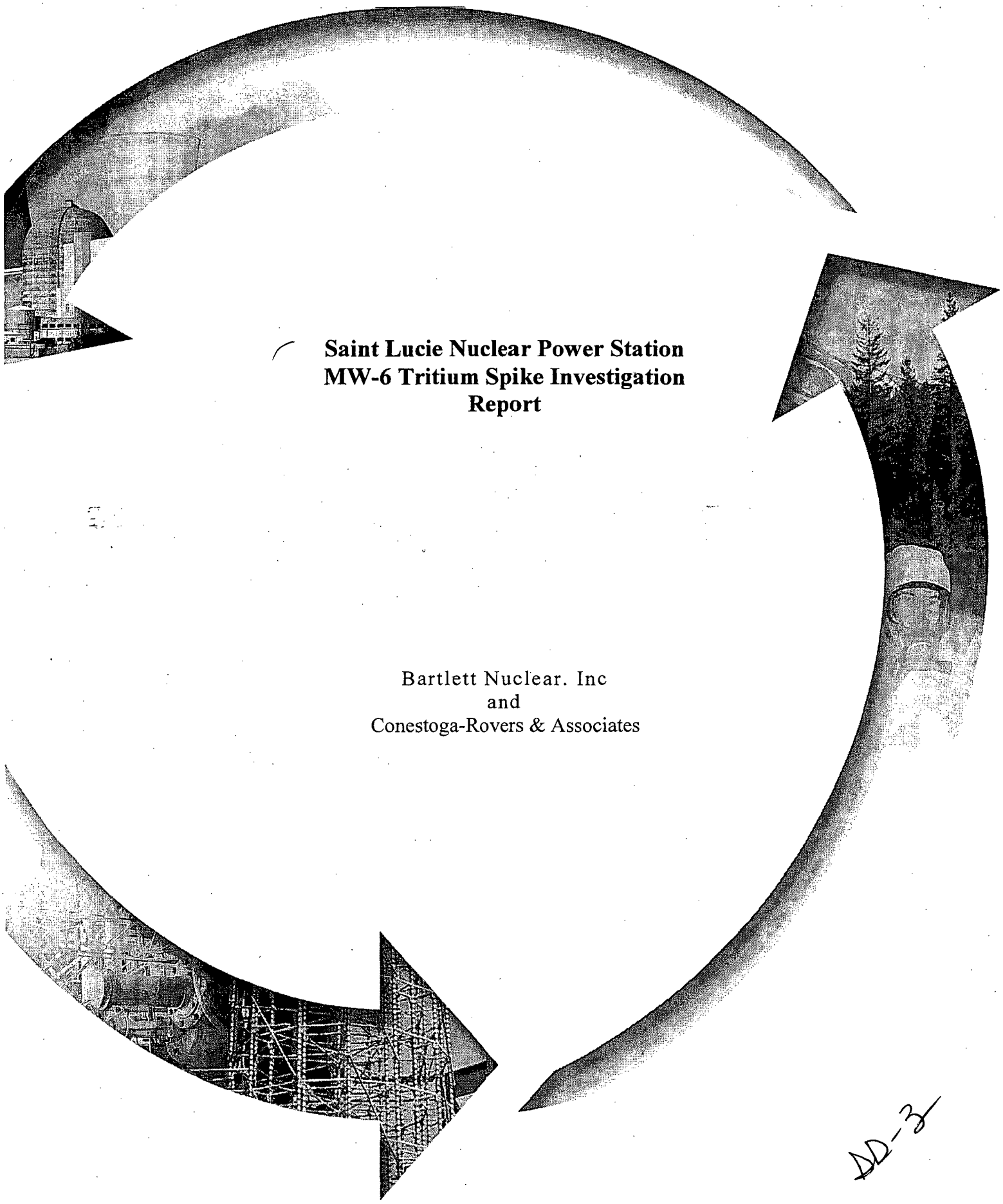

Saint Lucie Nuclear Power Station MW-6 Tritium Spike Investigation Report

Bartlett Nuclear. Inc
and
Conestoga-Rovers & Associates

DD-3

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1.0 EXECUTIVE SUMMARY

Bartlett Nuclear, Inc. (Bartlett) in conjunction with our teaming partner, Conestoga-Rovers & Associates (CRA); the Bartlett Project Team, was tasked with identifying the possible cause(s) for elevated tritium concentrations (also referred to as spikes) detected in two samples collected from monitoring well MW-6. Specifically, the investigation explored the possible correlation of operational events and spill history with the groundwater results from monitoring well MW-6. In addition, the Bartlett Project Team was tasked with preparing a Station Site Conceptual Model (SCM). A thorough understanding of Station hydrogeology was necessary in evaluating the MW-6 tritium spikes; the development of the SCM was conducted in parallel. This report summarizes the conclusions and recommendations of our investigation of the elevated tritium concentrations detected at monitoring well MW-6.

The Bartlett Project Team investigated an unexplained increase in tritium at monitoring well MW-6 at the Saint Lucie Nuclear Station owned/operated by Florida Power and Light (FPL). The investigation consisted of two onsite visits: related Station documentation, P&IDs, maintenance and operations logs were reviewed. In addition, interviews were conducted with key station personnel. See Attachment A for a complete listing of Station documents reviewed.

The investigation focused on two spikes in groundwater tritium concentrations. The first spike occurred on October 10, 2006 and the second occurred on May 15, 2007. Tritium concentrations on these dates were 14,050 pCi/l and 15,120pCi/l, respectively.

