June 10, 2002

EA-01-286

Mr. A. C. Bakken III
Senior Vice President
Nuclear Generation Group
American Electric Power Company
500 Circle Drive
Buchanan MI 49107

SUBJECT: D. C. COOK NUCLEAR POWER PLANT, UNITS 1 AND 2
NRC SPECIAL INSPECTION REPORT 50-315/01-17(DRP);
50-316/01-17(DRP); PRELIMINARY YELLOW FINDING

Dear Mr. Bakken:

On May 17, 2002, the NRC completed a Special Inspection at your D.C. Cook Nuclear Power Plant regarding the essential service water (ESW) debris intrusion event of August 29, 2001. The Special Inspection was conducted in accordance with the guidance of NRC Management Directive 8.3, “NRC Incident Investigation Program,” Inspection Procedure 71153, “Event Followup,” and Inspection Procedure 93812, “Special Inspection.” The enclosed report documents the inspection findings which were discussed on May 17, 2002, with you and members of your staff.

On August 29, 2001, Unit 1 was in cold shutdown and Unit 2 was operating at power when your staff shut down the Unit 1 circulating water system for maintenance. Subsequent to the Unit 1 circulating water system shutdown, cross-flow currents within the common intake structure caused significant amounts of debris to be entrained in the ESW system. Due to an unknown pre-existing fault in the Unit 1 East ESW pump strainer basket, which allowed bypass flow, and your practice of operating the ESW system fully cross-connected between both trains on both units, the debris was transported throughout the ESW systems of both units, fouling most of the heat exchangers dependent upon ESW. Because most components supplied by ESW were in standby, this fouling continued undetected for approximately 10 hours. Operators then identified the problem during a scheduled, routine, quarterly surveillance of the ESW system in Unit 2. A review of available data indicates that the emergency diesel generator (D/G) heat exchangers appeared to be most limiting components for debris fouling. The flow to one D/G decreased below the level of reliable indication, flow to two D/Gs decreased to 40% of nominal flow with a declining trend, and the flow to the remaining D/G flow leveled out at approximately 40% of nominal flow. After discovery, the operators cycled ESW supply valves to the D/G heat exchangers (the D/Gs were not operating) which improved flows to the heat exchangers. However, due to continued concerns about the cause of the fouling, you elected to shut down Unit 2 and correct the problem. Your staff replaced the damaged strainer basket, cleaned the heat exchangers and revised your operating procedures to prevent cross-connecting ESW system trains before restarting the units.

The Special Inspection began immediately after the event on August 30, 2001, and examined activities conducted under your license as they relate to safety and compliance with NRC regulations and the conditions of your license. The inspectors reviewed selected procedures and records, observed activities, interviewed personnel, and conducted extensive onsite reviews of the ESW and diesel generators' systems in the weeks immediately following the event. One finding was identified that appears to be significant. As described in Section 4OA3.4 of this report, documented instructions for installation of the ESW strainer baskets, an activity affecting quality, were not of a type appropriate to the circumstances. Specifically, the installation instructions for the Unit 1 East ESW pump discharge strainer basket, referenced by Job Order 723483, did not contain adequate detail associated with the verification of critical parameters affecting strainer basket alignment to prevent the basket from being deformed during installation in 1989. Subsequent to the initial onsite inspection, the inspectors and several NRC staff specialists continued to review information related to this finding including the detailed engineering and probabilistic evaluations that you provided in January and April 2002. These evaluations provided some useful inputs to our risk determination of this finding; however, some of the assumptions you provided could not be supported or confirmed and were not used.

This finding was assessed using the NRC Phase 3 Significance Determination Process and preliminarily determined to be Yellow, a finding with substantial importance to safety that will result in additional NRC inspection and potentially other NRC action. As described in more detail in the inspection report, our determination considered the August 29, 2001, event information, the engineering and probabilistic analyses you developed, generic risk information, and engineering analyses performed by the inspectors. The accident sequence of most concern was the loss of offsite power (LOOP) because of the vulnerability to the D/Gs created by the damaged strainer and the cross-connected ESW systems. A single unit LOOP event would result in a complete loss of the affected unit's circulating water system, and an emergency start of both the associated D/Gs and ESW pumps. The NRC concluded that this sequence would create a greater debris entrainment than the August 29 event; however, the continued sweeping of the debris by the operating unit circulating water system and availability of the operating unit's auxiliary feedwater system to feed the affected unit's steam generators would provide substantial mitigation of the event. A dual unit LOOP would have a lower initiating event frequency than the single unit LOOP, but the mitigative effects available during a single unit LOOP would not be available. Our engineering assessment of simultaneously stopping the circulating water pumps for both units concluded that the continued inrush of water from Lake Michigan to the intake structure, after the dual unit LOOP, would sufficiently entrain debris to provide significant fouling of the ESW system. This debris would bypass the Unit 1 East ESW pump strainer and disburse throughout heat exchangers in both units. Based on the observed distribution of debris during the August 29 event, it appears that each of the D/G heat exchangers could become fouled such that they could not be capable of supporting their expected loads. The calculated change in core damage frequency and the large early release frequency as a result of the damaged strainer were both determined to be Yellow.

This finding is also an apparent violation of NRC requirements and is being considered for escalated enforcement action in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions" (Enforcement Policy), NUREG-1600. The current Enforcement Policy is included on the NRC's website at http://www.nrc.gov.

We believe that sufficient information was considered to make a preliminary significance determination. However, before we make a final decision on this matter, we are providing you an opportunity to present to the NRC your perspectives on the facts and assumptions used by the NRC to arrive at the finding and its significance at a Regulatory Conference or by a written submittal. If you choose to request a Regulatory Conference, it should be held within 30 days of the receipt of this letter and we encourage you to submit supporting documentation at least one week prior to the conference in an effort to make the conference more efficient and effective. If a Regulatory Conference is held, it will be open for public observation. If you decide to submit only a written response, such submittal should be sent to the NRC within 30 days of the receipt of this letter.

Please contact David G. Passehl at 630-829-9872 within 10 business days of your receipt of this letter to notify the NRC of your intentions. If we have not heard from you within 10 days, we will continue with our significance determination and enforcement decision and you will be advised by separate correspondence of the results of our deliberations on this matter.

Since the NRC has not made a final determination in this matter, no Notice of Violation is being issued for this inspection finding at this time. In addition, please be advised that the number and characterization of apparent violations described in the enclosed inspection report may change as a result of further NRC review.

An additional human performance finding involving several examples of control room operator weaknesses during the degraded ESW flow event was identified. This issue was determined to be of very low safety significance (Green) and was determined to involve a violation of NRC requirements. However, because of its very low safety significance and because it has been entered into your corrective action program, the NRC is treating this issue as a Non-Cited Violation, in accordance with Section VI.A.1 of the NRC Enforcement Policy. If you contest the Non-Cited Violation, you should provide a response with the basis for your denial, within 30 days of the date of this inspection report, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001; with copies to the Regional Administrator, Region III; the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at the D.C. Cook facility.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

Sincerely,

/RA by James Caldwell Acting for/

J. E. Dyer
Regional Administrator

Docket Nos. 50-315; 50-316
License Nos. DPR-58; DPR-74

Enclosure: Inspection Report 50-315/01-17(DRP); 50-316/01-17(DRP)

cc w/encl: J. Pollock, Site Vice President
M. Finissi, Plant Manager
R. Whale, Michigan Public Service Commission
Michigan Department of Environmental Quality
Emergency Management Division
MI Department of State Police
D. Lochbaum, Union of Concerned Scientists

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U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket No:	50-315; 50-316
License Nos:	DPR-58; DPR-74
Report No:	50-315/01-17(DRP); 50-316/01-17(DRP)
Licensee:	American Electric Power Company
Facility:	D.C. Cook Nuclear Power Plant, Units 1 and 2
Location:	1 Cook Place Bridgman, MI 49106
Dates:	August 30, 2001 through May 17, 2002
Inspectors:	B. Bartlett, Senior Resident Inspector S. Burgess, Senior Risk Analyst M. Cheok, Senior Reliability and Risk Analyst, NRR K. Coyne, Resident Inspector S. Jones, Senior Reactor Systems Engineer, NRR K. O'Brien, Senior Reactor Inspector P. Prescott, Senior Resident Inspector, Duane Arnold
Approved by:	Geoffrey E. Grant, Director Division of Reactor Projects

SUMMARY OF FINDINGS

IR 05000315-01-17(DRP), IR 05000316-01-17(DRP); on 08/30/2001 - 5/17/2002, Indiana Michigan Power Company, D.C. Cook Nuclear Power Plant, Units 1 and 2. Special Inspection.

This Special Inspection was conducted by NRC resident, region-based and headquarters-based inspectors and staff. The inspectors identified one preliminarily Yellow finding and one Green finding. These findings were assessed using the applicable significance determination process as a potentially safety significant finding that was preliminarily determined to be Yellow. The significance of most findings is indicated by their color (Green, White, Yellow, Red) using IMC 0609, “Significance Determination Process” (SDP). The NRC’s program for overseeing the safe operation of commercial nuclear power reactors is described at its Reactor Oversight Process website at http://www.nrc.gov/NRR/OVERSIGHT/index.html. Findings for which the SDP does not apply are indicated by “No Color” or by the severity level of the applicable violation.

A. Inspector Identified Findings

Cornerstone: Mitigating Systems

- TBD. Documented instructions for essential service water (ESW) pump discharge strainer maintenance did not contain adequate detail regarding critical parameters for basket installation. Consequently, faulty strainer basket installation practices contributed to the failure of an ESW pump discharge strainer basket and created the potential for debris to bypass the strainer and enter the ESW system. On August 29, 2001, the failed 1 East ESW pump discharge strainer, in conjunction with the ESW system alignment with all normal and alternate diesel generator (D/G) ESW supply valves open, caused significant debris fouling of D/G heat exchangers. While operator actions prevented the debris fouling from causing a complete loss of the D/Gs ability to perform their emergency AC power safety function, the potential for a complete loss of all emergency AC power during a loss of offsite power was determined to exist. This issue is identified as **Apparent Violation (AV) 50-315/01-17-01; 50-316/01-17-01**. This finding was assessed using the applicable SDP as a potentially safety significant finding that was preliminarily determined to be of substantial safety significance. (Section 4OA3.3 and 4OA3.4)

- Green. The inspectors identified a Non-Cited Violation of Technical Specification 6.8.1 associated with operator procedural adherence deficiencies during the degraded ESW event of August 29, 2001. Specifically, the operators failed to (1) effectively monitor the control boards for changing indications, adverse trends, and abnormal indications, (2) effectively communicate receipt of an abnormal temperature alarm for the CCW heat exchanger, and (3) enter the CCW abnormal operating procedure as directed by the abnormal temperature alarm response procedure.

The inspectors determined that the failure to adequately implement procedures associated with control board monitoring, logkeeping, and annunciator response had a credible impact on safety and therefore were more than a minor concern. Specifically, these issues could reasonably result in the failure to identify and promptly correct degradation of safety related equipment and therefore impact the reliability and availability of a safety system. Because these performance deficiencies contributed to delays in identifying degradation of the ESW and CCW mitigating systems, the inspectors determined that these human performance weaknesses were associated with the mitigating systems cornerstone. Although this issue adversely impacted the licensee's response to the August 29, 2001 event, none of the performance deficiencies directly resulted in the actual loss of safety system function or the loss of a single safety system train for greater than its TS allowed outage time. Consequently, the inspectors concluded that this issue was of very low safety significance (Green). (Section 4OA4)

Report Details

Summary of Plant Event

On the evening of August 29, 2001, the plant experienced problems with Essential Service Water (ESW) system performance on both Units, which subsequently resulted in an unplanned shutdown of Unit 2. Unit 1 was already shutdown and in Mode 5 (Cold Shutdown) to support circulating water system repairs. At 10:55 p.m. on August 29, 2001, plant staff noted abnormally low ESW flow to both Unit 2 Emergency Diesel Generators (D/Gs) during a Technical Specification (TS) surveillance test. The licensee entered TS 3.0.3 after the plant staff determined that both D/Gs were inoperable due to debris buildup.

At 11:47 p.m. on August 29, 2001, the licensee exited TS 3.0.3 after ESW flow for the D/Gs increased after the control room operators cycled the ESW supply valves to the D/Gs.
At 2:15 a.m. on August 30, 2001, control room operators observed abnormally low ESW flow to the Unit 2 West Component Cooling Water (CCW) Heat exchanger and declared the Unit 2 West CCW train inoperable. The operators cycled the Unit 2 West CCW heat exchanger ESW inlet and outlet valves to improve ESW flow; however, ESW flow remained below normal values. Because the degraded ESW flow condition was not fully understood, the licensee subsequently shut down Unit 2.

Subsequent NRC engineering evaluations of the conditions present on August 29, 2001, indicated that the presence of similar conditions during a single or dual unit loss of offsite power event could potentially result in a loss of all onsite emergency alternating current power.

