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Tank 241-AX-104 Integrity Assessment Report

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract:
This document provides the results of a tank integrity leak assessment performed for tank 241-AX-104 during June, 2014 in accordance with the leak assessment process (TFC-ENG-CHEM-D-42). The assessment team concluded that a tank leak was unlikely given the low level of gamma activity measured in drywells and other more probable sources for the drywell activity. The recommendation of the leak assessment team was that the integrity designation for tank AX-104 be changed from "Assumed Leaker" to "Sound."

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EXECUTIVE SUMMARY

This document provides the results of a tank integrity leak assessment performed for tank 241-AX-104 (AX-104). The leak assessment process is described in Engineering Procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*.

Single-shell tank 241-AX-104 is a one million gallon capacity, 75-foot diameter, mild steel-lined concrete shell tank located in the southeast corner of the four-tank 241-AX Tank Farm. The tank was placed in service in 1965, and continued to receive and store waste until August 1978 when it was removed from service. The tank was sluiced in 1977 and 1978 and declared interim stabilized on August 10, 1981 based on a review of tank photographs. The tank was classified as having questionable integrity in August 1978 based on radioactivity detected in drywell 11-04-08. The source of the radioactivity could not be determined. The four valve and service pit drain lines connecting to the tank were removed during August 1981 to prevent water intrusion.

In 2007, CH2M HILL Hanford Group Inc., with the U.S. Department of Energy – Office of River Protection and the Washington State Department of Ecology, developed a process to re-assess selected tank leak volume and inventory estimates, and to update single-shell tank leak and unplanned release volumes and inventory estimates as emergent field data are obtained. The process is described in RPP-32681, *Process to Estimate Tank Farm Vadose Zone Inventories*.

In February, 2008, a review of waste released to the soils from tank AX-104 was conducted in accordance with the RPP-32681 process. The review concluded that a leak from the tank was unlikely given the low levels of gamma activity measured in drywells and other more probable sources for the drywell activity. The AX farm tanks were reassessed in January 2014, and a tank leak integrity assessment was recommended. A formal leak assessment of tank AX-104 was performed during June, 2014. The method of analysis used for the formal leak assessment process was Engineering Procedure TFC-ENG-CHEM-D-42.

The leak assessment team developed plausible hypotheses for the observed tank behavior based on the review of in-tank and ex-tank data:

Leak Hypothesis:

> "The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104."

No-Leak Hypothesis:

> "The change in radioactivity in dry well 11-04-08 resulted from a source or sources other than a tank leak and may include the AX farm ventilation system, transfer line leaks, operations releases and/or other sources."

The consensus of the assessment team was that the data did not appear to support a tank leak. The following general observations were made: Liquid level decreases reported in Occurrence Report OR 77-19 have been explained and did not appear to be a concern in the past; the leak detection pit (LDP) liquid level continually decreased and should increase for a tank leak; radioactivity at drywell 11-04-08 likely didn't originate from the ventilation header Dresser coupling leaks between the tanks and radionuclide concentration appears to be too low to be from a tank leak, but appears to be consistent with a condensate leak; if the tank leaked, other radionuclides such as ^{137}Cs or ^{60}Co would be expected in spectral gamma scans; a leak from ventilation lines near drywell 11-04-08, flush pit leaks or surface runoff and migration are viable sources for the Ru-106 in drywell 11-04-08.

The recommendation of the leak assessment team was that the integrity designation of tank AX-104 be changed from "Assumed Leaker" to "Sound."

The results of the assessment were presented to the Executive Safety Review Board (ESRB) on August 25, 2014. The board concurred that the integrity status of tank AX-104 should be changed from "Assumed Leaker" to "Sound."

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LIST OF TERMS

Abbreviations and Acronyms

BDGRE	buoyant displacement gas release event
BGS	below ground surface
CASS	Computer Automated Surveillance System
CC	complexant concentrate
CY	Calendar Year
DIL	drainable interstitial liquid
DLR	drainable liquid remaining
DOE-GJO	U.S. Department of Energy Grand Junction Office
DOE-RL	U.S. Department of Energy Richland Operations Office
DOE-ORP	U.S. Department of Energy Office of River Protection
DSSF	double-shell slurry feed
FY	Fiscal Year
GRE	gas release event
IDMS	Integrated Data Management System
PCSACS	Personal Computer Surveillance Analysis Computer System
PSS	PUREX Sludge Supernatant
SGLS	Spectral Gamma Logging System
SST	single-shell tank

Units

Cfm	cubic feet per minute
Ci	Curies
C/s	counts per second
Ft	Foot
Gal	Gallon
In	Inch
Kgal	kilogallon (10^3 gallons)
pCi	picocuries (10^{-12} curies)
pCi/gm	picocuries (10^{-12} curies) per gram soil
Yr	Year

1.0 INTRODUCTION

This document provides the results of a tank integrity leak assessment performed for tank 241-AX-104 (AX-104). The leak assessment process is described in Engineering Procedure TFC-ENG-CHEM-D-42.

Tank AX-104 was one of several 241-A and 241-AX tank farm tanks selected for leak integrity reassessment in accordance with RPP-32681, *Process to Estimate Tank Farm Vadose Zone Inventories*. The RPP-32681 process involves reviewing and updating of tank leak estimates, single-shell tank (SST) leak and unplanned release volumes, and inventory estimates as emergent field data are obtained. The assessment concluded tank AX-104 may not have leaked and recommended reassessing the integrity designation for the tank (RPP-ENV-37956, *Hanford A and AX-Farm Leak Assessments Report: 241-A-103, 241-A-104, 241-A-105, 241-SX-102, 241-AX-104 and Unplanned Waste Releases*).

The report is organized as follows: Section 2.0 describes the assessment method used; Section 3.0 provides a brief summary of tank design and history; Section 4.0 summarizes past leak evaluations; Sections 5.0 and 6.0 present in-tank monitoring surface level data and ex-tank data; Section 7.0 shows the leak and non-leak hypotheses for the tank and Section 8.0 summarizes assessment observations and results. Meeting minutes and elicitation leak probability evaluations are included as Appendices A and B, respectively.

2.0 TANK INTEGRITY ASSESSMENT METHOD

The TFC-ENG-CHEM-D-42 leak assessment process to assess tank integrity is based on probabilistic analysis to assess the mathematical likelihood (probability) that a specific tank is leaking or has leaked. The technical basis for the process and additional details and examples of the methodology for implementing the process can be found in HNF-3747, *Tank Leak Assessment Technical Background*. For each step a description of the process, products, and responsibilities is provided.

The assessment team consisted of a panel of experienced engineers and managers to review the tank AX-104 historical data and re-evaluate the basis for declaring the tank an "Assumed Leaker." The panel consisted of: J. G. Field, (Assessment Coordinator, Base Operations Process Engineering); D. G. Baide (Manager, Tank Farm Projects Engineering), N. W. Kirch (Manager, Base Operations Process Engineering), D. W. Strasser (Manager, A/AX/AY/AZ Farm Team), C. L. Girardot (Process Engineer, Tank and Pipeline Integrity), K. J. Hull (System Engineer, Electrical/Area/242A-Evap Engineering), J. S. Schofield (Consultant, Tank and Pipeline Integrity), D. G. Harlow (Consultant, Tank and Pipeline Integrity); and D. J. Washenfelder (Consultant, Tank and Pipeline Integrity). The team met between June 4 and June 26, 2014 to gather and review information, develop the Leak and Non-Leak Hypotheses, and reach a consensus leak integrity recommendation for tank AX-104.

3.0 TANK DESCRIPTION AND HISTORY

Tank 241-AX-104 (tank AX-104) is a one million gallon capacity, 75-foot diameter, mild steel-lined concrete shell tank located in the southeast corner of the four-tank 241-AX Tank Farm. The tanks in the 241-AX Tank farm were designed to contain liquid and solid wastes at a maximum temperature of 350°F. Each tank contains a network of drain slots in the concrete base immediately below the carbon steel liner. The drain network is connected to a 24-inch, 60-foot deep leak detection pit, equipped to monitor tank leaks.

An underground 20-inch vent line from each of the 241-AX tanks connects to a 24-inch vapor exhaust header that runs to the 241-AX-152 diverter station, then to a tie-in with the 241-A Tank Farm vent header, then on to the ventilation system at 241-A-702 Building. The ventilation system provided for the removal of off-gas and water vapor from the boiling waste tanks.

The tank was placed into service in 1965, and continued to receive and store waste until August, 1978 when it was removed from service. The tank was classified as having questionable integrity in August 1978 based on radioactivity detected in drywell 11-04-08. The source of the radioactivity could not be determined, but a leak from tank AX-104 was identified as a possible source.

Tank AX-104 received PUREX Plant waste from 1965 to 1969. The tank also received high-activity waste from 221-B Plant in 1969. Supernatant was transferred out of tank AX-104 in 1970 and again in 1972. Tank AX-104 was then refilled with PUREX sludge supernatant (PSS) from SST A-102 from October 1972 through March 1973. Tank AX-104 also received PSS from sluicing tank A-104 in September 1974 and PSS from sluicing tank A-103 in the second quarter of FY 1976. The PSS was transferred from SST AX-104 in February 1977 for cesium ion exchange processing in the 221-B Plant and to prepare the tank for sluicing. The sludge in SST AX-104 was sluiced from March 31, 1977 through April 20, 1978. During sluicing, no increased radiation was reported to have been detected in the leak detection pit for tank AX-104 (See Figure 3-1).

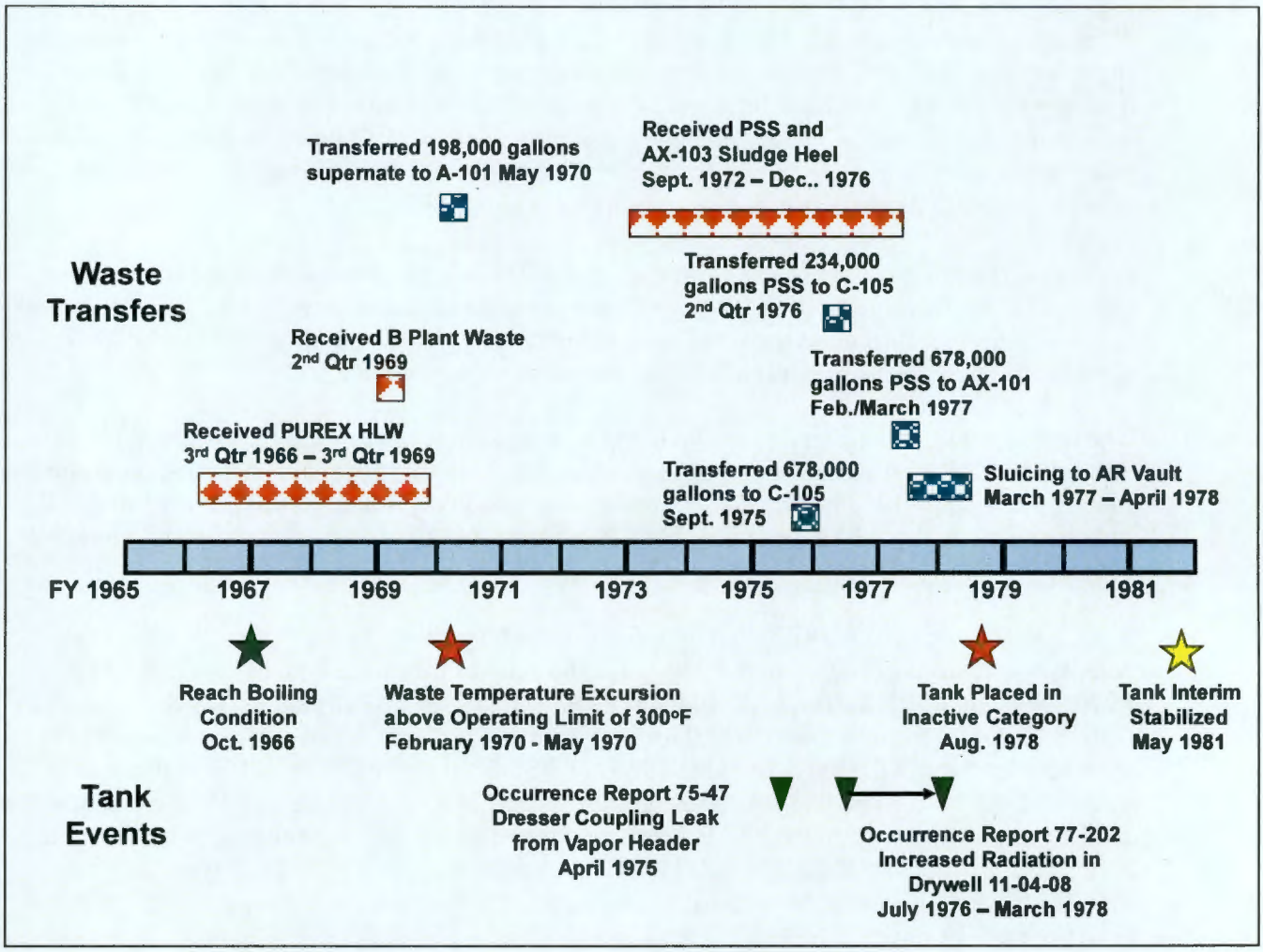
The tank was classified as having questionable integrity in August 1978 based on radioactivity detected in drywell 11-04-08. The tank was declared interim stabilized on August 10, 1981 based on a review of tank photographs. The four valve and service pit drain lines connecting to the tank were removed during August 1981 to prevent water intrusion

Tank AX-104 currently holds 5 to 7.5 kgal of dry sludge and no free supernatant (RPP-RPT-42918, 2009 *Auto-TCR for Tank 241-AX-104*).

The tank was equipped for liquid level monitoring initially with a manual tape. An ENRAF® surface level instrument is currently deployed for water intrusion detection. There is no liquid observation well. The tank is passively ventilated.

Additional descriptions and history for tank AX-104 are presented in RPP-ENV-37956 and referenced reports.

Figure 3-1. Tank AX-104 Operational Timeline (1965-1981)



Reference: RPP-ENV-37956, Hanford A and AX-Farm Leak Inventory Assessments Report

4.0 PAST LEAK ASSESSMENTS

Tank AX-104 was designated a questionable integrity tank and was removed from active service in August 1978 as a result of the radioactivity detected in drywell 11-04-08 (Figure 4-1). The strongest gamma radiation signal was detected due east, toward tank AX-104, which led personnel in 1978 to suspect the integrity of the tank (Routson, Letter 60110-78-019, "Probable Source of Activity Detected in Well 11-04-08," In: HNF-4872, *Single-Shell Tank History Compilation,* Vol. II, ref. 6). The tank was designated an assumed leaker in 1988 (HNF-EP-0182).

