

ACE/CCA/RCR Grading Criteria

Date: 8/22/07

Grade	Rating	Issues/Problems
5	Very Good	No changes or only typographical errors
4	Good	Editorial or minor technical changes
3	Satisfactory	Some administrative/technical changes needed (i.e., significance or consequence missing, extent of condition is weak, etc.)
2	Poor (Rejection)	Too many changes needed; investigation was inadequate (Another MRC review required due to quantity or significance of changes, or nature of changes needed could not be determined without further investigation)
1	Unacceptable (Rejection)	Wrong Apparent or Root Cause; CAs/CAPRs don't match the cause

Use of Operating Experience (OE) during Causal Analysis (N/A for QHPIs)

Did OE review include event information from other sources such as INPO and NRC databases? Yes / No

Was OE adequately reviewed for useful lessons learned? Yes / No

Was OE adequately utilized in the development of CAs for this causal analysis? Yes / No

ACE / EACE / CCA / RCR / QHPI

MRC Review / PORC Review

Dept: RP

CR #: 632816

Grade: _____

NM/3

Root Cause Analysis

1. **Title:** High Winds Caused Tritiated Water from West Waste Water Treatment (TR) Lagoon to Spill onto the Ground due to procedural inadequacies and cross contamination.
2. **Unit(s):** Braidwood Unit 0
3. **Event Date:** 05/23/07
Event Time: 1055
4. **Action Tracking Item Number:** 632816
Report Date: August 16, 2007
5. **Sponsoring Managers:** John Moser, RP Manager
6. **Investigators:**
 - Dan Morse - RP (Team Leader) Root Cause Qualified
 - Roxana Taylor - Maintenance, Root Cause Qualified
 - Scott Butler - Training, Root Cause Qualified
 - James Crawford - Maintenance, Root Cause Qualified
 - Bob Claes - Chemistry
 - Brian Bergmann - Operations
 - Jim Gosnell - Engineering
 - Dave Kapinus - Project Management
 - Karen Eppers - Organizational Specialist
 - Tim Meents - Chemistry
 - Sondra Massey - Security (Developmental Root Cause Personnel)
7. **Executive Summary:**

Reason for the Investigation /Scope of the Review

On 5/23/07, high winds caused tritiated water from one of two concrete lagoons just west of the plant to lap over one side to the ground. Approximately 1,500 gallons of water from the west lagoon was deposited to the ground. The spill was a 24-hour reportable event to State and Local agencies under the Exelon Reportability Manual RAD 1.34, "Release of Radionuclides at Nuclear Power Plants." No notification to the NRC was required. Based on the significance of this event, a root cause investigation was initiated.

During the investigation, it was determined that the plant's east lagoon also contained significant concentrations of tritium. These lagoons discharge to the station cooling lake, which has led to the administrative limit for activity input to the lake (4 Curies/yr) to be exceeded. The OCC was staffed to respond to the

spill, to understand and address the tritium concentrations within plant systems, and to assess the ability for tritiated water to be introduced into clean/non-contaminated systems or locations.

Immediate Actions Taken

- To prevent additional spillage, berms were installed around the lagoons and bladders were staged to collect the water. This included stacking sand bags around the edge of the lagoon to prevent further lapping of the water.
- Floating booms were also placed in the lagoon to limit further wave motion. Additionally, the standing water on the ground (approximately 200 gallons) was vacuumed into a portable container.

Root Cause, CAPRs, Extent of Condition, and Extent of Cause

(Root Cause 1) EN-AA-103-0002 "Maintaining Environmental Equipment" did not properly identify environmental equipment on Attachment 1, to ensure TR system repairs were made in a timely manner. Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority.

- **(CAPR1)** Update EN-AA-103-0002 Attachment 1 for Braidwood based on Byron Attachment 2 for applicability at Braidwood.
- **(Extent of Condition)** Each site review EN-AA-103-0002 to re-evaluate the environmental equipment listed to ensure proper coding.
- **(Extent of Cause)** The SOC was unaware of the EN-AA-103-0002 requirements. The SOC has demonstrated awareness of all procedural requirements for prioritization of equipment repair, with the exception of EN-AA-103-0002.

(Root Cause 2) BwOP WM-2 did not contain guidance on checking lagoon levels before starting pretreatment.

- **(CAPR2)** Revise BwOP WM-2 for guidance on checking lagoon levels before starting pretreatment. (Completed)
- **(Extent of Condition)** Station procedures for filling systems and tanks, the Main Cooling Lake, and Sewage Treatment include one instance where additional controls to prevent an environmental discharge were warranted (BwOP CW-9). IR 658901 was written to address BwOP CW-9. This applies to other sites.
- **(Extent of Cause)** The lack of procedural guidance was a result of informal communication and system operations. Operations is assigned an evaluation for similar items in OP-BR-101-111-1002, "Braidwood Operations Craft Capability".

(Root Cause 3) Tritiated water was allowed to siphon from the east (contaminated) to the west (non-contaminated) lagoon through a transfer hose.

- **(CAPR3)** Revise BwOP TR-1, "Waste Water Treatment System Startup", and BwOP TR-2, "Waste Water Treatment System Shutdown", to address operation of the TR lagoon pumps. Revision needs to address control of the hose between the two TR lagoons. Remove operation of TR lagoon pumps from OP-BR-101-111-1002.
- **(Extent of Condition)** A temporary sump was used as a tool, which bypassed the original designed location. Incorrect operation of the tool caused cross contamination between systems. This can apply to any site.
- **(Extent of Cause)** Operations procedures for Sewage Treatment, Temporary Sump Pumps, Tritium Remediation Equipment, and Wastewater Treatment were reviewed for other similar occurrences of informal operations. Issues 658529 and 658567 were written for problems identified with Wastewater Treatment. Instances of temporary equipment installed in the other systems were properly evaluated and tracked by the associated procedure. This can apply to any site.

Risk Assessment

The risk associated with the event is high as a result of:

- Lack of procedural guidance for the TR system.
- Lack of prioritization of repairs in the TR system.

The result was spill of the west lagoon to the ground after the west lagoon had become cross-contaminated.

Reportability

This event was reportable to the State of Illinois per RAD 1.34 of the Exelon Reportability Manual based on a water spill of concentration greater than 200 pCi/l as a new release that could affect ground water. It was not reportable to the NRC.

Previous Events:

No similar events at Braidwood or the other Stations were noted during this review. No actions were identified that could be used in the development of corrective actions in this root cause.

8. **Event Description:**

The following sub-sections are included for this section:

- Event Summary
- Background Information and Event Timeline
- Tritium Concentrations in the Plant Prior to or as a Result of Reprocessing Water
- PW System Leaks
- TR System Problems
- Other Items

Event Summary

At 1055, on May 23, 2007, a Chemistry Technician noticed that the wind from the south was pushing water over the north side of the west Waste Water Treatment (WWT or TR) lagoon (retention pond) onto the surrounding gravel/rocks. The Chemistry Technician was performing a routine check of the TR system ODCM (Off-site Dose Calculation Manual) compositor when he noticed the lagoons were full. The Chemistry Technician observed the west lagoon overflowing and notified Operations of the problem.

To prevent additional spillage, berms were installed around the lagoons and bladder tanks were staged to collect the water. This included stacking sand bags around the edge of the lagoons to prevent further lapping of the water. Floating booms were also placed in the lagoons to limit further wave motion. Additionally, the standing water on the ground (approximately 200 gallons) was vacuumed into a portable container.

The lagoons (labeled east and west), concrete storage pools just west of the plant, hold wastewater from the plant before being processed by the Waste Water Treatment System that discharges to the station cooling lake. Each lagoon is 60 feet wide, 240 feet long and holds about 500,000 gallons of water. They are within the Protected Area approximately 500 yards from the station property line.

The water lapping over the edge of the lagoon was visually observed and it was determined that approximately 1,500 gallons of water was deposited on the ground. All of the water that was spilled over from the west lagoon remained on Braidwood property and, based on modeling performed during the Tritium 2 effort, is not expected to migrate offsite at concentration above 200 pCi/l. The tritium concentration of the water in the west lagoon was approximately 75,000 pCi/l. The west lagoon was operated with the intent to remain non-contaminated. The normal inputs to the west lagoon are clean non-radioactive water from the river via the holding pond and the make up demineralizer system (MUDS) pretreatment system. The west lagoon water did not contain any other detectable radionuclides.

The causes of the water flowing out of the west lagoon were the result of excessive inputs from the TF, TE, and pretreatment systems (that feed TR) that caused the lagoon levels to increase, and TR system deficiencies. Two of the three quadricell feed pumps were broken limiting processing of the lagoons to the lake to lower the level. The startup of pretreatment (without checking the west lagoon level) provided an additional input that exceeded system capability. Although the west lagoon only receives input from pretreatment, it could not be pumped to the east lagoon due to excessive level in the east lagoon, resulting in the west lagoon overflowing.

The east lagoon normally contains tritium at concentrations of 50,000 – 70,000 pCi/l due to input from Turbine Building floor drains. However, the east lagoon contained a significantly higher concentration (~2,335,000 pCi/l) due to an input from the Primary Water (PW) system through a failed rupture disk in the PW vacuum catch tank. The only method of contaminating the west lagoon was siphoning of water from the east lagoon to the west lagoon via the installed portable submersible pump and hose.

Background Information and Event Timeline

Attachment 4 (Event and Causal Factor Chart) contains numerous items that comprise two overall timelines, representing the TR system and recycle operation. The following discussion contains only the higher-level items that are pertinent in understanding what occurred.

On November 23, 2005, Braidwood Station stopped liquid releases to the Kankakee River via the blowdown pipe as a result of tritiated water being found on site and offsite. The concentrations of tritiated water exceeded the drinking water limit of 20,000 pCi/l. This is addressed in IR 428868 and the associated Root Cause Report. As a result of the decision not to release liquids to the river, the Station still needed to process water from the reactor coolant system (RCS) and other sources. One aspect of managing this was the use of FRAC tanks to provide temporary storage of the processed water. The other significant actions were centered around physical modifications that could be made to the plant to: 1) reduce the amount of water to be processed, 2) restore the Primary Water Storage Tanks (PWSTs) to the original design as permanent tanks containing tritiated water, and 3) erect a new tank (and associated piping) to contain and allow the management of highly tritiated water. Several project teams were put together to address the various issues associated with the tritiated ground water. One team reviewed the management of water (both short-term and long-term) and worked on the physical modifications that could be made. This team was known as Tritium 1. The Tritium 2 team focused on characterization of the groundwater, remediation of past spills and the regulatory and community outreach. The decisions made during this time frame directed Braidwood Station to change to a recycle mode of operation.

In February and March 2006, new radwaste processing equipment was installed in the radwaste building to assist in the processing and purification of liquid radwaste.

Tritium concentrations in plant systems prior to or as a result of reprocessing water

On 2/20/06, IR 456328 was generated to document the fact that the PWSTs were going to contain (in the near future once EC 359102 was completed) primary grade water with elevated concentrations of tritium. The IR requested changes to BwOP PW-9 to not allow the use of water from the PWST to be supplied to the CSTs if the MUDS were not available. This demonstrates there was knowledge (on some level) of the tritium concentrations that would be seen in the PWST. The originator (Operations SRO) of the IR realized the water in the PWST was not to be used in the secondary systems at the Station. The IR is silent of the expected tritium concentrations in the PWST. **(Contributing Cause 2)**

On 2/22/06, IR 456970 was generated documenting tritium concentrations of $4.576E-5$ uCi/g (45760 pCi/l) being found in the water in the OC Blowdown Monitor Tank. This was unexpected from the Operations point of view. A work group evaluation was performed by Chemistry. The evaluation noted that tritium has been in the secondary systems for "awhile". The evaluation states "the source of tritium in the secondary side is from primary to secondary leaks, or leaks via the cross-tie of the SGBD system with the CV system resin flush and removal headers." The evaluation also stated that tritiated water from the secondary systems is routed through Waste Water Treatment (WWT or TR) and this is a monitored pathway as part of the ODCM. Note: This monitoring is performed up to a month after the discharge through a sample taken from the compositor. The wording used in the evaluation normalizes the presence of tritium in the secondary systems. This is considered **Missed Opportunity #1. (Failed Barrier 1, Causal Factor 1)**

On 2/22/06, IR 457323 was generated by the Station CAP Manager to clearly document the presence of approximately 40,000 pCi/l of tritium in the secondary water on both Units. A work group evaluation was performed by Chemistry. Many of the same words used in the response in IR 456970 were used in the response to this IR.

On 3/6/06 in response to the review of EC 359102, RP generated IR 462432 to document that the PWST modification would result in the presence of radioactive material in the PWST. There is very little information in the IR. The recommended action was for "RP to evaluate proper postings associated with the PWST modification." A work group evaluation was performed by RP. The response focused on controlling access and posting the entry hatch to the PWST. The response noted that Operations had already posted all the PW drops in the

Turbine Building. Nowhere in the IR or response is the type/concentration of radioactive material discussed. The IR originator was interviewed.

He stated he became concerned when reviewing the EC because he realized the processing equipment used to clean up the water before it was sent to the PWST would not be able to remove all the radionuclides. He stated he was concerned with beta, gamma and alpha emitters, but no thought was given to tritium and the associated concentrations it would eventually get to in the PWST.

On 3/7/06, IR 463042 was generated to consider secondary system radiological controls based on other IRs documenting tritium concentrations in the secondary water. The work group evaluation noted that postings and bioassays were not required for the concentrations of tritium in the secondary systems. However, the interpretation of the 10CFR20 exemption was incorrect. Because of this misinterpretation, postings were not placed when they should have been. This is **Missed Opportunity #2. (Failed Barrier 1, Causal Factor 1)**

On 3/13/06, IR 465719 was generated to document a spill of tritiated water from the FRAC Tank berm when wind caused the berm wall to collapse. A root cause investigation was conducted. The root causes were: 1) Berm design, construction and installation did not account for degrading the integral "A" frame design of the berm wall due to high winds or objects falling upon the berm wall; 2) Inaccurate risk perception resulted in a lack of standards with regard to tritiated water inside of the FRAC tank berm; and, 3) Standards, Policies or Administrative Controls (SPACs) were not established to ensure proper monitoring and control of water in the FRAC tank berm. As a result of this event and the investigation, the sensitivity of tritiated water getting anywhere to the ground was raised.

On 3/18/06, EC 359102 (titled "Allow the PWST to be used for storage of tritium and implement the necessary calc, document, procedure and process changes") was approved. This EC evaluated using the PWST for storage of tritium from recycled radioactive water, including system interfaces, design document changes (UFSAR, Tech Specs, drawings, etc.), procedures and process changes. The EC was performed because the PWST had only been used to store demineralized water, although designed to hold demineralized and recycled water. Section 4.1.20 "System Operating Requirements" of the EC stated "The design basis of the systems that PW interfaces with has not been changed from their original design basis regarding the interface with PW." Section 4.1.22 "Procedure Changes" primarily identifies procedure changes to indicate the PW system would contain radioactive water. It did list revising BwOP PW-M1 to "Change valve line-up as appropriate to prevent radioactive water from entering non-radioactive systems." Section 4.1.24 "System Interface Requirements" stated "The focus of the review (system interface review) was to identify interfaces with non-radioactive systems, structures or components." Six recommendations were made as a result of this review:

- Designate PW lines in Passport as radioactive

- Reasonably quantify the amount of gasses released from the PWST vent and add into the ODCM
- Install a test well to monitor ground water in the vicinity of the PWSTs
- Evaluate the use of berms or eliminate storm sewers in the vicinity of the PWST
- Drains from the PW make-up sample panel to the Steam Generator Blowdown Sample Sink need to be isolated before the sink or re-routed to an appropriate location. This was needed to prevent the introduction of radioactive water into the secondary side of the plant.
- Due to concerns of leakage of PW water past check valve 0WX283, valve 0WX282 should be maintained closed to isolate the two systems. An ATI was created to determine if 0WX283 should be included in the Preventative Maintenance Program.

The following is contained in the EC: "Check valve 0WX283 provides isolation between the Demineralizer Water System (WM) and the Primary Water System. Line 0WM68A3" may be used to supply make-up to the PW System. Once the PW contains tritium, leakage through the check valve could potentially contaminate WM. **Recommendation:** For the interim, Valve 0WX282 shall be maintained closed (consistent with Mechanical Lineup procedure BwOP WX-M2, Rev. 13) to isolate the two systems. If the original system configuration (0WX282 open) is desired, the leak tightness of Valve 0WX283 must be ensured. ATI#549009-01 has been opened to determine if 0WX283 should be included in the Preventive Maintenance Program". Based on this information, the potential to contaminate WM was understood. However, leakage past valve seats was not addressed. Review of the ATIs under AR 549009 shows that a WR was created for disassembly of 0WX283 but the work was never done. Also, it was determined that the valve will not be added to the Preventative Maintenance Program.

The recommendations of EC 359102 did note potential cross-contamination with SD (SG Blowdown) and through WX. Section 4.1.26 (item #3 "On-site radiological Consequences") briefly discusses tritium. It does not list any quantity/concentration in any of the systems discussed. This section also states "The recycling of water in the PWSTs will eventually appear in other systems. The Radiation Protection Program is designed to monitor and resolve radiation issues in the station."

The ALARA Design review (Attachment 1) of EC 359102 contained only 5 sentences (4 lines). This review could have been more detailed. The Passport notes panel for Attachment 1 states "This form was approved by (design engineer) for (RP) based on a phone conversation on 3/16/06 at 1800."

