ATTACHMENT 1

Engineering Analysis (EA-FC-04-010) Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01

PRODUCTION ENGINEERING DIVISION
GENERAL ENGINEERING INSTRUCTION FORM

PED-GEI-1.1
R4

PROCESSING ENGINEERING ANALYSIS
EA ADMINISTRATIVE CHECKLIST

EA-FC- 04-016	Rev. No.: 0		
	Yes	No	N/A
1. Have both pages of the EA Cover Sheet been included?	✓		
2. Has all required Review Documentation been included and legibly signed?	✓		
3. Are all sections of the EA included and addressed and does the Table of Contents accurately reflect the contents of the EA?	✓		
4. Has the EA number and revision number been correctly provided on each page of the EA?	✓		
5. Has each page of the EA been numbered consecutively?	✓		
6. If Applicable, has an identification number been listed on the EA Cover Sheet as part of the description for all computer programs used in the EA?			✓
7. Have all attachments indicated in Section VIII of the EA, been included?	✓		
8. Have all Attachments been page numbered either separately or as part of the EA?	✓		
9. Is the correct total page number indicated on the EA Cover Sheet?	✓		
10. Does the Record of Revision indicate the correct revision number and the reason for the issue?	✓		
11. Is the EA legible and reproducible?	✓		
12. If applicable, have the microfiche of computer analysis been generated and attached to the EA?			✓
13. Is Form PED-QP-5.6 complete?	✓		
Document Control: Julie Sa[illegible]	Date: 11-23-04		

EA COVER SHEET

EA-FC- 04-010	Rev. No. 0	EC#: ~~30663~~ 35559 MJF 11/23/04	Page No. 1
EA TITLE (include computer program designation):			Total Pages 91

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

QA CATEGORY:
- X CQE
- ___ Fire Protection
- ___ Non CQE
- ___ Limited CQE

REPORT TYPE:
- ___ Revision
- X Analytical Report
- ___ Special

ENGINEERING ANALYSIS TYPE:
- ___ Electrical Equipment Qualification (EEQ)
- ___ Seismic Equipment Qualification (SEQ)
- ___ Core Reload Analysis (CRA)
- ___ Fire Hazards Analysis (FHA)
- ___ Cable Separation Analysis (CSA)
- ___ Associated Circuits Analysis (ACA)
- ___ Safe Shutdown Analysis (SSA)
- ___ Computer Code Error Analysis (CCE)
- ___ Nuclear Mat'l Accountability(NMA)
- X Operations Support Analysis (OSA)
- ___ USAR Justification (USJ)
- ___ OTHER: ___

INITIATION: PED Department No. 357 Preparer Michael Friedman Initiation Date 3/5/04

REVIEW ASSIGNMENT (*name or group - by Preparer or Responsible Department Head*):

		Date
Reviewer	Joe Connolley	3/8/04
Independent Reviewer	Doug Molzer	3/8/04
*Interdisciplinary Review	Robert Luikens	3/8/04
** Mgr - Station Eng./Mgr - DEN		

*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 [signature] Date 3/23/04

OWNER ASSIGNMENT (by Department Head)
Name Michael Friedman Date 3/8/2004

EA CLOSE-OUT (Document Changes listed on PED QP-5.6) Completed PED QP-5.6 transmitted to Document Control.
Name [signature] Date 11/23/04

Condition Report (SO-R-2) written based on the results of this EA?
___ Yes CR ___ X No

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	✓			

EA COVER SHEET 35559

EA-FC- 04-010	Rev. No. 0	EC#: ~~30663~~ 35559	Page No. 2
[352] Manager - System Eng. [840] Manager - Operations [800] Training Program Configuration Management			

PREPARATION/REVIEW (signatures):

Preparer(s) Michael Friedman; [signature] (WD Associates) Date 3/10/04; 3/10/04

Reviewer(s) Joseph L. [signature]; [signature] Date 3/10/04; 3-22-04

Independent Reviewer(s) [signature] Date 3-22-04

Interdisciplinary Reviewer(s)* R. [signature] Date 3/23/04

*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

INPUT EA's & CALCS

1. FC06639 Rev 1: "Containment Spray Pump Minimum Performance Requirement."
2. FC06965 Rev 0: Westinghouse DAR-OA-03-16 "Evaluation of Emergency Core Cooling by Alternate Water Source in the Absence of Sump Recirculation."
3. OSAR 85-33; Electrical Equipment Qualification Environment Determination, Appendix B, Containment Flood Level Calculations
4. FC06728; Rev 0: "Calculation of Containment Free Volume"
5. FC05777 Rev 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."

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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 REFERENCE 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? EOP/AOP REVISION TO FOLLOW		✓	
14.	Are 10 CFR 50.59 (FC-154A) screening forms included with the document changes as required? PERFORMED AS PART OF EOP/AOP CHANGES.		✓	
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 Revisions 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?			✓

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EA REVIEWER CHECKLIST		Yes	No	N/A
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.			✓
24.	Are final computer runs correctly identified?			✓
25.	Is the computer program validated and verified in accordance with NCM-1?			✓
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: 13/14 – EOP/AOP CHANGES AS A RESULT OF THIS EA HAVE NOT BEEN FORMALIZED AT THIS TIME. CR 200302218 WILL DOCUMENT ASSOCIATED PROCEDURE CHANGES. DSM.

Reviewer	Date	Department	Organization
[signature]	3-22-04	357	DEN-MECH

PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

PED-QP-5.3
R8

EC#: ~~30663~~ 35559 MJ 11/13/04 EA-FC-04-010 Rev.: 0

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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)?	✓		
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:

[signature]	3-22-04	357	DEN - MECH
Independent Reviewer	Date	Department	Organization

PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

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R7

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RECORD OF REVISION

Rev. No.	Description/Reason for Change
0	Initial Issue

PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

PED-QP-5.5
R7

EC#: ~~30003~~ 35559 MJ 11/21/04

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COMMENT FORM

Reviewer Doug Molzer

Organization DEN-M

Page 1 of 5

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

Date 3/22/2004

COMMENT TYPE CODES*
*Editorial (ED)
*Technical (TC)
System Interaction/
Design Change (DCC)

RESOLUTION CATEGORY**
1=Resolution Required
2=Nonmandatory Recommendation

Comment Number	Comment Type Code*	Page	Comment	**	Resolution
			See Attached for Comments and Resolution		

PED-QP-5.5 Comment Review Form
EA-FC-04-010 Revision 0: Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01
Comments from Doug Molzer
Date: 3/22/2004

Comment Number	Page	Comment	Resolution
1	No numbered	EA affected documents form QP-5.6 has not been completed.	Form has been completed
2	1	I believe the "r" in "response" should be capitalized.	Corrected
3	EA cover sheet	QA category: CQE and non-CQE are both checked off. No distinction is made within the EA as to the sections in the evaluation that are safety-related or non safety-related. Never seen this done before. Discussed this issue with Kevin Holthaus in DEN Nuclear and he indicates they have never had an EA that was both non-CQE and CQE.	Due to the nature of the actions being evaluated in this EA, some sections are CQE and others are not. In general, the preemptive compensatory actions that occur prior to strainer clogging affect operation of CQE equipment that is still operating within its design basis; therefore has to be evaluated as CQE. The responsive corrective actions that occur following strainer clogging (a beyond design basis event) are non-CQE. Revised Section 2.0, Scope, to distinguish which sections of the EA are CQE.
4	6, section A, 2 nd paragraph	Reference the analysis that shows the sumps are currently in compliance with ref. 3.7 with 50% blockage.	No analysis has been found that shows the sumps are in compliance with the 50% blockage criterion. By letter from OPPD to NRC dated 5/1/1978, OPPD responded to NRC questions raised during their review of the license amendment request associated with License Amendment 52. OPPD stated that the sumps are in compliance with RG 1.82 R0 except for 4 items dealing with (1) the slope of the basement floor, (2) screen approach velocity larger than recommended, (3) the top of the strainer was mesh rather than solid, and (4) the sump screens were not specifically inspected during each refueling. No exception was taken to the 50% blockage criterion. On October 1980 the NRC

∞

PED-QP-5.5 Comment Review Form
EA-FC-04-010 Revision 0: Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01
Comments from Doug Molzer
Date: 3/22/2004

			issued an SER for license amendment #52 accepting the proposed changes and supporting documentation. As such, the NRC concurred in 1980 that the FCS sump screens were in compliance with RG 1.82 R0. Revised the EA section to state that the sumps are in compliance with the RG; and removed specific reference to the 50% blockage criterion. Added reference to 5/1/1978 letter to the NRC.
5	8, 1 st paragraph	EA states that only local pressure indication is available. HPSI discharge pressure indication, PI-309 is available in the control room	The HPSI header discharge pressure indicators (PI-309/310) are referenced in Table 5.1-1 and are used in the diagnosis of sump inoperability. Added reference to the HPSI header pressure indicators on p. 8 discussion regarding installed instrumentation.
6	13 last paragraph	EA states that CS actuation is initiated by SIAS. Logic actually requires both PPLS and CPHS. A SIAS can be generated from either a PPLS o r CPHS. Needs to be clarified.	Clarified
7	14, third paragraph	While it's true that CFC's will remove sufficient heat to limit pressure rise, they are not credited in Ch 14 for LOCA mitigation.	Added this statement of clarification to the paragraph
8	15, second bullet	Quantitative criteria has not been specified for sump inoperability, yet it is definitively stated that pump failure will result.	Changed the statement to say that "Taking no action upon indications of sump inoperability may result in degradation or failure..."