The following observations and conclusions are documented in RPP-ENV-37956.

No increase in radiation was detected in the leak detection pit or drywells associated with this tank that was attributed to a tank leak; however, an increase in radiation above background reaching a peak of 247 cps at 64-ft bgs was observed in drywell 11-04-08 in November 1977. The increase in radiation began in May 1976, but did not exceed background levels until August 1976. The radioactivity in this drywell had decreased to 204 cps on March 8, 1978, but then began to increase again reaching 287 cps on April 19, 1978 (OR 77-202, *Radiation Peak in Dry Well 11-04-08 Exceeding Increase Criterion*). Tank AX-104 was receiving PSS solution and sludge from final cleanout of tank AX-103 during the second quarter of FY 1976 through December 1976, and was actively being sluiced from March 31, 1977 through November 5, 1977 and March 2, 1978 through April 20, 1978.

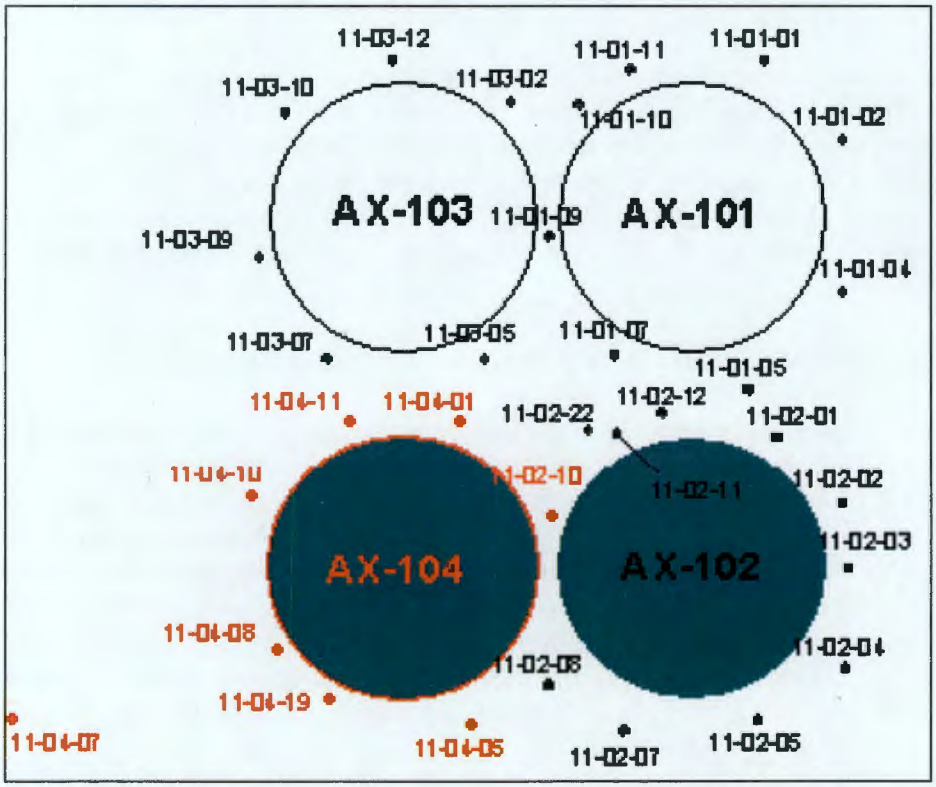
A new drywell, 11-04-19, was installed in March 1978 to further investigate the potential for tank AX-104 to have leaked waste. Drywell 11-04-19 is situated between drywells 11-04-08 and 11-04-07 and is closer to tank AX-104. Initially, the radioactivity detected in drywell 11-04-19 was less than the detection limit of 50 cps (WHC-SD-WM-TI-356 page 11-04-10). RPP-8821, *Analysis and Summary Report of Historical Dry Well Gamma Logs for the 214-AX Tank Farm – 200 East*, page 40, shows that the radioactivity in drywell 11-04-19 increased in 1978 and then rapidly decreased following a Ru-106 decay curve.

The cause for the increased radiation detected in drywell 11-04-08 could not be determined. The strongest source of the radiation detected in drywell 11-04-08 was determined to be due east, toward tank AX-104. The radioactivity detected in drywell 11-04-08 was subsequently correlated to ruthenium-106 decay rate (RPP-8821 pages 18-21).

Drywells nearby tank AX-104 currently do not show any significant contamination associated with a tank leak (GJO-97-14-TAR/GJ-HAN-12, *Vadose Zone Characterization Project and the Hanford Tank Farms, AX Tank Farm Report*). Migration of ^{137}Cs contamination down the inside or outside of the drywell casing is suspected to have affected the distribution of some of the contamination detected in the drywells.

The *Field Investigation Report for Waste Management Areas C and A-AX* (RPP-35484) states the following:

Figure 4-1. 241-AX Tank Farm Drywells



Reference: GJ-HAN-52, *Vadose Zone Characterization Project and the Hanford Tank Farms, Tank Summary Data Report for Tank AX-104.*
Note: Blue shading shows tanks previously designated "assumed leakers"

"Elevated gross gamma levels are reported in the first measurements taken at drywell 11-04-11 in January 1975 (1,490 c/s at 25 ft bgs, 255 c/s at 39 ft bgs, and 950 c/s at 64 ft bgs), suggesting the presence of pre-existing contamination. The higher level counts diminished rapidly thereafter to near detection limit levels by late 1978. A similar profile was also observed at nearby drywell 11-04-01. In this drywell, maximum levels were found in one depth interval between 15 and 40 ft bgs, and maximum values of nearly 8,000 c/s suggest that this drywell was closer to the source of leakage. Given the relatively rapid decrease in gross gamma levels shorter-lived radionuclides (e.g., ^{106}Ru) are likely the primary radiation producers. Recent spectral gamma analyses show only measurable ^{137}Cs concentration near the surface, which may be related to these losses or some other near-surface release. As with tank AX-102, analysts concluded that the source of this waste release was part of the buried 20-in. vapor line and vessel vent header system. [This conclusion is based on information presented in Occurrence Report 75-47, *Increasing Dry Well Radiation Adjacent to Tank 104-AX*].

Two other drywells indicated elevated gross gamma contamination around tank AX-104. In drywell 11-04-08, elevated gross gamma measurements (up to 350 c/s) were taken in 1977 and 1978 between 60 and 65 ft bgs. A reduction by half within a year's time

> suggests that ruthenium-106 was the primary contributor. Whether this observation indicates a continuation of waste migration from the same source affecting drywells 11-04-01 and 11-04-11 is not clear, though the timing and radiation levels are consistent with that hypothesis. On the other hand, no indications of elevated gross gamma activity were observed at drywell 11-04-10, which is located between drywell 11-04-08 and the other drywells. A migration path that bypassed drywell 11-04-10 appears problematic. Drywell 11-04-10 is also notable for an apparently independent near-surface waste spill. Unlike the other drywells around tank AX-104, mid 1990s spectral gamma data analyses for drywell 11-04-10 show ^{137}Cs peaks at approximately 5 ft bgs, accompanied by ^{60}Co and ^{154}Eu peaks in the same location."

In 2008 the RPP-32681 leak inventory assessment team concluded that it is doubtful that PSS waste actually leaked from tank AX-104 since the leak detection pit and drywells associated with this tank do not show the level of radiation that is normally associated with a tank waste loss. The likely source of radioactivity detected historically in drywells 11-04-01 and 11-04-11 is the leaking Dresser coupling associated with the tank off-gas piping. The source of the historical ^{106}Ru radioactivity detected in drywells 11-04-08 can't be definitively determined, but it could be from migration of contamination associated with the Dresser coupling leaks in this tank farm or nearby condensate lines which may have leaked. Ruthenium is known to readily migrate through Hanford soils.

The leak inventory assessment team recommended that HNF-EP-0182 be revised to indicate that there is no basis to assign a leak loss volume or inventory for tank AX-104. In the 2008 assessment, participants could not conclude whether tank AX-104 lost integrity. However, because the tank has been sluiced and remaining residuals are thermally "hot," participants believed that tank AX-104 was not a likely candidate for sluicing regardless of whether it has lost integrity, and an integrity analysis was not recommended. Upon reassessing the leak inventory for tank AX-104 and based upon the tank AX-102 integrity assessment and observed similarities with tank AX-104, an integrity assessment for tank AX-104 was initiated after swabbing the AX farm leak detection pits and reviewing sample results.

A formal assessment was conducted in accordance with TFC-ENG-CHEM-D-42. The Tank AX-104 Leak Assessment Team reviewed and discussed the RPP-ENV-37956 report. The following sections present data discussed for the tank AX-104 integrity assessment and evaluations of the data.

Tank AX-104 integrity leak assessment meeting minutes are presented in Appendix A.

5.0 IN-TANK DATA

5.1 SURFACE LEVEL BEHAVIOR

Tank liquid level measurements before 1973 were not available, other than from the transfer data in waste process reports. Table 5-1 shows liquid level measurements from 6/1973 to 12/1986 (WHC-SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*). Figure 5-1 shows surveillance analysis computer system waste level data for tank AX-104 from 1980 to 2014. There was no unexplained liquid level decrease in this tank attributed to a tank leak. Occurrence Report 77-19, *Liquid Level Decrease Exceeding Action Criteria* was issued for a liquid level decrease in January 1977 exceeding the action level criteria of 1.00 inch decrease in 72 hours. Occurrence Report 77-19 notes that a filter was installed on 1/26/77 in a six inch tank riser to improve air cooling in the tank. This action increased the evaporation rate in excess of criteria.

5.2 IN-TANK PHOTOGRAPHS

HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record* , reports that photographs taken on May 14, 1981 show a series of corrugation ridges in the tank bottom liner and no discernable liquid pools. In addition, areas of mounded dry sludge were seen at random locations about the tank. A discrepancy due the irregularity of the surface was noted between the measured liquid level in Riser 9E and the solids level in Riser 1B.

However, a tank composite photograph taken on August 11, 1987 (Figure 5-2) does <u>not</u> show the reported ridges or tank bottom buckling pattern. The entire tank bottom is visible in the August 11, 1987 photograph, which shows weld plates for the airlift circulators and a small amount of sludge and a sludge swirl pattern.

Table 5-1. Tank 241-AX-104 Liquid Level Measurements and Changes (1973 to 1986)

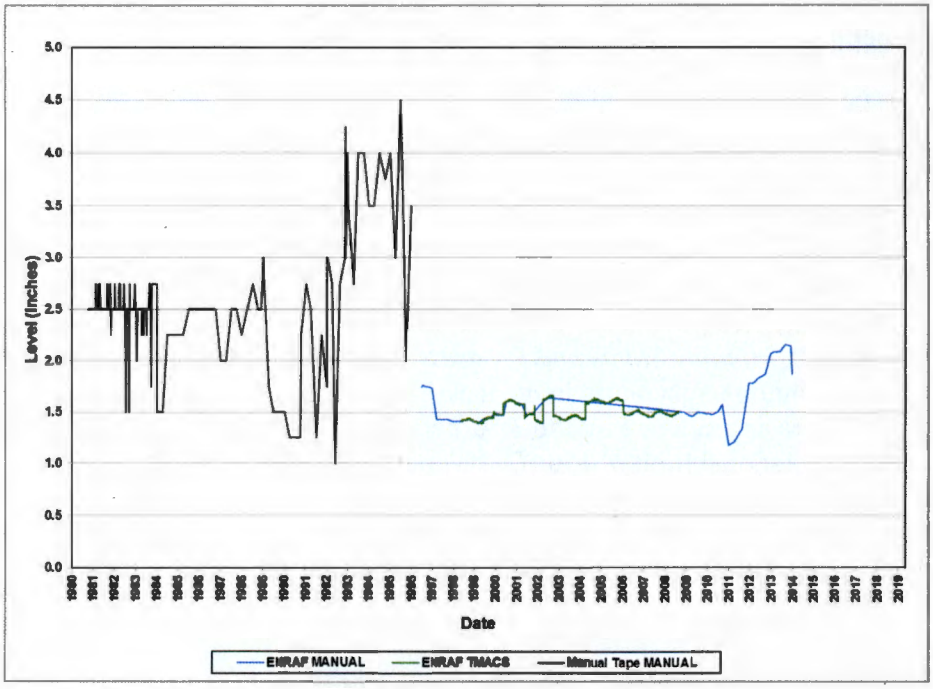
Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/18/73	37.50			0.00	Manual tape
07/16/73	36.75		-0.75	-0.75	Steady decrease
07/17/73	38.00			-0.75	Transfer
07/30/73	37.50		-0.50	-1.25	New tape installed
08/03/73	37.25		-0.25	-1.50	Steady decrease
11/09/73	42.00			-1.50	Transfer
12/03/73	38.00		-4.00	-5.50	Steady decrease
12/19/73	42.50		+4.50	-1.00	Steady increase
01/05/74	48.75			-1.00	Transfers
01/22/74	46.00		-2.75	-3.75	Steady decrease
02/01/74	50.00			-3.75	Transfers
07/08/74	40.00		-10.00	-13.75	Steady decrease
08/10/74	282.25			-13.75	Transfers
04/30/75	248.00			-13.75	Steady decrease evaporation
05/01/75	246.80			-13.75	FIC installed
03/10/76	185.15			-13.75	Steady decrease/ associated with evaporation
03/26/76	129.15			-13.75	Transfers
04/13/76	125.85			-13.75	Steady decrease/ evaporation
04/24/76	132.70			-13.75	Transfers
09/08/76	102.35			-13.75	Steady decrease/ evaporation
03/03/77	58.65			-13.75	Transfers
03/28/77	52.15			-13.75	Steady decrease/ evaporation
08/24/77	7.10			-13.75	Sluicing and transfers
09/23/77	3.15			-13.75	Steady decrease/ evaporation, now using manual tape
11/07/77	11.50			-13.75	Sluicing and transfers
12/04/77	10.00			-13.75	Steady decrease/ evaporation
12/05/77	10.50			-13.75	Water added-- circulators
01/23/78	9.00			-13.75	Steady decrease/ evaporation
02/02/78	11.70			-13.75	Now using FIC gage
02/28/78	10.90			-13.75	Slow decrease/ evaporation

