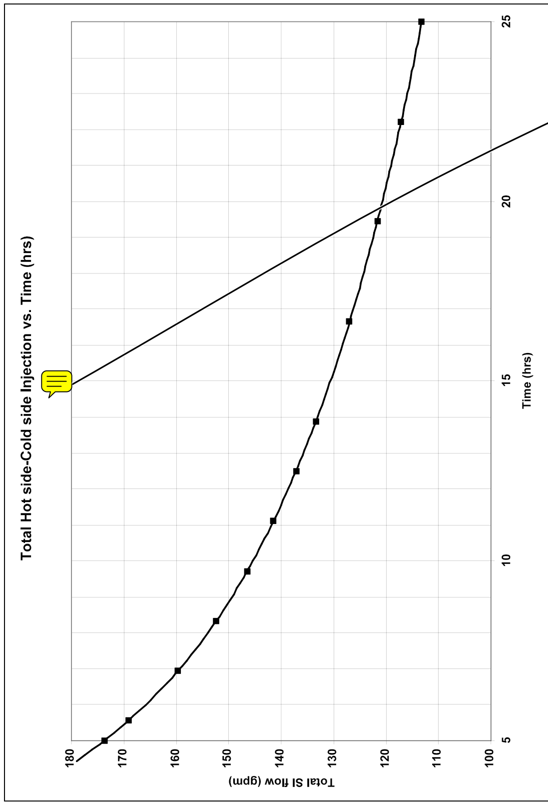
When Simultaneous Hot/Cold Leg Injection is established, Curve 3 - Total Hot Side - Cold Side Injection vs. Time (hrs.) should be used to determine minimum required flow rate.

Author: Greg
Subject: Note
Date: 11/16/2005 4:46:43 PM
Change title to:

Curve 2 - Total SI Pump Flow to Match Decay Heat vs. Time (hrs.)

Attachment 26

Total SI Pump Flow to Match Decay Heat vs. Time



Page: 19

Author: Greg
Subject: Note
Date: 11/16/2005 4:53:21 PM
Insert Note:

This curve should be used when Simultaneous Hot/Cold Leg Injection has been established.

Author: Greg
Subject: Note
Date: 12/22/2005 1:44:52 PM
Change title to:

Curve 3 - Total Hot Leg + Cold Leg Injection vs. Time (min.)

Technical Support Center Temporary Guideline

ECCS Recirculation Failure

ECCS RECIRCULATION FAILURE

1. PURPOSE

1.1. A potential beyond-design basis event has been identified that could result in the degraded performance or clogging of the ECCS recirculation suction strainers (SI-12A/B). This Guideline provides guidance and information to assess and mitigate the effects of a loss of ECCS recirculation capabilities. In the event of the degradation or loss of recirculation capabilities, the control room will take actions as directed by the EOPs to maintain sufficient recirculation flow to remove decay heat. If those actions fail, the HPSI system will be returned to the injection mode of operation from the SIRWT. This mode will continue to raise containment water level until the hot legs are covered, allowing backfill of the RCS from containment and alignment of the shutdown cooling system to provide long term cooling.

This Guideline supports those actions by providing methods of evaluating plant conditions and resources; and assists TSC personnel in providing the control room with guidance on required injection volumes, makeup water sources and flowpaths, and coping strategies for dealing with in-containment equipment that would be submerged during the process.

1.2. The TSC organization has the lead responsibility for the use of this Guideline. It is intended that implementation be a cooperative effort between the Control Room, Technical Support Center (TSC) and other emergency response facilities and resources.

2. PREREQUISITES/ENTRY CONDITIONS

2.1. An accident has occurred that requires the use of ECCS on recirculation for long term cooling, **AND**

2.2. The Control Room has contacted the TSC per AOP-22, EOP-03 or EOP-20 and stated that degraded or failed ECCS recirculation performance has been observed.

3. REFERENCES/COMMITMENT DOCUMENTS

3.1. EA-FC-04-010, R1, Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01.

3.2. LIC-05-131, Fort Calhoun Station Unit 1, Request for an Extension to the Completion Date for Corrective Actions Taken in Response to Generic Letter 2004-02 and Information Regarding Actions taken as a Result of Information Notice 2005-26.

3.3. AOP-22, Reactor Coolant Leak

3.4. EOP-03, Loss of Coolant Accident

3.5. EOP-20, Functional Recovery

4. DEFINITIONS

4.1. Degraded ECCS Recirculation Performance – ECCS recirculation strainer blockage or other failures have caused a loss of HPSI or CS pump suction, but control room actions in accordance with AOP-22, EOP-03 or EOP-20 have allowed the ECCS to remain in the sump recirculation mode of operation at reduced capacity (number of operating pumps or flow rate).

4.2. Failed ECCS Recirculation – ECCS recirculation strainer blockage or other failures have caused a loss of HPSI or CS pump suction, and operator actions to restore ECCS recirculation have failed. The failure results in entry into EOP-20, success path IC-2, and actions are taken to restore core cooling by returning HPSI to the injection mode of operation.

4.3. Return to Injection Cooling Mode – Following RAS, the HPSI system is re-aligned to take suction from the SIRWT, which has been re-filled to above the RAS setpoint. Core cooling is accomplished by HPSI flow, throttled to provide adequate heat removal to make up for core boil-off. This mode of cooling is entered if the ECCS recirculation mode of operation has failed.

4.4. Available Decay Heat Removal Duration – The amount of time that a given volume of water in the SIRWT will provide for core heat removal if injected at the minimum flow rate necessary to remove decay heat.

4.5. Mission Critical Components – Those components (equipment and instrumentation) inside containment that are critical to the implementation of the strategy of returning to injection cooling mode and filling containment until the hot legs are covered and shutdown cooling can be initiated.

4.6. Coping Strategy – The use of an alternate means to accomplish the function of a mission critical component if the component becomes inoperable due to submergence when containment water level is raised to cover the RCS hot legs.

5. IMPLEMENTATION OF ATTACHMENTS

NOTES:

1. **Steps within the EOPs currently direct the control room to begin filling the SIRWT immediately after RAS. They also direct the return to injection mode of cooling in the event of failed ECCS recirculation.**

2. **The combined volumes of the Fuel Transfer Canal and the Spent Fuel Pool drawn down to near the lower suction will provide approximately 23 hours of decay heat removal if HPSI flow is maintained IAW EOP/AOP Attachment 26.**

3. **Items 5.2 through 5.4 are listed in order of priority. However, if sufficient resources are available, they should be assessed concurrently.**

4. **In response to degraded ECCS recirculation capabilities, the EOPs direct that Containment spray will be secured. Evaluations indicate that control room dose rates should remain within limits. However, control room dose rates should be monitored closely to ensure against overexposure.**

5.1. Assess current ECCS system status.

5.1.1. Complete Attachment 6.1 every 30 minutes.

5.2. **IF** ECCS recirculation has failed, **THEN** assess the capability to return to injection cooling mode using CVCS and/or SI injection from the refilled SIRWT.