6

PED-QP-5.5 Comment Review Form

EA-FC-04-010 Revision 0: Recommendations for Implementing of Compensatory Actions in Response to NRC Bulletin 2003-01

Comments from Doug Molzer

Date: 3/22/2004

9	18	Fig 2 is of poor quality. Difficult to read.	Replaced Figures with more readable quality figures
10	25	Section is titled, "Effect of Rising Water Level on Components, Penetrations and Cables", yet there is no stated consequences or impact statement.	Added impact statement at the end of the section.
11	31	Radiological considerations. No impact statement on source term reduction.	After discussion with the reviewer, the paragraph was removed. The impact on source term reduction was discussed earlier in the evaluation on p. 15. Having this paragraph on p. 31 adds no value and is confusing.
12	31, forth bullet	Editorial. Add "for".	Corrected
13	31, fifth bullet	Do you mean, "below" 1000.9. It reads now as "above".	"above" is correct in this instance. The statement is intended to convey that as containment water level is raised above the EEQ flood level of 1000.9 ft, that submergence of non-submergence qualified equipment may cause erroneous readings or failures.
14	32, step 3, second paragraph	Editorial. Add "a" after "to".	Corrected
15	18	Suggest placing Figure 5.1-1 under graph. Not easy to distinguish this graph as Fig. 5.1-1. Same with other graphs.	Incorporated
16	33, forth paragraph	Provide reference to source document for ...3 out of 4 SIT tanks. Also, it would be SI tanks or SITs.	Inserted Reference, Corrected usage for SIT

17	33	Provide ref. document for 450 gpm flow. Seems to be run out flow number. Not a typical flow value in conjunction with other pumps running.	Changed the value for HPSI flow rate in this section to a nominal 400gpm and added references. Also changed total strainer flow rates to use more conservative numbers as described in the resolution of comment 18 below.
18	35, second bullet	3100 is for single pump flow. Non-conservative assumption for argument.	Corrected Used conservative flow numbers from Calculation FC05777 for the various pump/header configuration and containment pressure values.
19	37, second bullet	USAR 6.2.3.3 and 14.15 assumes 35% HPSI spillage	Corrected
20	45, first bullet	Wouldn't this also be an indication or symptom of discharge blockage such as a MOV(s) closing.	Yes The sump inoperability criteria require any of the conditions existing on 2 or more operating, or previously operating pumps. This is to minimize the risk of misdiagnosis of sump clogging due to an equipment malfunction such as the closure of a discharge MOV.
21	49	Editorial. First sentence is not grammatically correct.	Corrected
22	50, step 6.3, last paragraph	Provide PRA assessment reference for this conclusion.	Removed reference to positive risk benefit.
23			

EC#: ~~30663~~ 35559 MJ 7/11/12/04 EA-FC- 04-010 Rev.: 0

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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 a 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.
	Change to a DBD, USAR, etc., and plant procedures (no hardware) identified. EA is closed on receipt of the completed QP-5.6 form.
X	No documents changes or other changes are required. EA is closed on receipt of the completed QP-5.6 form. EA provides supporting analysis for EOP/AOP changes listed below. The document changes do not need to be completed prior to closure of this EA. Changes to the below documents are tracked by CR# 200302218 Action Item 3.

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 review or substantiate a 10CFR50.59 review.

Affected Documents		
Document Type	Document Number (NA if not applicable)	Procedure Change No, LAR No., etc.
Emergency Operating Procedure*	EOP-03 EOP-20	CR#200302218
Abnormal Operating Procedure*	AOP-22	CR#200302218
Annunciator Response Procedure	NA	NA
Technical Data Book	New	CR#200302218
Surveillance Test Procedure	NA	NA
Calibration Procedure	NA	NA
Operating Procedure	NA	NA

EC#: ~~30663~~ 35559 MJ 11/12/04 EA-FC- 04-010 Rev.: 0

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Affected Documents		
Document Type	Document Number (NA if not applicable)	Procedure Change No, LAR No., etc.
Maintenance Procedure	NA	NA
P.M. Procedure	NA	NA
E.P/E.P.I/R.E.R.P.*	NA	NA
Security Procedures * (Safeguards)*	NA	NA
Operating Instruction	NA	NA
System Training Manuals	NA	NA
Technical Specification*	NA	NA
U.S.A.R	NA	NA
Licensing Commitments	NA	NA
Standing Order	NA	NA
Security Plan (Safeguards)	NA	NA
CQE List	NA	NA
Vendor Manual Changes	NA	NA
Design Basis Documents	SDBD-SI-CS-131 SDBD-SI-HP-132	CR#200302218
Equipment Data Base	NA	NA
Oil Spill Prevention, Control and Countermeasure (SPCC) Plan	NA	NA
EEQ Manual	NA	NA
SE-PM-EX-0600	NA	NA
Updated Fire Hazard Analysis	NA	NA
EPIX	NA	NA
Electrical Load Distribution Listing (ELDL)	NA	NA
Station Equipment Labeling (FC-Label-1)	NA	NA
Engineering Analysis	NA	NA
Calculations	NA	NA
Drawing Number	NA	NA
Drawing Number	NA	NA
Other	TBD-EOP-03 TBD-EOP-20 TBD-AOP-22	CR#200302218

EC#: ~~30663~~ 35559 MJ 11/23/04 EA-FC- 04-010 Rev.: 0

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Completed By: N/A
Owner (if Plant Procedure Changes Required or n/a) Date

Completed By: Michael Friedman [signature] 3/26/04
Preparer Date

EC#: ~~30663~~ 35559 MM 11/23/04 EA-FC- 04-010 Rev.: 0
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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		

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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:

None

Preparer	Date	Department	Organization
Michael Friedman (signature)	22March 2004	DEN-M 357	OPPD

Engineering Analysis:

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

Revision 0
March 26, 2004

TABLE OF CONTENTS

TABLES:

FIGURES:

1.0 PURPOSE

This EA provides Engineering recommendations for responding 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.

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 recommendations contained in this EA are not intended for plant operations following the resolution of GSI-191. This EA provides technical justification and analysis for procedural changes to EOP's and AOP's to implement the interim compensatory measures.

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.

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 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, dated June 9, 2003

3.2 LIC-03-0105, Fort Calhoun Station Unit 1, 60 Day Response to NRC Bulletin 2003-01, dated August 8, 2003

3.3 EOP-03, Loss of Coolant Accident, Rev. 24

3.4 EOP-20, Functional Recovery Procedure, Rev. 11

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 223

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. 0, 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 Dated 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, dated 5/1/1978.
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.

4.0 ASSUMPTIONS

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

5.0 ANALYSIS

5.1 Response to Sump Clogging

The Emergency Operating Procedures (EOP) and Emergency Procedure Guidelines (EPG) currently do not include strategy or guidance to specifically address symptoms indicative of sump clogging. This condition is not considered within the current design basis. This section will evaluate:

- 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

FCS procedures do not specifically address symptoms of a degraded sump screen. 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 EOP's 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

Definitive indications of sump screen clogging 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 these indications.

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)

The 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.

Diagnosis of Pump Distress Using Local Indications

The suction lines from the containment sump are equipped with taps that could be used to install temporary pressure gages for monitoring of suction pressure. This would require a plant modification to allow the installation to remain in place during normal operations. Local discharge pressure indicators can be unisolated during the event and individual pump discharge pressures monitored and trended if resources allow. These indications are not available in the control room and require access to the SI Pump Rooms for monitoring. 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 could be dispatched to the SI Pump Rooms to monitor for excessive noise level that would indicate cavitation, or to unisolate and monitor the local discharge pressure indicators. Monitoring and trending of individual pump discharge pressures, in conjunction with containment water level and pressure data, can assist in determining the onset of pump distress due to clogged sump screens.

The following method can be used to obtain pump differential pressure (ΔP) for trending or comparison to pump curves:

Assumptions:

- Sump Water Temperature at RAS = 174°F [3.5; Section 6.2]
- Pump Centerline Elevations: [3.5; Section 6.2]

  HPSI = 972.67 ft.
  CS = 973.25 ft.

- 1 ft water @ 174°F = 0.4216psi [3.35]
- All water levels and elevations in units of feet

Pump differential pressure can be determined by the following:

$$\Delta P = P_{Discharge} - P_{Suction}$$

Where;

$P_{Discharge}$ = PI-323A/B/C (HPSI) and PI-303A/B/C (CS) reading

$P_{Suction} = P_{Level} + P_{Containment\ Vapor}$

P_{Level} = (Indicated Sump Level - Pump C/L Elevation)(0.4216)

$P_{Containment\ Vapor}$ = Indicated Containment Pressure (psig)

Calculation of HPSI Pump ΔP:

$$\Delta P = P_{Discharge} - ((\text{Sump Level} - 972.67)(0.4216) + \text{Cont. Press.})$$

Calculation of CS Pump ΔP:

$$\Delta P = P_{Discharge} - ((\text{Sump Level} - 973.25)(0.4216) + \text{Cont. Press.})$$

A decreasing trend for pump differential pressure can be used in conjunction with other indications to indicate individual pump degradation or sump screen clogging. It is important to note that sump screen clogging should not be diagnosed based on degradation of performance for a single pump.

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
Sump Level	LI-387-1 LI-388-1	No Change	No Change	Sump level unchanged after RAS
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 > 3100 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

It is recommended that procedural guidance be placed in the EOP's to assist the operators in diagnosing sump screen clogging. This guidance should be provided to operator's 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.

Discussion:

Following RAS, the above available indications should be monitored for signs of reduced pump performance. If resources are available, and SI Pump Room dose rates permit, individual pump discharge pressures could be monitored and trended. Local discharge pressure indication and trending is not necessary to confirm an inoperable sump.

The proposed criteria requires 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 proposed 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.

Containment level indication is not included in the proposed criteria because it is not a conclusive indication of sump screen clogging. Water level should remain relatively constant after the RAS occurs due to no injection of additional water sources. Unexpected changes in level may indicate in-leakage from other water sources, leakage outside containment, or pooling inside containment due to blocked choke points along the return path to the sump.

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

B. <u>Contingency Actions in Response to Sump Inoperability</u>

Once sump inoperability is identified, it is important that actions be taken 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 to time on the degraded sump to continue to cool the core.