No single event is believed to have caused both tritium spikes. The first increase was likely caused by the seat leak in the CS-500 recirculation line drain valve (V-07214). Leaks from a valve V-07214 (Condition Report [CR] 2006-24440) within the Emergency Core Cooling System (ECCS) transfer tunnel resulted in high-concentration tritium activity in the yard sump, which drains to the Component Cooling Water (CCW) foundation floor. This resulted in a release to the water table through an unidentified below-grade leak. The second increase was likely caused by a discrete spill or overflow to the CCW foundation floor. The source of the tritium was a leak from V-14163 CCW Heat Exchanger Vent.

2.0 BACKGROUND

On Tuesday June 12, 2007, the Bartlett Project Team began its hydrogeologic investigation of monitoring well MW-6 at the Saint Lucie Nuclear Station. The Station is located on Hutchinson Island, about seven miles southeast of the City of Fort Pierce in Saint Lucie County, Florida. The plant is owned by FPL and has been in operation since 1976. Two 850-megawatt (electric) nominal rating Pressurized Water Reactors (PWRs) at the site share once-through cooling water intake and discharge canals. There are three

evaporation/percolation basins located south of the power block area. These basins are constructed in the native soils and are unlined.

Sixty-One (61) monitoring wells currently exist on the Saint Lucie property. Although these wells were installed for non-radiological monitoring purposes, they provide a network of wells that can be utilized to provide baseline radiological monitoring data in accordance with the Nuclear Energy Institute (NEI) Groundwater Protection Initiative. The Station conducted three site-wide comprehensive groundwater sampling rounds in June 2006, October 2006, and March 2007 as part of an initial groundwater assessment. Four additional sampling campaigns were conducted in May, June, July and August of 2007. Based on these data and in conjunction with the requirements of the NEI Groundwater Protection Initiative, FPL determined that an investigation of the tritium spikes and a better understanding of the site hydrogeology were the immediate project objectives.

The Bartlett team consisted of Mr. Robert Decensi (President and C.O.O. Bartlett Nuclear, Inc.), Mr. Christopher Messier (Director of Engineering Bartlett Nuclear, Inc.), Mr. Conrad Sherman (CHP, CIH, Bartlett Nuclear, Inc. Consultant), John Garges (PG, Conestoga-Rovers & Associates) and Mr. David Tarbox (RG, PG, Geo-hydrologist for Conestoga-Rovers & Associates). Collectively, the investigation team possesses extensive experience in implementing system evaluations and hydrogeologic investigations at operating and decommissioned nuclear power plants.

Station personnel contacted include:
Robert Eavenson (Primary Chemistry Supervisor),
Yuan Kao (Corporate Engineering),
Al Gould (Corporate Project Engineering),
Pat Maher (Corporate Geologist),
Daniel Frey (Chemistry Supervisor)
Gary Swider (SCE Manager)

3.0 EVALUATION

For this focused tritium investigation, the Bartlett Project Team obtained Station drawings identifying the systems that traverse the MW-6 area and identified systems that could have contributed to the tritium spike in groundwater. The Project Team conducted a focused review of operations and maintenance logs, searching for events or conditions (maintenance, repairs or operational events) that could have resulted in leaks or spills of tritiated water.

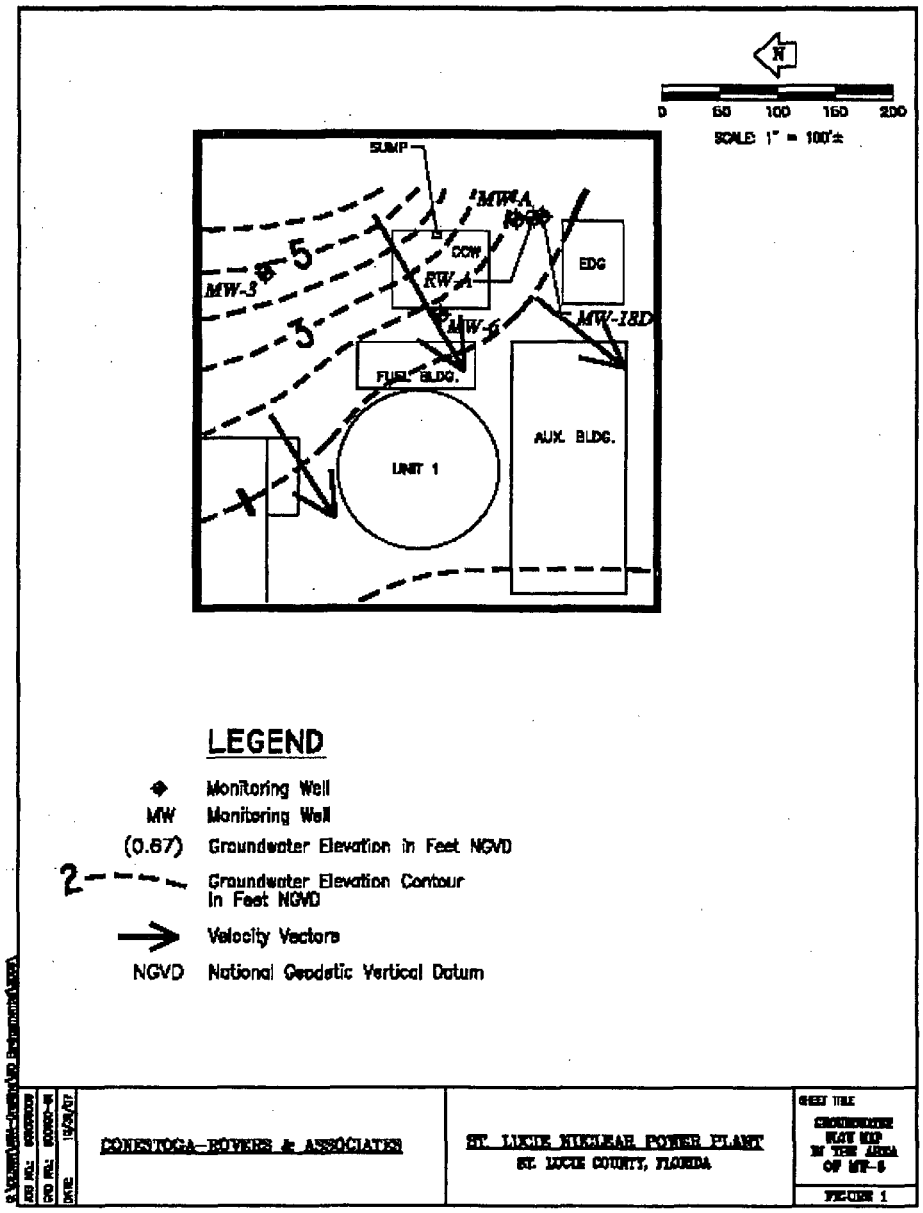
Primary system water contains on the order of 500,000 to 1,000,000 picocuries per liter (pCi/L) of tritiated water. Therefore, a relatively small leak of high concentrations of tritium can result in identifiable increases in groundwater concentrations. A number of piping systems containing primary water traverse the area in the vicinity of MW-6.

