ATTACHMENT 2
Complex Troubleshooting
(Troubleshooting Data Sheet)
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IR No: 1029126 Station: Braidwood

WR No System:Aux Bldg – SI8811valves

WO No: Component/ETN: 1SI8811A and 2SI8811A/B

Operating Conditions: Full Power

Initial Problem Statement: Tritiated water found under 2SI8811B in Aux Bldg

On 02/05/2010 Operating identified water on the floor under and around valve 2SI8811B. IR# 1026780 was written on 02/06/2010 identifying the issue. It was unknown where the water was originating from but from field inspections the water was not leaking from the overhead and no water was identified on the valve or piping components. There is a long standing issue with ground water originating from the penetration immediately adjacent to valve 2SI8811B. A dam area was constructed under 2SI8811B valve containment to channel the penetration ground water to a floor drain. A sample of the water was taken with a syringe by RP and was analyzed by Chemistry. The results of the sample indicate the following:

- Yellow in appearance (likely due to corrosion of penetration)
- Conductivity of 7340 uS/cm
- PH of 8.7
- Colbalt 58 present 7.2E-05 uCi/g
- Colbalt 60 present 4.5E-06 uCi/g
- Tritium present 4 million pCi/l
- Boron present 54 ppm

On 2/11/10 IR# 1029126 was written to document that the following tritium concentrations have been measured in water that has collected due to rain water or ground water ingress near the SI 8811 valves in the outer curved room area.

- 6/24/09 Valve Enclosure Sample 1,500,000 pCi/L
- 11/01/09 Valve Enclosure Sample 824,000 pCi/L
- 2/5/10 penetration near 2SI 8811B 4,900,000 pCi/L
- 2/11/10 penetration near 1SI 8811A 6,100,000 pCi/L
- 2/11/10 penetration near 2SI 8811A 2,400,000 pCi/L

There are several possible explanations for the high tritium concentration in this water. This could be contamination from spills, such as from the RWST, that can be spilled during refueling outages. Also this could be from tritium in the moisture in the room air that is transferred to any standing water. It could also be from unidentified leaks from water filled components or pools.

N-1

N-2024

☐ Engineering: Chris Bedford, Joshua Duch

☐ Corporate: Dominic Imburgia

☐ Op's: Craig Fobert

☐ Work Week Manager: NA

☐ Maintenance: NA

☐ Project Manager: N/A

☐ Vendor: NA

☐ RP: Hieu Nguyen

Personnel Knowledgeable of the Problems:

NAME	DEPARTMENT	TELEPHONE NUMBER
Raymond Hall, Morgan Davis	ENV	3203/3851
Chris Bedford	SEB	2440
Terry Schuster, John Wilson, Hasan Hannoun	Chemistry	3200/3204/3201

Is equipment Quarantine Req'd ☒NO ☐YES (if yes what equipment?)

Sequences of Events/Time Line: *See initial problem statement above.*

REQ'D ☒ YES (Attach) ☐ NO

Critical Component Impacted ☐ YES ☒ NO

Reviewed By: Raymond Hall Approved By: Terry Schuster

If the complex troubleshooting plan cannot be completed with high confidence document decision to continue operations in Operational Technical Decision Making (OTDM) in accordance with OP-AA-106-101-1006

Troubleshooting Team Lead: Raymond Hall OTDM# NA

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Document troubleshooting results identifying failed component and failure mode and the basis for high confidence (How physical evidence supports defined failed components and failure modes and refutes other potential failures.

Tritiated water under SI8811 valves

Executive Summary -2/18/10

Initial Problem Statement: Tritiated water found under 2SI8811B in Aux Bldg

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There are several possible explanations for the high tritium concentration in this water. This could be contamination from spills, such as from the RWST that can be spilled during refueling outages. Also this could be from tritium in the moisture in the room air that is transferred to any standing water. It could also be from unidentified leaks from water filled components or pools.