The EC did not discuss the expected tritium concentrations in PW or other systems and also did not discuss the timeframe for elevated concentrations of tritium. The scope of the EC was to determine whether plant changes affected the original design of the plant with respect to holding tritiated water. The EC did not attempt to put the expected concentration of tritium in PW in context (what the numbers meant). This is considered **Missed Opportunity #3. (Failed Barrier 2, Causal Factor 2)** The PW System Manager was interviewed. She stated she had only recently become aware of the extremely high concentrations of tritium 0.30uCi/g (300,000,000 pCi/l) in the PW system.

On 3/18/06, IR 467997 was generated to document the new lower limit of detection (LLD) of 200 pCi/l for tritium. This replaced the previous LLD of 1670 pCi/l for environmental samples.

On 3/20/06, IR 468645 was generated to question how the use of PW would be addressed in the Auxiliary and Turbine Buildings. Several examples/questions were presented in this IR. The IR response did not discuss the current tritium concentration in PW or the tritium concentrations in the future. This IR was closed to ATI 467734-01. This action was for engineering to "Review the recommended actions contained within EC 359102 and document whether the recommended actions will be pursued. For those being pursued, assign ATI's as required to ensure the recommendations are addressed." It had a due date of 3/30/06. The ATI for which this was closed is from a MREQ type AR, not an IR. IR 468645 was coded as a level 4 IR. This ATI was completed on 11/27/06 after being extended **20 times** waiting on Washington Group International (WGI) to complete the revision of the EC, including addressing PORC comments. The following reflects the responses in the ATI for the 6 recommendations from EC 359102 discussed above:

- Actions had been taken and documented in IR 462432 and its assignments
- No further action required as the amount of tritium vapor lost is insignificant with respect to the reported monthly releases
- Existing sample wells are adequate so no further actions were necessary
- ATI 467734-02 created to present a recommendation to PHC
- EC 361961 was installed during A2R12 to reroute the drains so this is complete
- ATI 549009-01 was created to track this item

Eight months to get the information above is inappropriate. This shows the Station did not have a sense of urgency in dealing with these issues.

Similar issues existed in IR 468754 written on 3/20/06. The originator questioned the ability to detect a small leak from PW into TF (and eventually into TR). Chemistry's response in the IR was that all releases through TR are a monitored path. IR 95538 (February 2002) was referenced in the response by Operations for this IR. In this IR, 100,000 gallons of PW leaked to TF and was not noticed for 2 weeks. This is considered **Missed Opportunity #4. (Failed Barrier 3, Causal Factors 1, 2 and 4)**

Numerous other IRs (469468, 469425, and 469514 for example) were generated in March 2006 that could have allowed the Station to understand the complexity and severity of the tritium issues. IR 469514 raised questions about keeping the lake below the 4 Curie administrative limit and similarities between the iodine in the gas decay tanks and the tritium in the secondary systems. Chemistry performed a work group evaluation and noted that secondary system releases were through a monitored pathway and within the limits of the ODCM. The question about the similarity of iodine in the gas decay tanks was not answered in the evaluation. This is considered **Missed Opportunity #5. (Failed Barrier 1, Causal Factor 1)**

IR 470161 was generated on 3/24/06. One of the statements in the IR was "With current usage of Primary Water vs. inputs into the radwaste system, long-term resolution of storage and release requirements remains to be evaluated by the project. The EPRI guidelines state that some form of liquid release will be required to prevent concentrating tritium concentrations in the plant to the point that will require bioassay monitoring in the Fuel Handling Building." The answer in the IR was that this was being tracked by the tritium project team. This IR shows that the originator had some information about expected tritium concentrations in PW and the potential affect. However, no quantification of the concentrations of tritium in PW was contained in the IR.

A Tritium 3 Team was chartered in March 2006 as part of a fleet-wide assessment. This team was tasked with identifying all the systems on site that could leak radioactive fluids to ground water without being noticed. This effort was performed as a result of the issues at Braidwood with the leaks from the blowdown line. This effort was performed at each Station with the same charter at each Station. Every plant system was evaluated and categorized into one or more of the following: 1) Systems that do or may contain radioactive liquid during normal process, 2) Systems that contain radioactive water during event/accident conditions (i.e. SG tube rupture), 3) Secondary side systems that contain tritium above naturally-occurring level, 4) System is mechanical but does not meet any of the three above, 5) System is electrical or electronic (non-mechanical). The systems that fell into categories 1, 2 or 3 were then further evaluated. Specific evaluation criteria were used to determine if a system (or the system components) "screened in" or "screened out". For those systems that "screened in" and the risk was higher than a predetermined limit, compensatory

actions had to be identified and evaluated. Twenty-nine ATIs were eventually created under IR 515964 to document the responses to the recommendations made by the Tritium 3 Team for those systems/components identified as risk consequences. This is not considered a missed opportunity because this event was outside the charter of the team. The scope of this review did not include cumulative affects or releases through monitored pathways (such as TF to TR to the lake).

IR 472248 was generated on 3/29/06 as a result of the Tritium 3 assessment to document historical releases to the environment from various plant systems (such as Main Steam and Station Heat) that have relief valves that discharge to the environment.

On 3/30/06, IR 472814 was generated to document tritium in the Stator Water systems of both units. Captured in the response to this IR was the response in IR 457323 with statements about the monitored pathway through TR. The RP response also stated "RP is not going to post any system containing tritium inside the Turbine Building. It is known that tritium is in the majority of the water systems in the Turbine Building. RP will continue to post known systems containing tritium outside of the Turbine Building."

IR 472838 was generated on 3/30/06 to document and question the use of WM (demin) water during sludge lancing of the Steam Generators. RP acknowledged WM contained tritium and provided guidance on the actions necessary during these activities.

NOTE: Tritium has been in both Stator Water and WM for a number of years, since both systems are filled from secondary system water (tritiated). This was not common knowledge across the Station, as evidenced by these two IRs.

During the responses in many of the IRs during the March/April 2006 time frame, two different units (uCi/g versus pCi/l) were used, which could have led to confusion about the tritium concentrations in plant systems. Chemistry personnel provided numbers such as 2.43E-6 uCi/g (or uCi/ml) based on the values in the licensing basis. Tritium Team 1, 2 and 3 efforts used numbers such as 2430 pCi/l. There is a significant difference in these numbers and the context the number provides (a factor of 10^9). An example of this is documented in IR 469997. Chemistry spoke in the terms uCi/g with respect to tritium concentrations in plant systems. The pCi/l numbers were used when associated with tritium in the environment. Using two different units prevented comprehension as to what the numbers meant.

On 4/14/06, IR 478730 was generated to document that tritium was found in the west lagoon. Tritium concentrations were 7620 pCi/l and the IR states the levels should be <200 pCi/l. The responses in this IR revealed a failure to address the real issue. Chemistry assumed Ops pumped the east lagoon to the west lagoon, which caused the increase in tritium in the west lagoon. Ops stated they had not and Ops does not pump the east lagoon to the west lagoon. Project Management speculated the increase could have been from the steam release from the 25B Drain Cooler relief on 4/6/06. The issue was closed after Chemistry stated they were satisfied with Ops' response that they do not pump from the east to west lagoon. How the west lagoon became contaminated was at was not addressed. This is considered a significant missed opportunity and is **Missed Opportunity #6. (Failed Barrier 5, Causal Factor 1)** Interviews for this root cause identified the probable cause as backflow from the east lagoon to the west lagoon through a transfer hose. A mixing calculation performed during this investigation showed that the west lagoon could not have been contaminated to 7620 pCi/l by the 25B Drain Cooler relief valve failure event. (Refer to Attachment 5 for a calculation for the west lagoon and the 25B Drain Cooler relief event.) The Root Cause team walked down both lagoons and the only method to contaminate the west lagoon was through siphoning of water from the east lagoon via the temporary submersible pump and hose. **(Root Cause 3)**

On 5/10/06, IR 488843 was generated to document tritium concentrations >LLD in the effluents from the north oil separator. These concentrations were believed to have occurred because of the 25B Drain Cooler relief valve failure. The MRC questioned who was the single owner for tritium, which had previously been the Tritium Teams. The IR response stated "Chemistry has ownership of offsite dose (ODCM) tritium issues and responsibility for sampling and the timeliness of the results. Rad Protection has ownership for day to day contamination control and pumping of the water." During this investigation,(RCR 632816) a key Chemistry individual was interviewed. When asked who owned tritium management, his response was "no one". This individual attends SOC and provided responses to many IRs. **This is considered Missed Opportunity #7. (Failed Barrier 6, Causal Factor 2)**

On 7/12/06, IR 508677 was generated to document the lake was approaching the administrative limit of 4 Curies discharged to the lake for the year. This IR did discuss the tritium concentration in the RCS of 1.3E9 pCi/l and the secondary side of Unit 1 (1E6 pCi/l) and Unit 2 (1E4 pCi/l). The Shift Manager asked why the 2006 numbers were 4 times those of all of 2005 and what can be done about it. These questions were not specifically addressed. The Chemistry response indicated the secondary side tritium concentration were most likely from leaks through WX. The response also stated: "Engineering and Operations are working on a complex troubleshooter and work orders have been created to address the identified valves (IR 513520)".

A significant amount of work was being performed to identify and fix or isolate leaking valves that were allowing communication between the RCS side and secondary sides of the WX system (system cross-contamination). This is discussed in IR 513520. No considerations were given to changing the sampling regimes/frequency to prevent the lake from receiving a significant tritium input. This is considered **Missed Opportunity #8. (Failed Barrier 1, Causal Factor 1)**

On 9/15/06, IR 531688 was generated to document the tritium concentrations in the lake was 134 pCi/l. In late 2005, the lake concentration was 35 pCi/l. The response centered around not running the Exelon Pond pump due to concerns over exceeding 200 pCi/l in the blowdown line.

Liquid releases and remediation effluents to the Kankakee River through the blowdown line were resumed on 10/1/06.

On 10/5/06, IR 540373 was generated by Chemistry requesting an evaluation on the impact to the environment in case a PWST catastrophically failed. The IR states "the tritium concentration has increased to approximately 0.25 uCi/ml with predictions that cycle the concentration in both PWSTs up to approximately 1.3 uCi/g (1,300,000,000 pCi/l) by 2012." This is the first time the future PWST tritium concentration is documented in an IR (as found during this investigation). The response stated that no further action or analysis was needed since the PWSTs were seismically designed and all regulatory/licensing basis requirements were met. The IR stated 0.25 uCi/g rather than 250,000,000 pCi/l. If the value were listed in pCi/l, this may have prompted a better response from SOC and MRC personnel.

On 11/9/06, IR 555795 was generated to document an increasing tritium level in the Unit 1 secondary systems. This increase started after 11/3/06 and the concentration went from 255,000 pCi/l to 363,000 pCi/l. Additional troubleshooting identified leakage from PW into the secondary side at the demin flushing pumps. It also appears that Ops had re-opened some valves as part of the troubleshooting plan that could have caused this increase. IR 556396 was generated to document continuing increasing tritium numbers in the secondary systems. Engineering noted seven locations where spectacle flanges could be installed to create a positive isolation from PW.

On 4/18/07, IR 618654 was generated to question what water sources could be used in containment for various tasks. The IR states the tritium level in PW was 0.3 uCi/g. A SOC member was questioned to determine if he understood what this number meant. He stated he did not realize 0.3 uCi/g was equal to 300,000,000 pCi/l. There were numerous IRs reviewed by SOC over the past several months where the values were discussed in terms of uCi/g.

This IR moved between SOC, RP, Ops and the MRC from 4/19/07 until it was closed on 6/19/07. SOC and the MRC were not educated as to what these numbers meant, both in value and in ramification. This is considered **Missed Opportunity #8. (Failed Barriers 1 and 6, Causal Factor 2)**

PW System Leaks

On 1/9/07, clearance order 50142 was placed for repair of OLE-PW037, isolating the vacuum catch tank. No problems were noted when the C/O was placed.

On 1/31/07, IR 585821 was generated for a minor leak (1 drop per 2 minutes) from the PW Heat Exchanger tube side vent. RP's response was that the water will remain inside the plant with permanent plant processing and no further action with tritium was needed.

On 4/12/07, IR 616048 was generated to document a leak from the flange on the PW Vacuum Catch Tank Level Switch. The IR states "The tank went water solid while in a shutdown condition most likely due to valve leak by." (This is the valve [OPW087] that leaked by and caused the rupture disc to fail on 5/9/07.) This statement is not addressed. This is considered **Missed Opportunity #9. (Failed Barrier 4, Causal Factors 1 and 2)** The RP response states to take actions to prevent the leak from occurring or to install a catch container to direct the leakage to a floor drain where it can be routed to a monitored pathway. The Operations response was that neither is necessary since there is no active leak. The leak was repaired on 4/30/07 via WR 237326.

On 5/7/07, clearance order 52723 was placed for PW flange work, isolating the vacuum catch tank. Based on a review of the TE sump run times, the rupture disc on the vacuum catch tank ruptured on 5/9/07. It is believed the rupture disc (OPW15M) failed because of valve leak by (OPW087) causing the tank to go water solid. The water leaking through the rupture disc went to TE through a hard pipe installed connection. Therefore, leakage past the rupture disc was very difficult to identify. This leak was too small to identify through PWST level monitoring or through the monitoring program maintained by Chemistry. The leak could have been identified by the TE sump run times, which were not trended. The tritium concentration in TR prior to the rupture disc failure was in the 20,000 – 40,000 pCi/l range. After this leak occurred, the tritium concentration in TR increased to 2,335,000 pCi/l. IR 634185 documented the leak by past OPW087. IR 634575 documented the rupture of OPW15M.

On 5/15/07, IR 629946 was generated to document a leak from OPW01T (PW vacuum catch tank) with water flowing down the side of the tank and overflowing the buckets placed to catch the water. It took a week to get through SOC. There are no comments in the IR addressing any actions that were taken to stop the leak or control the water that was overflowing the buckets.

There appears to be a lack of sensitivity in the screening of this IR and the affects of the leak. This is considered **Missed Opportunity #10. (Failed Barrier 1 and 4, Causal Factors 1 and 4)** IR 631058 was generated on 5/18/07 but was considered and processed as a duplicate of IR 629946. The leak was scheduled to be repaired on 7/30/07 under WO 1008886-01 but was actually worked on 5/25/07 during the event response.

The above items associated with PW recycle and system leaks contributed to the severity of the event. At the time of the event, the west lagoon tritium concentration was about 75,000 pCi/l while the east lagoon was 2,335,000 pCi/l. Using these concentrations, it would only take 8290 gallons of water from the east lagoon to contaminate the west. If the same volume of water had been added without recycling, the west lagoon would still have been over 670 pCi/l. If the east lagoon had been overflowed at a concentration of 670 pCi/l, reportability in accordance with RAD 1.34 would still have applied.

TR System Problems

On 7/26/06, IR 513223 was generated to document continuing problems with the health of TR. The IR discusses the low priority assigned to TR components. There is no discussion concerning EN-AA-103-0002 "Maintaining Environmental Equipment" and how the requirements in this procedure could have helped drive the necessary repairs in a more timely manner.

On 9/5/06, IR 527510 was generated to document the need to remove oil from the east lagoon. The IR documented having overflowed the east lagoon in the past and acknowledged tritium in the lagoon at this time. It also stated that high winds and high concentration in the past had caused spillage from the lagoon. An ATI was created to evaluate the recommended action of a 3 year predefine for removing the oil. There were no responses provided in the IR to the other information provided by the originator concerning high levels and high winds that could lead to the potential release of tritiated water to the environment. This is considered **Missed Opportunity #11. (Failed Barrier 5, Causal Factor 3)**

On 12/21/06, IR 572319 was generated to document that OTR04PC (Quadricell Feed Pump) tripped and would not restart. This affected the ability of TR to process water. The OB pump was started to restore flow. The response by Chemistry was that this pump would not start until the Equalization Tank was at the high-high level. Operation's response was that the pump would trip immediately when taken to the normal after close switch position. Work request 228240 was created for repairs. On 12/29/06, the OTR04PC did not start again while the Equalization Tank was at a level requiring pump start (above high-high level).

On 1/13/07, IR 578806 was generated to document that OTR04PB tripped. The IR discussed problems with OTR04PA starting on a high level. The IR stated all three pumps had AR tags on their control switches. This was also affecting the ability of TR to function. The Chemistry response again indicated the cycling of the pumps via a multiplexer to even out the run time of the pumps. Training Request 07-079 was created to train the NLOs on the pump operation.

On 1/19/07, EN-AA-103-0002 revision 1 was implemented. The revision added equipment for multiple sites. In particular, Byron Station added a large portion of the TR and ST systems' equipment. The procedure approval was signed at Braidwood without considering if Braidwood should incorporate a similar change.

On 2/9/07, IR 589841 was generated to request a High Impact Team be put together to identify the inputs into TR and to identify the actions that could minimize the inputs into TR. An ATI was created to form this team. The team never met. The ATI was extended twice with the response of: "Due to current workload/emergent work and availability of resources this team has not been established." The ATI was closed after the lagoon spill and the formation of teams during this event to address these types of issues. This is considered **Missed Opportunity #12. (Failed Barrier 5, Causal Factor 3)**

On 3/2/07, IR 598558 was generated to document continuing problems with the health of TR. This IR discusses problems with the OB and OC pumps. It also discusses lower than expected flows through TR. The Chemistry response regarding pump operation was the same as that discussed in IR 572319. The Operations and Chemistry responses were not aligned so the functioning of the pumps was still not understood. Work request 237593 was generated to create a troubleshooter for these pumps and was scheduled for 8/5/07.