Small volume episodic leaks from any of these systems or a discrete spill event on the surface could have resulted in a source of tritium capable of causing tritium spikes at monitoring well MW-6.

3.1 Groundwater Flow Patterns in the Vicinity of MW-6

Groundwater flow patterns depicted on Figure 1 indicate groundwater flow from the discharge canal under CCW foundation pad towards MW-6.

Figure 1: Groundwater Flow Direction in the Area of MW-6



3.2 System Structures and Components Risk Ranking

Table 1, "System Structures and Components Risk Ranking", presents the results of a systematic assessment of Structures, Systems and Components (SSCs) by St Lucie Station using the Exelon[1] model developed to implement the Nuclear Energy Institute tritium initiative requirement by Zigmund Karpa of Exelon Nuclear and provided to Bartlett by Mr. Eavenson. The purpose of the assessment is to help prioritize various corrective actions to minimize risk to groundwater, system-by-system, using a standard risk assessment model.

The following systems may impact MW-6 ground water radiochemical concentrations as noted in Table 1:

- Waste Monitor System
- Demin Water tank
- Refueling Water Tank
- *ECCS Tunnel

Notes:

* - this system is most likely to influence MW-6, absent an unknown preferential flow path.

Table 1: Systems, Structures and Components Risk Ranking

Unit	System	Ground Water Impact Risk Total Score
1	2 - Chemical and Volume Control System	450
1	3 - Safety Injection System	450
1	7 - Containment Spray	450
1	6 - Waste Management	360
1	25n - ECCS Drains	180
1	14 - Component Cooling Water System	162
1	4 - Fuel Pool System (Cooling and Purification)	150
1	01b - Reactor Coolant System	40
1	12 - Condensate System	40
1	21a - Circulating Water - Intake Cooling Water	40
1	21b - Intake Cooling Water	40
1	8 - Main Steam	36
1	9 - Feedwater	36
1	10 - Extraction Steam System	36
1	11 - Heater Drains and Vents System	36
1	23 - Blowdown System - SGBTF	36
1	13 - Turbine Cooling Water System	30
1	28 - Condensate Recovery System	20
1	5 - Sampling System	6
1	Electrical Manhole & Handhole Drainage System	Not Available
0	19 - Condensate Polishing System	40

[1] by Zigmund Karpa of Exelon Nuclear

3.3 Condition Reports Summary

The Bartlett Project Team completed a detailed review of Station CRs. The following presents a summary of each CR reviewed.

CR 2006-21070

CR 2006-21070 (Event Date: 7/19/06) details leakage into cable vaults at manholes(s) 211 and 291. These vaults are located at the Unit 2 site between Component Cooling Water (CCW) and the Fuel Handling Building (FHB). The CR recommended that "determine input source of water to vaults and potential leakage pathway for water from vaults." This action was assigned to system engineering. This CR also identified that seepage from the surrounding substrate was the source as the vaults are not watertight. The CR also identified Unit 2 Primary Water Storage Tank (PWST) and Unit 2 Refueling Water (RW) tanks as having had prior leakage. The two vaults were reported to be connected; however, it is noted that the concentrations in each vault were sufficiently different that they do not appear to be well mixed, or impacted necessarily from a single source. The CR also identified drainage to Electrical Catch Basin 2 that is pumped to Catch Basin #70, which in turn drains to the East Settling Pond (ESP).

CR 2006-24440

CR 2006-24440 (Event Date: 8/24/06) addresses an issue in which the Unit 1 Emergency Containment Cooling Spray (ECCS) system sump water was found to contain water containing approximately 1,000,000 pCi/l of tritiated water in August of 2006. The ECCS tunnel contains piping and valves for the containment spray system, in particular line CS-500 (6 inch) and valve (V-07214). Primary coolant containing on the order of 1,000,000 pCi/l of tritium is used in this system. Review of the CR indicated that a valve had been known to be leaking since 2005 and that a work request to repair the valve had been written.

CR 2007-9920

CR 2007-9920 (Event Date: 4/4/07) indicates that a drum staged in the Unit 1 CCW to collect leaking water from V14163 CCW Heat Exchanger Vent overflowed between 24 and 44 gallons of tritiated water. The activity concentration for tritium in the water on the floor of the CCW was analyzed at $2.34E^{-4}$ uCi/ml (234,000 pCi/l).

CR 2007-15465

CR 2007-15465 (Event Date: 5/19/07) identifies a leak/spill from a temporarily chiller heat exchanger. The event and discovery date were identified as May 19, 2007. The volume of material lost, and tritium activity were not identified in this CR.