A Complex Troubleshooting Team was assembled on 2/12/2010 that was led by Ray Hall (Environmental). Other members of the team included John Wilson (Chemistry), Morgan Davis (Environmental), Chris Bedford, Joshua Duc (Engineering), Craig Fobert (Operations), Hieu Nguyen (Radiation Protection) and Dominic Imburgia (Corporate Environmental).

The problem statement was that water contaminated with Tritium and Co-58/60 was found under 2SI8811B in the Auxiliary Building curved wall area at 364' elevation. All actions in the troubleshooter address the water under all the SI8811 valves in both units and trains collectively. The following three potential causes were identified:

1. Water leaked from above 2SI881B (from plant systems/roof)
2. Water from groundwater contaminated external to Auxiliary Building
3. Water from groundwater contaminated inside the Auxiliary Building

To address the first potential cause that, the water was being leaked in from above the SI8811 valves from pant systems or the roof, the following actions were identified. Operator inspections which included the ACM to check for water on the floor under the SI8811 valves were reviewed. When operators noted that water was on the floor, there were no other signs of water in the area above the valves or on the valves. Water was identified as coming from the pipe penetration area. Additionally a review of historical IRs was conducted and discussed with an Engineering representative. The discussions with the engineer and the review of the historical IRs indicated that a long-standing issue with groundwater leaking in through the pipe penetrations near the SI8811 valves has been previously documented. An action plan to address the in-leakage from these penetrations was already documented in CAP with WR created. WR are still open pending scheduling and completion. The IRs also identified previous roof leakage around these areas. The roof was repair recently and no leaks have been identified in the roof since the repairs were completed. In conclusion there was no evidence that supported that the cause of the water on the floor under the SI8811 valves was from water leaks from above.

The second potential cause was that, the water under the SI8811 valves was groundwater that was contaminated external to the Auxiliary Building and leaking in through the pipe penetrations to the floor. If the contaminated groundwater was leaking in through the pipe penetrations the contamination would indicate that a leak existed in a nearby highly tritiated system. Potential systems identified included Spent Fuel Pool, RWST, CWBD, and PWSTs.

The potential for the groundwater being contaminated from the SFP was investigated by the System Engineer walking down the system and visually observing the tell tails for signs of leakage. No leakage was identified. Operator rounds were reviewed to see if any signs of leakage or abnormal conditions were observed and documented. There were no documented abnormal conditions or signs of leakage. Review of SPF make-up trends and sump run time trends were reviewed to validate that no gross leakage existed. No adverse trends were identified. Sample results from the floor samples taken on 2/5/10 and 2/11/10 along with the sample results from the penetration sample taken on 2/16/10 were compared with the SFP characteristics. Key parameters included Tritium, boron and PH.

System	Boron(ppm)	Conducitivy(us/cm)	Tritium pCi/l	PH
SFP	2496	NA	386,000,000	4.67

Boron concentrations were 54ppm from the floor sample and <1ppm from the penetration. Much higher boron concentrations would be expected to be found if the groundwater was contaminated from the SPF. Tritium concentrations from the floor samples and the penetration were in the range of 2.4million to 6.1million pCi/l. Much higher tritium concentrations would be expected to be found if the groundwater was contaminated from the SPF but could be lower based on dilution. PH from the floor samples and the penetration were in the range of 8.7 to 10.2. A much lower pH would be expected to be found if the groundwater was contaminated from the SPF, although the elevated pH could be attributed to the contact with the concrete as it is leached through the penetrations. All results obtained from actions taken to identify leakage from the SFP indicate that no leakage is occurring and that the analytical results do not indicate that the contamination is from the SPF.

The potential for the groundwater being contaminated from the RWSTs was investigated by reviewing operator rounds to see if there were any signs of leakage observed and documented. No signs of leakage were documented. Review of RWST makeup trends did not show adverse trends. These trends would only validate gross leakage. Sample results from the floor samples taken on 2/5/10 and 2/11/10 along with the sample results from the penetration sample taken on 2/16/10 were compared with the SFP characteristics. Key parameters included Tritium, boron and PH.

