UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 13, 2018

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SUBJECT: TRANSMITTAL OF FINAL ACCIDENT SEQUENCE PRECURSOR ANALYSIS – CLINTON POWER STATION, SHUTDOWN SERVICE WATER PUMP (DIVISION 3) START FAILURE (LER-461-2017-008) - PRECURSOR

By letter dated August 11, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17228A043), Clinton Power Station submitted licensee event report (LER) 461-2017-008 to the U.S. Nuclear Regulatory Commission (NRC) staff pursuant to Title 10 of the *Code of Federal Regulations* Section 50.73. As part of the accident sequence precursor (ASP) program, the NRC staff reviewed the event to identify potential precursors and to determine the probability of the event leading to a core damage state. The results of the analysis are provided in the enclosure to this letter.

The NRC does not request a formal analysis review, in accordance with Regulatory Issue Summary 2006-24, "Revised Review and Transmittal Process for Accident Sequence Precursor Analyses" (ADAMS Accession No. ML060900007), because the analysis resulted in a conditional core damage probability (CCDP) of 6×10^{-6} which is less than the 1×10^{-4} review threshold.

Final ASP Analysis Summary. A brief summary of the final ASP analysis, including the results, is provided below.

Final Accident Sequence Precursor Analysis – Clinton Power Station, Shutdown Service Water Pump (Division 3) Start Failure (LER-461-2017-008) - Precursor. This event is documented in LER 461-2017-008 and in inspection report 05000461/2017011.

Executive Summary

On June 15, 2017, while performing in-service testing, the division 3 service water pump (1SX01PC) was started and after approximately 30 seconds, tripped due to thermal overload. The division 3 emergency diesel generator (EDG) and high-pressure coolant spray (HPCS) were declared inoperable due to the lack of cooling water and a 14-day limiting condition for operation was entered. The pump was repaired and on June 23rd, after successful post-maintenance testing the division 3 service water pump was declared operable. NRC inspectors determined that the division 3 service water pump was unavailable to fulfill it safety function since its last successful test on March 15, 2017. A review of LERs for Clinton Power Station revealed that the plant experienced two reactor scram events during this 84-day

unavailability of the division 3 service water pump. Because the division 3 service water pump was unavailable during these reactor scrams, an independent ASP analysis needs to be performed to capture the "windowed" effects of these events.

This event was modeled as a reactor scram with the failure of the division 3 service water pump, which results in a CCDP of 5.5×10^{-6}. The most likely core damage sequence involves a reactor scram, a consequential loss of offsite power with a subsequent station blackout due to the postulated failure of all the EDGs, the unavailability of HPCS due to the failed division 3 service water pump, the postulated failure of reactor core isolation cooling, operators successfully shed electrical load to extend battery operation, and operators fail to recover alternative current power prior to battery depletion (12 hours). This accident sequence accounts for approximately 16 percent of the event CCDP.

NRC inspectors identified a performance deficiency associated with the licensee's failure to review the suitability of application of materials, parts, equipment, and processes that were essential to the safety-related functions of structures, systems and components. This inspection finding was preliminarily determined to be *White* (i.e., low-to-moderate safety significance) based on a condition assessment of an 84-day unavailability of the division 3 service water pump.

Summary of Analysis Results. This operational event resulted in a best estimate CCDP of 6×10^{-6}.

If you have any questions, please contact me at (301) 415-1530 or at by email at Jennivine.rankin@nrc.gov.

Sincerely,

Jennivine K. Rankin, Project Manager
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 05000461

Enclosure:
Final Accident Sequence Precursor Analysis –
Clinton Power Station, Shutdown Service Water
Pump (Division 3) Start Failure (LER-461-2017-008) - Precursor

cc: Listserv

ENCLOSURE

Final Accident Sequence Precursor Analysis – Clinton Power Station Shutdown Service Water Pump (Division 3) Start Failure LER-461-2017-008 - Precursor