CR 2007-15476

CR 2007-15476 (Event Date 5/19/07) also identifies a leak/spill from a temporarily chiller heat exchanger. In this CR the event is indicated as having occurred on May 18, 2007 and the discovery date was identified as May 19, 2007. The CR describes the volume as a stream 3 feet across and 10 feet long running into a storm drain. An inter-office correspondence identifies the volume of water spilled to be no more than 6 to 10 gallons.

3.4 Tritium Spike Analysis

The following presents an analysis of the potential cause(s) of each tritium spike. Attachment B presents a timeline to evaluate the temporal relationship of plant activities and groundwater monitoring results. It was developed from the review of CR reports and other information provided by the Station. It is recommended Attachment B, "MW-6 Tritium Spike Evaluation Timeline" be referenced when reading sections 3.2.1, "October 2006 Tritium Spike and 3.2.2, "May 2007 Tritium Spike" of this report.

3.4.1 October 2006 Tritium Spike

The event described by CR 2006-24440 is considered relevant to the tritium activity discovered in monitoring well MW-6 during the October 10, 2006 sampling event. This leak occurred over a long period of time and tritiated water is known to have been transferred to locations where leakage could have directly impacted MW-6.

Monitoring results of the yard sumps and CCW sump between August 31, 2006 and September 13, 2006 show tritiated water at similar concentration levels as found in MW-6. The time of detection and the leakage rate inside the ECCS tunnel were not identified in the CR. Contaminated samples collected from the CCW and yard sumps confirm that tritiated water was transferred from the ECCS tunnel. The leaking line in question is CS-500 which runs subsurface in the ECCS tunnel between the Refueling Water Tank (RWT) and the Reactor Auxiliary Building (RAB) of Unit 1. The CR identifies that valve V-07214 did in fact leak during monthly surveillance testing. The ECCS tunnel has a trough that runs to the yard sump. All liquids from the trench floor run to the yard sump. The yard sump discharges to the common CCW sump (a clean system not designed for radioactive material), located on the CCW foundation floor. The CCW sump overflows to the East Storm drain system which in turn drains to the East Settling Pond (ESP). The leaking of V-07214 was identified when tritium identified in the ESP was traced back from the ESP to the CCW sump.

ECCS leak
↓
ECCS tunnel
↓
yard sump
↓
Clean CCW sump
↓
Overflow goes to East storm drain
↓
East Settling Pond (ESP)

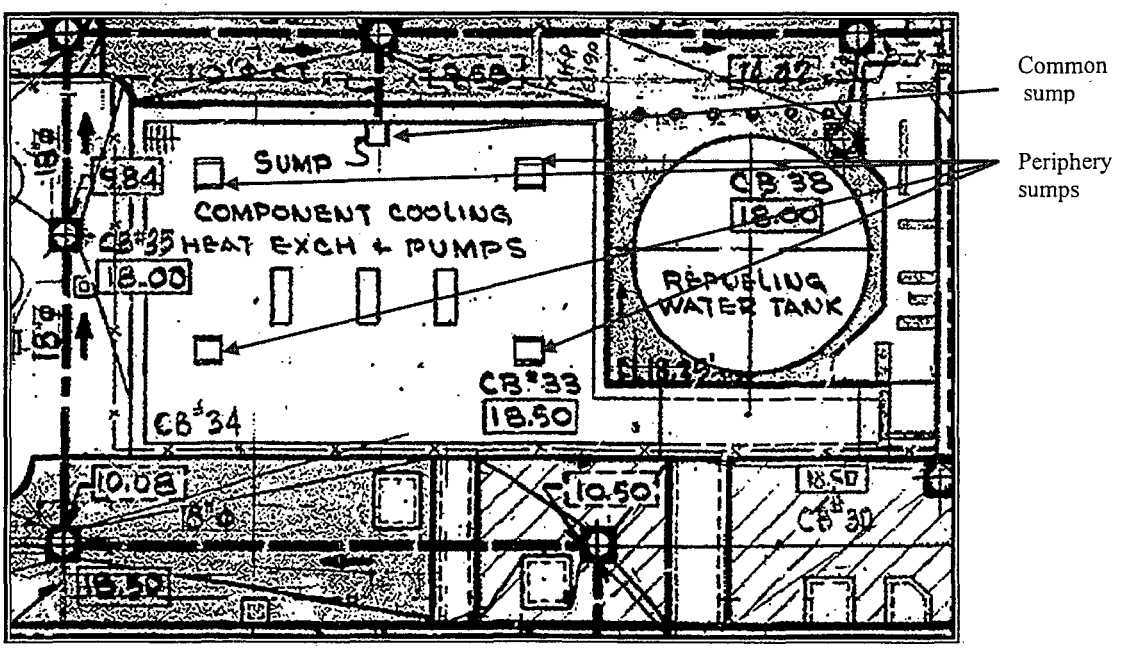
The repair of leaking valve V-07214 was scheduled for the SL-1-21 outage, however this condition allowing contaminated water to leak from the valve into the ECCS transfer tunnel (as described in CR 2006-24440) was corrected by August 27, 2006, when the yard sump was bypassed so that contaminated water did not get transferred to the CCW sumps (clean system). Between June 18, 2006 (date of 1,650 pCi/liter sample result) and August 27, 2006 (date bypass yard sump), there was ample chance during either monthly

surveillance testing or other water transfers between the RWT and reactor cavity using the CS-500 line for leakage to occur. This leakage created conditions that led to contamination of the CCW sumps. Presumably, the presence of tritiated water in this system led to the activity seen in MW-6. CR 2006-24440 describes the flow path from the ECCS transfer tunnel (Figure 3) floor to the yard sumps and CCW sumps, thence to the storm drain system.