5.2.1. Use attachment 6.2 to determine the amount of available decay heat removal time in return to injection cooling mode.

5.2.2. Use attachment 6.3 to determine the required volume of makeup water to fill containment to desired elevation.

5.2.3. Use attachment 6.4 to determine the pH and boron concentration of makeup water.

5.3. Determine status of makeup water supply to SIRWT.

5.3.1. **IF** Blair water is not available **OR** makeup flow through the Reverse Osmosis unit is not providing adequate makeup water flow rate to the demineralized water system, **THEN** use attachment 6.5 to determine and establish alternate makeup water flow paths.

5.3.2. **IF** the normal primary makeup water flow path to the SIRWT is not operating, **THEN** use attachment 6.6 to determine a method for supplying makeup water to the SIRWT.

5.4. **IF** return to injection cooling mode from the refilled SIRWT is in progress, **THEN** use attachment 6.7 to assess submerged EQ equipment and establish coping strategies for mission critical equipment and indications.

NOTE:

RCS hot leg piping is completely submerged at El. 1,007.75 ft.

5.5. **WHEN** containment level exceeds 1,007 ft., **THEN** monitor for initiation of Shutdown cooling.

5.5.1. **IF** Shutdown Cooling has been established, **THEN** use attachment 6.8 to monitor system performance.

5.5.2. **IF** Shutdown Cooling can **NOT** be established, **THEN**

- Consider opening PORVs to ensure the RCS is adequately vented.
- Implement the SAMGs.
- Assess the need to continue filling of containment.

6. ATTACHMENTS

6.1. ECCS System Status Check

6.2. Available Decay Heat Removal Duration Worksheet

6.3. Estimation of Required Volume for Containment Fill

6.4. Evaluating Makeup Water pH and Boron Concentration

6.5. Identification of Makeup Water Flowpaths to the Demineralized Water System

6.6. Identification of Makeup Water Flowpaths to the SIRWT

6.7. Assessment of Effects of EQ Equipment Submergence

6.8. Shutdown Cooling System Status Check

Attachment 6.1 – ECCS System Status Check

Page 1 of 1

1. Establish Trend Plots for the following parameters:
    - SIRWT Level (L-381/382)
    - Total HPSI Flow (F-313/316/319/322)
    - Charging Flow (F-236)
    - RVLMS
    - Representative CET Temperature
    - Containment Water Level (L-387/388)
2. If needed to support attachment 6.7, use the “Aspen” program or request Process Computing assistance in providing post-RAS data on the following additional parameters:
    - HPSI pump SI-2A/B/C amps
    - HPSI pressure (P-309/310)
    - Containment Pressure (P-744/745)
    - Containment Fan Cooler operation (VA-3A/B, VA-7A/B)

End of Attachment 6.1

Attachment 6.2 – Available Decay Heat Removal Duration Worksheet

NOTE:

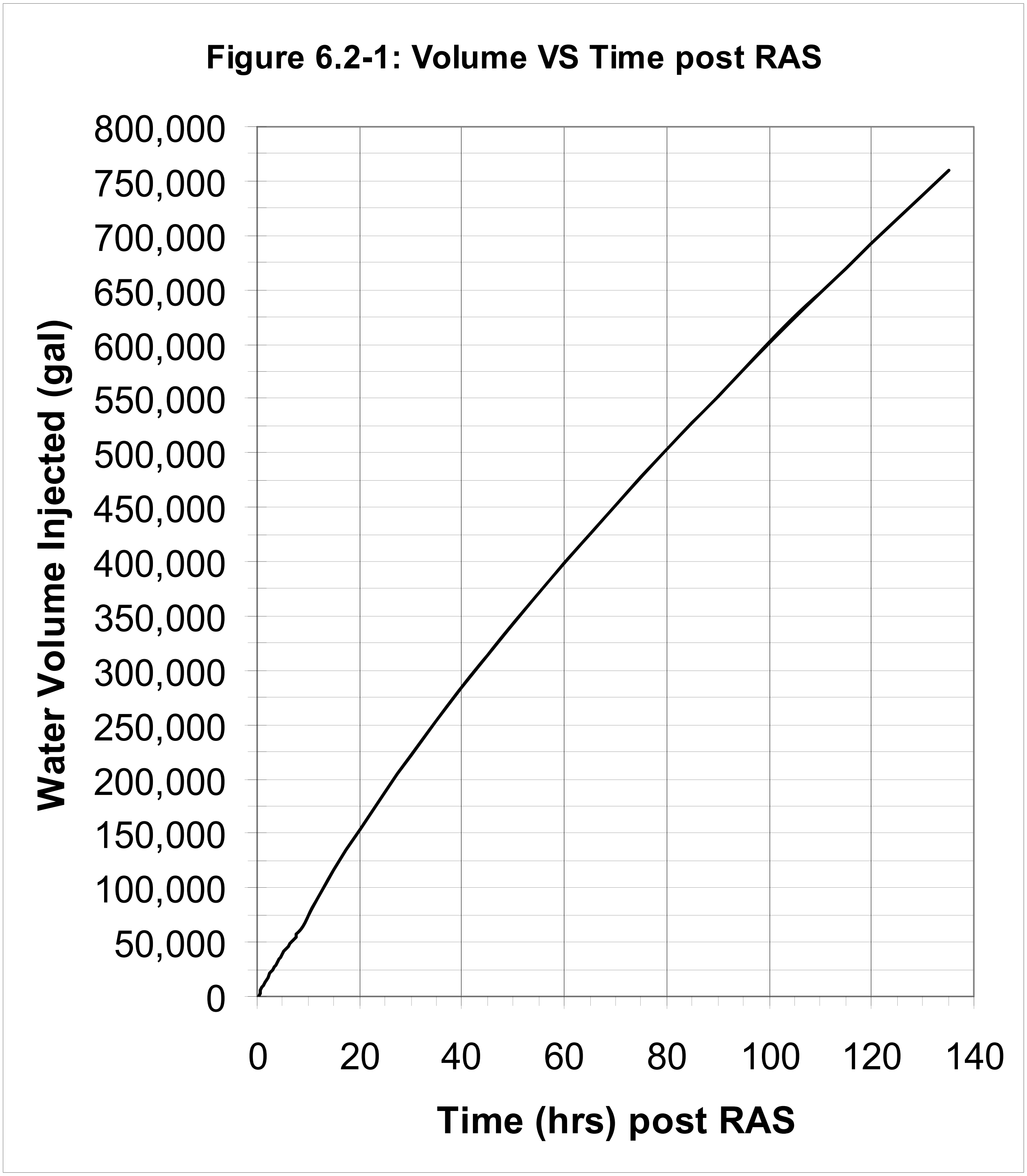
All volumes are based on HPSI flow rate maintained IAW EOP/AOP Attachment 26.