1. REACTOR SAFETY

Cornerstones: Initiating Events, Mitigating Systems, Barrier Integrity

1R04 Equipment Alignment (71111.04)

a. Inspection Scope

The inspectors performed complete safety system walkdowns of the following risk-significant system:

Mitigating Systems Cornerstone

- Unit 1 ESW System
- Unit 2 ESW System

The inspectors selected this system based on its degraded performance and its risk significance relative to the mitigating systems cornerstone. The inspectors reviewed operating procedures, TS requirements, Administrative Technical Requirements (ATRs), and system diagrams. In addition, the inspectors assessed the impact of ongoing work activities on redundant trains of equipment in order to identify conditions that could have rendered these systems incapable of performing their intended functions.

b. Findings

The inspectors assessed the condition of the ESW system, the adequacy of the licensee's root cause evaluation, and the effectiveness of corrective actions during this complete safety system walkdown. Findings relative to the performance of this inspection module are discussed in Section 4OA3, "Event Followup."

1R07 Heat Sink Performance (71111.07)

a. Inspection Scope

The inspectors observed or reviewed portions of the following heat exchanger inspections:

- Unit 1 CCW heat exchangers, containment spray (CTS) system heat exchangers, D/G heat exchangers, north control room air conditioning (CRAC) heat exchangers and the auxiliary feedwater (AFW) pump room coolers.

These inspections were conducted following the ESW flow degradation event on August 29, 2001. The inspectors assessed the heat exchanger condition relative to the observed flow reduction to certain ESW cooled components and the potential for common cause failure of ESW cooled components. Because ESW provided the ultimate heat sink (UHS) for the emergency core cooling system, the inspectors determined that this inspection was associated with the mitigating systems cornerstone.

b. Findings

The inspectors assessed the impact of the debris intrusion event on heat exchanger capability in order to determine the safety impact of degraded ESW system performance and the effectiveness of licensee corrective actions. Findings relative to the performance of this inspection module are discussed in Section 4OA3, "Event Followup," Subsections 4OA3.1, 4OA3.4, and 4OA3.5.

1R13 Maintenance and Emergent Work (71111.13)

a. Inspection Scope

The inspectors reviewed the risk assessment and risk management for the following risk significant maintenance activities:

Mitigating Systems Cornerstone

- Unit 1 dual ESW train outage to support forebay cleaning

The inspectors selected this maintenance activity based on ESW system degraded performance and its risk significance relative to the mitigating systems cornerstone. The inspectors reviewed the scope of maintenance work to ensure that applicable safety functions were maintained during the maintenance activity. The inspectors also reviewed TS and ATR requirements and walked down portions of redundant safety systems, to verify that risk analysis assumptions were valid and applicable requirements were met.

b. Findings

No findings of significance were identified.

1R15 Operability Evaluations (71111.15)

a. Inspection Scope

The inspectors evaluated the potential operability impact associated with the following issues:

Mitigating Systems Cornerstone

- Operability of the ESW system following pump discharge strainer failure
- Operability of the D/Gs with degraded ESW flow

The inspectors selected these issues based upon their risk significance and their importance to the special inspection. The inspectors reviewed the licensee's evaluation and supporting documentation to assess the basis and quality for the operability determination. The inspectors concluded that this inspection was associated with the Mitigating Systems cornerstone.

b. Findings

The inspectors reviewed the operability impact of the degraded ESW flow condition to determine the safety significance of the event and assess the effectiveness of the licensee's corrective actions. Findings relative to the performance of this inspection module are discussed in Section 4OA3, "Event Followup," subsections 4OA3.4 and 4OA3.5.

1R19 Post Maintenance Testing (71111.19)

a. Inspection Scope

The inspectors reviewed the post maintenance testing requirements associated with the following scheduled maintenance activity:

Mitigating Systems Cornerstone

- Unit 1 CD D/G heat exchanger inspection

The inspectors reviewed post maintenance testing acceptance criteria specified in the applicable corrective maintenance work orders. The inspectors verified that the activities and acceptance criteria were appropriate for the scope of work performed. Documented data was reviewed to verify that the testing was complete and that the equipment was able to perform the intended safety functions.

b. Findings

No findings of significance were identified.

4. OTHER ACTIVITIES (OA)

4OA3 Event Followup (93812)

.1 Sequence of Events for Degraded ESW System Flow

a. Inspection Scope

The inspectors reviewed documentation and conducted interviews to determine the sequence of events that resulted in degraded ESW flows to safety related equipment. Additionally, the inspectors reviewed licensee actions during and immediately following the degraded ESW event.

b. Findings

Based on a review of control room logs, operator statements, and plant process computer data and instrumentation, the inspectors developed a sequence of events for the degraded ESW flow event. The sequence of events covers the time period from July 2001 through September 2001.

Date	Time	Event Description
July 1-2		Unit 1 and Unit 2 were operating in Mode 1 (Power Operation) while the licensee performed biocide treatment of the circulating water system for zebra mussel control. Unit 1 Circulating Water (CW) pump 13 reverse rotated following stoppage to support biocide treatment. The licensee determined that the CW pump 13 discharge valve (1-WMO-13) was partially open and could not be fully shut, resulting in backflow through the pump. In order to stop the reverse rotation of CW pump 13 and allow restart of the pump, the licensee took the Unit 1 main turbine offline and removed the CW system from service . Following restart of CW pump 13, Unit 1 was returned to full power.
August 27		Unit 1 was shut down to support repairs to CW system valve 1-WMO-13. Unit 2 continued to operate at full power.
August 29	~6:30 a.m.	Prior to the degraded ESW flow event, all ESW unit cross tie valves were open and the normal and alternate ESW supply valves to each D/G were open. Initial ESW flows to the diesel generators were approximately: 1 AB D/G= 920 gpm 1 CD D/G= 933 gpm 2 AB D/G= 860 gpm 2 CD D/G= 884 gpm

Date	Time	Event Description
August 29	11:06 a.m.	The Unit 1 West ESW pump was started to support Unit 1 cooldown to Mode 5 (Cold Shutdown). The ESW system was aligned in the following configuration: • Unit 1 West and Unit 2 East ESW pumps supplied their common ESW header with associated unit cross-tie valves open • Unit 1 East ESW pump supplied the Unit 1 East and Unit 2 West ESW common header with associated unit cross-tie valves open. The Unit 2 West pump was aligned for standby operation. • The normal and alternate ESW supply valves to all D/Gs were open
August 29	11:26 a.m.	Unit 1 commenced cooldown using Residual Heat Removal (RHR) system to Mode 5. This cooldown approximately doubled ESW flow rates in Unit 1.
August 29	1:14 p.m. - 1:36 p.m.	Unit 1 CW pumps 11, 12 and 13 were stopped in succession. Circulating water pump 13 was stopped last to minimize the potential for backflow through the pump due to the degraded condition of valve 1-WMO-13.
August 29	~3:00 p.m.	Unit 1 cooldown completed and ESW flow rates in Unit 1 decreased. Although the operators did not identify any abnormal ESW system conditions during the cooldown, ESW flows to each of the D/G indicate degradation: 1 AB D/G= 674 gpm 1 CD D/G= 791 gpm 2 AB D/G= 760 gpm 2 CD D/G= 744 gpm
August 29	7:00 p.m.	Unit 2 commenced surveillance testing of the Unit 2 East ESW system in accordance with Procedure 02 OHP 4030.STP.022E. The cross-tie valve between the Unit 1 West and the Unit 2 East ESW headers was shut in accordance with the procedure.

Date	Time	Event Description
August 29	~7:15 p.m.	The ESW flows to the Unit 1 AB and the Unit 2 CD D/G decreased below the UFSAR Table 9.8-5 minimum required flowrate of 540 gpm. Flows to each D/G were: 1 AB D/G= 400 gpm 1 CD D/G= 575 gpm 2 AB D/G= 618 gpm 2 CD D/G= 532 gpm
August 29	~8:00 p.m.	Both Unit 2 D/G ESW flowrates decreased below UFSAR Table 9.8-5 minimum required flowrate. Flows to each D/G were: 1 AB D/G= 265 gpm 1 CD D/G= 447 gpm 2 AB D/G= 538 gpm 2 CD D/G= 475 gpm
August 29	~10:30 p.m.	The Unit 1 East CCW heat exchanger outlet temperature exceeded the alarm setpoint of 95°F. The reactor operator experienced difficulty in increasing ESW flow to the affected heat exchanger; consequently, the outlet temperature remained above the 95°F alarm setpoint until approximately 2:30 a.m. on August 30, 2001. The reactor operator failed to log receipt of the high temperature alarm in the control room log, did not enter the abnormal CCW operating procedure as directed by the associated annunciator response procedure, and failed to adequately communicate the difficulty in controlling CCW outlet temperature to the operations shift crew. Flows to each D/G were less than 40 percent of flow rates prior to the event: 1 AB D/G = 96 gpm* 1 CD D/G = 360 gpm** 2 AB D/G = 363 gpm 2 CD D/G = 256 gpm * The Plant Process Computer recorded the 1AB D/G flow rate as "BAD DATA". A flow rate of 96 gpm was recorded prior to the "BAD DATA" points.

Date	Time	Event Description
		** The ESW flow rate for the 1 CD D/G remained essentially constant for the remainder of the event until the operators cycled system valves to clear the debris blockage at approximately 12:40 a.m..
August 29	10:55 p.m.	While performing the Unit 2 East ESW system surveillance test procedure, the control room operators noted that ESW flow to the 2 AB and 2 CD D/Gs were less than the surveillance test acceptance criteria of 590 gpm. Unit 2 entered TS 3.0.3 due to two inoperable D/Gs. It was later determined that the limiting condition for operation of TS 3.8.1.1.e should have been entered rather than TS 3.0.3. Unit 1 was informed of the low ESW flow condition in Unit 2. Unit 1 also identified low ESW flow to the 1 AB and 1 CD D/G. Unit 1 entered TS 3.8.1.2 for two inoperable diesel generators while in Mode 5.
August 29	11:47 p.m.	The Unit 2 AB D/G was declared operable following cycling of the remotely operated ESW supply valves. Unit 2 AB D/G ESW flow improved to approximately 800 gpm. Unit 2 exited TS 3.0.3 but entered TS 3.8.1.1 for one inoperable D/G.
August 29	11:50 p.m.	The Unit 2 CD D/G declared operable following cycling of the remotely operated ESW supply valves. Unit 2 CD D/G ESW flow improved to approximately 800 gpm. Unit 2 exited TS 3.8.1.1.
August 30	12:40 a.m.	The Unit 1 CD D/G declared available but remained inoperable due to degraded ESW flow following cycling of the remotely operated ESW supply valves. ESW flow improved to 760 gpm.
August 30	1:25 a.m.	The Unit 1 AB D/G declared available but remained inoperable due to degraded ESW flow following cycling of the remotely operated ESW supply valves. ESW flow improved to 700 gpm.

Date	Time	Event Description
August 30	1:55 a.m.	Unit 2 control room operators continued performance of Unit 2 East ESW system surveillance and aligned the normally isolated Unit 2 East containment spray system (CTS) heat exchanger for flushing in accordance with 02-OHP 4030.STP.022E. At this time the source and extent of the debris intrusion had not been positively identified and the inspectors determined that this action could have transported debris into the otherwise isolated CTS heat exchanger. Because the source of debris intrusion was later determined to be the Unit 1 East ESW pump strainer (which was independent from the Unit 2 East ESW header), this action did not adversely impact the Unit 2 East CTS heat exchanger.
August 30	2:09 a.m.	The Unit 2 West ESW pump was started.
August 30	2:13 a.m.	The Unit 2 ESW unit cross-tie valve, 2-WMO-706, was shut to split the ESW systems. All four ESW pumps were running with all unit cross-tie valves closed.
August 30	2:15 a.m.	Unit 1 East ESW and CCW trains were declared inoperable (but available) due to degraded ESW flow system. Actions associated with TS 3.7.3.1 and TS 3.7.4.1 were not applicable with Unit 1 in Mode 5. Unit 2 West CCW heat exchanger flow indicated approximately 2000 gpm with outlet temperature rising slowly at 92° F. Cycling of the ESW inlet and outlet valves improved heat exchange flow to 5500 gpm. This flow rate was less than the expected value of approximately 8500 gpm. Unit 2 entered TS 3.7.3.1 for the inoperable Unit 2 West CCW loop.
August 30	2:30 a.m.	Unit 2 East CTS heat exchanger declared operable following completion of ESW surveillance testing flush.

Date	Time	Event Description
August 30	2:45 a.m.	Unit 2 control room operators started the south control room air conditioning (CRAC) unit and stopped the north CRAC for flushing during 02-OHP4030.STP.022E. At this time the source and extent of the debris intrusion had not been positively identified and the inspectors determined that placing the south CRAC unit into service could have allowed transport of debris into the associated heat exchanger. Because the source of debris intrusion was later determined to be the Unit 1 East ESW pump strainer (which was isolated from Unit 2 by closure of 2-WMO-706), this action did not adversely impact the CRAC unit.
August 30	3:45 a.m.	Unit 1 AB D/G declared operable after closing and de-energizing the alternate ESW supply remotely operated valve from the Unit 1 East ESW header. Unit 1 exited TS 3.8.1.2.
August 30	6:23 a.m.	Licensee completed 8 hour report to the NRC regarding degraded ESW flow to the D/Gs (Event Number 38249).
August 30	7:55 a.m.	Unit 2 commenced 15 percent per hour power reduction for reactor shutdown.
August 30	1:36 p.m.	Unit 2 entered Mode 2 (Reactor Startup).
August 30	1:47 p.m.	Unit 2 entered Mode 3 (Hot Standby).
August 31	4:15 a.m.	Unit 1 East motor driven auxiliary feedwater pump (MDAFWP) inoperable due to low ESW flow to its room cooler.
August 31	6:10 a.m.	Unit 1 East MDAFWP declared operable after ESW flow to room cooler restored.
September 3	12:28 p.m.	Unit 2 entered Mode 5 and exited TS 3.7.3.1.