Table 5-1. Tank 241-AX-104 Liquid Level Measurements and Changes (1973 to 1986)

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
04/26/78	5.60			-13.75	Sluicing and transfers
05/08/78	5.00		-0.60	-14.35	Steady decrease
05/11/78		1.70		-14.35	Transfers
05/24/78	1.20		-0.50	-14.85	Slow decrease
06/06/78		3.70		-14.85	Transfer and leaking valve
11/10/78	0.80			-14.85	Slow decrease/ evaporation
03/11/79	1.40		+0.60	-14.25	Erratic readings
03/16/79		2.50		-14.25	Leak in AX-B pit
07/29/79	1.00			-14.25	Slow decrease/ evaporation
07/30/79				-14.25	FIC o/s
07/31/79	2.00			-14.25	Manual tape installed
09/05/79		2.50	+0.50	-13.75	Slow increase
12/10/80	2.50			-13.75	Stable
12/12/81	2.50			-13.75	Stable
10/07/82	2.50			-13.75	Stable
12/12/82	1.50			-13.75	Readings fluctuate between 1.50 and 2.50 in.
11/07/83		2.25		-13.75	New MT installed
12/12/83	2.75		+0.50	-13.25	Stable
10/04/84	2.25		-0.50	-13.75	Stable
10/04/85	2.50		+0.50	-13.50	Stable
10/01/86	2.50			-13.50	Stable

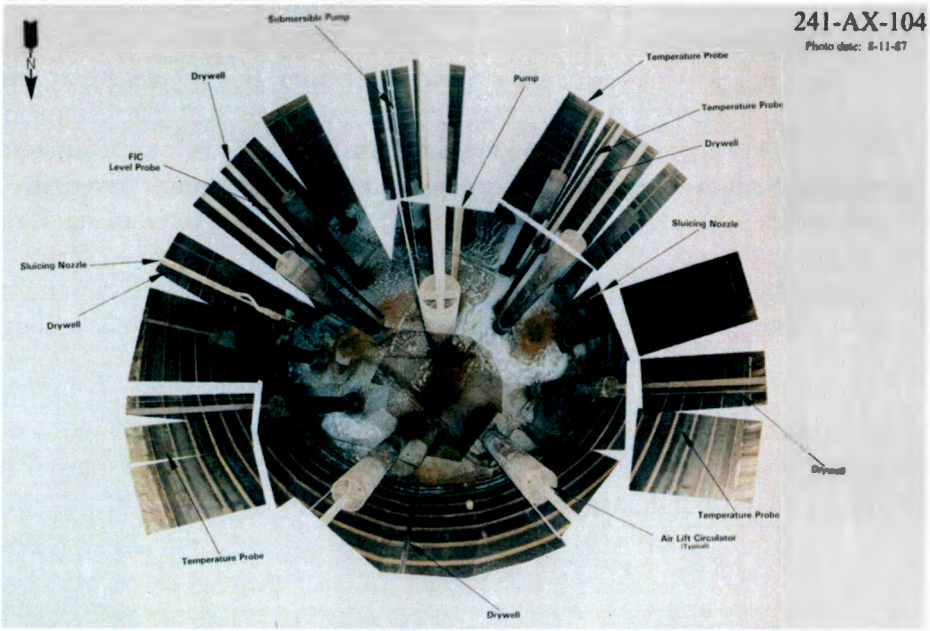
Reference: WHC-SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria.*

Figure 5-1. Tank 241-AX-104 Waste Surface Level Measurements



Reference: Surveillance Analysis Computer System, PCSACS

Figure 5-2. 241-AX-104 Composite Photograph – 1987



Reference: WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area.*

Tank AX-104 is a high heat tank currently monitored by a single thermocouple tree located in Riser 9C. Temperature data were found for tank AX-104 from 1966 to present. Figure 5-3shows temperature data from 1966 to 1971 and Figure 5-4 shows temperature data at several elevations near the bottom of the tank from 1976 to 2010.

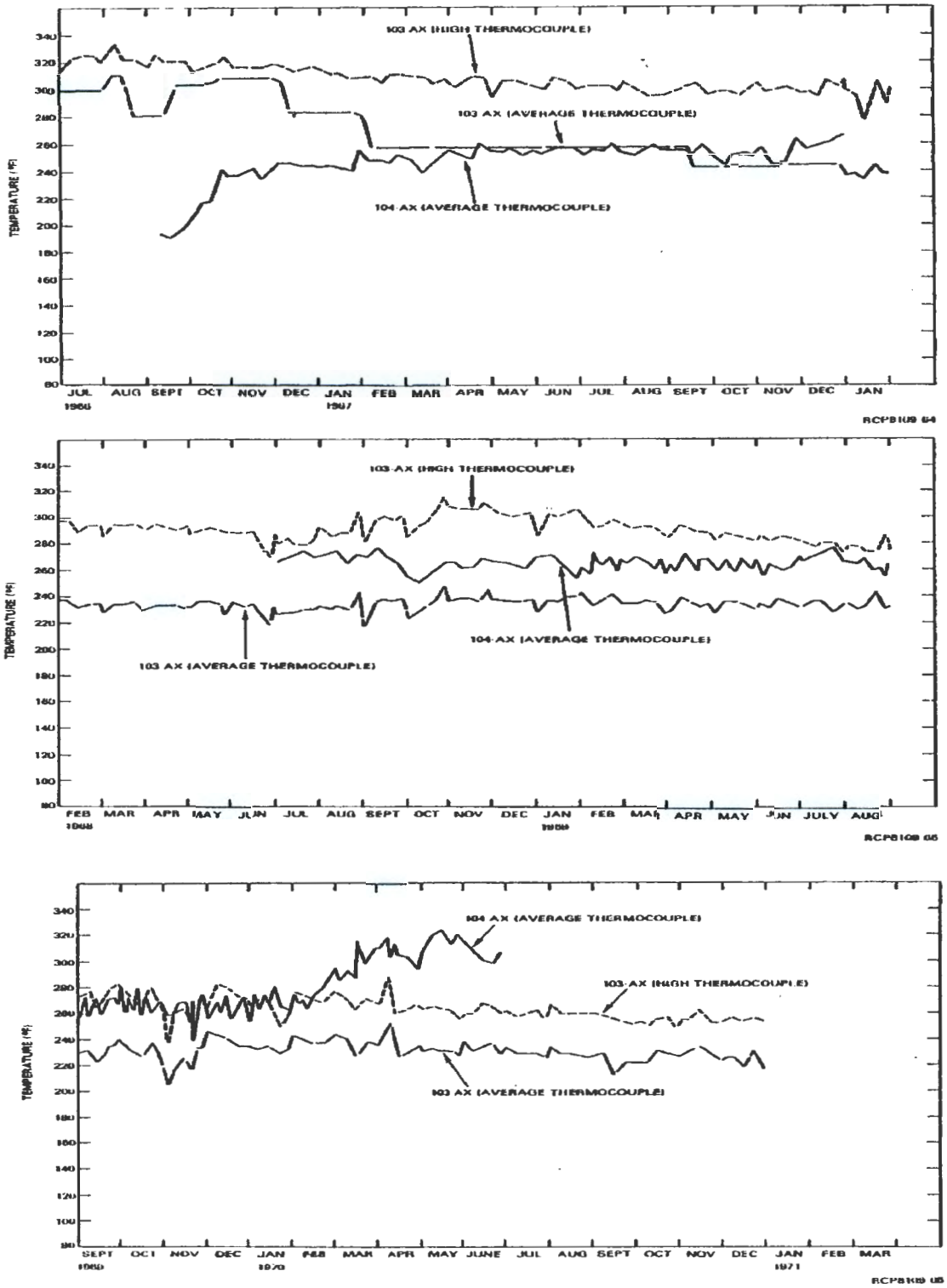
The waste temperature in tank AX-104 began to increase from ~260 °F in September 1969 to ~340 °F in May 1970 (RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories,* page B-57), which is above the maximum operating limit of 300 °F. The waste temperature had been between 260 to 280 °F for ~3 years. Air flow to the airlift circulators was adjusted and the temperature of the sludge was reduced in all but one location below the operating limit of 150 °C (300 °F); the eastern periphery of the tank reached 158 °C (~316 °F) in February 1970 (PR-REPORT FEB70, *Monthly Status and Progress Report, February 1970,* page AV-3). By March 1970 the maximum temperature in the tank had reached 213°C (~415 °F) and the temperature was increasing at a rate of 2 to 3 °C per day. Two other peripheral temperatures also exceeded the operational limit of 150 °C. "The localized hot spots near the tank sidewall did not cause the sidewall differential temperatures to exceed the operational limit of 17 °C per foot of concrete" (PR-REPORT MAR70, *Monthly Status and Progress Report, March 1970,* page AIV-5). Supernatant was transferred and water added to the tank in an effort to reduce the temperature.

The maximum temperature in the tank AX-104 sludge continued to rise after the dilution and reached a maximum of 225 °C (~437°F) in April 1970 (PR-REPORT APR70, *Monthly Status and Progress Report, April 1970,* page AIV-5). The sludge temperature then began to increase again and reached 233 °C (~451 °F) in the western sector of the tank periphery in May 1970 (PR-REPORT MAY70, *Monthly Status and Progress Report, may 1970,* page AIV-6). This prompted transfer of an additional 198,000 gal of supernatant (~20% of total) from SST AX-104 to A-101 and 195,000 gal of water at 65 °C were added to SST AX-104 to reduce the sludge temperature (PR-REPORT MAY70 page AIV-6 and ARH-1666 B, *Chemical Processing Division Waste Status Summary 04/01/1970 thru 06/30/1970*, page 10). The calculated sodium molarity in SST AX-104 was only 3M following this transfer. The maximum temperature across the concrete wall of the tank exceeded the recommended operational limit. Excessive differential temperatures across the concrete wall of the tank can lead to cracking of the concrete.

The dilution of tank AX-104 waste in May 1970 resulted in a gradual decrease in tank temperature. No additional waste or water additions to tank AX-104 were reported again until September 1972.

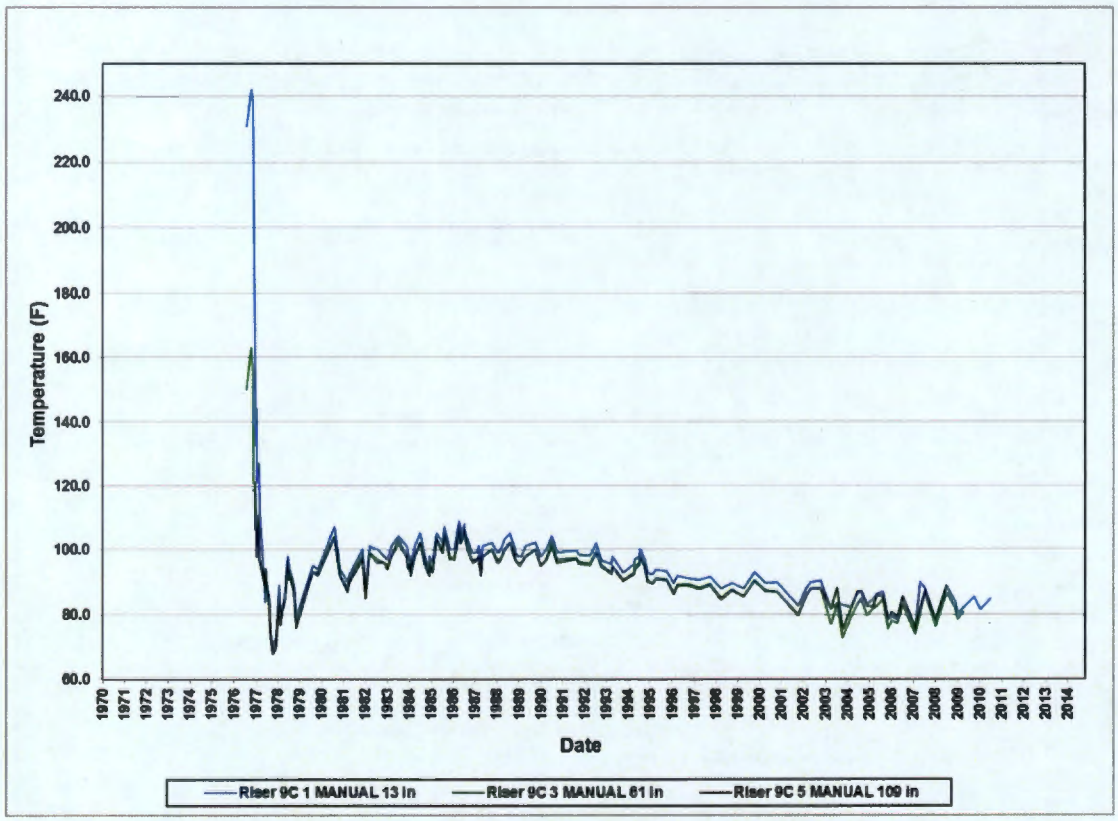
Additional temperature data was not available until October 1976. Between February 1977 and January 1978 a rapid decrease in the waste temperature was observed due to transfer liquids and final sluicing of the tank during this period.

Figure 5-3. AX-104 Temperature, 1966-71



Reference: RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories*

Figure 5-4. AX-104 Temperature, 1976-2010



Reference: Surveillance Analysis Computer System, PCSACS

6.0 EX-TANK DATA

There are two ex-tank leak detection systems installed for tank AX-104: drywells in the soil surrounding the tank, and a leak detection pit connected to a system of drain slots built into the concrete foundation of tank AX-104.