Measurement confirmed transfer of activity to Yard and CCW sumps. Between August 31, 2006 and September 13, 2006 at least three samples were collected from the Unit 1 Yard sump and CCW sumps. Sample results ranged from 18,800 to 37,400 pCi/l of tritium. Activity in these sumps correlates time-wise with ongoing leaks in the ECCS tunnel.

Based on location, proximity and groundwater flow direction, leakage from the stormwater transfer system is a potential source capable of impacting concentrations in MW-6. The tritiated water in the CCW/yard sumps could have made its way to groundwater either from subsurface leaks in the storm drain system itself or overflow from sumps in the CCW floor. Groundwater flow directions support the theory that water that spilled or drained to the CCW foundation floor, CCW sumps and transfer piping to the storm drain system are all plausible sources of tritiated water introduction to ground in the vicinity of MW-6.

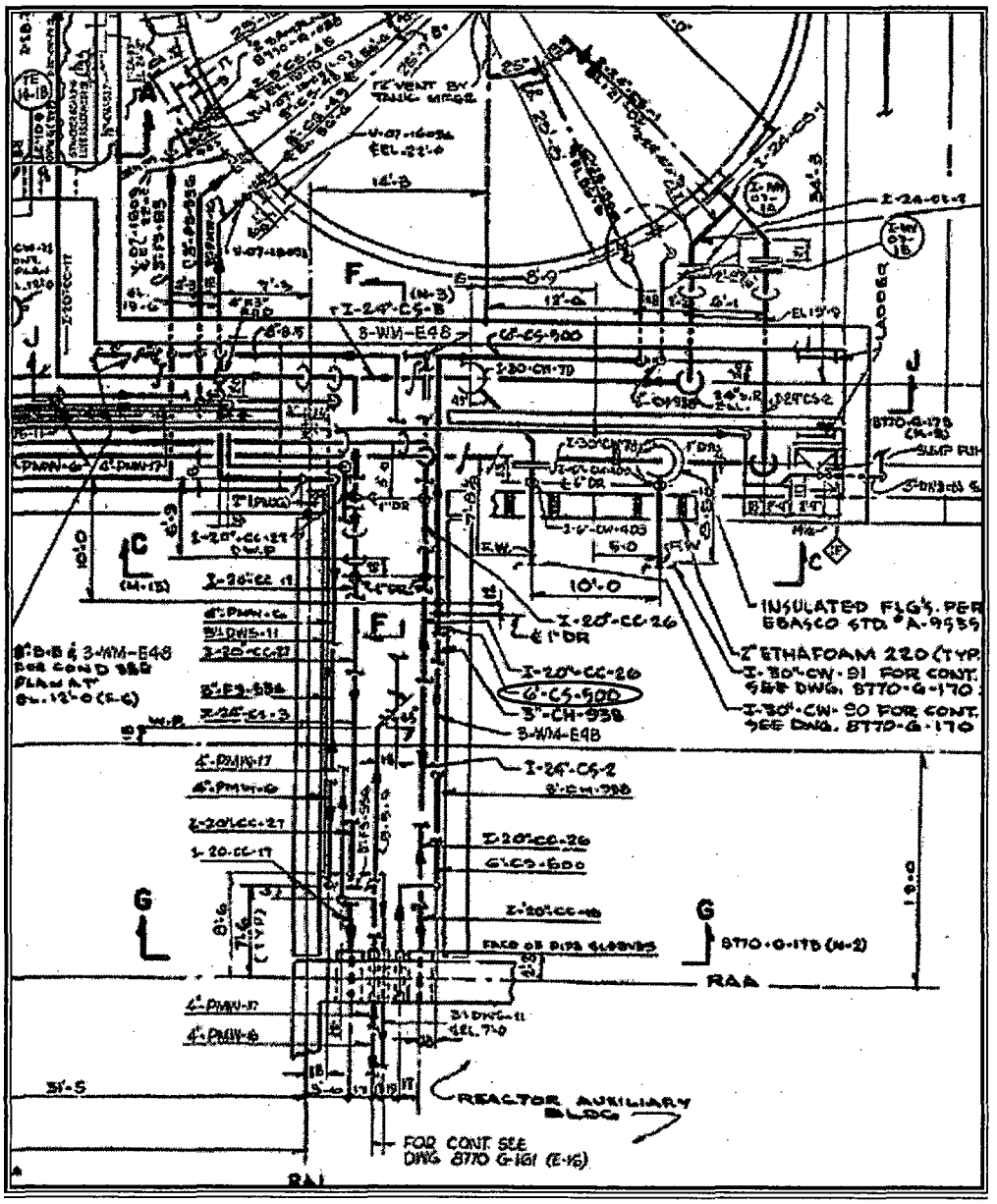
Figure 2: CCW Foundation Pad



This CCW structure contains four periphery sumps that feed a central common sump. The central sump discharges to the storm drain system.

The location of CS-500 line is shown on Figure 3.

Figure 3: CS-500 Line Location



The ECCS tunnel runs between RWT and Reactor Auxiliary Building and is in the vicinity of MW-6.

Storm water piping (designed as non-radioactive system) may provide a conduit to groundwater if integrity is deteriorated. The systems not designed to transport

radioactive fluids may have been constructed to a lower standard, and are thus more likely to be the source of a leak path.

The CCW foundation floor sumps and the path to the ESD system are considered the most likely place for water to have impacted groundwater around MW-6. Although the sump was bypassed on August 27, 2006, the highest sample measured in the yard sump was 37,400 pCi/l on September 13, 2006. Twenty seven (27) days later, elevated activity was recorded at MW-6.

3.4.2 May 2007 Tritium Spike

The second tritium spike occurred in a sample collected on May 15, 2007 forty-three (43) days after a significant spill of high activity water, caused by a drum overflow at CCW to the CCW foundation floor.

