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February 8, 2008

PG&E Letter DCL-08-012

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

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Response to Request for Additional Information on License Amendment Request 07-02, "Revision to Technical Specification (TS) 3.5.4, 'Refueling Water Storage Tank (RWST)'"

Reference: 1. PG&E Letter DCL-07-093, "License Amendment Request 07-02, Revision to Technical Specification (TS) 3.5.4, 'Refueling Water Storage Tank (RWST),'" dated October 2, 2007

Dear Commissioners and Staff:

By letter dated October 2, 2007 (Reference 1), Pacific Gas and Electric Company (PG&E) submitted License Amendment Request (LAR) 07-02, "Revision to Technical Specification (TS) 3.5.4, 'Refueling Water Storage Tank (RWST).'" LAR 07-02 proposes a change to TS 3.5.4 Surveillance Requirement 3.5.4.2 to increase the minimum required borated water volume. This proposed change is required to meet commitments related to the resolution of issues raised in NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," dated September 13, 2004.

By e-mail dated December 13, 2007, the NRC requested additional information required to complete their review of LAR 07-02. PG&E's response to that request is included in Enclosure 1. Revised TS and proposed TS Bases pages are included in Enclosure 2. These pages supersede the same numbered pages provided in Reference 1.

This information does not affect the results of the technical evaluation, or the no significant hazards consideration determination, previously transmitted in Reference 1.

A001
NRR

This letter contains a new commitment to be implemented in conjunction with implementation of the license amendments when issued. The commitment is contained in Enclosure 3.

If you have any questions, or require additional information, please contact Stan Ketelsen at (805) 545-4720.

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

Executed on February 8, 2008.

Sincerely,

James R. Becker
Vice President - Diablo Canyon Operations and Station Director

tcg/4231
Enclosures
cc: Elmo E. Collins, NRC Region IV
Michael S. Peck, NRC Senior Resident Inspector
Sandra Shewry, DHS
Diablo Distribution
cc/enc: Alan B. Wang, Project Manager NRR

Response to Request for Additional Information on License Amendment Request 07-02, "Revision to Technical Specification (TS) 3.5.4, 'Refueling Water Storage Tank (RWST)'"

NRC Question 1

1. *What is the basis for the new minimum RWST water volume?*

PG&E Response:

The new containment recirculation sump strainers are designed to operate under fully submerged conditions for a large-break loss of coolant accident (LOCA). The top of these strainers is slightly below elevation 93.6 ft, so a minimum containment water level of 93.6 ft is required for strainer operation under design-basis large-break LOCA conditions. A calculation was performed to determine the required contained borated water volume and equivalent water level in the RWST to meet this requirement.

The calculation to support the proposed TS revision is based on the results of an existing calculation performed to assess post-LOCA containment water levels that determined the minimum sump water level for the onset of switchover for a large-break LOCA when the first residual heat removal pump starts taking suction from the sump. The initial calculation evaluated a large-break LOCA for the current TS minimum contained borated water volume and level, and an administratively-controlled RWST minimum water level of 90 percent. The administrative minimum level was established in order to protect the minimum TS RWST water level for the worst-case potential leakage that could occur during the operation of a temporary reverse osmosis purification system in support of changes approved in License Amendments 144/143, issued January 29, 2001.

The existing calculation established that under the limiting large-break LOCA conditions, approximately 219,700 gallons of water would be injected into the containment from the RWST at the start of switchover to recirculation if the starting inventory of the RWST was at the current TS minimum level. The corresponding containment water level is 93.02 ft. Similarly, the calculation also evaluated the changes associated with the administrative RWST water level of 90 percent. The results of the evaluation of the 90 percent administrative RWST water level established that there would be approximately 253,000 gallons of RWST water injected into containment after accounting for instrumentation uncertainties and leakage. This change in initial RWST water level resulted in an increase in the containment water level from 93.02 ft to 93.41 ft.

Conservatisms contained in these calculations include consideration of the loss of a quantity of water to the containment atmosphere as vapor, water in transit to the sump, water pooling in locations other than in the sump, the water film condensing on surfaces of structures, piping and components, the filling of dry containment spray system piping, and sample system leakage. The removal of these water volumes resulted in minimization of the water level available in the containment sump. This established the minimum initial water level inside containment at 93.41 ft for the case where the RWST water level started at 90 percent. Based on the initial containment water level described above, and the water level required to submerge the new strainers, the most recent calculation established that an additional 16,097 gallons is required to raise the water level to an elevation of 93.6 ft.

The minimum required containment water volume is based on the maximum containment area to containment water level relationship which considered containment to be a cylindrical structure, and only accounted for displacement of water volume by major structures inside containment such as the steam generator and reactor coolant pump pedestals and the secondary shield wall. No credit was taken for minor items like smaller structural steel, removable storage units, and equipment whose displacement volume would increase the net containment water level.

The increased water volume required was then converted into a change in the water level in the RWST. Since the RWST is an ideal geometric, cylindrical tank, the water level change required is easily calculated based on a linear relationship between tank level and volume. The additional required volume of 16,097 gallons was conservatively rounded up to 16,500 gallons. This resulted in an increase of 3.6 percent in tank volume, from the starting level of 90 percent to a final level of 93.6 percent.

The minimum required contained tank inventory was then determined based on this new required level. The volume of water corresponding to 93.6 percent corresponds to a volume of approximately 428,900 gallons of measured inventory. Since there is a volume of water below the lower instrumentation tap which is not measurable (approximately 26,400 gallons), the actual contained tank inventory at this new water level is the measured volume at the new required level plus the unavailable volume below the lower tap. This volume is (428,900 plus 26,400) gallons or 455,300 gallons.

Calculations N-227, "Post-LOCA Minimum Containment Sump Level," (specifically Section 8.2), and STA-255, "Minimum Required RWST Level for GE Sump Strainers," provide the basis for the proposed minimum RWST borated water volume. These calculations are included as Attachments 1 and 2 to Enclosure 1.

<u>NRC Question 2</u>

2. *Specify the uncertainties associated with the instruments relied upon to meet Surveillance Requirement (SR) 3.5.4.2 and how these uncertainties are determined.*

PG&E Response:

The Unit 1 containment recirculation sump screen was replaced during the Unit 1 Fourteenth Refueling Outage (1R14). The proposed SR 3.5.4.2 RWST minimum required borated water volume of 455,300 gallons (93.6 percent level) was administratively implemented at that time. Because of the narrow margin between the proposed SR limit and the RWST high level alarm, a high accuracy Heise gauge was installed during 1R14, to verify RWST level, pending installation of new level transmitters (LT-920, -921, -922) with digital readout at the transmitter. The Unit 1 level transmitters will be replaced during the Unit1 Fifteenth Refueling Outage; the Unit 2 level transmitters will be replaced during the Unit 2 Fourteenth Refueling Outage when the Unit 2 containment recirculation sump screen will be replaced.

The Heise gauge uncertainty is calculated as follows:

$$CU = B \pm \sqrt{\{PMA^2 + SCA^2 + \mathrm{Re}\,adabilty^2\}}$$

Where:

Bias Error (B) = .0361 pounds per square inch (psi)
Process Measurement Allowance (PMA) = ± 0.0726 psi
Sensor Calibration Accuracy (SCA) = ± 0.0313 psi
Readability = ± 0.01 psi

Therefore the uncertainty associated with use of the Heise gauge is the following:

$$CU = B \pm \sqrt{\{PMA^2 + SCA^2 + \mathrm{Re}\,adabilty^2\}}$$

$$CU = 0.0361 \pm \sqrt{\{0726^2 + 0.0313^2 + 0.01^2\}}$$

$$CU = 0.0361 + \sqrt{\{0726^2 + 0.0313^2 + 0.01^2\}} = +\ 0.1158\text{psi, or } +\ 0.39\%$$

$$CU = 0.0361 - \sqrt{\{0726^2 + 0..0313^2 + 0.01^2\}} = -\ 0.0797\text{psi, or } -\ 0.27\%$$

The replacement level transmitter digital indicator uncertainty is calculated as follows:

$$CU = B \pm \sqrt{\{PMA^2 + PEA^2 + SCA^2 + SMTE^2 + SD^2 + STE^2 + SPE^2 + \mathrm{Re}\,adabilty^2\}}$$

Where

Bias Error (B) = ± 0.25 in
Process Measurement Allowance (PMA) = ± 2 in
Primary Element Accuracy (PEA) = 0
Sensor Calibration Accuracy (SCA) = ± 1.47 in
Sensor Measuring and Test Equipment (SMTE) =± 0.90 in

Sensor Drift (SD) = ± 2 in
Sensor Temperature Effect (STE) =± 0.37 in
Sensor Pressure Effect (SPE) = 0
Readability of Indicator on Sensor/transmitter = 0

Therefore, the uncertainty for the digital indicator for LT-920, -921, -922 is the following:

$$CU = B \pm \sqrt{\{PMA^2 + PEA^2 + SCA^2 + SMTE^2 + SD^2 + STE^2 + SPE^2 + \mathrm{Re}\,adabilty^2\}}$$

$CU^{\pm} = \pm 0.25 \pm \sqrt{2^2 + 0 + 1.47^2 + 0.9^2 + 2^2 + 0.37^2 + 0 + 0} = \pm 3.58 INWC$, or ±0.61%

The above calculations are consistent with the current setpoint methodology contained in WCAP-11082, Revision 6, which was submitted in PG&E Letter DCL-03-111, "License Amendment Request 03-12, Revision to Technical Specifications 3.3.1, 'RTS Instrumentation,' and 3.3.2, 'ESFAS Instrumentation,'" dated September 12, 2003. WCAP-11082, Revision 6 was approved by the NRC for Diablo Canyon Power Plant by Amendment No. 178 to Facility Operating License No. DPR-80 and Amendment No.180 to Facility Operating License No. DPR-82 in NRC Letter "Issuance of Amendment Re: Revised Technical Specifications 3.3.1 'Reactor Trip System (RTS) Instrumentation' and 3.3.2, 'Engineered Safety Features Actuation System (ESFAS) Instrumentation' (TAC Nos. MC0893 and M0894)," dated December 2, 2004.

NRC Question 3

3. *Describe the surveillance and how the uncertainties are applied to assure that the requirements in SR 3.5.4.2 are met.*

PG&E Response:

The proposed SR 3.5.4.2 requires verification that the RWST borated water volume is greater than or equal to 455,300 gallons or 93.6 percent RWST level. Allowance for instrument uncertainty is not included in the proposed SR. To ensure that the SR 3.5.4.2 requirement is met, the minimum RWST level will be maintained greater than or equal to 94 percent using the temporary installed Heise gauge, or greater than or equal to 94.25 percent using the local digital readout on the new level transmitters, when installed. These acceptance criteria will be included in the TS Bases 3.5.4.2. Based on the inclusion of the acceptance criteria reflecting an allowance for instrument uncertainty in the TS Bases, the RWST level equivalent to contained borated water volume of 455,300 gallons in the proposed SR 3.5.4.2 (i.e., the 93.6 percent level uncorrected for uncertainty), can be relocated to the TS Bases 3.5.4.2. This proposed change has been discussed with the NRC staff.

Revised TS and TS Bases pages are included in Enclosure 2. They supersede the same numbered pages included in PG&E Letter DCL-07-093, "License Amendment

Request 07-02, Revision to Technical Specification (TS) 3.5.4, 'Refueling Water Storage Tank (RWST),'" dated October 2, 2007.

Although verification of the RWST borated water volume to satisfy the SR will be done using local instrumentation, RWST level changes can be observed by plant operators using installed instrumentation in the Control Room. Also, a plant process computer alarm will inform the operators when the SR limit is approached.

Attachment 1

Calculation N-227
Post-LOCA Minimum Containment Sump Level

NUCLEAR POWER GENERATION
CF3.ID4
ATTACHMENT 7.2

TITLE: Design Calculation Cover Sheet

Unit(s): 1&2 File No.: ______ Responsible Group: NSTA Calculation No.: N-227

Design Calculation YES ☒ NO ☐ System No. 7 Recirc Sump Quality Classification Q

Structure, System or Component: Post-LOCA Minimum Containment Sump Level

Subject: The purpose of this calculation is to conservatively estimate the minimum post LOCA containment sump water level (flood elevation) for various size breaks up to the design basis large break LOCA, at the time when the sump is required to provide suction flow to the RHR pump(s).

Computer/Electronic calculation YES ☐ NO ☒

Computer ID	Application Name and Version	Date of Latest Installation/Validation Test
N/A	N/A	N/A

Registered Engineer Stamp: Complete A or B

A. Insert PE Stamp or Seal Below	B. Insert stamp directing to the PE stamp or seal
REGISTERED PROFESSIONAL ENGINEER MARK L. MAYER No 23066 MECHANICAL STATE OF CALIFORNIA Expiration Date: 9/30/06	

NOTE 1: Update DCI promptly after approval.

NOTE 2: Forward electronic calculation file to CCG for uploading to EDMS, only if the calculation is complete and can be used from EDMS.

TITLE: Design Calculation Cover Sheet

Calculation No.: N-227

RECORD OF REVISIONS

Rev No.	Status	No. of Pages	Reason for Revision / Remarks	Prepared By: Initials/ LAN ID/ Date	LBIE Screen Yes/ No/ NA	LBIE Yes/ No/ NA	Check Method*	LBIE Approval PSRC Mtg. No.	LBIE Approval PSRC Mtg. Date	Checked Initials/ LAN ID/ Date	Supervisor Initials/ LAN ID/ Date	Registered Engineer Signature/ LAN ID/ Date
0	F	7	For previous revisions see historical cover sheets.	2/12/97	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	☐ A ☐ B ☐ C					
2	F	37	Updates RWST net injection volume per J-142 (AR A099219) See previous signature sheets.	J4B5	☒ Yes ☐ No ☐ NA	☐ Yes ☐ No ☒ NA	☐ A ☐ B ☒ C			MLM3	MLM3	MLM3
3	F	54	Incorporate revised N-224 values per AR A0602904.	J4B5 8/27/04	☒ Yes ☐ No ☐ NA	☐ Yes ☐ No ☒ NA	☐ A ☐ B ☒ C			ARLE 9/16/04	MLM3 9/17/04	MLM3 9/17/04
4	F	63	INCORPORATE REVISED N-73 VALUES. ADDRESS ENERCON REVIEW COMMENTS.	JAB5 1/13/06	☒ Yes ☐ No ☐ NA	☐ Yes ☒ No ☐ NA	☐ A ☐ B ☒ C			DDC1 2/27/06	MLM3 2/28/06	MLM3 2/28/06

*Check Method: A: Detailed Check, B: Alternate Method (note added pages), C: Critical Point Check

Input Reference Calc / Procedure No.	Input Reference Comments	Output Reference Calc / Procedure No.	Output Reference Comments
N-224 /STA-106		M-591	
N-073 /STA-071			
M-580 / M-585			
J-142			

SUBJECT Post - LOCA Minimum Containment Sump Level

MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table of Contents

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

1. Purpose / Background

The purpose of this calculation is to conservatively estimate the minimum post LOCA containment sump water level (flood elevation) for various size breaks up to the design basis large break LOCA, at the time when the sump is required to provide suction flow to the RHR pump(s).'

This calculation relies and builds on previous PG&E calculations and also Westinghouse LOCA analysis performed specifically to support this work. In order to bound the potential range of break sizes and various ESF configurations and failures that can impact the net post-LOCA containment sump inventory, this calculation evaluates a spectrum of eight break sizes ranging from 1.5 inch to the large break LOCA. The eight cases evaluated are listed below.

Table 1.1 Post-LOCA Sump Level Cases Evaluated

Case	Description
1	DEG LBLOCA, Minimum SI Flow, 3 CFCUs, 2 CSP actuated
2	6" Break, Minimum SI Flow, 3 CFCUs 2 CSP actuated
3	4" Break, Minimum SI Flow , 3 CFCUs, 2 CSP actuated
4	3" Break, Maximum SI Flow, 3 CFCUs, No CSP actuated, w/ RCS cooldown
5	3" Break, Minimum SI FLOW, 2 CSP actuated, w/cooldown
6	2" Break, Maximum SI FLOW, No CSP actuated, w RCS cooldown
7	2" Break, Minimum SI FLOW, No CSP actuated, w/ RCS cooldown
8	1.5" Break, Minimum SI FLOW, No CSP actuated

Where
DEG = Double Ended Guillotine
LBLOCA = Large Break Loss of Coolant Accident
CFCU = Containment Fan Cooler Unit
SI = Safety Injection
CSP = Containment Spray Pump
RCS = Reactor Coolant System

2. Revision Summary

Revision 1 - This revision addresses the following revised reference values and identified deficiencies:

1. M-585 Rev. 4 has revised the open volume for the containment elevation less than 91' from a value of 11198 ft3 to 11136 ft3.
2. J-54 Rev. 15 has revised the low level RWST injection volume from a value of 218560 gal. to 219877 gal.
3. Per AR A0491684, the assumption that the paint and/or insulation debris does not impede the water flow into the sump has been documented in assumption.
4. Per AR A0491684, the calculation has been updated to subtract the potential RWST sample line leakage which could occur during each of the eight LOCA scenarios as calculated in N-073 Rev. 1 (Ref. 23).

5. Per AR A049168, the calculation has been updated to include the dynamic pressure drop error effect on the RWST level transmitters which occurs due to the suction across the vent screen created by the RWST depletion flow as calculated in STA-106 (Ref. 22).
6. Per AR A0491684, the N-227 design input list has been revised to include STA-071.
7. Per AR A0491684, N-227 now takes all containment moisture volume values from the N-224 tables, which have been revised to cover the complete temperature range of the eight LOCA cases evaluated in this calculation.
8. Per AR A0491684, the most conservative minimum moisture content value from the four temperature and relative humidity tables in N-224 is selected for each particular N-227 case.

Revision 2 –

1. This revision updates design input 2 for the net RWST injection volume as determined in the new calculation J-142 Rev. 0 (AR A099219) which has been added as Reference 25. Calculation J-142 Rev. 0 consolidates and supersedes the old calculations J-54 Rev. 15 and SC-I-9-L920 Rev. 2 which have been deleted as References 2 and 24, respectively.
2. The calculated initial RWST volume (Item 1) has changed and is now provided in measured or usable volume instead of contained volume. Item 3 the low level RWST usable volume has also changed, along with the calculated RWST injected volume (Item 4).
3. The RCS spill and RCS shrinkage values changed slightly for Case 1 based on a more accurate application of the temperature dependent volumes taken form calculation M-580.
4. While there has been no change in the use of significant digits for the actual calculations, an effort has been made to reduce the number of significant digits reported for ease of viewing.
5. The Section 17 Results have been deleted as it is completely redundant to the Results Summary provided in section 3.
6. Section 20 along with the Enclosures and Attachments has been deleted. These documents were included for historical information only and no longer provide value to this calculation.