Results of Essential Service Water Inspections

Following shutdown of Unit 2, the licensee performed inspections on the ESW system to determine the cause and extent of condition of degraded ESW system performance. The results of significant ESW system inspections conducted after implementation of the licensee's immediate corrective actions following the event are summarized below:

Component	Inspection Results
Unit 1 East ESW pump discharge strainer	Deformation of the strainer basket and resultant bypass flowpath around the basket was identified. Additionally, the basket support bracket was deformed.
Unit 1 East CCW Heat Exchanger	Inspections identified the following: • 213 tubes were obstructed with debris (approximately 10 percent tube blockage). All tubes were cleaned using a hand brush. • Approximately 1.5 cubic feet of debris found in the interpass region and about one half cubic foot of debris found in the inlet plenum. • Debris measuring greater than 1/8 inch (the ESW strainer mesh size) was identified in the heat exchanger. In general, the debris consisted of zebra mussel shells and sand. Note: The CCW heat exchanger is a two pass shell and tube heat exchanger with ESW flowing through the tube side.
Unit 1 West CCW Heat Exchanger	Inspections identified the following: • 33 tubes blocked with silt and debris (approximately 1.5 percent tube blockage) • Minimal amounts of shells and debris Note: 85 additional tubes in the Unit 1 West CCW heat exchanger were mechanically blocked during previous maintenance activities.
Unit 1 East CTS Heat Exchanger	Inspection identified the following: • Very light silting, less than 1/4 inch thick in the lower shell area. No shells were found. Note: The CTS heat exchanger is a shell and U-tube heat exchanger with ESW flowing on the shell side.
Unit 1 AB D/G Heat Exchangers	Inspection identified minimal amounts of debris and no tube blockage.

Component	Inspection Results
Unit 1 CD D/G Heat Exchangers	Inspection of the 1 CD D/G heat exchangers identified the following: • Lube oil cooler had 14 blocked tubes with debris and 7 partially blocked tubes (approximately 10 percent of the heat exchanger tubes had some blockage and were degraded). All tubes were cleaned. • The jacket water heat exchanger had 14 tubes blocked with debris (approximately 6 percent total had some blockage and were degraded). Two tubes remained blocked after cleaning.
Unit 1 North CRAC	Inspection of the CRAC unit identified minimal debris and no blocked tubes.
Unit 1 East MDAFWP Room Cooler	Inspection of room cooler identified 18 pre-cooler tubes fully blocked with debris and 18 pre-cooler tubes partially blocked with debris (approximately 27 percent of the pre-cooler tubes had some blockage and were degraded). The associated job order stated that the pre-cooler section was "full of dirt, zebra mussels, and a steel ball."
Unit 1 West MDAFWP Room Cooler	Inspections identified 1 pre-cooler tube of 132 total tubes blocked with a small amount of sand and mussel shell debris.
Unit 1 East Turbine Driven Auxiliary Feedwater Pump (TDAFWP) Room Cooler	Approximately one pound of debris was removed from the room cooler during flushing activities. Inspections identified that 7 of 48 pre-cooler tubes were blocked with sand, silt and/or zebra mussel shells.
Unit 1 West TDAFWP Room Cooler	10 of 48 pre-cooler tubes were blocked with zebra mussel shells and sand.
Unit 2 West CCW Heat Exchanger	Inspections identified less than 24 tubes blocked with weed-like growth, tubercles, and zebra mussel shells (approximately 1 percent tube blockage). Because this inspection was performed approximately 4 weeks after the event, normal system flow through the heat exchanger could have facilitated cleanup of debris.

Component	Inspection Results
Unit 2 West CTS Heat Exchanger	This heat exchanger was not inspected immediately following the event, but was inspected during the January 2002 Unit 2 refueling outage. Results of inspections performed on February 4, 2002 identified minor amounts of debris, including sand and shell fragments, on top of tube sheet (4 - 6 cups total).
Unit 2 AB D/G Heat Exchangers	Inspection identified: • 6 partially blocked tubes in the lube oil heat exchanger (less than 3 percent tube blockage). • 2 partially blocked tubes in the jacket water heat exchanger (less than 1 percent tube blockage). All tubes were cleaned.
Unit 2 CD D/G Heat Exchangers	Inspection identified: • 2 blocked tubes in the lube oil heat exchanger (less than 1 percent tube blockage). • 3 blocked tubes in the jacket water heat exchanger (less than 2 percent tube blockage).
Unit 2 North CRAC Heat Exchanger	Inspection identified no blocked tubes.
Unit 2 West MDAFWP Room Cooler	Inspection of room cooler identified 5 pre-cooler tubes fully blocked with debris and 11 pre-cooler tubes blocked at the inlet with debris (approximately 12 percent of the pre-cooler tubes had some blockage and were degraded)
Unit 2 West TDAFWP Room Cooler	Inspections identified 18 of 48 pre-cooler tubes to be blocked with zebra mussel shells and sand. Condenser coil for refrigeration unit also appeared to be partially blocked.

.2 Adequacy of Licensee Response to ESW Low Flow Condition Including Emergency Plan Implementation

a. Inspection Scope

The inspectors reviewed the licensee's immediate corrective actions in response to the ESW low flow condition and the corrective actions to restore the ESW trains to their design and licensing basis.

b. <u>Findings</u>

<u>Initial Identification</u>

The inspectors determined that control board indication of the trend of the degrading ESW flow could have been identified by the operators at least 3 hours prior to the initial identification of the degraded flow. The delay in the identification of the low flow by the operators was due, in part, to the failure of the operators to perform hourly control board walkdowns recommended by procedure. The inspectors determined that operator practice was to no longer perform the recommended walkdowns. However, the delay in the identification did not result in a significant impact on event recovery actions.

<u>Initial Response</u>

The inspectors determined that the operators' initial response to the event was adequate to ensure that reactor safety was maintained. The operators ensured that the reactor coolant system (RCS) temperature was being maintained within the required parameters and the ability to cool the RCS was maintained. In addition, the Unit 2 operators promptly informed the Unit 1 control room operators upon the identification of the degraded ESW flow.

The inspectors determined that the Unit 2 Unit Supervisor (US) inappropriately entered TS 3.0.3 upon declaring both Unit 2 D/Gs inoperable. Inoperability of both D/Gs required an entry into Limiting Condition of Operation (LCO) TS 3.8.1.1.e, which required that two offsite power source circuits be demonstrated operable within 1 hour. Although the wrong TS LCO was entered, the licensee performed the off-site power operability verifications and complied with the time limits specified in TS 3.8.1.1.e.

The licensee identified that the Unit 1 US failed to enter TS 3.1.2.3, for inoperable boration flow paths, when the D/Gs were inoperable. The action statement required that no core alterations be performed. Since no core alterations were in progress, the TS LCO was met.

The operating crews correctly diagnosed the low ESW flow and were able to improve ESW flow to the D/Gs by repeatedly cycling ESW supply and return flow valves. Approximately 3 hours after initially identifying the degraded ESW condition, the operators closed the ESW unit cross-tie valves so that each unit was receiving ESW flow only from its associated ESW pumps. The licensee did not identify that ESW flows to the Unit 1 East and Unit 2 West CCW heat exchangers were degraded until after the ESW cross tie valves were shut. The inspectors determined that communication inadequacies contributed to the 3 hour delay in the identification of the low ESW flows to the CCW heat exchangers. For example, the Unit 1 high CCW temperature condition was not adequately communicated to the Senior Reactor Operators, and the Unit 2 operators were not promptly informed of the high Unit 1 CCW temperature.

<u>Emergency Classifications</u>

The licensee did not declare an emergency classification for this event. The operations Shift Manager and Operations Director considered declaring an emergency classification at approximately 4:30 a.m. following the initial indications of degraded ESW flow. The licensee's emergency plan and implementing procedures have no specific Emergency Condition Categories (ECC), Initiating Condition (IC), or Emergency Action Level (EAL) that would address significantly reduced ESW flow. Emergency Condition Category S-5, "Loss of Systems Needed to Achieve/Maintain Hot Shutdown," was most appropriate; however, the entry conditions required a complete loss of the function with entry into EOP FR-H1, "Response to Loss of Secondary Heat Sink," or FR-C1, "Response to Inadequate Core Cooling." The ECC for Site Emergency Coordinator (SEC) Judgement did give a threshold value of "In the judgement of the SEC: Conditions indicate that plant safety systems may be degraded, and increased monitoring of plant functions is needed." Under the licensee's procedures this would result in the declaration of an Unusual Event. The inspectors concluded that a declaration of an Unusual Event should have been made due to the degradation of multiple trains of safety-related equipment on each unit. However, the failure to declare an Unusual Event was determined to not constitute a violation of regulatory requirements.

<u>Subsequent Response</u>

The licensee was conducting an ESW system surveillance test during the event. While the performance of the surveillance aided the operators in the identification of the degraded ESW flow, continuation of the surveillance test procedure could have exacerbated the heat exchanger fouling. For example, the CTS heat exchanger and South CRAC heat exchanger isolation valves were opened per the surveillance procedure, which could have introduced debris into these otherwise clean heat exchangers. However, subsequent analysis of the heat exchangers by the licensee determined that heat exchanger performance was not affected.

.3 <u>Determination of Root Cause for ESW Low Flow Condition</u>

a. <u>Inspection Scope</u>

The inspectors reviewed the as-found condition of components of the ESW system including the Unit 1 East ESW pump discharge strainer. The inspectors' review included the observation of heat exchanger end bell removal, pump discharge strainer inspections, and flushing activities. The inspectors also interviewed individuals involved in these activities and reviewed the licensee's apparent root cause for the ESW low flow condition.

b. <u>Findings</u>

The licensee evaluated the root cause of the degraded ESW flow event and concluded that the root cause of the event was the following:

> "The root cause for this event was that a strainer basket was installed incorrectly during basket replacement activities that occurred in the 1989 time frame. The failure to adjust the height of the basket to align the top edge of the basket with the lip of the strainer body allowed the basket to be placed in compression when the » 700 lb. strainer lid was reinstalled. The compressive force exerted by the lid

caused the basket mesh to tear in the area of the weld on the basket's vertical support bracket and was the initiating event for the resultant damage and eventual failure of the basket."

The licensee inspected all eight ESW strainer baskets and identified that the Unit 1 East ESW pump discharge strainer east basket had a weld failure on the height adjustment bracket that allowed the bracket to bend and drop the basket by approximately 3 inches. This deformation allowed a bypass of debris greater than the 1/8" strainer mesh size. The passage of debris greater than the normal strainer mesh size resulted in fouling of heat exchangers in the ESW system and the consequent flow degradation experienced on August 29, 2001. The licensee reviewed past maintenance performed on the failed strainer and concluded that the strainer was initially damaged during a basket replacement that occurred in 1989.

The inspectors assessed the licensee's root cause methodology and conclusions and determined that the licensee adequately identified the root cause of the degraded ESW flow event. The inspectors concluded that the licensee's approach was reasonable, and adequately addressed contributing causes to the event. The inspectors reviewed records from the Unit 1 East ESW pump discharge strainer replacement conducted in 1989 and concluded that the strainer installation instructions used in 1989 were inadequate. The instructions provided for replacement of the strainer baskets, contained in Job Order 723483, lacked sufficient detail to ensure that critical parameters associated with strainer installation were maintained. Specifically, the JO 723483 instructions did not contain sufficient detail regarding adjustment of strainer basket height within the strainer housing or verification that the installation prevented basket bypass paths greater than 1/8" in size. The inspectors determined that the failure to provide adequate instructions for ESW strainer basket maintenance constituted a violation of regulatory requirements.

10 CFR 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," stated, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances. The inspectors determined that the documented instructions for installation of the ESW strainer baskets, an activity affecting quality, were not of a type appropriate to the circumstances. Specifically, the Unit 1 East ESW pump discharge strainer east basket, was installed on April 18, 1989 in accordance with Job Order 723483. The strainer basket installation instructions referenced by Job Order 723483 did not contain adequate detail associated with the verification of critical parameters affecting strainer basket alignment during installation. The failure to adequately align the ESW strainer basket within the strainer housing would allow debris greater than 1/8" in size to bypass the strainer or allow damage to the basket vertical support bracket during strainer cover re-installation. This issue is identified as **Apparent Violation (AV) 50-315/01-17-01; 50-316/01-17-01**. This finding was assessed using the applicable SDP as a potentially safety significant finding that was preliminarily determined to be Yellow. The details of the SDP evaluation are contained in Section 4OA3.4 below.