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 the floor 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 manually transferable between either safeguards bus. 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. 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 60psig 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 limiting LOCA analysis shows that the peak containment pressure results are 57.81psig occurring at 290 seconds, and peak containment temperature results are 280.9°F occurring at 282 seconds [3.5; Section 14.16]. This pressure decreases as the containment is cooled and at RAS initiation (approximately 20 minutes into the LOCA) containment pressure is approximately 50psig and decreasing. At one hour into the event, containment pressure will decrease to approximately 31 psig. [3.9]

If all containment cooling is lost during the LOCA, pressure will rise and approach the design limit of 60psig. 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 60psig [3.14; Section 3.5]. Initial containment testing was performed at 1.15 X Design Pressure (69psig) [3.8]. The containment has a high confidence of low probability of failure (HCLPF) up to pressures of 130psig. The median failure pressure of the FCS containment structure is 190psig. At 190psig the containment has a 50/50 probability of remaining intact. [3.11]

The LOCA analysis assumes operation of one CS pump and one CS header, with one spray nozzle missing and five spray nozzles per header blocked. 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 two CS pumps pre-RAS is 280 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 CFC's operate independent of the CS system to remove heat from the containment atmosphere. The CFC's 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 CFC's will operate.

The CFC's were designed to remove heat from moisture saturated air at 60psig 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]. 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 200×10^6 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 3100gpm post-RAS for the remainder of the 5 hour period [3.5; Section 14.15.8]. The analysis does not credit the containment charcoal filters for removal of iodine in the containment atmosphere. [3.13]

Two of the CFC's 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 [3.13]. 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].

Reference 3.15 assessed the impact of natural deposition on the quantity of radioiodines that are released to the FCS containment atmosphere during a LOCA, and quantified the radiological impact of these radioiodines based on analytical models. The analyses 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. 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 LOCA just by crediting natural deposition.

Quantifying the radiological consequences of a loss of the CS pumps prior to T=5 hours requires additional analysis. 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, preliminary analysis shows a reduction in dose 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 60psig 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 a LOCA just by crediting natural deposition.

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

- The ERO could be notified for consideration of entry into the SAMG Guidelines. It may be appropriate to implement mitigative strategies in the Candidate High Level Actions (CHLA).
- 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 higher particulate and iodine activity in the containment atmosphere.

2. 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 is required.

Injection of water from a refilled SIRWT tank is evaluated as a compensatory measure [3.2] that maintains core cooling. In order for this measure to be considered a success path for long-term core cooling, it is necessary to fill the containment to above the loop level. With the loops covered there are two success path possibilities: 1) countercurrent flow through the break with fan coolers providing the ultimate decay heat removal, or 2) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS. If flooding is not performed to the loop level, then this method is only a temporary measure and will not ensure long-term core cooling.

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 a 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 that can be injected into the containment without violating containment design limits.
- Effect of rising containment water level on plant equipment, components, and installed instrumentation.

a. Reinjection Water Boron Requirement

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 965ppm 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]

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 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 side/cold side 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 due to lower decay heat production. [3.16]

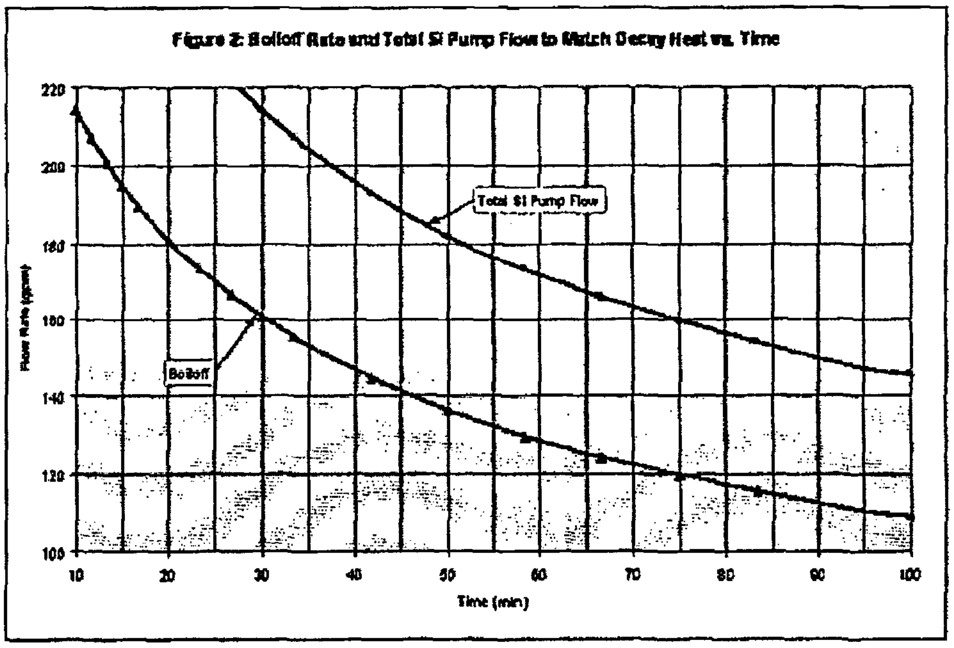

Figure 5.1-1 above shows the Boiloff rate and total SI pump flow to match decay heat vs. time to T=100 minutes [3.16; Figure 2]

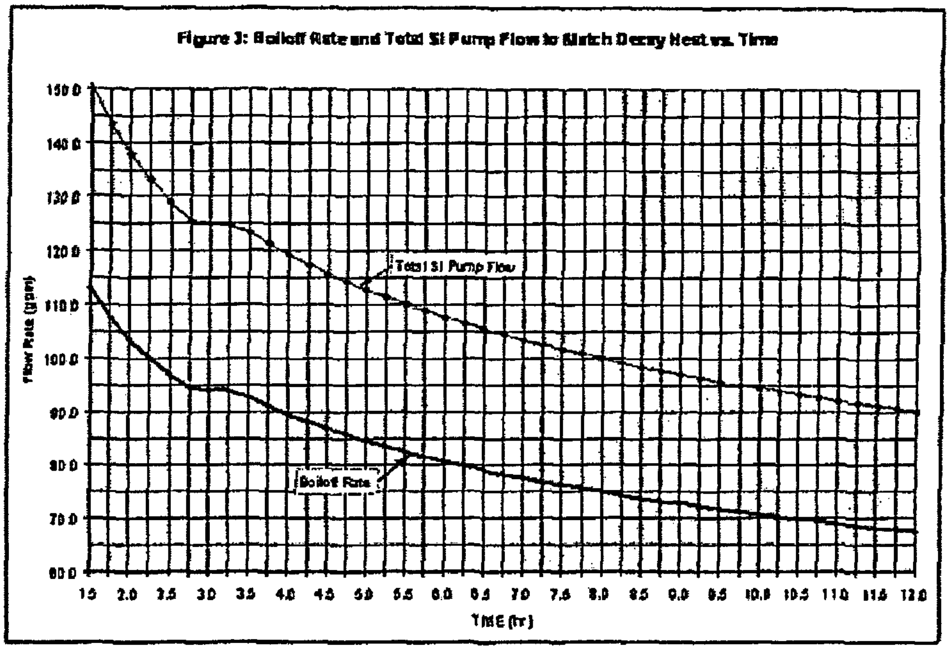

Figure 5.1-2 extends the Figure 5.1-1 graph out to T=12hours: [3.16; Figure 3]

In addition to the SI flow required to remove decay heat, flow 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 side/cold side 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. 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 2400ppm.

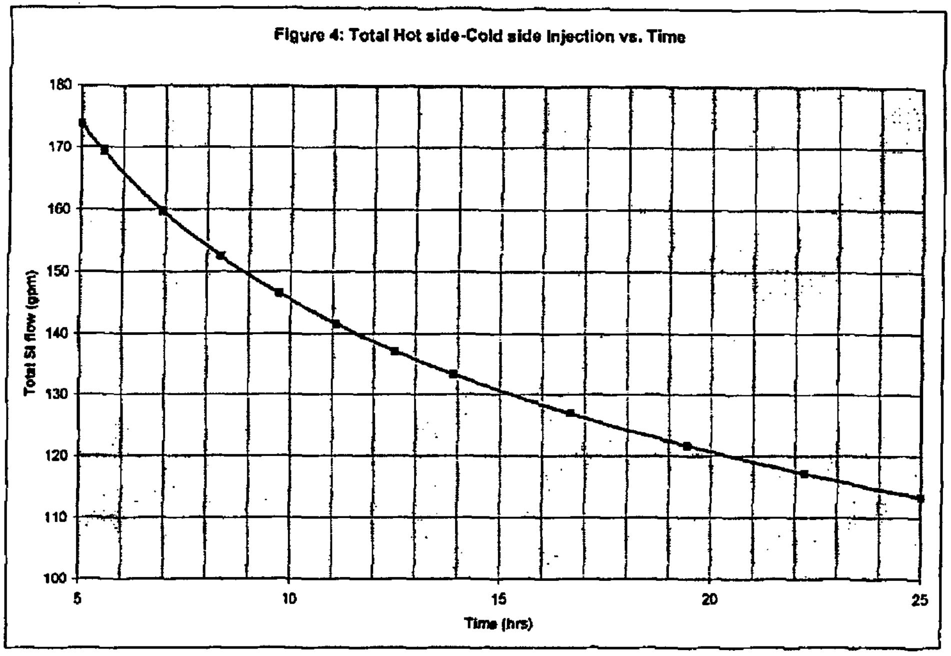

Figure 5.1-3 above shows the total hot side/cold side injection flow required vs. time [3.16; Figure 4]:

c. <u>Neutralization of Containment Sump Water</u>

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.