On 3/11/07, IR 602115 was generated to document many long-standing issues in TR. The shift manager review noted there are more than 12 action requests (laundry tags) and 4 ESTs in TR. The Work Control response was that TR is prioritized along with other Station work to meet Station goals and six PM work orders and eight non-PM work orders for the TR system were scheduled for the 3/19/07 workweek. EN-AA-103-0002 prioritization was not mentioned.

On 4/13/07 while researching TR 07-0079, a NLO Instructor noted that the wiring of the relay scheme in the field did not match information on the manufacturer's website. The instructor thought that a wire needed to be installed on terminal 3 to allow the pumps to cycle for even run time. There was no wire on terminal 3 in the field. This was documented in IR 617830. The Chemistry System Owner believes that this jumper will simply allow the OC pump to be manually started at any time. This shows that there is a longstanding dispute about how the TR quadricell pumps cycle. An ATI was created for System Engineering (Electrical Group) to review the relay wiring and provide an independent assessment (to finally answer how the system was supposed to function). WO 1022672 was

created and was scheduled for 7/19/07. These items are considered **Missed Opportunity #16. (Failed Barrier 5, Causal Factor 3)**

On 5/1/07, IR 624083 was generated to document that the west lagoon was half full of lime. This limited the useable volume in the lagoon for water. The IR was closed to ATI 478730 assignment 05. This ATI was to remove the lime from the lagoon, and was originally scheduled to be completed on 3/14/07. The ATI was extended to 9/14/07 per the Chemistry Manager. Removal of the lime had been budgeted since 2005 but was cut each year for other activities. This is considered **Missed Opportunity #13** because it reduced the usable volume of the west lagoon by half. **(Failed Barrier 5, Causal Factor 3)**

On 5/18/07, IR 631243 was generated for a WS leak on the 2B TO Cooler. The leak was isolated but had added a large water volume to the east lagoon.

In each of the above TR system issues, EN-AA-103-0002 was not used by the SOC to screen the work request to a higher-level priority. On 1/19/07, revision 1 to EN-AA-103-0002 was implemented. This revision added a significant amount of TR and ST equipment to the Byron list of Category 1 and Category 2 equipment. Braidwood did not make any changes to their list, as the changes were disregarded as station-specific. The Byron list is 4 pages, while Braidwood's list is 1 page. Byron's classification of TR equipment results in a B2 priority provided to failed equipment that affects flow capability. If Braidwood had performed a similar revision and used the categorization process, problems with TR volume control could have been avoided and the lagoon would not have overflowed. Failure to use EN-AA-103-0002 caused the work request for TR related equipment to be categorized as a "C" priority and a "facility" type code. This is considered **Missed Opportunity #15. (Failed Barrier 5, Causal Factor 3, Root Cause 1)** IR 656448 was generated to document this problem.

In late May 2007, work order 912101 tasks 09 and 11 identified tripped thermals and broken linkage on OTR04PB and OTR04PC, quadricell feed pumps.

Interviews with personnel associated with the event indicate that multiple discussions were held on the weekend of 5/19/07. The status of the lagoons was discussed on the 5/19/07 (Saturday) Plan of the Day Meeting with no specific actions. No formal documentation exists for those discussions.

On 5/20/07, the pretreatment system was started to fill onsite storage tanks with the lagoons nearly full. Pretreatment had been offline earlier in the week for planned maintenance, so Operations needed to fill the Filtered Water Storage Tank and the U1/U2 Condensate Storage Tanks. BwOP WM-2 startup procedure did not address looking at lagoon level prior to startup.

The pretreatment system adds a significant volume of water to the west lagoon. The rate of input during startup has the potential to exceed TR processing capability. With only one quadricell feed pump working (see below), the TR processing capabilities were significantly exceeded causing the west lagoon to overflow on 5/23/07. Also contributing to the issue is that there was no formal monitoring or trending of lagoon levels (e.g. Operation Rounds) at that time. This is considered **Missed Opportunity #14. (Failed Barrier 6, Causal Factor 4, Root Cause 2)**

At 0548 on 5/22/07, the Operations Field Supervisor noted that the TR system was "at the point of overload" and generated IR 632140. This IR documented high volume input since May 1, 2007. It also documents tritium in the east lagoon as well as oil on the surface of the water from the east lagoon. This IR documents continuing problems with TR and the fact that Byron does not have similar problems with their TR system. The IR states that TR is only processing about 35 GPM.

The IR discusses issues with the cuno filters and carbon filters. This IR was with SOC when the event occurred on 5/23/07. IRs 632427 and 632430 were also written on 5/22/07 to document the 0A and 0B Gravity Filters being stuck in backwash.

On 5/23/07, IR 632816 was generated to document the spillage of water from the lagoons caused by high winds. This is the event and the reason this root cause investigation is being performed. As a result of the spillage and identification of the tritium concentrations in the west lagoon, Chemistry was directed to sample all the water systems on site on 5/23/07. Tritium was found in almost every water system on site and in many cases in significant concentrations. IRs were generated for these issues. The OCC was staffed and teams were formed to address the various issues as well as the identification of the inputs into TR.

On 6/17/2007, IR641205 documented the differences between Byron and Braidwood concerning EN-AA-103-0002 Attachments 1 and 2 for prioritization of environmental equipment. EN-AA-103-0002 was viewed by the Chemistry System Manager to be a backup to the Work Control Process instead of an input to the process. By not listing the TR equipment on the EN-AA-103-0002 Attachment 1, the work process did not give the appropriate screening for degraded equipment such as B1 or B2 work order, and therefore, the TR equipment was not repaired in a timely manner.

The Station demonstrated insensitivity to maintaining environmental equipment. All the major pumps and filters at the WWT facility are classified as run-to-failure. A review of open work orders determined that the majority of them are job type F (facility) with a C priority. This classification results in a low priority

for station resources and is inconsistent with applicable Exelon procedures (EN-AA-103-0002 and WC-AA-106).

The PCM procedure (MA-AA-716-201), Attachment 2, for performing a run-to-failure analysis states that if there are adverse regulatory consequences from allowing the equipment to fail then the equipment cannot be classified as run-to-failure. Clearly, TR equipment that is needed to maintain compliance with EPA effluent regulations qualifies for this condition.

The procedure for Maintaining Environmental Equipment (EN-AA-103-0002) Step 4.2.5 states that "environmental equipment shall not be designated as "run-to-failure" unless contingencies are in place to prevent regulatory non-compliance". Chemistry relied on the installed, 100% capacity spare pumps and filters for the contingency but did not consider new contingency actions in the event that one of these failed. Also, a review of open work orders determined that while there are contingency work packages for major pumps, few of them had spare pumps or repair parts reserved (WO 912101).

The purpose of EN-AA-103-0002 is to "ensure that equipment needed for permit or regulatory compliance is maintained in an operational state...". Two levels of equipment importance are defined in the procedure. Category 1 environmental equipment are "those SSCs whose proper functioning is essential for compliance with permit conditions ...(which) includes...: SSCs necessary to remove, neutralize or otherwise reduce regulated or targeted pollutants from air or water emissions or solid waste streams..." Most major components in the TR and ST systems as well as some ventilation systems could be considered environmental equipment. Byron has 4 pages of environmental equipment listed in the procedure while Braidwood has one. In the WWT system for example, Byron lists most of the major equipment in the TR system while Braidwood lists only a flow totalizer.

The Work Screening and Processing procedure, WC-AA-106 recognizes the importance of Category 1 environmental equipment and assigns a B1 priority to their work orders. Braidwood therefore has not given the proper priority to environmental equipment maintenance because these procedures (EN and MA procedures) are not well implemented. **Missed Opportunity #15. (Failed Barrier 5, Causal Factor 3)**

Other Items

The team reviewed benchmarking information (AR 513544) from a trip performed by Braidwood Station personnel (to Harris, South Texas and Wolf Creek) and by MPR Associates (to Duke Energy – McGuire, Catawba, and Oconee). The Braidwood information in AR 513544 was limited to a questionnaire with responses. The MPR report was very detailed. This information was very high level. None of the information got into the details of how these Stations managed the tritium on site and the affects of the recycling on a system level. The spent fuel pool was the only system/component discussed. Braidwood did not capture the lessons learned from these Stations.

The team reviewed CC-AA-212-1001, Configuration Change ALARA Review Guidance. A member of RP management was interviewed to discuss the procedure application. He believed it would be Chemistry's responsibility to identify the high concentration of tritium in any system. In his review of the EC, he stated the water was going to be "clean" (chemically pure). He discussed this with the radwaste vendor and he stated the water out of the ALPS was "clean".

The concern the RP Management person had was low concentration of beta/gamma/alpha emitters and "some" tritium. He generated IR 462432 to document the need for radiological posting changes, but did not address contamination concerns. His responses on CC-AA-212-1001 Attachment 1 indicated potential concerns in both areas. His concern was more related to the beta/gamma/alpha emitters rather than tritium. He stated that RP did not learn until early 2007 that PW tritium concentration was in the hundred thousand-pCi/l ranges. He stated there was concern over the spilling of any of the water because there was tritium in the water. He also stated that tritium was part of the ALARA concern, but he was unaware of the level of tritium in PW. Other members of RP management were interviewed and they indicated they became aware of the high concentration of tritium in PW during some period in 2007 (some were February or March and one was when the lagoon event occurred).

The team reviewed the Benchmarking Report (AR 340677) written for a trip that was taken to Shearon Harris, South Texas and Wolf Creek. There was wording in this report that leads the team to believe there was some knowledge for the people who went on the trip that tritium concentration in some systems would be very high. The report had the following words: "maintaining heightened sensitivity to leaks and spills in the plant. The single largest difference between Braidwood and the plants we visited was each had a clear strategy to aggressively manage effluents and a recognized owner to drive performance." "The levels, contents and concentrations of all tanks on site are closely trended. Strict rules govern the draining of clean systems in the Aux Building to ensure that the water does not enter the radwaste processing system." It does not appear that this information was used as the Station started recycle operation.

The team interviewed the engineer who was responsible for the owner's review of EC 359102 about the modifications and knowledge of tritium concentration. He stated the tritium concentration in the hundreds of millions of pCi/l was never discussed during the modifications. Knowing people could not and would not drink the water from PW was understood. Not allowing the water on your skin was not discussed. He stated Chemistry and RP were involved in reviewing the modification. He said he understood the CC system could get tritium in it since PW was a make-up source. Getting tritium into any other systems was not identified as part of the evaluation. Not using the PW drops in the Turbine Building was identified and implemented.

IR 636122 for NRC comments

This IR was written as a result of an NRC inspection for the event. The IR contains the following.

“Evaluation of the corrective actions for the issues below should extend back to the beginning of the Primary Water Recycling Program approximately April 2006:”

- “Failure in planning, controlling, evaluating job site hazards, and lack of surveys related to the Primary Water Recycling program. 10 CFR 20.1501.”

Root Cause Team Response – The team determined that the initial ALARA review was weak. RP misinterpreted the exception in 10CFR20 when challenged about posting the systems in the Turbine Building. RP and Chemistry (as well as SOC and MRC) relied on all Turbine Building effluents being routed to TR, which is a monitored pathway.

- “Planning and controlling work with regards to considered the TE tank atmospheric vent path including possible exposures and dose assessments. 10 CFR 20.1501”

Root Cause Team Response - RP did not perform a dose assessment or risk assessment to determine if individuals needed to be monitored for exposure to the TE tank atmospheric vent when the high levels of tritium were first discovered in the TE tanks. The tanks vents, on top of the tanks, are vented into the turbine building. As such the vents are about 15 feet off the floor level and do not vent into the normal work or travel path. As stated in IR 637600, RP performed sampling of the vents from 0TE01TA and 0TE01TB on 5/30/2007 and both tanks were less than LLD so there is no dose concern.

- “Failure to consider radiological hazards associated with the installation of a blank flange in the PW System. 10 CFR 20.1501”

Root Cause Team Response - From IR 633717, Individuals Splashed With PW, the root cause team determined that water from the primary water storage tank was splashed on the hands of two Operators who were hanging a catch funnel. They were wearing regular Personal Protective Equipment--gloves which were neither waterproof nor radiological protective clothing. Prior to the job there was no risk assessment through the work planning process for working with the tritiated water. RP did not provide guidance for protection from the radiological hazard. In addition the tritium risk matrix had not been developed and there was not adequate guidance on what protective actions were necessary. Maintenance Planning has added a review matrix to tasks to identify items that need additional protective measures.

- "Failure to consider dosimetry requirements for the changes associated with the recycling of water (areas of Source Term). 10 CFR 20.1502."

Root Cause Team Response - this investigation determined that the initial ALARA review was weak. RP misinterpreted the exception in 10CFR20 when challenged about posting the systems in the Turbine Building. RP and Chemistry (as well as SOC and MRC) relied on all Turbine Building effluents being routed to TR, which is a monitored pathway.

IR 655218 NRC Green NCV – Failure to post radioactive materials area

The following is from this IR and needs to be answered in this report. IR 636141 was originally generated for this issue and was answered by RP through a work group evaluation.

In the Second Quarter 2007 Inspection Report (2007004) the NRC identified a Green Non-Cited Violation of NCV of 10 CFR 20.1902(e) for the licensee's failure to post areas in which licensed material was used or stored. Specifically, two waste water lagoons, located within the Protected Area, and the Turbine Building each contained greater than 10,000 uCi of tritium and were not posted in accordance with 10 CFR 20.1902(e).

The NRC assessed the concentration and volume and questioned whether the lagoons were posted in accordance with NRC requirements. The licensee responded by posting the access point to the lagoons and by reviewing the posting of other areas of the plant including the turbine building.

A walkdown of the turbine building was conducted by the NRC inspectors and the licensee, which identified that some tanks within the building were posted as Radioactive Material but other areas within the turbine building that contained tritium in excess of 10,000 micro-curies (uCi) in secondary-side systems were not posted. The inspectors concluded that the licensee had not adequately evaluated

the radiological conditions to determine if the requirements of 10 CFR 20.1902(e) were met.

The finding involved the ability to protect workers from exposure to radiation.

Work Group Evaluation response (from IR 636141)- Condition/Problem Statement: As a result of the Braidwood lagoon spill follow-up inspection, the NRC will be issuing a Green finding with an associated NCV for 10CFR 20.1902(e) Posting Requirements where the Licensee failed to post Radioactive Materials Areas where tritium values exceeded ten times the value listed in 10 CFR 20 Appendix C.

Statement of Cause: The turbine building piping systems meets the criteria for posting set forth in 10CFR20 appendix C for H3. A review was performed of labeling exemptions listed in 10CFR20 as a result of the lagoon spill event. 10CFR20.1905 (f) states, "Installed manufacturing or process equipment, such as reactor components, piping and tanks" as an exemption. However the regulator stated that this applies to labeling only and no exemption to the posting requirement could be used. When the NRC inquired about radiological posting of the turbine building, a conference call was initiated to discuss appropriate response. The RPM peer group with CFAM concurrence concluded that this was an industry precedence setting determination and that we would allow the Regulator to determine applicability. The RP CFAM is meeting with NEI and NRC to determine consistent industry application.

Extent of Condition: This condition applies to Byron Station and TMI. This issue was communicated across the Fleet.

Evaluation of any SOC Comments: The turbine building, condensate polisher area, and TR was posted IAW 10CFR20 upon exit and notification of the violation. The postings that are currently in place would have satisfied the posting requirement prior to the recycle campaign. Additional elevation of H3 concentration will not require a change or additional posting other than what is currently in place.

Root Cause Team Response – The response provided above is accurate.

IR 655173 – NRC Green NCV – Failure to implement a Radiation Protection Program

The following is from this IR and needs to be answered in this report. This item will be answered by answering the 4 items listed under IR 636122 above. IR 636122 was generated to capture the NRC's concerns at the end of the inspection.

In the Second Quarter 2007 Inspection Report (2007004) the NRC identified a Green Non-Cited Violation of 10 CFR 20.1101(a) for the licensee's failure to implement a radiation protection program commensurate with licensed activities and the ongoing radiological issues at the plant. Specifically, radiological controls were not effectively applied to secondary systems, which contained contaminated (tritium) fluids, to ensure that worker exposures and radiological effluents were fully monitored and controlled. The work control process at the plant failed to evaluate the radiological impact of radioactive waste reduction activities for work on secondary systems that were contaminated with tritium.

Root Cause Team Response – refer to the response to IR 636122 above.

9. Analysis:

Analysis techniques used during this investigation were:

- Event and Causal Factor Charting (ECF Attachment 4) was utilized to provide a visual description of the sequence of events leading up to the
- TapRoot® analysis was utilized to analyze and evaluate the identified causal factors.
- Barrier Analysis (Attachment 2) was utilized in conjunction with Event and Causal Factor charting to identify failed or challenged barriers.
- A Cause and Effect analysis was performed and is contained in Attachment 3.
- Interviews were conducted with selected individuals to supplement the team knowledge.

ECF

The ECF and the time line of the root cause started when the decision was made to stop releases to the river. This was to capture major events that included when the decision to become a primary water recycle plant was made. The ECF has two timelines on it. The first timeline has all of the major plant issues with tritium and primary water recycle on it. The timeline has a second branch of TR system events added. This started at the event where tritium was unexpectedly found in the west lagoon. The two timelines join back together just after the lagoon spill event. The ECF also has tritium values from TR and the lake put in at the corresponding time frames. This was to show that tritium existed in the secondary systems before recycle and to show how it changed over time.