Final ASP Program Analysis - Precursor

Accident Sequence Precursor Program – Office of Nuclear Regulatory Research			
Clinton Power Station	Shutdown Service Water Pump (Division 3) Start Failure		
Event Date: 6/15/2017	**LER(s):** 461-2017-008, 461-2017-005-01 461-2017-007-01 **IR(s):** 05000461/2017011		**CCDP=** 6×10^{-6}
Plant Type: General Electric Type 6 Boiling-Water Reactor (BWR) with Mark III Containment			
Plant Operating Mode (Reactor Power Level): Mode 1 (97% Reactor Power)			
Analyst: Dale Yeilding	**Reviewer:** Christopher Hunter	**Contributors:** Keith Tetter	**Approval Date:** 2/28/2018

EXECUTIVE SUMMARY

On June 15, 2017, while performing in-service testing, the division 3 service water pump (1SX01PC) was started and after approximately 30 seconds, tripped due to thermal overload. The division 3 emergency diesel generator (EDG) and high-pressure coolant spray (HPCS) were declared inoperable due to the lack of cooling water and a 14-day limiting condition for operation (LCO) was entered. The pump was repaired and on June 23rd, after successful post-maintenance testing, the division 3 service water pump was declared operable. NRC inspectors determined that the division 3 service water pump was unavailable to fulfill its safety function since its last successful test on March 15, 2017. A review of licensee event reports (LERs) for Clinton Power Station revealed that the plant experienced two reactor scram events during this 84-day unavailability of the division 3 service water pump. Because the division 3 service water pump was unavailable during these reactor scrams, an independent accident sequence precursor (ASP) analysis needs to be performed to capture the "windowed" effects of these events.

This event was modeled as a reactor scram with the failure of the division 3 service water pump, which results in a conditional core damage probability (CCDP) of 5.52×10^{-6}. The most likely core damage sequence involves a reactor scram, a consequential loss of offsite power (LOOP) with a subsequent station blackout (SBO) due to the postulated failure of all the EDGs, the unavailability of HPCS due to the failed division 3 service water pump, the postulated failure of reactor core isolation cooling (RCIC), operators successfully shed electrical load to extend battery operation, and operators fail to recover alternative current power prior to battery depletion (12 hours). This accident sequence accounts for approximately 16 percent of the event CCDP.

NRC inspectors identified a performance deficiency associated with the licensee's failure to review the suitability of application of materials, parts, equipment, and processes that were essential to the safety-related functions of structures, systems and components. This inspection finding was preliminarily determined to be *White* (i.e., low-to-moderate safety significance) based on a condition assessment of an 84-day unavailability of the division 3 service water pump.

EVENT DETAILS

Event Description. On June 15, 2017, while performing in-service testing, the division 3 service water pump (1SX01PC) was started and after approximately 30 seconds, tripped due to thermal overload.[1] Operators attempted a restart of the pump. The second run lasted approximately 8 seconds with the pump rotating at 70 rotations-per-minute before operators manually secured the pump. The division 3 EDG and HPCS were declared inoperable due to the lack of cooling water, and a 14-day LCO was entered.

A new motor with higher starting-torque characteristics was installed. In addition, the pump breaker, thermal overload, pump shaft sleeves, and pump packing were replaced. On June 23rd, the baseline and surveillance test procedures were performed without incident. NRC inspectors determined that the division 3 service water pump was unavailable to fulfill its safety function since its last successful test on March 15, 2017. See LER 461-2017-008 (Ref. 1) and inspection report (IR) 05000461/20170011 (Ref. 2) for additional information.

During the same period that the division 3 service water pump was unavailable, two separate reactor scram events occurred on May 30th [LER 461-2017-005-01 (Ref. 3)] and June 10th [LER 461-2017-007-01 (Ref. 4)].

Cause. The licensee determined the root cause of the failure of the division 3 service water pump to be increased internal pump resistance that could not be overcome by the pump's starting torque. The increased pump resistance was caused by unidentified impacts during a design modification (e.g., dry pump packing during pump starts, unidentified corrosion effects on the packing shaft sleeve, and inadequate hard-face material). Note: in 2014, the licensee identified corrosion as a contributing cause for the failure of this same pump and subsequently failed to appropriately evaluate and correct this issue.