Revision 3

1. This revision was implemented due to the correction of an error in input calculation N-224 as identified AR A0602904. The original N-224 water vapor mass was incorrectly reduced by the partial pressure fraction. Correcting this error results in a slightly larger mass of water calculated to remain in the containment atmosphere for the same post-LOCA conditions.
2. The net RWST injected volume has been revised based on performing a statistical based evaluation of the initial indicated RWST level and the RHR pump trip setpoint uncertainties.
3. The RWST leakage has been revised to include leakage due to the failure of the non-seismic Reverse Osmosis (ROS) skid in addition to the RWST sample line leakage.
4. The calculation format has been revised to be consistent with the latest revision of CF3.ID14.

Revision 4

1. The RWST sample line leakage has been revised in N-73 Rev. 2 (Reference 11.1.7) which eliminates the ¾" line leakage case for isolation valve SI-1/2-8971. Recent design changes have made the downstream 3/8" RWST sample line and associated sample valve SI-1/2-267 design

class 1 such that it is no longer considered credible that an upstream failure could occur in the ¾" line section.

2. This revision incorporates additional assumptions, evaluations, and calculations which address the ENERCON technical review comments as requested in AR A0641926 (Reference 11.2.2) The Enercon review comments were originally provided in Table 1 of Attachment 2 in Reference 11.3.22. Each revision below designated a through k resolves the corresponding Enercon comment which has been reproduced and labeled as shown in Table 1 of Appendix B.

   a. The credited Large Break LOCA case RCS spill volume has been revised in Assumption 18.

   b. The pressurizer surge line break case has been evaluated as being bounded by the 6" case as documented in the new Assumption 30.

   c. Additional text has been added to Assumption 5 establishing the basis for the conservatism of the accumulator volume credited for injection.

   d. Additional text has been added to Assumption 19 establishing the basis for the conservatism of the two minute transit time and the volume of water assumed to be held up in transit that has not reached the sump.

   e. Additional text has been added to Assumption 6 establishing that the volume of liquid determined to be held up in the containment atmosphere conservatively accounts for the potential contribution associated with the Containment Spray flow transit time.

   f. Additional text has been added to Assumption 15 establishing that that the assumption for not crediting any RHR flow to the sump after the RWST low level is reached, conservatively bounds the liquid holdup in the small volume associated with the RHR suction line.

   g. Added new Assumption 31 to clarify that the potential volume of leakage from the ECCS and CS systems is considered insignificant for the period of interest to initiate recirculation.

   h. Corrected the case summary tables to reflect that Assumption 15 (originally listed as assumption 6) establishes there is no credit for any RHR flow to the sump after the RWST low level is reached.

   i. For Case 2, the reference for line item 9 was corrected to the appropriate Reference 11.3.12.

   j. Additional text has been added to Assumption 19 establishing that the holdup or transit time of containment spray flow liquid associated with the refueling canal drain is considered insignificant for this calculation.

   k. Additional text has been added in new Assumption 32 conservatively estimating several additional potential sources of liquid holdup in containment and establishing the basis that there are no other significant sources for liquid holdup inside containment that need to be considered as part of the water assumed to be held up or in transit.

3. Methodology

This calculation first defines the sources of water contributing to the containment recirculation sump, for post-LOCA conditions and the potential ways that this water can be diverted from reaching the sump.

The possible sources of water for filling the sump are:

- Reactor Coolant System (RCS)
- Accumulators
- RWST
- Spray Additive Tank (SAT)

The conditions that could reduce the water contribution to the sump are:

- Remaining liquid volume in the RCS
- RCS shrinkage due to cooling, requiring RWST makeup
- Partial to zero accumulator discharge (RCS pressure above 600 psig)
- Water vapor retained in the containment atmosphere
- Liquid condensation and pooling on containment surfaces
- Water in transit from the break to the sump
- Water volume required to fill the containment spray piping
- RWST leakage
- RWST level errors and uncertainties

The assumptions are then discussed, which lead to the identification of the limiting conditions to be evaluated in order to determine the various sources and losses which establish the minimum sump level. It should be noted that where plant physical drawings are used or referenced to establish assumptions regarding liquid path and/or holdup geometries, only one unit drawing needs to be listed since both units are essentially identical with respect to sump related geometry. This calculation relies and builds on previous PG&E calculations and also Westinghouse LOCA analysis performed specifically to support this work. A spectrum of eight break sizes ranging from 1.5 inch to the large break LOCA have been evaluated as summarized below. Since not all case data provided by Westinghouse were directly used, and the data were provided from several different sources, the case number designations used in Table 3-1 for this calculation do not correspond with the various case numbers provided in the individual references. However, the case description may be used to track and verify the appropriate source data form the applicable references as summarized below.

Table 3-1 Post-LOCA Sump Level Cases Evaluated

Case	Description	RCS Response Ref.	Contain. Response Ref.
1	DEG LBLOCA, Minimum SI Flow, 3 CFCUs, 2 CSP actuated	11.1.2	11.3.11
2	6" Break, Minimum SI Flow, 3 CFCUs 2 CSP actuated	11.3.12	11.3.15
3	4" Break, Minimum SI Flow , 3 CFCUs, 2 CSP actuated	11.3.12	11.3.15
4	3" Break, Maximum SI Flow, 3 CFCUs, No CSP actuated, w/ RCS cooldown	11.3.13	11.3.13

5	3" Break, Minimum SI FLOW, 2 CSP actuated, w/cooldown	11.3.14	11.3.14
6	2" Break, Maximum SI FLOW, No CSP actuated, w RCS cooldown	11.3.13	11.3.13
7	2" Break, Minimum SI FLOW, No CSP actuated, w/ RCS cooldown	11.3.14	11.3.13
8	1.5" Break, Minimum SI FLOW, No CSP actuated	11.3.14	11.3.14

For Case 1, the RCS response was calculated explicitly in M-580 (Reference 11.1.2) while the containment response data were obtained from the containment integrity analysis documented in WCAP-13907 (Reference 11.3.11). In support of this sump evaluation effort, Westinghouse provided RCS response data based on the existing spectrum of SBLOCA cases performed for the DCPP analysis of record as documented in PGE-97-520 (Reference 11.3.12). For Cases 2 and 3 the RCS response data was obtained from PGE-97-520. However, since there were no specific containment response data available for these cases, the containment response data were obtained from comparable large break data in the FSARU (Reference 11.3.15). As part of this sump evaluation effort, Westinghouse generated RCS and containment response data for five small break cases in PGE-97-537 (Reference 11.3.14). In the process of evaluating one additional case in PGE-97-543 (Reference 11.3.13), Westinghouse also revised two cases originally provided in PGE-97-537 when it was determined that containment spray would probably not actuate any of the 2" break cases. Case 5 and Case 8 were not revised and the RCS and containment response data are obtained from the first set of small break data transmitted in PGE-97-537. The RCS response data for Case 7 was not impacted and was obtained from PGE-97-537, however the containment response data were revised and obtained from PGE-97-540 based on containment spray not actuating. The RCS and containment response data for Case 4 were obtained from PGE-97-543, since this was a new additional case not in PGE-97-537. The RCS and containment response data for Case 6 were revised and obtained form PGE-97-543.

4. Assumptions

1. The containment sump provides RHR suction to support switchover from the post-LOCA injection phase (RWST water source) to the recirculation phase. Alignment to recirculation starts after the RHR pumps are tripped on reaching RWST low level. After the valve alignment to take suction from the sump, the RHR pumps are restarted. This is the time that the sump level is calculated.

2. Following a postulated LOCA, the water in the RWST, or accumulators is pumped/injected into the reactor for cooling and to keep the fuel covered. This water and some or all of the RCS fluid is spilled from the break to the containment atmosphere/containment sump.

3. LBLOCAs have blowdown rates that far exceed the ECCS injection rate and result in a large fraction of the RCS and accumulator water volume entering the containment sump. Therefore, the post LOCA RCS level would be significantly lower than the normal operating water level.

4. The ECCS injection rate usually exceeds the lower blowdown rates for SBLOCAs, which can significantly extend the time to reach RWST low level. This provides more time for the operators to initiate recovery steps and restore RCS level. Therefore, for all breaks smaller than the LBLOCA, the RCS level is assumed to be maintained near the normal operating value such that there is no net RCS spill contribution to the sump.

5. This calculation only credits accumulator injection when RCS pressure drops below the accumulator injection setpoint, and only up to the point when the RWST low level is reached. The accumulator volume is temperature corrected to the equivalent RWST volume.

   Enercon review comment 2.4.2.a discussed the possibility that the operators would isolate the ECCS accumulators for some SBLOCA cases such that the volume might not be credited to reach the sump. Only the very small break cases 7 and 8 which last a very long time would have any potential for the RCS pressure to remain elevated long enough for this to become a factor. Additionally the applicable operating procedure EOP E-1.2 "Post LOCA Cooldown and Depressurization" (Reference 11.3.16), has a Caution statement before step 22.a that the accumulators should only be isolated if SI has been terminated. SI termination is not considered likely for these adverse SBLOCA cases being evaluated, and it is assumed that for any scenario severe enough to result in initiating cold leg recirculation the operators would allow the accumulators to inject and increase the sump level. Conversely, if the SBLOCA scenario is not severe enough to result in the initiation of cold leg recirculation then accumulator injection is irrelevant. Therefore, the accumulator volumes credited for these SBLOCA cases are appropriate.

6. The amount of steam retained in the containment atmosphere for each case will be determined from data in calculation N-224 (Reference 11.1.1) based on the containment temperature and pressure conditions at the time the RWST low level is reached.
   The Enercon review comment 2.4.2.a requested an evaluation for the potential of containment spray liquid holdup in transit requiring a separate quantification. The terminal velocity of the containment spray drops is listed as 480 cm/sec (≈ 16 ft/sec) along with a spray fall height of 128 feet on SER 00 Page 15-4 (Reference 11.3.17). Therefore, the containment spray transport time in the containment atmosphere would only be about 8 to 10 seconds which is not

considered significant. Any containment spray fluid in the atmosphere is bounded by the conservative calculation of N-224 which maximizes the atmospheric moisture as a function of containment conditions.

7. The liquid film thickness of the condensation on the various containment surfaces is a function of the differential temperature between the atmosphere and the surface. As stated in Reference 11.3.1, the heat transfer occurs very quickly for steel such that, the temperature difference between the heat sink surfaces and containment atmosphere and the resulting film thickness are expected to be small. Although this evaluation was for a small break case, this conclusion is also applicable for the LBLOCA case since the short switchover time (14 minutes and 26 seconds) is still reasonably long by heat transfer standards. Based on the Reference 11.3.1 methodology, the total condensation and pooling volume is assumed to be 1000 ft^3.

8. Deleted in Revision 2.

9. It was noted that the calculated flood depth per reference 11.1.2 is lower for Unit 2 than in Unit 1, unless otherwise noted, this calculation will use data from Unit 2 as input.

10. The nominal initial RWST volume is assumed to be the Tech. Spec. (Reference 11.3.5) minimum of 81.5% per SR 3.5.4.2 plus the indication uncertainty of 2.5% per J-142 (Reference 11.1.3) or a minimum level of 84% as established per AR A0539565 (Reference 11.3.2). At 4583 gal/% (design input 2), this represents 384,900 measured or usable gallons. Per the administrative requirements documented in AR A0539565 the RWST volume is maintained at ≥ 90%. This value can be credited since the RWST low alarm setpoint is maintained at ≥ 91% as listed in annunciator response AR PK-06-20 (Reference 11.3.3). The 90% administrative initial RWST level represents 412,400 usable gallons. These same nominal and administrative values are assumed for each case evaluated.

11. The minimum RWST injected volume is determined from the initial volume minus the remaining RWST usable volume when the RHR pumps are tripped on the RWST RHR trip setpoint of 32.56% per design input 2 (149,200 gallons). As discussed in the calculation section, the applicable RWST level uncertainties are statistically bounded by assuming a net uncertainty of 3.5% in the TS minimum injected RWST volume or 16,041 gallons. So the minimum net RWST injection volume between the TS minimum level and the RHR pump trip setpoint is reduced by 16,041 gal. to a value of 384,900 – 149,200 – 16,041 = 219,659 gal.

    As discussed in the calculation section, the applicable RWST level uncertainties are statistically bounded by assuming a net uncertainty of 2.2% in the net administrative injected RWST volume. So the minimum net RWST injection volume between the administrative alarm level and the RHR pump trip setpoint is reduced by 10,083 gallons to account for instrument uncertainties to a value of 412,400 – 149,200 – 10,083 = 253,117.

12. When the Containment Spray System is actuated, 487.5 ft^3 of water are assumed lost in order to fill the empty containment spray header which bounds Design Input 11.

13. Deleted per Revision 2

14. Credit is taken for the additional spill volume out the break (minimum ECCS flow rate) and containment spray (if actuated) during the time after the RHR pumps have tripped until the

earliest time they could be restarted to begin ECCS recirculation. This time has been established to be 3 minutes per Reference 11.3.4.

15. It is expected that the operator will start one RHR pump first at step 6 of EOP E-1.3. For a small break LOCA up to approximately 6 inches, the RCS pressure remains above the RHR pump shutoff head. Therefore, this evaluation conservatively does not credit any RHR flow contribution to the sump after the RWST low level has occurred.

In response to the Enercon review comment 2.4.2.f, the liquid holdup volume associated with filling the RHR sump recirculation suction piping is not considered significant. Per drawing 500054 (Reference 11.1.10), there is only about 20 feet of a vertical 14 inch pipe above the RHR recirculation suction valve. This represents only about 20 ft^3 of piping based on the Crane B-18 (Reference 11.3.18) Schedule 5S flow area of 1.0219 ft^2. This small value is not considered significant and is bounded by the numerous other conservative assumptions associated with minimizing the calculated sump volume at the time of ECCS recirculation.

16. For the case of a stuck open PORV, the water lost in filling the PRT is offset by the reduced amount of condensation, water in transit, and steam in the atmosphere. Therefore, this condition (where RCS fluid is used to fill the PRT) is not considered for determination of minimum sump level.

17. All of the net contributions and losses of water to the sump are initially calculated based on the equivalent nominal RWST volumetric conditions of 100 °F and 14.7 psia with a specific volume of 0.016129 ft^3/lbm (ASME Steam Tables Reference 11.3.6). Therefore, a temperature correction factor is used to account for the thermal expansion of the RWST water as it equilibrates to the containment sump conditions. These sump water conditions are assumed to at a temperature of 200 °F and the particular post LOCA containment pressure for each break case. Assuming a more reasonable maximum RWST temperature of 90 °F and a sump temperature of 220 °F could increase the net sump level by approximately 0.5 inches.

18. The full RCS spill volume is only credited for the LBLOCA case and is obtained from Reference 11.1.2 based on a liquid temperature of 270 °F and a specific volume of 0.01717 ft^3/lbm. The total Unit 2 RCS volume established in calculation M-580 (Reference 11.1.2) is 9958 ft^3 (temperature corrected to 270 °F) which is found by adding the RCS retained volume of 3040 ft^3 to the RCS spill volume of 6918 ft^3. Note that the previous revisions of N-227 used the Unit 2 RCS spill volume of 6918 ft^3, since it was conservatively smaller than the calculated Unit 1 RCS spill volume of 6963 ft^3. The Unit 2 spill volume represents 6918/9958 = 69.5% of the RCS volume spilling to the containment sump. The Enercon review comment 2.4.2.a indicates that it is more conservative to assume that the RCS volume up to the top of the hot legs remains filled. According to the latest RETRAN model of DCPP in STA-164 (Reference 11.3) as summarized in Appendix C, the top of the hot leg would represent a retention volume fraction of about 4350 ft^3 / 11273 ft^3 or 39% and a spill fraction of about 61%. To conservatively account for this additional RCS retention volume, the RCS spill volume in M-580 is reduced by 15% to a value of 5880 ft^3. This RCS spill volume is then temperature corrected to the equivalent RWST volume of 0.016129 ft^3/lbm or reduced by a factor of 1.0645 to a value of 5524 ft^3.

The Enercon review comment regarding the potential for RCS liquid holdup due to condensation and vacuum conditions in the SG tubes is considered a long term effect only and is not significant for this scenario. Immediately following the large break LOCA, a considerable amount of air would be expected to enter the breached RCS. This in combination with the high decay heat and metal temperatures would preclude any significant liquid condensation and potential vacuum conditions for the relatively short term conditions associated with establishing ECCS recirculation.

19. The water in transit is assumed to be 250 ft^3 or approximately 1800 gallons for each case. This is considered reasonable based on a typical small break blowdown rate (at the time of switch over) of 500 to 1000 gpm and a corresponding estimated transport time of 2 minutes. In response to the Enercon review comment 2.4.2.d, a two minute transport time is reasonably conservative based on the minimum expected liquid flow velocities of 0.5 - 1 feet per second along with an average transport distance to the recirculation sump of 60 -120 feet. Therefore, a more detailed estimate of liquid transit time is not considered necessary

    In response to Enercon review comment 2.4.2.j, this assumption also evaluates that the refueling canal is not a significant source of liquid holdup which does not reach the sump. Per drawing 500039 (Reference 11.1.11) the drain size is 8 inches and there is about 8 feet of 8 inch drain line to HCV-111 which per DCM S-9A 4.3.1.j (Reference 11.3.20) is required to remain open during operation and allow drainage to the 91' level of containment. A review of the refueling cavity and containment physical geometry indicate that the associated drain line 3073 is not considered a credible risk for debris obstruction that could cause any significant flow impedance of water to the recirculation sump during post-LOCA conditions. The refueling cavity is cleaned and inspected at the end of each refueling outage. In addition, the refueling cavity is not considered a likely credible location for the deposition of any substantial post-LOCA debris such as insulation and/or paint. The RCS piping and branch lines are located in physically separated compartments within containment. The intervening walls, floors, and steam generator cubicle compartments make it very unlikely that even the large break LOCA could transport a significant enough amount of debris up, through, and over the tortuous path of intervening structures necessary to reach the refueling cavity.

20. Deleted in Revision 2.

21. Deleted in Revision 2.

22. Per Reference 11.3.4, operator action is credited to maintain the RCS/pressurizer water level near normal values (i.e. will not allow the RCS to go water solid). Thus, the post LOCA RCS volume for all but the large break case is assumed equal to the initial full power liquid volume of 12160 ft^3 with a specific volume of .02221 ft^3/lbm for a Tavg = 577 °F and an average RCS pressure of 2280 psia (Reference 11.3.15).

23. This calculation assumes the operator will maintain the RCS at a subcooled condition when possible (at least 20 °F subcooling per reference 11.3.7 and Reference 11.3.4). This assumption is conservative since it results in a greater net RCS shrinkage. Throughout this calculation, a 30 °F subcooling is assumed.