To estimate the amount of decay heat removal time available for a given volume of SIRWT water, perform the following:

1. Determine SIRWT level (Attachment 6.1) : __________ Inches
2. Determine total SIRWT volume using TDB VII: __________ Gallons
3. To establish usable SIRWT volume (above RAS setpoint), subtract 28,000 gallons from volume determined in step 2:
   __________ Gallons (step 2) – 28,000 Gallons =__________ Gallons
4. Determine time since RAS initiation.
5. Plot SIRWT "water volume injected" against time recorded in step 4:
   __________ Gallons
6. Determine total available injection volume (water volume injected plus water volume available for injection) by adding volumes obtained in steps 3 and 4:
   __________ Gallons (step 3) + __________ Gallons (step 5) = __________ Gallons
7. Determine total cooling time available post-RAS by plotting available injection volume established in step 6 on Figure 6.2-1: _____ Hours
8. Establish decay heat removal time available from current SIRWT volume by subtracting time recorded in step 4 from time established in step 6:
   Total time available post-RAS (step 7) _____ Hours – time post-RAS (step 6) _____ Hours = _____ Hours available from current SIRWT volume.

Attachment 6.2 – Available Decay Heat Removal Duration Worksheet

Page 2 of 2



End of Attachment 6.2

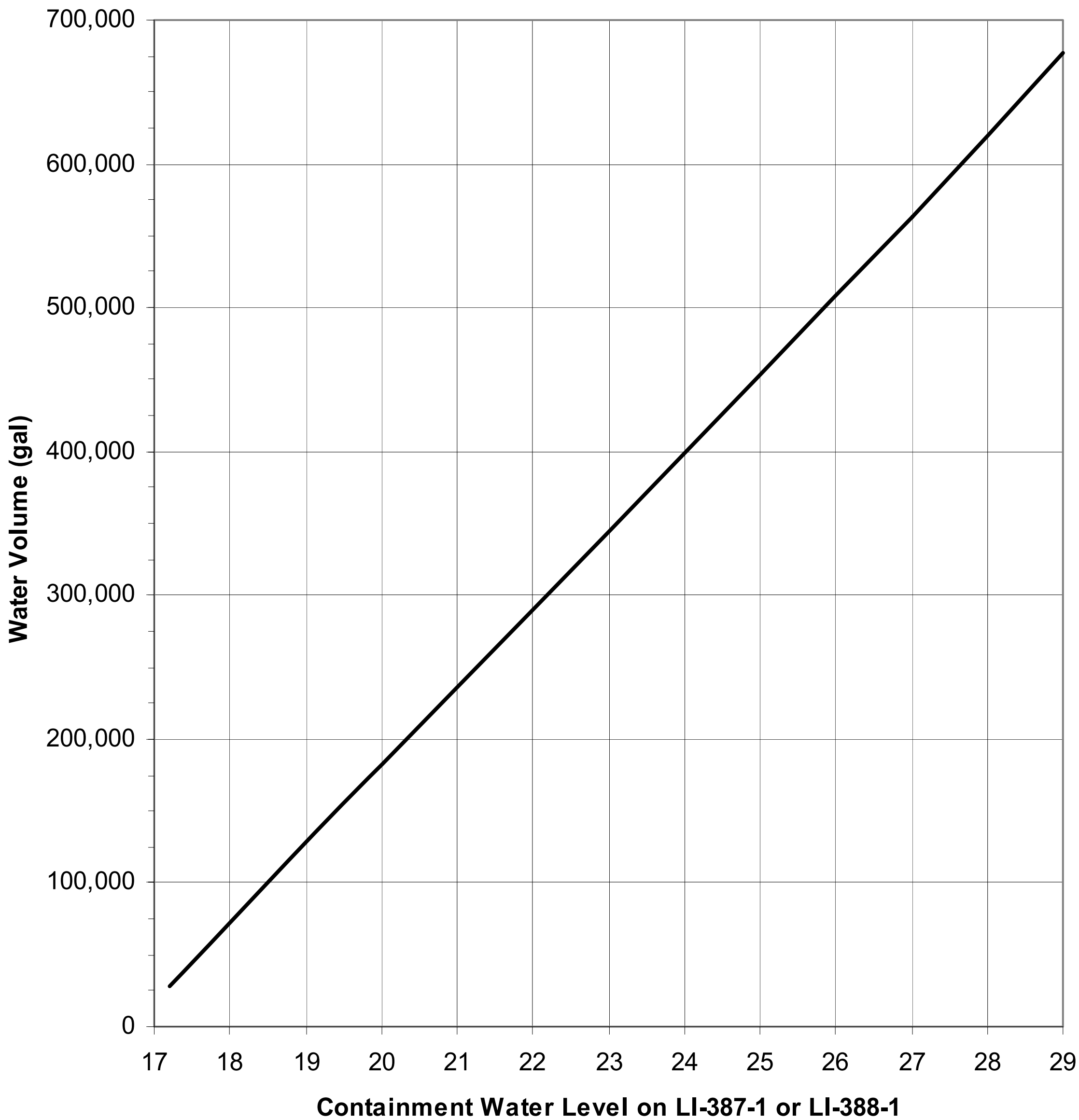
Attachment 6.3 – Estimation of Required Volume for Containment Fill

Page 1 of 2

NOTE:

This figure shows the calculated volume of water in containment as a function of level indicated on LI-387-1 and LI-388-1. Top of indicating range is approximately 27.5 ft.