6.1 OCCURRENCE REPORTS

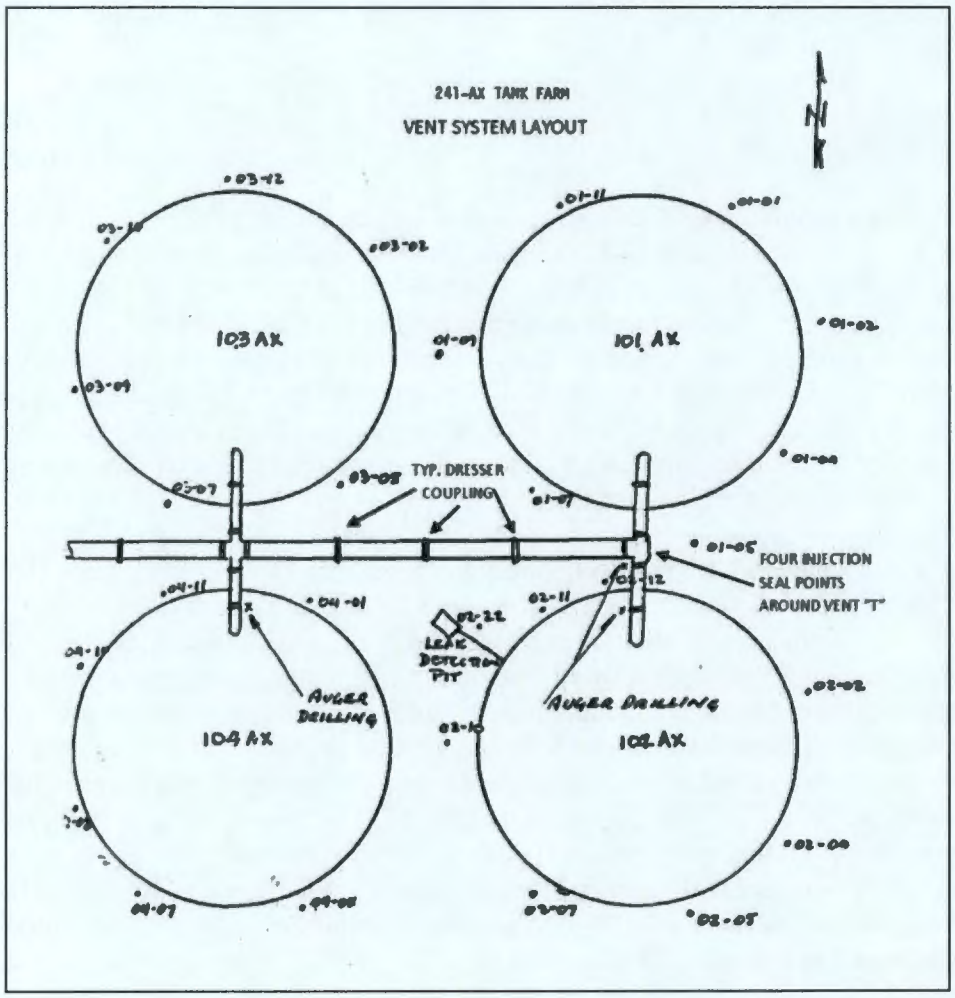
Several occurrence reports were issued for increased radiation in drywells near tank AX-104. In April 1975, Occurrence Report 75-47 reported increased radiation in drywell 11-04-11 (later reports determined 11-04-11 is a typo; should be 11-04-01) at the 40 ft level since the drywell was drilled in January 1975. The report states that neither the tank liquid level nor leak detection pit liquid level or radiation monitoring give any indications of a tank leak. The source of the radiation around the drywell was not identified. Occurrence Report 75-47 noted that past experience had shown shallow contamination to be the result of failed transfer lines, surface spills or other direct buried facility features. The OR also states "action taken to attempt sealing leaky vapor header will determine further action."

In January 1976, Occurrence Report 76-08, *Radiation Increase Monitored by Tank Dry Well*, was issued for a gradual increase in the radiation peak at 32 ft BGS in drywell 11-04-01. The report states that "the increased radiation is considered normal migration of radionuclides transported by the unusually high moisture content in the ground. A program is being implemented to prevent further contamination leakage from the exhaust header system." The report also suggests that the vapor header leak was a past leak, and "corrective action is planned if and when vapor header exhaust gives evidence of renewed leakage." Occurrence Report 76-59, *Increase in Dry Well Radiation Exceeding Action Criteria,* issued in April 1976, notes that the exhaust header is located at a depth of 10 ft and ~10-15 ft from drywell 11-04-01. WHC-SD-WM-TI-356 states "through subsequent investigation the source of the contamination has been determined to be the tank's 20-in vapor line at points above the tank and at the line tied into the 24-in vessel vent header" (Figure 6-1).

On November 11, 1977 Occurrence Report 77-202 was issued when drywell 11-04-08 was observed to have an increase in radiation above background reaching a peak of 247 c/s at 64-ft bgs. The increase in radiation began in May 1976, but did not exceed background levels until August 1976. The radioactivity in this drywell decreased to 204 c/s on March 8, 1978, but then began to increase again reaching 287 c/s on April 19, 1978. Four possible sources of radiation were investigated: 1) A Dresser coupling leak in the exhaust header system between tanks AX-103 and AX-104 (See Figure 6-1), 2). Leak in the tankAX-102 to tank AX-103 exhaust header system, 3) Process piping leak south of tank AX-104, 4) a leak in tank AX-104. A specific apparent cause was not determined at that time and the normal surveillance of the tank continued.

Figure 6-1. 241-AX Tank Farm Ventilation System Plan

Drywell locations are shown in relation to the Dresser couplings (from ARH-CD-587, Containment of the Deteriorated Vapor Exhaust Header in 241-AX Tank Farm [Sketch B]).



Two of three auger sample locations found highly contaminated soil at a depth of 10-feet. One location was on top of tank AX-104 at the first Dresser coupling off of the tank vapor exhaust line. The second location was at the intersection of the 20-inch vapor exhaust lines from tanks AX -101 and AX-102 with the 24-inch main header. From this junction the main vapor exhaust header proceeds to an intersection with the 20-inch vapor exhaust lines from tanks AX-103 and AX-104, and then on a tie-in with the 241-A tank farm vent system. The third location, on the tank AX-102 branch of the vapor exhaust line, found no evidence of leakage (see Figure 6-1).

It should be noted that tank AX-104 began receiving high level waste beginning September, 1965 and reached boiling temperature in April, 1969. The vapor exhaust system would have contained some condensed vapors as well as radionuclides that had become

entrained in the vapor as it was removed from the tank throughout this period, to the time when drywell 11-02-11 was first monitored and the Ru-106 contamination found at 55-feet in 1975.

The quantity of condensate and radionuclides is dependent on the temperature of the stored wastes, relative volatility of the radionuclides and other factors. Waste temperatures for the period May, 1969 – September, 1971 indicate the tank was at or near boiling temperature (RHO-CD-1172).

Drawings H-2-44618, *Direct Buried Piping Plan Tks 101 & 102 AX,* H-2-44619, *Direct Buried Piping Plan Tks 103 & 104 AX,* and H-2-44620, *Direct Buried Piping Plan 241-AX-152 Area,* show that the 24-in vapor exhaust line and the branch lines to the individual tanks sloped down toward tanks AX-101 and AX-102. Any condensate formed in the 24-inch vapor exhaust line would have gutter-flowed back into these two tanks, continuously wetting the lower parts of the Dresser couplings.

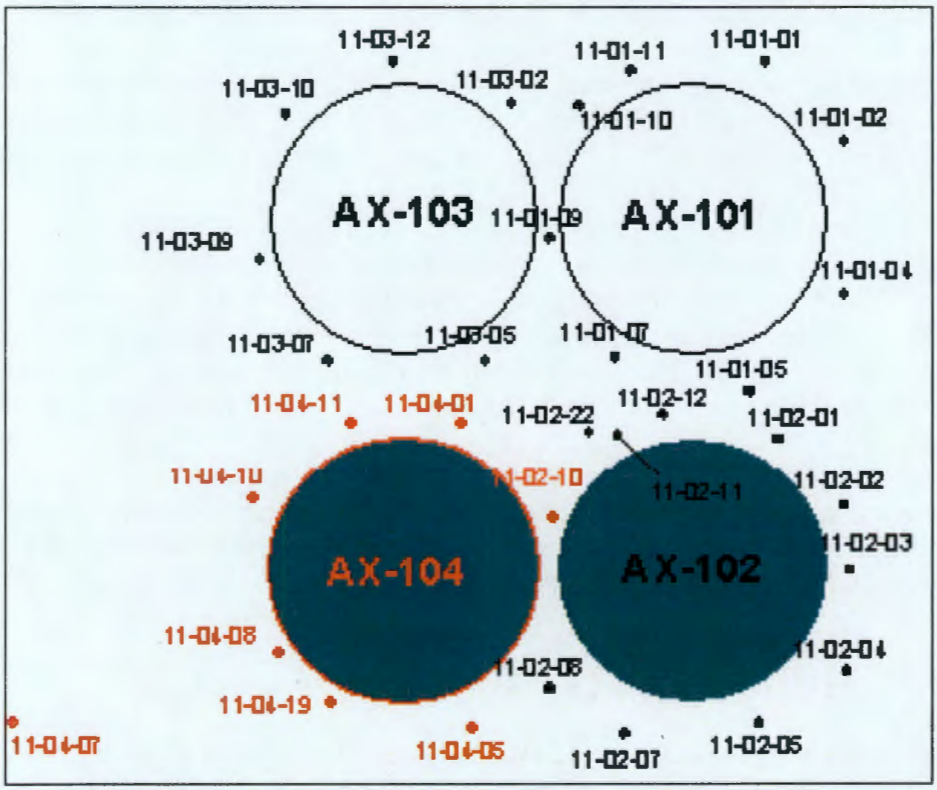
A detailed review of the same drawings also suggests that the Dresser couplings were utilized to compensate for some slight elevation differences between vent piping sections, adding a potential strain on the coupling seal or forming low spots where condensate could accumulate.

6.2 DRYWELL LOGGING DATA

Eight drywells surround tank AX-104 (11-04-01, 11-02-10, 11-04-05, 11-04-07, 11-04-19, 11-04-08, 10-04-10 and 11-04-11) (Figure 6-2). Until 1975, gross gamma ray logging data from the drywells were collected in non-digital format. In 1975 the surveillance program was upgraded to a digital logging system, and gross gamma ray logs were captured utilizing several types of detectors. Gross gamma logs were collected from these drywells until mid-1994. In 1996 spectral gamma logging data was collected.

Table 6-1 and Table 6-2 provide information about the tank AX-104 drywell construction and location with respect to the tank.

Figure 6-2. 241-AX Tank Farm Drywells



Reference: GJ-HAN-52, *Vadose Zone Characterization Project and the Hanford Tank Farms, Tank Summary Data Report for Tank AX-104.*
Note: Blue shading shows tanks currently designated "assumed leakers"

Table 6-1. Tank AX-104 Drywell Construction

Drywell	Initial Drilling	Depth – ft	Hanford Coordinates	
			North	West
11-04-01	12/31/1974	100	41672	47547
11-02-10	2/28/1975	100	41644	47519
11-04-05	2/28/1975	100	41583	47544
11-04-07	3/31/1975	96	41588	47586
11-04-19	3/31/1978	125	41591	47588
11-04-08	2/28/1975	100	41605	47604
11-04-10	3/31/1975	100	41650	47612
11-04-11	1/31/1975	125	41672	47581
Tank AX-104	N/A	N/A	41629	47565
104-AX Leak Detection Pit	N/A	60	41669.5	47605.5

Table 6-2. Distance from Selected Tank AX-104 Drywells to Tank Features

From	To	
Drywell	**Tank Sidewall – ft**	**Tank Footing Edge – ft**
11-04-01	7.07	3.07
11-02-10	8.84	4.86
11-04-05	11.03	7.03
11-04-07	6.52	2.53
11-04-19	4.88	0.88
11-04-08	6.25	2.25
11-04-10	11.94	7.94
11-04-11	6.36	2.34
Leak Detection Pit	17.5	13.7

References:
Mactec – ers Log Data Reports
H-2-44562, *Structural Waste Storage tanks Composite Section & Details*
H-2-36935, *Wells in 241-AX Farm As Built,*

Drywell 11-02-08 is not listed in Table 6-1 because it was used for only one and a half months in 1975 before being capped due to construction interference.

Historical gross gamma logs for the period 1975 – 1994 are presented in Figure 6-3 through Figure 6-5 for the three drywells indicating radiation changes during the period (drywells 11-04-01, 11-04-08, and 11-04-11). The primary indication of tank waste loss occurred in April 1975, when increased gross gamma levels at 40 ft bgs were noticed at drywell 11-04-11. Welty (WHC-SD-WM-TI-356) reported elevated gross gamma levels in the first measurements taken at this drywell in January 1975 (1,490 c/s at 25 ft bgs, 255 c/s at 39 ft bgs, and 950 c/s at 64 ft bgs), suggesting the presence of pre-existing contamination. The higher level counts diminished rapidly thereafter to near detection limit levels by late 1978 (Figure 6-6). A similar profile was observed at nearby drywell 11-04-01. In this drywell, maximum levels were found in one depth interval between 15 and 40 ft bgs, and maximum values of nearly 8,000 c/s suggest that this drywell was closer to the source of leakage.

Drywell 11-04-08 also indicated elevated gross gamma contamination around tank AX-104. Elevated gross gamma measurements (up to 350 c/s) were taken in 1977 and 1978 between 60 and 65 ft bgs. The increased activity in borehole 11-04-08 resulted in an investigation into the probable source of the contamination. Directional logging probes were run in borehole 11-04-08 in an apparent attempt to determine the source of the contamination. The direction of highest activity was from the east, and the gamma-emitting contamination was identified as Ru-106.

A new drywell, 11-04-19, was installed to investigate the potential for tank AX-104 to have leaked waste. Drywell 11-04-19 is situated between drywells 11-04-08 and 11-04-07 and is

closer to tank AX-104. Between 1978 and 1986 <50 c/s of radioactivity was detected in the well (WHC-SD-WM-TI-356 page 11-04-10) (Figure 6-7).