The impact on sump pH of the addition of a 965ppm boron solution into the RCS at a rate of 250gpm was evaluated. Figure 5.1-4 below 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]

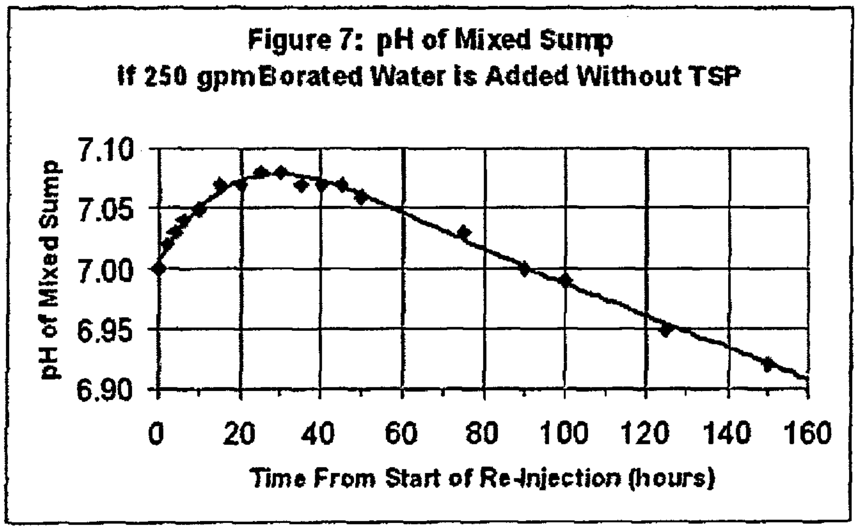

Figure 5.1-4: pH of a Mixed Sump if 250gpm Borated Water is Added without TSP [3.16; Figure 7]

d. Effects of Water Level on Containment Design Parameters

This section evaluates the effect of raising containment water level to above the design basis elevation of 1000.9ft up to El. 1013ft on the following:

- Existing containment level instrumentation
- Containment structural/hydraulic limits
- Equipment, instrumentation, and components needed to mitigate the LOCA

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 below 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. 1008ft) may allow for makeup to the RCS via reverse break flow and may allow the initiation of Shutdown Cooling (SDC). Flooding of containment to El. 1013ft will ensure that the RCS loops and SG bottom heads including the primary side manholes are underwater. To cover the reactor vessel, including the Instrument Flange, level would need to be raised to approximately El. 1020ft.

Figure 5.1-5 below provides a graph of containment water volume vs. indicated containment water level up to El. 1006' [3.19]. The top of the range of level indicators LI-387-1/388-1 is 27.5ft, which corresponds to El. 1004.5ft. [3.20]

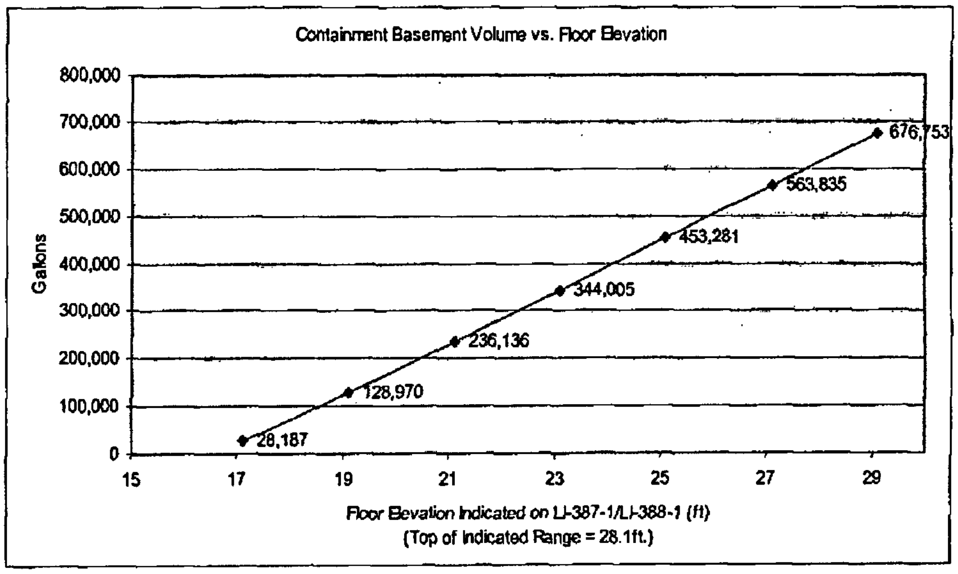

Figure 5.1-5 – Containment Basement Volume vs. Floor Elevation

Above elevation 1004'6", 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. 1006 ft.

Figure 5.1-6 below provides estimated containment water volume vs. elevation above the top of the containment level indicators to El. 1014 ft. The assumptions used in developing this figure are as follows:

- The average level increase is approximately 55,000 gallons per foot based on review of the Ref. 3.19 data.
- The figure does not account for the volume of structures or equipment.

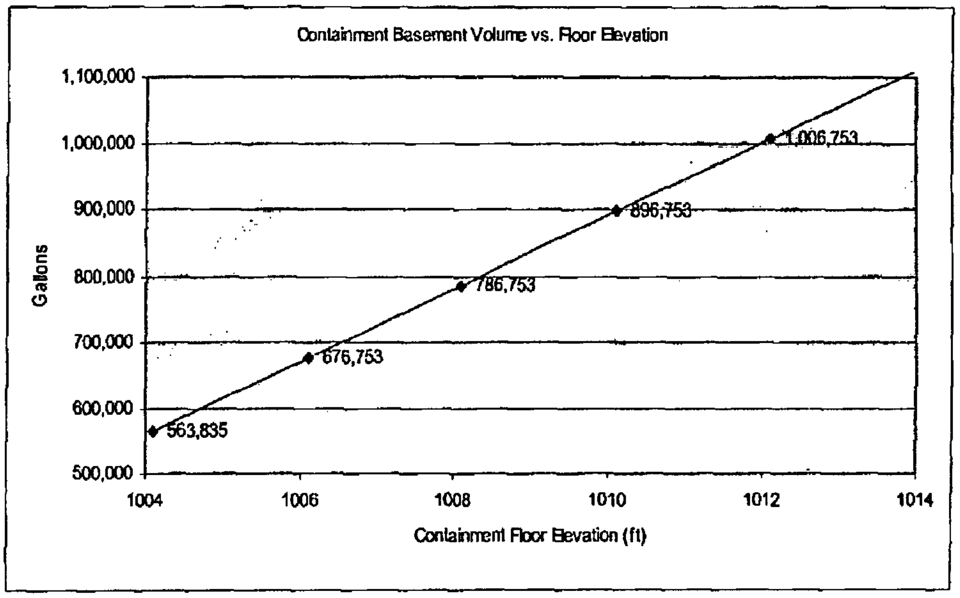

Figure 5.1-6 – Containment Basement Volume vs. Floor Elevation (Above El. 1004)

Figure 5.1-6 above shows that it will take approximately 1,060,000 gallons to fill the containment to El. 1013ft. This is consistent with Reference 3.21 that states that it requires injection of >790,000 gallons to fill to El. 1008ft, and >1,000,000 gallons to fill to El.1013ft. [3.21]

Effects of Hydraulic Pressure

The normal design basis assumes a maximum post-LOCA water level in containment of El. 1000.9ft. This level is based on injection of one SIRWT, four SIT, and the RCS volume with worst-case assumptions regarding maximum deliverable water inventory [3.17]. This evaluation considers the hydraulic effects of injecting water to El. 1013ft.

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; Appendix G)

Table 5.1-3 shows the results of the calculation of water pressure at specific elevations inside containment for a containment water level of 1013ft.

Table 5.1-3: Pressure With Height of Water at El. 1013'			
El (ft)	Feature	Δ El. (ft)	P_{water}
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

The containment building and associated penetrations are designed to withstand an internal containment pressure of 60psig at 305°F [3.8]. At pressures near design, containment integrity is assured based on performance of routine surveillance activities that test the liner and penetrations [3.14]. Initial testing was performed at 69psig [3.8]. The containment has a high confidence of low probability of failure (HCLPF) up to pressures of 130psig. At 190psig the containment has a 50/50 probability of failure. [3.11]

Maintaining containment vapor pressure below 44psig will ensure that the liner and penetrations below the water level are maintained less than the design pressure of 60psig. Containment pressure will be less than 44 psig at approximately 26 minutes [3.9]. Based on a flow rate of 250gpm, it would take two to three days to fill to El. 1013ft. At this time containment pressure will be significantly less than 44psig. The additional pressure due to the water level inside containment would not be significant enough to approach design pressure limits.

If containment pressure is assumed to be at the design pressure of 60psig, with water level at El. 1013ft, the pressure at the basement floor and all containment penetrations will be less than 69psig.

If design basis water level (El. 1000.9ft) were assumed, the pressure on the reactor cavity floor during at 60psig is:

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

$$= 60psig + (1000.9 - 976.5)(0.4335)$$

$$= 70.6psig$$

The addition of water to El. 1013ft will result in a pressure at the reactor cavity floor of approximately 75.8 psig. This represents an increase 5.2psig as compared to the pressure on the reactor cavity floor at the design basis water level. This is above the actual tested pressure of the containment liner; however, is well below the HCLPF upper pressure of 130psig.

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

Electrical equipment located above the EQ flood level (El. 1000.9 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.

The following tables summarize the components affected by rising containment water level up to El. 1013ft. 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 1004'5". Above this elevation no level monitoring is available. [3.20]

Table 5.1-4 summarizes components subjected to submergence as containment water level is raised to 27.5ft (El. 1004.5ft). The indicated level is as indicated on LI-387-1/LI-388-1.

Table 5.1-4: 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	1000.9	HCV-248	Charging to Loop 1B	Operator
24.1	1001	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	1001.3	PT-105	Pressurizer Pressure for A Sub-Cooled Margin	Cable
		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	1001.5	TCV-202	Loop 2A Letdown TCV	Operator
25.1	1002	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

Table 5.1-4: 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
26.1	1003	PT-105	RC Pressure (WR) for A Sub Cooled Margin Mon.	Transmitter
		HCV-348	SDC Isolation Valve	Operator
26.4	1003.3	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
		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 5.1-5 summarizes components subjected to submergence as containment water level is raised from El. 1004.5ft to El. 1013 ft.