System	Boron(ppm)	Conducitivy(us/cm)	Tritium pCi/l	PH
RWST	2379	NA	420,000,00	4.42

Boron concentrations were 54ppm from the floor sample and <1ppm from the penetration. Much higher boron concentrations would be expected to be found if the groundwater was contaminated from the RWSTs. Tritium concentrations from the floor samples and the penetration were in the range of 2.4million to 6.1million pCi/l. Much higher tritium concentrations would be expected to be found if the groundwater was contaminated from the RWSTs but could be lower based on dilution. PH from the floor samples and the penetration were in the range of 8.7 to 10.2. A much lower pH would be expected to be found if the groundwater was contaminated from the RWSTs, although the elevated pH could be attributed to the contact with the concrete as it is leached through the penetrations. All results obtained from actions taken to identify leakage from the RWSTs indicate that no leakage is occurring and that the analytical results do not indicate that the contamination is from the RWSTs.

The potential for the groundwater being contaminated from the PWSTs was considered but was not investigated due to the location of the tanks. A leak from the PWST tanks would not likely flow to this area without first being identified in other areas.

The potential for the groundwater being contaminated from the CWBD line was considered but was not specifically investigated due to the location of the line. Other sample results that will be discussed later indicate that the contamination is from the CWBD line.

3,000-7,000 pCi/L

The potential for the groundwater being contaminated from the Spent Fuel Pool, RWST, CWBD, and PWSTs was also investigated collectively. If the contaminated groundwater was from a nearby highly tritiated system leaking in through the pipe penetrations the contamination would be expected to be found in other groundwater located in this area. Groundwater inleakage was sampled in the 1B/C MSIV and 2 B/C MSIV Rooms at the 377' elevation. This water should be representative of the groundwater in this area excluding any internal contamination in these rooms. The results of these samples that were taken on 2/12/10 showed tritium concentrations in the range of 3668 to 7393 pCi/l and no Co- 58/60 activity. Much higher tritium concentrations would be expected to be found if the groundwater was contaminated from one of the highly tritiated sources listed above. Also MW-BW-201I, MW-BW-202I and MW-BW-203I groundwater monitoring wells were sampled on 2/13/10 for tritium. These monitoring wells would be representative of groundwater that has migrated from the area of concern as these wells are located to the north and east of the area. The primary groundwater flow on the site is to the north-northeast. The wells are sample semiannually per the RGPP and historically tritium concentrations have been < 200 pCI/l. The sample results from the 2/13/10 sampling indicate that the tritium concentrations in all three wells were < 171pCi/l. Sampling the groundwater in the tendon tunnel was also considered but was determined as not needed based on the results of the samples listed above and the potential for internal contamination. Collectively these results indicate that the groundwater has not been contaminated in this area.

The third potential cause was that the water under the SI8811 valves was groundwater is leaking in through the pipe penetrations to the floor and was contaminated internally to the Auxiliary Building. Four methods were used to determine if uncontaminated water could be contaminated by being exposed to the environmental conditions inside the Auxiliary Building.

The first method used to investigate contamination internal to the CWA of the Auxiliary Building was to take smear samples of the floor in the area of the SI8811 valves. The smear sample indicated that the floor is contaminated with Co-58/60 likely due to previous historical spills in this area.

The second method used was to place a 24" berm on the floor in the curved wall area in both the U1 and U2 sides near the SI8811 valves on the 364' elevation. Two liters of DI water was placed in each berm and then sampled at approximately 4 hour intervals for tritium. Results from the U1 berm samples showed concentrations of tritium of 840,000 pCi/l after 4.75 hrs of soak time and a maximum of 4.2million pCi/l after 11.75 hrs. No additional samples could be taken after the last sample due to no sample volume being available due water removed during previous sampling and evaporation. The U2 berm was sampled after 2.5 hrs of soak time and yielded a tritium concentration of 391,009 pCi/l. The U2 berm could only be sampled one time due to no additional sample volume being available due to possible leakage and evaporation. The results of this test indicate that it is possible to contaminate clean water to very high levels of tritium concentration as found in the water samples collected under the SI8811 valves by just being exposed to the floor surface and air in the CWA of the Auxiliary Building.