24. Operator action is credited to cool down the RCS using steam generator relief valves and AFW for small breaks when switchover occurs more than one hour after the accident (Reference 11.3.4). This reduces the RCS pressure and allows more accumulator injection.

25. The SAT contribution is based on crediting 90% of the eductor flow of 35 gpm (Reference 11.3.8) from CS actuation to RHR pump restart.

26. The flow path ways to the sump are assumed to remain effectively free from debris blockage since the flow areas are large while the flow velocities are small. A significant fraction of debris would have to accumulate in order to impede flow, and this net reduction in debris inventory at the sump screen would result in a less limiting condition for sump level.

27. RWST leakage due to the failure of the non-seismic Reverse Osmosis (ROS) skid connected to the RWST is only considered for those cases which credit the administratively increased RWST level since ROS operation is administratively controlled per reference LAR-00-02 Commitment 4 as documented in AR A0503748 (Reference 11.3.9).

28. Deleted in Revision 4..

29. For the Administrative RWST level cases, the maximum leakage from the non-seismic ROS flow limiting orifice is assumed to be 70 gpm per AR A0495677 (Reference 11.3.10). Per AR A0503748 (Reference 11.3.9) the ROS skid is assumed to be isolated and the leakage stopped after five hours. It should be noted that this ROS leakage is still conservatively incorporated into this calculation even though the ROS skids have been removed per Unit 1 DCP N-49578 and Unit 2 DCP N-50578. This provides additional conservative margin which can be used to assess other RWST leakage or sump related issues.

30. The current Case 2 6" break case is considered to be bounding for a pressurizer surge line break which addresses the Enercon review comment 2.4.2.b. Case 2 already assumes no credit for any RCS spill volume. While the larger pressurizer surge line break would result in a slightly greater containment pressure and liquid vapor holdup in the atmosphere, this is offset by reduced RCS pressure (larger break size) and a resultant increase in ECCS flow that would exist when the RWST low level is reached. The other post accident conditions would be expected to be very similar for these two relatively large break cases. Since the Case 2 6" break already assumes no credit for any RCS spill volume, it can be considered conservatively representative of a potential pressurizer surge line case.

31. In response to Enercon review comment 2.4.2.g, the post-LOCA ECCS recirculation leakage is not considered significant with respect to reducing the available sump liquid inventory. The design basis small ECCS recirculation leakage is only 1910 cc/hr as listed in DCM T-15 Table 4.6-10 (Reference 11.3.21) which is insignificant for the even the longest Case 8 which lasts only about 6.3 hours. The RHR pump seal failure leakage of 50 gpm is a very conservative ECCS recirculation leakage assumption associated with calculating a limiting post-LOCA offsite dose. This RHR seal leakage is assumed to last only 30 minutes and the 1500 gallons of lost inventory is more than offset by assumption 14 which conservatively only credits three minutes of ECCS injection flow after the RHR pumps trip off. In conclusion, these additional sources of ECCS leakage may be neglected since they are not significant and are bounded by other conservative assumptions which minimize the credited sump inventory.

32. In response to the Enercon review comment 2.4.2.k, Ventilation ducts are considered effectively sealed to preclude any significant water intrusion. In addition, any water in leakage into the largest ventilation ducts associated with the CFCUs would still exhaust down to the 91' level. Per drawing 438234 (Reference 11.1.12) detail I, the reactor head ring stand has six

equally spaced drain openings that allow water to exit the enclosure. The Incore shaft and equipment room are sealed off from general containment volume. There are no elevators in containment. As discussed in Assumption 19, the majority of the refueling cavity effectively drains down to the 91' level. The upper internals lay down area is slightly recessed (113' 9 ½ " – 113' 1 ½" = 8") below the nominal refueling cavity floor and could trap a quantity of water. Based on drawing 438233 (Reference 11.1.13) this trapezoidal volume is estimated to be

$V = (a + b)/2\,h$
$V = (20' \times 23')/2 \times 17' \times 0.666' = 244\ ft^3$

The polar crane trench and refueling manipulator crane bridge trench have drains to 91' level as shown in DWG 500159 (Reference 11.1.15) and DWG 500160 (Reference 11.1.14) such that these are not considered to be a source of liquid holdup.

In response to the Enercon review comment 2.4.2.k, the originally assumed liquid holdup volume is conservatively increased by 10% to 275 ft^3 to bound any miscellaneous minor sources of liquid holdup. Thus, there are no other significant physical sources for liquid hold up inside containment that require specific itemizing within this calculation. The total liquid holdup volume therefore 244 + 275 = 519 ft^3. In addition to the drawings referenced in this calculation, the following drawings were reviewed to help make conclusions regarding the geometry inside containment.

Dwg 500973 U2 Equipment Location Section C-C
Dwg 500969 U2 Equipment Location Section A-A
Dwg 500971 U2 Equipment Location Section Cont. & FHB, Els. 85' , 91', and 100'
Dwg 57724 U1 and U2 Equipment Location Aux & Cont., Plan at EL 85'

Dwg 59531 U1 Containment Structure Plan below EL 91'

Dwg 501392 U2 Containment Mech Ventilation Section Areas F & G ., EL 74' to 140'
Dwg 501390 U2 Containment Mech Ventilation Section Area G ., EL 74' to 140'
Dwg 501389 U2 Containment Mech Ventilation Section Area F ., EL 74' to 140'
Dwg 500055 U1 Piping & Mech, Area G, GW, GE plan at El 85' and 91'

Dwg 437999 U1 Piping & Mech, Design Review Isometric Refueling Canal Drain

Dwg 500155 U1 Embedded Pipe – Reactor Cavity Area G and F

Dwg 438235 U1 Interior Concrete Outline Misc Sections Containment
Dwg 438232 U1 Civil Interior Concrete Outline Plans @ EL 74' and 91' Containment

5. Design Inputs

1. Containment volumes are from Calculation M-585 (Reference 11.1.5).

2. RWST volume vs level indication (4583 gal/%), the RWST levels, and the RHR low level trip setpoint (32.56%) are from I&C calculation J-142 Rev. 0 (Reference 11.1.3). The calculated RWST volume values versus level are rounded to the nearest conservative hundreth value (rounded down for sump volume additions and rounded up for sump volume subtractions). In

addition. All of the RWST level instrument uncertainty terms are from I&C calculation J-142 Rev. 0 (Reference 11.1.3)

3. The amount of water vapor in the containment atmosphere is from calculation N-224 (Reference 11.1.1).

4. The amount of condensation in the containment surface area is estimated using guidance in Reference 11.3.1.

5. For the large break LOCA case, containment pressure & temperature are from WCAP 13907 (Reference 11.3.11).

6. Containment & RCS conditions at the time of switch over and 3 minutes after switch over are per Westinghouse letters (References 11.3.12 & 11.3.13)

7. Steam/water properties are per ASME Steam Table (Reference 11.3.6)

8. RHR recirculation flows are from STA-071 (Reference 11.1.6)

9. Deleted per Revision 2.

10. The RWST sample line leakage determined in calculation N-073 (Reference 11.1.7).

11. The Containment Spray System header fill volumes are Header A = 253.98 ft^3 and Header B = 233.54 ft^3 per of ^{3} per Calculation M-085 (Reference 11.3.14).

12. For the Large break LOCA Case 1, the RWST low level is reached at 14 minutes 26 seconds per reference STA-071 (Reference 11.1.8)

13. The RWST level error due to the dynamic air pressure drop across the RWST vent screen (due to the decreasing RWST level) is provided by STA-106 (Reference 11.1.9).

14. The RCS volumes are from Calculation M-580 (Reference 11.1.2) and from the DCPP RETRAN model in STA-164 (Reference 11.3.19).

6. Acceptance Criteria

There are no explicit acceptance criteria for the minimum sump level calculation. These results will be used in calculation M-591 (Reference 11.2.1) to determine the amount of positive head margin that is available in the recirculation sump screen structure during post-LOCA ECCS recirculation flow conditions.

7. Calculation

7.1. Net RWST Injection Volume Error.

Tech Spec Minimum RWST Level and RHR Pump Trip Setpoint

The previous revisions of this calculation conservatively bounded the RWST instrument uncertainties by decreasing the assumed initial RWST level by the vertical board indication uncertainty and increasing the assumed RHR pump trip setpoint by the setpoint uncertainty. This methodology is overly conservative and results in an unrealistic penalty on the amount of RWST volume that is credited to reach the recirculation sump. The same level transmitter (LT-920, LT-921, and LT-922) feeds both a corresponding RHR pump trip setpoint (LC-920A, LS-921, and LS-922) and a vertical board indicator (LI-920, LI-921, and LI-922), respectively. Thus any error due to the level transmitter will affect both the RWST level indication and the RHR trip setpoint the same, and will always cancel during the net subtraction of these two terms. For example, a +1% level transmitter error would cause the actual initial RWST level to be 1% less than the minimum Tech Spec value, it would also cause the RHR trip setpoint to be 1% greater than the nominal setpoint, for that given channel.

The only level transmitter uncertainty term that could affect the net RWST injection volume is the positive one inch bias which can occur due to an increase in the fuel building air pressure as discussed in Calculation J-142 (Reference 11.1.3). After a LOCA, the auxiliary building and fuel building ventilation system could be placed in charcoal mode. In order to conservatively bound the worst potential change in the fuel building air pressure and associated level transmitter bias after a LOCA , the 1% bias will not be applied to the initial RWST level indication but will be applied to the RHR trip setpoint.

This calculation revision credits a more realistic but still conservative estimate of the net RWST injection volume error due to the applicable uncertainties. As discussed in design input 2, calculation J-142 (Reference 11.1.3) establishes the individual uncertainty terms which are applicable to the RWST level transmitter, the level indicator, and the RHR trip setpoint. In Appendix A , Table A-1 provides a summary of the component uncertainty terms and total statistical uncertainty as compiled from J-142. In addition, Appendix A details the level transmitter terms which can be cancelled out for the net subtraction of the initial RWST level and the RHR trip setpoint, and calculates the revised applicable uncertainty values using the Square Root of the Sum of the Squares (SRSS) methodology per J-142, as summarized in Table A-2. The applicable Table A-2 error values are listed below:

LC-920A (RHR Trip): +1.34%, -1.17% LI-920 (VB Indication): +2.31% , -2.31%
LS-921 (RHR Trip): +1.17%, -1.00% LI-921 (VB Indication): +2.31% , -2.31%
LS-922 (RHR Trip): +1.17%, -1.00% LI-922 (VB Indication): +2.31% , -2.31%

Table A-3 summarizes all of the possible combinations of errors for the initial RWST level error (VB indication) minus the 2/3 RHR trip setpoint error. When the vertical board indication error and the RHR pump trip setpoint errors are in the same direction there is a partial cancellation of the error values which makes the effect on the net injection volume less limiting. Appendix A details the possible combination of errors which can occur for the net RWST injection volume based on the 2/3 RHR trip logic. The limiting cases are when the VB indication error is maximum negative and the

2/3 RHR trip error is maximum positive. Appendix A shows that the worst case new RWST injection volume error occurs for Cases 2 and Case 4 which have the following calculated value:

Case 2 and Case 4 net RWST injection volume error = (-2.31) – (1.17) = -3.48%,

As discussed in Assumption 11, assuming a net RWST injection volume error of 3.5% or 16,041 gallons conservatively bounds the probabilistic effects of the 2/3 RHR trip logic . So the minimum net RWST injection volume between the TS minimum level and the RHR pump trip setpoint is reduced by 16,041 gal. to a value of 384,900 – 149,200 – 16,041 = 219,659 gal.

Administrative RWST Level and RHR Pump Trip Setpoint

As discussed in assumption 10, the administrative requirements documented in AR A0539565 require that the RWST volume be maintained at ≥ 90%. This is ensured by setting the RWST low alarm setpoint to at ≥ 91%, such that the initial RWST level error is based on the low level alarm channel accuracy. It should be noted that per J-142 (Reference 11.1.3) the RWST low level setpoint uncertainty for LC-920D is equal to LC-920A and that for LC-921B is equal to LS-921.

The individual RWST low level alarm channel accuracy can be calculated identical to that for the RHR low level trip setpoints (excluding the level transmitter error terms), except that the bias error does not apply for the initial pre-accident RHR level error. The individual component uncertainties using the Square Root of the Sum of the Squares (SRSS) methodology per J-142 provides the following values for LC-920B and LC-920D :

LC-920D CU+/CU- = SQRT (RCA^2 + RD^2 + RT^2)/589
= +1 + SQRT (2.95^2 + 5.89^2 + 2^2) /589
or CU+ = +/- 1.17%

LC-920B CU+/CU- = SQRT (RCA^2 + RD^2 + RT^2) / 589
= SQRT (2.95^2 + 4.71^2+ 2^2) / 589
or CU+ = + 1.00%

Similar to the error evaluation above, when the low level alarm and the RHR pump trip setpoint errors are in the same direction there is a partial cancellation of the errors which makes the effect on the net injection volume less limiting. The limiting case is when the low level alarm error is maximum negative and the 2/3 RHR trip error is maximum positive. The worst case net RWST injection volume error would occur for the following values:

Maximum new RWST injection volume error = (-1.17) – (1.00) = 2.17%

So the net RWST injection volume error between the initial indicated level at the low level alarm setpoint and the RHR pump trip setpoint will be reduced by 2.2% or 10,083 gallons to a value of 412,400 – 149,200 – 10,083 = 253,117, as discussed in Assumption 11.

7.2. *Case 1 - LBLOCA, Min. SI, 2 CS trains.*

The following table gives the derivation of the sump level for LBLOCA. RWST low level is reached at 14 minutes 26 seconds per reference 11.1.8. Two trains of CS are actuated at essentially zero seconds. No RCS cooldown is modeled as the switchover time is less than one hour.

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	RWST Instrument Uncertainty	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 - Items(2 + 3)
5	RWST (CS after low level trip)	7851	1049.5*	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15
7	RCS (ECCS after low level trip)	2726	364.4*	
8	RCS spill volume	41325*	5524	Reference 11.1.2 / Assumption 18
9	Accumulators	25248*	3375	Reference 11.1.2
10	SAT	1014*	135.6	Assumption 25
	Subtotal (+)'s	297824	39811	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000	Assumption 7
12	Steam in the Containment Atmosphere	27014*	3611	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	5324*	711.7	
15	CS piping fill	3647	487.5*	Reference 11.1.4
16	RWST sample line leakage	19	2.5*	Reference 11.1.7
17	RWST vent screen Δp error	3631.7	485.5*	Reference 11.1.9
	Subtotal (-)'s	50999	6817	
	RWST equivalent sump volume	246825	32994	Subtotal(+) – Subtotal (-)
18	RWST / sump expansion factor	1.0313	1.0313	
19	Net sump liquid volume	254550	34026	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was not originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine this corresponding value.

Per reference 11.1.5:

Volume below 91 feet elevation = 11136 ft^3

Volume from 91 feet to 94 feet elevation is conservatively assumed to have the same unoccupied volume as greater than 94 feet that is: = $11.20X10^3$ ft^3/ft ± 125 ft^3/ft
(M-585 actually lists $11.020X10^3$ ft^3/ft ± 125 ft^3/ft for 91 feet to 94 feet)

From the above table, the volume of water at the sump is 34026 ft^3. Therefore, the flood elevation is:

$$\frac{34026-11136}{11.20X10^3+125}+91=93.02ft.$$ (Please refer to the conclusion for additional discussion)

When the first RHR pump is started, the maximum flow from the Sump per Reference 11.1.6 is 7769 gpm. This is based on a reasonable assumption that RCS pressure is equal to containment pressure (therefore zero differential pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, which is at least one or more minutes later, the actual sump water level should be higher due to additional water contribution from the CS system.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. This is the amount of water that discharged from the Containment Spray system during the 3 minute duration after the RHR pumps have tripped until they are restarted (Reference 11.3.4). The Containment Spray flow rate is based on the containment pressure at the time of switchover. For this case the spray flow is 2617 gpm (Reference 11.3.13) and the CS flow volume credited is 7851 gallons. Crediting one train of spray is conservative since the switchover time is based on two trains of containment spray.
6. For a large LOCA, even though the RCS pressure is below the shutoff head of the RHR pumps, as discussed in assumption 15, no RHR flow is credited after the low level trip for this evaluation.
7. This is the minimum amount of water that is injected into the reactor via one train of ECCS (one CCP and SIP) during the 3 minute interval after the RHR pumps have tripped until they are restarted by the operator. For this case the injection flow is 908.76 gpm based on an RCS pressure of 38 psig at the time of switchover. Assuming that this injection flow all spills out the break is appropriate for a large break LOCA.

8. The RCS volume that is spilled from the break is 5880 ft^3 based on an RCS temperature of 270 °F and a specific volume of 0.01717 ft^3 as determined in Assumption 18 and Reference 11.1.2. As discussed in assumption 18, this RCS contribution is reduced by a factor of 1.0645 to an equivalent RWST volume of 5524 ft^3.

9. This is the amount of water from the accumulators (Reference 11.1.2). For a large break LOCA, all accumulator volume (3375 ft^3)would have been injected by the time RWST low level is reached.

10. Credit is taken for a SAT eductor flow of 63 gpm (Assumption 25) from time zero to 14 minutes, 26 seconds when the RWST low level is reached per reference 11.1.8. The 80 second SAT fill time is subtracted, while an additional 3 minutes is added (until the RHR pump is restarted) for a total SAT contribution of 135.6 ft^3.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water retained in the containment atmosphere as steam. Per WCAP 13907, Figure 3-1 (Reference 11.3.11), the containment temperature at switchover is 259 °F. At this containment temperature, N-224 (Reference 11.1.1) estimates the maximum steam held in the atmosphere would be 3611 ft^3 based on the initial conditions of 120 °F and 100% RH.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the containment saturation temperature for 38 psig or at 254.35 °F (ν = 0.01704 ft^3/lbm) . The post LOCA remaining RCS volume was determined to be 3040 ft^3 per M-580 (Reference 11.1.2), based on a RCS temperature of 576 °F, and a specific volume of ν = 0.02264 ft^3/lbm. Thus, establishing the required subcooling reduces the remaining RCS volume by a factor of 1.3286 to a value of 2288.1 ft^3. This net RCS shrinkage of 751.9 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.0565 to a value of 711.7 ft^3.

15. As discussed in assumption 12, the amount of water used to fill the empty containment spray piping is 487.5 ft^3.

16. Per design input 10 the RWST leakage from the sample line would be 19 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of 4.636 inches across the vent screen which is conservatively assumed to be 80% plugged. This converts to a 3631.7 gal.error in RWST level (783.36 gal/in per Ref. 11.1.3)

18. As discussed in assumption 17, the equivalent RWST volume of water is based on a specific volume of ν = 0.016129 ft3 /lbm, would expand by a factor of 1.0313 for the post LOCA sump water conditions of 200 °F and a containment pressure of 38 psig.