TapRoot

The TapRoot system was also used to analyze the causal factors.

CF 1 was put through the TapRoot analysis and it was determined to be the result of a Management System. From Management System, there were two applicable directions: a) Had management been warned of this problem or had it happened before, and b) Were policies, admin controls, or procedures not used, missing, or in need of improvement? The answers to both of the questions were yes. The warnings were multiple IRs on equipment problems at TR. The procedure needs improvement because individuals implementing EN-AA-102-0003 did not list appropriate environmental equipment on the Braidwood Attachment.

Those TapRoot questions led to the cause categories:

- First level cause Management Systems
- Second level causes Procedures Wrong and Standards, Policies, or Admin Controls Needs Improvement (SPAC NI)
- Third level causes Situation No Covered and SPAC Not Strict Enough.

CF 2 was put through the TapRoot analysis and it was determined to be the result of Management System - Were policies, admin controls, or procedures not used, missing, or in need of improvement? The procedures were in need of improvement because the PC-AA-1005 Projects Implementation did not require a formal change management plan per HU-AA-1101 when starting a project.

Those TapRoot questions led to the cause categories:

- First level cause Procedures
- Second level cause Wrong
- Third level cause Facts Wrong

CF 3 was put through the TapRoot analysis and it was determined to be the result of Management System - Were policies, admin controls, or procedures not used, missing, or in need of improvement? The procedures were in need of improvement because EN-AA-102-0003 Attachment 1 did not contain the list of environmental equipment to identify items that need more urgent repair.

Those TapRoot questions led to the cause categories:

- First level causes Procedures and Management Systems
- Second level causes Procedures Wrong and Standards, Policies, or Admin Controls Needs Improvement (SPAC NI)
- Third level causes Situation Not Covered and SPAC Technical Error.

CF 4 was put through the TapRoot analysis and it was determined to be the result of Management System - Were policies, admin controls, or procedures not used, missing, or in need of improvement? The procedures were in need of improvement because BwOP WM-2 did not contain guidance on checking the lagoon prior to starting the MUDS.

Those TapRoot questions led to the cause categories:

- First level cause Procedures
- Second level cause Procedures Wrong
- Third level cause Situation Not Covered

CF 5 was put through the TapRoot analysis and it was determined to be the result of Management System - Were policies, admin controls, or procedures not used, missing, or in need of improvement? The IRs were approved by SOC and MRC with statements or questions not resolved or answered.

Those TapRoot questions led to the cause categories:

- First level cause Management Systems and Work Direction
- Second level causes SPAC Not Used and Selection of Worker
- Third level causes Enforcement Needs Improvement and Accountability Needs Improvement and Not Qualified

Rejected Root Causes

The root cause team identified that the following conditions were required for the event to occur:

- Tritium present in the west lagoon.
- High input rate/volume in the lagoons.
- Low throughput through TR.

The team considered the following as root causes:

1) When the decision was made to become a recycle plant, Braidwood Station did not implement HU-AA-1101 "Change Management" and did not develop an effective and comprehensive change management plan to address all facets of what this change meant.

This was rejected because tritium was known to exist in the secondary plant and in TR before recycle operation was instituted. Although the concentrations during this event were higher than if recycling had not occurred, tritiated water spilling over the west lagoon would still have happened if recycle had not occurred. In addition, if a thorough change management plan had been implemented during recycle implementation it would not have prevented the spill of tritiated water from the west lagoon. Since the TR system was a monitored release pathway and had been used for that for multiple years, the change management plan would not have changed the way that path was viewed. Even communication of the higher tritium concentrations that were expected due to recycle would not have changed the approach the Station took in implementing the recycle process.

The following discussion validates that recycling was not a root cause: The Waste Water Treatment (WWT) facility process water was typically around 20,000 pCi/l prior to recycling. This is based on sampling performed in late 2005, when the Unit's condensate systems were around 40,000 pCi/l. At the time of the event, the west lagoon tritium concentration was about 75,000 pCi/l while the east lagoon was 2,335,000 pCi/l. Using these concentrations, it would only take 8290 gallons of water from the east lagoon to contaminate the west. If the same volume of water had been added without recycling, the west lagoon would still have been over 670 pCi/l.

2) The valve leak by that caused the rupture disc to leak was also considered as a Root cause and was rejected for the same reason as stated above.

10. Evaluation:

Problem Statement	Cause (describe the cause and identify whether it is a root cause or contributing cause)	Basis of Cause Determination
<p>(Causal Factor 1) – In early and mid-2006, Braidwood Station failed to fully investigate multiple instances of tritium in the secondary and other systems to understand the sources and mitigate further increases</p>	<p>Chemistry personnel did not effectively communicate to station personnel about the concentration of tritium in PW, the timeframe for these concentrations, and the context of what these concentrations meant to people and the effects of any leak on the receiving system. (Contributing Cause 2)</p>	<ul style="list-style-type: none"> • Multiple IRs indicated that leaks were OK since they were through a “monitored release path”. Responses provided by both Chem and RP personnel. • Prior to recycle, tritium was known and expected by Chemistry to exist in multiple systems as a routine.

Problem Statement	Cause (describe the cause and identify whether it is a root cause or contributing cause)	Basis of Cause Determination
<p>(Causal Factor 2) – Braidwood Station did not create and implement a change management plan for becoming a recycle plant, including the communication of the expected tritium concentration in PW, what the numbers meant and the effect of any leak from PW on the tritium concentration in the receiving system.</p>	<p>When the decision was made to become a recycle plant, Braidwood Station did not implement HU-AA-1101 “Change Management” and did not develop an effective and comprehensive change management plan to address all facets of what this change meant. (Contributing Cause 1)</p> <p>Chemistry personnel did not effectively communicate to station personnel about the concentration of tritium in PW, the timeframe for these concentration, and the context of what these concentration meant to people and the effects of any leak on the receiving system. (Contributing Cause 2)</p>	<ul style="list-style-type: none"> • EC 359102 had limited scope. • The change to recycle was beyond the EC process. • Multiple issues written documenting that station personnel did not understand tritium concentration in plant systems. • RP ALARA review (CC-AA-212-1001) of EC 359102 lacking in detail. • Chemistry review of EC 359102 did not include changes in monitoring of plant systems. • Large change in PWST tritium concentrations not addressed. <ul style="list-style-type: none"> • Chemistry personnel were aware of tritium concentration in the various systems. • High level communications documents included information on the concentration changes. • The high level communications documents were not passed on by department heads to Station personnel.

Problem Statement	Cause (describe the cause and identify whether it is a root cause or contributing cause)	Basis of Cause Determination
<p>(Causal Factor 3) – Braidwood Station did not place a priority on fixing equipment problems in TR in a timely manner.</p>	<p>EN-AA-103-0002 did not properly identify environmental equipment on attachment 1 to ensure TR system repairs were made in a timely manner and Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority. (Root Cause 1)</p>	<ul style="list-style-type: none"> • Multiple issues/WRs not receiving greater than a “C” priority in the WC process. • Byron revision 1 of EN-AA-103-0002 to include additional equipment was not considered for implementation at Braidwood. • Repeat issues/misunderstanding related to operation of the quadricell pumps. • Lime sludge removal in West lagoon was deferred multiple times, leading to smaller functional volume available.
<p>(Causal Factor 4) – Braidwood Station did not have a comprehensive water management/monitoring program for recycle implementation.</p>	<p>When the decision was made to become a recycle plant, Braidwood Station did not implement HU-AA-1101 “Change Management” and did not develop an effective and comprehensive change management plan to address all facets of what this change meant. (Contributing Cause 1)</p> <p>BwOP WM-2 did not contain guidance on checking lagoon level before starting pretreatment. (Root Cause 2)</p>	<ul style="list-style-type: none"> • Monitoring program for ODCM limits at TR was reactive in nature (composite sample), and sump monitoring inside the plant was not performed. • Sump runtimes were documented in the operator rounds, but were not tracked/trended. • BwOP WM-2 pretreatment startup did not have a step to check TR lagoon levels prior to providing inputs.

Problem Statement	Cause (describe the cause and identify whether it is a root cause or contributing cause)	Basis of Cause Determination
<p>(Causal Factor 5) IRs were approved at SOC and MRC with statements or questions that were not resolved.</p>	<p>This is not a Root/Contributing cause for this event.</p>	<ul style="list-style-type: none"> • When west lagoon was found contaminated, the 25B heater steam leak was postulated as the source with out basis by SOC. • Inadequate risk analysis for actual / potential effects of overflowing the lagoons not addressed by SOC. • Valve leak-by was not addressed in the original issue for OLE-PW037 was leaking by SOC

11. Extent of Condition/Cause:
Extent of Condition Review

Cause Being Addressed	Extent of Condition Review
<p>EN-AA-103-0002 did not properly identify environmental equipment on attachment 1 to ensure TR system repairs were made in a timely manner and Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority. (Root Cause 1)</p>	<p>The RCT reviewed EN-AA-103-0002 and discovered three of the sites have many more pieces of equipment listed as environmental equipment as compared to the other sites. With the exception of Braidwood, Dresden, Limerick, and Quad Cities, all other sites revised their attachments of EN-AA-103-0002 on 1/19/06. This shows engagement in the process at many sites. Braidwood, Dresden, Limerick, and Quad Cities continue to have a small list that has not been recently revised. There are also inconsistencies in the types of equipment listed across the sites (e.g. Byron includes chillers for refrigerant leaks, Clinton includes cathodic protection). Recommended action is for the peer group to perform a review of the equipment in the procedure for each of the sites to achieve a consistent approach. (ACIT 8)</p>
<p>BwOP WM-2 did not contain guidance on checking lagoon level before starting pretreatment. (Root Cause 2)</p>	<p>The RCT reviewed Station procedures for filling systems and tanks and concluded that there are sufficient controls in place to prevent an environmental discharge. The team also considered the Main Cooling Lake and the Sewage Treatment Plant for potential overflow.</p> <p>The Main Cooling Lake is filled by BwOP CW-9, Circulating Water System Makeup System Startup. The Main Cooling Lake level is monitored via operator rounds and 0BwOSR 0.1-0 Shiftly/Daily Operating Surveillance. Neither BwOP CW-9 nor 0BwOSR 0.1-0 has actions to take on high lake level. The spillway is an emergency overflow, and overflow would require additional NPDES permit sampling. IR 658901 was written as a result to evaluate any needed changes.</p> <p>Inputs to the Sewage Treatment System are not under Operations control. As a result, it is monitored on operator rounds, and actions are taken as necessary to prevent overflow. The equipment will be evaluated for inclusion in EN-AA-103-0002 as a part of CAPR1.</p> <p>This is applicable to any site that has a system of the same nature (Lagoons/Retention ponds/outdoor tanks) and will be covered in the NNOE (632816-13)</p>

Cause Being Addressed	Extent of Condition Review
<p>Tritiated water was allowed to siphon from the east to the west lagoon through a transfer hose. (Root Cause 3)</p>	<p>The RCT reviewed this issue of utilizing a temporary sump as a tool and not pumping the output to the original designed location, which caused cross contamination between systems. This does apply to other sites and will be covered in the NNOE (632816-13)</p>

Extent of Cause Review

Cause Being Addressed	Extent of Cause Review
<p>EN-AA-103-0002 did not properly identify environmental equipment on Attachment 1 to ensure TR system repairs were made in a timely manner and Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority. (Root Cause 1)</p>	<p>The team reviewed all procedures that mention the "SOC" to determine whether the SOC has demonstrated awareness of all procedural requirements. Additionally, the team looked for other processes that could be assumed satisfied by the work control process (SOC). The following procedures were included in this review: SA-BR-116-1200 Industrial Safety Classification & Risk Assessment Coding ER-AA-1200 Critical Component Failure (CCF) Clock LS-AA-115 Operating Experience Procedure MA-AA-716-017 Equipment Readiness And Reliability WC-AA-106 Work Screening and Processing The team interviewed 2 individuals who routinely attend SOC and found that all of the proceduralized responsibilities have been observed. Procedures that place specific duties on the SOC are being followed as demonstrated by the SOC's actions. Therefore, the team concluded that the SOC is generally aware of their responsibilities, performing them adequately and that there are no other procedures that rely on SOC action that are not being implemented by the SOC.</p> <p>A Chemistry SOC representative was interviewed and was not aware of the his role and requirements in EN-AA-103-0002 as to being a representative at SOC. (ACIT 4)</p>

Cause Being Addressed	Extent of Cause Review
<p>BwOP WM-2 did not contain guidance on checking lagoon level before starting pretreatment. (Root Cause 2)</p>	<p>Informal communication and system operations. Tribal knowledge.</p> <p>Operations will perform evaluation of OP-BR-101-111-1002 for extent of cause in operation of systems that should be controlled via other plant procedures. (CA 10)</p> <p>This does apply to other sites and will be covered in the NNOE (632816-13)</p>
<p>Tritiated water was allowed to siphon from the east to the west lagoon through a transfer hose. (Root Cause 3)</p>	<p>The sump pump was considered a tool and was not in an approved procedure to ensure no siphoning would occur. Operations procedures for Sewage Treatment, Temporary Sump Pumps, Tritium Remediation Equipment, and Wastewater Treatment were reviewed for other similar occurrences. Issues 658529 and 658567 were written for problems identified with Wastewater Treatment. Instances of temporary equipment installed in the other systems were properly evaluated and tracked by the associated procedure.</p> <p>This does apply to other sites and will be covered in the NNOE (632816-13)</p>

12. Risk Assessment:

Plant-specific Risk Consequence	Basis for Determination
<p>BwOP WM-2 did not contain guidance on checking lagoon levels before starting pretreatment</p>	<p>The risk associated with this is high. The operators were aware that the lagoon levels were high, but did not understand the impact to the overall volume of providing an additional input. Procedural guidance would have supplemented operator knowledge.</p>
<p>Tritiated water was allowed to siphon from the east (contaminated) to the west (non-contaminated) lagoon through a transfer hose</p>	<p>The risk associated with this issue is high due to the fact the Station cross-contaminated the west lagoon. If the west lagoon had not been contaminated, the resultant event would not have provided a noncompliance.</p>
<p>Elevated concentration of tritium in the lagoons</p>	<p>The risk associated with this was high from the perspective of Regulator notification of the spill. Calculations performed, as part of Tritium 2 showed the water from the lagoon spill would not migrate off site.</p>
<p>Failure to use EN-AA-103-0002 to get TR components repaired in a timely manner</p>	<p>The risk associated with this was high. If the TR equipment was repaired in a timely manner, the lagoon levels would have been low enough to prevent the spill.</p>

13. Previous Events:

Site Corrective Action Database Review

A search using the corrective action database for site and fleet deficiencies that would have applicability or add insights while completing this root cause analysis was performed. The date range for the searches was 5/1/95 to 05/23/2007. Key word searches using the words “lagoon”, “settling pond”, and “NPDES violation” were conducted.

Similar issues with respect to lime in the lagoons were noted at Braidwood prior to the time frame discussed in this report. No similar events at Braidwood or the other Stations were noted during this review. No actions were identified that could be used in the development of corrective actions in this root cause.

Previous Event	Previous Event Review
<p>The NRC Event Database was searched using the words “tritium”, “tritiated”, “change management”, and “ground water”. More than 200 events were reviewed. There were no items identified in this search on the NRC database that could have helped Braidwood Station prevent the event with overflowing the west lagoon.</p> <p>A search of the INPO OE Database was performed using the same words. Over 500 hits were identified. Based on a review of the OEs, there was operating experience that should have told the Station that the secondary systems (condensate, feedwater, etc.) contained tritium. Chemistry knew these systems contained tritium and typically operated around 40,000 pCi/l. Most of the rest of the Station did not know this until the root cause was performed for the blowdown line leaks (IR 428868). Chemistry saw the concentration of tritium in the secondary as “normal” as they had existed for a significant amount of time. There were</p>	<p>The review did not identify any OPEX relating to restoring the plant to the original design of being a recycle plant.</p> <p>The Station and MPR Associates did perform benchmarking of plants that recycled RCS water. The lessons learned from these Stations, with respect to the lessons they learned as they recycled the water, were not captured in either benchmarking report.</p> <p>None of the OPEX reviewed provided any insights to the corrective actions created in this report.</p>

<p>several examples of OEs that noted tritium in other plant systems. In these cases, the cause was cross-contamination. The Station identified the cause and took actions to stop the leakage causing the cross-contamination. Braidwood started identifying the causes of tritium in the secondary systems in 2006 and started fixing the leaking valves or took other actions such as the installation of blind flanges to stop the cross-contamination</p>	
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In conclusion, none of the OPEX reviewed provided any insights to the corrective actions created in this report.