MODELING ASSUMPTIONS

Basis for ASP Analysis/SDP Results. The ASP Program uses SDP results for degraded conditions when available and applicable. However, the ASP Program performs independent analyses for initiating events. In addition, ASP analyses of initiating events account for all failures/degraded conditions and unavailabilities (e.g., equipment out for test/maintenance) that occurred during the event, regardless of licensee performance.[2]

NRC inspectors identified a performance deficiency associated with the licensee's failure to review the suitability of application of materials, parts, equipment, and processes that were essential to the safety-related functions of structures, systems and components. Specifically, the performance deficiency resulted in the failure of the division 3 service water pump, which impacted the operability and functionality of the HPCS and the division 3 EDG. This inspection finding was preliminarily determined to be *White* (i.e., low-to-moderate safety significance). This determination was based on a detailed risk assessment of the 84-day unavailability of the division 3 service water pump and resulted in a ΔCDF (core damage frequency) of 4×10^{-6} per year for internal events. Additional information is provided in IR 05000461/20170011.

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1 The division 3 service water pump provides cooling water to the HPCS pump room coolers, the division 3 EDG, and the division 3 switchgear heat removal system.

2 ASP analyses also account for any degraded condition(s) that were identified after the initiating event occurred if the failure/degradation exposure period(s) overlapped the initiating event date.

A review of LERs for Clinton Power Station revealed that the plant experienced two reactor scram events during the 84-day unavailability of the division 3 service water pump. See LERs 461-2017-005-01 and 461-2017-007-01 for additional information. No other windowed events were identified. Because the division 3 service water pump was unavailable during these reactor scrams, an independent ASP analysis needs to be performed to capture the "windowed" effects of these events.

Analysis Type. An initiating event analysis was performed using the Clinton Standardized Plant Analysis Risk model Revision 8.54, created on December 20, 2017.

Key Modeling Assumptions. The following assumptions were determined to be significant to the modeling of this event:

- This analysis models a reactor scram at Clinton Power Station based on the two reactor scram events that occurred on May 30th and June 10th. Therefore, the probability for IE-TRANS (*general plant transient*) was set to 1.0; all other initiating event probabilities were set to zero.
- Basic event SSW-MDP-FS-1C (*service water pump C fails to start*) was set to TRUE to represent the nonrecoverable failure of the division 3 service water pump.

ANALYSIS RESULTS

CCDP. The point estimate CCDP for this initiating event analysis is 5.52×10^{-6}. The ASP Program acceptance threshold is a CCDP of 1×10^{-6} or the CCDP equivalent of an uncomplicated reactor trip with a non-recoverable loss of main feedwater or loss of condenser heat sink, whichever is greater. This CCDP equivalent for Clinton is 2.37×10^{-6}. Therefore, this event is a precursor.

Dominant Sequence. The dominant accident sequence is Transient Sequence 67-40-24 (CCDP = 8.75×10^{-7}) that contributes approximately 16 percent of the total CCDP. The dominant sequence is shown graphically in Figures A-1 through A-3 in Appendix A. The sequences that contribute at least 1.0 percent to the total CCDP are provided in the following table.

Sequences Contributing at Least One Percent to Total CCDP

Sequence	CCDP	Percentage	Description
TRANS 67-40-24	8.75×10^{-7}	15.9%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs open-relieve pressure-close Success of recirculation pump seal integrity Failure of HPCS Success of RCIC Success for operator to strip non-essential DC loads Failure to extend RCIC or refill CST Failure to depressurize Failure to recover offsite power in 4 hours Failure to recover a diesel generator in 4 hours

Sequence	CCDP	Percentage	Description
TRANS 67-40-30	6.02×10^{-7}	10.9%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs to open-relieve pressure-close Success of recirculation pump seal integrity Failure of HPCS Success of RCIC Failure to recover offsite power in 30 minutes Failure to recover a diesel generator in 30 minutes
TRANS 67-40-31-13	4.99×10^{-7}	9.0%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs to open-relieve pressure-close Failure of recirculation pump seal integrity Failure of HPCS Failure of RCIC
TRANS 67-40-32-13	4.79×10^{-7}	8.7%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Failure of SRVs Failure of HPCS Failure of RCIC
TRANS 63	4.75×10^{-7}	8.6%	Success to shutdown Success of offsite electrical power Success of SRVs to open-relieve pressure-close Failure reestablish steam condensing DHR Failure main feedwater Failure of RCIC Failure of HPCS Success to depressurize Failure condensate system to inject Failure low pressure injection
TRANS 67-35	4.12×10^{-7}	7.5%	Success to shutdown Failure of offsite electrical power Success of onsite emergency power Success of SRVs open-relieve pressure-close Failure of RCIC Failure of HPCS Success to depressurize Success of low pressure injection Failure of RHR suppression pool cooling Failure of RHR containment spray Failure to reestablish Decay Heat Removal by steam condensing Failure of containment venting Failure of late injection