Figure 6-3. Drywell 11-04-01 Historical Gross Gamma Logs

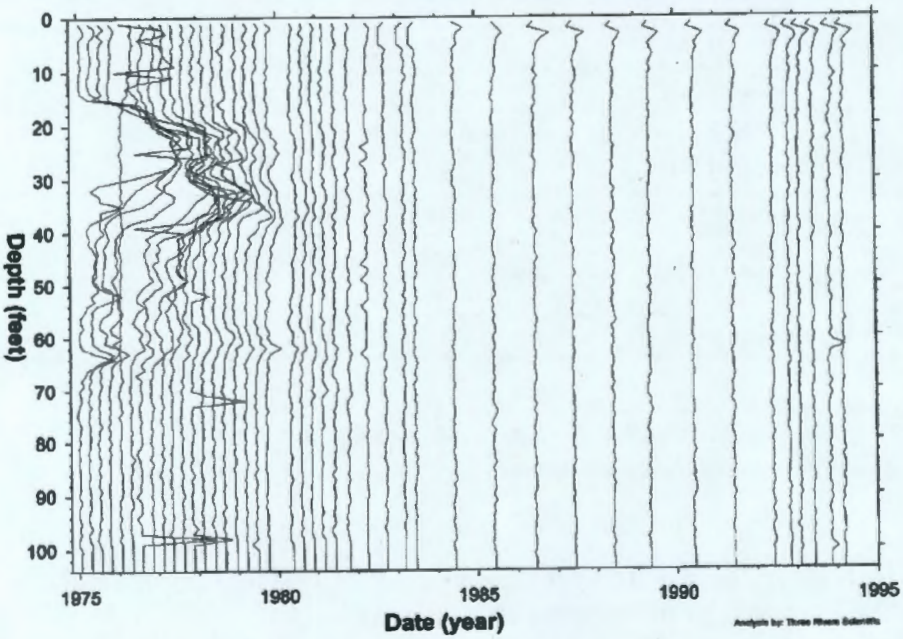


Figure 6-4. Drywell 11-04-08 Historical Gross Gamma Logs

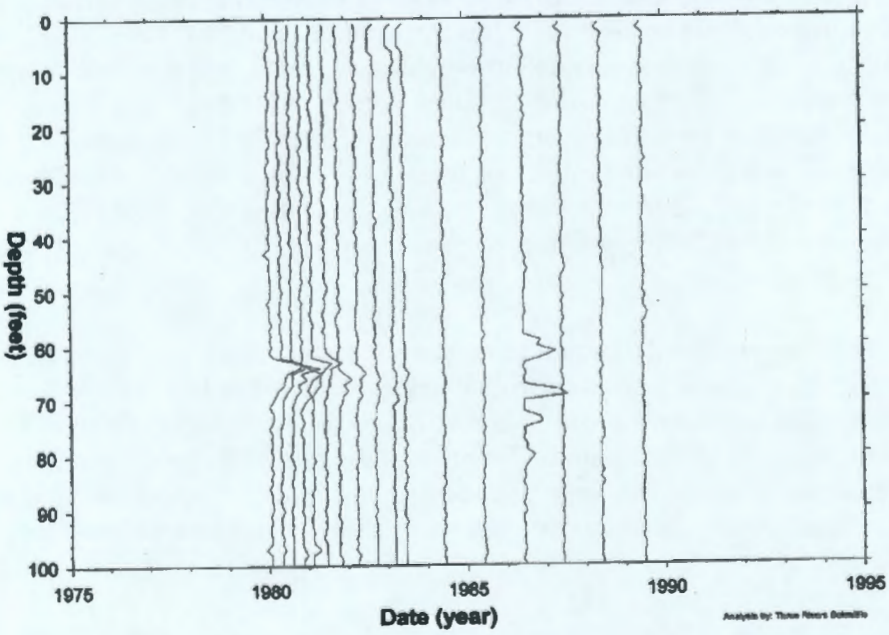


Figure 6-5. Drywell 11-04-11 Historical Gross Gamma Logs

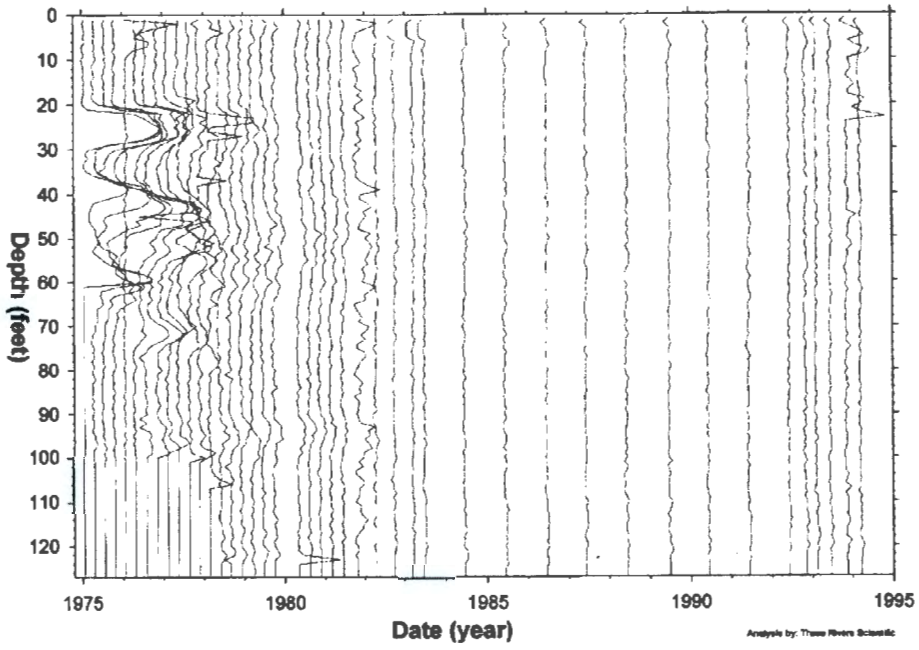
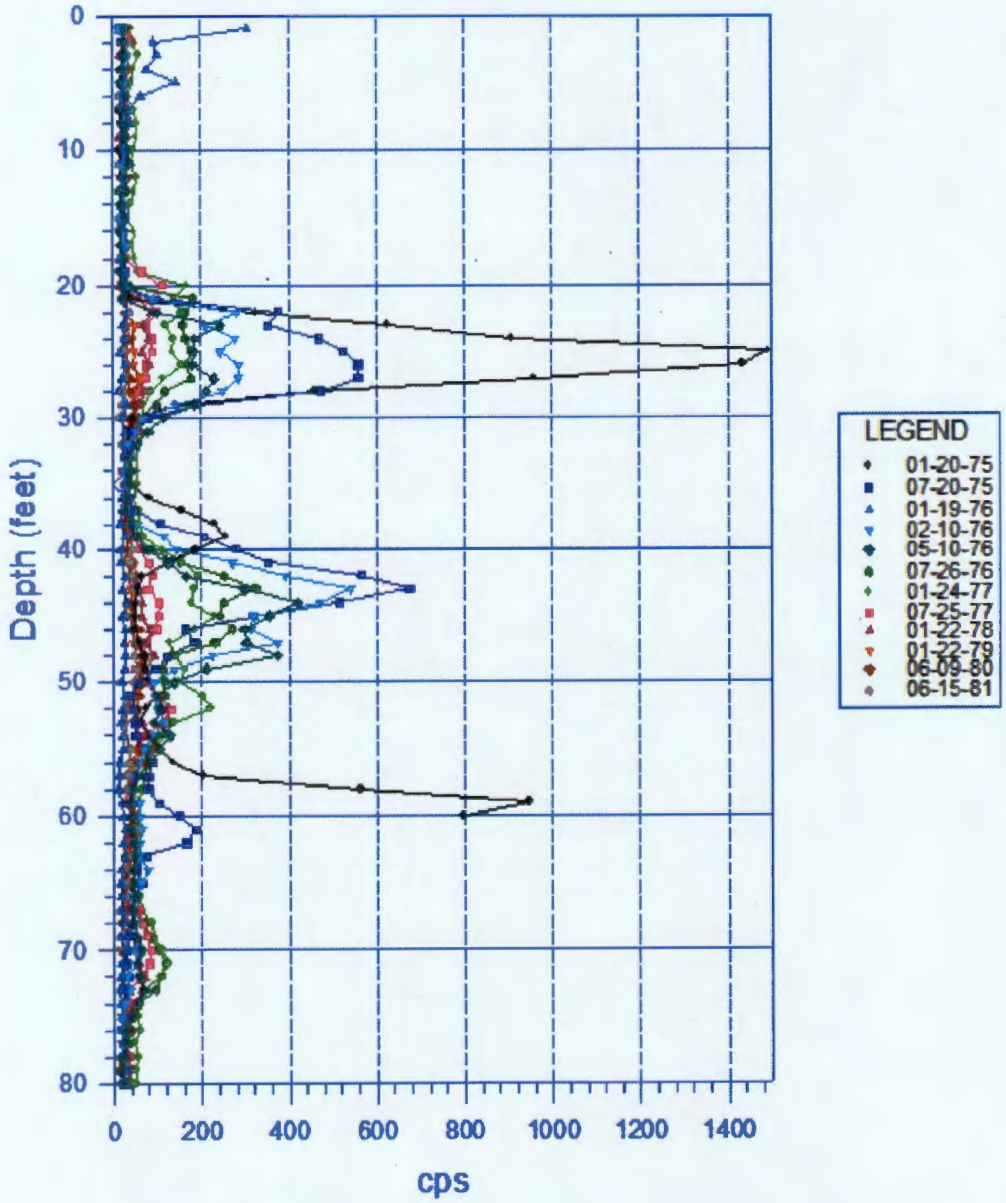


Figure 6-6. Historical Gamma Logging Results for Drywell 11-04-11.



Reference: RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*

Figure 6-7. Drywell 11-04-19 Historical Gross Gamma Logs

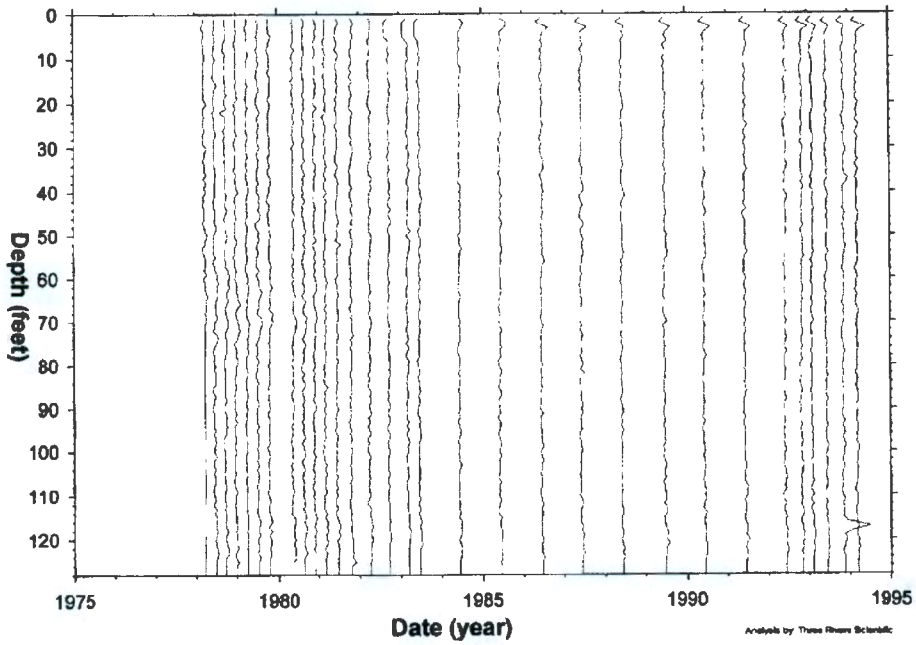
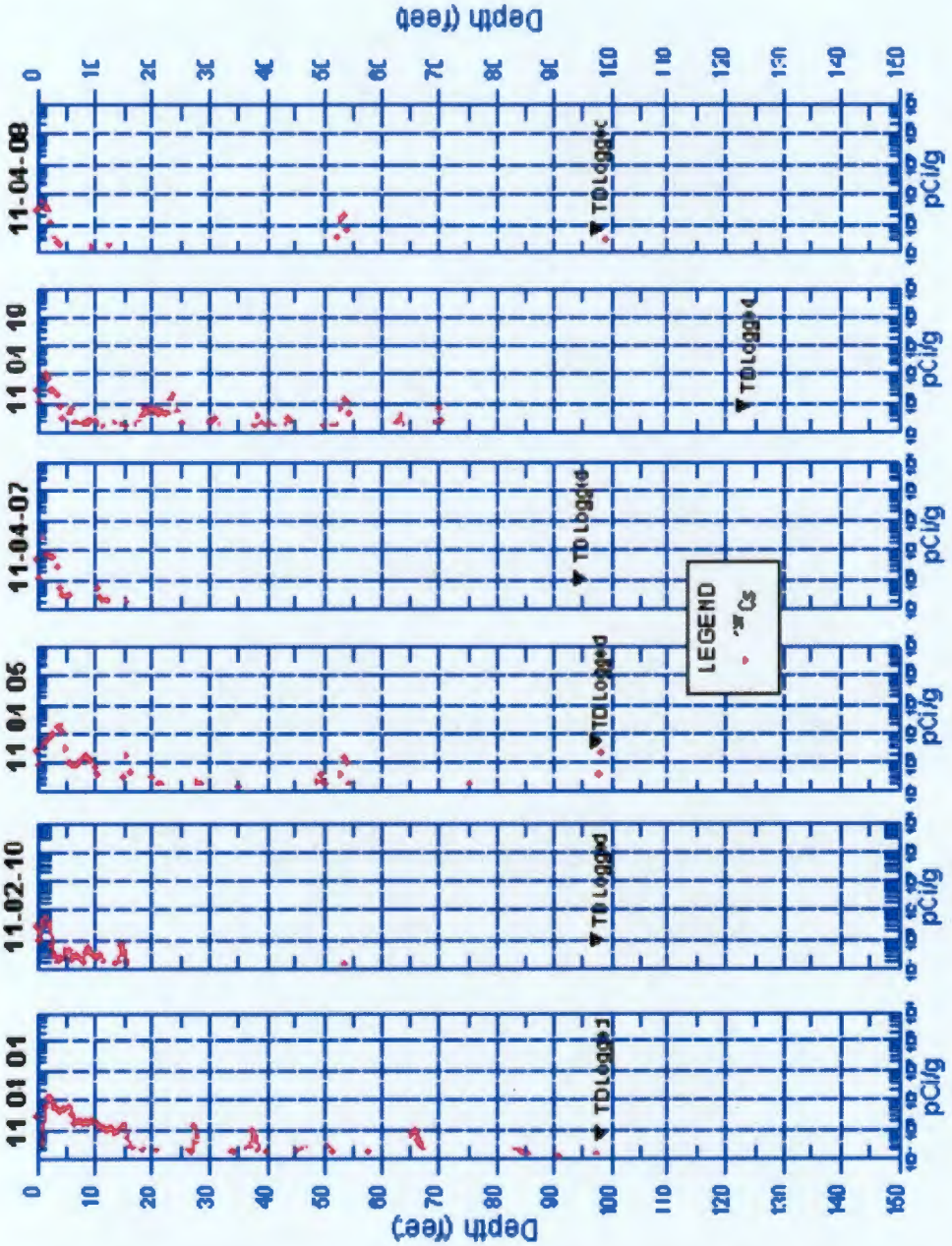