CR 2007-9920 identifies a drum staged in the CCW to collect leaking water from V-14163 CCW Heat Exchanger Vent overflowed between 24 and 44 gallons of tritium contaminated water. The tritium concentration measured on the May 15th sampling campaign was reportedly 15,120 pCi/l; the activity of the water on the floor just 43 days prior was measured to be 243,000 pCi/l.

Additionally, an event involving the discovery of a leak of CCW water to the Storm Drain System between the Unit 1 Fuel Handling Building and the Reactor Auxiliary Building may also be a tritium contributor to groundwater in the vicinity of MW-6. Two Condition Reports (CR 2007-15476 and CR 2007-15465) identify a leak from the Unit 1 A/C Chiller and its hoses as having occurred on May 18th or 19th. The event as described is considered not to have impacted groundwater tritium concentrations in monitoring well MW-6 at the time of the May 15, 2007 sampling event as the event would have occurred after sampling. However ambiguity on when the leak occurred and the quantity of the spill warrant further investigation.

3.4.3 Estimated Travel Time Calculation

Measurement of the horizontal hydraulic gradient on August 24, 2007 in the vicinity of monitor well MW-6 revealed a gradient of 0.03. Using Darcy's Law with a hydraulic conductivity of 4 ft/day, hydraulic gradient of 0.03 ft/ft, and a porosity of 0.2, results in an average groundwater velocity of 0.6 ft/day. This calculation suggests CCW periphery sumps and/or cracks and seems in the CCW foundation floor as likely sources of the measurable concentrations of tritiated water at MW-6.

4.0 SUMMARY

Two tritium spikes were detected in groundwater samples collected from MW-6 in October 2006 and May 2007. Since May 2007, tritium concentrations in well MW-6 have decreased. Two unrelated causes were identified as the sources of the tritium spikes

in MW-6. However, associations of the two events suggest one or more of the CCW sumps and/or cracks/seems in the CCW foundation floor as potential source(s) allowing tritiated water to reach groundwater.

The first spike at monitoring well location MW-6 occurred October 10, 2006 after a series of events related to the ECCS transfer tunnel (likely occurring over a year long period). These events are detailed in CR 2006-24440 and had significant potential to cause the anomalous monitoring result of 14,050 pCi/l. The first tritium spike was the result of a leak into some portion of the Stormwater Water Collection System, which transmitted water through the ECCS transfer tunnel. It is believed that the leak introduced into the CCW sump(s), which is open to the subsurface thereby allowing tritiated water to reach MW-6. The decrease in tritium concentration at MW-6 following the October 2006 spike is explained by the rerouting of the Yard Sump, which included repairing the CS-500 line valve leak that impacted the Yard Drain System and the CCW Sump(s).

The second tritium spike was the result of a CCW Heat Exchanger Vent overflowed and spill to the CCW foundation floor, which drains to one or more of the CCW periphery sumps. The second spike occurred May 15, 2007 with tritium concentrations of 15,120 pCi/l. This result was based on a sampling event 43 days after a spill to the CCW foundation floor. CR 2007-9920 identifies a drum staged in the CCW to collect leaking water from V14163 overflowed high activity tritiated water. A sample collected from the floor of the CCW was reported as 234,000 pCi of tritium per liter of water.

Based on groundwater flow data the following systems are considered primary suspects for the tritium spikes and should be the focus of any ongoing investigation.

Sumps from CCW foundation floor
Storm Drain System
ECCS Tunnel Yard Sump

5.0 RECOMMENDATIONS

The following presents the Bartlett Project Team's recommendations for future activities related to the tritium spikes detected at MW-6. The goal of future monitoring is to determine if a source or active leak may be present or if the trend is a result of activity remaining from a prior (historical) event. Other recommendations are presented based on the EPRI recommendations and regulatory requirements.

5.1 Groundwater Monitoring

We recommend that the sampling frequency of MW-6 be increased, once per month, until the tritium concentrations are consistent with pre-spike levels. Even if the principal tritium source has been eliminated, continued spiking may be seen from groundwater

flow reversals caused by elevation changes, and from an unknown reservoir of tritiated water.

5.2 Potential Optional Activities

There are interim steps that can be considered that may help pinpoint a potential source or refute the likelihood of a particular system as a potential source. The following presents some of the optional tasks that may be warranted in the future.

Soil Sampling

EPRI team recommended consideration of sampling interstitial spaces in soil to determine if legacy material is an ongoing source. There are several considerations that should be evaluated before beginning a sampling campaign to look for residual material in the vadose zone. The Bartlett Project Team does not recommend this approach, unless it is focused on a specific source for the tritium. In the case of the ECCS tunnel, additional soil sampling, water sampling may indicate that the ECCS tunnel is serving as a continuing source. A sample program can be designed to have adequate sensitivity and coverage to resolve this issue. Provided the monitoring results down-gradient from this potential source remain low, further investigation may not be warranted.

Dye Testing

A leak in the underground sump piping may be identified by testing each sump with a different dye, so that sampling of MW-6 and testing for the specific dye can be used to determine the source of the leak. Rhodamine WT dye has the ability to stain organic materials from plants matter found in silt and dirt. With fluorometry, detection of the dye as low as 10 ppt (parts per trillion) can be made. It can also be observed by the naked eye at higher concentrations.

Washout

EPRI also suggested looking at washout as a possible source in terms of a systematic evaluation. This is not likely to be a significant source because washout of tritium tends to be diluted from precipitation not influenced by washout; nevertheless, if wind patterns show a propensity for predominant wind to be concentrated in just a few sectors, then groundwater tritium may rise in those sectors only. Experience and review of data from several sites suggest that rainwater will typically contain less than 10,000 pCi/l of tritium and then only directly under the precipitation plume. Actual groundwater influenced rainout tends to be much lower for two main reasons; first, natural attenuation and mixing of groundwater; and second, washout itself, tends to vary with wind patterns, providing, dilution from rainwater over time. At least one PWR limits venting to non-rain periods, however that approach is not recommended for the Saint Lucie Station.