Figure 6.3-1: Containment Water Volume vs. Indicated Level



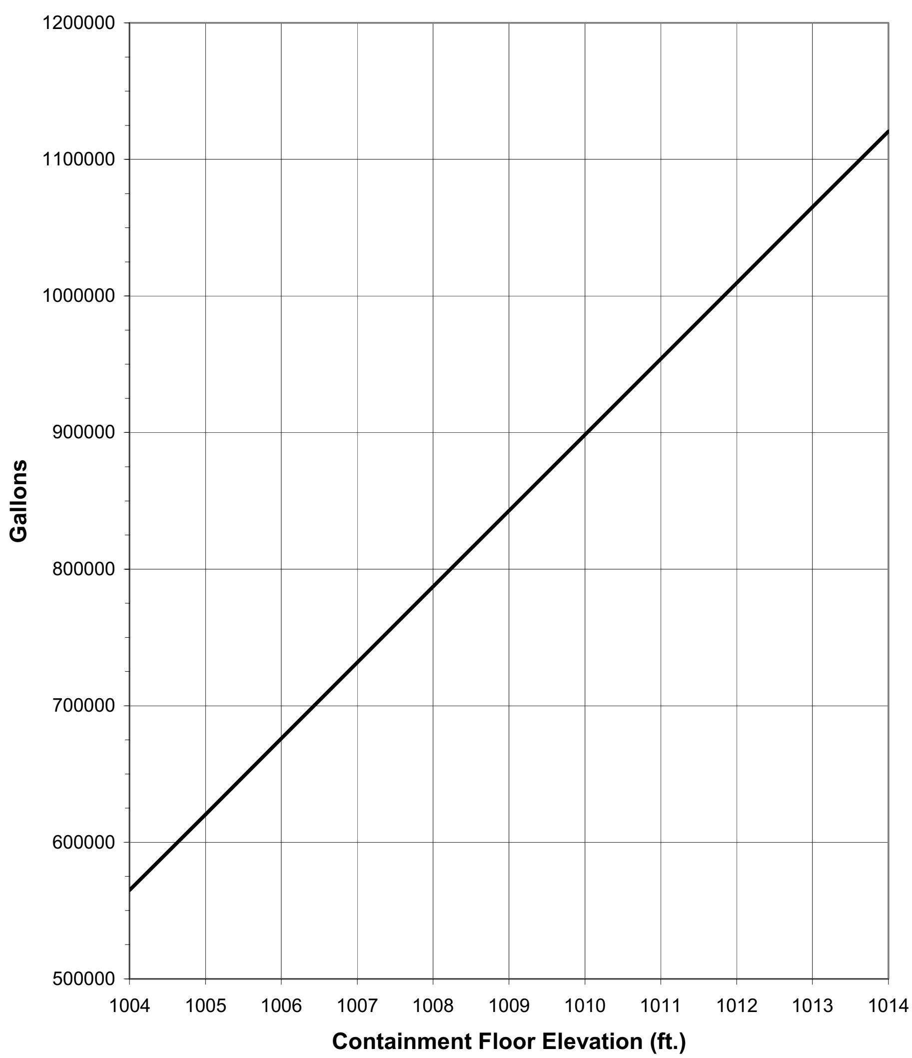
Attachment 6.3 – Estimation of Required Volume for Containment Fill

Page 2 of 2

NOTE:

This figure shows estimated volume required to reach a given water level in containment above the indicating range of LI-387-1 and LI-388-1. This figure overlaps Figure 6.3-1. Top of LI-387/388 indicating range is El. 1,004.5 ft.

Figure 6.3-2:
Containment Water Volume vs. Floor Elevation



End of Attachment 6.3

Attachment 6.4 – Evaluating Makeup Water pH and Boron Concentration

Page 1 of 2

NOTES:

1. **This attachment uses simple mathematical equations to estimate current makeup water pH and boron concentration. Page 1 of 2 tracks actual SIRWT samples. Page 2 of 2 is used to estimate SIRWT boron concentration. Perform periodic sampling to verify/adjust estimations.**
2. **SIRWT boron concentration must remain greater than 1,000 ppm to ensure the reactor will remain shut down.**
3. **pH of the containment water should be assessed if possible. It is expected that containment water pH will remain above 7 for at least 3 days when containment water level is being raised.**
4. **If containment water is approaching a pH of 7, consider addition of a pH buffer to RCS makeup water. Core cooling takes precedence over pH control.**
5. **If better mixing of chemicals in the SIRWT is desired, consider opening HCV-385/386 to recirculate HPSI pump discharge to the SIRWT.**

SIRWT Sampling Data

Sample Time/Date:						
PPM Boron:						
SIRWT Volume (gal):						
SIRWT pH						

Sample Time/Date:						
PPM Boron:						
SIRWT Volume (gal):						
SIRWT pH						

Sample Time/Date:						
PPM Boron:						
SIRWT Volume (gal):						
SIRWT pH						

Attachment 6.4 – Evaluating Makeup Water pH and Boron Concentration

Page 2 of 2

SIRWT Boron Estimates

Estimate current SIRWT boron concentration or predict future SIRWT boron concentration using the following formula:

(Original PPM Boron X Original SIRWT Volume) + (Makeup Water PPM Boron X Makeup Water Volume) ÷ (Original SIRWT Volume + Makeup Water Volume) = New SIRWT PPM Boron

Time/Date*:	________	________	________	________	________	________
PPM Boron:	________	________	________	________	________	________
SIRWT Volume (gal):	________	________	________	________	________	________
Time/Date*:	________	________	________	________	________	________
PPM Boron:	________	________	________	________	________	________
SIRWT Volume (gal):	________	________	________	________	________	________
Time/Date*:	________	________	________	________	________	________
PPM Boron:	________	________	________	________	________	________
SIRWT Volume (gal):	________	________	________	________	________	________
Time/Date*:	________	________	________	________	________	________
PPM Boron:	________	________	________	________	________	________
SIRWT Volume (gal):	________	________	________	________	________	________
Time/Date*:	________	________	________	________	________	________
PPM Boron:	________	________	________	________	________	________
SIRWT Volume (gal):	________	________	________	________	________	________

***NOTE: This is the time for which the estimate is calculated. It can be based on makeup water already added or a future predicted time for when a makeup addition has been completed.**

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 1 of 6

NOTES:

1. **The preferred source of makeup water to the demineralized water system is via the Reverse Osmosis unit. The capacity of the RO system is approximately 125 gpm. If the RO system is not available, or does not provide adequate flow, any of the following alignments may be used, based on availability.**

2. **The alignments provided in this attachment will show the major valves in the intended flow path using the referenced P&IDs. Prior to the implementation of a given flow path, it should be assessed and a complete valve alignment should be developed for use by the operations department.**

3. **The DW booster pumps (DW-8A/B) and the DW transfer pumps (DW-40A/B) are powered from MCC-3C4C-2, which is load shed on SIAS, but not locked out. Therefore, MCC-3C4C-2 can be re-energized and the pumps can be restarted if necessary to transfer water.**

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 2 of 6

1. Blair Water bypassing the Reverse Osmosis unit. Use P&ID page 3 (11405-M-3, Sh. 1).

   Capacity: Unlimited

   Note:

   Conversations with several equipment operators has established that Bypassing RO unit allows higher volume flow (estimated greater than 250 gpm with 40 psi header pressure) and negates need for electric power to RO unit (LOOP where Blair water is still available).

   Flow Path:

   Blair Water → DW-648 → DW-531 → DW-542 → DW-538 → DW-549 → DW-550 → DW-551 → DW-637 → Ecolochem filter trailer (filters bypassed) → DW-64 (augmented by opening DW-626 as necessary) → DW-624 → RO Unit Surge Tank → DW-625 → DW-633 → DW-641 → DW-636 → RO Trailer (RO unit bypassed) → Normal flowpath to demineralized water system.