Sequence	CCDP	Percentage	Description
TRANS 67-40-22-31	3.93×10^{-7}	7.1%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs to open-relieve pressure-close Success of recirculation pump seal integrity Failure of HPCS Success of RCIC Success for operator to strip non-essential DC loads Failure to extend RCIC or refill CST Failure to depressurize Success to recover offsite power in 4 hours Failure of RCIC Failure of HPCS Success to depressurize Failure of low pressure injection
TRANS 67-37	3.83×10^{-7}	6.9%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs to open-relieve pressure-close Failure of RCIC Failure of HPCS Failure to depressurize
TRANS 67-13	2.71×10^{-7}	4.9%	Success to shutdown Failure of offsite electrical power Success of onsite emergency power Success of SRVs open-relieve pressure-close Success of RCIC Failure of RHR suppression pool cooling Failure of HPCS Success to depressurize Success of low pressure injection Failure of RHR containment spray Failure to reestablish DHR by steam condensing Failure of containment venting Failure of late injection
TRANS 64	1.55×10^{-7}	2.8%	Success to shutdown Success of offsite electrical power Success of SRVs to open-relieve pressure-close Failure of DHR by steam condensing Failure of main feedwater Failure of RCIC Failure of HPCS Failure to depressurize
TRANS 67-40-31-09	9.72×10^{-8}	1.8%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs to open-relieve pressure-close Failure of recirculation pump seal integrity Failure of HPCS Success of RCIC Success for operator to strip non-essential DC loads Failure to recover offsite power in 4 hours Failure to recover a diesel generator in 4 hours

Sequence	CCDP	Percentage	Description
TRANS 67-40-32-09	9.33×10^{-8}	1.7%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Failure of SRVs Failure of HPCS Success of RCIC Success for operator to strip non-essential DC loads Failure to recover offsite power in 4 hours Failure to recover a diesel generator in 4 hours
TRANS 67-38-14	7.74×10^{-8}	1.4%	Success to shutdown Failure of offsite electrical power Success of onsite emergency power Failure of SRVs Success of RCIC Failure of HPCS Success low pressure injection Failure of RHR suppression pool cooling Failure of RHR containment spray Failure to reestablish DHR by steam condensing Failure of containment venting Failure of late injection
TRANS 67-36	6.21×10^{-8}	1.1%	Success to shutdown Failure of offsite electrical power Success of onsite emergency power Success of SRVs open-relieve pressure-close Failure of RCIC Failure of HPCS Success to depressurize Failure low pressure injection
Trans 67-40-28-31	6.01×10^{-8}	1.1%	Success to shutdown Failure of offsite electrical power Failure of onsite emergency power Success of SRVs open-relieve pressure and close Success of recirculation pump seal integrity Failure of HPCS Failure of RCIC Failure to recover offsite power in 30 minutes Success to depressurize Failure of low pressure injection

REFERENCES

1. Clinton Power Station, Unit 1, "LER 461/2017-008 - Division 3 Shutdown Service Water Pump Start Failure", dated August 11, 2017 (ADAMS Accession No. ML17228A043).

2. Clinton Power Station, Unit 1, "Inspection Report 05000461/2017011 and Preliminary White Finding), dated January 26, 2018 (ADAMS Accession No. ML18026A965).

3. Clinton Power Station, Unit 1, "LER 461/2017-005-01 - Regarding Automatic Reactor Scram During the Performance of Scram Time Testing As a Result of an Invalid Oscillation Power Range Monitor Growth Rate Trip," dated September 28, 2017 (ADAMS Accession No. ML17275A173).