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

7.3. *Case 2 - 6 inch break, Min. SI, 2 CS trains.*

The following table gives the derivation of the sump level for a 6 inch break. RWST low level is reached at 1750 seconds per reference 11.3.12. Two trains of CS actuated at time 173 seconds. No cooldown is modeled as switchover time is less than an hour.

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	8463	1131.3*	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0	No RHR credit –Assumption 15.
7	RCS (ECCS after low level trip)	2600.1	347.6*	
8	RCS spill volume	0.	0*	Not credited per Assumption 18
9	Accumulators	25281*	3379.3	Reference 11.3.12
10	SAT	1761*	235.4	Assumption 25
	Subtotal (+)'s	257764	34456	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	15890*	2124.0	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	15428*	2062.3	
15	CS piping fill	3646*	487.5	Reference 11.1.4
16	RWST sample line leakage	39	5.2*	Reference 11.1.7
17	RWST vent screen Δp error	1164.1	155.6*	Reference 11.1.9
	Subtotal (-)'s	47531	6354	
	RWST equivalent sump volume	210232	28102	Subtotal(+) – Subtotal (-)
	RWST / sump expansion factor	1.0314	1.0314	
18	Net sump liquid volume	216833	28985	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft

From the above table, the volume of water at the sump is 28985 ft^3. Therefore, the flood elevation is:

$\frac{28985-11136}{11.20X10^3+125}+91=92.58ft.$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 200 psia, the maximum flow from the Sump per reference 11.1.6 is 3329.4 gpm based on a 163.3 psid (200 RCS pressure - 36.7 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the CS system.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. This is the amount of water that discharged from the Containment Spray system during the 3 minute duration after the RHR pumps have tripped until they are restarted (Reference 11.3.4). The Containment Spray flow rate is based on the containment pressure at the time of switchover is 2821 gpm (Reference 11.3.13) and the CS flow volume credited is 8463 gallons. Crediting one train of spray is conservative since the switchover time is based on two trains of containment spray.
6. For a 6 inch break, even though the RCS pressure is below the shutoff head of the RHR pumps, as discussed in assumption 15, no RHR flow is credited after the low level trip for this evaluation.
7. This is the minimum amount of water that is injected into the reactor via one train of ECCS (one CCP and SIP) during the 3 minute interval after the RHR pumps have tripped until they are restarted by the operator. The blowdown is assumed to be equal to the minimum ECCS flow rate at 866.7 gpm (i.e. one SI & one charging pump) for 3 minutes. This assumption is reasonable as the flow rate from a 6 inch break at 200 psia far exceeds this minimum ECCS flow rate.

8. No credit is taken for RCS contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.12). For a 6 inch break, this is 209885 lbm or 3379.3 ft^3.

10. Credit is taken for a SAT eductor flow of 63 gpm (Assumption 25) from 173 seconds to 1750 seconds when the RWST low level is reached per reference 11.1.8. The 80 second SAT fill time is subtracted, while an additional 3 minutes is added (until the RHR pump is restarted) for a total SAT contribution of 235.4 ft^3.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per FSAR figure 6.2-4 (Reference 11.3.15), the containment pressure at switchover (1750 seconds per Reference 11.1.1) is ~ 22 psig (36.7 psia). Interpolating at this containment pressure, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 2124 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit /holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 200 psia (Reference 11.3.12) or at 351.8 °F (ν = 0.018005 ft^3/lbm) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.2335 to a value of 9858 ft^3. This net RCS shrinkage of 2302 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1163 to a value of 2062.3 ft^3.

15. As discussed in assumption 12, the amount of water used to fill the empty containment spray piping is 487.5 ft^3.

16. Per design input 10 the RWST leakage from the sample line would be 39 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of 1.486 inches across the vent screen which is conservatively assumed to be 80% plugged. This converts to a 1164.1 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 22 psig (ν = 0.016635 ft^3 /lbm).

7.4. *Case 3 - 4 inch break, Min. SI, 2 CS trains.*

The following table gives the derivation of the sump level for a 4 inch break. RWST low level is reached at 2000 seconds per reference 11.3.12. Two trains of CS actuated at time 420 seconds. No cooldown is modeled as switchover time is less than an hour.

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	8538*	1141.3*	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (ECCS after low level trip)	2421.9	323.7*	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	6927*	926.0	Reference 11.3.12
10	SAT	1764*	235.8	Assumption 25
	Subtotal (+)'s	239310	31989	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	14386	1923	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	11824*	1580.6	
15	CS piping fill	3646*	487.5	Reference 11.1.4
16	RWST sample line leakage	45	6.0*	Reference 11.1.7
17	RWST vent screen Δp error	776.3	103.8*	Reference 11.1.9
	Subtotal (-)'s	42042	5620	
	RWST equivalent sump volume	197268	26369	Subtotal(+) – Subtotal (-)
	RWST / sump expansion factor	1.0314	1.0314	
18	Net sump liquid volume	203462	27197	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft

For Case 3, the volume of water at the sump is 27197 ft^3. Therefore, the flood elevation is:

$$\frac{27197-11136}{11.20X10^3+125}+91=92.42\,ft.$$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 400 psia, the maximum flow from the Sump per reference 11.1.6 is 1819.5 gpm based on a 365.3 psid (400 RCS pressure - 34.7 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the CS system.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.

2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.

3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.

4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).

5. This is the amount of water that discharged from the Containment Spray system during the 3 minute duration after the RHR pumps have tripped until they are restarted (Reference 11.3.4). The Containment Spray flow rate is based on the containment pressure at the time of switchover is 2846 gpm (Reference 11.3.13) and the CS flow volume credited is 8538 gallons. Crediting one train of spray is conservative since the switchover time is based on two trains of containment spray.

6. As discussed in assumption 15, at the time of switchover the RCS pressure is still above the RHR pump shutoff head so no RHR flow is credited after the low level trip for this evaluation.

7. This is the minimum amount of water that is injected into the reactor via one train of ECCS (one CCP and SIP) during the 3 minute interval after the RHR pumps have tripped until they are restarted by the operator. The blowdown is assumed to be equal to the minimum ECCS flow rate at 807.3 gpm for a total of 2421.9 gallons. This assumption is reasonable as the flow rate from a 4 inch break at 400 psia far exceeds the minimum ECCS flow rate.

8. No credit is taken for RCS contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.12). For a 4 inch break, this is 57510 lbm or 926.0 ft^3.

10. Credit is taken for a SAT eductor flow of 63 gpm (Assumption 25) from 173 seconds to 1750 seconds when the RWST low level is reached per reference 11.1.8. The 80 second SAT fill time is subtracted, while an additional 3 minutes is added (until the RHR pump is restarted) for a total SAT contribution of 235. 8 ft^3.

11. As discussed in assumption #7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per FSAR table 6.2-4, the containment pressure at switchover (2000 seconds) is ~ 20 psig. At this containment pressure (34.7 psia), interpolation from calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 1923 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 400 psia (Reference 11.3.12) or at 414.6 °F ($\nu = 0.018838\ ft^3/lbm$) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 ($\nu = 0.02221\ ft^3/lbm$) per assumption 22, by a factor of 1.179 to a value of 10314 ft^3. This net RCS shrinkage of 1846 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig ($\nu = 0.016129\ ft^3$) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1168 to a value of 1580.6 ft^3.

15. As discussed in assumption 12, the amount of water used to fill the empty containment spray piping is 487.5 ft^3.

16. Per design input 10 the RWST leakage from the sample line would be 45 gallons from the TS minimum level to the RHR pump start

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of -0.991 inches across the vent screen conservatively assuming it is 80% plugged . This converts to a 776.3 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 20 psig ($\nu = 0.016636\ ft^3/lbm$).

7.5. Case 4 - 3 inch break, Max. SI, 3 CFCUs and 1 CS Train, with cooldown

The following table gives the derivation of the sump level for a 3 inch break. RWST low level is reached at 5305 seconds. Containment spray is not actuated at switchover time. Cooldown is modeled starting at 3600 seconds per reference 11.3.13

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	0	0.0	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (blowdown after low level trip)	8036.2	1074.2*	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	25280*	3379.2	Reference 11.3.12
10	SAT	0	0.0	Assumption 25
	Subtotal (+)'s	252975	33816	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	4900*	655	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	16120*	2154.8	
15	CS piping fill	0*	0.0	Reference 11.1.4
16	RWST sample line leakage	119	15.9*	Reference 11.1.7
17	RWST vent screen Δp error	524.9	70.2*	Reference 11.1.9
	Subtotal (-)'s	33027	4415	
	RWST equivalent sump volume	219948	29401	Subtotal(+) – Subtotal (-)
	RWST / sump expansion factor	1.0314	1.0314	
18	Net sump liquid volume	226854	30324	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft
For Case 4 the volume of water at the sump is 30324 ft^3. Therefore, the flood elevation is:

$$\frac{30324-11136}{11.20X10^3+125}+91=92.69\,ft.$$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 150 psia, the maximum flow from the Sump per reference 11.1.6 is 4822.7 gpm based on a 124.9 psid (150 RCS pressure - 25.1 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the blowdown from the RCS.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.

2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.

3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.

4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).

5. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

6. As discussed in assumption 15, even though the RCS pressure is below the shutoff head of the RHR pumps, no RHR flow is credited after the low level trip for this evaluation.

7. This is the amount of RCS blowdown that occurs during the 3 minute interval after the RHR pumps have tripped and until they are restarted by the operator. This RCS blowdown rate is 2679 gpm at the time of switchover per based Reference 11.3.13.

8. No credit is taken for RCS contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.13). For this case, this is 209880 lbm or 3379.2 ft^3.

10. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per Westinghouse Letter PGE-97-543 (Reference 11.3.13), the containment temperature at switchover (5305 seconds) is ~ 180 °F. At this containment temperature, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 655 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 150 psia (Reference 11.3.12) or at 338.43 °F (ν = 0.017852 ft^3/lbm). Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.2441 to a value of 9775 ft^3. This net RCS shrinkage of 2385 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1070 to a value of 2154.8 ft^3.

15. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

16. Per design input 10 the RWST leakage from the sample line would be 119 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of -0.67 inches across the vent screen which is conservatively assumed to be 80% plugged. This converts to a 524.9 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 25.1 psig (ν = 0.016635 ft^3 /lbm).

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

7.6. *Case 5 - 3 inch break, Min. SI, 2 CS Train, with cooldown*

The following table gives the derivation of the sump level for a 3 inch break. RWST low level is reached at 3838 seconds. Two Containment spray trains actuated at 2240 seconds. Cooldown is modeled at 3600 seconds. - see reference 11.3.14

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	8848.5	1182.8*	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (blowdown after low level trip)	651.6	87.1*	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	1584*	211.8	Reference 11.3.12
10	SAT	1783*	238.3	Assumption 25
	Subtotal (+)'s	232526	31082	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	6396*	855	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	9821*	1312.8	
15	CS piping fill	3646*	487.5	Reference 11.1.4
16	RWST sample line leakage	86	11.5*	Reference 11.1.7
17	RWST vent screen Δp error	803.7	107.4*	Reference 11.1.9
	Subtotal (-)'s	32118	4293	
	RWST equivalent sump volume	200409	26789	Subtotal(+) – Subtotal (-)
	RWST / sump expansion factor	1.0314	1.0314	
18	Net sump liquid volume	206702	27630	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft

From the above table, the volume of water at the sump is 27630 ft^3. Therefore, the flood elevation is:

$$\frac{27630-11136}{11.20X10^3+125}+91=92.46ft.$$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 540 psia, the maximum flow from the Sump per Reference 11.1.6 is 1742.6 gpm based on a 514.3 psid (540 RCS pressure - 25.7 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the CS system and the blowdown from the RCS.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. This is the amount of water discharged from the Containment Spray system during the 3 minute duration after the RHR pumps have tripped until they are restarted (Reference 11.3.4). The Containment Spray flow rate is based on the containment pressure at the time of switchover is 2949.5 gpm (Reference 11.3.13) and the CS flow volume credited is 8848.5 gallons. Crediting one train of spray is conservative since the switchover time is based on two trains of containment spray.

6. The RCS pressure at the time of switchover is still above the shutoff head of the RHR pumps (Reference 11.3.14) and per assumption 15, there is no RHR flow is credited after the low level trip for this evaluation.

7. This is the amount of RCS blowdown that occurs during the 3 minute interval after the RHR pumps have tripped and until they are restarted by the operator. This RCS blowdown rate is 30 lbm/sec or 217.2 gpm at the time of switchover per Reference 11.3.14.

8. No credit is taken for RCS spill contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.12). For a 3 inch break, this is 13155 lbm or 211.8 ft^3.

10. Credit is taken for a SAT eductor flow of 63 gpm (Assumption 25) from 2240 seconds to 3838 seconds (Reference 11.3.14). The 80 second SAT fill time is subtracted, while an additional 3 minutes is added (until the RHR pump is restarted) for a total SAT contribution of 238.3 ft^3.

11. As discussed in assumption #7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per reference 11.3.14, the containment temperature at switchover (3838 seconds) is 190° F. At this containment temperature, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 855 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 540 psia (Reference 11.3.12) or at 445.71 °F (ν = 0.019336 ft^3/lbm) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.1486 to a value of 10587 ft^3. This net RCS shrinkage of 15742 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1988 to a value of 1312.8 ft^3.

15. As discussed in assumption 12, the amount of water used to fill the empty containment spray piping is 487.5 ft^3

16. Per design input 10 the RWST leakage from the sample line would be 86 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of -1.026 inches across the vent screen which is conservatively assumed to be 80% plugged . This converts to a 803.7 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 25.7 psia ($\nu = 0.016636\ ft^3/lbm$).

7.7. *Case 6 - 2 inch break, Max. SI, 19.3 psig CS setpoint*

The following table gives the derivation of the sump level for a 2 inch break. RWST low level is reached at 6136 seconds. Containment spray is not actuated at switchover time. Cooldown is modeled starting at 3600 seconds. - see reference 11.3.13

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	0	0.0	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (blowdown after low level trip)	7601.8	1016.1*	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	8418*	1125.2	Reference 11.3.12
10	SAT	0*	0. 0	Assumption 25
	Subtotal (+)'s	235678	31504	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	8162	1091	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	10276*	1373.6	
15	CS piping fill	0*	0.0	Reference 11.1.4
16	RWST sample line leakage	137	18.3*	Reference 11.1.7
17	RWST vent screen Δp error	30.6	4.1*	Reference 11.1.9
	Subtotal (-)'s	29969	4006	
	RWST equivalent sump volume	205710	27498	Subtotal(+) – Subtotal (-)
	RWST / sump expansion factor	1.0314	1.0314	
18	Net sump liquid volume	212169	28361	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft

From the above table, the volume of water at the sump is 28361 ft^3. Therefore, the flood elevation is:

$\frac{28361-11136}{11.20X10^3+125}+91=92.52ft.$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 590 psia, the maximum flow from the Sump per reference 11.1.6 is 1718.1 gpm based on a 560.8 psid (590 RCS pressure - 29.2 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the blowdown from the RCS.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. For this case, containment spray system did not reach its setpoint (Reference 11.3.13) therefore, the contribution from this source is zero.
6. The RCS pressure at the time of switchover is still above the shutoff head of the RHR pumps (Reference 11.3.14) and per assumption 15, there is no RHR flow is credited after the low level trip for this evaluation.
7. This is the amount of RCS blowdown that occurs during the 3 minute interval after the RHR pumps have tripped and until they are restarted by the operator. This RCS blowdown rate is 350 lbm/sec or 2534 gpm at the time of switchover per Reference 11.3.13.

8. No credit is taken for RCS contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.13). For a 2 inch break, this is 69885 lbm or 1125.2 ft^3.

10. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per reference 11.3.13, the containment temperature is ~ 200° F. At this containment temperature, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 1091 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 590 psia (Reference 11.3.12) or at 439.59 °F (ν = 0.019220 ft^3/lbm) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.1556 to a value of 10523 ft^3. This net RCS shrinkage of 1637 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1916 to a value of 1373.6 ft^3.

15. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

16. Per design input 10 the RWST leakage from the sample line would be 137 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of 0.039 inches across the vent screen which is conservatively assumed to be 80% plugged . This converts to a 30.6 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 29.2 psia (ν = 0.016636 ft3 /lbm). The water in the RWST is assumed to be at a maximum of 100 °F and 14.7 psig

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

7.8. *Case 7 - 2 inch break, Min. SI, 1 CS Train @ 22 psig setpoint, with cooldown*

The following table gives the derivation of the sump level for a 2 inch break. RWST low level is reached at 19201 seconds. Containment spray is not actuated at switchover time. Cooldown is modeled starting at 3600 seconds. - see reference 11.3.13

Item	Description	In gallons	In ft^3	Reference/Assumption
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	0	0.0	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (blowdown after low level trip)	825.3	110.3*	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	25281*	3379.4	Reference 11.3.12
10	SAT	0*	0.0	Assumption 25
	Subtotal (+)'s	245765	32852	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	6396*	855	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	14786*	1976.5	
15	CS piping fill	0*	0.0	Reference 11.1.4
16	RWST sample line leakage	430	57.5*	Reference 11.1.7
17	RWST vent screen Δp error	110.5	14.8*	Reference 11.1.9
	Subtotal (-)'s	33086	4423	
	RWST equivalent sump volume	212679	28429	Subtotal(+) – Subtotal (-)
18	RWST / sump expansion factor	1.0314	1.0314	
	Net sump liquid volume	219357	29322	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Per reference 11.1.5,

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ±125 ft^3/ft

From the above table, the volume of water at the sump is 29322 ft^3. Therefore, the flood elevation is:

$\frac{29322-11136}{11.20X10^3+125}+91=92.61ft.$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 230 psia, the maximum flow from the Sump per reference 11.1.6 is 1900.3 gpm based on a 203.9 psid (230 RCS pressure - 26.1 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the blowdown from the RCS.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.
6. The RCS pressure at the time of switchover is still above the shutoff head of the RHR pumps (Reference 11.3.14) and per assumption 15, there is no RHR flow is credited after the low level trip for this evaluation.
7. This is the amount of RCS blowdown that occurs during the 3 minute interval after the RHR pumps have tripped and until they are restarted by the operator. This RCS blowdown rate is 275 gpm at the time of switchover per Reference 11.3.13.

8. No credit is taken for RCS spill contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.13). For a 2 inch break, this is 209890 lbm or 3379.4 ft^3.

10. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per reference 11.3.13 the containment temperature at switchover (19201 seconds) is < 190° F. At this containment temperature, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 855 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 230 psia (Reference 11.3.12) or at 363.7 °F (ν = 0.018005 ft^3/lbm) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.2238 to a value of 9936 ft^3. This net RCS shrinkage of 2224 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1252 to a value of 1976.5 ft^3.

15. For this case, containment spray system did not reach its setpoint (Reference 11.3.13), therefore, the contribution from this source is zero.