   Ensure the following valves are closed:

   - DW-554
   - DW-555

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 3 of 6

2. Water Plant Storage Tanks (DW-1, DW-5, DW-6).

   Use P&ID pages:

   3 (11405-M-3, Sh. 1)
   4 (11405-M-3, Sh. 2)
   6 (11405-M-4, Sh. 1)
   8 (11405-M-4, Sh. 3)

   Capacity: Approx. 100,000 gal.

   Notes:

   - Water in water plant storage tanks is clean, but not demineralized. Tanks are flushed periodically.
   - Option 1 provides a more direct path with potential for higher flow rates (if large diameter fire hose can be used).
   - Option 2 provides a path that can be established using already available equipment (spool piece), but at potentially reduced flow rate due to smaller diameter piping and longer piping runs. However, this path could supply the RO unit if demineralization is more important than high flow rate, and power is available to the RO unit.

   Flow Path:

   a. Common section - Tanks to Booster Pumps: Pre-sedimentation Tank→ DW-279 → Clarifier/Softener → DW-280 → Surge Tank → DW-8a or 8b
   b. Option 1 - Booster Pumps to Demineralized Water Tank (DW-39): DW-8a or 8b → Blind flange on 6” line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-MV-367 → LCV-1515 to demineralized water tank.
   c. Option 2 - Booster Pumps to Demineralized Water Tank (DW-39): DW-8a or 8b → Spool piece → DW-288 → DW-289 → Normal RO flow path, bypassing RO unit to demineralized water tank.

   Ensure the following valves are closed:

Common	Option 1	Option 2
• DW-MV-303	• YCV-1592	• DW-542
• DW-612		• DW-277

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 4 of 6

3. Condensate Storage Tank (DW-48).

Use P&ID pages:

70 (11405-M-254, Sh. 4)
65 (11405-M-253, Sh. 4)
6 (11405-M-4, Sh. 1)
8 (11405-M-4, Sh. 3)

Capacity: Approx. 125,000 gal.

Notes:

- Water from this source is high quality demineralized water.
- Water from this source is supplied via a pump capable of very high discharge pressure (approx. 1,100 psi). Care must be taken to avoid overpressurization of some portions of the flow paths.
- Option 1 provides the most direct path but through a smaller (2" diameter) pipe.
- Option 2 provides a less restrictive flow path, but will require more adapters to establish the proper hose connections.

Flow Path:

a. Common section - CST to Condensate Clean-up Hose Connection: CST → FW-684 → FW-1016 → FW-54 → FW-1513 → FW-1230 → hose connection.

b. Option 1 - Condensate Clean-up Hose Connection to Demineralized Water Tank: Hose from condensate clean-up connection to hose connection on demineralized water tank recirculation line → DW-245 → DW-164 to demineralized water tank.

c. Option 2 - Condensate Clean-up Hose Connection to Demineralized Water Tank: Hose from condensate clean-up connection to blind flange on 6" line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-MV-367→ LCV-1515 to demineralized water tank.

Ensure the following valves are closed:

Common	Option 1	Option 2
• FW-683	• DW-244**	• YCV-1592
• FW-1017		
• FW-1151		
• FW-1029*		

* **NOTE:** FW-1029 may be throttled to regulate system pressure.

** **NOTE:** DW-244 could be throttled to provide water directly to DW system.

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 5 of 6

4. Emergency Feedwater Storage Tank (FW-19).

Use P&ID pages:

65 (11405-M-253, Sh. 4)
6 (11405-M-4, Sh. 1)
8 (11405-M-4, Sh. 3)

Capacity: T.S. Minimum - 55,000 gal.

Notes:

- Water from this source is high quality demineralized water.
- Water from this source is supplied via a pump capable of very high discharge pressure (approx. 1,100 psi). Care must be taken to avoid overpressurization of some portions of the flow paths.
- Option 1 provides the most direct path but through a smaller (2” diameter) pipe.
- Option 2 provides a less restrictive flow path, but will require more adapters to establish the proper hose connections.

Flow Path:

a. Common section - EFWST to Condensate Clean-up Hose Connection: EFWST → FW-6 → HCV-1384 → FW-1017→ FW-1513 → FW-1230 → hose connection.

b. Option 1 - Condensate Clean-up Hose Connection to Demineralized Water Tank: Hose from condensate clean-up connection to hose connection on demineralized water tank recirculation line → DW-245 → DW-164 to demineralized water tank.

c. Option 2 - Condensate Clean-up Hose Connection to Demineralized Water Tank: Hose from condensate clean-up connection to blind flange on 6” line DW-152N → Large Fire Hose → Blind flange upstream of DW-MV-142 or DW-MV-132 or DW-MV-367 → LCV-1515 to demineralized water tank.

Ensure the following valves are closed:

Common	Option 1	Option 2
• FW-1016	• DW-244**	• YCV-1592
• FW-170		
• FW-1029		
• FW-1049*		

* **NOTE:** FW-1049 may be throttled to regulate system pressure.

** **NOTE:** DW-244 could be throttled to provide water directly to DW system.

Attachment 6.5 –

Identification of Primary Makeup Water Flowpaths to the Demineralized Water System

Page 6 of 6

5. Training Center/Admin Building Fire Water Head Tank.

   Use Drawing:

   C-4333, Sh. 1

   Use P&ID page:

   3 (11405-M-3, Sh. 1)

   Capacity: Approx. 135,000 gal.

   Notes:

   - Water from this source originally supplied by Blair water.
   - DW-534, which is the bypass around the backflow preventer for the TC/Admin fire water head tank, may held in its closed position by a semi-permanent locking method, such as a tack weld or locking collar. Contact the fire protection engineer for details.

   Flow Path:

   a. Common section - Head Tank to RO Unit/Water Plant: Head Tank (on hill across Hwy. 75) → DW-534 →DW-648 →DW-531 →DW-542
   b. Option 1 - RO Unit: DW-538 → DW-549 → RO Unit or Bypass → Normal flow path to demineralized water tank.
   c. Option 2 - Water Plant: DW-277 → DW-278 → DW-MV-1 → LCV-1506 → Pre-sedimentation tank (DW-1) → Flowpath #2 (described on page 2 of this attachment).
   d. Alternative approach: Large fire hoses from TC/Admin hydrant to RO Unit.