14. Corrective Actions to Prevent Recurrence (CAPRs):

Root Cause Being Addressed	Corrective Action to Prevent Recurrence (CAPR)	Owner	Due Date
<p>EN-AA-103-0002 did not properly identify environmental equipment on attachment 1 to ensure TR system repairs were made in a timely manner and Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority. (Root Cause 1)</p>	<p>(CAPR 1) Update EN-AA-103-0002 Attachment 1 for Braidwood based on Byron Attachment #2 for applicability for Braidwood.</p>	<p>A8932CHEM</p>	<p>11/30/2007</p>
<p>BwOP WM-2 did not contain guidance on checking lagoon level before starting pretreatment. (Root Cause 2)</p>	<p>(CAPR 2) Revise BwOP WM-2 for guidance on checking lagoon level before starting pretreatment.</p>	<p>A8910OP</p>	<p>Completed</p>
<p>Tritiated water was allowed to siphon from the east to the west lagoon through a transfer hose. (Root Cause 3)</p>	<p>(CAPR 3) Revise BwOP TR-1, "Waste Water Treatment System Startup", and BwOP TR-2, "Waste Water Treatment System Shutdown", to address operation of the TR lagoon pumps. Revision needs to address control of the hose between the two TR lagoons. Remove operation of TR lagoon pumps from OP-BR-101-111-1002.</p>	<p>A8910OP</p>	<p>11/30/2007</p>

15. Corrective Actions:

Cause Being Addressed	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
<p>EN-AA-103-0002 did not properly identify environmental equipment on attachment 1 to ensure TR system repairs were made in a timely manner and Chemistry did not drive the proper prioritization of open work orders on equipment in the TR system as B2 priority. (Root Cause 1)</p>	<p>(CA 1) Chemistry to review the Equipment classification for RTF equipment per step 4.2.5 of EN-AA-103-0002. Re-classify the D31 panel as required and notify CMO of the affected changes to update PMCI Tool</p>	A8932CHEM	11/30/2007
	<p>(CA 2) Brief SOC and MRC on the changes from CAPR 1 made to EN-AA-103-0002.</p>	A8932CHEM	12/07/2007
	<p>(CA 3) WC to recode any affected equipment work orders to the new classification of EN-AA-103-0002 following the revision based on CAPR 1.</p>	A8940WC	12/14/2007
	<p>(ACIT 1) FMS entry for coaching/counseling and evaluate for clock reset. The issues to be addressed are for documenting unconfirmed assumptions about TR operations with out validating the assumptions to approved prints and not understanding the importance of forming the TR Hit Team.</p>	A8932CHEM	9/14/2007
	<p>(ACIT 4) Evaluate if a qualification matrix is warranted for SOC members to ensure roles and responsibilities are maintained.</p>	A8901RA	9/21/07
	<p>(ACIT 8) Chemistry Manager to take this issue to peer group to perform a review of the equipment in EN-AA-103-0002 for each of the sites. Drive the peer group to achieve a consistent approach for Environment equipment listed in the attachments of EN-AA-103-0002. Ensure peer group members understand the purpose statement for the procedure.</p>	A8932CHEM	11/30/2007

Cause Being Addressed	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
<p>When the decision was made to become a recycle plant, Braidwood Station Project Management did not implement HU-AA-1101 "Change Management" and did not develop an effective and comprehensive change management plan to address all facets of what this change meant.</p> <p>(Contributing Cause 1)</p>	<p>(CA 8) Implement a change management plan for all on going PW recycle activities.</p>	A8966PM	11/30/2007
	<p>(ACIT 2) FMS entry for coaching/counseling and evaluate for clock reset. The issues to be addressed are for not implement a change management plan for PW recycle activities.</p>	A8966PM	9/14/2007
	<p>(CA 9) Evaluate revising PC-AA-1001 and PC-AA-1005 to added requirements to ensure HU-AA-1101 "Change Management" is utilized. Initiate additional actions as necessary to track revision.</p>	A8966PM	11/30/2007
<p>Chemistry personnel did not effectively communicate to station personnel about the concentration of tritium in PW, the timeframe for these concentration and the context of what these concentration meant to people and the effects of any leak on the receiving system.</p> <p>(Contributing Cause 2)</p>	<p>(CA 4) Brief SOC/MRC/Chemistry/ RP on need to investigate sources of tritium or radioactive liquids</p>	A8932CHEM	9/14/2007
	<p>(CA 5) Institute tritium sampling plan for in-plant sumps.</p>	A8932CHEM	Completed
	<p>(CA 6) Operations implemented an Operator Rounds point associated with monitoring of sump runtimes. The point uses PI data to develop a trend, provided in gallons per day. Administrative limits for notification were established for key sumps, requiring supervisor notification and additional evaluation.</p>	A8910OP	Completed

Cause Being Addressed	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
Tritiated water was allowed to siphon from the east to the west lagoon through a transfer hose. (Root Cause 3) Extent of Cause Evaluation.	(CA 10) Operations evaluate OP-BR-101-111-1002 for extent of cause in operation of systems that should be controlled via other plant procedures. Initiate additional actions as necessary to track any changes identified.	A8910OP	11/30/2007

16. Effectiveness Reviews:

CAPR/CA Being Addressed	Effectiveness Review Action	Owner	Due Date
(CAPR 1) Update EN-AA-103-0002 Attachment 1 for Braidwood based on Byron Attachment #2 for applicability for Braidwood.	(EFR 1) Perform effectiveness review of CAPR 1	A8932CHEM	9/12/2008
(CAPR 2) Revise BwOP WM-2 for guidance on checking lagoon level before starting pretreatment.	(EFR 2) Perform effectiveness review of CAPR 2	A8910OP	9/12/2008
(CAPR 3) Revise BwOP TR-1, "Waste Water Treatment System Startup", and BwOP TR-2, "Waste Water Treatment System Shutdown", to address operation of the TR lagoon pumps. Revision needs to address control of the hose between the two TR lagoons. Remove operation of TR lagoon pumps from OP-BR-101-111-1002.	(EFR 3) Perform effectiveness review of CAPR 3	A8910OP	9/12/2008

17. Programmatic/Organizational Issues:

Programmatic/Organizational Weaknesses	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
<p>When the decision was made to become a recycle plant, Braidwood Station Project Management did not implement HU-AA-1101 "Change Management" and did not develop an effective and comprehensive change management plan to address all facets of what this change meant.</p> <p>(Contributing Cause 1)</p>	<p>(CA 8) Implement a change management plan for all on going PW recycle activities.</p>	A8966PM	11/30/2007
	<p>(ACIT 2) FMS entry for coaching/counseling and evaluate for clock reset. The issues to be addressed are for not implementing a change management plan for PW recycle activities.</p>	A8966PM	9/14/2007
	<p>(CA 9) Evaluate revising PC-AA-1001 and PC-AA-1005 to added requirements to ensure HU-AA-1101 "Change Management" is utilized. Initiate additional actions as necessary to track revision.</p>	A8966PM	11/30/2007

Programmatic/Organizational Weaknesses	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
<p>Chemistry personnel did not effectively communicate to station personnel about the concentration of tritium in PW, the timeframe for these concentrations and the context of what these concentrations meant to people and the effects of any leak on the receiving system. (Contributing Cause 2)</p>	<p>(CA 4) Brief SOC/MRC/Chemistry/ RP on need to investigate sources of tritium or radioactive liquids</p>	A8932CHEM	9/14/2007
	<p>(CA 5) Institute tritium sampling plan for in-plant sumps.</p>	A8932CHEM	Completed
	<p>(CA 6) Operations implemented an Operator Rounds point associated with monitoring of sump runtimes. The point uses PI data to develop a trend, provided in gallons per day. Administrative limits for notification were established for key sumps, requiring supervisor notification and additional evaluation.</p>	A8910OP	Completed

Programmatic/Organizational Weaknesses	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
Equipment classification as RTF equipment (CW Vacuum breakers/TR System) resulted in spills of tritiated water	(CA 1) Chemistry to review the Equipment classification for RTF equipment per step 4.2.5 of EN-AA-103-0002. Re-classify the D31 panel as required and notify CMO of the affected changes to update PMCI Tool	A8932CHEM	9/28/2007
<p>The current owner of the TR system is in the Chemistry department. This individual was the system owner when in the Engineering department. This is a point of contact system.</p> <p>Interview with the Engineering director noted inconsistencies for ownership of this type of system across the fleet.</p>	<p>(ACIT 5 – ATI 632140-02) The Chemistry Manager to work with Engineering to determine if Engineering should own the TR system.</p> <p>(ACIT 6) Engineering Director to take this issue to peer group to resolve.</p>	<p>A8932CHEM</p> <p>A8950EM</p>	<p>8/16/2007</p> <p>11/30/2007</p>
TR system was classified as RTF. Another system CW vacuum breakers were originally coded as RTF, which resulted in root causes being performed on both events.	IR 659339 generated for Engineering to evaluate classification of run to failure equipment.	N/A	N/A

Other Issues:

Other Issues Identified During Investigation	Corrective Action (CA) or Action Item (ACIT)	Owner	Due Date
IRs were approved at SOC and MRC with statements or questions that were not resolved. CF 5	(CA 7) Brief SOC and MRC on need to challenge assumptions and all questions raised in the issue	A8901RA	9/14/2007
There are 3 portable pumps utilized in TR system that are not covered by a procedure and are not per design drawings. Note 1 & 2	IR 658567 was generated to track/resolve this issue	N/A	N/A
There is a plug installed in the outlet of the east lagoon to the sump on the south side of the lagoon that is not per design drawing. Note 2	IR 658529 was generated to track/resolve this issue	N/A	N/A
Evaluate the need for high lake level actions. Identified during EOC review that there are no procedural controls in place during CW makeup system operation.	IR 658901 was generated to track/resolve this issue.	N/A	N/A
Operations Standing Order 07-003 and Op Aid 06-002 are in place to monitor/control TR lagoon levels, but are not a part of permanent plant procedures.	(ACIT 7) Evaluate the appropriate mechanism for incorporation of Operations Standing Order 07-003 and Op Aid 06-002 into permanent plant procedures/process. Initiate additional actions for incorporation as necessary.	A8910OP	11/30/2007

Radiation Protection ALARA review for EC 359102 was incomplete. Attachment 1 of CC-AA-212-1001 identified contamination concerns that were not addressed in the evaluation or IR 462432.	(ACIT 9) FMS entry for coaching/counseling and evaluate for clock reset associated with incomplete RP ALARA review of EC 359102. Attachment 1 of CC-AA-212-1001 identified contamination concerns that were not addressed in the evaluation or IR 462432.	A8931RP	9/20/2007
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Note 1 – ECR 77621 was generated in February 1998 to evaluate the two floating pumps and hose running to TR as a temporary alteration. The ECR was cancelled after it was determined that this configuration did not meet the definition of a temporary alteration. Under the rules in place today, this configuration is considered a temporary alteration.

Note 2 – Neither of these apparent temporary alterations were identified through Station efforts to identify unauthorized alterations to the plant.

19. Communications Plan:

Lessons Learned to be Communicated	Communication Plan Action	Owner	Due Date
RCR summary communication	(ACIT 3) Submit RCR summary slides to be included in the Station Alignment Package	A8931RP	09/10/2007

20. Evaluator and Reviewer signatures:

Roxanna Taylor, Scott Butler, 8/09/2007
Root Cause Investigator / Date

Dan Morse 8/13/2007
Team Lead / Date

John Moser 8/16/2007
Sponsor Manager / Date

Root Cause Report Quality Checklist
Page 1 of 2

A. Critical Content Attributes	YES	NO
1. Is the condition that requires resolution adequately and accurately identified?	X	
2. Are inappropriate actions and equipment failures (causal factors) identified?	X	
3. Are the causes accurately identified, including root causes and contributing causes?	X	
4. Are there corrective actions to prevent recurrence identified for each root cause and do they tie DIRECTLY to the root cause? AND, are there corrective actions for contributing cause and do they tie DIRECTLY to the contributing cause?	X	
5. Have the root cause analysis techniques been appropriately used and documented?	X	
6. Was an Event and Causal Factors Chart properly prepared?	X	
7. Does the report adequately and accurately address the extent of condition in accordance with the guidance provided in Attachment 4 of LS-AA-125-1003, Reference 4.3?	X	
8. Does the report adequately and accurately address plant specific risk consequences?	X	
9. Does the report adequately and accurately address behavioral, programmatic and organizational issues?	X	
10. Have previous similar events been evaluated? Has an Operating Experience database search been performed to determine useful lessons learned or insights for development of CAs?	X	
11. If required, does the report adequately address the NRC's Safety Culture Components in accordance with the guidance provided in Attachment 20?	N/A	N/A
B. Important Content Attributes		
1. Are all of the important facts included in the report?	X	
2. Does the report explain the logic used to arrive at the conclusions?	X	
3. If appropriate, does the report explain what root causes were considered, but eliminated from further consideration and the bases for their elimination from consideration?	X	
4. Does the report identify contributing causes, if applicable?	X	
5. Is it clear what conditions the corrective actions are intended to create?	X	
6. Are there unnecessary corrective actions that do not address the root causes or contributing causes?		X
7. Is the timing for completion of each corrective action commensurate with the importance or risk associated with the issue?	X	

Root Cause Report Quality Checklist
Page 2 of 2

C. Miscellaneous Items	YES	NO
1. Did an individual who is qualified in Root Cause Analysis prepare the report?	X	
2. Does the Executive Summary adequately and accurately describe the significance of the event, the event sequence, root causes, corrective actions, reportability, and previous events?	X	
3. Do the corrective actions include an effectiveness review for corrective actions to prevent recurrence?	X	
4. Were ALL corrective actions entered and verified to be in Action Tracking?	Note 1	
5. Are the format, composition, and rhetoric acceptable (grammar, typographical errors, spelling, acronyms, etc.)?	X	
6. Have the trend codes been added or adjusted in Passport to match the investigation results?	X	

Note 1 – To be entered into Action Tracking after MRC Approval

**Attachment 1
Root Cause Investigation Charter
Page 1 of 2**

The Charter will be reviewed by MRC for concurrence within two business days, or as directed by MRC, and should be included as an attachment to the Root Cause Report.

IR Number: 632816
Associated IR Numbers: 636122 & 632852

Sponsoring Manager: John Moser

Qualified Root Cause Investigator: Daniel Morse / Radiation Protection (part time)

Team Investigator(s):

Maintenance - Eric Johnston (full time), Root Cause Qualified
Chemistry - Bob Claes (full time)
Operations - Brian Bergmann (full time)
Engineering - Jim Gosnell (full time)
Training - Scott Butler (full time) Root Cause Qualified
Project Management - Dave Kapinus (part time)
Organizational Specialist - Karen Eters (part time)
Developmental Root Cause Personnel - Sondra Massey (part time)

Industry Peer(s) - TBD (prefer Comanche Peak, Wolf Creek, and/or HB Robinson)

Problem Statement:

Braidwood Station experienced a leak of tritiated water from the west TR lagoon during high wind conditions. The water was identified to contain higher tritium concentrations than previously experienced due to tritium recycling and system interfaces. This resulted in inadvertent release of RAM to the environment.

Scope:

The Root Cause Investigation will identify any shortcomings in the following:

- Station recognition of the impact of tritium recycling on concentrations of tritium in communicating systems.
- Station recognition of the impact of tritium recycling on non-traditional potential environmental pathways.
- Missed opportunities present that may have prevented the inadvertent leak from the west TR lagoon.
- Change management aspects associated with the change in operating philosophy to tritium recycling.

Attachment 1
Root Cause Investigation Charter
Page 2 of 2

The Root Cause Investigation team will develop lessons learned / corrective actions. These actions will be shared with the fleet.

Interim Corrective Actions:

- Implemented EN-AA-407 and organized the site to respond.
- Installed temporary berms and wave suppressors in and around the lagoons.
- Characterized spill and modeled for off-site transport.
- Performed sampling and system analysis to identify and isolate increased tritium concentrations to the TR.
- Completed an extent of condition evaluation on current plant and system leaks.
- Characterized systems by tritium level and risk.
- Installed radiological postings and labels to applicable piping systems and areas based upon occupational and environmental risk.
- Developed guidelines for leak response by station organizations by system/anticipated tritium concentrations.
- Provided site communications to inform work force of event and additional actions moving forward.