16. Per design input 10 the RWST leakage from the sample line would be 430 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of -0.141 inches across the vent screen which is conservatively assumed to be 80% plugged . This converts to a -110.5 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 11.4 psig (ν = 0.016636 ft^3 /lbm).

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

7.9. Case 8 - 1.5 inch break, Min. SI, 1 CS Train

The following table gives the derivation of the sump level for a 1.5 inch break. RWST low level is reached at 19760 seconds. Containment spray is not actuated at switchover time. Cooldown is modeled starting at 3600 seconds. - see reference 11.3.14

Item	Description	In gallons	In ft^3	Reference
1	Initial RWST usable volume	384900	51450*	Reference 11.1.3 / Assumption 10
2	Non-usable RWST water volume	16041	2144*	Reference 11.1.3 / Assumption 11
3	Low level trip, RWST usable volume	149200	19944*	Reference 11.1.3 / Assumption 11
	Water contributions to sump (+)			
4	RWST (Initial to low level trip)	219659	29362*	Calculated Item 1 – Items (2 + 3)
5	RWST (CS after low level trip)	0*	0.0	Reference 11.3.13
6	RWST (RHR flow after low level trip)	0	0.0	No RHR credit –Assumption 15.
7	RCS (blowdown after low level trip)	2324*	310.7	
8	RCS spill volume	0	0.0	Not credited per Assumption 18
9	Accumulators	27786*	3045.8	Reference 11.3.12
10	SAT	0*	0.0	Assumption 25
	Subtotal (+)'s	244769	32719	
	Water diverted away from sump (-)			
11	Condensation, pooling, etc,.	7481*	1000.0	Assumption 7
12	Steam in the Containment Atmosphere	4900*	655	Reference 11.1.1
13	Water in transit to sump	3883*	519	Assumption 19
14	RCS shrinkage	14001*	1871.6	
15	CS piping fill	0*	0.0	Reference 11.1.4
16	RWST sample line leakage	442	59.1*	Reference 11.1.7
17	RWST vent screen Δp error	64.2	8.6	Reference 11.1.9
	Subtotal (-)'s	30771	4113	
	RWST equivalent sump volume	213997	28605	Subtotal(+) – Subtotal (-)
18	RWST / sump expansion factor	1.0314	1.0314	
	Net sump liquid volume	220717	29504	RWST vol. x expansion factor

* The applicable volumes are provided in both gallons and cubic feet to provide versatility in the use of the data. Some volumes were originally calculated in gallons and some in cubic feet. An asterisk in a column indicates that the volume was originally calculated in these units and a conversion factor of 7.481 gal. per cubic feet was used to determine the other corresponding unit volume.

Per reference 11.1.5

Volume below 91 feet elevation = 11136 ft^3

Volume above 91 feet to 94 feet elevation = $11.20X10^3$ ft^3/ft ± 125 ft^3/ft

From the above table, the volume of water at the sump is 29504 ft^3. Therefore, the flood elevation is:

$\frac{29504-11136}{11.20X10^3+125}+91=92.62ft.$ (Please refer to the conclusion for additional discussion)

The RCS pressure when the first RHR pump is started is approximately 270 psia, the maximum flow from the Sump per reference 11.1.6 is 1880.2 gpm based on a 244.3 psid (270 RCS pressure - 25.7 psia containment pressure). Note that the above flow rate is based on two RHR pumps. When both RHR pumps are started, the actual sump water level should be higher due to additional water contribution from the blowdown from the RCS.

Notes by line item:

1. As discussed in assumption 10, the initial RWST usable volume at 84% is 384,900 gallons.
2. Per Assumption 11, the amount of RWST level lost due to the statistically evaluated instrument uncertainties is 3.5% or 16,041 gallons.
3. Per assumption 11, the usable RWST volume left when the RHR pumps are tripped on RWST low level at 32.56% is 149,200 gallons.
4. This represents the minimum RWST injected volume to the low level RHR pump trip and is calculated as the initial RWST usable volume minus the usable volume at the low level trip minus the level error due to instrument uncertainties. (Item 1 minus (Items 3 and Item 2)).
5. For this case, containment spray system did not reach its setpoint (Reference 11.3.14) therefore, the contribution from this source is zero.
6. The RCS pressure at the time of switchover is still above the shutoff head of the RHR pumps (Reference 11.3.14) and per assumption 15, there is no RHR flow is credited after the low level trip for this evaluation.
7. This is the amount of RCS blowdown that occurs during the 3 minute interval after the RHR pumps have tripped and until they are restarted by the operator. This RCS blowdown rate is 775 gpm at the time of switchover per Reference 11.3.13.

8. No credit is taken for RCS contribution. Per assumption 22, the RCS water is conservatively assumed to be at its normal volume of 12160 ft^3.

9. This is the amount of water from the accumulators (Reference 11.3.14). For a 1.5 inch break, this is 189175 lbm or 3045.8 ft^3.

10. For this case, containment spray system did not reach its setpoint (Reference 11.3.13) therefore, the contribution from this source is zero.

11. As discussed in assumption 7, the amount of water diverted away from the sump due to condensation on various surfaces is assumed to be 1000 ft^3.

12. This is the amount of water diverted to the containment atmosphere as steam. Per reference 11.3.14, the containment temperature at switchover (19760 seconds) is 180° F. At this containment temperature, calculation N-224 (Reference 11.1.1) gives the steam held in the atmosphere as 655 ft^3.

13. As discussed in assumption 19, the volume of water assumed to be still in transit / holdup and not credited to the sump is 519 ft^3.

14. This is the additional RWST volume that must fill the RCS to account for the shrinkage of the remaining RCS liquid as it cools from the initial operating conditions to the post-LOCA containment conditions. As discussed in assumption 23, the RCS liquid is assumed to be subcooled by 30 °F with respect to the RCS pressure of 270 psia (Reference 11.3.12) or at 377.8 °F (ν = 0.018326 ft^3/lbm) . Thus, establishing the required subcooling reduces the initial RCS volume of 12160 ft^3 (ν = 0.02221 ft^3/lbm) per assumption 22, by a factor of 1.2119 to a value of 10033 ft^3. This net RCS shrinkage of 2127 ft^3 must be made up by RWST water. Since the RWST water is at 100° F and 14.7 psig (ν = 0.016129 ft^3) the actual volume required to offset the RCS shrinkage is reduced by a factor of 1.1362 to a value of 1871.6 ft^3.

15. For this case, containment spray system did not reach its setpoint (Reference 11.3.14), therefore, the contribution from this source is zero.

16. Per design input 10 the RWST leakage from the sample line would be 442 gallons from the TS minimum level to the RHR pump start.

17. Per Reference 11.1.9, the RWST depletion rate would cause a dynamic pressure drop level error of -0.082 inches across the vent screen, which is conservatively assumed to be 80% plugged. This converts to a -64.2 gal. error in RWST level (783.36 gal/in)

18. As discussed in assumption 17, the equivalent RWST volume of water would expand by a factor of 1.0314 to the post LOCA sump water conditions of 200 °F at a containment pressure of 11 psig (ν = 0.016636 ft^3 /lbm).

8. Results

8.1. Tech Spec Minimum RWST Level - Minimum Post-LOCA Sump Level

The post-LOCA containment sump level is dependent on the accident scenario and recovery actions. The details of the various cases and assumptions are contained in this calculation. The calculated sump flood elevation at the time of RHR pump start to support post-LOCA recirculation for the Tech Spec minimum RWST cases are provided in the Table 8-1 below.

Table 8-1: Tech Spec Minimum RWST Level - Minimum Sump Level

Case #	Break size	Switchover time (seconds)	Sump Elevation (ft.)	Max. RHR/ Sump Flow (gpm)
1	Large LOCA, Min. SI, 3 CFCU, 2 CS (both actuated)	866	93.02	7769.0
2	6" Break, Min. SI, 3 CFCU, 2 CS (both actuated)	1750	92.58	3329.4
3	4" Break, Min. SI, 3 CFCU, 2 CS (both actuated)	2000	92.42	1819.5
4	3" Break, Max. SI, 3 CFCU, 1 CS (none actuated), w/cooldown	5305	92.69	4822.7
5	3" Break, Min. SI, 2 CS (both actuated), w/cooldown	3838	92.46	1742.6
6	2" Break, Max. SI, 2 CS, 19.3 psig (none actuated), w/cooldown	6136	92.52	1718.1
7	2" Break, Min. SI, 1 CS @ 22 psig, (none actuated), w/cooldown	19201	92.61	1900.3
8	1.5" Break, Min. SI, 1 CS, (none actuated)	19760	92.62	1880.2

8.2. Administrative RWST Level - Minimum Post-LOCA Sump Level

The eight minimum post-LOCA sump level cases are also calculated for the initial condition in which the non-seismic Reverse Osmosis (ROS) skid is connected to the RWST with the potential for additional RWST leakage due to failure of the ROS. Whenever the ROS skid is connected to the RWST, the initial level is administratively ensured to be at least 90% by setting the RWST low alarm setpoint to 91% per LAR-00-02 Commitment 4 as documented in AR A0503748 (Reference 11.3.9). The only terms that change for these administrative RWST level cases are the RWST injection volume, the RWST sample line leakage, and the leakage from the ROS skid which is assumed to fail.

As discussed in assumption 10, the minimum net RWST injection volume between the 90% administrative RWST level and the RHR pump trip setpoint is 253,117 gal. This represents a gain in RWST injected volume of 253,117 – 219,659 = 33,458 gallons compared to the Tech Spec minimum results above. Since the ECCS injection flow rates for the eight LOCA cases have not changed, the additional RWST injection time until switchover occurs is directly proportional to the fractional increase in the injected volume. For example in Case 1, the 866 seconds until switchover occurs is increased by the ratio 253,117 / 219,659 = 1.15 to a new switchover time of 996 seconds.

The additional sample line leakage is calculated based on subtracting the N-073 integral leakage value at the RWST lo level for the Tech Spec Minimum case from the integral leakage value for the Administrative RWST level as summarized in N-073 Table 9. Therefore, the additional sample line leakage or Case 1 is 23 -19 = 4 gallons which is rounded up to 4 gallons. The other additional sample line leakage values for the other Cases are as follows:

Case 2 = 47 - 39 = 8 gal.
Case 3 = 54 – 45 = 9 gal.
Case 4 = 143 - 119 = 24 gal.
Case 5 = 103 – 86 = 17 gal.
Case 6 = 165 – 137 = 28 gal.
Case 7 = 515 – 430 = 85 gal.
Case 8 = 530 - 442 = 88 gal.

Per assumption 29, the ROS leakage of 70 gpm continues until the recirculation time is reached plus the additional three minutes assumed to start the RHR pumps. Therefore the total ROS leakage is calculated as 70 gpm x (996 + 180) seconds /60sec/min, which is rounded to 1372 gallons. Note that for cases, which last more than 5 hours, the maximum ROS leakage is 21,000 gallons since as discussed in assumption 29, the ROS leakage is terminated by that time. The total additional leakage is subtracted from the additional RWST injection volume of 33,458 gallons to give a net increase in the Case 1 sump volume of 32,082 gallons. The net additional RWST injection volume is then increased by the appropriate volumetric temperature correction factor of 1.0313 which was established for Case 1 in Section 7.2. The administrative Case 1 total sump volume is the temperature adjusted additional injection volume plus the sump liquid level determined in Section 7-2 or 1.0313 x 32,082 + 254,550 = 287,636 gallons or a sump level of 93.41 feet. The other cases results are listed in Table 8-2 below.

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table 8-2: Administrative RWST Level - Minimum Post-LOCA Sump Level

Case	Adjusted Time to Switchover (sec)	Additional sample line leakage (gal)	ROS leakage (gal)	Net Post-LOCA Sump Addition (gal)	Post-LOCA Sump Volume (@200 °F) (gal)	Post-LOCA Sump level (ft.)
1	996	4	1372	32082	287636	93.41
~~2~~	~~2013~~	~~8~~	~~2558~~	~~30892~~	~~248695~~	~~92.95~~
3	2300	9	2893	30556	234977	92.79
4	6101	24	7328	26106	253780	93.01
5	4414	17	5359	28082	235665	92.80
6	7056	28	8442	24988	237941	92.83
7	22081	85	21000	12373	232119	92.76
8	22724	88	21000	12370	233475	92.77

9. Conclusions

The results indicate that the most limiting cases for the minimum post LOCA sump level occur with Case 3 and Case 5, which are intermediate break sizes of 4" and 3", respectively. Both of these cases assume a minimum ECCS injection capability and also result in a CS actuation. The CS actuation drains the RWST quicker, causes an earlier recirculation switchover time, and provides less opportunity to perform an RCS cooldown. This in combination with less ECCS cooling, results in a significantly larger RCS temperature and pressure at the time of switchover. Thus, there is much less accumulator volume injected during the event, and the blow down rate out the break is less, as would be expected with two phase flow conditions. Note that these two cases assume two CS trains for minimizing the time to the RWST low level switchover, but only credit one CS train for additional spray inventory to the sump during the 3 minute RHR restart period. This conservatively bounds the offsetting effects of break size and CS flow rate with respect to minimum available RCS cooldown time and liquid inventory to the sump.

Case 4 also models a 4" break size, but it assumes maximum ECCS injection capability, which results in a less limiting minimum sump level. The maximum ECCS cooling helps maintain the RCS blowdown as mostly liquid. This reduces the containment pressure, prevents CS actuation, and provides more time to perform an RCS cooldown. While the RCS cooldown causes more shrinkage and retains more RWST inventory in the RCS, this effect is more than offset by the increased accumulator injection and greater liquid break flow rates into the sump.

Cases 6, 7, and 8 demonstrate that as the break size is reduced to 2" or less, the sump level begins increasing and becomes less limiting. These smaller break sizes have a lower mass and energy release rate such that the containment pressure never reaches the Containment Spray system actuation setpoint. This dramatically increases the RWST drain time and allows for a significant RCS cooldown by the time the RHR pumps are restarted. As discussed earlier, the RCS cooldown provides significant benefits for increasing the net sump liquid volume.

Cases 1 and 2 demonstrate that as the break size increases to 6" and larger, the sump level also begins increasing and becomes less limiting. As Case 1 shows, the RCS spill contribution for a large break significantly increases the sump volume. The Case 2 results for a 6" break are extremely conservative in that they do not credit any RCS spill volume, while analysis results indicate a significant fraction of the RCS would be lost for a break this size. In addition to the RCS spill fraction assumed, the larger break sizes reduce the RCS pressure enough to ensure the full accumulator volume is injected.

The wide spectrum of break sizes and ECCS assumptions along with the conservative assumptions for these eight cases establish a conservatively bounding evaluation of the minimum post LOCA sump liquid volume for DCPP.

10. Impact Evaluation

The N-227 post-LOCA sump levels are direct inputs into calculation M-591 (Reference 11.2.1). The post-LOCA sump level values listed in Table 8-1 based on the Tech Spec minimum RWST initial level are the design basis analysis values. The post LOCA sump level listed in, which are based on the administrative RWST initial level are not considered design basis values but may be used for operability evaluations or other engineering evaluations.

11. References

11.1. Input References

11.1.1. Nuclear calculation N-224 Revision 2 dated 4/29/04, "Post LOCA Water Volume in Containment Atmosphere".

11.1.2. Calculation M-580 Revision 4 dated 9/2/97, "Determination of Post LOCA Flood Water Levels Inside the Containment Building for Units 1 & 2.

11.1.3. Calculation J-142, Rev. 0 dated 2/14/01, "RWST Nominal Setpoint and Indication Uncertainty Calculations".

11.1.4. Mechanical calculation M-85, rev. 0 "To Calculate Volume of Containment Spray Lines"

11.1.5. Calculation M-585 Rev. 3 dated 6/3/97, "Determination of Unoccupied Volume in the Containment Building Per Unit Height".

11.1.6. Calculation STA-071 Rev. 1 dated 2/25/99 "Max. RHRP Suction flows (EOP E-1.3).

11.1.7. Calculation N-73 Rev. 2 dated 12/30/05, "RWST Sample Line Failure", 10/20/99

11.1.8. Calculation STA-061 Rev 3 dated 6/5/01, "FSAR table 6.3-5 Update".

11.1.9. STA 106 Rev. 0 dated 7/8/99, "Evaluate RWST Vent Screen DP Error on Containment Sump Level".

11.1.10. Dwg 500054, U1 Piping & Mech, Area GW, GE plan at El 62' and 73'

11.1.11. Dwg 500039, U1 Piping & Mech, Area F & L plan at El 91'

11.1.12. Dwg 438234, U1 Civil Interior Concrete Outline Main Sections Containment

11.1.13. 438233, U1 Civil Interior Concrete Outline Plans @ EL 124' and 140' Containment

11.1.14. Dwg 500160 Drainage & Fire Fighting Containment Area F Plan EL 140

11.1.15.Dwg 500159, Drainage & Fire Fighting Containment Area G Plan EL 140'

11.2. Output References

11.2.1. M-591, future revision.

11.2.2. AR A0641926

11.3. Other References

11.3.1. IOM Tien Lee/Dave Dion to File dated May 8, 1997, Chron. # 232869.

11.3.2. AR A0539565

11.3.3. Annunciator Response AR PK-06-20

11.3.4. Concurrence from Operation for Operator action, Chron. # 232927.

11.3.5. Technical Specifications for Diablo Canyon Power Plant Units 1 and 2.

11.3.6. ASME Steam Tables, sixth edition.

11.3.7. Emergency Operating Procedure EOP E-1.2 “Post LOCA Cooldown and Depressurization”.

11.3.8. Design Criteria Memorandum DCM S-12 “Containment Spray System”.

11.3.9. AR A0503748

11.3.10. AR A04965677

11.3.11. WCAP 13907 “Analysis of Containment Response Following Loss-Of-Coolant Accidents for Diablo Canyon Units 1 & 2.

11.3.12. Westinghouse letter 97-520 dated May 3, 1997, Chron. # 232557.

11.3.13. Westinghouse letter 97-543 “Small Break LOCA - Sump response additional Evaluation” dated May 8, 1997. Chron. No. 232926.

11.3.14. Westinghouse letter 97-537 dated May 3, 1997 “Small Break LOCA - Sump Response”. Chron. No. 232841.

11.3.15. DCPP FSAR Update Revision 15

11.3.16. Emergency Operating Procedure U1 EOP-1.2 "Post LOCA Cooldown and Depressurization", Rev. 16,

11.3.17. SER 00, Safety evaluation by the directorate of licensing U.S. Atomic Energy Commission in the matter of Pacific Gas and Electric company Diablo Canyon Nuclear Power Station, Units 1 and 2 San Luis Obispo County, California Docket Nos.50-275 AND 50-323, October 16, 1974.

~~11.3.18. Crane Technical Paper No. 410, Flow of Fluids, 25th Printing, Crane~~ Company, 1988.