   Ensure the following valves are closed:

Common	Option 1	Option 2
• DW-541	• DW-277	• DW-538
• DW-289		

End of Attachment 6.5

Attachment 6.6 –

Identification of Makeup Water Flowpaths to the SIRWT

NOTES:

1. **This attachment does not address equipment alignment for initial transfer of water from the Fuel Transfer Canal or the Spent Fuel Pool (SFP) to the SIRWT, nor does it address the use of fire water to fill the SIRWT. Those alignments are already defined in EOP/AOP Attachment 25. However, it should be noted that the SFP cooling pumps (AC-5A/B) which are part of the SFP transfer path will be load shed on SIAS and locked out. Therefore, engineered safeguards must be reset before SFP transfer to the SIRWT can be accomplished.**

2. **In all alignments described in this attachment, the source of water is the primary water storage tank. Water is transferred from the demineralized water tank to the primary water storage tank via the demineralized water pumps DW-40A/B. Use attachment 6.5 of this procedure to identify makeup water sources to the demineralized water system.**

3. **The alignments provided in this attachment will show the major valves in the intended flow path using the referenced P&IDs. Prior to the implementation of a given flow path, it should be assessed and a complete valve alignment should be developed for use by the operations department.**

4. **The primary water booster pumps (DW-41A/B) and the De-aerator booster pumps (DW-43A/B) are load shed on SIAS and locked out. Therefore, engineered safeguards must be reset before the pumps can be restarted.**

5. **Flow Path #4 is a direct injection flow path to the RCS, bypassing the SIRWT. However, it is limited by charging pump capacity to 120 gpm.**

Attachment 6.6 –

Identification of Makeup Water Flowpaths to the SIRWT

Page 2 of 5

1. Primary Water Storage Tank (DW-45) to Boric Acid Blending Tee (FCV-269X&Y).

   Use P&ID pages:

   9 (11405-M-5, Sh. 1)
   10 (11405-M-5, Sh. 2)
   142 (E-23866-210-121, Sh. 2)

   Notes:

   - Approximate flow through normal flow path is 100-125 gpm.
   - Higher flow rates may be achieved by bypassing PCV-1553.

   Flow Path:

   a. Normal flow path - PWST → Primary Water booster pumps (DW-41A/B) → Vacuum De-aerator (DW-42) → De-aerator Booster Pumps (DW-43A/B) → De-aerated demineralized water header → FCV-269X → FCV-269 → CH-152 →SIRWT.
   b. Alternate flow path - PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119→ DW-127 → DW-128 → De-aerated demin water header → FCV-269X → CH-152 →SIRWT.
   c. Option 2 - Booster Pumps to Demineralized Water Tank (DW-39): DW-8a or 8b → Spool piece → DW-288 → DW-289 → Normal RO flow path, bypassing RO unit to demineralized water tank.

   Ensure the following valves are closed:

   - DW-156
   - DW-157
   - DW-158
   - DW-497
   - DW-547

Attachment 6.6 –

Identification of Makeup Water Flowpaths to the SIRWT

Page 3 of 5

2. Primary Water Storage Tank (DW-45) to Fuel Transfer Canal.

Use P&ID page:

9 (11405-M-5, Sh. 1)

Notes:

- Multiple hoses may increase flow rate. However, total flow will be restricted due to all connections being supplied by the same 1 ½" supply line.
- Boric acid would be added directly to the canal, with hose flow acting to mix the crystals into solution.

Flow Path:

a. Common Supply – PWST → Primary Water booster pumps (DW-41A/B) → Vacuum De-aerator (DW-42) → De-aerator Booster Pumps (DW-43A/B) → De-aerated demineralized water header → De-aerated demineralized water header → Hose bibs in Room 27 or Corridor 26 → Hoses dump to fuel transfer canal.
b. Room 27 – Three hose connectors: DW-281, DW-282, WD-566
c. Corridor 26 – Two hose connectors: DW-251a, DW-252.

Attachment 6.6 –

Identification of Makeup Water Flowpaths to the SIRWT

Page 4 of 5

3. Primary Water Storage Tank (DW-45) to SIRWT via Boric Acid Storage Tanks (CH-11A/B).

   Use P&ID pages:

   9 (11405-M-5, Sh. 1)
   10 (11405-M-5, Sh. 2)
   141 (E-23866-210-121, Sh. 1)
   142 (E-23866-210-121, Sh. 2)

   Notes:

   - Flow rate through this path will be limited to the capacity of FCV-269Y.

   Flow Path:

   a. PWST to Boric Acid Batch Tank – PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119 → DW-147 → CH-278 → Boric Acid Batch Tank → CH-104 or CH-105 → BAST(s).

   b. BAST to SIRWT – CH-4A/B → FCV-269Y → FCV-269 → CH-152 → SIRWT.

Attachment 6.6 –

Identification of Makeup Water Flowpaths to the SIRWT

Page 5 of 5

4. Primary Water Storage Tank (DW-45) to RCS via Boric Acid Storage Tanks.

   Use P&ID pages:

   9 (11405-M-5, Sh. 1)
   10 (11405-M-5, Sh. 2)
   141 (E-23866-210-121, Sh. 1)
   142 (E-23866-210-121, Sh. 2)
   136 (E-23866-210-120, Sh. 1)

   Notes:

   - This flow path will allow for direct RCS injection at a maximum of 120 gpm. Sustained flow rate will be limited to the rate at which demin water can be supplied to the BAST via the 2" boric acid batch tank transfer piping. This flow rate has historically been quite small.
   - CH-202 will allow for a charging flow path to RCS loop 1A even if charging loop injection valves fail closed.

   Flow Path:

   a. PWST to Boric Acid Batch Tank – PWST → Primary Water booster pumps (DW-41A/B) → PCV-1553 or DW-119 → DW-147 → CH-278 → Boric Acid Batch Tank → CH-104 or CH-105 → BAST(s).
   b. BAST to RCS – CH-4A/B → HCV-268 → Charging pump(s) (CH-1A/B/C) → Normal charging flow path → RCS.