4. Clinton Power Station, Unit 1, "LER 461/2017-007-01 - Regarding Manual Reactor Scram Due to Loss of Feedwater Heating," dated November 9, 2017 (ADAMS Accession No. ML17318A085).

Appendix A: Key Event Trees

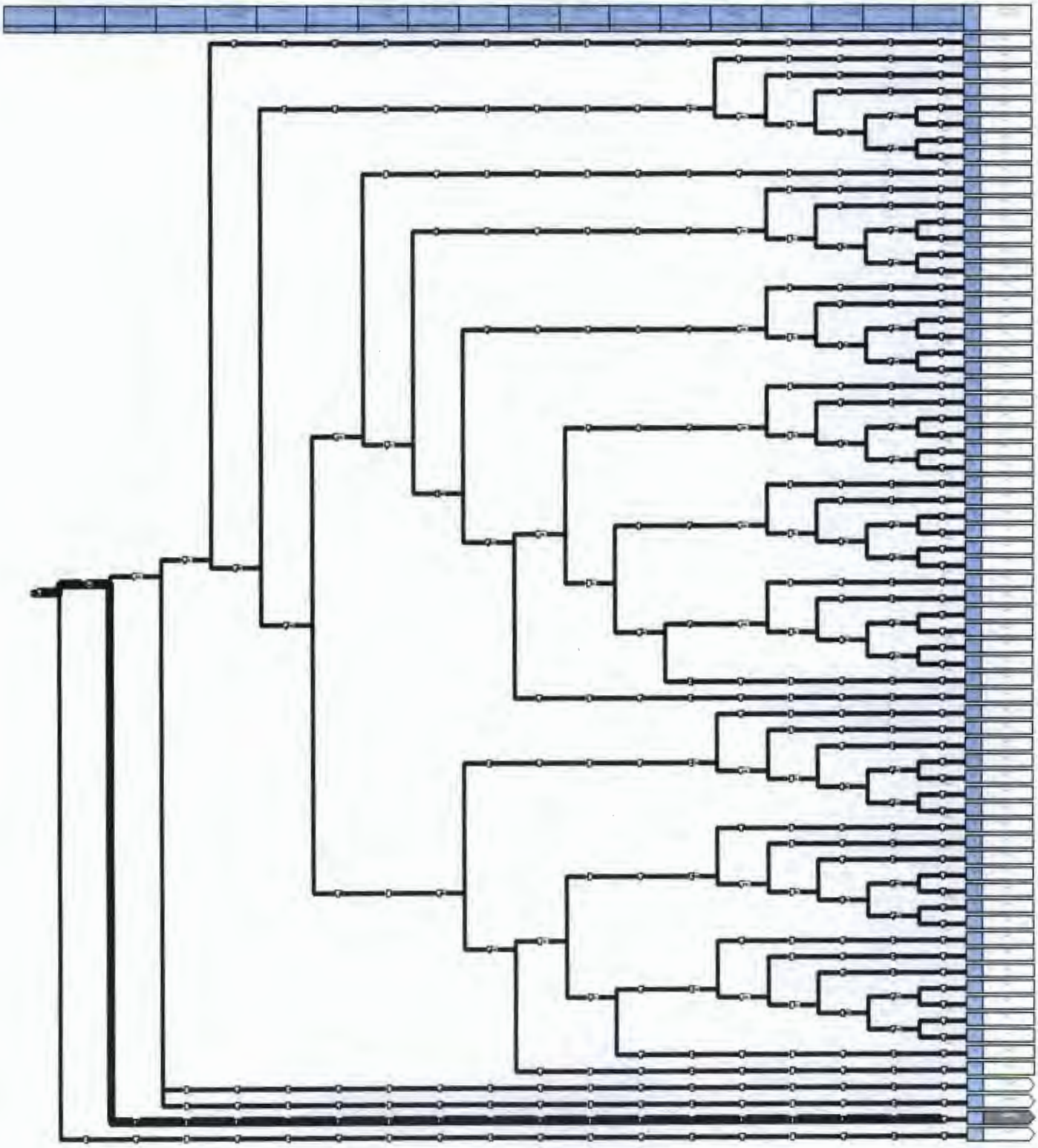