11.3.19. Calculation STA-164, Rev. 0, "Evaluate 1R11 As-Found Pressurizer Safety Valve Setpoints", 6/10/03

11.3.20. Design Criteria Memorandum DCM S-9A, "Containment Recirculation Sump Function", Revision 4.

11.3.21. Design Criteria Memorandum DCM T-15, "Radiation Protection", Rev. 6

11.3.22. Enercon Draft Report, WES007-PR-02, Rev. A, "Evaluation of Containment Recirculation Sump Upstream Effects for Diablo Canyon Power Plant".

11.3.23. DCPP Operator Information Manual

12. Appendix A: Net RWST Injection Volume Error

This appendix performs a statistical based evaluation of the RWST level indication and RHR trip setpoint uncertainties that accounts for the common error terms of the level transmitter and the two out of three logic of the RHR trip function. Table A-1 lists the individual uncertainties for the level transmitter (LT-920, LT-921, and LT-922), level indicator (LI-920, LI-921, and LI-922), and RHR trip level setpoint (LC-920A, LS-921, and LS-922), and the total statistical error as compiled by calculation J-142 (Reference 11.1.3).

As discussed in Assumption 11, all of the level transmitter error terms (except for the one inch bias error) can be eliminated since they will be canceled out during the calculation of the net RWST injection volume error which is the initial RWST level error minus the RHR trip setpoint error. Also discussed in Assumption 11, is the conservative application of the +1 inch bias error to the RHR trip setpoint (but not the initial RWST level) to conservatively bound any change in the auxiliary and/or fuel building ventilation systems after the LOCA has occurred. Table A-2 lists the applicable error terms for the RWST level indication and RHR trip setpoint error values, and shows the level transmitter terms which have been canceled as highlighted in bold text. The individual channel uncertainty (CU) using the SRSS methodology for the RWST level indication and RHR trip setpoint is then calculated are as follows using the 589 inch span of the RWST level channel per J-142 (design input 5.2):

LI-920, LI-921, LI-922 CU+/- = +/- SQRT (RTE^2 + DCA^2 + DD^2) / 589
= +/- SQRT (2^2 + 11.78^2 + 6.48^2) / 589

or CU +/- = +/- 2.31%

LC-920 CU+ = (B+ SQRT (RCA^2 + RD^2 + RT^2))/589
= (+1 + SQRT (2.95^2 + 5.89^2 + 2^2))/589

or CU+ = +1.34%

CU- = (B+ SQRT (RCA^2 + RD^2 + RT^2))/ 589
= (0 + SQRT (2.95^2 + 5.89^2 + 2^2)) / 589

or CU- = -1.17%

LS-921, LS-922 = (B+ SQRT (RCA^2 + RD^2 + RT^2)) / 589
= (+1 + SQRT (2.95^2 + 4.71^2+ 2^2)) / 589

or CU+ = + 1.17%

CU- = (B+ SQRT (RCA^2 + RD^2 + RT^2)) / 589
= (0 + SQRT (2.95^2 + 4.71^2+ 2^2)) / 589

or CU- = -1.00%

Figure A-1 illustrates the nominal values for the minimum Tech Spec RWST level and nominal RHR trip setpoint, and also shows the relative impact of the instrument uncertainty on the actual RWST levels. As shown in the Figure, the net percent of the RWST volume injected (L_{NET}) accounting for the instrument errors for any combination of errors between the initial RWST level (L_{INIT}) and the RHR trip level (L_{RHR}) is calculated as:

$L_{NET} = (L_{INIT} + E_{IND}) – (L_{RHR} + E_{RHR}) =$

Where E_{IND} is the RWST initial level error and E_{RHR} is the RHR trip setpoint error.
The equation can be re-arranged as:

$L_{NET} = (L_{INIT} - L_{RHR}) + (E_{IND} - E_{RHR})$

The term ($E_{IND} - E_{RHR}$) is the net error in the RWST injection volume (E_{NET}) to the instrument uncertainties.

In order to evaluate the potential impact of the 2 out 3 trip logic on the RHR trip setpoint and the net RWST injection volume error E_{NET} Table A-3 lists the twelve different possibilities of error combinations and calculates the net resulting error for each case. Since the RWST level indication error is equally distributed (+/-2.31%), there is a 50% probability the error will be positive and a 50% probability that the error will be negative. Since the RHR trip logic requires two out of the three channels to reach their trip setpoint in order to actuate, there are three possible combinations of a positive 2/3 trip logic and three possible combinations of a negative 2/3 trip logic. As Table A-3 shows, this results in a possible six positive error cases and six negative error cases. There is an equal probability that the actual error values could fall anywhere between the maximum positive or negative values. However, any value less than the maximum error would result in a smaller net error, and is bounded by evaluating the net error based on the maximum values.

The RHR trip does not occur until two out of the three channels have reached their setpoint. Therefore, for each case, the net RWST injection volume error (E_{NET}) is calculated by subtracting the lowest of the 2/3 RHR trip values from the RWST initial level error value. Table A-3 summarizes the twelve possible error cases with the selected error values highlighted in bold text. For example the Case 2 and Case 9 net errors are detailed in Figure A-1 and are calculated as follows:

Case 2 $E_{NET} = - 2.31\% - (+1.17\%) = - 3.48\ \%$
Case 9 $E_{NET} = + 2.31\% - (-1.17\%) = + 3.48\ \%$

Table A-4 summarizes the twelve possible net error case values. The maximum negative error value is generated in Cases 2 and 4 or a value of -3.48%. Therefore, assuming a maximum negative net RWST injection volume error of -3.5% conservatively bounds the potential effects of the 2/3 logic with respect to the initial RWST level indication error and the RWST low low level RHR trip setpoint error.

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table A-1: RWST Level Instrumentation Uncertainties from Calculation J-142

RWST Level Indication Uncertainty

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RTE	DCA	DD	DMTE	LI-920 TOTAL	TOTAL LT-920 + LI-920
LT-920	CU+	0	1	2	0	2.95	0.9	2.95	3.17	0	1.1%	LI-920	NA*	0	NA**	2	0	11.78	6.48	0	2.3%	2.7%
	CU-	0	0	2	0	2.95	0.9	2.95	3.17	0	-1.0%		NA*	0	NA**	2	0	11.78	6.48	0	-2.3%	-2.5%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-921		RCA	RMTE	RD	RTE	RTE	DCA	DD	DMTE	LI-921 TOTAL	LT-921 + LI-921
LT-921	CU+	0	1	2	0	2.95	0.9	2.95	3.17	0	1.1%	LI-921	NA*	0	NA**	2	0	11.78	6.48	0	2.3%	2.7%
	CU-	0	0	2	0	2.95	0.9	2.95	3.17	0	-1.0%		NA*	0	NA**	2	0	11.78	6.48	0	-2.3%	-2.5%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-922		RCA	RMTE	RD	RTE	RTE	DCA	DD	DMTE	LI-921 TOTAL	LT-922 + LI-922
LT-922	CU+	0	1	2	0	2.95	0.9	2.95	3.17	0	1.1%	LI-922	NA*	0	NA**	2	0	11.78	6.48	0	2.3%	2.7%
	CU-	0	0	2	0	2.95	0.9	2.95	3.17	0	-1.0%		NA*	0	NA**	2	0	11.78	6.48	0	-2.3%	-2.5%

NA* - RCA term (bistable calibration accuracy) is not applicable for indication
NA** - RD term (rack drift) is already included in DD (display drift) term

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table A-1; Cont. RWST Instrumentation Uncertainties from Calculation J-142

RHR Pump Trip - RWST Level Indication Uncertainty

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RTE	LC-920A TOTAL		TOTAL LT-920 + LC-920A
LT-920	CU+	0	1	2	0	2.95	0.9	2.95	3.2	0	1.1%	LC-920A	2.95	0	5.89	2	0	1.2%		1.7%
	CU-	0	0	2	0	2.95	0.9	2.95	3.2	0	-1.0%		2.95	0	5.89	2	0	-1.2%		-1.5%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RTE	LS-921 TOTAL		LT-921 + LS-921
LT-921	CU+	0	1	2	0	2.95	0.9	2.95	3.2	0	1.1%	LS-921	2.95	0	4.71	2	0	1.0%		1.6%
	CU-	0	0	2	0	2.95	0.9	2.95	3.2	0	-1.0%		2.95	0	4.71	2	0	-1.0%		-1.4%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RTE	LS-922 TOTAL		LT-922 + LS-922
LT-922	CU+	0	1	2	0	2.95	0.9	2.95	3.2	0	1.1%	LS-922	2.95	0	4.71	2	0	1.0%		1.6%
	CU-	0	0	2	0	2.95	0.9	2.95	3.2	0	-1.0%		2.95	0	4.71	2	0	-1.0%		-1.4%

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table A-2;. RWST Instrumentation Uncertainties Minus Level Transmitter

Initial RWST Level Indication Uncertainty

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920 TOTAL		RCA	RMTE	RD	RTE	RME	DCA	DD	DMTE	LI-920 TOTAL	TOTAL LT-920 + LI-920
LT-920	CU+	0	0	**0**	0	**0**	**0**	**0**	**0.0**	0	**0.0%**	LI-920	NA*	0	NA**	**2**	0	11.78	6.48	0	2.3%	2.31%
	CU-	0	0	**0**	0	**0**	**0**	**0**	**0.0**	0	**0.0%**		NA*	0	NA**	**2**	0	11.78	6.48	0	-2.3%	-2.31%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-921 TOTAL		RCA	RMTE	RD	RTE	RME	DCA	DD	DMTE	LI-921 TOTAL	LT-921 + LI-921
LT-921	CU+	0	**0**	**0**	0	**0**	**0**	**0**	**0.0**	0	0.0%	LI-921	NA*	0	NA**	**2**	0	11.78	6.48	0	2.3%	2.31%
	CU-	0	0	**0**	0	**0**	**0**	**0**	**0.0**	0	0.0%		NA*	0	NA**	**2**	0	11.78	6.48	0	-2.3%	-2.31%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-922 TOTAL		RCA	RMTE	RD	RTE	RME	DCA	DD	DMTE	LI-921 TOTAL	LT-922 + LI-922
LT-922	CU+	0	**0**	**0**	0	**0**	**0**	**0**	**0.0**	0	0.0%	LI-922	NA*	0	NA**	**2**	0	11.78	6.48	0	2.3%	2.31%
	CU-	0	0	**0**	0	**0**	**0**	**0**	**0.0**	0	0.0%		NA*	0	NA**	**2**	0	11.78	6.48	0	-2.3%	-2.31%

BOLD = Level Transmitter error value cancels and is excluded from net RWST injection volume error calculation

NA* - RCA term (bistable calibration accuracy) is not applicable for indication
NA** - RD term (rack drift) is already included in DD (display drift) term

Table A-2 Cont.: RWST Instrumentation Uncertainties Minus Level Transmitter

RHR Pump Trip - RWST Level Indication Uncertainty

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RME	LC-920A TOTAL	TOTAL LT-920 + LC-920A
LT-920	CU+	0	1	**0**	0	**0**	0	**0**	**0.0**	0	0.2%	LC-920A	2.95	0	5.89	**2**	0	1.17%	1.34%
	CU-	0	0	**0**	0	**0**	0	**0**	**0.0**	0	0.0%		2.95	0	5.89	**2**	0	-1.17%	-1.17%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RME	LS-921 TOTAL	LT-921 + LS-921
LT-921	CU+	0	1	**0**	0	**0**	0	**0**	**0.0**	0	0.2%	LS-921	2.95	0	4.71	**2**	0	1.00%	1.17%
	CU-	0	0	**0**	0	**0**	0	**0**	**0.0**	0	0.0%		2.95	0	4.71	**2**	0	-1.00%	-1.00%

		EA	B	PMA	PEA	SCA	SMTE	SD	STE	SPE	LT-920		RCA	RMTE	RD	RTE	RME	LS-922 TOTAL	LT-922 + LS-922
LT-922	CU+	0	1	**0**	0	**0**	0	**0**	**0.0**	0	0.2%	LS-922	2.95	0	4.71	**2**	0	1.00%	1.17%
	CU-	0	0	**0**	0	**0**	0	**0**	**0.0**	0	0.0%		2.95	0	4.71	**2**	0	-1.00%	-1.00%

BOLD = Level Transmitter error value cancels and is excluded from net RWST injection volume error calculation

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table A-3 Cont.: Possible Net RWST Injection Error Cases

CASE 1			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	**1.17%**	1.17%
	-1.17%	-1.00%	-1.00%
Max Net Error	1.14%		

CASE 2			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	**1.17%**	1.17%
	-1.17%	-1.00%	-1.00%
Max Net Error	-3.48%		

Case 3			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	**1.17%**
	-1.17%	-1.00%	-1.00%
Max Net Error	1.14%		

Case 4			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	**1.17%**
	-1.17%	-1.00%	-1.00%
Max Net Error	-3.48%		

Case 5			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	**1.17%**	**1.17%**
	-1.17%	-1.00%	-1.00%
Max Net Error	1.14%		

Case 6			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	**1.17%**	**1.17%**
	-1.17%	-1.00%	-1.00%
Max Net Error	-3.48%		

BOLD = *Selected error values for Case net error calculation*

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Table A-3 Cont.: Possible Net RWST Injection Error Cases

Case 7			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	**-1.00%**	-1.00%
Max Net RWST Volume Error	3.48%		

Case 8			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	**-1.00%**	-1.00%
Max Net RWST Volume Error	-1.14%		

Case 9			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	-1.00%	**-1.00%**
Max Net RWST Volume Error	3.48%		

Case 10			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	-1.00%	**-1.00%**
Max Net RWST Volume Error	-1.14%		

Case 11			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	**-1.00%**	**-1.00%**
Max Net RWST Volume Error	3.31%		

Case 12			
Initial RWST Level Error	LI-920	LI-921	LI-922
	2.31%	2.31%	2.31%
	-2.31%	-2.31%	-2.31%
RHR PP Trip RWST Level Error	LC-920A	LS-921	LS-922
	1.34%	1.17%	1.17%
	-1.17%	**-1.00%**	**-1.00%**
Max Net RWST Volume Error	-1.31%		

BOLD = Selected error values for Case net error calculation

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

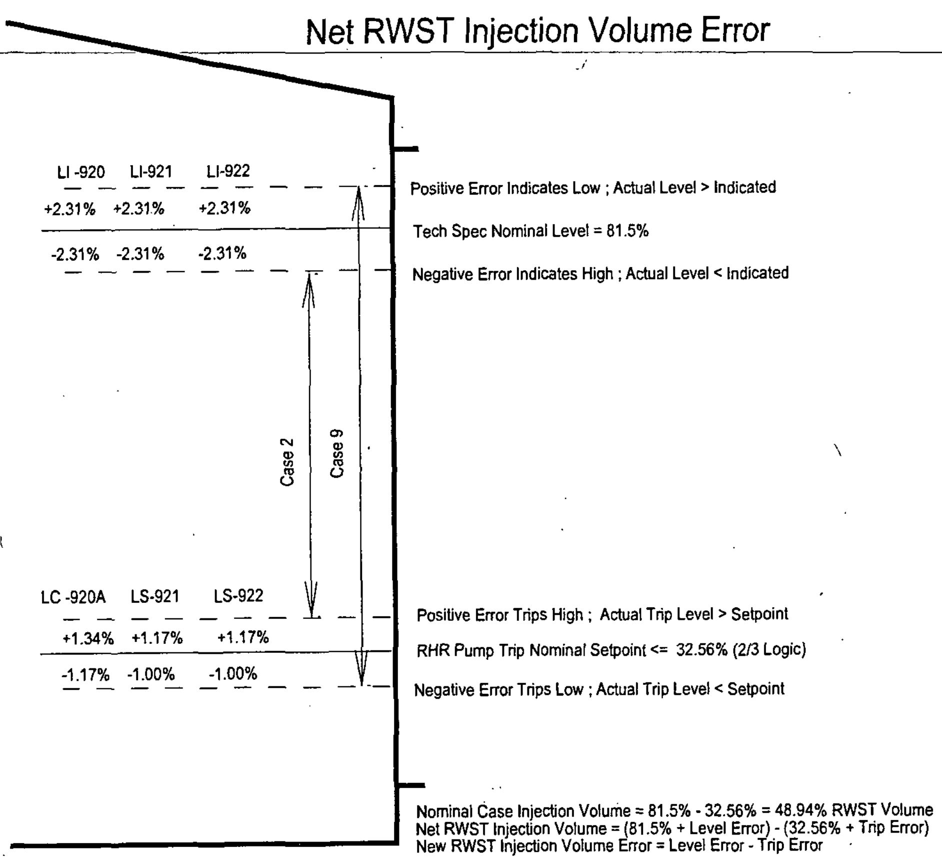
Table A-4.: Summary of Potential Net RWST Injection Error Cases

Error Case	Net RWST Injection Volume Error	Error Case	Net RWST Injection Volume Error
Case 1	1.14%	Case 2	-3.48%
Case 3	1.14%	Case 4	-3.48%
Case 5	1.14%	Case 6	-3.48%
Case 7	3.48%	Case 8	-1.14%
Case 9	3.48%	Case 10	-1.14%
Case 11	3.31%	Case 12	-1.31%

SUBJECT Post - LOCA Minimum Containment Sump Level

MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

Figure A-1 : Net RWST Injection Volume Diagram



Net RWST Injection Volume Error = Indication Error minus Lowest 2/3 RHR Trip Setpoint
Negative Net Error subtracts from RWST injected volume
Positive Net Error adds to RWST injected volume

Case 2 Example

Indication	Trip (2/3)
-2.31%	+1.34% +1.17%

Net RWST Injection Volume Error = -2.31% - (+1.17%) = -3.48%

Case 9 Example

Indication	Trip (2/3)
+2.34%	-1.17% -1.00%

Net RWST Injection Volume Error = +2.31% - (-1.17%) = +3.48%

13. Appendix B: Enercon Review Comments

Note that the Table 1 comments from Reference 11.3.22 shown here, have been designated a through k to enable correlation with respect to the Revision 4 summary provided in section 2.