Figure 6-8 shows the 1996 SGLS results for these drywells. The SGLS results are discussed in GJ-HAN-52, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank AX-104.*

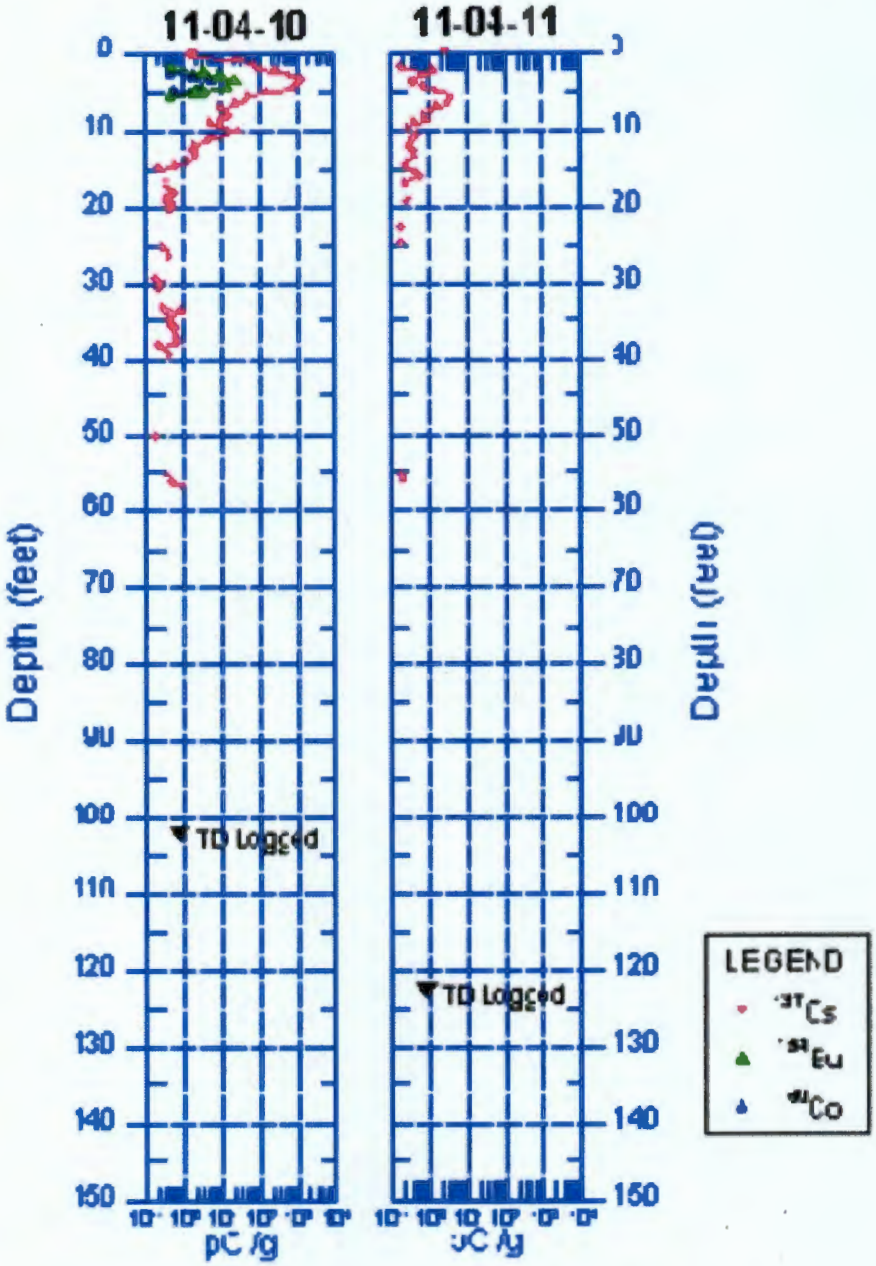
Drywells nearby tank AX-104 currently do not show any significant contamination associated with a tank leak, as shown in Figure 6-8. Migration of ^{137}Cs contamination down the inside or outside of the drywell casing is suspected to have affected the distribution of some of the contamination detected in the drywells. Much of the bias of the drywell log data that is due to drywell migration effects was removed from the surveys and is designated as "removed" in Figure 6-8.

Figure 6-8. 1996 Spectral Gamma Logging Results for Drywells near Tank 241-AX-104.



Reference: GJ-HAN-12, *Vadose Zone Characterization Project at The Hanford Tank Farms, AX Tank Farms Report.*
Note: Maximum value of log scales shown is 1,000 pCi/g.

Figure 6-8. 1996 Spectral Gamma Logging Results for Drywells near Tank 241-AX-104 (Cont.).



Reference: GJ-HAN-12, *Vadose Zone Characterization Project at The Hanford Tank Farms, AX Tank Farms Report.*
Note: Maximum value of log scales shown for 11-04-10 and 11-04-11 is 10,000 pCi/g.

6.3 LEAK DETECTION PITS

In addition to drywell data, AX farm has leak detection pits (LDPs) as described in Section 3.0. The tank AX-104 LDP is located 45 degrees west of north at ~57 ft from the center of the tank. Both surface level and radiation measurements are available from the LDPs. Table 6-3 shows liquid and radiation levels in the tank AX-104 LDP from 1973 to 1986 and Figure 6-9 shows liquid levels in the leak detection pit in 1995 and from 2000 to 2006 based on weight factor measurements. The tank AX-104 LDP monitoring was discontinued after April 2006. The liquid level spike shown in Figure 6-9 in 2004 appears to be an anomaly.

Swab samples were obtained from the AX farm LDPs in May, 2014. Wet samples were scanned for gross gamma and gross alpha radioactivity, and then air dried and rescanned to determine any shielding effects from sample moisture. Table 6-4 shows swab sample results (see Appendix A.1 June 5, 2014 Meeting Minutes, Attachment 4).

Although gamma activity was detected in the tank AX-104 LDP, 1000 cpm is well below the level of radioactivity that would be expected for a leak from tank AX-104. The waste in tank AX-104 currently contains no free liquid, but 1978 liquid samples (TWINS) showed supernatant concentrations of ~1.7 Ci/L of 137Cs; ~0.65 Ci/L decayed from 1978 to 2014. Specific activity tables (SD-RE-TI-131) show that 0.65 Ci/L of ^{137}Cs is approximately equal to $1.4X10^{12}$ dpm/L or ~$1.4X10^{11}$ cpm (1 Ci/L of ^{137}Cs = $2.2X10^{12}$ dpm/L). The total gamma concentration of 1,000 cpm from the LDP swab samples was eight orders of magnitude lower than the concentration of ^{137}Cs in tank AX-104 liquids in 1978. It is clear from the radiation measurements that tank waste had never accumulated in the LDP.

Table 6-3. AX-104 Leak Detection Pit Liquid and Radiation Levels (1973-1986)

Date	Liquid level (in.)	Radiation level (c/min)
06/15/73	24	300
09/15/73	24	0
12/15/73	24	0
04/15/74	24	0
05/15/74	23	0
06/15/74	23	0
07/15/74	22.8	0
08/15/74	21.1	0
09/15/74	20.7	0
10/15/74	21.1	0
11/15/74	21.1	0
12/15/74	20.7	0
01/15/75	21.1	0
02/15/75	20.7	0
03/15/75	20.7	0
04/15/75	21.1	0
05/15/75	20.7	0
06/15/75	20.7	0
07/15/75	21.1	0
08/15/75	21.1	0
08/25/75	21.6	0
09/21/75	21.1	0
12/18/75	21.6	0
12/28/75	21.1	0
01/08/76	21.6	0
03/31/76	21.0	0
04/26/76	22.0	0
05/26/76	22.5	0
06/26/76	21.0	0
09/15/76	21.5	0
10/29/76	16.0	0
11/03/76	16.0	0
12/05/76	15.0	0

Table 6-3. AX-104 Leak Detection Pit Liquid and Radiation Levels (1973-1986)

Date	Liquid level		Radiation level (c/min)	Comments
	Gage	Weight factor (in.)		
12/27/76		14.0	0	LL slow decrease
12/28/76	4.8	0.0	<40	Radiation pen jumping
12/29/76	4.9	0.0	1	
12/30/76	5.0	21.0	1 to 4	Radiation pen erratic
12/30/76	5.0	21.0	<30	Radiation pen erratic
01/05/77		16.5	8 to 20	LL decrease
01/06/77	4.9	0.0	8	
01/07/77	4.9	20.0	10	
07/09/77	4.5	17.0	1 to 25	LL very slow decrease
10/26/77	0.0	0.0	0 to 30	LL steady decrease
03/02/78	0.0	0.0	2 to 60	LL stable at 0 in., radiation erratic
03/03/78	0.0	0.0	580	Radiation increase
03/29/78	0.0	0.0	500	Stable
03/30/78	0.0	0.0	800	Radiation increase
12/20/78	0.0	0.0	850	Radiation varies 600 to 1,000 c/min
08/21/79	1.0	6.5	100	Water added
12/31/79	1.0	2.0	107	Stable
12/11/80	0.8	1.5	200	LL slow decrease
01/25/81	0.0	0.0	400	LL steady decrease, radiation increase
01/27/81	1.5	6.5	80	Water added
02/25/81	1.0	3.0	150	LL steady decrease, radiation increase
02/26/81	2.5	10.5	100	Water added
05/13/81	0.5	0.0	3	LL steady decrease, radiation increase
05/14/81	2.2	9.0	120	Water added
09/23/81	0.0	0.0	300	LL steady decrease, radiation increase
09/24/81	2.5	10.0	200	Water added
01/13/82	1.0	1.0	100	LL steady decrease, radiation stable
01/14/82	3.0	12.5	90	Water added
04/18/82	3.0	8.5	100	LL stable, radiation stable
12/12/82	3.5	17.0	90	Readings vary from 0.3 to 3.8 in. due to evaporation, water additions, and rain. Radiation stable

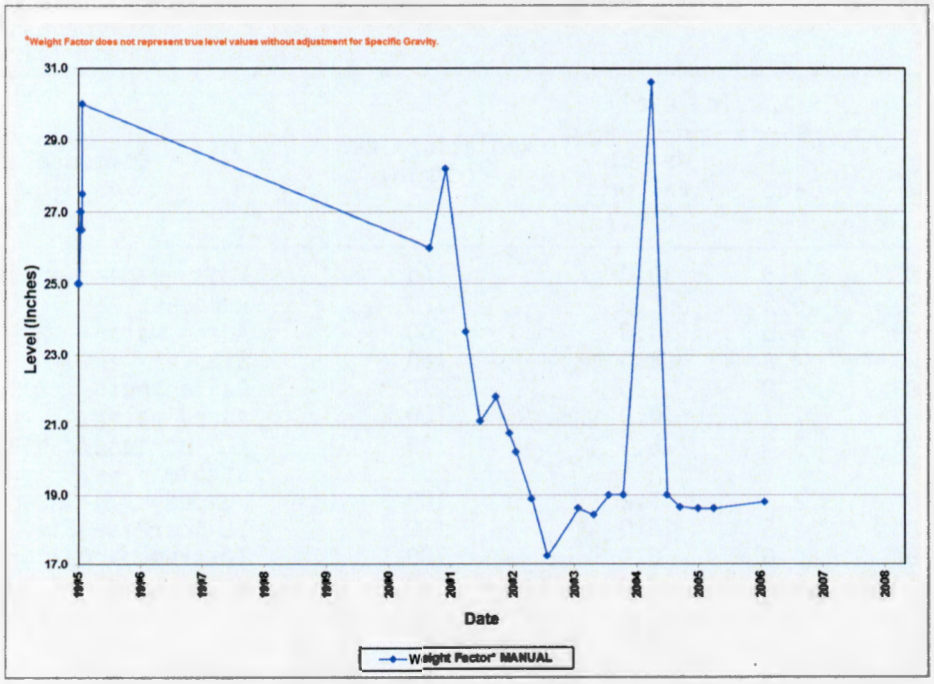
Table 6-3. AX-104 Leak Detection Pit Liquid and Radiation Levels (1973-1986)

Date	Liquid level		Radiation level (c/min)	Comments
	Gage	Weight factor (in.)		
03/25/83	9.5	30.0	140	Rain, radiation stable
03/29/83	0.5	0.0	120	Pumped
07/01/83	4.8	18.0	100	Added water
07/21/83	4.8	18.0	160	Stable
07/26/83	1.0	1.5	70	Bailed out
08/25/83	2.1	10.0	100	Added water
12/12/83	3.5	16.0	100	LL increase/radiation stable
02/04/84	2.0	3.2	100	Pumped
07/25/84	2.5	6.0	120	LL increase
07/26/84	0.0	0.0	100	Instrument calibration
10/20/84	1.0	3.0	80	Water added
11/14/84	1.2	4.0	95	LL slow increase
02/19/85	3.8	16.0	60	LL slow increase
02/20/85	1.1	4.4	65	Pumped
08/19/85	2.0	8.0	55	LL erratic increase
10/24/85	0.5	3.0	50	LL erratic decrease
10/27/85	1.5	7.5	50	Water added
11/19/85	1.5	7.5	60	Stable
01/20/86	3.5	18.0	40	Water added
01/21/86	16.5	18.0	40	New dial gage
03/07/86	14.0	14.0	50	LL slow decrease
03/08/86	9.0	9.0	40	Pumped
05/19/86	14.0	15.0	50	LL slow increase
05/20/86	3.5	4.0	60	Pumped
06/22/86	0.0	0.0	100	LL slow decrease
07/08/86	7.0	8.0	40	Water added
08/20/86	3.0	3.0	60	LL slow decrease
08/21/86	9.3	9.0	30	Water added
11/08/86	0.0	0.0	175	LL slow steady decrease
11/13/86	8.5	9.0	150	Water added
12/13/86	2.2	2.5	60	LL slow steady decrease

Table 6-4. Leak Detection Pit Swab Sample Results

Tank LDP	Wet Sample (cpm)		Dry Sample (cpm)	
	βγ	α	βγ	α
AX-101	50	0	250	0
AX-102	NA	NA	50	N/A
AX-103	50	0	450	0
AX-104	800	0	1,000	0