Local Leak Rate testing (LLRT)

Local Leak Rate testing (LLRT) should be considered when monitoring well results and groundwater quality data indicate a significant leak rate, that must be identified because of either system implications (the leak rate portends critical system failure) or environmental radiological impact offsite. The Bartlett Project Team considers it premature to recommend local leak rate testing (LLRT) for systems in the vicinity of MW-6 provided tritium results continue to trend downwards.

Regulatory Analysis

Several operating Nuclear Power Plants continue to have ongoing problems with tritium leakage, most notably Indian Point 2.

Two criteria apply:

1. First, that a licensee control, monitor and perform radiological evaluations of all releases (based on GDC 60, 61 and 64) and document and report **all**[2] radiological effluents discharged into the environment; and
2. Second, the Annual Radiological Environmental Operating Report (AREOR), should include a determination (using conservative means) as to whether or not the tritium release could exceed ten percent of the dose to the maximum offsite (Member of the Public) receptor (based on a regulatory position in Regulatory Guide 1.109 Rev. 1). Indian Point demonstrated using a dose assessment and precipitation mass balance that releases were in control and accounted for.

The focus at Saint Lucie Station should be to characterize, quantify and define any new effluent pathways, and to demonstrate that dose consequences are below regulatory concern i.e., < 1 mrem/yr. Groundwater monitoring should continue to be utilized to provide data on potential leak sources for further investigation and backup leak detection as well as primary leak detection for systems or structures that cannot be monitored with the requisite sensitivity by other means. Identifying the source of every groundwater monitoring result that is not anticipated is an ideal goal; however, experience has shown that for some events, the source may never be fully explained, or that multiple minor sources or conditions contribute to the observed spikes in tritium concentration.

[2] The word **all** appears in an NRC summary document found at http://www.nrc.gov/reactors/operating/ops-experience/tritium/tritium-handout-40506.pdf; but this does not appear in any of the GDC that form its basis.

ATTACHMENT A

List of Documents Reviewed In Support of the MW-6 Investigation

EPRI Groundwater Assessment for FPL Saint Lucie Plant, May 2007

Station drawings:
- 8770G-701.R3
- 8770-G-170.S1.R16
- 8770-G-172.R23
- 8770-G-407.S1.R20
- 8770-G-408.S1.R19
- 8770-G-483.R18
- 8770-G-069.R20
- 8770-G-068.R18
- 8770-G-067.R15
- 2998-G-483

Saint Lucie - Unit 1 & 2 Location Plan
Saint Lucie - Unit 1 & 2 Owner Controlled Area Plan

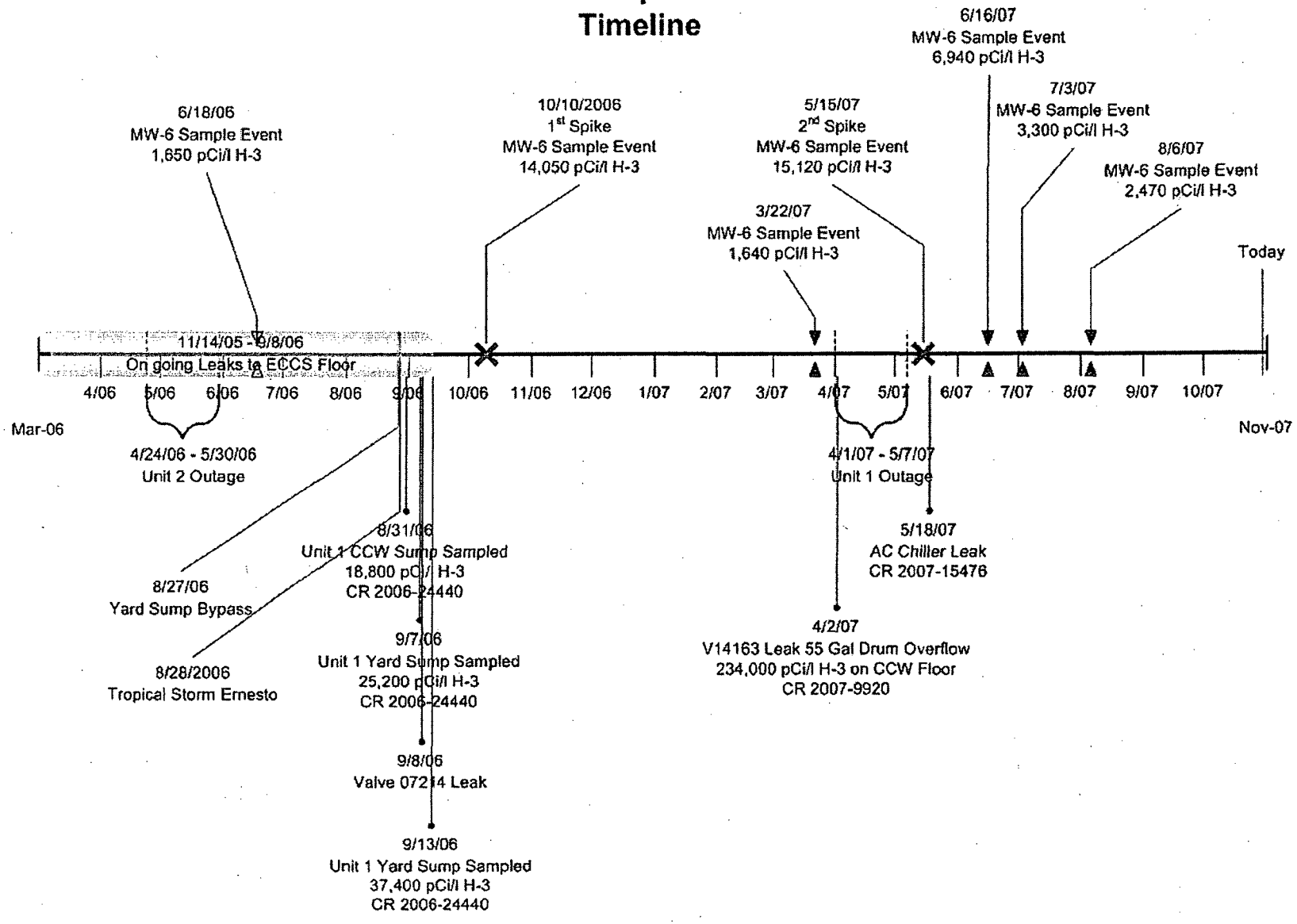
Condition Reports
- 2006-21070-Condition Report
- 2006-24440-Condition Report
- 2007-9920-Condition Report
- 2007-15465-Condition Report
- 2007-15476-Condition Report