The third method used to determine if clean water could be contaminated by the Auxiliary Building environment in the CWA was to place a bucket in the U1 and U2 areas near the SI8811 valves. Four liters of DI water was added to the buckets and then sampled approximately 8 hrs after the water was added and then at 4 hr interval after the first sample. The U1 bucket sample after 8 hrs yielded a tritium concentration of 286,050 pCi/l with a maximum value of 4.9million pCi/l after 20hrs. The U2 bucket sample after 9 hrs yielded a tritium concentration of 48,385 pCi/l with a maximum value of 167,068 pCi/l after 28hrs. Although the same maximum values were not achieved in both units, this test does indicate that it is possible to contaminate clean water with tritium by being exposed to the atmosphere in the CWA of the Auxiliary Building.

The fourth method used to determine if clean water could be contaminated by the Auxiliary Building environment in the CWA was to place a dehumidifier in the U1 and U2 areas near the SI8811 valves. The dehumidifiers were placed in area of the SI8811 valves and ran for 5 days and still did not yield any volume of liquid to sample. This test yielded no results.

In summary, based on the investigation documented above, there is no indication that the groundwater leaking into the Auxiliary Building through the penetrations on the 364' elevation in CWA near the SI8811 valves is externally contaminated. The groundwater that is on the floor under the SI8811 valves appears to be leaking through the pipe penetrations and is being contaminated by the internal environment in the CWA of the Auxiliary Building.

Troubleshooting Team Lead: Raymond Hall

Date: 2/18/10

Not in Scope

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Data Gathering Checklist (Check box for data attached)	
Internal Sources:	
Documentation	Recorded Data
☒ Interviews	☒ Operating Logs
☐ Correspondence	☐ Maintenance Work Packages and Records
☐ Internal Sources	☒ Inspection Records
☐ Industry Bulletins	☐ Equipment History Records
☐ EPIX Records	☐ Strip Chart Recordings
☒ OPEX Records	☐ Trend Chart Recordings
☒ Procedures and Instructions	☐ Sequence of Event Recorders
☐ Vendor Manuals	☐ Radiological Surveys
☒ Drawings and Specifications	☐ Plant Parameter Readings
☒ Sample Analysis and Results	☐ Post Maintenance/Mod Test Results
☐ Design Basis Information	
☒ Previous CRs	**External Sources:**
☐ Written Statements	☐ Correspondence
☐ PRA	☐ Industry Bulletins
☐ **Part 21 Records**	☐ Vendor Contacts
☐ Recent Mods to SSC	☐ NRC NRR

Suggested Topics/Questions to Support Failure Modes Analyses	
☐ What is the purpose/function of the system/component?	☐ When did the failure(s) occur? How do you know for sure?
☐ How is the system/component designed to work?	☐ Could the unwanted energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) have been deflected or evaded?
☐ How does the system/component really work?	☐ Have all reasonable failure modes been identified?
☐ What components are potentially involved?	☐ Were adequate human factors considered in the design of the equipment?
☐ How is the system/component supposed to be operated?	☐ Have similar failures occurred before at Exelon stations or the industry?
☐ How is the system/component really operated?	☐ Is the system/component properly labeled for ease of operation?
☐ Are vendor operation and maintenance recommendations followed?	☐ How was the failed component maintained?
☐ Is there sufficient technical information for operating the component properly?	☐ What is the maintenance history for the system/component?
☐ What is the operating history for the system/component?	☐ Is there sufficient technical information for maintaining the component properly?
☐ What form of energy (e.g., motive power,	☐ Did the environment (e.g., humidity, vibration, etc.)