Figure 6-9. AX-104 Leak Detection Pit Liquid Level (1996 to 2006)



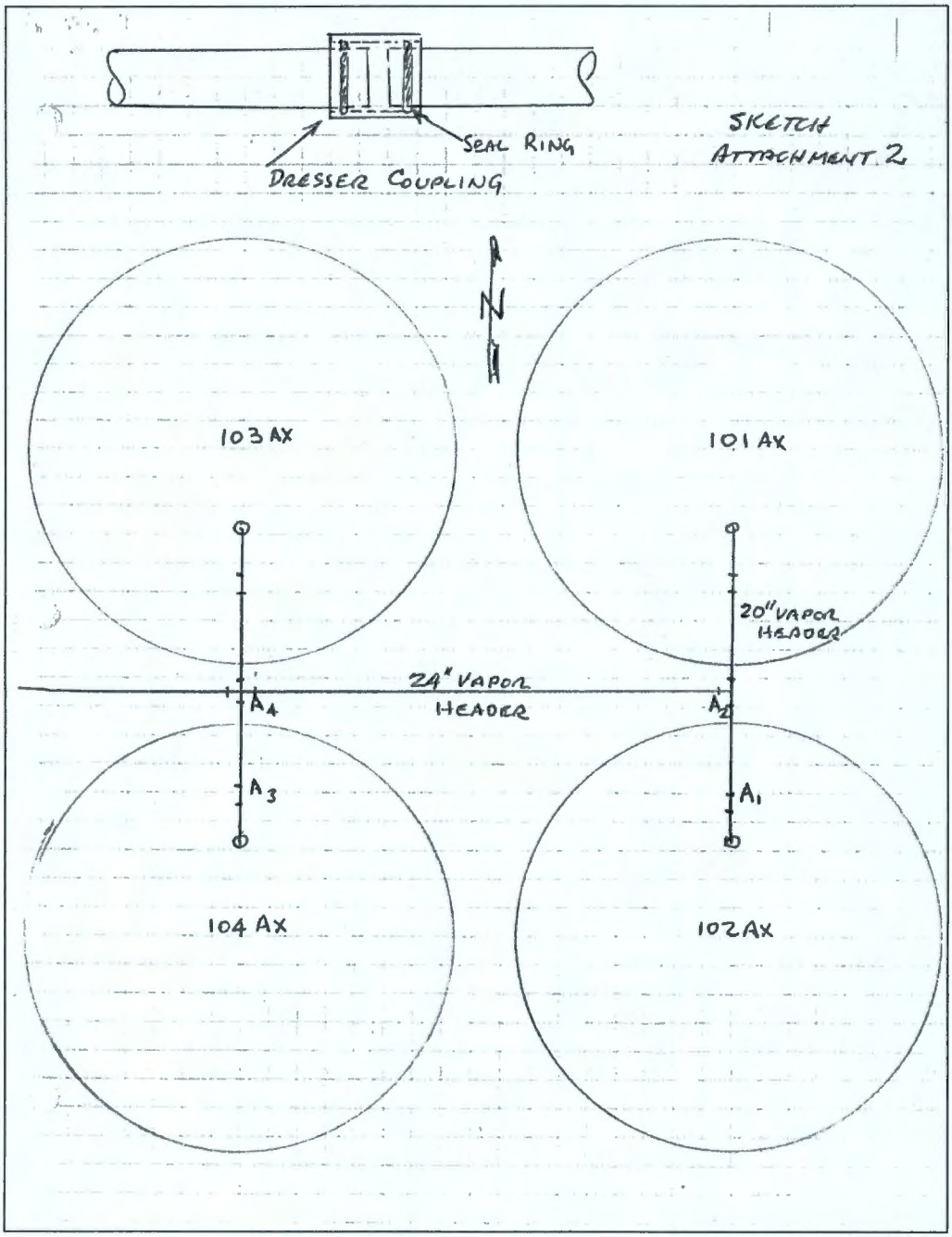
6.4 AUGER DRILLING

Another soil investigation during the 1975 period involved auger drilling near several of the likely failure points on the 241-AX tank farm vapor exhaust system, where the duct sections were joined together using Dresser couplings, a type of large diameter compression fitting (Figure 6-10). Dresser couplings can be used to compensate for thermal expansion in pipelines, and apparently minor section misalignment based on the 241-AX tank farm system construction drawings.

Occurrence Report 75-60 shows that highly contaminated soils were found at a depth of ten feet at Auger locations A2 and A3 (Figure 6-10). These locations are in close proximity to Dresser couplings which provide piping junctions allowing for expansion/contraction of the pipe. The seal is provided by a mechanically energized ring which is compressed by an adjustable flange ring to form a seal. Aging and wear have apparently caused the seal to fail. Point A3 is in the soil over the dome of tank AX-104.

Tests were started on evaluating a method of sealing the coupling itself by injecting a tar-based sealant around the coupling in-situ.

Figure 6-10. Auger Sampling Locations



Reference: Occurrence Report 75-60, *Increasing Radiation in A Dry Well Adjacent to 102-AX*, Attachment II

7.0 HYPOTHESES

The leak assessment team developed plausible hypotheses for the observed tank AX-104 behavior based on the review of in-tank and ex-tank data:

Leak Hypothesis:

"The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104."

No-Leak Hypothesis:

"The change in radioactivity in dry well 11-04-08 resulted from a source or sources other than a tank leak and may include the AX farm ventilation system, transfer line leaks, operations releases and/or other sources."

8.0 EVALUATION

The tank AX-104 Leak Assessment team reviewed past assessments and documentation and three indicators that could influence a judgment on the leak integrity of tank AX-104. They are briefly summarized below.

8.1 DRYWELL 11-04-08 DATA

After drywell 11-04-08 was drilled, soil contamination was found during the initial logging of the drywell. Ru-106 was identified as the responsible radionuclide; none of the other gamma radionuclides present in tank waste were detected. The source is either related to vapor condensate leaks from the nearby Dresser coupling or a tank leak.

Tank AX-104 operated at high boiling temperatures for several years. Radionuclide volatility could have carried Ru-106, as well as ^{137}Cs, into the soil column via the Dresser coupling leaks. It is possible that the ^{137}Cs could have been preferentially adsorbed to the soil at the upper levels of the soil column while the Ru-106 was carried with the moisture plume to lower levels. Interestingly, when the drywell was re-logged with the SGLS system in 1995, trace amounts of ^{137}Cs were detected in the drywell. By this time, the Ru-106 had decayed below the SGLS' detection threshold.

Routson (Letter 60110-78-019) noted that the two possible sources for increased activity in drywell 11-04-08 included a Dresser coupling failure near well 11-04-11 or a leak in tank AX-104. "If the source was the Dresser coupling break, activity would likely be detected in either well 11-04-10 or 11-04-05 which are both clean. In addition a plot of the activity increase against time shows two decreases in activity at approximately the same time after a liquid source was removed from the tank. In the first case, the tank was pumped in mid-February and the activity decrease began about the first of May. In the second case, sluicing stopped in mid-August and the activity decrease began about mid-November. These time lapses are about what can be expected once liquid is removed. Thus the 241-AX-104 would seem to be a more likely source of activity."

Based on the letter from Routson and discussion with the Geological Sciences Unit, Stalos concluded "it is highly improbable that the exhaust line leakage could reach the 11-04-08 drywell without also appearing in the 11-04-10 drywell." (Stalos, 1978, Memo to J.H. Garbrick, dated April 24, Tank 104-AX, In: HNF-4872, Vol. II, Ref. 7).

As noted above, RPP-35484 concludes that whether elevated gross gamma measurements of ^{106}Ru indicates a continuation of waste migration from the same source affecting drywells 11-04-01 and 11-04-11 (the Dresser coupling failure) is not clear, "though the timing and radiation levels are consistent with that hypothesis. On the other hand, no indications of elevated gross gamma activity were observed at drywell 11-04-10, which is located between drywell 11-04-08 and the other drywells. A migration path that bypassed drywell 11-04-10 appears problematic. Drywell 11-04-10 is also notable for an apparently independent near-surface waste loss. Unlike the other drywells around tank AX-104, 1995 spectral gamma

data analyses show ^{137}Cs peaks at approximately 5 ft bgs, accompanied by ^{60}Co and ^{154}Eu peaks in the same location."

The integrity assessment team concurred that based on the location of the Dresser coupling leaks near tanks AX-104 (see Figure 6-10), migration to drywell 11-04-08 without by-passing drywells 11-04-19 or 11-04-10 appears to be infeasible. However, other potential leak sources are closer to drywell 11-04-08 including flush pits from two valve pits, a ventilation line about 50 ft west of the drywell and a direct buried condensate drain line from tank AY-102 that passes just to the west of drywell 11-04-08 (See Figure 8-1). Tank waste losses from the valve and flush pits are possible; but as for a tank loss, the gamma activity level from waste losses should be greater than the drywell gamma activity observed. Losses from the condensate line or condensate drain line from tank AY-102 are not documented but appear likely, given other condensate leaks and provide a viable source for the low activity Ru-106 observed in gamma measurements. Although the ventilation line is ~50 ft away, the excavation foundation west of tanks AX-103 and AX-104 slopes downward to the east, toward the tanks and migration of mobile and short-lived radionuclides along this path is feasible. It was also noted that ventilation lines were encased and supported by concrete beams (Figure 8-2). After being excavated, the soils replaced around the beams were likely more loosely compacted than natural background soils, creating an enhanced flow path to the excavation base.

8.2 LEAK DETECTION PIT CONTAMINATION

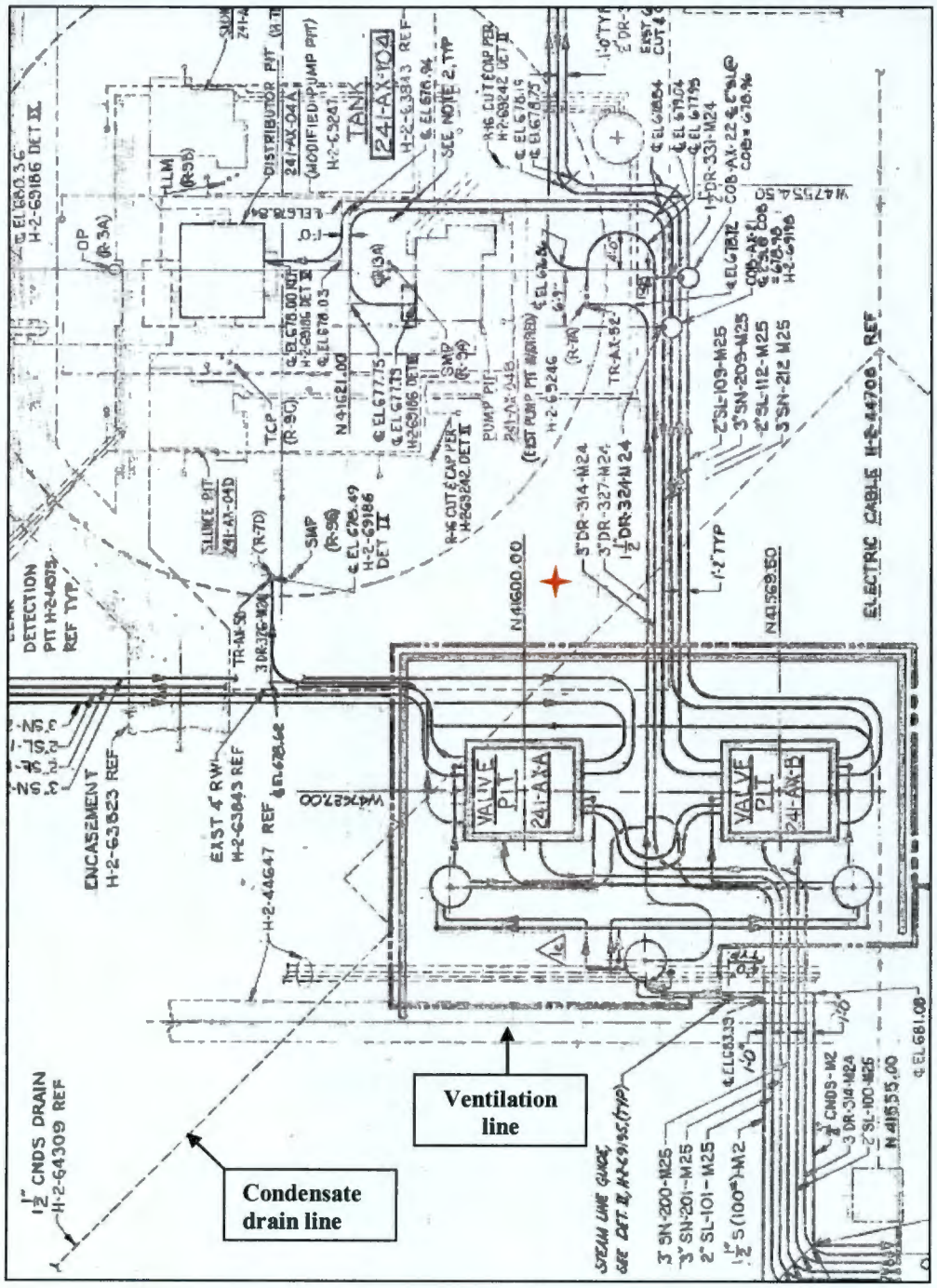
The source of the radiation detected in the tank AX-104 LDP has not been verified. Recent pit swabs showed total gamma radioactivity levels of ~1,000 cpm on dry swab samples from the LDP (See Appendix A.1, Meeting Minutes #1, Attachment 4). The recent total gamma activity is essentially the same as historical gamma monitoring results for the LDP. As noted in Section 6.3, 1,000 cpm is eight orders of magnitude lower than the level of radioactivity that was measured in the tank supernatant. The 241-AX tank farm ventilation header was connected to the leak detection pit and condensate may have drained back through leaking seal pots to the leak detection pit.