Root Cause Report Milestones:

1. Event Date	(05/23/07)
2. Screening Date	(05/31/07)
3. Completion of Charter	(06/06/07)
4. Status Briefing for Charter	(06/06/07)
5. One Week Update	(06/14/07)
6. Two Week Update	(06/21/07)
7. Three Week Update	(06/28/07)
8. Sponsoring Manager Report Approval	(07/05/07)
9. Review by PORC/MRC	(07/12/07)
10. Final Root Cause Investigation Due Date	(07/06/07)

Attachment 2

Page 1 of 5 Barrier Analysis

Failed or ineffective barrier	How Barrier Failed	Why Barrier Failed	Corrective action to Restore Barrier to Effectiveness
<p>The station failed to fully investigate multiple instances of Tritium in the secondary and other systems to understand the sources, mitigate further problems.</p> <p><u>Failed Barrier 1</u> <u>(FBI)</u> <u>(CFI)</u></p> <p><u>IR 456970,457323, 469514, 470469.</u></p>	<p>Accepted that all tritiated secondary water leaks were normally released through a monitored pathway and within ODCM limits without looking at the rate of change of discharge concentrations.</p> <p>Did not sample secondary side to track tritium sources to prevent exceeding the 4Ci lake admin limit.</p> <p>Did not fully understand the ODCM monitoring of release pathways, including the reactive nature. TR compositor samples are reactive- samples analyzed after discharge. OPR05J rad monitor does not monitor for tritium.</p> <p>TR lagoon pumps were operated for multiple years without procedural controls to prevent cross-contamination.</p>	<p>Lack of understanding that the higher tritium concentration would have a much larger effect for a small leak volume.</p> <p>Justified multiple times on many IRs 13 total that any and all secondary leaks were through an ODCM monitored release path so there was no concern</p> <p>Used historical data and did not explore potential future data knowing that a new process was being implemented.</p> <p>TR lagoon pumps had been in place since initial startup, and had operated without problems.</p>	<p>(CA4) Brief SOC/MRC/Chemistry/ RP on need to investigate sources of tritium or radioactive liquids</p> <p>(CA5) Institute tritium sampling plan for in-plant sumps.</p> <p>(CA6) Operations implemented an Operator Rounds point associated with monitoring of sump runtimes. The point uses PI data to develop a trend, provided in gallons per day. Administrative limits for notification were established for key sumps, requiring supervisor notification and additional evaluation.</p> <p>(CAPR 3)Revise BwOP TR-1, "Waste Water Treatment System Startup", and BwOP TR-2, "Waste Water Treatment System Shutdown", to address operation of the TR lagoon pumps. Revision needs to address control of the hose between the two TR lagoons. Remove operation of TR lagoon pumps from OP-BR-101-111-1002.</p>

Attachment 2

Page 2 of 5

Barrier Analysis

Failed or ineffective barrier	How Barrier Failed	Why Barrier Failed	Corrective action to Restore Barrier to Effectiveness
<p>EC359102 evaluation of PW recycle. Scope was not sufficiently broad to prevent the event (Change Management).</p> <p><u>Failed Barrier 2 (FB2) (CF2)</u></p>	<p>Did not look at future tritium concentrations</p> <p>Looked instead of challenging design. (overlooked) primarily for plant changes from original design</p> <p>Did not identify the need to increase the monitoring of tritium in sumps and tanks to avoid exceeding the 4 Curie limit (annual) to the lake</p>	<p>Original design was assumed to be adequate.</p> <p>The scope of the EC was to evaluate changes made from the original plant design that would invalidate recycle ability.</p> <p>Did not understand the full impact of Tritium-how high the concentrations would be and the small amount of leakage that could cause problem.</p> <p>Station had never operated under the original design, and offsite OPEX researched provided limited information.</p>	<p>(CA 8) Implement a change management plan for all on going PW recycle activities.</p> <p>(CA 9) Evaluate revising PC-AA-1001 and PC-AA-1005 to added requirements to ensure HU-AA-1101 "Change Management" is utilized. Initiate additional actions as necessary to track revision.</p>
<p>**PWST Drains to TE/TF Monitoring Questions Poorly evaluated</p> <p><u>Failed Barrier 3 (FB3) (CF1,2,4)</u></p> <p><u>IR 468754</u></p>	<p>Issue was poorly evaluated, with misleading answers.</p> <p>Previous similar event was mentioned but not evaluated. The previous event allowed 100,000 gallons PWST to TF leak in 2002, which was not identified for 2 weeks.</p>	<p>Justified no additional actions because of ODCM monitored pathway</p> <p>Closed in part to Tritium Team 3 analysis based on team response. Response implied that further evaluation was being done, although this issue was not really in the scope.</p>	<p>(CA5) Institute tritium sampling plan for in-plant sumps.</p> <p>(CA6) Operations implemented an Operator Rounds point associated with monitoring of sump runtimes. The point uses PI data to develop a trend, provided in gallons per day. Administrative limits for notification were established for key sumps, requiring supervisor notification and additional evaluation.</p>

Attachment 2

Page 3 of 5 Barrier Analysis

Failed or ineffective barrier	How Barrier Failed	Why Barrier Failed	Corrective action to Restore Barrier to Effectiveness
<p>**IR Results not challenged--TR West Lagoon Found contaminated</p> <p><u>Failed Barrier 4 (FB-4) (CF1,2,4)</u></p> <p><u>IR 478730, 616048</u></p>	<p>Lack of questioning attitude and understanding the issue.</p> <p>Invalid assumption made regarding 25B drain cooler event.</p> <p>Sudden leak in OLE-PW037 cause not investigated (questioning attitude).</p>	<p>25B event eight days earlier provided a bias for accepting steam relief condensation as the cause.</p> <p>Lack of technical rigor in the conclusion of condensation as the cause.</p> <p>Focused on only completing repair of OLE-PW037 and did not address extent of condition for valve leakage.</p>	<p>(CA7) Brief SOC and MRC on need to challenge assumptions and all questions raised in then issue.</p>

Attachment 2

Page 4 of 5 Barrier Analysis

Failed or ineffective barrier	How Barrier Failed	Why Barrier Failed	Corrective action to Restore Barrier to Effectiveness
<p>Work Control Process--Material condition of WWT system</p> <p><u>Failed Barrier 5 (FB-5) (CF3)</u></p> <p><u>IR 513223, 527510, 527515, 572319, 578806, 589841, 598558, 624083</u></p>	<p>EN-AA-103-0002 does not include most TR equipment in Braidwood Attachment (only includes flow totalizer).</p> <p>Multiple IRs were screened and prioritized as low and placed in work windows that were repeatedly rescheduled.</p> <p>Lime, sludge and oil build up in lagoons not removed in a timely manner. Budgeted every year since 2005 but not completed. Potential for overflow as a result not addressed.</p> <p>20 outstanding defective tags, some several years old.</p> <p>Assumptions on quadricell operation were made without validation of prints etc.</p> <p>Multiple request for help resolving system issues were addressed inefficiently</p> <p>TR Hit Team was never formed by System Manager</p>	<p>Chemistry procedure owners did not see the revision as applicable to Braidwood.</p> <p>Without EN-AA-103-0002 priority, the equipment failures screen as C priority.</p> <p>Budget constraints on other projects used money budgeted for TR lime removal.</p> <p>Inadequate Risk Perception related to failure modes and effects of overflowing the lagoon.</p> <p>Work rescheduled based on workload, resource availability, and priorities.</p> <p>Lack of technical rigor and knowledge related to system design and operation.</p> <p>Technical lead response accepted without challenge.</p>	<p>(CAPR1) Update EN-AA-103-0002 Attachment 1 for Bwd based on Byron Attachment #2 for applicability for Braidwood.</p> <p>(CA1) Chemistry to review the Equipment classification for RTF equipment per step 4.2.5 of EN-AA-103-0002. Re-classify the D31 panel as required and notify CMO to update PMCI Tool</p> <p>(CA2) Brief SOC and MRC on the changes made to EN-AA-103-0002.</p> <p>(CA3) WC to recode any affected equipment work orders to the new classification of EN-AA-103-0002.</p> <p>(ACIT 1) FMS entry for coaching/counseling and evaluate for clock reset. The issues to be addressed are for documenting unconfirmed assumptions with out validating the assumptions to approved prints and not understanding the importance of forming the TR Hit Team.</p>

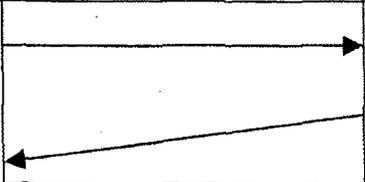
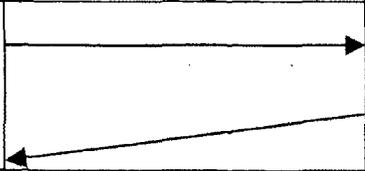
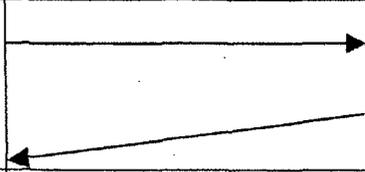
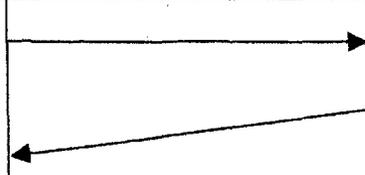
Attachment 2

Page 5 of 5
Barrier Analysis

Failed or ineffective barrier	How Barrier Failed	Why Barrier Failed	Corrective action to Restore Barrier to Effectiveness
<p>Primary Recycle Change management</p> <p><u>Failed Barrier 6</u> <u>(FB-6)</u> <u>(CF2)</u></p> <p><u>IR 618654</u></p>	<p>Water source for use in containment for various tasks to replace PW.</p> <p>Understanding of the concentration of Tritium 0.3uCi/g</p> <p>No one related the amount of Tritium in PW to being a high level or where it could potentially be going.</p>	<p>Inadequate change management for tritium recycle (change management process HU-AA-1101 was not used).</p>	<p>(CA 8) Implement a change management plan for all on going PW recycle activities.</p> <p>(CA 9) Evaluate revising PC-AA-1001 and PC-AA-1005 to added requirements to ensure HU-AA-1101 "Change Management" is utilized. Initiate additional actions as necessary to track revision.</p>
<p>Procedure issues-- Pretreatment started with lagoons nearly full</p> <p><u>Failed Barrier 7</u> <u>(FB-7)</u> <u>(CF4)</u></p> <p><u>IR -634407</u></p>	<p>No procedure/rounds monitoring of TR lagoon levels</p> <p>Pre-treatment procedure did not ensure that there are precautions to allow for the lagoons to accept the additional input.</p>	<p>Tribal knowledge to check the lagoon level prior to starting up MUDS.</p> <p>Inaccurate perception regarding overflowing the west lagoon.</p>	<p>(CAPR2) Procedure BwOP WM-2 has been rev'd to reflect the TR storage capacity in the lagoons.</p> <p>(CA6) Operations implemented an Operator Rounds point associated with monitoring of sump runtimes. The point uses PI data to develop a trend, provided in gallons per day. Administrative limits for notification were established for key sumps, requiring supervisor notification and additional evaluation.</p>

Attachment 3 - C&E Analysis

(CF1) The station failed to fully investigate instances of Tritium in the Secondary and other systems to understand the source(s) and mitigate further increases. **IR 456970, 457323, 469514, 456970, 470469, 471747, 468754, 478730, 616048**

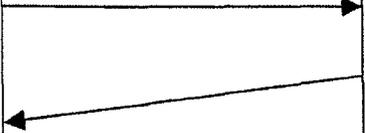
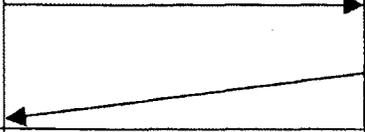
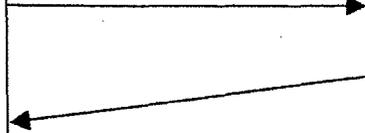
Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
The station failed to fully investigate instances of Tritium in the Secondary and other systems to understand the source(s) and mitigate further increases.		Accepted that all tritiated secondary water leaks were normally released through a monitored pathway (and within ODCM limits).
Accepted that all tritiated secondary water leaks were normally released through a monitored pathway (and within ODCM limits).		Multiple IR responses indicated that it was a monitored pathway.
Multiple IR responses indicated that it was a monitored pathway.		The current monitoring program was believed to be adequate.
The current monitoring program was believed to be adequate.		The monitoring program had been in place for multiple years without an issue.

<p>The monitoring program had been in place for multiple years without an issue.</p>		<p>A large release challenging the 4 Ci admin limit was not considered credible, and had not yet occurred.</p>
<p>A large release challenging the 4 Ci admin limit was not considered credible, and had not yet occurred.</p>		<p>Tritium sources were significantly smaller than FSAR assumptions prior to the event.</p>
<p>Tritium sources were significantly smaller than FSAR assumptions prior to the event.</p>		<p>The plant had experienced limited S/G tube leakage, and the plant had not recycled reactor water.</p>
<p>The plant had experienced limited S/G tube leakage, and the plant had not recycled reactor water.</p>		<p>The plant was operated different than the FSAR assumptions (recycling) by transferring all radwaste water to the river.</p>
<p>The plant was operated different than the FSAR assumptions (recycling) by transferring all radwaste water to the river.</p>		<p>The original boric acid and radwaste evaporator systems to perform recycle did not function properly.</p>
<p>The original boric acid and radwaste evaporator systems to perform recycle did not function properly.</p>		<p>The evaporators were labor intensive, and considered not needed.</p>

<p>The evaporators were labor intensive, and considered not needed.</p>		<p>Discharge to the river was performed instead, with ODCM and NPDES permit limits continuing to be maintained (much less labor intensive).</p>
<p>Discharge to the river was performed instead, with ODCM and NPDES permit limits continuing to be maintained (much less labor intensive).</p>		<p>Tritium concentrations did not present a challenge to the limits.</p>
<p>Tritium concentrations did not present a challenge to the limits.</p>		<p>Plant tritium inventory did not accumulate.</p>
<p>Plant tritium inventory did not accumulate.</p>		<p>Total curie discharge rate match rate of production.</p>
<p>Total curie discharge rate match rate of production.</p>		<p>Recycling had not been implemented.</p>

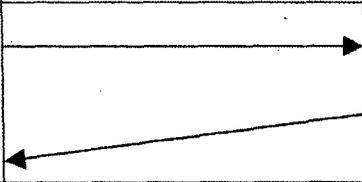
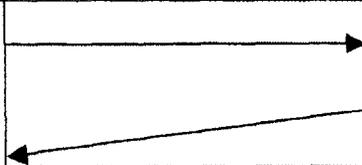
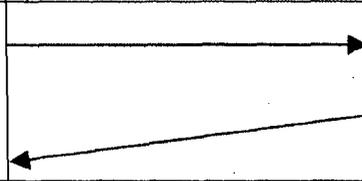
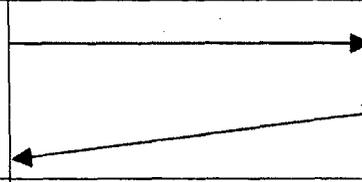
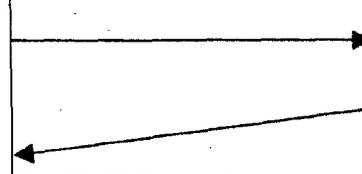
Attachment 3 - C&E Analysis

(CF1-second analysis path) The station failed to fully investigate instances of Tritium in the Secondary and other systems to understand the source(s) and mitigate further increases. **IR 456970, 457323, 469514, 456970, 470469, 471747, 468754, 478730, 616048**

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
The station failed to fully investigate instances of Tritium in the Secondary and other systems to understand the source(s) and mitigate further increases.		Accepted tritiated secondary water leaks without looking at the aggregate of these leaks.
Accepted tritiated secondary water leaks without looking at the aggregate of these leaks.		The values for secondary tritium were considered to be normal.
The values for secondary tritium were considered to be normal.		The values were well below the FSAR assumptions, and there were no problems identified with releases.
The values were well below the FSAR assumptions, and there were no problems identified with releases.		Recycling had not been implemented.

Attachment 3 - C&E Analysis

(CF2) When implementing the recycle plant, the station did not implement a change management plan including: communication of the H3 concentrations in PW, what these numbers meant, and the effect of any leak from PW on the H3 concentrations in the receiving system. **IR 468754, 478730, 616048, 618654, and EC 359102**

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
When implementing the recycle plant, the station did not implement a change management plan.		The change management process was not considered to be needed.
The change management process was not considered to be needed.		The change was considered to be a restoration to original design basis.
The change was considered to be a restoration to original design basis.		The engineering change dealt with looking for physical changes (procedures and plant), but did not look at process changes (culture and monitoring).
The engineering change dealt with looking for physical changes (procedures and plant), but did not look at process changes (culture and monitoring).		The engineering change evaluated its intended scope. The intended scope was limited to physical plant changes.
The engineering change evaluated its intended scope. The intended scope was limited to physical plant changes.		The change management procedure was not used.

Attachment 3 - C&E Analysis

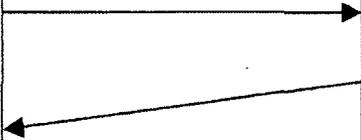
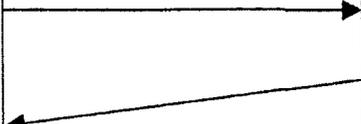
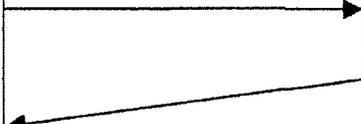
(CF2-second analysis path) When implementing the recycle plant, the station did not implement a change management plan including: communication of the H3 concentrations in PW, what these numbers meant, and the effect of any leak from PW on the H3 concentrations in the receiving system. **IR 468754, 478730, 616048, 618654, and EC 359102**

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
When implementing the recycle plant, the station did communicate the H3 concentrations in PW, what these numbers meant, and the effect of any leak from PW on the H3 concentrations in the receiving system.	←	Chemistry, Project Management and some senior managers understood what H3 concentrations in the PWSTs would eventually be, but the rest of the station did not have the same knowledge and understanding/context.
Chemistry, Project Management and some senior managers understood what H3 concentrations in the PWSTs would eventually be, but the rest of the station did not have the same knowledge and understanding/context.	←	The information concerning tritium concentrations in PW, what this meant and the affects of a leak on the tritium concentrations in other systems was not developed and communicated to Station personnel.
The information concerning tritium concentrations in PW, what this meant and the affects of a leak on the tritium concentrations in other systems was not developed and communicated to Station personnel.	←	Chemistry and Project Management did not determine the effects of the increased tritium concentrations in PW should a leak occur and the water entered other water systems. This was also not communicated to Station personnel.
Chemistry and Project Management did not determine the effects of the increased tritium concentrations in PW should a leak occur and the water entered other water systems. This was also not communicated to Station personnel.	←	Chemistry assumed Station personnel were aware of the concentrations of tritium in PW since they were contained in presentations to senior management.