control, power, instrument air, hydraulic fluid, etc.) caused the first component/subcomponent to fail?	have an effect on the problem?
☐ What form of energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) caused the second, third, etc., component/subcomponent to fail?	☐ Could the commercial grade dedication process have contributed to the failure(s)?
☐ Was this energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) supposed to be present or was it undesirable?	☐ Could this failure affect the opposite train/unit? If **not**, why?
☐ What failed first?	☐ Is this failure also on the opposite train/unit? What is the difference? Why is it different?
☐ Could something have failed earlier than the time of the event?	
☐ Did any thing else fail as a result of the first failure?	
☐ What barriers existed between the energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) and the first failure?	

ATTACHMENT 2(Failure Mode Tree)
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PROBLEM

Water contaminated with Tritium and Co-60 found under 2SI8811B in Aux Building

CAUSE 1

Water leaked from above 2SI8811B (from plant systems/roof)

1) Observe area to determine origin of water. – No water observed from above.
2) Long standing issue with groundwater. All water contained within bermed area. Confirmed with Engineering and historical IRs.

CAUSE 2

Water from groundwater contaminated external to Aux Bldg.

1) Sample groundwater in MSIV room. – Sample results were 7400 pCi/L No Co-58/60.
2) Sample nearby ground water monitoring wells for tritium. Co-58/60 will not be sampled because it's affinity to be absorbed in soil.
3) Sample tendon tunnel- Not completed due to other sample results and potential internal contamination.
4) Check leakage from
   a. Fuel pool
   b. RWST
   c. CWBD
   d. PWST

CAUSE 3

Water from groundwater contaminated inside the Aux Bldg

1) Floor or air contaminated in the aux building.
   a. Pool created in CWA of deionized water. Measure tritium over time. – Three measurements yield increasing tritium for U1 DI berm . Only one measurement on U2 DI berm due to no additional sample available. No unusual isotopes were found during analysis.
   b. Smear floors – Smears show floor is contaminated with Co-58/60
   c. Contamination from floor
   d. Contamination from air – U1 and U2 dionized water buckets show increasing trend with tritium concentration.

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Failure Mode No. 1 Description: Water leaked from above the 2SI8811B (from plant system/roof)			
	Refer to Attachment 4 for examples of risk and rigor determination for steps below	Results *Expected results are based on system operation as designed, not as failed	Owner Status

Cause(s)	Validation/Action Steps	Expected	Actual	
Observe area to determine origin of water.	Observe area to determine origin of water. Operator inspections (ACM round data) did not identify any process water sources over head or in the area. Water was identified from the wall penetration. Rigor D	No visual water source observed from overhead	No visual water observed overhead. Visual water source seen from well penetration.	Operations – ACM Rounds Data Review COMPLETE
Long standing issue with ground water. All water contained within berm.	Review historical IRs and discuss issue with Engineering to determine that ground water has been previously identified in this area. Roof was repaired recently and roof leakage was resolved. Rigor D	Corrective actions for the groundwater intrusion in this area have not been implemented. Roof was repaired and is not leaking.	NA NA	C. Bedford – Eng COMPLETE A. Mahadevia - Eng IR Review COMPLETE C. Bedford –Eng COMPLETTE

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Failure Mode No. 2 Description: Water from groundwater contaminated external to aux building.