Table 5.1-5: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
1005	LT-387A/B/C LT-388A/B/C	Containment Water Level	Transmitters
1005.8	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
1006	HCV-239	Charging to Loop 2A	Cable
	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
1006.8	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

Table 5.1-5: Components Affected By Rising Containment Level El. 1004.5ft. to El. 1013ft.			
El. (ft)	Tag #	Description/Service	Submerged Component
	HCV-820C HCV-820D HCV-820E HCV-820F HCV-820G HCV-820H	Hydrogen Analyzer Sample Valves	Cable
1007	D/LT-911	S/G Wide Range Water Level	Cable
	D/PT-913	S/G Wide Range Pressure	Cable
1007.9	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
	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
1008	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
1008.9	HCV-238	Charging to Loop 1A Isolation	Cable

Table 5.1-5: Components Affected By Rising Containment Level
El. 1004.5ft. to El. 1013ft.

El. (ft)	Tag #	Description/Service	Submerged Component
	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
1009	HCV-239	Charging Loop 2A Isolation Valve	Operator
1011	HCV-821B	Hydrogen Analyzer Isolation Valve	Operator
1013	A/LT-901 B/LT-901	S/G Water Level Indication	Transmitters
	A/LT-904 B/LT-904 C/LT-904	S/G Water Level Indication	Transmitters
1013	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

A review of the preceding tables shows that equipment required for monitoring of key parameters is affected as soon as water level is raised above El. 1000.9ft. 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. 1000.9ft. may cause erroneous reading or equipment failures.

Conclusion:

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. 1008ft. This may allow for long-term cooling via: 1) countercurrent flow through the break with fan coolers providing the ultimate decay heat removal, or 2) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS.

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 965ppm to prevent localized re-criticality in the core.
- Re-injection of a 965ppm boric acid solution at 250gpm for approximately three days does not result in the need for additional sump neutralization.
- 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 additional pressure of water due to increased level will not challenge containment design limits.

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

- The ERO could be notified for consideration of entry into the SAMG Guidelines. It may be appropriate to implement mitigative strategies in the Candidate High Level Actions (CHLA).
- 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.
- The SIRWT should be sampled prior to injection to ensure that the boron concentration is at least 965ppm, if practical. Core cooling takes precedence if insufficient time exists for verification of SIRWT boron concentration.

3. 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. In addition, the increased water level in containment may raise the $NPSH_{Available}$ to a point that may allow HPSI pump operation from the sump.

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.

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 HPSI Pumps Not Required For Core Cooling

This section evaluates actions to secure HPSI pumps not required for core heat removal. The intent of this compensatory measure is to reduce flow through the sump screens and to preserve operability of pumps that may be needed later in the event to provide core cooling. 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 HPSI pumps will reduce the total flow to the sump screen and may delay or prevent sump clogging.

The design basis function of the HPSI System is to provide emergency core cooling to the reactor core in the event of a LOCA. The HPSI system injects borated water from the SIRWT 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.

The HPSI System has three pumps, two of which are powered from the respective safeguards buses, and one (SI-2C) that is manually transferable between either safeguards buses if required.

The HPSI pumps take suction from the SIRWT for initial injection of borated water. Once the SIRWT volume is depleted, the RAS signal shifts the suction source to the containment sump and the 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. Securing HPSI Pump SI-2C Pre-RAS

The compensatory action to secure SI-2C prior to RAS may provide 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 some 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.

- 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.

The action to secure SI-2C should only be taken if all other HPSI pumps have started and are verified to be operating normally. 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.

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

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 requires further analysis to show that no core damage occurs during the time that HPSI flow is lost, and requires evaluation under 10CFR50.59 to determine if substituting the manual action of restarting the HPSI pump represents an unreviewed safety question (USQ).

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.A) 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. More analysis is required to demonstrate that the loss of flow will not result in core uncovery and damage.
- The action introduces a pump failure to start failure mode that may be risk adverse.

5.3 <u>Early Termination of CS Pumps</u>

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 strip radioactive particles from the atmosphere where they fall to the floor 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 manually transferable between either safeguards bus.

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 1885gpm prior to RAS, and 3100gpm 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 by up to 3100gpm depending on initial CS system configuration and containment pressure. Assuming all CS and HPSI pumps running post-RAS, with containment pressure at 60psig 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

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 still be 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.

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.

If SI-3B or SI-3C is secured, HCV-344 will automatically close resulting in isolation of the "A" CS header. It is preferred that SI-3A be secured to prevent HCV-344 closure to allow for 2 CS pump and two header operation, and to minimize flow on strainer SI-12A.

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 5psig, 3) one train 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.

The LOCA analysis peak containment pressure occurs at 290 seconds, and peak containment temperature occurs at 282 seconds [3.5; Section 14.16]. The action to secure CS pumps occurs after the pressure and temperature peaks. The containment pressure is 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. Therefore, loss of the remaining CS pump will not adversely affect containment pressure and temperature control.

The current FCS licensing basis does not account for interruption of CS flow in the LOCA radiological consequences analysis. Therefore, this action requires further analysis to show that the radiological consequences due to the loss of the remaining CS pump will not increase, and requires evaluation under 10CFR50.59 to determine if substituting the manual action of restarting the CS pump represents an unreviewed safety question (USQ).

The preemptive compensatory measure to reduce to one train of CS cannot be implemented without further analysis; however, due to the risk benefits associated with reduction of flow through the sump screens and delaying the time to sump screen blockage, the following actions are recommended:

- Perform further analysis to determine the effect of a temporary loss of all CS on the LOCA radiological consequences.
- Perform a 50.59 evaluation or a license amendment request, as necessary, to justify implementing this compensatory action.

5.4 Refilling the SIRWT Post-RAS.

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.

SIRWT Design Function:

The SIWRT 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]

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

A. Makeup Water Requirements:

Reference 3.16 summarizes the minimum required flow rate post-RAS, and the minimum Boron Concentration to ensure that the core remains shutdown. The conclusions of the Westinghouse Report are as follows:

- Minimum SIRWT Boron Concentration upon refill should be greater than 965ppm 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 hot side/cold side injection following hot leg switchover.
- 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 providing at least 250gpm, and either borated or able to be borated to a minimum of 965ppm.

B. SIRWT Refill Water Sources:

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 the following water sources that have the capability to refill the SIRWT at the required flow rates. Preference is given to those sources that are at the Refueling Boron Concentration and can be easily transferred to the SIRWT with limited personnel resources. If water is added at to the SIRWT at the refueling boron concentration, it can be diluted to approximately 1000ppm [3.16] by doubling the volume of water with demineralized or fire protection water.

The following water sources were evaluated:

- Fuel Transfer Canal (FTS) (Borated)
- Spent Fuel Pool (SFP)(Borated)
- Chemical and Volume Control System (CVCS) (Borated)
- Fire Protection Water (Non-Borated – Last Resort Method)

Fuel Transfer Canal:

The FTC is normally drained; however, if the LOCA occurred when it was full it is a source of borated water at the Refueling Boron Concentration. (Note: This evaluation will recommend that the canal remain full during plant operation)

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
= 6105 ft^3 x 7.48052 gal/ft^3
= 45,669 gallons

Methods:

1. 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 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.

2. Gravity Drain

   The contents of the FTC can be gravity drained via AC-306 and AC-307. (Calculations contained in Attachment 8.3)

   The estimated flow rate to the SIRWT via gravity drain is considerable 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 2000-3000 gallons remaining in the Canal).

<u>Spent Fuel Pool</u>:

The Spent Fuel Pool (SFP) is a source of borated water at the 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. 1036' 9"
7.48052 gallons/ft^3 water
Gate Stop at El. 1009' 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. Draining of the SFP is limited by the gate stop installed at El. 1009' 81/2". The gate stop level is above the top of the active fuel in a Westinghouse spent fuel assembly. [3.30]

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:

1. 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 available. Realistic flow rate to the SIRWT via this method is estimated at 300gpm 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.

2. 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.

3. 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.

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 the Refueling Boron Concentration, during plant operations. This provides a readily accessible volume of 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 185,098 gallons of water, at the refueling boron concentration, for transfer from the FTC/SFP to the SIRWT.

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.

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 left dry until the end of the cycle when fuel transfer preparations begin. Maintenance on fuel transfer equipment located in the FTC requires it to be drained, and it is preferred that transfer machine testing be performed dry to facilitate identification of problems prior to refueling activities. Fuel transfer equipment is designed for operation in a borated water environment and will not be adversely affected by this change in operational strategy.

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 Radwaste over an operating cycle.

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 following two issues require further evaluation before implementing this operational change:

1) 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.

2) 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 evaluation 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, as a compensatory action, is not recommended.

Chemical and Volume Control System:

The CVCS system can be used to blend the contents of the Boric Acid Storage Tanks (BAST) to the SIWRT 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 and should be used to supplement other SIRWT fill methods.

Non-borated Sources of Makeup to the SIRWT

The following non-borated sources of water should be used as a last resort because the water source contains a great deal of impurities. In addition, mixing of boric acid at lower temperatures may result in poor mixing.

The Fire Protection System can supply approximately 250gpm using a 2 ½ inch fire hose connection. Fire Protection 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 >965ppm 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 965ppm by this method:

1ppm = 1mg/liter
1gal = 3.785 liters
1lb = 453592.4mg

$$\text{lbs Boron as B required} = \frac{(\text{Reqd Conc})(\text{gallons})(3.785\text{liter/gal})}{(453592.4\text{mg/lb})}$$

$$= \frac{(965)(45{,}000)(3.785)}{453592.4}$$

$$= 362 \text{ lbs}$$

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

Lbs boric acid = 362lbs/ 0.1748 = 2071 lbs

Each bag is 50 lbs, therefore require 2071lbs/50 or 42 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 965ppm. 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 965ppm by this method assuming volume of water is 250,000 gallons:

1ppm = 1mg/liter
1gal = 3.785 liters
1lb = 453592.4mg

$$\text{Lbs Boron as B required} = \frac{(\text{Reqd Conc})(\text{gallons})(3.785\text{liter/gal})}{(453592.4\text{mg/lb})}$$

$$= \frac{(965)(250{,}000)(3.785)}{453592.4}$$

$$= 2013\text{lbs}$$

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

Lbs boric acid = 2013lbs/ 0.1748 = 11516 lbs

Each bag is 50 lbs; therefore require 11516 lbs/50 or 230 bags Boric Acid for each fill of the SIRWT.