.4 <u>Specific and Generic Impacts of ESW Debris Intrusion</u>

a. Inspection Scope

Subsequent to the August 2001 debris intrusion event, the licensee conducted engineering and probabilistic evaluations that assessed the specific and generic impacts of the failed IE ESW system strainer on ESW supported systems. The licensee described their engineering evaluation in Technical Report NTS-2002-002-REP, "ESW Debris Intrusion Event Evaluation," Revision 0, completed in January 2002. The licensee described their probabilistic evaluation in Technical Report NTS-2002-010-REP, "Debris Intrusion Into the Essential Service Water System - Probabilistic Evaluation," Revision 0, completed in April 2002. The inspectors reviewed the evaluations, assessed their fidelity to the August 2001 data, and used the evaluations and other design information to determine the capability of ESW supported safety-related systems to perform their functions during the August 2001 event and applicable design basis events.

b. Findings

b.1 Engineering Evaluation

The licensee's engineering evaluation examined the August 2001 debris intrusion event and the potential consequences of a similar debris intrusion following a single unit loss of offsite power (LOOP) event. The evaluation considered debris entrainment within the intake structure and ESW system, the hydraulic characteristics of the ESW-D/G system, and the performance characteristics of the ESW-D/G heat exchangers. As a separate part of the engineering evaluation, the licensee developed a revised single unit LOOP initiating event frequency, a human performance reliability analysis of the operator's response to a similar debris intrusion event, and a plant-specific Large Early Release Frequency (LERF) analysis.

Debris Entrainment

Overall, the licensee's engineering evaluation concluded that debris intrusion events, assuming a failed 1 East ESW strainer, could not be precluded. Debris intrusion into the ESW system was expected to occur following a single unit LOOP event, a seismic event that causes a LOOP, or during a severe storm that resulted in a LOOP event. Though not explicitly stated, the engineering evaluation focused on a single unit LOOP event. A detailed review of the potential for and consequences of a dual unit LOOP event were not evaluated. During discussions with the inspectors, the plant staff indicated their belief that a single unit LOOP event would result in entrainment of the largest amount of debris.

The licensee's engineering evaluation determined that low vertical flow velocities were required to entrain debris in the intake structure, on the order of 0.15 feet/second for sand and 0.30 feet/second for shells. Once entrained, the evaluation calculated that the debris could take up to an hour to re-settle to the intake structure floor depending on the hydrofoil effect associated with the shells. The plant staff assumed that intake structure cross flows, created during the August 2001 event and expected to exist following a single unit LOOP event, would entrain the greatest amount of debris. However, the licensee's engineering evaluation did not assess the potential for intake structure cross flows or intake structure debris to be entrained by flow perturbations following a dual unit LOOP.

Once debris was ingested into the ESW system, the engineering evaluation determined that flow rates on the order of 140 gallons/minute were necessary to maintain the debris suspended within the flow of a horizontal section of 6 inch diameter ESW supply piping to the D/G heat exchangers. Based upon calculations , flow rates of 200 and 400 gallons/minute were determined to be needed to maintain sand and shells, respectively, suspended in the flow of a vertical section of 6 inch diameter pipe. Though the engineering evaluation recognized that lower flow rates could maintain shells within the flow stream if shell hydrofoil effects were considered.

The inspectors reviewed the licensee’s records of circulating and service water intake structure inspections and determined the intake structure often contained debris, e.g. sand, silt, and mussel shells. The debris was typically located in the quiescent flow regions of the intake structure, including directly in front of the ESW pump bays. Recent and past operating experience indicated that debris, present in the intake structure quiescent flow areas, could be entrained in the circulating and essential service water flows as a result of intake structure flow disturbances. Changes in the circulating and essential service water system flow rates, severe weather, and LOOP events were all conditions capable of causing intake structure flow disturbances.

The inspectors reviewed the August 2001 circulating and essential service water system operating information and determined that significant changes in the intake structure flow patterns were the most likely cause for debris entrainment. The changed flow patterns entrained debris, previously located in quiescent flow areas, and transported the debris to the 1 East ESW system pump suction area. This effect was consistent with the staggered shutdown of the Unit 1 circulating water pumps, which limited perturbations of the intake structure water inventory; the continued operation of the Unit 2 circulating water pumps, which caused a significant change in the intake structure water flow patterns; and the observed gradual degradation of ESW system flow to the D/Gs.

The inspectors also determined that a larger short-term ingestion of debris would likely occur as a consequence of either a single unit LOOP, dual unit LOOP, or severe weather event. These events would be expected to cause both changes to the intake structure flow patterns, as observed with the August 2001 event, and significant intake structure water perturbations, due to an approximate 10 to 12 foot increase in the intake structure water level following a dual unit LOOP. As a result, the inspectors concluded that a dual unit LOOP event would likely result in a significantly larger ingestion of debris over a shorter period of time than that created by the circulating water system cross-flow associated with the August 2001 event or which would likely occur following a single unit LOOP.

<u>ESW-D/G Hydraulic Characteristics</u>

The licensee’s engineering evaluation determined an approximate percentage of blocked ESW-D/G heat exchanger tubes that would be necessary to cause the August 2001 observed degraded flow conditions. Initial results indicated that plugging in excess of 90% of the heat exchanger tubes would be necessary to cause the observed flows. Because of the ease with which the operators were able to restore flow through some of the heat exchangers, the licensee rejected the engineering evaluation initial conclusion that a high percentage of tubes were blocked.

As an alternate hypothesis, the licensee conjectured that the August 2001 degraded flow conditions were caused by a combination of blocked tubes and the buildup of a porous debris pile on the heat exchanger tube sheets. The debris pile was assumed to be composed of a combination of shells, sand, and silt. The majority of the buildup was assumed to occur at the ESW-D/G lube oil heat exchanger tubesheet for the August 2001 event. While the presence of a debris pile would significantly decrease ESW-D/G flow rates, the licensee assumed that only a limited number of heat exchanger tubes would not be available for heat transfer.

Based upon computer logs of ESW-D/G flow data from the August 2001 event, the licensee’s engineering evaluation concluded that the buildup of a debris pile on a heat exchanger tubesheet would: 1) be self-limiting with a minimum average ESW-D/G flow rate of 200 gallons/minute; 2) occur initially at the D/G lube oil heat exchanger inlet tubesheet; and, 3) be limited to a single ESW-D/G heat exchanger tubesheet location during a LOOP event. The evaluation supported the minimum average ESW-D/G flow rate by rejecting non-numerical computer data recorded for the 1 AB D/G and by averaging the remaining lowest recorded flow values. The evaluation supported the single location debris buildup position by assuming that the debris piles were inherently unstable and could not be maintained, due to a constant loss of material, if the source of new material was lost due to a change in the ESW-D/G flow path following a LOOP.

The inspectors determined that the engineering evaluation likely overestimated the percentage of blocked tubes necessary to cause the observed August 2001 degraded flow conditions. The inspectors noted that the licensee’s evaluation did not consider several factors which would affect the blocked tube estimate including entry and exit pressure losses caused by changes in the ESW mass flow velocity and an increased flow resistance caused by the presence of a two-phase mixture down stream of the jacket water heat exchanger. The inspectors estimated the percentage of blocked tubes, which alone could have caused the observed degraded flow conditions, to be well in excess of 50% but less than the near 90% values initially calculated in the licensee’s engineering evaluation.

The inspectors performed independent flow hydraulic calculations and concluded that a relatively thin “filter bed”, on the order of 3 inches or less, of sand could have caused the observed degraded flow conditions. The filter bed was assumed to be developed from an initial layer of shell fragments and other debris on tubesheet with a subsequent buildup of a variety of particle sizes of sand, silt, and clay particles forming a filter bed of relatively low porosity. The calculation results were noted to be very sensitive to the bed composition because of the ability of the smaller particles to fill the flow paths between the larger sand particles. Based upon post August 2001 photographs of heat exchanger tubesheets, which showed some tubes still blocked by wedged shell fragments and other debris, the inspectors concluded that the observed ESW-D/G flow reduction was most likely caused by a combination of heat exchanger tube blockage and a non-uniform debris pile buildup on the heat exchanger tubesheet.

The inspectors evaluated the computer logs of ESW-D/G flow data for the August 2001 event and determined that the data did not specifically support the licensee's assumptions of a self-limiting debris buildup, with a minimum ESW-D/G flow rate of 200 gallons/minute, or a single heat exchanger tubesheet debris pile buildup location. While the computer logs of ESW-D/G flows did indicate that the 1 CD ESW-D/G flow leveled off at a degraded flow rate of 350 gallons/minute; data for the 1 AB ESW-D/G indicated a steady decreasing trend which lowered flow below the level of reliable indication. In addition, computer logs for the Unit 2 ESW-D/G flow rates indicated that both Unit 2 ESW-D/G flow rates experienced a decreasing trend with low recorded flow values of approximately 300 and 250 gallons/minute. Operator and computer logs of ESW flow data also indicated that not all debris piles were inherently unstable, a pre-condition for a self-limiting process. The logs indicated that the ESW-D/G flows appeared to drop relatively rapidly, as the blockage built up, and the ESW-component cooling water (CCW) and 1 AB D/G heat exchanger flows remained degraded, despite several attempts by the operators to clear the blockage. Combined, these data indicated that ESW system debris piles were not self-limiting or unstable in their buildup, with a minimum ESW-D/G flow rate of 200 gallons/minute.

Based upon information provided in the licensee's engineering evaluation, the inspectors concurred with the licensee's contention that a debris pile buildup was most likely to occur at the first flow restriction in the ESW-D/G flow path. However, the inspectors also noted that the first flow restriction location would change during the course of the plant's response to a LOOP event potentially resulting in multiple debris piles restricting ESW-D/G flow. Initially, the first flow restriction would be at the D/G lube oil heat exchanger tubesheet, as observed during the August 2001 event. However, once the D/Gs began to operate, the first flow restriction location would change, due to an automatic system re-alignment, to either the inlet to the D/G air after-cooler temperature control valve or to the D/G air after-cooler heat exchanger tubesheet. A debris buildup at either of these locations may be quicker to develop and may be more difficult to clear than a debris build up at the lube oil heat exchanger due to vertical piping upstream of the three-way valve and the smaller air after-cooler heat exchanger intake head volume. Additionally, the presence of distributed pressure drops, due to multiple debris piles, would also reduce the effectiveness of operator actions to flush debris from the system.

<u>ESW-D/G Cooler System Performance Characteristics</u>

The licensee's engineering evaluation considered the minimum ESW-D/G flow required to maintain D/G lube oil and jacket water coolers within maximum allowed parameters assuming variable degree and location of heat exchanger plugging, tube fouling, and design event loading. Overall, the evaluation determined that approximately 140 gallons/minute ESW-D/G flow was required to assure minimum D/G performance during a LOOP event. This calculation assumed the blockage of up to 60% of one pass of the D/G heat exchanger tubes and design fouling. Approximately 200 gallons/minute ESW-D/G flow was required to assure minimum D/G performance during a LOOP-loss of coolant accident (LOCAL). This calculation assumed the blockage of up to 50% of one pass of the heat exchanger tubes and design fouling. Calculations for both cases indicated that the minimum ESW-D/G flow required to maintain the D/G lube oil and jacket water cooler within maximum allowed parameters increased rapidly with increased tube blockage beyond the levels stated above.

The inspectors determined that the licensee's engineering evaluation did not consider several factors which would affect the calculated minimum flows necessary to support continued D/G functioning. Examples included: 1) entry and exit pressure losses caused by changes in the ESW-D/G mass flow velocity through a smaller number of heat exchanger tubes; 2) an increased ESW-D/G flow resistance caused by the presence of a two-phase mixture down stream of the jacket water heat exchanger at reduced ESW-D/G flow rates, and; 3) changes in the ESW-D/G heat transfer rates due to the presence of a debris bed which would have degraded ESW-D/G flow through the individual tubes. While the exact impact on the minimum ESW-D/G flow rate of each of these factors was not determined, the inspectors concluded that the overall level of ESW-D/G flow rate, necessary to support continued D/G functioning, was significantly less than the Updated Final Safety Analysis Report (UFSAR) value of 540 gallons/minute and may be approximated by the licensees calculations.

Single Unit LOOP Initiating Event Frequency

In conjunction with the engineering analysis, the licensee proposed that both the August 2001 event and the generic impacts of an ESW-D/G debris intrusion event should be evaluated using a revised single unit LOOP initiating frequency. Based upon recent changes to the plant switchyard, the licensee conducted a review of data from several databases (including NUREG/CR-5496 and NUREG/CR-5750) to determine a revised initiating event frequency for a single unit LOOP event at a dual unit site. In conducting the analysis, the licensee assumed that a single unit LOOP was the risk dominant event, and that a dual unit LOOP event would not result in sufficient debris entrainment in the ESW-D/G flow. Therefore, the licensee's analysis only considered single unit LOOP events at dual unit sites. The analysis eliminated all dual unit LOOP events, as well as events that the licensee determined to be not applicable to the plant. Based upon the analysis, the licensee proposed that a single unit LOOP initiating event frequency of 0.004 per year should be used to evaluate the August 2001 and a potential generic ESW-D/G debris intrusion event.