Cause(s)	Refer to Attachment 4 for examples of risk and rigor determination for steps below Validation/Action Steps	Results *Expected results are based on system operation as designed, not as failed Expected	 Actual	Owner Status
Groundwater contaminated form highly contaminated tritium source (Fuel Pool, RWST, CWBD, PWST)	Sample groundwater in 2 B/C MSIV and 1 B/C MSIV rooms for tritium and Co-58/60 contamination. This water should be representative for groundwater in area except for internal contamination. Rigor D	Low levels for both tritium and no levels of Co-58/60	Tritium levels: 2 B/C MSIV – 7393 pCi/L 1 B/C MSIV – 3668 pCi/L Co-58/60 Analysis – No Co-58/60 identified	Ray Hall – Chemistry COMPLETE Ray Hall – Chemistry COMPLETE
Groundwater contaminated form highly contaminated tritium source (Fuel Pool, RWST, CWBD, PWST)	Sample groundwater monitoring wells in the vicinity and down gradient of potential contamination sources for tritium. Co-58/60 was not sampled due to these isotopes having an affinity for soil. Rigor D	Low levels for both tritium	Tritium levels: All well samples <171 pCi/L	Ray Hall – Chemistry COMPLETE
Groundwater contaminated form highly contaminated tritium source (Fuel Pool, RWST, CWBD, PWST)	Sample ground water in tendon tunnel for tritium and Co-58/60 contamination. This water should be representative for groundwater in area except for internal contamination. Rigor D	Low levels for both tritium and no levels of Co-58/60	N/A	Ray Hall – The team Determined that this sample was not needed based on previous results and potential internal contamination

Groundwater contaminated form Fuel Pool.	Visual observation of tell tails to identify any leakage. Review ops round to see if there are any signs of leakage observed and documented. Review spent fuel pool make-up trends and sump run time trends. This parameter is only valid for gross leakage. Rigor D	No leakage identified during observation of tell tails. No leakage identified during the review of ops round data for fuel pool. No adverse trends identified.	No leakage identified during observation of tell tails. No leakage identified during the review of ops round data for fuel pool. No adverse trends identified.	Josh Duc – Eng. COMPLETE C. Fobert – Ops. COMPLETE C. Fobert – Ops. COMPLETE
Groundwater contaminated form RWST	Review ops round to see if there are any signs of leakage observed and documented. Review RWST make up trends. This parameter is only valid for gross leakage. Rigor D	No visual leakage documented No change in RWST make up rates.	No visual leakage documented No change in RWST make up rates.	C. Fobert – Ops. COMPLETE C. Fobert – Ops. COMPLETE
Groundwater contaminated form PWST	This cause was ruled out due to location of tank., A PWST leak would not likely flow to this area.	N/A	N/A	N/A
Groundwater contaminated form CWBD	Sample groundwater in 2 B/C MSIV and 1 B/C MSIV rooms for tritium and Co-58/60 contamination. This water should be representative for groundwater in area except for internal contamination. Rigor D	Low levels for both tritium and no levels of Co-58/60	Tritium levels: 2 B/C MSIV – 7393 pCi/L 1 B/C MSIV – 3668 pCi/L Co-58/60 Analysis – No Co-58/60 identified	Ray Hall – Chemistry COMPLETE Ray Hall – Chemistry COMPLETE

Failure Mode No. 3 Water from the groundwater contaminated inside the Aux Building.				
	Refer to Attachment 4 for examples of risk and rigor determination for steps below	Results *Expected results are based on system operation as designed, not as failed		Owner Status
Cause(s)	Validation/Action Steps	Expected	Actual	
Contamination source is from aux building.	Air and Floor - Create a pool in the CWA of deionized water for U1 and U2. Measure tritium concentration over time.	Lower levels of tritium expected.	U1 and U2 DI berm sample results show a increasing trend in tritium concentration over time.	Ray Hall – Chemistry COMPLETE
	Floors - Smear floors in the area.	Floor is contaminated due to historic spills in the aux building.	Floor is contaminated with Co-58 and Co-60	Hieu Nguyen – RP COMPLETE
	Air – Stage buckets with DI water in the vicinity and measure tritium concentration over time.	TBD	U1 and U2 DI bucket sample results show a increasing trend in tritium concentration over time.	Hieu Nguyen – RP COMPLETE Ray Hall – Chemistry COMPLETE
	Air – Stage de-humidifiers in the vicinity and measure tritium concentration over time.	TBD	No sample volume was obtained from dehumidifers.	Hieu Nguyen – RP COMPLETE Ray Hall – Chemistry COMPLETE