The FCS Site currently has sufficient inventory of boric acid to perform at least one refill of the SIRWT, as described above, to a concentration of 965ppm. The warehouse stock for Boric acid is 13,800 lbs (276 bags) min to 39,200 lbs (784 bags) maximum. A quick inventory of the BA Batch Tank Room performed on 11/2/2003 found 77 bags of boric acid.

Mixing of the boric acid will be difficult in the above scenarios 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, by dumping just enough boric acid in the transfer canal to mix one bag of boric acid into a volume of approximately 1000 gallons (< 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. The ideal method would be to use the boric acid batching tank.

C. 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 design to maintain the valves open for a period of 13 hours following a loss of the air supply [3.28; Attachment 5]. The valves should be manually shut prior to 13 hours to ensure that they will not drift open, resulting in contamination of the SIWRT water with containment sump water.

6.0 RESULTS AND CONCLUSIONS

6.1 Response to Sump Clogging

A. Sump Inoperability Criteria:

It is recommended that procedural guidance be placed in the EOP's 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.

Discussion:

Following RAS, the above available indications should be monitored for signs of reduced pump performance. If resources are available, and SI Pump Room dose rates permit, individual pump discharge pressures could be monitored and trended. Local discharge pressure indication is not necessary to confirm an inoperable sump.

The proposed criteria requires 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 proposed 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.

Containment level indication is not included in the proposed criteria because it is not a conclusive indication of sump screen clogging. Water level should remain relatively constant after the RAS occurs due to no injection of additional water sources. Unexpected changes in level may indicate in-leakage from other water sources, leakage outside containment, or pooling inside containment due to blocked choke points along the return path to the sump.

B. Contingency Actions for Sump Inoperability:

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 60psig 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 a LOCA just by crediting natural deposition.

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

- The ERO could be notified for consideration of entry into the SAMG Guidelines. It may be appropriate to implement mitigative strategies in the Candidate High Level Actions (CHLA).
- 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 due to higher particulate and iodine activity in the containment atmosphere.

2. 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. 1008ft. This may allow for long-term cooling via: 1) countercurrent flow through the break with fan coolers providing the ultimate decay heat removal, or 2) initiation of shutdown cooling for decay heat removal once adequate level is established in the RCS.

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 965ppm to prevent localized re-criticality in the core.
- Re-injection of a boric acid solution at 965ppm at 250gpm for approximately three days does not result in the need additional sump neutralization.

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- 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 additional pressure of water due to increased level will not challenge containment design limits.

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

- The ERO could be notified for consideration of entry into the SAMG Guidelines. It may be appropriate to implement mitigative strategies in the Candidate High Level Actions (CHLA).
- 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.
- The SIRWT should be sampled prior to injection, if practical, to ensure that the boron concentration is at least 965ppm. Core cooling takes precedence if insufficient time exists for verification of SIRWT boron concentration.

3. 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.

6.2 <u>Securing HPSI Pumps Not Required for Core Cooling</u>

A. 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.

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.

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.

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

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.A) 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. More analysis is required to demonstrate that the loss of flow will not result in core uncovery and damage.
- The action introduces a pump failure to start failure mode that may be risk adverse.

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. 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.

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.

B. Securing Two CS Pumps

The preemptive compensatory measure to reduce to one train of CS cannot be implemented without further analysis; however, due to the risk benefits associated with reduction of flow through the sump screens and delaying the time to sump screen blockage, the following actions are recommended:

- Perform further analysis to determine the effect of a temporary loss of all CS on the LOCA radiological consequences.
- Perform a 50.59 evaluation or a license amendment request, as necessary, to justify implementing this compensatory action.

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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 1000ppm 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 the BAST to the SIRWT using the normal method	Dependent on BAST content	No	Will not provide the required flow rates; can be used to supplement other methods
Fire Protection fill of the FTC and dumping bags of boric acid into the FTC	250gpm	Yes	Last resort method. Water contains impurities; Requires addition of 42 bags of boric acid for each FTC volume; Poor mixing at low water temperatures.

Table 6.4-1: Summary of SIRWT Refill Water Sources and Methods			
Fire Protection fill of SIRWT through the vent and dumping bags of boric acid through the floor plug	250gpm	Yes	Last resort method. Water contains impurities; requires adding 230 bags of boric acid to achieve 965ppm; 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 should be used for initial fill activities. Mixing of Boron in the fuel transfer canal or the SIRWT may result in inadequate mixing and should be used after all other sources of borated water are depleted.

4) 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.

5) The SIRWT should be sampled, if practical, prior to use to determine that Boron concentration is >965ppm to prevent localized re-criticality in the core. Core cooling takes precedence if insufficient time exists for verification of SIRWT boron concentration.

6) This EA does not 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.

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

7.1 DBD Updates

No DBD Updates are required by this EA.

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 will be used as inputs for the development of EOP and AOP changes for compensatory actions in response to a potential sump clogging event.

EOP and AOP Procedures will be revised to:

1) Provide direction and methods for refilling the SIRWT immediately following RAS
2) Provide direction to secure HPSI Pump SI-2C pre-RAS.
3) Provide direction to secure one CS pump pre-RAS.
4) Provide direction for the diagnosis of sump screen clogging.
5) Provide direction for responsive actions for sump screen clogging and injection of water to the RCS from a refilled SIRWT.

7.5 Change to an NRC Commitment

This EA supports implementation of commitments made to the NRC in Reference 3.2.

No changes to NRC commitments were identified, or required, by the results of this EA.

7.6 Condition Report Determination

No Condition Reports were identified or required as a result of this EA.

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

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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

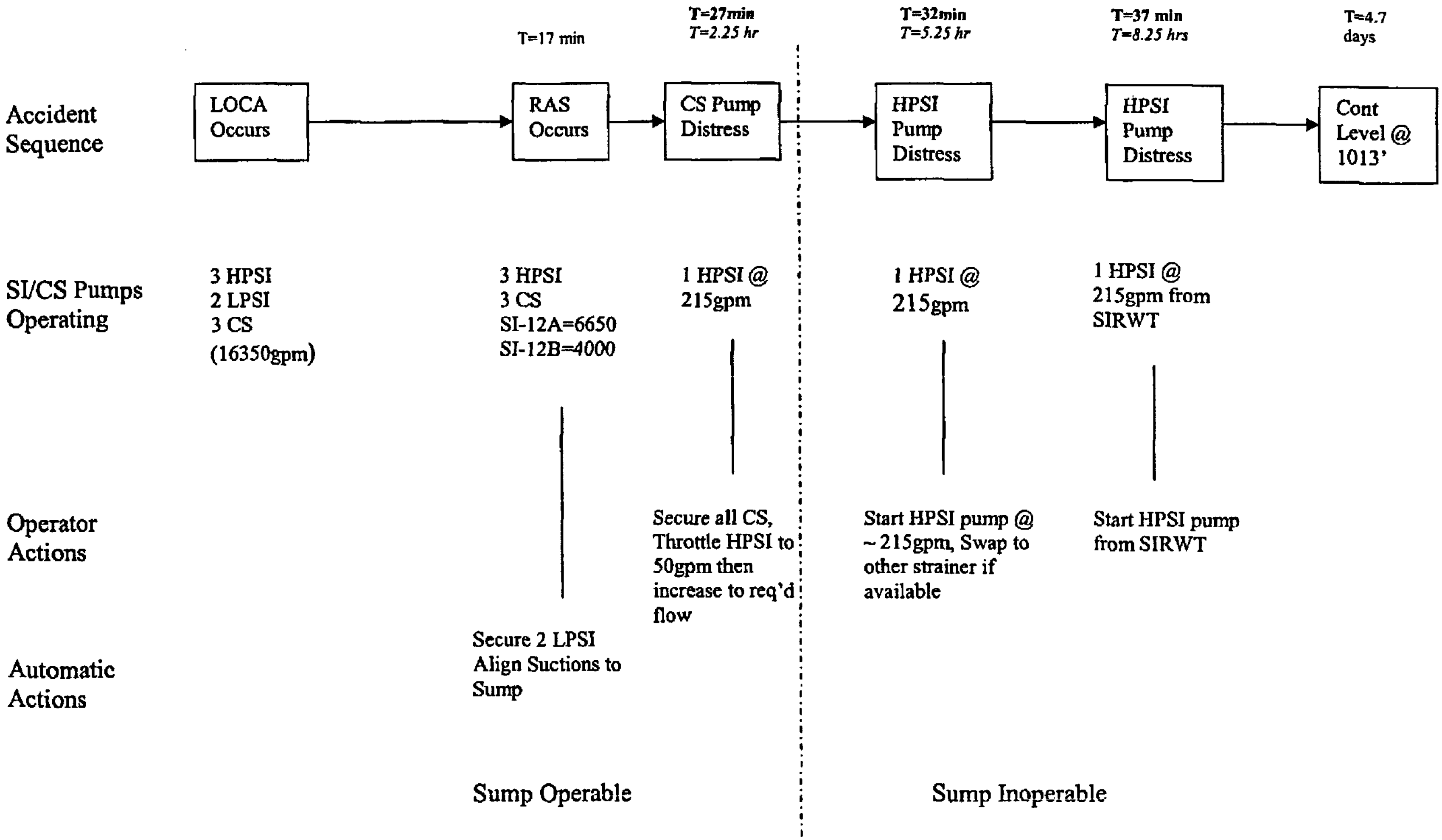
Maximum pump flows for the above pumps are as follows:

LPSI = 2850gpm   HPSI = 450gpm   CS = 3100gpm

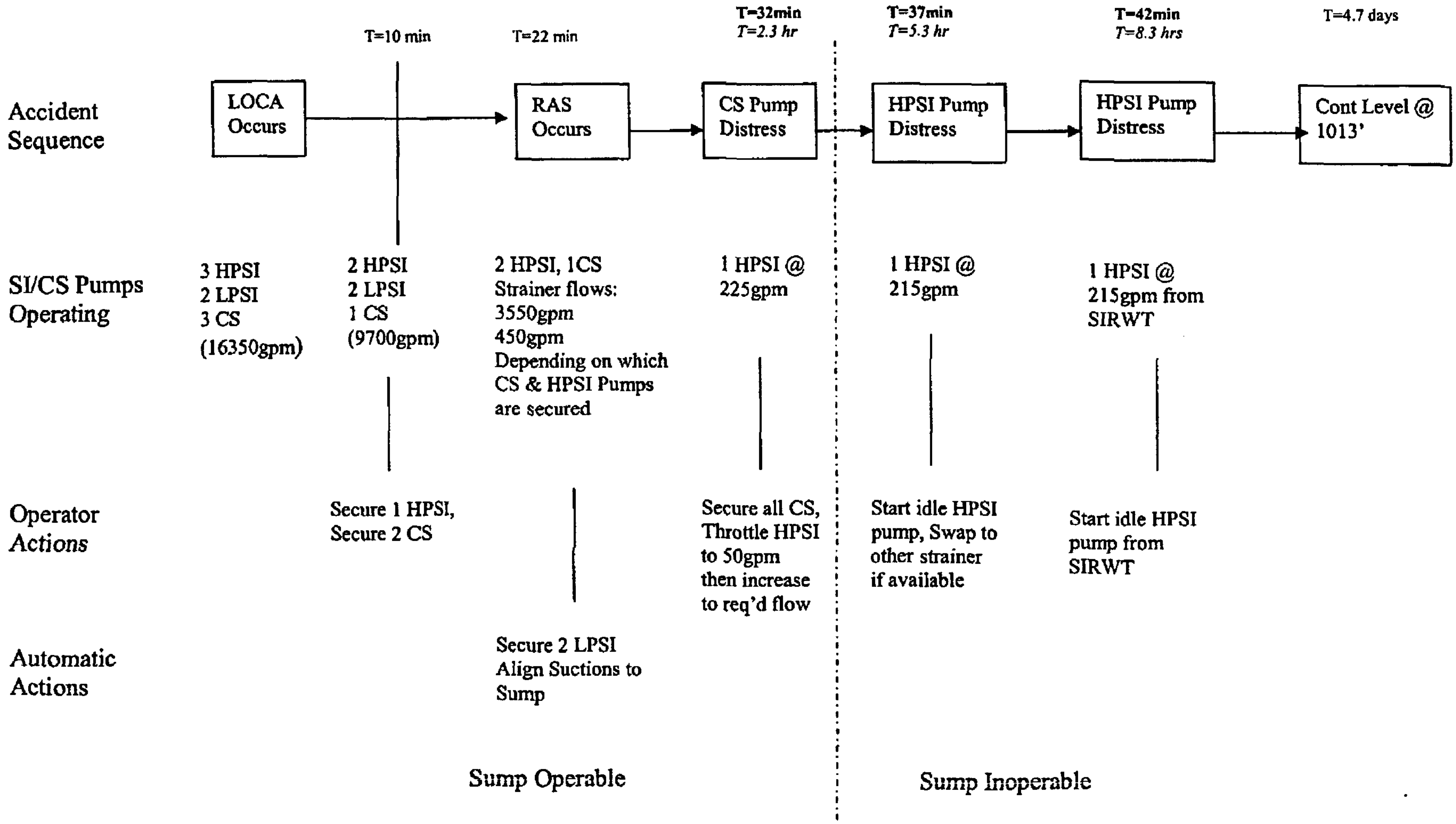
The following assumptions were made in the development of the attached flowcharts:

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.

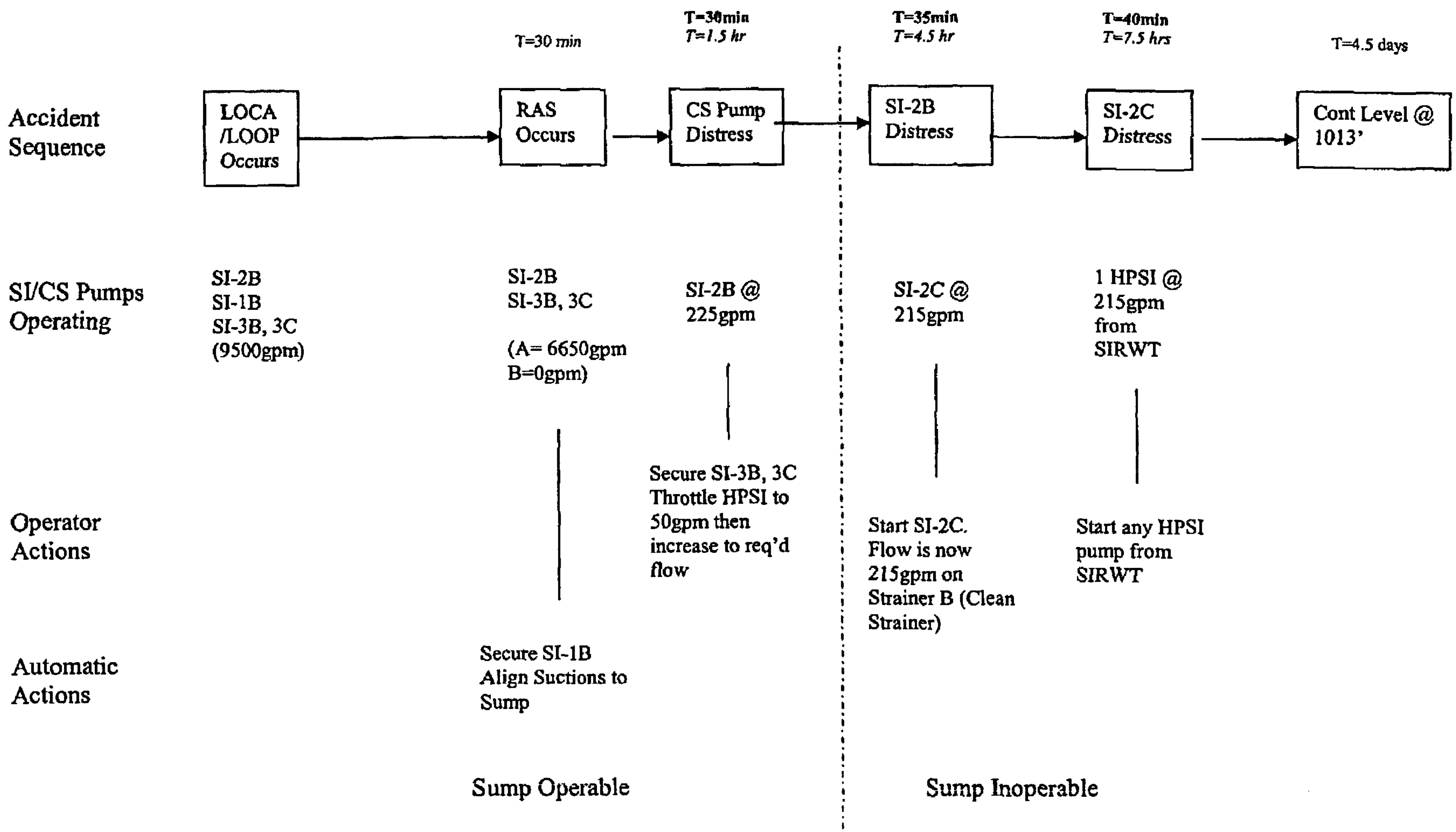
Case 1: No Compensatory Actions, No LOOP, Normal ECCS Operation



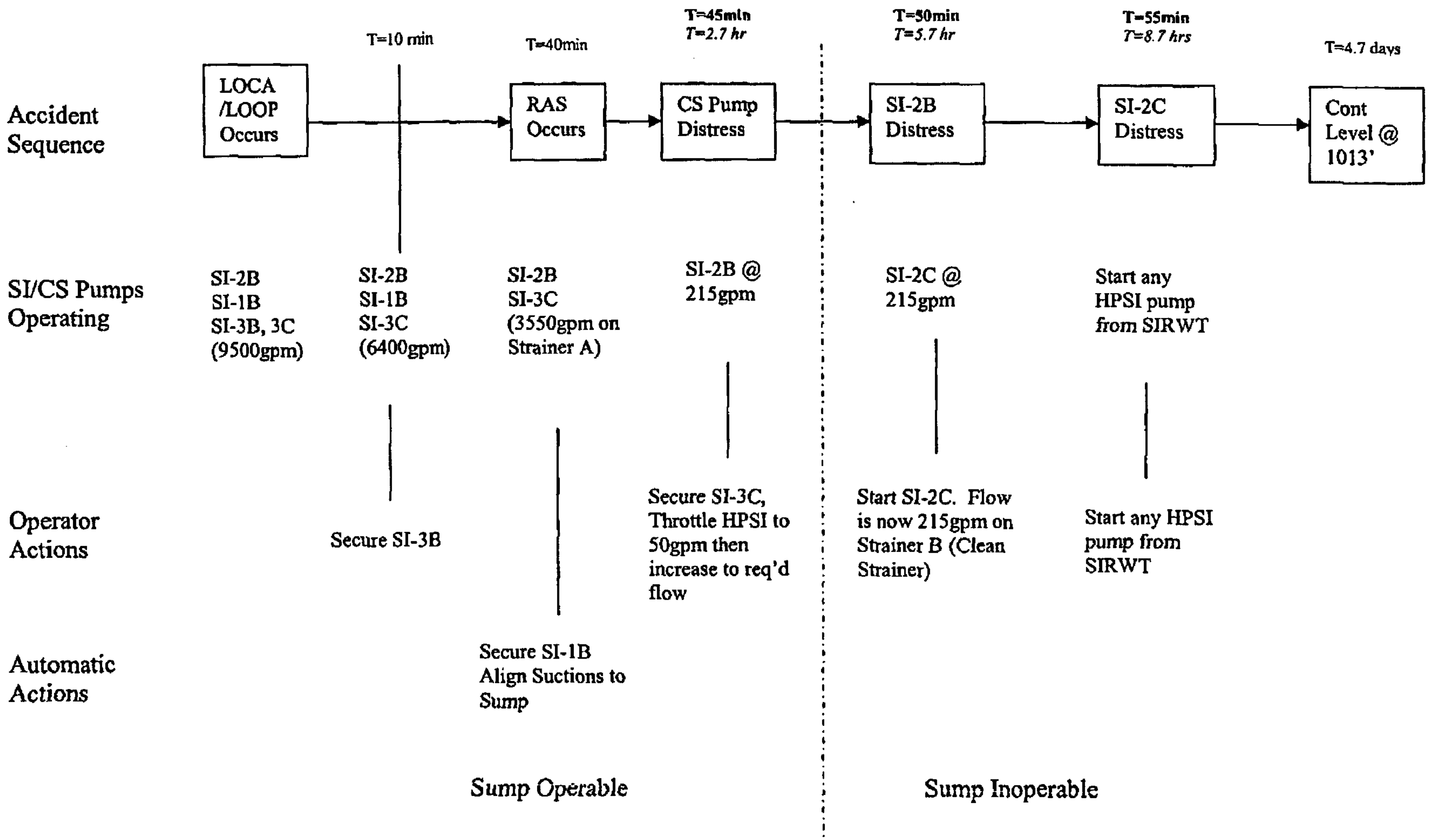
Case 2: Compensatory Actions, No LOOP, Normal ECCS Operation