End of Attachment 6.6

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 1 of 6

NOTES:

1. **As containment water level is raised above El. 1,000.9 ft., EQ equipment will begin to submerge. This attachment identifies mission critical equipment and indications that may be affected due to submergence of cabling, connections, or the components themselves.**

2. **Often, cabling or a containment penetration is the first part of a component to become submerged. The component may not be disabled by this initial submergence.**

3. **Table 6.7-1 shows all components by minimum submergence level.**

4. **Components in tables 6.7-2 thru 6.7-6 are grouped by function. The minimum submergence level is shown, and alternate means of accomplishing the function (coping strategy) are provided.**

5. **Data collected in Attachment 6.1 should be used to assist in implementation of the coping strategy.**

Table 6.7-6: Minimum Submergence Elevations

Elevation	Component Tag #
1,001	FT-316
1,001.3	FT-313
1,002	FT-319 FT-322
1,003	HCV-348
1,003.3	A/TE-112H B/TE-112H A/TE-122H B/TE-122H YE-116A (HJTCs) Core Exit T/Cs
1,005	LT-387 A/B/C LT-388 A/B/C
1,005.9	HCV-311 HCV-320
1,006	HCV-318 HCV-315 HCV-329
1,006.9	HCV-320
1,007.9	HCV-725A/B
1,013	HCV-724A/B

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 2 of 6

Table 6.7-2: HPSI Flow Control			
Tag #	Elev.	Description/Function	Coping Strategy*
FT-313	1,001.3	HPSI Flow Transmitters. Used for determination of effect of throttling HPSI.	Estimate flow rate based on the following: 1. HPSI header pressure. 2. HPSI pump amps. 3. Rate of change of SIRWT level.
FT-316	1,001		
FT-319	1,002		
FT-322	1,002		
HCV-311	1,005.9	HPSI Loop Injection Valves. Throttled to minimize injection rate.	4. Utilize HCV-312/314/317/321 for throttling HPSI flow. 5. De-energize valves in throttled position prior to submergence. 6. Hand jack HCV-308 & HCV-307 to throttle flow.
HCV-315	1,006		
HCV-318	1,006		
HCV-320	1,005.9		

***Description of HPSI Flow Control Coping Strategies:

1. Estimate flow based on HPSI pump discharge pressure – Utilize HPSI pump curve to determine total flow rate, based on discharge pressure. Adjust based on recorded flow rates vs. pressures.

2. Estimate flow based on HPSI pump discharge pressure – Utilize HPSI pump curve to determine total flow rate, based on power consumption. Adjust based on recorded flow rates vs. amperage.

3. Estimate flow based on rate of change of SIRWT level – Figure 6.7-1 shows rate of change of SIRWT level vs. injection flow rate, with no makeup flow. Find injection flow rate based on SIRWT level change (number will be negative if SIRWT level is rising) and add makeup flow rate to determine actual injection flow rate.

4. Utilize HCV-312/314/317/321 for throttling HPSI flow – If all of these valves are operable, then throttle HPSI flow with those valves and close HCV-311/315/318/320 and de-energize to prevent spurious operation.

5. De-energize valves in throttled position prior to submergence – De-energizing valves will prevent spurious operation

6. Hand jack HCV-308 & HCV-307 to throttle flow – If HPSI flow must be throttled further and all HPSI valves are de-energized, HCV-308 and HCV-307 can be hand jacked in a throttled position to further reduce flow.

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 3 of 6

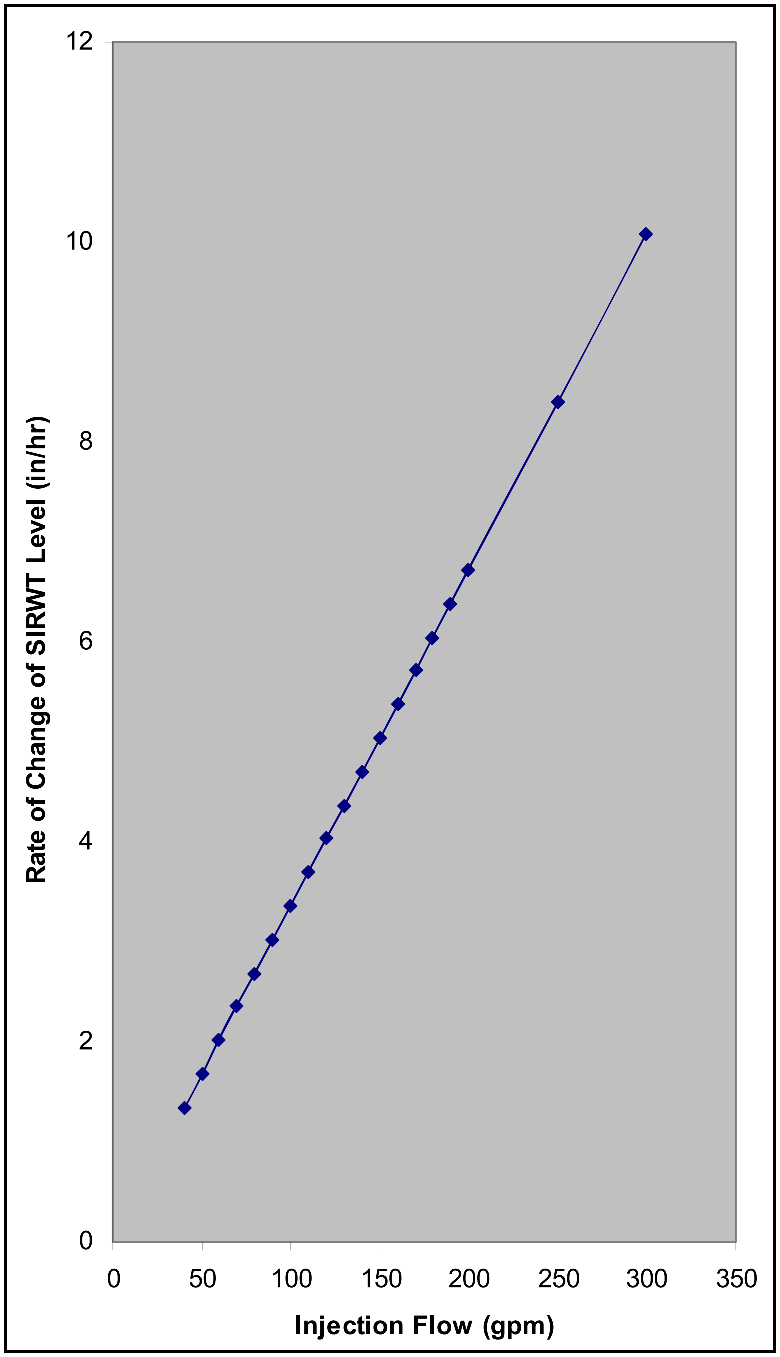


Figure 6.7-1: SIRWT Level Change vs. Injection Flow Rate

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 4 of 6

Table 6.7-3: Water Levels

Tag #	Elev.	Description/Function	Coping Strategy*
LT-387 A/B/C	1,005	Containment Water Level. Used to monitor approach to covering hot leg. This instrument is out of range high at El. 1004.5 ft.	1. Estimate water level based on total volume added to containment. 2. Use PI-303A/B/C on the idle CS pump(s) to estimate level based on elevation head.
LT-388 A/B/C	1,005		
YE-116A	1,003.3	HJTC-MI Cable System for RVLMS. Used to determine when water level is above top of core.	3. Use RVLMS. 4. See 1 & 2, above.

*Description of Water Level Measurement Coping Strategies:

1. Estimate water level based on total volume added to containment – Use Figure 6.3-1 to determine containment water volume at the last known level, then use Figure 6.2-1 to determine volume injected from that time to present.