Inter-Office Correspondence
- Subject: CCW Spill during Dismantling of the Unit 1 Air Conditioner Heat Exchanger

Operations Logs from 6-1-2006 to 3-31-2007
Power Point Presentation, "PSL Groundwater Protection Program Status"
FPL St. Lucie Plant - Units 1 and 2 Table 3: Groundwater Elevation Table
Boring Logs - Unit 1 & 2 Diesel Plume Wells
Saint Lucie - Groundwater Impact Risk Table

ATTACHMENT B

MW-6 Tritium Spike Evaluation Timeline



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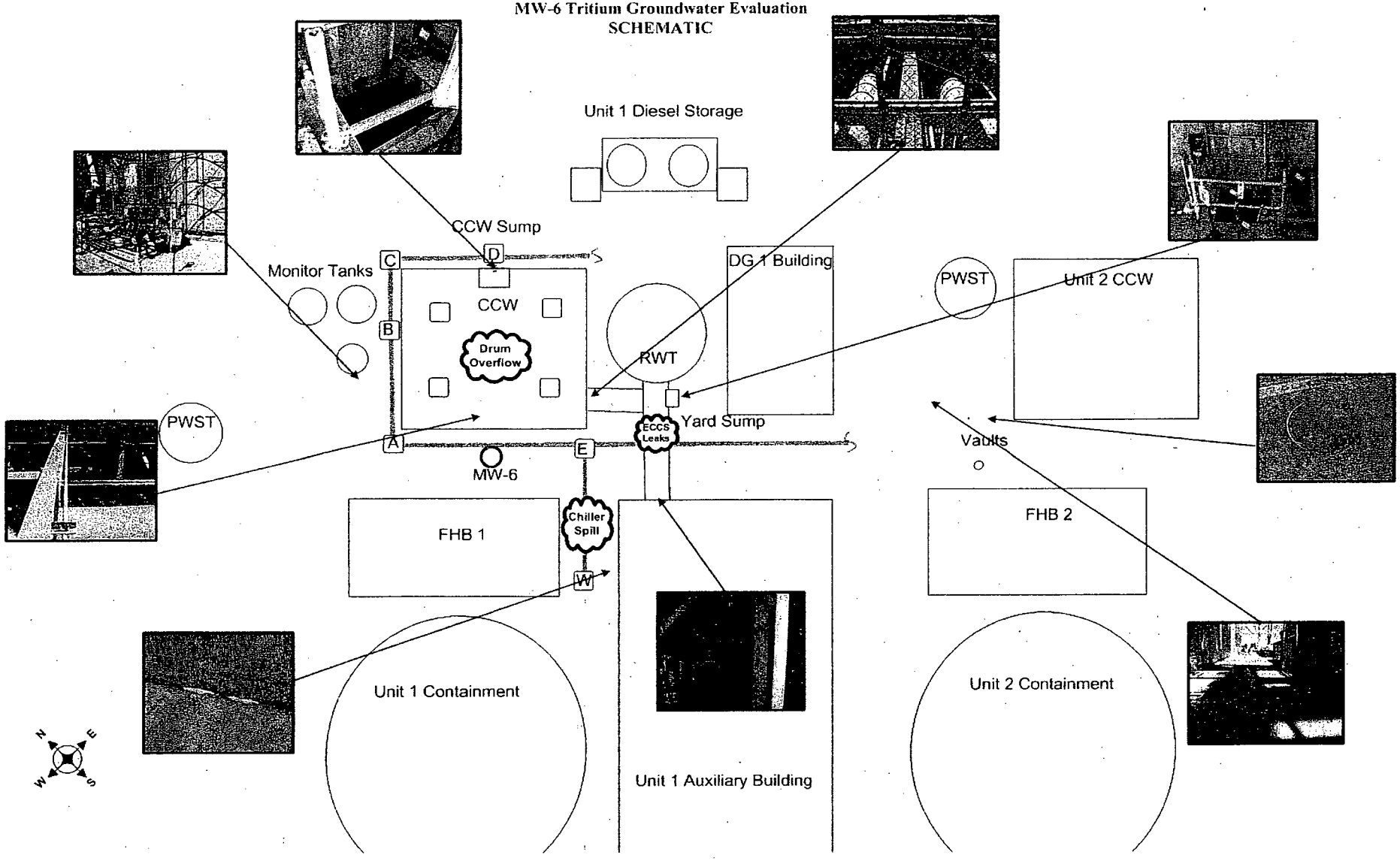
MW-6 Tritium Groundwater Evaluation
SCHEMATIC