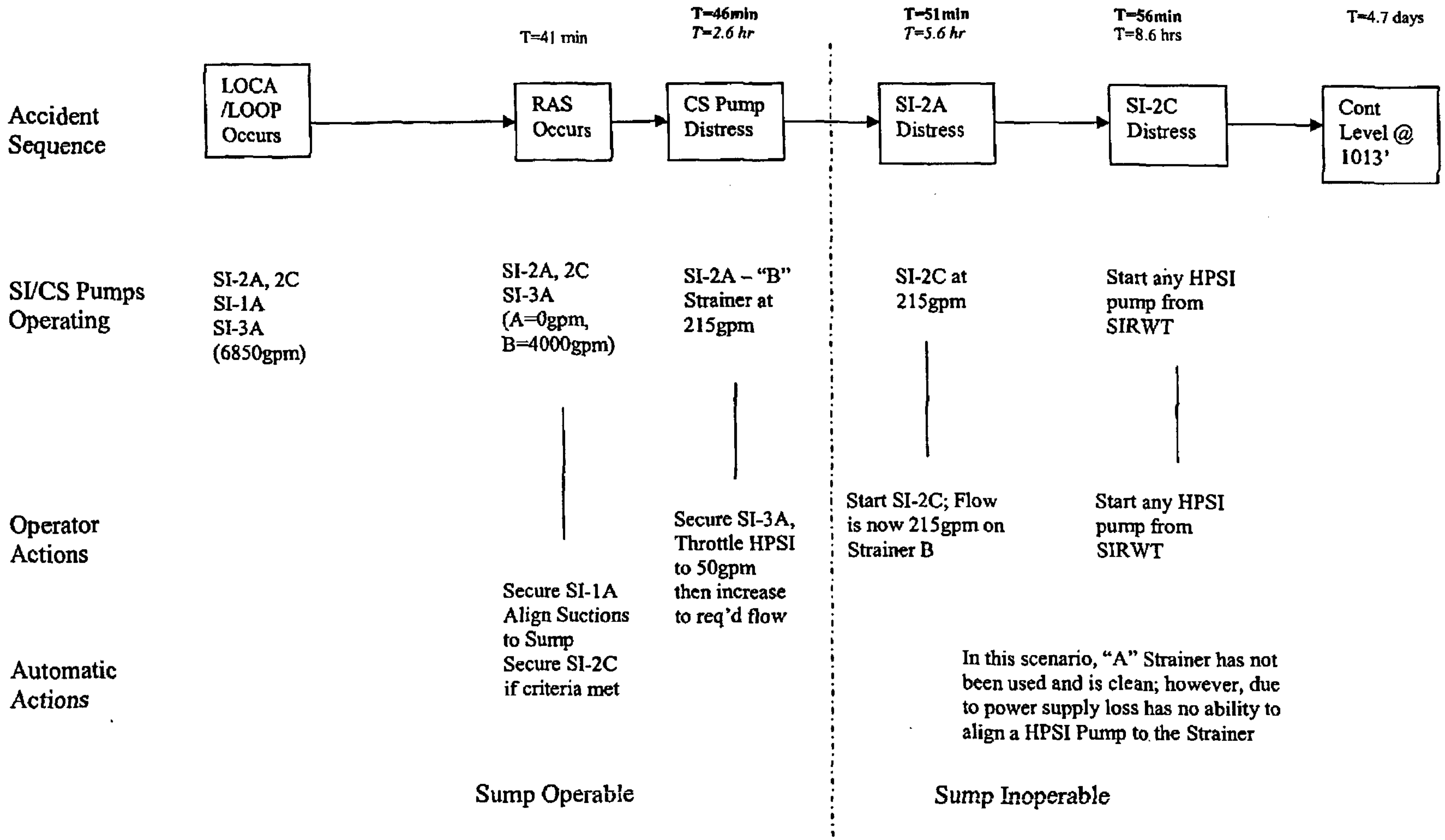
Case 3: No Compensatory Actions LOOP with failure of D-1 Diesel



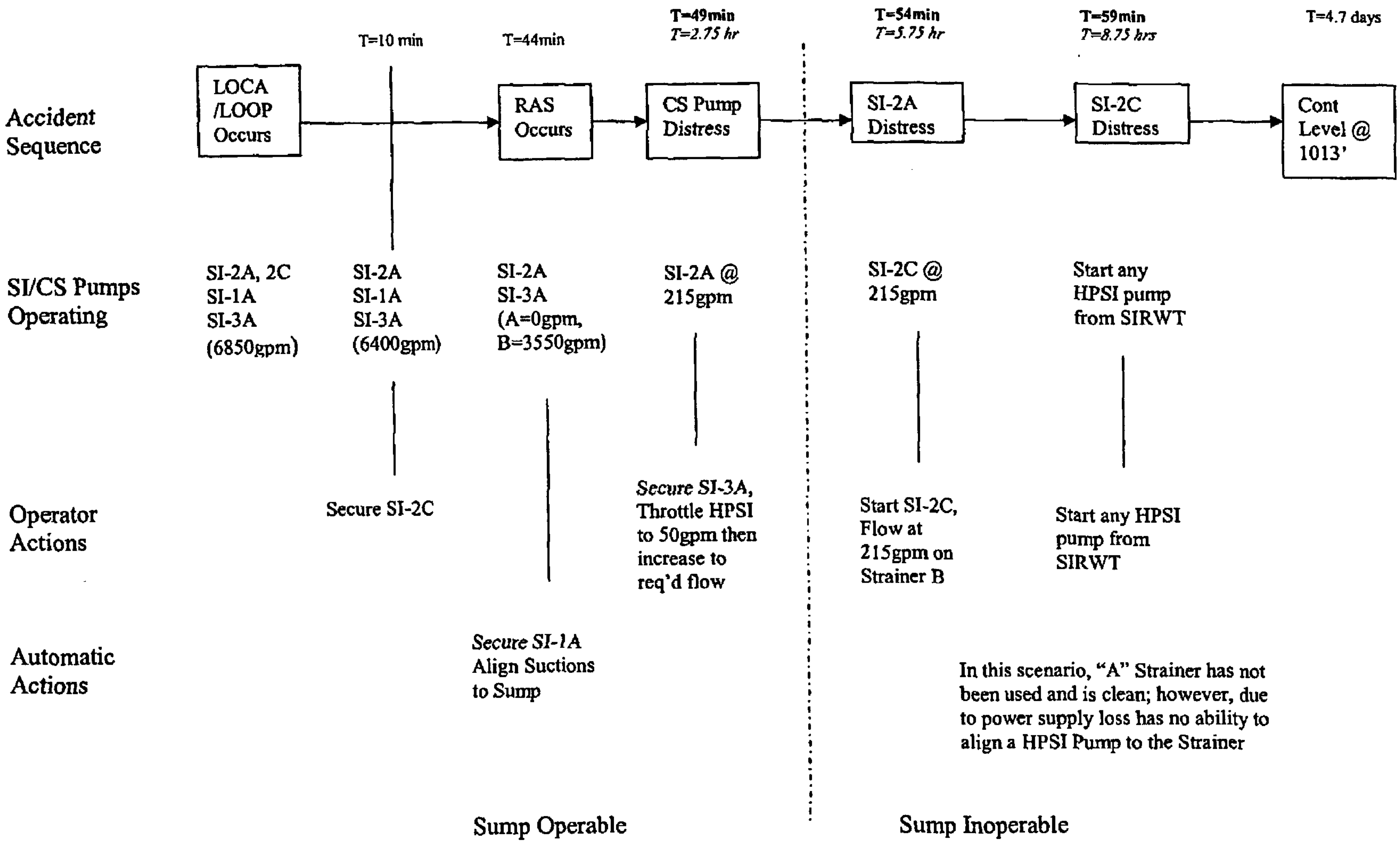
Case 4: Compensatory Actions LOOP with failure of D-1 Diesel



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



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



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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.

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
		HCV-883E/F/G/H HCV-820G	H2 Analyzer Sample Isolation

Table 8.2-1 – EEQ Components vs. Containment Elevation			
El. (Ft)	Ind. Level	Tag #	Description / Service
		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
		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

Table 8.2-2: Electrical Penetrations vs. Containment Elevation			
El. (Ft)	Ind. Level	Pen. #	Description/Service
		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

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ATTACHMENT 8.3
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.