Table 1: Diablo Canyon Post-LOCA Reactor Containment Building Minimum Water Level Comments and Recommendations

Comment	Recommendation
a. For a large break LOCA (Case 1), this calculation states that the containment sump includes about 80% of the RCS inventory in addition to the SI accumulator inventory. Based on Enercon's experience performing containment minimum flood level calculations, the RCS holdup volume assumed in this calculation is approximately equivalent to the RCS volume below the bottom of the RCS hot leg and cold leg piping. A double ended guillotine break in the cross-over leg (sometimes referred to the pump suction leg or intermediate leg) at the connection with the steam generator will result in significantly larger RCS holdup volume. For a break at this location, it is expected that most of the RCS loop piping as well as the reactor vessel up to the top elevation of the cold leg and hot leg piping will holdup up water inventory. Based on the RCS volumes at other U.S. PWRs, this RCS holdup volume is approximately equal to half of the total RCS volume. In the long term, the steam that fills the steam generators, pressurizer and the upper portion of the reactor vessel will condense causing vacuum conditions. Because of the loop seals (water traps) in the RCS cross-over leg and the reactor vessel downcomer, noncondensables from the containment building may not be drawn into these components. Instead, ECCS inventory could be drawn into these components causing the entire RCS to be filled with ECCS inventory. This impact is not expected to happen for a long period of time after the LOCA (many hours and possibly days).	Include a larger RCS holdup volume for the large break LOCA case based on the two considerations discussed – RCS water volume up to the top elevation of loop piping and ECCS inventory retention due to long term internal RCS steam condensation. Enercon is currently discussing this approach with Westinghouse. In the long term, ECCS inventory could be held up in all of the steam generators and the pressurizer if the steam in these components (from the blowdown) condenses.
b. A pressurizer surge line break was not considered. Given the size of this break, it is expected that the majority of the RCS will blowdown through the break. However, because the elevation of the break is above the RCS loop piping, it is expected that the steam generators and the upper portion of the reactor vessel could refill to the same elevation as the break.	Consider adding a pressurizer surge line break case, which would include a larger RCS holdup volume than the LBLOCA case. Adding this case may not be necessary if the break in the pressurizer surge line is evaluated with the small break water level. These small break water levels assume that the entire volume of the reactor vessel and steam generators retain ECCS inventory

c. This calculation currently credits portions of the SI accumulator inventory for small break LOCA cases 2 to 8. During a small break LOCA, the high head ECCS pumps may prevent the RCS from depressurizing to the cover pressure within the SI accumulators. Based on Enercon's experience at other U.S PWRs, the operators could have the option of closing the SI accumulator outlet valve prior to the accumulators emptying, thus retaining the remaining water volume within the accumulators.	It should be determined if the SI accumulator volume credited for these small break LOCA cases considered the possibility of the operators securing the SI accumulators. If not, the small break LOCA cases should consider the possibility of excluding the SI accumulator inventory.
d. The water in transit holdup volume of 250 ft3 specified in Assumption 19 compares fairly closely with the volumes that Enercon has calculated at other U.S. PWRs for both the containment spray flow traveling from the headers and the inventory traveling from the break. e. However, this assumption does not specifically discuss the containment spray flow water-in-transit as a separate holdup quantity.	Describe the containment spray flow water-in-transit holdup quantity as a separate quantity in the assumptions. Include this containment spray water-intransit holdup quantity for cases 2, 3, and 5, in which CSS actuates. Further, provide some additional discussion as basis for assumption 19 and the 2 minute transport time.
f. A portion of the RHR suction lines from the recirculation sumps are empty prior to the accident. The holdup of water in these suction lines does not appear to be a holdup volume that is considered.	Include the holdup of inventory within the RHR suction piping from the recirculation sumps.
g. Leakage is considered from the RWST at the ROS and the sample lines; however, leakage from the ECCS and CS systems is not considered.	Include the leakage from these additional systems.
h. In each case, there is no RHR flow credited after the RWST low level trip, which the calculation attributes to assumption 6, which appears incorrect. It appears that assumption 15 should be referenced.	Consider revising the calculation as noted.
i. For case 2, line item 9 notes its basis as "reference 9." The correct reference from sections 11.1 or 11.3 should be added	Consider revising the calculation as noted
j. Assumption 26 does not specifically address holdup of containment spray inventory within the refueling cavity nor is this issue discussed elsewhere. If the drain line is large enough, there may not be any holdup in the refueling cavity. Another Diablo Canyon calculation may document that there is no containment spray holdup in the refueling cavity.	Determine if there is another calculation that documents whether there is any containment spray holdup in the refueling cavity. If there isn't another calculation, consider including a section in this calculation that evaluates whether there is any containment spray holdup in the refueling cavity.
k. Enercon has observed a number of additional miscellaneous holdup volumes within the other containment building post-LOCA minimum water level calculations that it has reviewed or performed. It should be evaluated whether these items could holdup water at Diablo Canyon Power Plant. A review of plant drawings, walkdown photos or walkdown video may help in identifying	Determine whether these items are creditable holdup volumes at Diablo Canyon Power Plant.

whether these items or other miscellaneous items could holdup water. Refueling cavity due to low point volumes without drains Elevator shaft HVAC ductwork Lube oil collection system Enclosed rooms above the flood plane Polar crane and/or refueling crane tracks	
Holdup behind curbs above the flood plane Water held up on the operating deck Clogged floor drains Reactor Head shield ring	

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

14. Appendix C : DCPP RETRAN Model RCS Volume versus Liquid Level

The table in this appendix summarizes the volumes, elevations, and heights of the DCPP RETRAN model which is used to determine the RCS liquid volume associated with a liquid level at the elevation at the top of the RCS hot leg. Per the OIM Figure A-1-3 (Reference 11.3.23), the top of the RCS hot leg is at elevation 108.25 feet. The RCS volumes with a maximum elevation height less than or equal to this value are completely filled with liquid. The RCS volumes with a minimum elevation greater than the hot leg elevation are empty. The RCS volumes with a minimum elevation below 108.25 feet but with a maximum elevation greater than this value are partially filled with liquid. The partial volume occupied by liquid is determined based on assuming that the RETRAN control volume is linear as a function of RCS level. This is reasonable and physically accurate for the RETRAN control volumes of interest. The partial volume occupied by liquid is then equal to the fraction of the net RCS liquid height within the volume as compared to the total volume height. For example the partial liquid volume in the upper downcomer (RETRAN volume 1) is determined as:

$V_1 = (108.25 - 103.92) / 9 * 280 = 134.7\ ft^3$

The RETRAN RCS volumes are color coded below to delineate which volumes are completely filled, partially filled, and empty. It should be noted that the RCS loop volumes listed are for the single RCS loop modeled in RETRAN. Since there are actually four RCS loops, the total loop volume is equal to four times the individual single loop volume value. Summing up the net filled volume values form the table indicates that the RCS liquid volume at the hot leg elevation of 108.25 feet is equal to 4349.5 ft^3.

The table also determines the relative retention fraction this volume represents with respect to the normal operating RCS volume. Per OIM Figure A-1-3, the nominal pressurizer liquid level elevation is at about 144.33 feet. For this condition, all RCS volumes are completely filled with liquid except for the pressurizer which is partially filled. The pressurizer partial liquid volume is determined the same as above and is:

$V_{402} = (144.33 - 1113.16) / 52.8 * 1800 = 1062.6\ ft^3$

The total RCS liquid volume at the normal full power operating conditions is summed up to be 11273.1 ft^3.

The RCS liquid volume retention fraction associated with the top of the RCS hot leg elevation is then determined to be 4349.5 / 11273.1 or about 39%.

	Volume is partially filled
	Volume is completely filled
	Volume is empty

Pacific Gas and Electric Company
Engineering - Calculation Sheet
Project: Diablo Canyon Unit ( )1 ( )2 (X)1&2

CALC. NO. N - 227
REV. NO. 4
SHEET NO. 63 of 63

SUBJECT Post - LOCA Minimum Containment Sump Level
MADE BY Jerry E. Ballard DATE 2/27/06 CHK'D BY D.Christensen DATE 2/28/06

DCPP RETRAN Model Volumes and dimensions - Liquid

Description	Volume ID	Volume * (ft3)	Height (ft)	Lowest Elevation (ft)	Highest Elevation	Net Filled Volume (ft3) 108.25	Normal Operating Volume (ft3) 144.33
Upper Downcomer	1	280	9	103.92	112.92	134.7	280.0
Lower Downcomer	2	408.6	15.29	88.63	103.92	408.6	408.6
Lower Plenum	3	1023.7	9.95	79.51	89.46	1023.7	1023.7
Lower Core Section	5	218	4.46	89.46	93.92	218.0	218.0
Middle Core Section	6	218	4.46	93.92	98.38	218.0	218.0
Upper Core Section	7	218	4.46	98.37	102.83	218.0	218.0
Core Bypass Volume	8	71.3	13.38	89.46	102.84	71.3	71.3
Upper Plenum	9	1206.4	12.67	102.83	115.5	516.1	1206.4
Reactor Vessel Head	10	503	7.14	112.92	120.06	0.0	503.0
RCS Hot Leg 1	105, 305	16	2.93	105.53	108.46	59.4	64.0
RCS Hot Leg 2	106, 306	60.3	2.42	105.79	108.21	241.2	241.2
Steam Generator HL Inlet	107, 307	19.5	3.65	105.79	109.44	52.6	78.0
SG HL Plenum	108, 308	158.8	5.23	108.69	113.92	0.0	635.2
RCS HL SG Tube Bundle	141 , 341	61.6	5.55	113.92	119.47	0.0	246.4
RCS HL SG Tube Bundle	142, 342	143.9	12.96	119.48	132.44	0.0	575.6
RCS HL SG Tube Bundle	143, 343	143.9	12.96	132.44	145.4	0.0	575.6
RCS SG U-Tube Bundle	144, 344	77	4.99	145.4	150.39	0.0	308.0
RCS CL SG Tube Bundle	145, 345	143.9	12.96	132.44	145.4	0.0	575.6
RCS CL SG Tube Bundle	146, 346	143.9	12.96	119.48	132.44	0.0	575.6
RCS CL SG Tube Bundle	147, 347	61.6	5.55	113.92	119.47	0.0	246.4
SG CL Plenum	111, 311	158.8	5.23	108.69	113.92	0.0	635.2
SG CL Outlet	112, 311	16.5	3.14	105.72	108.86	53.2	66.0
RCS CL Cross Under 1	113, 313	23.7	4.53	101.19	105.72	94.8	94.8
RCS CL Cross Under 2	114, 314	37	5.79	95.4	101.19	148.0	148.0
RCS CL Cross Under 3	115, 315	18.4	2.58	95.4	97.98	73.6	73.6
RCP Suction	116, 316	37	5.79	95.4	101.19	148.0	148.0
Reactor Coolant Pump	101, 301	79	8.43	101.19	109.62	264.6	316.0
RCS Cold Leg 1	102, 302	76.7	2.29	105.85	108.14	306.8	306.8
RCS Cold Leg 2	103, 303	26.9	2.61	105.85	108.46	98.9	107.6
Pressurizer Surge Line	401	45.9	6.88	106.53	113.41		45.9
Pressurizer	402	1800	52.8	113.16	165.96		1062.6
TOTAL Filled Volume (ft3)						4349.5	11273.1

Attachment 2

Calculation STA-255
Minimum Required RWST Level for GE Sump Strainers

NUCLEAR POWER GENERATION
CF3.ID4
ATTACHMENT 7.2

TITLE: Design Calculation Cover Sheet

Unit(s): 1 & 2 File No.: ____ Responsible Group: NSTA Calculation No.: STA-255

Design Calculation YES ☒ NO ☐ System No. 09 Quality Classification Q

Structure, System or Component: Safety Injection System

Subject: Minimum Required RWST Level for GE Sump Strainers

Computer/Electronic calculation YES ☐ NO ☒

Computer ID	Application Name and Version	Date of Latest Installation/Validation Test

Registered Engineer Stamp: Complete A or B

A. Insert PE Stamp or Seal Below	B. Insert stamp directing to the PE stamp or seal
REGISTERED PROFESSIONAL ENGINEER MARK L. MAYER No 23066 Mark L Mayer Expiration Date: 9/30/08	

NOTE 1: Update DCI promptly after approval.

NOTE 2: Forward electronic calculation file to CCG for uploading to EDMS, only if the calculation is complete and can be used from EDMS.

TITLE: Design Calculation Cover Sheet

Calculation No.: STA-255

RECORD OF REVISIONS

Rev No.	Status	No. of Pages	Reason for Revision / Remarks	Prepared By: Initials/ LAN ID/ Date	LBIE Screen Yes/ No/ NA	LBIE Yes/ No/ NA	Check Method*	LBIE Approval PSRC Mtg. No.	LBIE Approval PSRC Mtg. Date	Checked Initials/ LAN ID/ Date	Supervisor Initials/ LAN ID/ Date	Registered Engineer Signature/ LAN ID/ Date	Owner's Acceptance per CF3.ID17 Signature/ LAN ID Date
0	f	13	Initial Issue Refer to DCP C-49857 for LBIE	[signature] 3/15/07	☐ Yes ☒ No ☐ NA	☐ Yes ☒ No ☐ NA	☐ A ☐ B ☒ C			[signature] DDC1 3/15/07	[signature] MLM3 3/15/07	[signature] MLM 3/15/07	
1	f	10	ref. DCP C-49857 for LBIE	[signature] 5/10/07	☐ Yes ☒ No ☐ NA	☐ Yes ☐ No ☒ NA	☐ A ☐ B ☒ C			[signature] DDC1 5/10/07	[signature] MLM3 5/10/07	[signature] MLM3 5/10/07	
2	F	12	in support of a RWST LAR. see A0708213 NO LBIE required	[signature] 9/28/07	☐ Yes ☒ No ☐ NA	☐ Yes ☐ No ☒ NA	☒ A ☐ B ☐ C			JTEB / JTB5 / 9/28/07	[signature] MLM3 9/28/07	[signature] MLM3 9/28/07	
					☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	☐ A ☐ B ☐ C						

*Check Method: A: Detailed Check, B: Alternate Method (note added pages), C: Critical Point Check

Input Reference		Output Reference	
Calc / Procedure No.	Comments	Calc / Procedure No.	Comments
Calc. M-585, Rev. 3			
Calc. N-227, Rev. 4			
Calc. J-142, Rev. 0			
Calc. STA-071, Rev. 1			

TITLE: Design Calculation Cover Sheet

Calculation No.: STA-255

Calc. N-100, Rev. 2			
Calc. STA-061, Rev. 3			
Calc. J-142A Rev. 0			
Calc. SC-I48-1 Rev. 3			

TABLE OF CONTENTS

RECORD OF REVISIONS

Revision 0: Initial Issue.

Revision 1: The 1R14 as-installed sump strainers height is incorporated. The sump level instrumentation uncertainties sensitivity section in revision 0 is deleted as sump level volume changes are determined only based on depleted RWST inventory. This methodology is documented in Reference 12.1.8.

Revision 2: Delete level instrument uncertainties since it is addressed in Calc. J-142A (Ref. 12.1.4). Include the conversion (A0708213) for the 93.6% minimum RWST level to the minimum required RWST measurable volume in Section 7.1.D. A sump level margin assessment is added in Section 7.2 to ensure the full submergence of the GE sump strainers.

This calculation only becomes applicable for each Unit after installation of the new GE recirculation sump strainers is completed and the License Amendment Request (LAR) for the new minimum Tech Spec RWST level has been implemented.

1. PURPOSE

The purpose of this calculation is to determine the minimum required RWST water level to provide sufficient water inventory to meet the design requirement of the new GE containment recirculation sump strainers which were procured to address Generic Safety Issue (GSI)-191 (Ref. 12.3.1) sump strainers performance concerns. This calculation also determines the containment sump suction flow rate versus recirculation sump water level as the ECCS pumps are aligned to the sump during cold leg switchover.

2. BACKGROUND

GSI-191 requires licensees to address the potential of the containment recirculation sump strainers clogging which may occur as a result of a LOCA. Debris may include insulation material dislodged by the impingement of a LOCA jet as well as loose dust and dirt already inside the containment. DCPP has contracted GE to design new sump strainers to be installed during 1R14 and 2R14. The new GE sump strainers are of a submerged design so this calculation determines the minimum required water inventory in the RWST required for submergence of the strainers. In addition, this calculation also provides sump suction flow rate versus sump water height for strainers design considerations.

3. ASSUMPTIONS

1. Figure 1 shows a portion of the new GE sump strainers (Ref. 12.3.2). The vertical height of the sump strainers is 29", or 2'-5" above the 91' containment floor elevation. The top of the installed sump strainers is at 93.59' (Ref. 12.1.9). A maximum strainers height of 93.6' is assumed in this calculation.
2. Since an increase in the initial RWST water inventory will result in a slight increase in the RWST drain down time, there is also a longer period for RWST sample line leakage to occur than calculated in N-073 (Reference 12.1.10) and used in the post-LOCA sump level calculation N-227 (Reference 12.1.2). This additional RWST leakage penalty is not directly calculated but is bounded by assuming a conservative increase to the calculated additional required RWST volume as discussed in Section 7.1.A
3. The post-LOCA sump level calculated in N-227 was based on a very conservative and minimum time interval of three minutes from the RWST Low level trip to the start of the first RHR pump. This calculation is based on STA-061 which establishes the design basis ECCS switchover sequence of events as presented in FSARU Table 6.3-5 and which determined the first RHR pump was started five minutes after the RWST Low level trip occurs. In order to determine the relative increase in the post-LOCA sump level for the subsequent ECCS switchover time intervals as established in STA-061, it is appropriate to assume that the increased initial net post-LOCA sump level as based on the N-227 calculated value occurs at the STA-061 operator action time associated with starting the first RHR pump as discussed in Section 7.3.
4. This calculation uses the same operator action time intervals and ECCS flow values as STA-061 for the post-LOCA sump level versus time evaluation since this was the original basis provided to GE for the sump strainer design.
5. For the sump strainers submergence margin assessment, a +/- 0.65% RWST local gauge indication accuracy and a +/- 1.01% accuracy on the Low level RHRP trip transmitters per Calc. J-142A are assumed.

4. DESIGN INPUTS

1) The maximum unoccupied containment area per foot of elevation between elevation 93' and 94' is 11,200.7 ft^2 + 125 ft^2 = 11,325.7 ft^2 / ft (Ref 12.1.1). Above 94', the unoccupied unit area is 11,960.0 ft^2 + 119 ft^2 = 12079 ft^2 /ft.

2) For a large break LOCA, the worst case minimum sump water level, per Calc. N-227 is 93.41' which corresponds to an RWST water level of 90% (Ref. 12.1.2).

3) The radius of the RWST is 20' per drawing 438038 Rev. 7 (Ref. 12.1.3).

4) RWST 100% level instrument span is 585" per Calc. J-142A, Rev. 0 (Ref. 12.1.4).

5) The total maximum sump suction flow with both RHR pumps operating during the cold leg recirculation phase is 7,769 gpm per Calc. STA-071, Rev. 1 (Ref. 12.1.5).

6) The maximum sump suction flow for one RHR pump operating during the cold leg recirculation phase is 4,541.6 gpm per Calc. N-100 Sect. VI-1a (Ref. 12.1.6).

7) The timing for the cold leg switchover process is conservatively based on Calc. STA-061, Rev. 3 (Ref. 12.1.7).

8) The conversion factor for gal/ft^3 is the industry standard value of 7.4805 gal/ft^3.

9) Per calculation SC-I48-1 (Reference 12.1.11) there is 26,438 gallons of unmeasurable volume below the RWST lower instrument level tap.