<p>Chemistry assumed Station personnel were aware of the concentrations of tritium in PW since they were contained in presentations to senior management.</p>		<p>Chemistry communicated this to senior management but further communications to station personnel were not conducted.</p>
<p>Chemistry communicated this to senior management but further communications to station personnel were not conducted.</p>		<p>No change management plan was created for the change to being a recycle plant.</p>
		<p>Note: The tritium concentrations in the FSAR are in uCi/g units compared to the current standard of pCi/l. This is a factor of 10^9, which leads to confusion in reporting. Chemistry spoke in terms of uCi/g as this is how tritium in systems is reported. Most of the Station personnel spoke in terms of pCi/l based on the CW blowdown leaks and root cause for tritium in the ground water.</p>

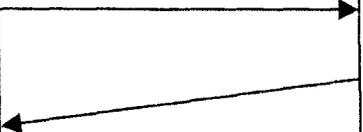
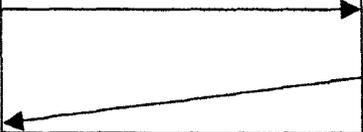
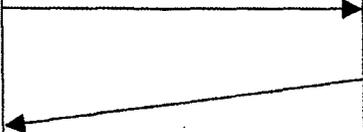
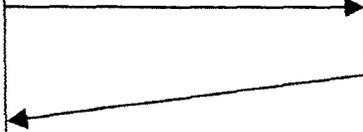
Attachment 3 - C&E Analysis

(CF3) The station did not place a priority on fixing equipment problems in TR in a timely manner. IR 513223, 527510, 624083, 527515, 572319, 598558, 578806, 589841

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
The station did not place a priority on fixing equipment problems in TR in a timely manner.		Most TR process components were not identified in EN-AA-103-0002 as "environmental equipment"
Most TR process components were not identified in EN-AA-103-0002 as "environmental equipment"		We did not implement rev. 0 of the procedure as written.
We did not implement rev. 0 of the procedure as written.		Thought that redundant equipment was exempt from the requirements of the procedure.
Thought that redundant equipment was exempt from the requirements of the procedure.		Individual implementing the procedure was involved with the procedure development however the written procedure differs from discussion during development and resulted in an abbreviated list.

Attachment 3 - C&E Analysis

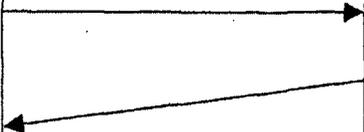
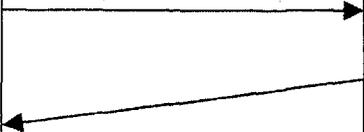
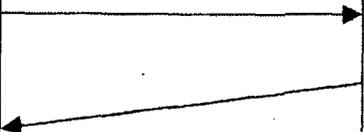
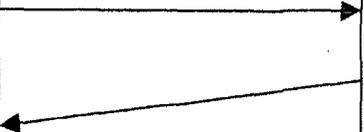
(CF4) The station did not have a comprehensive water management/monitoring program for recycle implementation. **IR**
468754, 478730, 616048, 634407

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
The station did not have a comprehensive water management/monitoring program for recycle implementation. Trending sump/lagoon inventory and concentration.		No perceived need for a monitoring program.
No perceived need for a monitoring program.		There were no events with adverse consequences requiring changes to existing practices.
There were no events with adverse consequences requiring changes to existing practices.		Inventory: TR was maintained as low as possible, and previous issues stopped discretionary inputs prior to overflow. Tritium: There was no significant tritium concentration in the water entering TR for processing.
Inventory: TR was maintained as low as possible, and previous issues stopped discretionary inputs prior to overflow. Tritium: There was no significant tritium concentration in the water entering TR for processing.		Inventory: TR was able to maintain inventory level to support plant operation Tritium: The Plant did not have leaks with high tritium concentration that entered TR.

Inventory: TR was able to maintain inventory level to support plant operation		Inventory: N/A
Tritium: The Plant did not have leaks with high tritium concentration that entered TR.		Tritium: The plant was not recycling water and increasing the concentration of tritium in PW.
		Note: As documented in IR 95538 (Feb 2002) there was a 100,000 gallon leak of PW from a vacuum deaeration system relief valve that entered TR. The event was non-consequential since PW did not contain elevated tritium concentration.

Attachment 3 - C&E Analysis

(CF5) IRs were approved at SOC and MRC with statements or questions that were not resolved. **IR 478730, 527510, 616048**

Effect / Symptom	<u>Why</u>	<u>Cause / Reason</u>
IRs were approved at SOC and MRC with statements or questions that were not resolved		Participants had inattention to detail
Participants had inattention to detail		Lack of questioning attitude and understanding that other open items needed to be addressed.
		
		

Attachment 4

Event and Causal Factor Chart

Attachment 5

General Dilution formula:

$$\Sigma (C_X * V_X) = C_F * V_F \quad \text{equation 1}$$

where, C_X = Concentration of fluid X
 V_X = Volume of fluid X
 C_F = Concentration of final, combined fluids
 V_F = Volume of all fluids combined

For the mixing of 2 fluids composed of a lagoon (1/2 full of lime) and an unknown volume from the 25B FWH shell side relief:

$$C_L * V_L + C_R * V_R = C_F * V_F \quad \text{equation 2}$$

where, C_L, V_L are the concentration and volume of lagoon water.
 C_R, V_R are the concentration and volume of water from the relief.
 C_F, V_F are the concentration and volume of composite mixture in the lagoon.

The total volume is composed of the sum of the individual volumes. Therefore:

$$V_F = V_L + V_R \quad \text{equation 3}$$

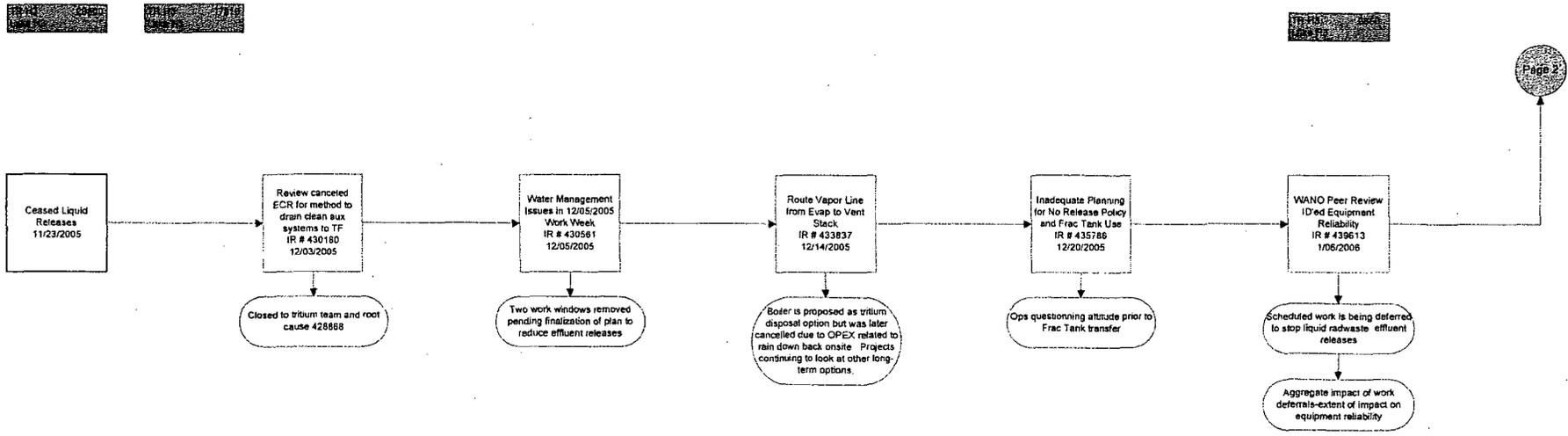
Combining equations 2 and 3 solving the equation 2 for relief Volume (V_R):

$$V_R = [V_L (C_L - C_F)] / (C_F - C_R) \quad \text{equation 4}$$

Applying this to the west lagoon in IR 478730 where the lagoon is assumed to have 250,000 gallons of water due to being half full of lime, initial concentration of 35 pCi/L, condensate had 46,000 pCi/L and a final composite concentration of 7620 pCi/L as documented in the IR, the required volume of water needed from the relief valve is:

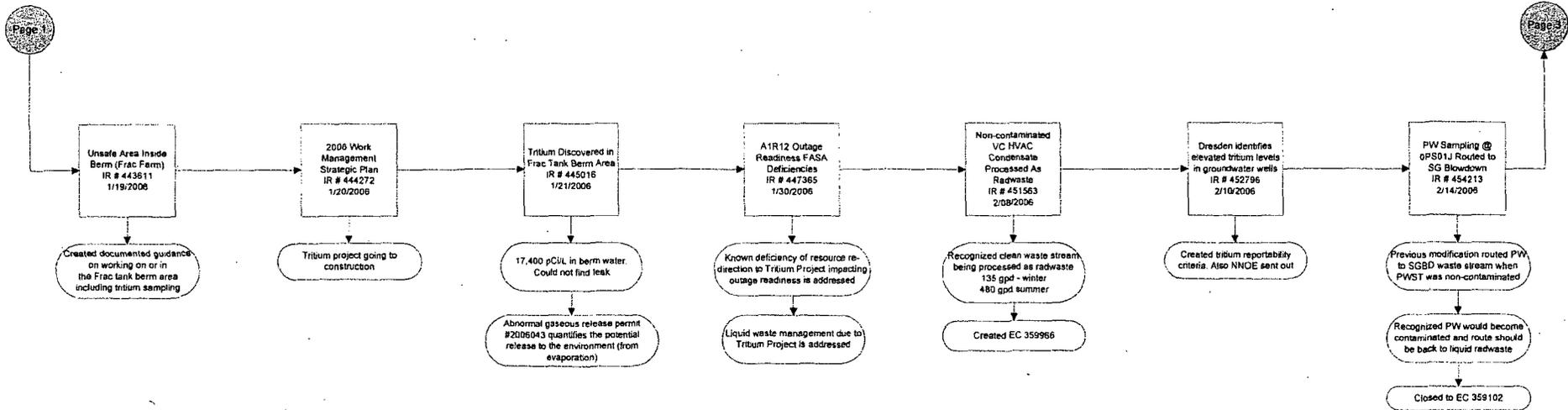
$$V_R = [250,000 (35 - 7620)] / (7620 - 46,000)$$

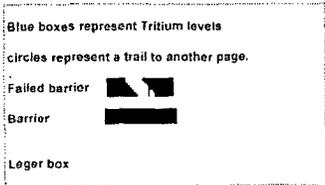
$$V_R = 49,407 \text{ gallons}$$



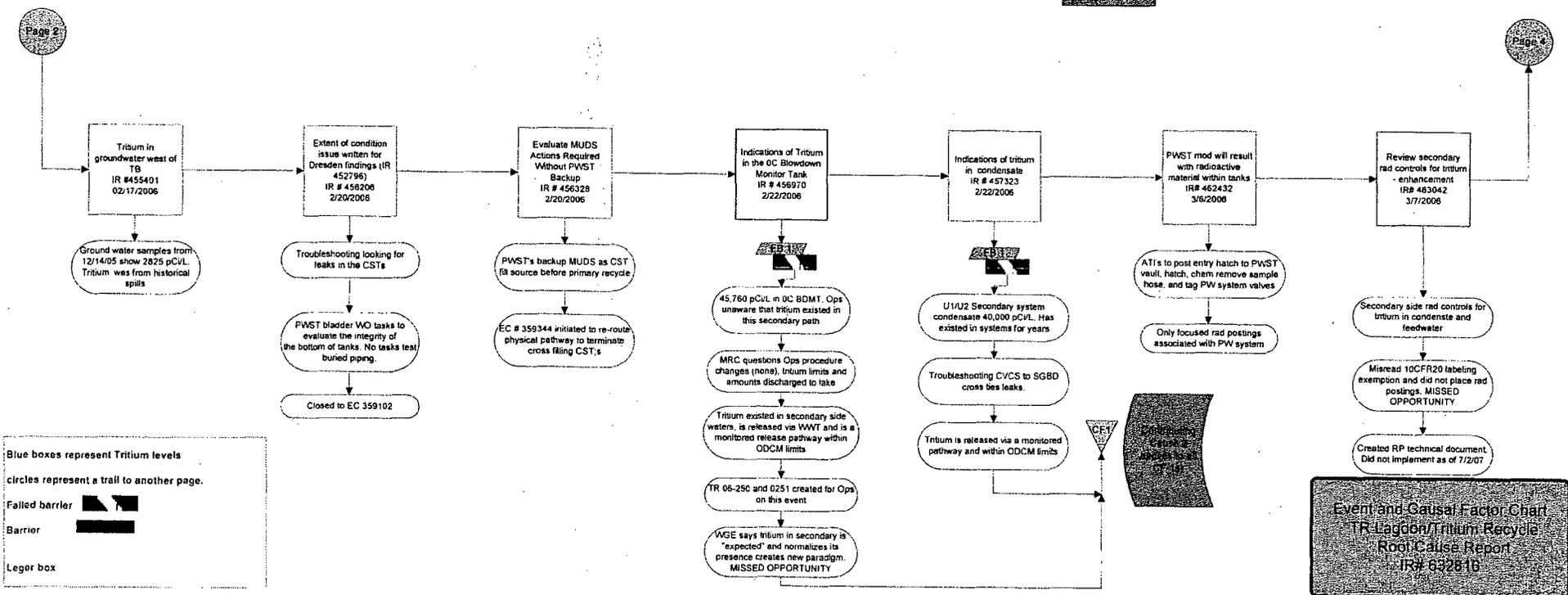
Blue boxes represent Tritium levels
circles represent a trail to another page.
Failed barrier 
Barrier 
Leger box 

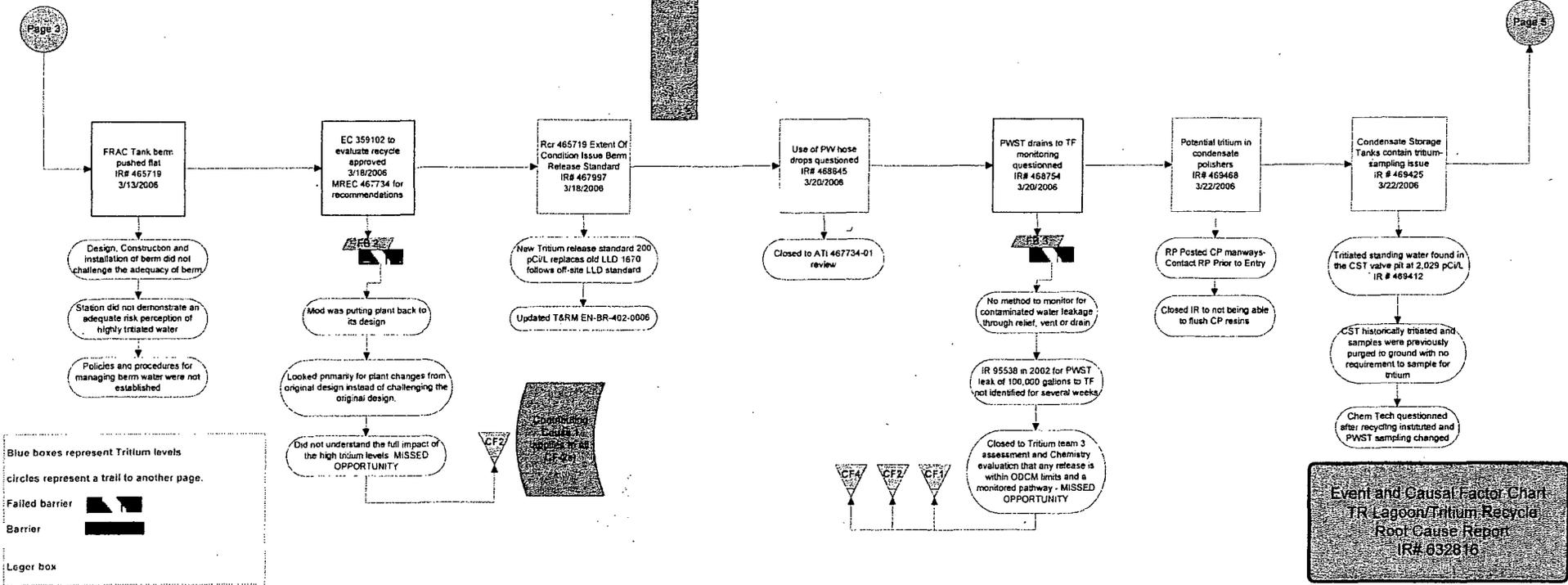
Event and Causal Factor Chart
TR Lagoon/Tritium Recycle
Root Cause Report
IR# 632816