Figure A-1. Clinton Power Station General Transient Event Tree

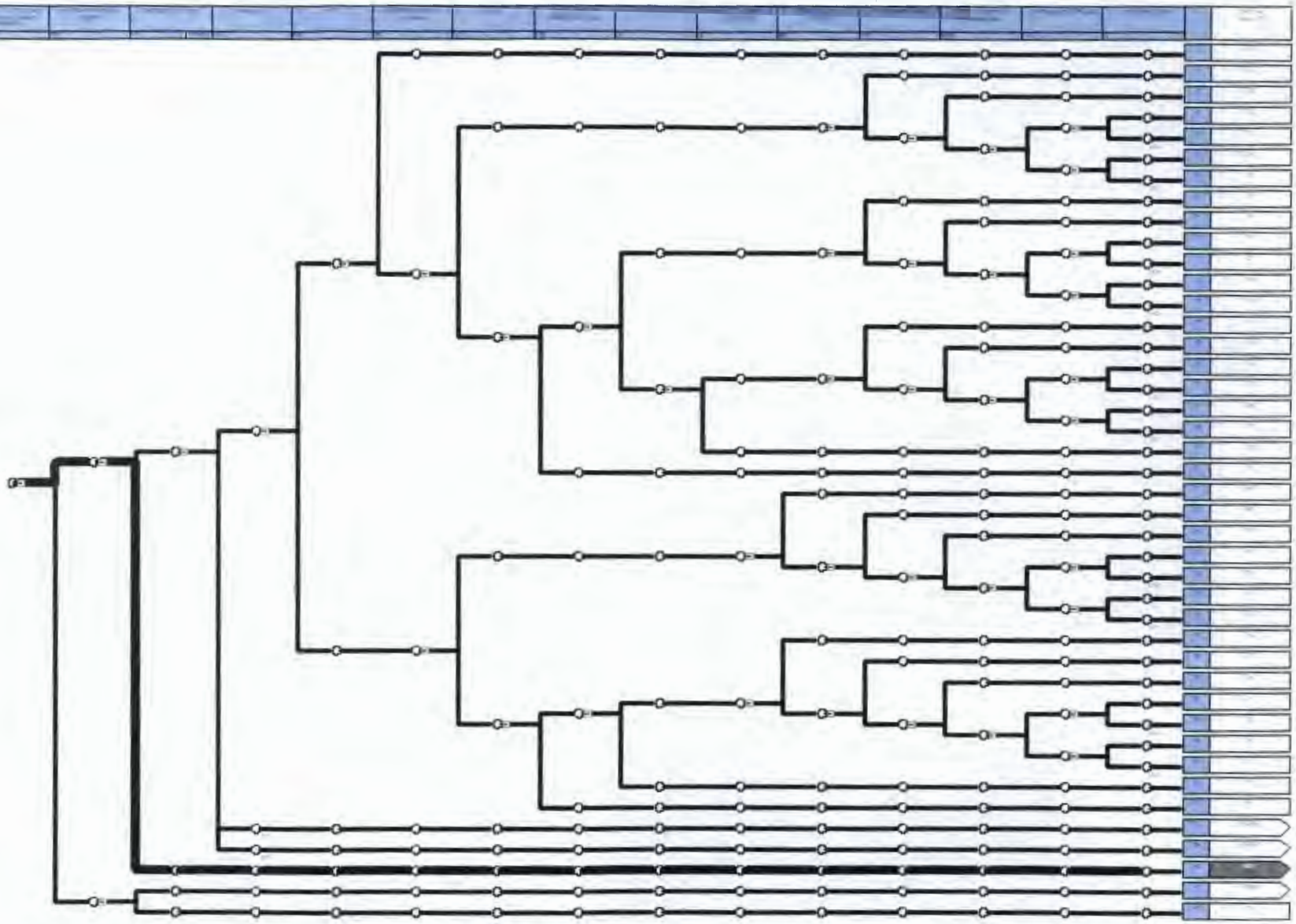

Figure A-2. Clinton Power Station Plant-Centered LOOP Event Tree

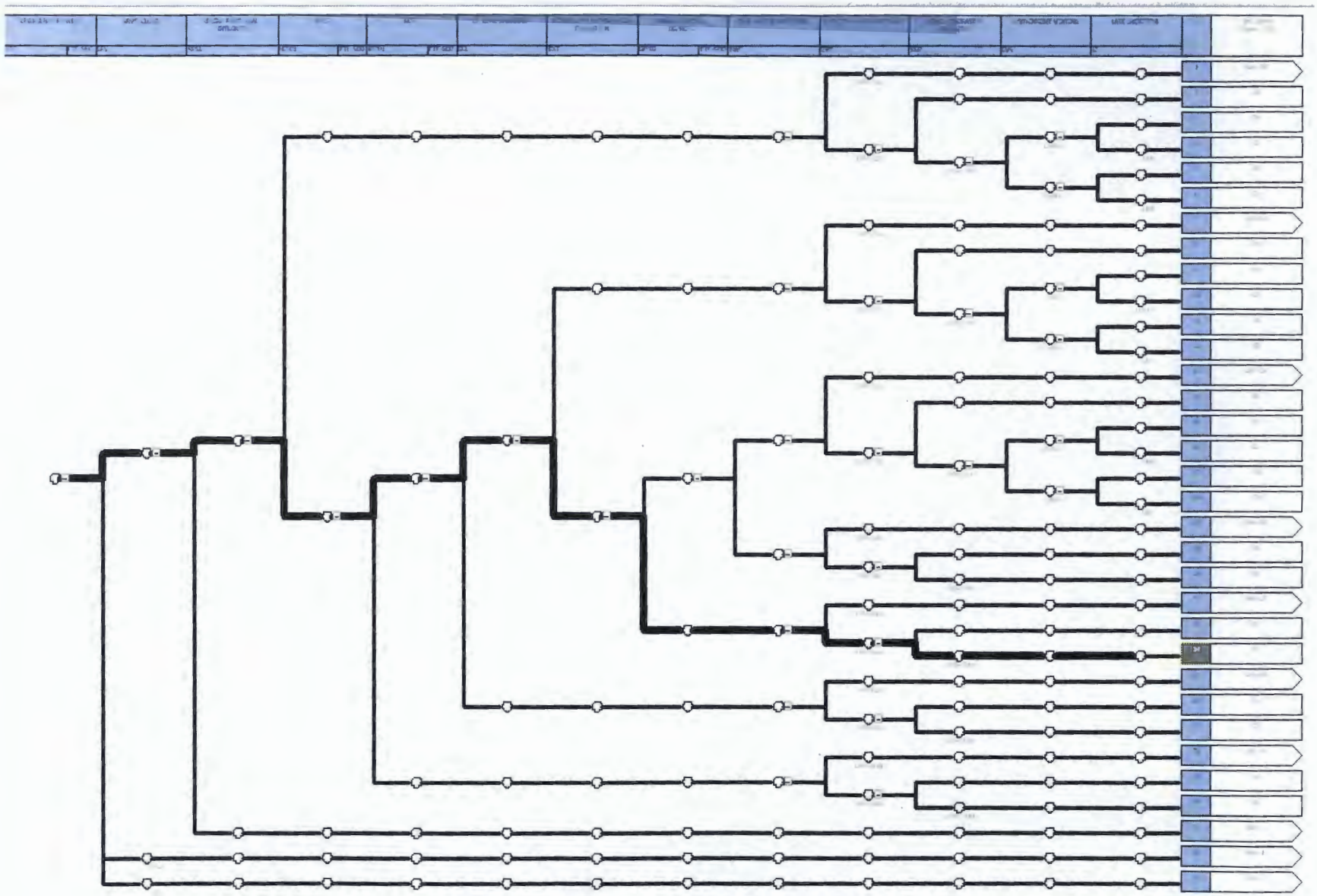

Figure A-3. Clinton Power Station SBO Event Tree

SUBJECT: TRANSMITTAL OF FINAL ACCIDENT SEQUENCE PRECURSOR ANALYSIS – CLINTON POWER STATION, SHUTDOWN SERVICE WATER PUMP (DIVISION 3) START FAILURE (LER-461-2017-008) – PRECURSOR DATED MARCH 13, 2018

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