The inspectors reviewed the licensee's analysis and determined that the proposed initiating event frequency may be an underestimation for the following reasons:

- Although the licensee's analysis credited the plant-specific electrical distribution system as being unique and better than assumed in the generic cases (by eliminating events that the licensee believed could not occur at the plant), there was no similar effort done for the plant-specific electrical distribution system to determine if any plant-specific events could occur that could not occur at the other plants. Thus, only a limited scope comparison was performed. (One example would be that, although hurricane events were eliminated due to plant's location, vulnerability to events caused by ice storms were not explicitly considered.)

- The licensee included data from sites like Indian Point, Nine Mile Point and Fitzpatrick that share control of switchyard activities among differing licensees.

Data from these sites may not be appropriate for use in determining a plant-centered loss of offsite power initiating event frequency for D.C. Cook because D.C. Cook may be more vulnerable to a common cause failure or switchyard error that may result in a loss of offsite power to both units.

- The licensee's assumption that the dual unit LOOP initiator will not entrain debris into the ESW-D/G was not considered a valid assumption. Therefore, the licensee's elimination of dual unit initiators from inclusion in the overall initiating event frequency was not acceptable. The generic frequency of severe weather events, which are the most probable cause for dual unit LOOP events, was approximately 0.007 per year, about twice the licensee's estimate for the single unit initiator.

Based upon current generic estimates of a single unit LOOP initiating frequency and plant specific information provided by the licensee, the inspectors concluded that the single unit LOOP initiating frequency for the plant could be lower than the generic frequency. However, the inspectors did not consider the differences to be supported to the extent to justify a plant-specific initiating frequency one tenth the generic initiating frequency (0.004 versus 0.046). Based upon licensee provided information and engineering judgement, the inspectors used a single unit LOOP initiating frequency of 0.01 for subsequent NRC risk analyses.

Human Error Probability Analysis

The licensee performed an analysis to estimate the human error probability (HEP) associated with operator actions to recover ESW-D/G flow to the heat exchangers for a single unit and dual unit LOOP event. The HEP for a single unit event was estimated to be 0.05 for the recovery prior to the initiating event and for recovery during a single unit LOOP event. The licensee estimated the HEP for operator action to recover for a dual unit LOOP event to be either 0.13 or 1.0 depending on the time available. The HEP analyses took into account cognitive as well as execution errors. Although the licensee did not have approved procedures or training for the recovery actions credited in the analyses, the licensee concluded that credit could be taken for the actions since operators had actually performed the actions during the August 2001 ESW-D/G intrusion event.

The inspectors reviewed the analysis methodology used by the licensee and concluded that the methodology was acceptable and was applied correctly. The inspectors also determined that the licensee's assumption of credit for the operators proper implementation of the unproceduralized and untrained recovery actions was appropriate given the fact that these actions were actually carried out during the August 2001 event.

Although a level of uncertainty existed as to how much time might be available for operator action during a single unit LOOP event, the inspectors determined that the licensee's HEP estimate of 0.05 was reasonable if sufficient time was available (i.e., time from the start of a LOOP event to the time when below reliable indication of ESW-D/G flow through the heat exchanger exceeds 5 to 6 hours). The 0.05 was considered optimistic for recovery times of 2 hours or less. For a dual unit LOOP event, the inspectors determined that an HEP of 0.13 was appropriate when the operators would have approximately 1 hour to response. This is the value used for subsequent NRC risk analysis of a dual unit LOOP event. If the operators did not have sufficient time to respond, less than 1 hour, the inspectors determined that ESW-D/G flow from the opposite Unit could not be credited for valve cycling or heat exchanger flushing actions. In these cases, an HEP of 1.0 was considered appropriate.

Large Early Release Frequency

Prior to the August 2001 ESW-D/G debris intrusion event, the licensee developed a plant-specific large early release frequency (LERF) estimate. Using methodology described in NRC document NUREG/CR-6595 and figure 2-2 of the document, the licensee estimated a plant-specific LERF to CDF ratio of 0.1. During discussions with the NRC of the engineering evaluation of the August 2001 intrusion event, the licensee proposed that risk analyses of the event should use the plant-specific LERF to CDF ratio value of 0.1.

The inspectors reviewed documentation provided by the licensee to support their proposed use of a LERF to CDF ratio of 0.1. The inspectors determined that the licensee evaluation only modeled a single unit LOOP, therefore adequate time was postulated for ESW-D/G recovery and for onsite and offsite emergency response. As a result of the credit taken for these actions, a large fraction of the core damage sequences were allocated to the non-large early release category. Only approximately 16 percent of the revised core damage sequences were considered in calculating the LERF.

In the NRC's risk evaluations of the ESW-D/G debris intrusion event that lead to core damage sequences, a station blackout event was modeled. In these cases, containment hydrogen igniters were not considered available due to an absence of required power. In such scenarios, recent NRC studies (e.g., studies for the containment significance determination process and for the resolution of the generic issue for the combustible gas issue) indicated that the conditional probability of large early release given a core damage event for an ice condenser containment was approximately 0.82.

Considering that both the licensee's and the NRC's LERF values were developed using NRC guidance, though with differing assumptions, and the potential uncertainty in assessing the effectiveness of the licensee's onsite and offsite emergency response efforts, a LERF value of 0.4 was used in subsequent NRC risk analyses.

b.2 Probabilistic Evaluation

Subsequent to and in support of the licensee's engineering evaluation discussed above, the licensee performed a probabilistic evaluation of the impact of a failed ESW-D/G strainer on the plant's response following a LOOP event. The evaluation assumed a single or dual unit LOOP as the initiating event [Block 1] and identified a logical sequence of steps [Blocks 2 through 9] which could lead to D/G failure as a result of debris intrusion into the ESW-D/G flow. The licensee's probabilistic evaluation considered the likelihood of the sub-events which collectively comprised an ESW-D/G debris intrusion event. The probabilistic evaluation considered debris intrusion events following both single and dual unit LOOPs. The licensee selected subjective probabilities for each of the steps using an expert elicitation technique similar to one described in NUREG/CR-5424. The individual probabilities were then combined to determine the conditional failure probability of each sequence of steps. These results were then incorporated into the plant probabilistic risk analysis model to determine resultant increases in the core damage frequency (CDF) and large early release frequency (LERF). Results of these efforts indicated only slight increases in the CDF and LERF values, 2.8E-07 per year and 4.2E-08 per year, respectively.

The inspectors evaluated the engineering and probability information provided for each of the licensee-defined blocks. The results of the individual block evaluations were then combined into an D/G common cause failure factor. This factor was then used to modify SPAR model risk analysis results. Based upon information provided in the licensee's probabilistic evaluation, the inspectors developed a common cause failure factor of 0.14 for a single unit LOOP event and 0.024 for a dual unit LOOP event. Using the NRC's SPAR model and the assumptions stated below, the inspectors and NRC Headquarter's staff determined that the delta CDF and LERF values for the issue were 1.8E-05 per year and 7.1E-06 per year, respectively.

A summary of the inspectors' assessment of the licensee's overall evaluation methodology and the individual block results were as follows.

<u>Overall Methodology</u>

The inspectors reviewed the overall evaluation methodology and NUREG/CR 5424. The inspectors determined that the overall methodology was reasonable and that the identified steps in the sequence of events were consistent with the course of events that would be necessary for a debris intrusion event to occur. However, the inspectors also determined that the subjective probability scale developed by the licensee using the referenced NUREG/CR 5424 was not consistent with the information provided in the NUREG/CR 5424. Instead of the relatively continuous scale proposed and used in the NUREG/CR 5424, the licensee's scale tended to stratify event probabilities near 1.0 and 0. As a result, the licensee's under-estimation of one or two steps in a sequence of steps would tend to significantly decrease the overall probability for a sequence. Several sequences appeared to have been affected by the licensee's use of their subjective probability scale, as described below.

<u>Block 1: Loss of Offsite Power</u>

The licensee's analysis assumed the LOOP event, either single or dual unit, as a given. Therefore, this probability was set equal to 1.0.

The inspectors used a similar approach to developing their common cause factor. Therefore, the inspectors also considered the probability for this Block to be 1.0.

<u>Block 2: Suspended Debris is Sufficient to Challenge the ESW-D/G System</u>

The licensee evaluated this Block as the combined probability that flows coming into the intake structure contained a sufficient amount of debris with the probability that changes to the intake structure flow caused the entrainment of a sufficient amount of debris to challenge the ESW-D/G system. Using a combination of plant data and industry information, the licensee developed probabilities for each of several sub-blocks identified necessary to construct the overall probability. The resultant Block single unit and dual unit LOOP probabilities were 0.1033 and 0.0189, respectively.

The inspectors reviewed the sub-blocks used to construct the overall probability for Block 2 and concurred with the licensee's general characterization of the sub-blocks. However, the inspectors did not agree with the licensee's assumptions that: 1) debris generation, as a result of wind and wave action, was independent of the severe weather initiating event frequency; 2) debris, brought into the intake structure and of concern for challenging the ESW-D/G system, would be very unlikely (P=0.05) to bypass the traveling screens; 3) intake structure water vertical velocities, developed during an inrush of water following a dual unit LOOP, would be unlikely (P=0.1) to entrain debris resident between the traveling screens and the ESW pumps, and; 4) debris, present between the traveling screens and the ESW pumps, would be unlikely (P=0.1) to be of sufficient quantities to challenge the ESW-D/G system.

Since Items 1 and 2 above did not contribute significantly to the final probability for Block 2, the inspectors did not further evaluate these items.

Of the remaining items, the inspectors determined that engineering judgement accounted for differences in the probabilities assumed for Items 3 and 4. Specifically, for Item 3, the inspectors assumed that the inrush of approximately 1.6 million gallons/minute of water, expected to occur immediately after a dual unit LOOP event, would provide sufficient energy and flow velocities to cause local eddies and vertical water velocities sufficient to entrain debris located in the previous quiescent flow areas of the intake structure (P=1.0). In their analysis, the licensee assumed that the intake structure vertical water velocities would be limited to the bulk rate of rise of the intake structure water level, a level which may not support entrainment of significant quantities of debris. For Item 4, the inspectors assumed that debris was present in sufficient quantities, between the traveling screens and the ESW pump intakes, to challenge the ESW system approximately one half of the time each year (P=0.5). This value was considered a conservative estimate based upon the licensee's practice of cleaning ½ of the intake structure during unit refueling outages, on an approximate once every 9 month time frame.

<u>Block 3: Suspended Debris Reaches the ESW Pump Suction</u>

The licensee assumed that, if sufficient debris was suspended in the intake structure water, it was nearly certain that at least some of the debris would reach the Unit 1 East ESW pump suction and be ingested. Therefore, the licensee assigned a probability of 0.99 to this block.

The inspectors used a similar approach to developing their common cause factor. Therefore, the inspectors considered the probability for this Block to be 1.0.

<u>Block 4: Failed Strainer Basket is in Service During a LOOP Event</u>

The licensee evaluated this block as a combination of probabilities that the failed 1 East ESW strainer was in service at the start of a LOOP event or was brought into service during the LOOP event as a result of an automatic timer or due to sensed high differential pressure across the undamaged duplex strainer. Results of the licensee's evaluation indicated a single unit LOOP probability of 1.0 and a dual unit LOOP probability of 0.77.

The inspectors reviewed the sub-blocks used to construct the overall probability for Block 4 and concurred with the licensee's general characterization of the sub-blocks and the resultant probabilities.

Blocks 5 and 6: ESW Flow is High and Ingested Debris Bypasses the 1 East ESW Strainer

The licensee's analysis proposed that all sequences, which could result in the D/Gs being affected by ingested debris, include two steps which were dependent upon the presence of high ESW flow rates. High ESW flow rates were characterized as a flow rate greater than 5000 gallons/minute. The relative probability of having high ESW flow rates was determined based upon ESW system heat loads throughout the year. Assuming the presence of high ESW flow rates, the analysis concluded that debris entering the ESW strainer housings would have a high likelihood of being able to reach the 1 East ESW pump strainer defect and pass through into the ESW-D/G flow stream. Without the presence of high ESW flow rates, ingested debris was assumed to be retained in the strainer housing, probability of high flow and strainer bypass equal to 0.14.

Based upon the information provided in the evaluation, the inspectors could not independently confirm the basis for the proposed high ESW flow rate steps. Specifically, the inspectors could not validate the licensee's technical basis for concluding that ESW flow rates of greater than 5000 gallons/minute were necessary to transport debris within the ESW strainer housing from the inlet point up to the strainer defect location, a change in elevation of approximately 2 feet. In addition, the inspectors noted that evaluation did not consider the presence of a second bypass path or the consequences of a buildup of debris within the housing during post-LOOP periods with low ESW flow rate. As a result, the inspectors concluded that debris which entered the ESW pump suction was transported into the ESW-D/G flow stream, probability of strainer bypass for all flow conditions equals 1.0.