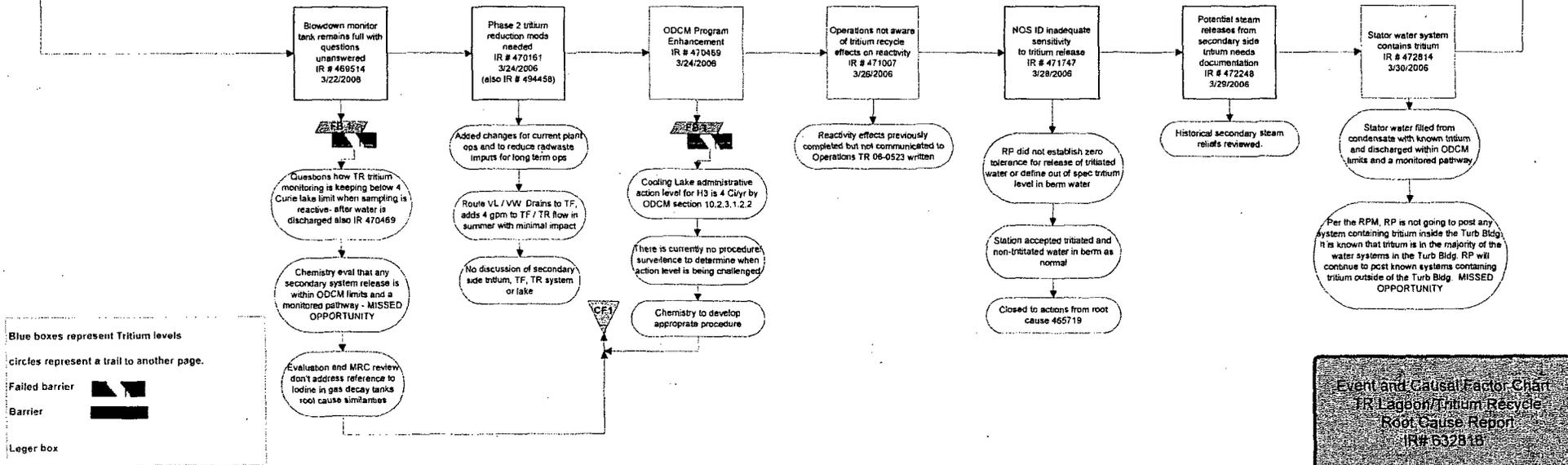


Blue boxes represent Tritium levels
 circles represent a trail to another page.
 Failed barrier 
 Barrier 
 Leger box 

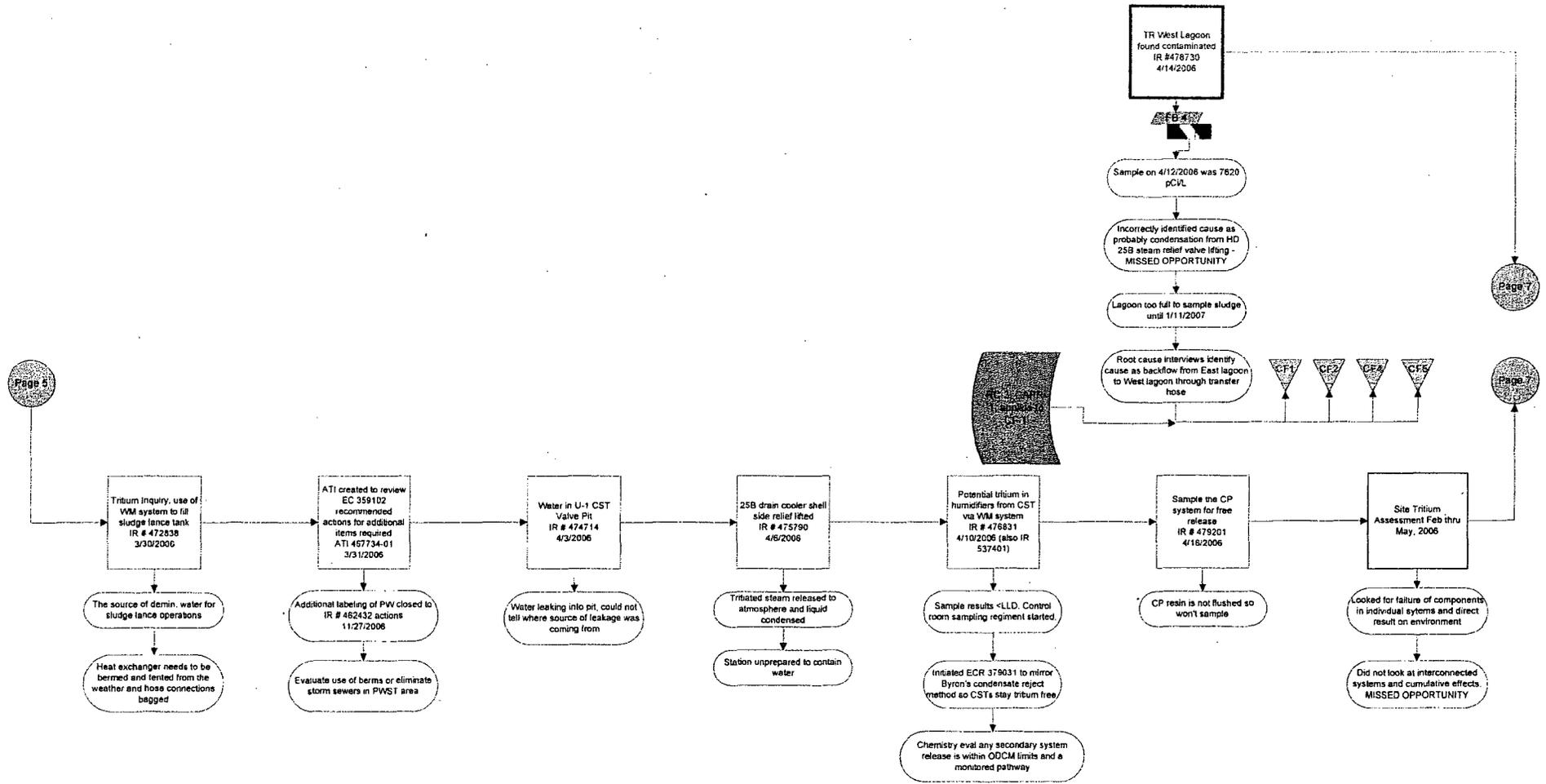
Event and Causal Factor Chart
 TR Lagoon/Tritium Recycle
 Root Cause Report
 IR# 632816





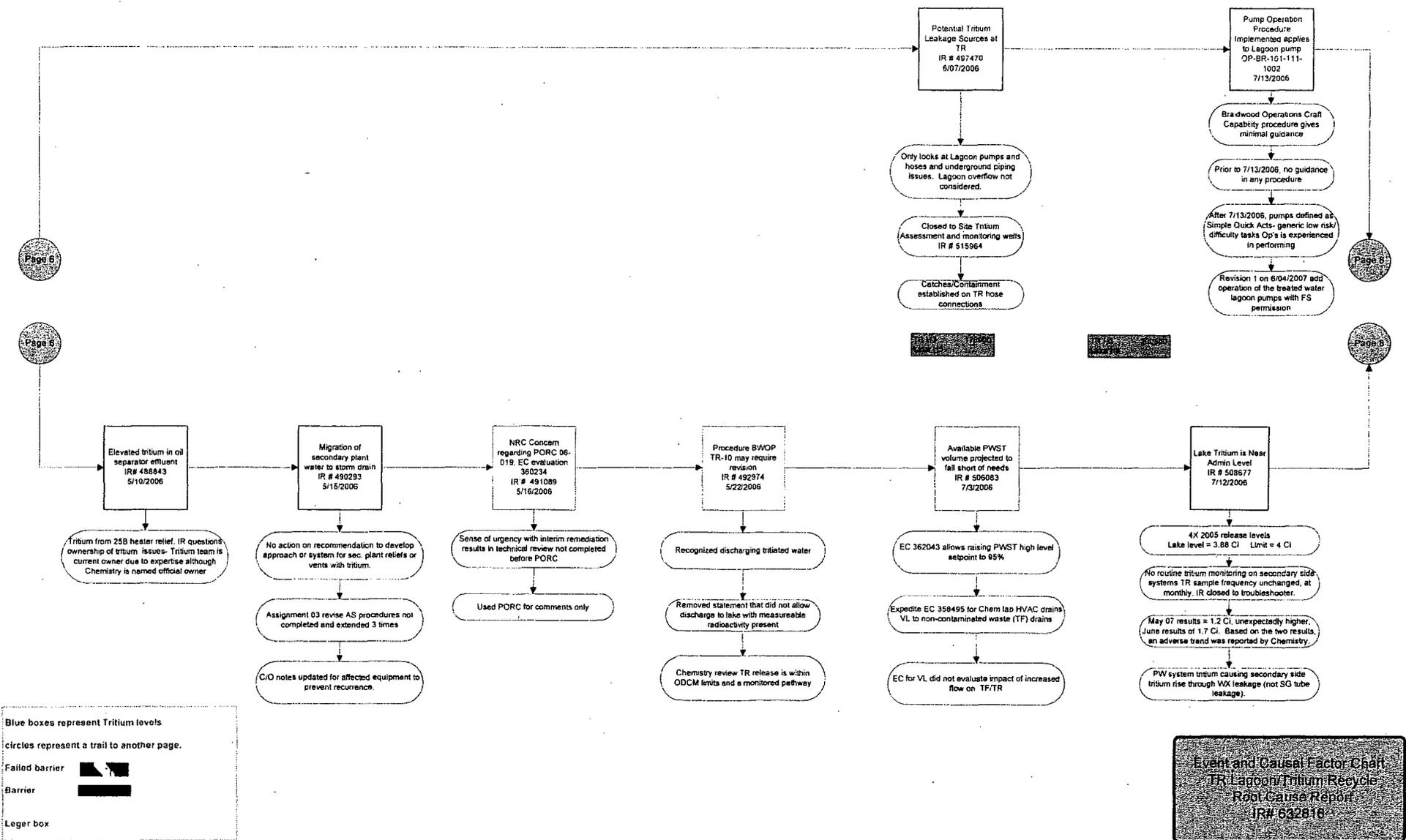


Attachment 4
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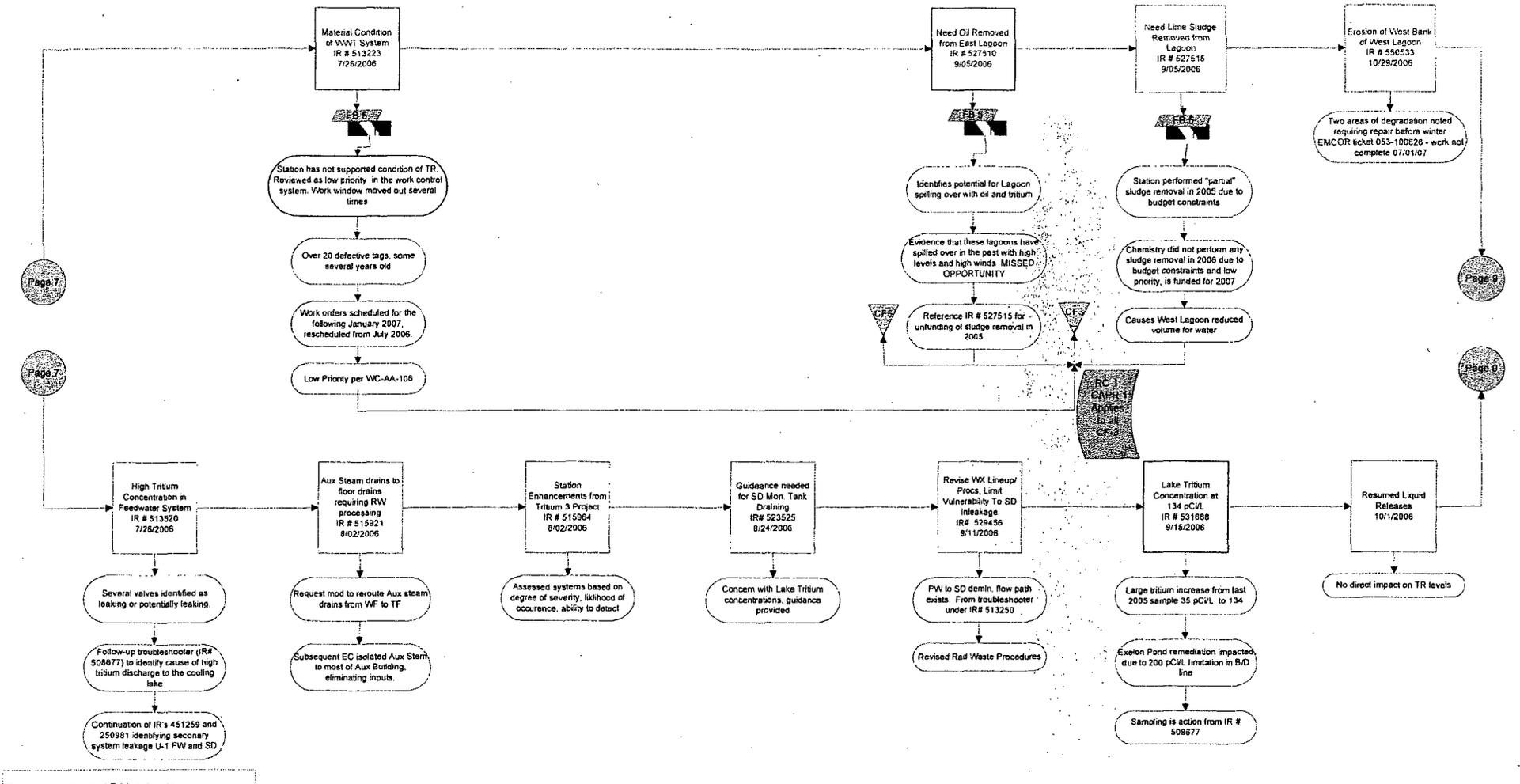


Blue boxes represent Tritium levels
 circles represent a trail to another page.
 Failed barrier 
 Barrier 
 Leger box 

Event and Causal Factor Chart
 TR Lagoon/Tritium Recycle
 Root Cause Report
 IR# 632816

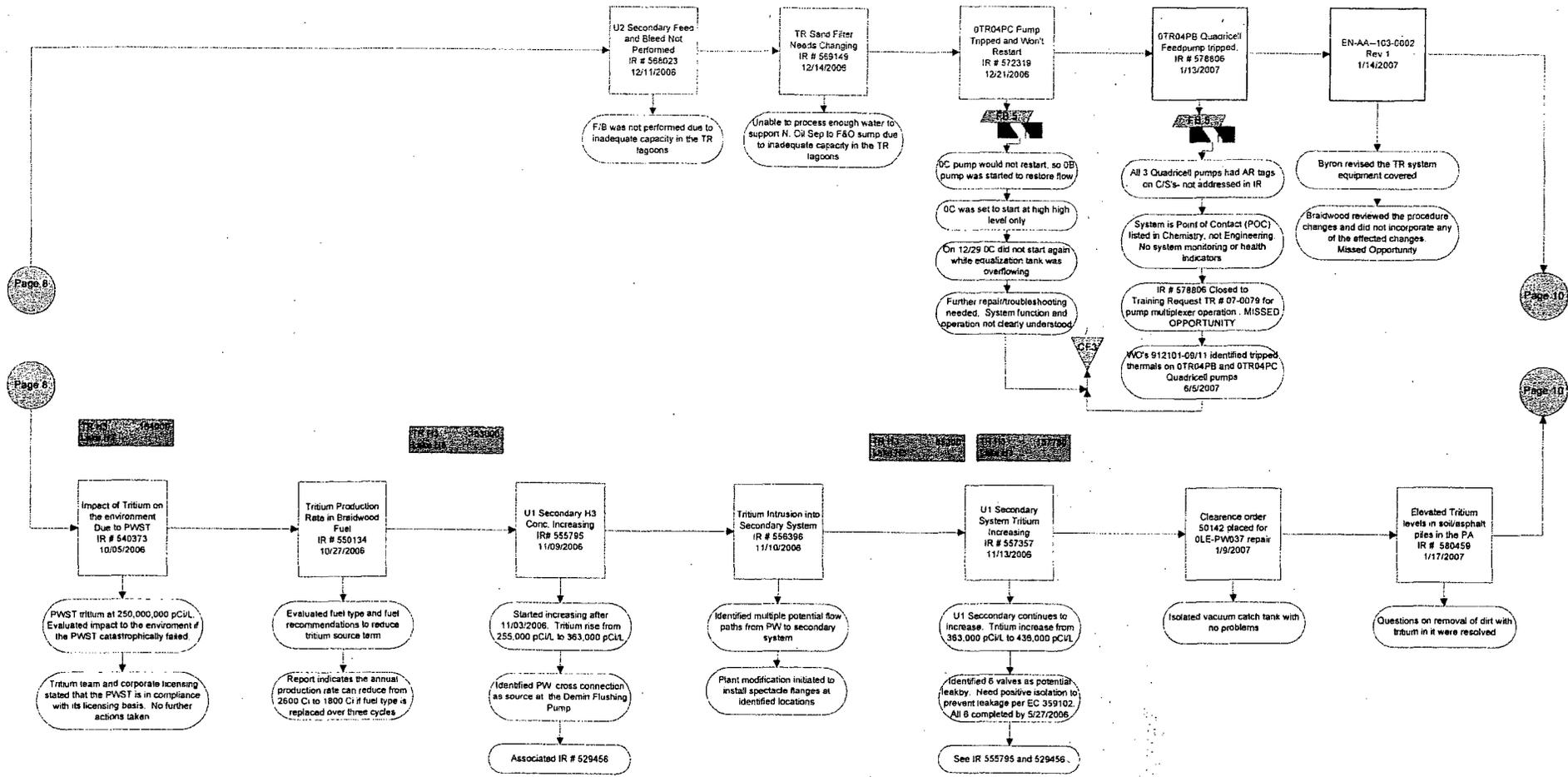


Attachment 4
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Blue boxes represent Tritium levels
circles represent a trail to another page.
Failed barrier 
Barrier 
Leger box 

Event and Causal Factor Chart
TR Lagoon/Tritium/Recycle
Root Cause Report
IR# 632816



Blue boxes represent Tritium levels
circles represent a trail to another page.
Failed barrier
Barrier
Leger box

Event and Causal Factor Chart
TR Lagoon/Tritium Recycle
Root Cause Report
IR# 632816