2. Use PI-303A/B/C on the idle CS pump(s) to estimate level based on elevation head – Even with ECCS sump strainers SI-12A/B clogged, there will be enough permeability in the debris bed for pressure due to the elevation head of the sump water to be transmitted through the recirculation piping. With the CS pumps idle, the pressure seen at the CS pump discharge will be equivalent to elevation head of the containment water plus containment pressure. Subtract containment pressure (in PSIG) from CS pump discharge pressure, the convert to feet of head. Add elevation of CS pump discharge transmitter to elevation head to determine water level elevation in containment. PI-303A/B/C are normally isolated. Local operator action will be required to obtain CS pump discharge pressure.

3. Use RVLMS – MI cables for RVLMS are have been qualified for a boric acid spray environment and are likely to be available even if submerged.

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 5 of 6

Table 6.7-4: RCS Temperatures			
Tag #	Elev.	Description/Function	Coping Strategy*
A/TE-112H B/TE-112H A/TE-122H B/TE-122H	1,003.3 1,003.3 1,003.3 1,003.3	RCS hot leg temperatures. Used to verify effectiveness of recirculation/once-through cooling/SDC.	1. Use channel C or D temperature indications. 2. Sample RCS hot legs via HCV-2500/2501 through HCV-2504A/B (TE-2513, outlet of sample cooler).
Core Exit Thermocouples	1,003.3	MI Cable System for CETs. Used to determine core exit temperature.	3. RVLMS - HJTC Unheated Thermocouples 4. See 1 & 2, above.

*****Description of RCS Temperature Measurement Coping Strategies:

1. MI cables for RVLMS are have been qualified for a boric acid spray environment and are likely to be available even if submerged.

2. Use channel C or D temperature indications – Train "A" and "B" Hot leg temperature elements may become submerged due to their containment penetration elevation. Therefore, Train "C" & "D" should still be available.

3. Eventually, all four hot leg temperature detectors may be submerged, if SDC cannot be initiated prior to completely covering the hot legs. However, at this point, RCS temperature should be low enough to allow a sample to be taken without CCW supplied to the sample heat exchanger. TE-2513 can then be used to trend RCS temperature.

Table 6.7-5: Containment Cooling			
Tag #	Elev.	Description/Function	Coping Strategy
HCV-725A/B	1,007.9	Containment Fan Cooler dampers. CFCs are primary means of removing decay heat from containment.	De-energize dampers in open position before submergence.
HCV-724A/B	1,013	Containment Fan Cooler dampers. CFCs are primary means of removing decay heat from containment.	De-energize dampers in open position before submergence.

Attachment 6.7 – Assessing Effects of EQ Equipment Submergence

Page 6 of 6

Table 6.7-6: Shutdown Cooling Initiation			
Tag #	Elev.	Description/Function	Coping Strategy
HCV-348	1003	SDC Suction Valve. Needed to establish SDC.	Open and de-energize valve prior to submergence. This direction is already provided in EOP.
HCV-327	1,006.9	LPSI Loop Injection Valves. Needed to align SDC.	Open and de-energize valves prior to submergence. This direction is already provided in EOP.
HCV-329	1,006		

End of Attachment 6.7

Attachment 6.8 – Shutdown Cooling System Status Check

Page 1 of 1

NOTE:

This attachment contains a list of SDC related parameters to be monitored when SDC is established.

1. Establish Trend Plots for the following parameters:
   - SDC Temperatures (T-346X/Y)
   - SDC Flows (F-326/339/340)
   - CCW Temperatures (T-486/487)
   - RVLMS
   - Representative CET Temperature

End of Attachment 6.8

Fort Calhoun Station
Unit 1

FCSG-39

GUIDELINE

OPERATIONAL CONTINGENCY ACTION GUIDELINE

Change No.	EC ~~37248~~
Reason for Change	~~Update OCAG to reflect receipt of monitor nozzles, relocation of SFP patches and add words to consider sandbagging when using spray for release mitigation.~~
Preparer	J. Koske
Editorial Correction (a) (b)	~~Pages 34, 35, and 38 (12-20-05)~~ ~~Pages 31, 32, 38, 51 and 52 (01-24-06)~~
Issue Date	09-22-05 3:00 pm

NOTE: Prior to making any changes to this guideline, contact Licensing to determine if any B.5.b response items are affected. [AR 36796]

Page: 50

Author: Greg
Subject: Cross-Out
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Incorporate discussion of potential ECCS recirculation strainer clogging event and identify additional guidance for addressing the event.

Author: Greg
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OPERATIONAL CONTINGENCY ACTIONS

SECTION FOUR - RCS MAKEUP RESOURCES

DISCUSSION

Following a long term station blackout event, charging pump flow to the RCS may be lost. With a loss of makeup, RCS inventory will lower due to leakage through the RCP seals and other RCS leakage paths. Unless there is a break in the RCS boundary or pressurizer PORVs and safety valves are opening, RCS inventory will be sufficient to prevent core uncovery for greater than 8 hours.

The charging pumps can be used as a high pressure makeup source once 480 volt power is restored. Section five of this guideline addresses methods for repowering electrical buses at FCS. Various water sources to the suction of the charging pumps exist. They include the VCT, the SIRWT, the BASTs and the Demineralized Water Storage Tanks. The borated water sources, the SIRWT and the BASTs, are the preferred water sources following an extended station blackout.

RCS makeup using charging pumps is addressed in the EOPs.

If the RCS pressure is below the shutoff head of the Safety Injection Pumps and 480 volt power is available, the Safety Injection Pumps can be used to provide makeup to the RCS from the SIRWT.

If the RCS is depressurized and 480 volt power is available, the Boric Acid pumps can also be used. OI-CH-4, “Chemical and Volume Control System makeup Operations”, Attachment 9 addresses use of the Boric Acid pumps for RCS makeup when the RCS is depressurized.

1. Makeup to water storage tanks used to provide water for RCS makeup

1.1 Safety Injection and Refueling Water Storage Tank (SIRWT)

1.1.1 EOP/AOP Attachments, Attachment 25, Methods for refilling the SIRWT Post RAS

1.1.2 SAMG Restoration Attachments, Attachment 1, “SIRWT Makeup from Blair Firewater”

1.1.3 SAMG Restoration Attachments, Attachment 2, “Filling the SIRWT via Gravity Drain from the Fuel Transfer Canal”

1.1.4 SAMG Restoration Attachments, Attachment 3, “Filling the SIRWT via Access Plug (AKA “The Old AOP-04”)

Page: 51

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If ECCS recirculation fails, core cooling can be restored by re-establishing safety injection from a refilled SIRWT.

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1.1.5 TSC Temporary Guideline, "ECCS Recirculation Failure"