Block 7: Ingested Debris Reaches the Unit 2 D/G Heat Exchangers

The licensee's analysis proposed that debris which entered the ESW-D/G flow stream had a certain probability of reaching the Unit 2 D/G heat exchangers based, in part, on the system pre-LOOP ESW system alignment and ESW system demand. Because the ESW-D/G system included both train and Unit cross ties, the 1 East ESW pump, with its faulted strainer, had the potential to feed any and both ESW-D/G trains for both Units. This was the situation during the August 2001 event. However, the licensee's analysis appropriately highlighted that during a LOOP condition, all four ESW pumps would be in operation. This condition would change the post-LOOP ESW system flow dynamics and result in a significantly decreased cross flow, and debris transport, through the Unit cross tie. The licensee’s analysis also proposed that only one of the four normal ESW system pre-LOOP alignments would result in sufficient Unit cross flow to carry debris from Unit 1 to Unit 2.

The inspectors reviewed the licensee’s basis for the proposed probability and concurred that the post-LOOP starting of all four ESW pumps would change the system flow characteristics and the relative likelihood that debris, ingested through the 1 East ESW pump, would reach the Unit 2 D/Gs. However, the inspectors did not concur with the licensee’s conjecture that a minimum 2500 gallons/minute of Unit 1 to Unit 2 cross flow was necessary to transport debris between the Units during a post-LOOP alignment. Instead, the inspectors concluded that debris could be transported from Unit 1 to Unit 2, at varying rates, even with very low cross flow rates, due to the relatively short, 15 foot, cross tie connection distances. Lower post-LOOP debris transport rates between the Units would provide the operators with another opportunity to recognize and correct or halt ESW-D/G plugging of the Unit 2 D/Gs. As a result, the inspectors concluded that the proposed step probability of 0.25 was appropriate.

Block 8: ESW Flow Degradation Impacts D/G Function

In this block, the licensee estimated the probability that debris, having reached the D/G coolers, would impact the D/G function. Through a review of information gathered from the August 2001 event, the licensee concluded that only 1 of the 4 D/Gs were actually impacted by the debris intrusion. As a result, the licensee assumed a per D/G impact probability of 0.25. In their development of the event trees for these sequences, the licensee further treated this failure probability as an independent random variable. This approach resulted in an overall failure probability for the 4 D/G system of approximately 0.004.

Based upon an independent review of operator and computer logs from the August 2001 event, the inspectors determined that 3 D/Gs were impacted by the debris. Specifically, the 1AB D/G experienced less than reliable flow indication conditions, and the two Unit 2 D/Gs were trending to a less than reliable flow indication condition. The 1CD D/G experienced degraded flow which levelized at approximately 350 gallons/minute and was not considered substantially impacted by the debris intrusion. Based, in part, on the observed August 2001 debris intrusion D/G impacts, the inspectors concluded that the probability of a debris intrusion event impacting an individual D/G was approximately 0.75. The inspectors assumed a probability that all 4 D/Gs would be impacted by a debris intrusion event to be approximately 0.25.

Block 9: Condition is Not Identified and Cleared by the Operators

In this block the licensee proposed to assign the HEP values previously developed and evaluated by the inspectors as a part of the engineering evaluation. The licensee-proposed HEP values were 0.054, for a single unit LOOP event, and 0.13, for a dual unit LOOP event, respectively.

The inspectors reviewed and concurred with the methodology used to develop these probabilities as discussed in Section 4OA3.4.b.1 of this report.

b.3 Essential Service Water Supported Safety Function Capability Assessment

Emergency Diesel Generators

The ESW system provided essential cooling for the D/G turbocharger air aftercoolers, and the lubricating oil and jacket water coolers. Each D/G could be aligned to either the East or West ESW supply header in the associated unit via normal and alternate ESW supply valves. The associated safety train supplied normal ESW cooling while the opposite safety train supplied alternate ESW cooling. The D/G ESW supply valve control logic was designed to fully open both the normal and alternate ESW motor operated supply valves in response to a diesel start signal.

Based upon independent review of operator and computer logs from the August 2001 event, post shutdown inspections of the ESW system heat exchangers, requirements specified in the licensee’s UFSAR, and the licensee’s engineering and probabilistic evaluation of the specific and generic impacts of the August 2001 event, the inspectors determined that one of the two Unit 1 D/Gs experienced a less than reliable ESW-D/G flow condition and may not have been able to perform its intended function, had it been called upon. The second Unit 1 D/G also experienced degraded ESW-D/G flow, however; the degraded ESW-D/G flow had stabilized and was sufficient to support D/G operations during a post-LOOP environment. The two Unit 2 D/Gs also experienced degraded ESW-D/G flow conditions as a result of the debris intrusion and were trending to a less than reliable flow indication condition when the operators identified the degrading condition. At the time the operators identified the degraded ESW-D/G to the Unit 2 D/Gs, the ESW-D/G flow rates were still sufficient to support D/G operations during a post-LOOP environment. However, the observed negative trend in the ESW-D/G flow rates may have resulted in the D/Gs being unable to continue to function in a very short time.

Considering the damaged condition of the 1 East ESW strainer basket, the less than reliable ESW-D/G flow condition for one of the D/Gs, degraded flow for two of the remaining D/Gs, and a review of engineering and probabilistic evaluations developed by the licensee, the inspectors concluded that, absent operator intervention, a similar debris intrusion event could cause ESW flow degradation to the heat exchangers for all four D/Gs and result in the D/Gs being unable to perform their assumed safety function in a post-LOOP environment. The loss of the emergency alternating current (AC) power safety function had a credible impact on safety and therefore was of more than minor concern. Because the D/Gs supported the operation of accident mitigation equipment, the inspectors determined that this issue was associated with the Reactor Safety-Mitigating Systems cornerstone. During a Phase 1 Significance Determination Process (SDP) screening of issue, the inspectors concluded that the issue represented a credible actual loss of safety function and therefore required a Phase 2 SDP Review. During the Phase 2 SDP review, the licensee provided the engineering and probabilistic evaluations of the specific and generic impacts of an ESW-D/G debris intrusion event. In order to properly incorporate the additional licensee-provided information, a Phase 3 SDP assessment was performed.

Risk Assessment Considerations

The inspectors and NRC Headquarters staff evaluated the risk significance of the inspection finding (failed ESW strainer which allowed a significant amount of debris to enter and form flow blockages in the ESW-D/G system) in terms of internal events using the NRC SPAR model. Consistent with the guidance for the SDP, the change in core damage frequency (CDF), stemming from the identified failed ESW strainer was assessed. The assessment focused on LOOP events which could: 1) cause debris, present in the intake structure, to be entrained and ingested into the ESW system, and; 2) result in the Units to rely upon the D/Gs for onsite AC power. The assessment assumed:

- An initiating event frequency of 0.01 for a single unit LOOP and 0.007 for a dual unit LOOP.
- An exposure time of 1 year, the maximum timeframe used for these time calculations, based upon evidence which indicated that the ESW strainer failure had likely occurred during initial installation in 1989.

- Cross flows within the intake structure, following a single unit LOOP event, would entrain sufficient debris in the ESW-D/G flow stream to cause less than reliable ESW-D/G flow through the D/G heat exchangers within 12 hours.

- Inrush flows into the intake structure, following a dual unit LOOP event, would entrain sufficient debris in the ESW-D/G flow stream to cause less than reliable ESW-D/G flow through the D/G heat exchangers within 1 hour.

- Debris entrained within the intake structure would resettle to the intake structure floor within 1 hour after the flow perturbation or change had subsided.

- Frequency-weighted non-recovery curves associated with plant-centered, grid, severe weather, and extreme weather events for a single unit LOOP; and, frequency-weighted non-recovery curves associated with severe and extreme weather events for a dual unit LOOP.

- Operator recovery from less than reliable ESW-D/G heat exchanger flow conditions were characterized by human error probabilities of 0.054 for a single unit LOOP and 0.13 for a dual unit LOOP.

- The electrical distribution system does not include capability to electrically cross-tie between the Unit 1 and Unit 2 safety related busses.

- The motor driven auxiliary feedwater systems could be cross tied between Units for a single unit LOOP.

- A common cause failure factor was used to account for probabilities that: 1) insufficient debris would be available within the intake structure; 2) the failed 1 East ESW strainer may not be in service during the LOOP event; 3) pre-LOOP system alignments may delay or reduce the debris transported from Unit 1 to Unit 2, and; 4) all debris intrusion events may not result in all of the D/Gs experiencing less than reliable ESW-D/G flow conditions. A value of 0.14 was used for the single unit LOOP and 0.024 for the dual unit LOOP common cause failure factor.

- Mitigating equipment was assumed to be available once offsite power was recovered. Potential unavailabilities of these components, due to degraded ESW cooling flow, was not considered.

- The conditional probability of a large early release, given a core damage event for an ice condenser containment, was assumed to be 0.4.

Using the NRC's SPAR model and the assumptions stated above, the inspectors and NRC Headquarter's staff determined that the per plant delta CDF value was dominated by a dual unit LOOP event. The calculated dual unit LOOP delta CDF value was determined to be 1.8E-05 per year (Yellow). For both the single and dual unit LOOP events, the dominant sequence was a station blackout with a failure to recover AC power before station battery depletion.

The inspectors and NRC Headquarter's staff also evaluated the impact of this issue on the LERF. Using a conditional probability of a large early release, given a core damage event for an ice condenser containment, of 0.4, the staff determined the delta LERF for the issue was 7.1E-06 (Yellow) for a dual unit LOOP.

The Regional Senior Risk Analyst and the NRC Headquarter's staff concluded that the risk significance of the inspection finding, based on the change in CDF due to internal events and LERF considerations, to be Yellow. A Yellow finding represents a finding of substantial safety significance.

b.4 <u>Other ESW Support Systems</u>

<u>Component Cooling Water System</u>

The CCW system provided cooling to heat exchangers in the following risk-significant systems: residual heat removal, ECCS, spent fuel pool cooling, reactor coolant pump thermal barrier, and containment air recirculating. Each Unit's CCW system was arranged in three flow circuits: two parallel safeguards equipment trains, and one miscellaneous services train which can be served by either safeguards train.

During the August 2001 debris intrusion event, ESW flow to the Unit 1 East and Unit 2 West CCW heat exchangers became degraded. Essential Service Water system flow to the Unit 1 East CCW heat exchanger was as low as 2100 gpm but increased to 3900 gpm following cycling of the inlet and outlet ESW valves. The Unit 2 West CCW heat exchanger ESW flow decreased to approximately 2400 gpm but improved to approximately 5000 gpm following cycling of the ESW inlet and outlet valve. Section 9.8 of the UFSAR stated that the minimum ESW flow required to support post-accident CCW heat loads was 5000 gpm, but up to 8700 gpm of ESW flow was required to support normal operation and cooldown. Additionally, Section 9.5.2 of the UFSAR stated that the CCW system was designed and analyzed to operate at CCW heat exchanger outlet temperatures up to 120°F during cooldown and accident conditions. Although debris intrusion reduced the maximum ESW flow capability for the Unit 1 East and Unit 2 West CCW heat exchangers below design requirements, the inspectors determined that the CCW heat exchanger outlet temperatures did not exceed the 120°F analysis limit during the event.

Because Unit 1 was in Mode 5 at the time of the event, its CCW system supported decay heat removal system operation, but it was not required to support post-accident heat loads. Additionally, the debris intrusion event did not degrade flow to the Unit 1 West CCW train and reactor coolant system temperatures remained stable during the event. Based on the availability of the opposite train and the stable reactor coolant system operation during and immediately following the event, the inspectors determined that the safety impact of degraded ESW flow to the Unit 1 East CCW heat exchanger was minimal.

Because Unit 2 was in Mode 1 at the time of the degraded flow event, the licensee entered TS 3.7.3.1 and placed the Unit in Mode 5 within the required TS limiting condition for operation time limits. During the event, the Unit 2 East CCW train remained available to provide cooling for normal operation and accident heat loads.

Based on the availability of the opposite CCW train and licensee compliance with TS 3.7.3.1 for one inoperable CCW train, the inspectors determined that the safety impact of degraded flow to the Unit 2 West CCW heat exchanger was minimal.

Auxiliary Feedwater Pump Room Cooling and Emergency Water Supply

The ESW system provided the safety-related water source to each AFW pump and support cooling to the AFW pump room coolers. Following the debris intrusion event, the licensee identified degraded performance of the Unit 1 East MDAFWP room cooler and the Unit 2 West TDAFWP room cooler. At the time of the event, Unit 1 was operating in Modes 4 and 5 and did not require the AFW system to support decay heat removal. The inspectors evaluated the safety impact of degraded ESW flow on the capability to provide secondary plant makeup to Unit 2. The inspectors considered the following factors:

- The condensate storage tank provided the normal suction supply to the AFW pumps and remained available during the event. Consequently, the inspectors determined that the loss of the emergency AFW pump suction water supply from the ESW system did not significantly impact the ability of the AFW system to perform its safety function.

- The TDAFWP room is cooled by two 100 percent capacity coolers. Because the Unit 2 East TDAFWP room cooler had adequate cooling capacity to maintain TDAFWP room temperatures, the loss of the Unit 2 West TDAFWP room cooler did not adversely impact the ability of the TDAFWP to perform its safety function.