5. METHOD AND EQUATION SUMMARY

This calculation determines the minimum RWST inventory required to ensure the minimum sump strainers water level of 93.6' is achieved prior to the initial RHR pump start during the cold leg switchover sequence. Then, starting with this initial sump level, this calculation integrates the total flow from the RWST during the cold leg switchover process to track sump level increases until no pumps are taking suction from the RWST.

6. ACCEPTANCE CRITERIA

None

7. BODY OF CALCULATION

The first portion of this calculation is to determine the required RWST water inventory to ensure the sump water level reaches $\geq$ 93.6' to submerge the new sump strainers when the first RHR pump is aligned to the sump. The second portion of this calculation is to determine the sump water level changes as ECCS pumps are aligned to take suction from the sump.

7.1 Minimum Required RWST Water Level in Percent Measured

7.1.A Additional Water Inventory To Raise Sump Level From 93.41' to 93.6'

The containment unoccupied area between elevation 93' and 94' is 11,325.7 ft^2 /ft per Design Input # 1 and the minimum sump water level for a large break LOCA is 93.41' with RWST water level at 90% per Design Input # 2; hence the additional RWST water inventory needed to raise sump level from 93.41' to 93.6' is:

$$
\begin{aligned}
{}_{sump}V_{93.6'} &= (93.6' - 93.41') \times 11{,}325.7\ ft^2 \\
&= 2151.9\ ft^3\text{, or } 16{,}097\text{ gallons}
\end{aligned}
$$

Since an increase in water inventory requirement in the sump will result in a slight increase in the RWST drain down time, a longer period for RWST leakage will also result than was assumed in N-227 (Reference 12.1.2). Thus, an additional leakage penalty is required as discussed in Assumption 2. Although the total sump water volume penalty due to RWST leakage is small (e.g., a 15% increase in switchover time resulted in a 4 gallon penalty increase per Reference 12.1.2), a total RWST inventory increase of 16,500 gallons is conservatively assumed in this calculation to account for any additional RWST leakage or other potential flow diversion.

7.1.B RWST Water Inventory Per % Level Measured

Per Design Input # 3, the radius of the RWST is 20' and per Design Input 4, the 100% RWST measured level span is 585"; thus the RWST water volume per % is:

$$
\begin{aligned}
{}_{RWST}V_{gal/\%.} &= 3.14159 \times (20')^2 \times 7.4805\ gal/ft^3 \times 585''/12 / 100\% \\
&= 4{,}582.63 / \%
\end{aligned}
$$

7.1.C The Minimum Required Measurable RWST Level

To accommodate the additional 16,500 gallons in the sump, the required minimum RWST water level, with 0% uncertainty is:

$RWST_{L\%.}$ = 90% + 16,500 gallons / 4,582.63 gal/%
= 93.6%

7.1.D The Tech Spec Minimum Required Measured & Contained RWST Inventory

The minimum measured RWST water inventory for the Tech Spec at 93.6% is calculated as:

$RWST_{L measure.}$ = 93.6% X 4,582.63 gal / %
= 428,934 gallons

To conservatively specify the Minimum RWST inventory, the above value is rounded down to **428,900 gallons, measurable volume**

Per design input 9, the un-measurable below the level instrument tap is 26,438 gallons, therefore, the total RWST contained volume corresponding to 93.6% measured level is:

$RWST_{L contained.}$ = 428,934 gallons + 26,438 gallons
= 455,372 gallons

To conservatively specify the Minimum RWST contained volume for the Tech. Spec., the above value is rounded down to **455,300 gallons contained volume**.

It should be noted that this reduction of 72 gallons in the RWST volume has an insignificant effect on the earlier calculated volume required for a sump level of 93.6 ft

7.2 Assessment of Margin Gained Due to More Accurate RWST Instrumentation

Calculation J-142A establishes that the new RWST local gauge indication will provide an accuracy on the new TS minimum RWST level of +/- 0.65% while the accuracy on the Low level trip will be improved to +/- 1.01% with new transmitters. As originally established in calculation N-227 Appendix A, the maximum net error in the RWST injected volume is based on a minimum initial RWST level minus the maximum or earliest lo level trip value. Therefore, based on J-142A, the maximum net RWST injection volume error would be: (-0.65%) – (1.01%) = -1.66%, which is rounded to -1.7%. This net error is less than the -3.5% value used in calculation N-227 and represents a net increase in the RWST injection volume to the sump equivalent to 1.8 % RWST measured level. Since the measured RWST level represents 4582.63 gal/%, this is an increase of 8248 gallons in the net RWST injection volume. This would increase the calculated minimum post-LOCA sump level (93.6') at the time of the first RHR pump as follows:

$$_{Sump}L_{18:31} = 93.6' + 8248 \text{ gal} / 7.4805 \text{ gal/ft3} / 11325.7 \text{ ft3} / \text{ft}$$
$$= 93.7'$$

Therefore, the more accurate RWST level instrumentation documented in calculation J-142A represents an increase in margin of 0.1 feet to the minimum post-LOCA sump level.

7.3 Sump Water Level Increases During Cold Leg Switchover Process

The post-LOCA sump level versus time during cold leg switchover sequence is calculated per STA-061. Once the recirculation sump strainers are fully submerged (with margin as demonstrated in Section 7.2), it eliminates the mechanism for the possible channel flow inside the plenum of the sump strainers (see figure 1). At the maximum RHR suction flow of 7,769 gpm, where both RHR pumps are taking suction from a total strainer area of over 3,000 square feet, the flow velocity across the strainers is insignificant to entrain air into the sump. This has been demonstrated during the actual GE recirculation sump strainer tests (Reference 12.3.5).

Per Design Input 6, the maximum RHR pump sump suction flow is 4,541.6 gpm when providing suction flow to two SIPs and two CCPs during ECCS cold leg recirculation operation. This flow is conservatively increased to 4562 gpm for this evaluation. In the ECCS cold leg recirculation configuration, the maximum flow for two CCPs and for two SIPs used in STA-061 (Reference 12.1.7) is 900 gpm each. Thus, the RHR suction flow just prior to ECCS cold leg recirculation operation is estimated at:

4,562 gpm – 900 gpm – 900 gpm = 2,762 gpm

The maximum Containment spray flow during cold leg switchover used in STA-061 is 6,800 gpm.

The critical steps which alter the RWST water inventory depletion rates and sump suction flow rates during the cold leg switchover alignments are documented in STA-061 (Reference 12.1.7). The reference chronologically lists these critical steps with the LOCA starting at time 0:00 and the RWST low level RHR pump trip occurring at 13:31. This evaluation of the additional RWST inventory uses the same time intervals and nomenclature, and establishes the following inventory and flow conditions for the subsequent critical steps as follows:

7.3.A <u>13:31 to 18:31 (RWST low level RHRP trip to start of RHRP #2 taking suction from sump)</u>

Per Reference 12.1.7, the RHRPs are tripped off at 13:31 and RHRP #2 is restarted taking suction from the sump at 18:31.

Per the Assumption 3, the sump level reaches 93.6' at 18:31.

At this time, the CCPs, SIPs and CSPs continue taking water from the RWST.

7.3.B <u>18:31 to 19:26 (RHRP #2 aligned to both SIPs when 8804B is opened)</u>

During this period, right before opening 8804B, both CSPs, CCPs and the SIPs are diverting water from the RWST into the sump. The sump water level just before 19:26 is:

$$
{}_{Sump}L_{19:26.} = 93.6' + [(19{:}26 - 18{:}31) \text{ min X } (6{,}800 \text{ gpm} + 900 \text{ gpm} + 900 \text{ gpm})] / (7.4805 \text{ X } 11{,}325.7) = 93.7'
$$

The total RHRP #2 suction from the sump during this interval from 93.6' to 93.7' is 2,762 gpm.

7.3.C <u>19:26 to 20:21 (RHRP #2 also aligned to 2-CCPs when 8807A/B opened)</u>

During this period, right before opening valves 8807A/B, both CSPs and both CCPs are diverting water from the RWST into the sump. The sump water level just before 20:21 is:

$$
{}_{Sump}L_{20:21.} = 93.7' + [(20{:}21 - 19{:}26) \text{ min X } (6{,}800 \text{ gpm} + 900 \text{ gpm})] / (7.4805 \text{ X } 11{,}325.7) = 93.8'
$$

At 19:26, Valve 8804B is opened which results in RHRP #2 providing flow to cold legs #3 and #4 and both SIPs. Thus, the total RHRP #2 suction from the sump during this interval from 93.7' to 93.8' is 2,762 gpm + 900 gpm = 3,662 gpm.

7.3.D 20:21 to 21:46 when RHRP #1 is started

During this period, right before opening the 8807A/B valves, both CSPs and both CCPs are pumping water from the RWST into the containment sump. The sump water level just before 20:21 is:

$$_{Sump}L_{21:46.} = 93.8' + [(21:46 - 20:21) \text{ min X } 6{,}800 \text{ gpm}] / (7.4805 \text{ X } 11{,}325.7)$$
$$= 93.9'$$

Note that the submergence of the sump strainers when the second RHR pump is started is: 93.9' – 93.6' = 0.3', or 3.6".

At 20:21, Valves 8807A/B are opened and RHRP #2 provides flow to cold legs #3 and #4, both SIPs, and both CCPs. Therefore, the total sump suction flow from RHRP#2 during this interval from 93.8' to 93.9' is 4,562 gpm.

7.3.E 21:46 to 29:17 when CSPs are shutoff

During this period, right before shutting off both CSPs, the sump water level at 29:17 is:

$$_{Sump}L_{29:17.} = 93.9' + [(29:17 - 21:46) \text{ min X } 6{,}800 \text{ gpm}] / (7.4805 \text{ X } 12{,}079.0)$$
$$= 94.5'$$

At this point, the sump submergence depth is: 94.5' – 93.6' = 0.9', or 10.8" above the top of the sump strainers.

At 21:46 when both RHR pumps take suction from the sump, the maximum total RHR pump flow from the sump for the interval 93.9' to 94.5' is 7,769 gpm per Design Input 5.

At 29:17, the water in the RWST reaches the 4% alarm level and the operator shuts down both CSPs. The total sump suction flow for both RHRPs then remains at 7,769 gpm.

8. RESULTS

To maintain the GE sump strainers submerged at 93.6' when the first RHR pump is started, the minimum RWST water level must be ≥ 93.6% (i.e., minimum measurable water volume of 428,900 gallons, or 455,300 gallons contained volume).

The sump water level changes as a function of critical cold leg switchover steps are shown in Table 1 below:

Table 1: Sump Water Level Vs. Sump Discharge Flow

Pump Operation Conditions	True Sump Level	Sump RHRP Flow
RHRP #2 to C.L. #3 & 4 only	93.6'	2762 gpm
RHRP #2 to C. L. #3 & 4 + 2 SIPs	93.7'	3662 gpm
RHRP #2 to C. L. #3 & 4 + 2 SIPs + 2 CCPs	93.8'	4562 gpm
All ECCS pumps taking suction from sump	93.9'	7769 gpm
RWST 4% reached; CSPs off	94.5'	7769 gpm

9. MARGIN ASSESSMENT

The new GE sump strainers result in a significant loss of operating margin between the Tech Spec minimum measured RWST level, the RWST high level alarm setpoint, and the RWST overflow level. This results in a significant negative impact on operating margin.

10. CONCLUSION

To maintain the GE sump strainers submerged, the minimum measured RWST water level must be ≥ 93.6% which corresponds to a minimum measured volume of 428,900 gallons in the RWST or a contained volume of 455,300 gallons.

11. IMPACT EVALUATION

An LAR is required to revise Tech Spec SR 3.5.4.2 to increase the RWST minimum level from the current value of ≥ 81.5% to ≥ 93.6%. (Reference 12.2.1).

This calculation only becomes applicable for each Unit after installation of the new GE recirculation sump strainers is completed and the License Amendment Request (LAR) for the new minimum Tech Spec RWST level has been implemented.

12. REFERENCES

12.1 Input References:

12.1.1 Calc. M-585, Rev. 3

12.1.2 Calc. N-227, Rev. 4

12.1.3 Dwg 438038, Rev. 6

12.1.4 Calc. J-142A, Rev. 0

12.1.5 Calc. STA-071, Rev. 1

12.1.6 Calc. N-100, Rev. 3

12.1.7 Calc. STA-061, Rev. 3

12.1.8 DIT-A0684593-01-00

12.1.9 AR A0684593 AE93

12.1.10 Calc. N-073, Rev. 2

12.1.11 Calc. SC-I48-1, Rev. 3

12.2 Output References:

12.2.1 License Amendment Request per A0690337 and A0708213

12.3 Other References:

12.3.1 GSI-191

12.3.2 GE Drawing 223D5299, Rev. 1

12.3.3 Calc. PAM-0-09-940, Rev. 44

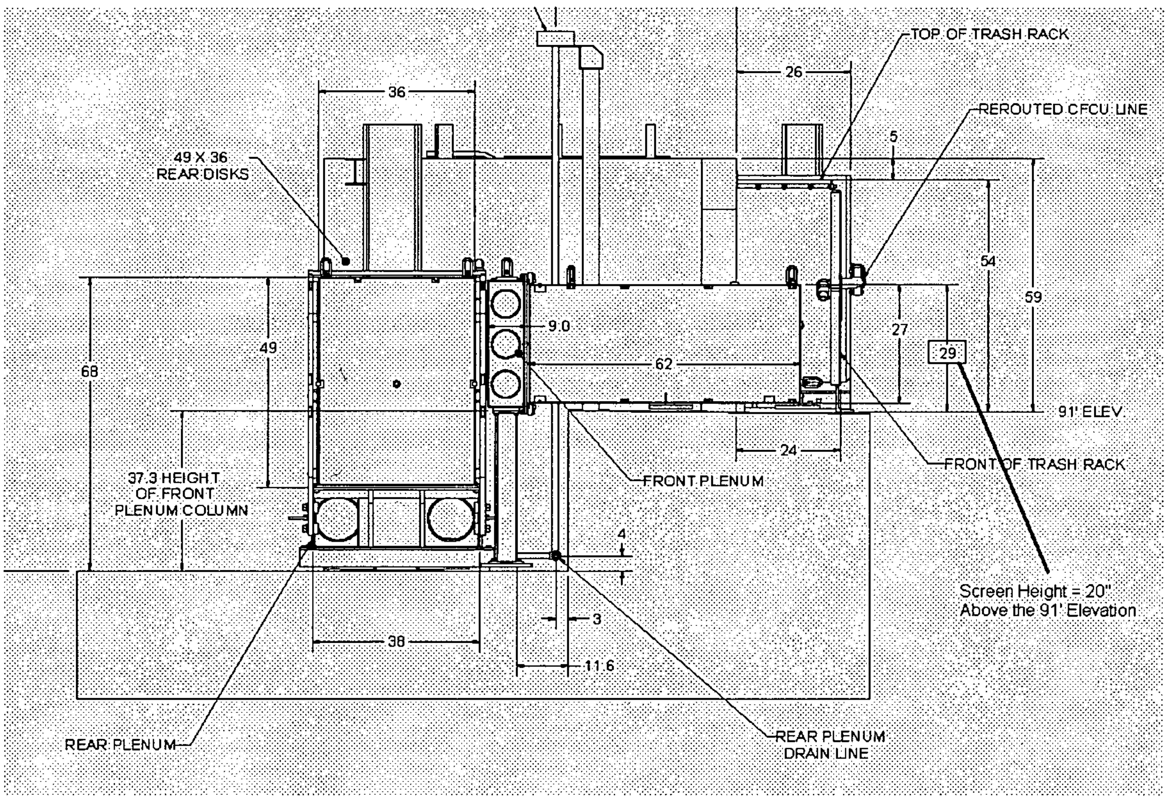
12.3.4 AR A0708213

12.3.5 GE Test Report S0100, Rev. 4

13. ATTACHMENT 1

Attachment 1 consists of one figure which is presented on the following page.

Figure 1 - GE Sump Strainers



Proposed TS Page 3.5-7

Proposed SR 3.5.4.2 Bases (for information only)

3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

3.5.4 Refueling Water Storage Tank (RWST)

LCO 3.5.4 The RWST shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3, and 4

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. RWST boron concentration not within limits. OR RWST borated water temperature not within limits.	A.1 Restore RWST to OPERABLE status.	8 hours
B. RWST inoperable for reasons other than Condition A.	B.1 Restore RWST to OPERABLE status.	1 hour
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 3. AND C.2 Be in MODE 5.	6 hours 36 hours

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.4.1	----------NOTE---------- Only required to be performed when ambient air temperature is < 35°F. -------------------- Verify RWST borated water temperature is ≥ 35°F.	 24 hours
SR 3.5.4.2	Verify RWST borated water volume is ≥ 455,300 gallons.	7 days
SR 3.5.4.3	Verify RWST boron concentration is ≥ 2300 ppm and ≤ 2500 ppm.	7 days

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.4.2

The RWST water volume should be verified every 7 days to be above the required minimum level in order to ensure that a sufficient initial supply is available for ECCS injection and CS System pump operation and to support continued ECCS on recirculation. Since the RWST volume is normally stable and the contained volume required is protected by a computer alarm, a 7 day Frequency is appropriate and has been shown to be acceptable through operating experience.

To ensure the minimum contained borated water volume of 455,300 gallons (equivalent to 93.6% RWST level uncorrected for uncertainty) is met, the RWST level shall be maintained $\geq$ 94% using the temporary installed Heise gauge (Unit 1), or $\geq$ 94.25% using the local digital indicator on LT-920, LT-921, or LT-922 (lowest reading) (Unit 2).

SR 3.5.4.3

The boron concentration of the RWST should be verified every 7 days to be within the required limits. This SR ensures that the reactor will remain subcritical following a LOCA. Further, it assures that the resulting sump pH will be maintained in an acceptable range so that boron precipitation in the core will not occur and the effect of chloride and caustic stress corrosion on mechanical systems and components will be minimized. Since the RWST volume is normally stable, a 7 day sampling Frequency to verify boron concentration is appropriate and has been shown to be acceptable through operating experience.

REFERENCES

1. FSAR, Chapter 6 and Chapter 15.
2. Surveillance Test Procedure R-20, "Boric Acid Inventory."
3. Calc STA-255, "Minimum Required RWST Level for GE Sump Strainers."
4. Calc N-227, “Post-LOCA Minimum Containment Sump Level.”
5. Calc J-153, “RWST Level Using Temporary Gauge.”
6. Calc J-143A, “RWST Level Instrument Channels with 3051N Transmittors.”

Regulatory Commitment

1. The Bases for Surveillance Requirement (SR) 3.5.4.2 will include the minimum refueling water storage tank level, (RWST), including allowance for instrument uncertainty, required to ensure the SR 3.5.4.2 requirement "that the RWST borated water volume is greater than or equal to 455,300 gallons" is met.