- The Unit 1 West and both Unit 2 MDAFWPs room coolers remained operable during and immediately following the event. Consequently, the inspectors determined that because of the availability of redundant trains of MDAFWPs sufficient AFW system capability was available to support Unit 2 during this event.

- The annunciator response procedures for high MDAFWP room temperature included proceduralized compensatory actions for degraded room cooling.

Based on these factors, the inspectors concluded that the impact of the ESW debris intrusion on the AFW system was minimal.

Control Room Air Conditioning System (CRAC)

The CRAC units provided cooling to maintain temperatures at which control room equipment was qualified for the life of the plant. As stated in the bases for TS 3.7.5.1, "Control Room Emergency Ventilation System," at control room temperatures less than or equal to 102°F, vital control room equipment remained within the manufacturers' recommended operating range. The inspectors reviewed control room logs and determined that control room temperatures did not exceed 80°F during and immediately following the degraded ESW event. Based on the ability of the CRAC units to adequately maintain control room temperatures, the inspectors determined that the impact of this event on the control room ventilation system was minimal.

Containment Spray System

The primary purpose of the Containment Spray System is to spray cool water into the containment atmosphere in the event of a loss-of-coolant to prevent containment pressure from exceeding the design value. With the exception of alignment of the Unit 2 East CTS heat exchanger for ESW flushing on August 30, 2001, the ESW supplies to the CTS heat exchangers were isolated during the event. Subsequent inspections and engineering evaluations of the CTS system identified no significant fouling or obstructions of flow. The inspectors concluded that the debris intrusion event had minimal safety impact on the CTS system.

.5 Adequacy of Corrective Actions

a. Inspection Scope

The inspectors attended licensee meetings, interviewed personnel, observed maintenance activities, reviewed testing plans, and performed system walkdowns as part of the assessment of the adequacy of the licensee's corrective actions for the restoration of:

- Emergency Diesel Generators
- Component Cooling Water System
- Other safety-related components served by ESW

b. Findings

The licensee established a series of recovery and support teams in order to identify equipment, procedural and personnel performance issues that needed to be addressed before the equipment could be restored to full service. The inspectors determined that the licensee's corrective actions were prompt, thorough, and effective.

Emergency Diesel Generators

The licensee inspected the cooling systems of all D/Gs immediately following the event. For each D/G, the licensee inspected and cleaned (as necessary) both air after-coolers, the lube oil cooler, the jacket water cooler, and supply piping.

In addition to cooling system inspection and cleaning, the licensee installed ESW differential pressure instrumentation on each lube oil cooler to assist in the future identification of cooling system blockage. The licensee also removed the automatic opening control logic for the alternate D/G cooling ESW supply valves to preclude cross train transport of debris into the D/G cooling systems.

Component Cooling Water System

The licensee removed the end bells of the Unit 1 East CCW heat exchanger and performed inspections. The licensee identified sand, zebra mussel shells, and large debris. The licensee considered large debris as debris that was greater than 1/8 inch. The debris blocked approximately 10 percent of the tubes. The licensee removed the debris and hydro-lanced the heat exchanger tubes. The ESW supply and return piping for the CCW heat exchanger was cleaned as part of the overall system flush.

Other Safety-Related Components Served by ESW

The licensee initiated a recovery team to specifically address the scope of corrective action necessary to restore the ESW system to service. The team evaluated other components served by ESW and recommended corrective actions. These corrective actions included:

- Inspecting and cleaning the CRAC units as necessary. The air conditioners were determined to be very clean with only minimal material.

- Inspecting and cleaning the AFW pump room coolers. The Unit 1 East MDAFWP room cooler and one of the two room coolers to the Unit 2 TDAFWP were identified to have significant blockage. These coolers were cleaned and returned to service.

- The Unit 1 East ESW pump discharge strainer was opened and inspected. The east strainer basket was determined to have significant damage and bypass. The west strainer basket was determined to have some smaller amount of bypass over the top of the basket. Both baskets were replaced.

- Two radiation monitors which drew sample flow from the ESW trains were cleaned.

- Instrumentation connected to the Unit 1 East ESW system was inspected and flushed.

- Portions of ESW piping that could not be inspected internally or were not assured of achieving high flow rates during flushing activities were Ultra-Sonically tested. The tests indicated that portions of the piping did contain debris. For example, one 12 inch diameter pipe contained approximately 2 inches of debris. The licensee flushed the material from the system.

- The licensee performed an ESW system flow verification surveillance test in order to ensure that all components served by the ESW system had been restored to operable.

.6 Adequacy of Overall Corrective Actions to Address Recurrence of Sand/Silt Buildup Problems

a. Inspection Scope

The inspectors attended licensee meetings, interviewed personnel, observed maintenance activities, reviewed testing plans, and performed system walkdowns as part of the assessment of the adequacy of the licensee's overall corrective actions.

b. Findings

The inspectors reviewed the licensee's corrective actions which included the following:

- all 8 ESW strainer baskets were inspected and replaced;
- detailed procedural guidance was given for strainer installation;
- a temporary modification to prevent the alternate ESW supply valves to the D/Gs from going open on a D/G start was installed;
- the normal configuration of the alternate ESW supply valves to the D/Gs was revised; and
- the new ESW strainer baskets received additional inspection to provide reasonable assurance of the new strainer baskets' structural capability.

The inspectors concluded that the licensee's actions appeared reasonable to prevent recurrence.

.7 Assessment of Interaction of the Maintenance Activities on the Non-Safety Related Circulating Water System with Operation of the ESW System

a. Inspection Scope

At the time of the event, the CW center intake crib was isolated in order to repair previously identified damage. The CW pump 13 discharge valve, 1-WMO-13, was degraded and could not be fully closed. The plant had been operating for several months with the center intake isolated. The inspectors assessed the interaction and potential impact of these non-safety related issues on the functioning of the ESW system.

b. Findings

The inspectors determined that CW system flow rates and configuration had a direct impact upon the functioning of the safety-related ESW system. However, if the Unit 1 East ESW pump discharge strainer east basket had been performing as designed, large debris would not have entered the ESW system and the operability of components served by ESW would not have been challenged.

4OA4 Cross-Cutting Issues

.1 Human Performance Issues During Degraded ESW Flow Event

a. Inspection Scope

The inspectors assessed operator performance during the degraded ESW flow event relative to the human performance cross-cutting issue. The inspectors reviewed control room logs, plant process computer data, and control room chart recorder data. In addition, the inspectors interviewed operators and reviewed operator statements.

b. Findings

The inspectors identified several weaknesses in the response of control room operators to the degraded ESW flow event of August 29, 2001. These weaknesses involved operator control board monitoring and procedural adherence. Specifically, the inspectors identified the following issues:

- Upon identifying that both Unit D/Gs were inoperable due to low ESW flow, the Unit 2 Senior Reactor Operator entered the action statement for TS 3.0.3. As described in the TS bases, TS 3.0.3 delineated the measures to be taken for those circumstances not directly provided for in the TS action statements. The inspectors determined that, because TS 3.8.1.1.e addressed two inoperable D/Gs, TS 3.0.3 was not the appropriate TS action statement to enter during this event. The Unit Supervisor stated that he assumed that TS 3.0.3 would apply with two inoperable D/Gs, and he did not read each TS 3.8.1.1 action statement. The inspectors noted that TS 3.8.1.1.e specified additional actions not covered by TS 3.0.3, such as demonstrating the operability of offsite power sources. In this case, the licensee complied with the action time limits specified in TS 3.8.1.1.e; thus, there was no impact from the failure to enter the appropriate TS action statement.

- Based on a review of Plant Process Computer data and control room chart recorder data, the inspectors concluded that indications of degraded ESW system performance (i.e., ESW flow below UFSAR minimum) were available to the control room operators at least 3 hours prior to the initial identification of degraded ESW flow to the D/Gs and CCW heat exchangers. Operations head instruction OHI-4017, "Control Board Monitoring," Step 4.2.8, required, in part that control boards shall be monitored for changing indications, adverse trends, and abnormal indications and Step 4.2.4 stated that during normal plant operations, the reactor operator should perform a walkdown of all control room panels every 60 minutes. The inspectors determined that the control room operators' failure to effectively implement the recommendations contained in OHI-4017 contributed to the failure to promptly identify degraded ESW system performance.

- Based on a review of CCW system temperatures recorded on chart recorder 1-SG-10, the inspectors determined that the Unit 1 East CCW heat exchanger outlet temperature exceeded the 95°F abnormal temperature alarm setpoint for over 3 hours. Annunciator response procedure 01-OHP 4024.104, Drop 85, "East CCW Hx Discharge Temp Abnormal," Step 3.3, stated that if the CCW heat exchanger outlet temperature cannot be maintained less than 95°F, enter Abnormal Procedure 01-OHP 4022.016.001, "Malfunction of the CCW System." Although the reactor operator reported receipt of the associated abnormal temperature alarm, the control room operators did not enter Abnormal Procedure 01-OHP 4022.016.001, contrary to instructions contained in 01-OHP 4024.104.

- Although the Unit 1 East CCW outlet abnormal temperature alarm actuated during the event, receipt of the alarm and the operator's subsequent difficulty in controlling CCW temperature were not recorded in the control room log and not effectively communicated to the operations shift management. The inspectors determined that the operator's failure to log receipt of the CCW abnormal temperature alarm and effectively communicate this abnormal condition was not consistent with instructions contained in OHI-2212 and OHI-4017. Specifically, OHI-2212, Step 4.5.7 required, in part, that the actuation of significant annunciators and unexpected system transients shall be contained in the control room log and OHI-4017, Step 4.2.11, required, in part, that the US shall be notified immediately of any indication that is not responding as expected.

The inspectors determined that the failure to adequately apply TS requirements and implement procedures associated with control board monitoring, logkeeping, and annunciator response had a credible impact on safety and therefore were more than a minor concern. Specifically, these issues could reasonably result in the failure to identify and promptly correct degradation of safety related equipment and therefore impact the reliability and availability of a safety system. Because these performance deficiencies contributed to delays in identifying degradation of the ESW and CCW mitigating systems, the inspectors determined that these human performance weaknesses were associated with the mitigating systems cornerstone. Although this issue adversely impacted the licensee's response to the August 29, 2001 event, none of the performance deficiencies directly resulted in the actual loss of safety system function or the loss of a single safety system train for greater than its TS allowed outage time. Consequently, the inspectors concluded that this issue was of very low safety significance (Green).

Technical Specification 6.8.1 required, in part, that written procedures shall be implemented for those activities recommended in Appendix "A" of RG 1.33, Revision 2. Regulatory Guide 1.33, "Quality Assurance Program Requirements," Revision 2, Appendix "A," recommended, in part, that written procedures cover the following activities: (1) authorities and responsibilities for safe operation, (2) log entries, and (3) abnormal, off normal or alarm conditions. The inspectors determined that

OHI-2212, "Narrative and Miscellaneous Logkeeping"; OHI-4017, "Control Board Monitoring"; and 01-OHP 4024.104, "Annunciator #104 Response: Essential Service Water and Component Cooling"; were written to implement the requirements of TS 6.8.1. Contrary to TS 6.8.1, the control room operators failed to implement the instructions contained in (1) OHI-2212, step 4.5.7, (2) OHI-4017, steps 4.2.8 and 4.2.11, and (3) 01-OHP.4024.104, drop 85, step 3.3, during the degraded ESW event of August 29, 2001. Specifically, the operators failed to (1) monitor the control boards for changing indications, adverse trends, and abnormal indications, (2) effectively communicate receipt of an abnormal temperature alarm for the CCW heat exchanger, and (3) enter the CCW abnormal operating procedure as directed by the abnormal temperature alarm response procedure. Because of the very low safety significance, this violation is being treated as a Non-Cited Violation consistent with Section VI.A of the NRC Enforcement Policy (NCV 50-315-01-17-02(DRP); 50-316-01-017-02(DRP)). This violation is in the licensee's corrective action program as CR 01250062.

4OA6 <u>Meeting</u>

<u>Exit Meeting</u>

The inspector presented the inspection results to licensee management listed below on May 17, 2002. The licensee acknowledged the findings presented. No proprietary information was identified.

KEY POINTS OF CONTACT

Licensee

G. Arent, Manager, Regulatory Affairs
C. Bakken, Senior Vice President, Nuclear Generation
G. Bourlodan, Plant Programs Manager
R. Gaston, Regulatory Affairs Compliance Supervisor
J. Gebbie, System Engineering Manager
J. Giessner, Assistant Manager, Operations
S. Greenlee, Director, Nuclear Technical Services
N. Jackiw, Regulatory Affairs
C. Lane, Inservice Inspection Supervisor
E. Larson, Manager, Operations
R. Meister, Regulatory Affairs
J. Molden, Reliability Programs
D. Moul, Assistant Manager, Operations
T. Noonan, Director, Performance Assurance
J. Pollock, Site Vice President and Acting Plant Manager
R. Smith, Assistant Director, Plant Engineering
L. Weber, Performance Assurance
D. Wood, RadChem Environmental Manager
T. Woods, Regulatory Affairs

NRC

Geoffrey Grant, Director, Division of Reactor Projects
Steven Reynolds, Deputy Director Division of Reactor Projects
Anton Vegel, Branch Chief Reactor Projects Branch 6
Sonia Burgess, Senior Reactor Analyst, Division of Reactor Safety

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

50-315/01-17-01 50-316/01-17-01	AV	Essential Service Water strainer maintenance instructions not appropriate to the circumstances.
50-315/01-17-02 50-316/01-17-02	NCV	Human performance weaknesses during the degraded essential service water event of August 29, 2001 associated with control board monitoring and procedural adherence.

Closed

50-315/01-17-02 50-316/01-17-02	NCV	Human performance weaknesses during the degraded essential service water event of August 29, 2001 associated with control board monitoring and procedural adherence.

Discussed

None

LIST OF ACRONYMS USED

AEP	American Electric Power
AFW	Auxiliary Feedwater System
ATR	Administrative Technical Requirement
CCW	Component Cooling Water
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CR	Condition Report
CRAC	Control Room Air Conditioning
CTS	Containment Spray System
CW	Circulating Water
D/G	Emergency Diesel Generator
DRP	Division of Reactor Projects
EAL	Emergency Action Level
ECC	Emergency Condition Categories
EOP	Emergency Operating Procedure
EP	Emergency Preparedness
ESW	Essential Service Water
FIN	Finding
JO	Job Order
HELB	High Energy Line Break
IC	Initiating Condition
IMC	Inspection Manual Chapter
LOOP	Loss of Off-Site Power
MDAFWP	Motor Driven Auxiliary Feedwater Pump
MHP	Maintenance Head Procedure
NRC	Nuclear Regulatory Commission
NRR	Nuclear Reactor Regulation
OA	Other Activities
OHI	Operations Head Instruction
OHP	Operations Head Procedure
PDR	Public Document Room
PMI	Plant Manager’s Instruction
PMP	Plant Manager’s Procedure
PMT	Post-maintenance Testing
PPC	Plant Process Computer
PRA	Probability Risk Assessment
RCS	Reactor Coolant System
RHR	Residual Heat Removal
SDP	Significance Determination Process
SEC	Site Emergency Coordinator
SRA	Senior Reactor Analysts
SRO	Senior Reactor Operator
SSC	Structures, Systems, and Components
STP	Surveillance Test Procedure
TBD	To Be Determined
TDAFWP	Turbine Driven Auxiliary Feedwater Pump

TS	Technical Specification
UFSAR	Updated Final Safety Analysis Report
UHS	Ultimate Heat Sink
URI	Unresolved Item
US	Unit Supervisor
VIO	Violation

LIST OF DOCUMENTS REVIEWED

Work Requests/Job Orders

JO 01095031	Unit 2 Traveling Water Screen Driving Inspection
JO 01242065	Inspect and Clean Unit 1 ESW and Circulating Water Pump Bays
JO 01244049	Open and clean 1-HV-ACR-1 (North CRAC)
JO 01244055	Drain and flush 1-HV-AFP-EAC, Unit 1 East MDAFWP room cooler
JO 01244059	Inspect, clean, and flush 1-HV-AFP-T1AC, the Unit 1 east TDAFWP room cooler
JO 01244069	Inspect/clean ESW side of heat exchanger 1-QT-110-AB
JO 01244071	Inspect/clean ESW side of heat exchanger 1-QT-110-CD
JO 01244072	Inspect/clean ESW side of heat exchanger 1-QT-131-AB
JO 01244073	Inspect/clean ESW side of heat exchanger 1-QT-131-CD
JO 01244089	Open/inspect/flush 2-HV-ACR-1 (North CRAC)
JO 01244092	2-HV-AFP-WAC Drain and Flush West Cooler
JO 01244094	2-HV-AFP-T2AC Drain and Flush T2AC Cooler
JO 01244097	Inspect/clean ESW side of heat exchanger 2-QT-110-CD
JO 01244099	Inspect/clean ESW side of heat exchanger 2-QT-131-CD
JO 01244096	Inspect/clean ESW side of heat exchanger 2-QT-110-AB
JO 01244098	Inspect/clean ESW side of heat exchanger 2-QT-131-AB
JO R0088138	Unit 1 Screenhouse Diving, Cleaning and Repairs
JO R0100035	2-HE-18W Open Shell Side of Heat Exchanger for Inspection

JO R0210330	Open shell side of 1-HE-18E for inspection (Unit 1 East CTS heat exchanger)
JO R021036	Unit 1 Screenhouse Diving, Cleaning and Repairs
JO R0217652	Inspect and clean 1-HE-15E (Unit 1 East CCW heat exchanger)
JO R0096582	Inspect and clean 1-HE-15W (Unit 1 West CCW heat exchanger)

Condition Reports (CRs)

CR 00273076	Silts/sand from the lake settling out in the dead leg section of ESW piping	September 28, 2000
CR 00295037	1-PP-7W-MTR Failed To Start	October 21, 2000
CR 01019031	SA-2001-REA-003, Perform Zebra Mussel Assessment During Year 2001	January 19, 2001
CR 01242007	2-ESW-162-CD Emergency Diesel Jacket Water Cooler QT-131-CD tube side vent valve is blocked and could not be flushed out	August 30, 2001
CR 01242008	Procedural Deficiency in 02 OHP 4030.STP.022E, the ESW system test - Step 4.30.3, which aligns the north CRAC for flushing is missing from the procedure	August 30, 2001
CR 01242009	2-ESW-163-CD, the Unit 2 CD D/G jacket water cooler tube side drain, is clogged and not allowing flow to pass when opened	August 30, 2001
CR 01242010	2-ESW-162-AB Emergency Diesel Jacket Water Cooler QT-131-AB tube side vent valve is blocked and could not be flushed out	August 30, 2001
CR 01242013	Slit/mud intrusion into Unit 1 and 2 ESW systems renders CCW and D/G inoperable	August 29, 2001
CR 01243013	2-HV-AFP-T2AC, the Unit 2 West TDAFWP room cooler, does not appear to be functioning	August 31, 2001
CR 01243015	Unit 1 East auxiliary feedwater pump room cooler flow (56 gpm) was less then minimum required (57 gpm)	August 31, 2001

CR 01243036	Both Unit 1 and Unit 2 D/Gs declared inoperable due to low ESW flow. This resulted in Unit 1 entering a RED shutdown risk path.	August 29, 2001
CR 01243038	Evaluate August 30, 2001, greater than 20 percent power reduction on Unit 2 due to degraded ESW flow for potential Maintenance Rule impact	August 30, 2001
CR 01243039	PRA analysis of Unit 2 indicates yellow risk status in that the west CCW heat exchanger is not receiving the required 5000 gpm ESW flow	August 30, 2001
CR 01244010	1-WMO-12 circulating water pump PP-2-2 discharge shutoff valve	September 1, 2001
CR 01244011	1-WMO-11 Circulating Water Pump PP-2-1 Discharge Shutoff Valve	August 31, 2001
CR 01244016	Wood, mussel shells, and debris larger than expected identified during inspection on the Unit 1 east CCW heat exchanger	September 1, 2001
CR 01244019	Degraded ESW flow documented in CR 01242013 may indicate that the GL 89-13 program is inadequate	September 1, 2001
CR 01245030	During inspection of Unit 1 East ESW pump discharge strainer baskets, large bypass flow paths were identified.	September 2, 2001
CR 01246015	Forced outage schedule does not match actual work planning and execution for Unit 1 West ESW pump work	September 3, 2001
CR 01247001	Declaration of unusual event during the Unit 1 and Unit 2 ESW restriction event on August 29, 2001 would have been prudent	September 3, 2001
CR 01247041	Open, inspect and clean 1-HV-AFP-WAC (Unit 1 west MDAFWP room cooler) to determine extent of ESW debris intrusion	September 4, 2001
CR 01247050	NRC identified several human performance weaknesses during the ESW fouling event of August 29, 2001. These included weaknesses in communication, possible training deficiencies for abnormal procedures, inconsistent log keeping and control board monitoring	September 4, 2001

CR 01247054	Due to potential debris buildup within ESW system, it is necessary to flush ESW piping	September 4, 2001
CR 01247055	AFW room coolers have been found to be blocked with debris (zebra mussel shells)	September 4, 2001
CR 01248001	Potential of debris build-up within the ESW system upstream of the D/G aircooler 3-way valves	September 4, 2001
CR 01248002	Flush piping upstream of D/G aftercooler 3-way valves WRV-727 and WRV-725	September 4, 2001
CR 01250062	NRC identified several operational issues associated with the August 29, 2001 degraded ESW flow event, including: command and control, control board monitoring, log keeping, use of technical specifications, conservative decision making, event reconstruction, emergency plan implementation, and procedural usage	September 7, 2001
CR 01251003	Performance Assurance identified that operators failed to establish mode constraint for operability issues identified during the extent of condition investigation for the ESW flow degradation event of August 29, 2001	September 7, 2001
CR 01251022	The downstream pipe of the Unit 1 East CTS heat exchanger shell side vent is blocked	September 8, 2001
CR 01251029	In-Service testing on the Unit 1 East ESW pump indicated rapid degradation	September 8, 2001
CR 01253005	Quarantine was lost on the Unit 1 East ESW strainer east basket. The basket had been placed in the scrap metal trash bin and taken to the scrap yard	September 9, 2001
CR 01260022	1-QT-131-CD diesel generator jacket water heat exchanger open, cleaned, and closed with 2 tubes blocked with debris	September 17, 2001
CR 01268045	Dedication Plan HP-1015 is inconsistent with the requirement of 12 EHP-5043-CGD-001	September 25, 2001
P-00-05677	Essential Service Water Radiation Monitors (WRA-3500, WRA-3600, WRA-4500 and WRA-4600) ESW Lines Are Plugged With Sand And Silt	

Other Documents

	Control Room Operator Logs	August 29, 2001 - August 30, 2001
	Final Expanded System Readiness Report - ESW System (Unit 2)	April 3, 2000
PMI-7033	Application and Use of Design Basis, Single Failure Criterion, Engineering Design Bases, and Current Licensing Basis	Revision 0
OHI-2212	Narrative and Miscellaneous Logkeeping	Revision 4
OHI-4017	Control Board Monitoring	Revision 0
01 OHP 4021.016.003	Operation of the Component Cooling Water System During System Startup and Power Operation	Revision 15
12 OHP 4021.019.001	Operation of the Essential Service Water System	Revision 23
01-OHP 4022.016.001	Malfunction of the CCW System	Revision 2
01-OHP-4024-104	Annunciator #104 Response: Essential Service Water and Component Cooling	Revision 12
02-OHP 4022.019.001	ESW System Loss/Rupture	Revision 2
01-OHP 4024.113	Annunciator #113 Response: Steam Generator 1 and 2	Revision 6
01-OHP 4024.114	Annunciator #114 Response: Steam Generator 3 and 4	Revision 6
01-OHP-4024.120	Annunciator #120 Response: Station Auxiliary CD	Revision 10
01- OHP 4030.STP027CD	CD Diesel Generator Operability Test (Train "A")	Revision 16
PMP 5030.001.005	Essential Service Water System Inspection Program	Revision 0
Drawing 12-3652	Screen House Plant At EL, 546'-0" Plan To Column 18-West Portion	Revision 5
Drawing 12-3653	Screen House Plant At EL, 546'-0" Plan To Column 9-West Portion	Revision 4

Drawing 12-5776-Y	Screen Housing Piping, Misc. Sections, Units 1 And 2	
12 MHP 5021.019.003	Essential Service Water Strainer Maintenance	Revision 4
Calculation TH-00-05	Auxiliary Feedwater Pump Room Heat-Up Temperatures	Revision 0
Design Information Transmittal DIT B-02217-00	Expected D/G Loading During a LOOP Event Only	Revision 0
EVAL-MD-02-ESW-092-N	Calculation of Pressure Spike in ESW System Due to Pressure Pulse (Column Rejoining)	Revision 0
EVAL-MD-01-ESW-095-N	Failure Analysis of Strainer Basket (CR 01242013, CR 01245030)	Revision 0
EVAL-MD-02-ESW-089-N	Reduction in ESW Temperature to Accommodate Reduced Flowrate to ESW Components	Revision 0
Calculation ENSM980327JDJ	Results of Operating the Diesel Generator Lube Oil Cooler & Jacket Water Cooler at Elevated ESW Temperatures	Revision 0
Dedication Plan No. HP-1015	Essential Service Water (ESW) Strainer Parts	Revision 4
OP-1-5113	Flow Diagram Essential Service Water	Revision 70
OP-1-5113A	Flow Diagram Essential Service Water	Revision 2
OP-1-5119A	Flow Diagram Circulating Water, Priming System And Screen Wash, Unit 1	Revision 60
OP-12-5119	Flow Diagram Circulating Water, Priming System And Screen Wash, Units 1 And 2	Revision 50
OP-2-5113	Flow Diagram Essential Service Water	Revision 63
OP-2-5113A	Flow Diagram Essential Service Water	Revision 4
OP-1-5151C	Flow Diagram Emergency Diesel Generator "CD"	Revision 42
Technical Report NTS-2002-010-REP	Debris Intrusion Into the Essential Service Water System - Probabilistic Evaluation	Revision 0