8.3 DRESSER COUPLING LEAK AND AUGER SAMPLES

Drywell radiation measurements, neutron moisture surveys, and auger drilling samples showed that at least two of the Dresser couplings in the ventilation header line leaked. One of the auger locations is near a Dresser coupling located over the dome of tank AX-104 (Figure 6-10). Auger sample results, occurrence reports, and other evaluations concluded that leaks from the Dresser couplings were the source of gamma radioactivity found in drywells 11-04-11 and 11-04-01. When the leakage started is not certain, but ^{106}Ru radioactivity was already present in the soil at 55 ft bgs in 1975 when the drywells near tank AX-104 were drilled in 1975. By 1975, the tanks had been in operation for about 11 years, several at high self-boiling waste temperatures. The vapor exhaust system would have already been subjected to very high thermal stresses that could have caused the Dresser couplings to leak. The question of what mechanisms contributed to the couplings' failure is open to conjecture, but the following mechanisms are credible: gasket damage caused by repeated thermal cycling of the vapor exhaust header,

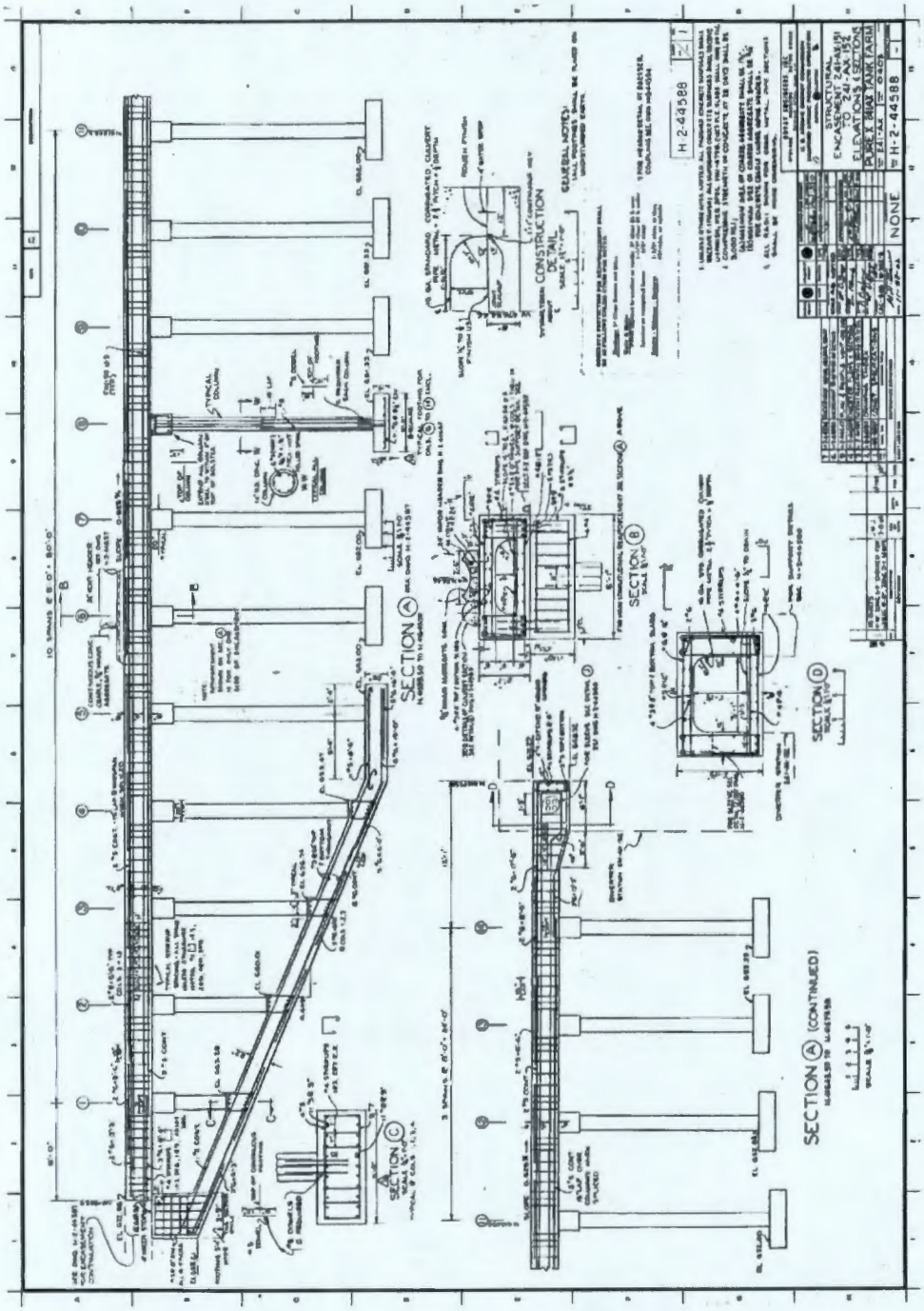
misaligned vapor exhaust duct section joints, and incomplete compaction of backfill material supporting the duct sections.

Figure 8-1. Piping Near Drywell 11-04-08 in AX Tank Farm (From H-2-69241)



Approximate location of Drywell 11-04-08

Figure 8-2. Structural Encasement 241-AX-151 to 241-AX-152 Elevations and Sections, H-2-44588



9.0 CONCLUSIONS

The process for assessing the leak status of a tank is designed to estimate a leak probability. Probability is defined as a measure of the state of knowledge or belief about the likelihood that a specific state of nature (e.g., a tank has leaked or is leaking) is true. Probability must be between 0 (absolute certainty that the state of nature is not true) and 1 (absolute certainty that the state of nature is true). The process starts with a prior probability independent of the available data. This establishes any pre-evaluation bias and is typically established at 0.5 that the tank is leaking or has leaked without consideration of the specific data initiating this process (i.e., no pre-evaluation bias, either for or against a leak). Then reviews of in-tank data and ex-tank data are used to establish conditional probabilities for whether the leak hypothesis or the non-leak hypothesis is supported by the data. The conditional probabilities are used to adjust the leak probability toward a leak hypothesis (probability > 0.5) or a non-leak hypothesis (probability < 0.5).

There was consensus among the members of the assessment team that the available in-tank and ex-tank data indicated that the "no-leak" hypothesis was more consistent with the data, and that tank AX-104 did not leak. Elicitation scores for the probability of a tank AX-104 leak ranged from p = 0.002 to p = 0.04 (See Appendix B). The following general observations were made: Liquid level decreases reported in OR 77-19 have been explained and did not appear to be a concern in the past; the LDP liquid level continually decreased and should increase for a tank leak; radioactivity at drywell 11-04-08 likely didn't originate from the ventilation header Dresser coupling leaks between the tanks and it appears to be too low to be from a tank leak, but appears to be consistent with a condensate leak; if the tank leaked, other radionuclides such as ^{137}Cs or ^{60}Co would be expected in spectral gamma scans. A leak from ventilation lines near drywell 11-04-08, flush pit leaks or surface runoff and migration are viable sources for the Ru-106 in drywell 11-04-08.

The recommendation of the leak assessment team is that the integrity status of tank AX-104 be changed from "Assumed Leaker" to "Sound".

The results of the assessment were presented to the Executive Safety Review Board (ESRB) on August 25, 2014. The board concurred that the integrity status of tank AX-104 should be changed from "assumed leaker" to "sound" (See Appendix A5).

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APPENDIX A – TANK AX-104 LEAK ASSESSMENT MEETINGS

A1. MEETING #1, JUNE 5, 2014 2
A2. MEETING #2, JUNE 12, 2014 18
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A1. MEETING #1, JUNE 5, 2014

MEETING MINUTES

SUBJECT: Tank AX-102 Integrity Assessment Meeting #5 and Tank AX-104 Meeting #1				
TO: Distribution	BUILDING: 2750E/B-225			
FROM: D. G. Baide	CHAIRMAN: J. G. Field			
DEPARTMENT-OPERATION-COMPONENT Engineering – Tank and Pipeline Integrity	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 06/05/2014	**NUMBER ATTENDING** 8

Distribution:
D. G. Baide[1]
J. G. Field[1]
C. L. Girardot[1]
D. G. Harlow[1]
K. J. Hull[1,2]
N. W. Kirch[1]
J. G. Schofield[1]
D. W. Strasser
D. J. Washenfelder[1]

[1]Attendee and Team Member
[2]Representing System Engineering and Operations

Purpose:

The purpose of the meeting was to review AX Farm leak detection pit (LDP) swab sample results, to close-out the AX-102 leak assessment and to kick-off the AX-104 leak assessment. A re-start meeting for the AX-102 leak assessment was held May 14, 2014 to review AX-102 background information and recommendations that were given to the Executive Safety Review Board (ESRB) on December 3, 2009. In the ESRB meeting it was recommended that the integrity status of tank AX-102 be changed from "assumed leaker" to "sound." The ESRB requested that swab samples from the AX-102 leak detection pit be obtained and results reported back to the ESRB as additional evidence to support the recommendation to change the integrity status for tank AX-102.

AX-102 Discussion:

The team meeting agenda (attachment 1), actions from the May 14 re-start meeting, and information presented and discussed during the June 5, 2014 meeting are attached.

Actions discussed included:

1. Look into the purpose and details for the 30-day sluicing test that was conducted in 1975 (See attachment 2),
2. To determine how the vent header is connected to the LDPs (information was provided to team members after the meeting [see attachment 3]).

Leak detection pit results (attachment 4) showed that <1,000 dpm/100 cm or <100 cpm beta-gamma in the AX-102 LDP. In comparison, the AX-101, AX-103, and AX-104 LDP's showed higher sample results. The highest result was found in the AX-104 LDP (~10,000 dpm beta-gamma activity or ~1,000 cpm) (See Attachment 4). The beta-gamma activity level in the AX-104 LDP was determined to be ~8 orders of magnitude lower than the level of radioactivity in previous tank liquid samples (decayed to 2014). It was recommended that the methodology used for LDP samples be described in the assessment report (included in attachment 4).

The team concluded that the LDP sample results supported the determination that tank AX-102 did not leak. Results of previous elicitation scores ranged from 0.01 to 0.16 with an average of 0.065, indicating a low probability (6.5%) that the tank leaked. The team concurred with the earlier elicitation results and determined that a separate elicitation was not needed.

No additional data needs for the AX -102 tank integrity assessment were identified. Suggestions were given for statements to include in the AX-102 integrity assessment report.

AX-104 Integrity Assessment Kick-off

Tank AX-104 was classified questionable integrity in August 1978 based on radioactivity detected in drywell 11-04-08. The source of the radioactivity was determined to be either from dresser coupling leaks from the ventilation header, as for tank AX-102, or from a tank AX-104 leak. The location of the dresser coupling leaks and drywells near tank AX-104 showing gamma activity were briefly discussed. Past AX-104 LDP results and auger sampling results were presented for comparison with LDP swab sample results obtained in May 2014. It was determined that other than the LDP swab samples recently obtained, no additional field investigations should be needed for the AX-104 integrity assessment.

Tank AX-104 process history, liquid level changes, drywell monitoring results, auger sample results, and LDP results will be reviewed and discussed in more detail in the next meeting. Information to be discussed is included in a draft AX-104 leak detection report available in the \ETIG share area at the following link: \\hanford\data\sitedata\ETIG\D-42 Assessments\AX-104\

Next Meeting:
The next assessment team meeting is tentatively scheduled for 6-12-2014.

Team Member Actions:

1. JGF – Prepare June 5, 2014 meeting summary.
2. JGF – Schedule ESRB presentation for AX-102.
3. JGF – Complete AX-102 Integrity Assessment Report and distribute to team for review by June 10.
4. KJH – provide description/drawings for the AX-102 integrity assessment report showing how the ventilation header is connected to the LDPs.
5. JGF – Prepare AX-104 Information for next meeting.
6. All – Review AX-102 meeting minutes and AX-102 Integrity Assessment Report and provide comments by June 16.
7. All – Review Draft AX-104 integrity assessment sections 1- 6 in preparation for the next meeting.

Attachment 1: Tank AX-102 Integrity Assessment Meeting Agenda
6-5-2014

Finalize AX-102 Integrity Assessment

1. Discuss re-start meeting/ where we are.
2. Actions from previous meeting.
3. AX Leak Detection Pit Results.
4. Discussion of results/ Implications from previous assessment conclusions.
5. Additional data/ Information needs (if any).
6. Elicitations?
7. Final Report/ Recommendations to ESRB.

Start AX-104 Integrity Assessment

1. Brief overview/ available information.
2. Additional data needs.
3. Next meeting.

Attachment 2. Purpose and Details for the 30-Day Sluicing Test

Monitoring of drywells and several special sealant injection tubes using a Battelle Northwest DC-potential soil moisture monitoring system was not able to confirm that sluicing operation in tank AX-101 was a contributor to additional leakage from the vapor exhaust header. The sluicing test was performed prior to an attempt to seal the suspect leaking Dresser coupling on the vent header "T" between tank AX-101 and tank AX-102 vent lines.

In September, 1975, a soil sealant test was initiated with the intention of encapsulating the suspect Dresser coupling in an asphalt emulsion. The sealant test had no measurable effect on either drywell 11-02-11 or 11-02-12 radiation increases. Regular soil moisture measurements continued to show high moisture levels around the drywells and a small increase near the test Dresser coupling. The final occurrence report recommended that the anticipated sluicing of tank AX-102 commence since there was no evidence that the tank was leaking (Occurrence Report 75-90, *Increase Dry Well Radiation Adjacent to Tank 102-AX*).

Note: From Section 6 of draft AX-102 Integrity Assessment Report.

Attachment 3. Potential Contamination Routes for AX Farm Leak Detection Pits

Contamination other than a direct tank leak may have entered the AX Farm Leak Detection Pits (LDPs) through one or more of the following routes:

1. Pit cover blocks
2. Drain lines
3. Ventilation lines

Contamination can be introduced into the LDPs through the cover blocks by insertion of contaminated equipment or transported from the surrounding environment by natural runoff. The surrounding grounds are a radiological contamination area which is a potential source to affect both equipment and surfaces. (H-2-44575, H-2-44576, H-2-44501 sheet 69).

Drain lines from the LDP pump area floors are connected to their respective tanks. These drain lines are connected to a tank riser with a down leg pipe that ends 60 inches above the tank floor. The drain is in communication with the tank head space when the tank waste level is below 60 inches. When the tank level is above 60 inches, the drain line contacts tank waste and is filled to the level of the waste surface. Contamination may have been transported in vapors up through the drain lines to the LDP (H-2-44576, H-2-44571).

Each LDP has a seal pot assembly that was connected to the primary tank ventilation system. This connection was below the LDP pump area floor. The seal pot is dependent on maintaining a specific level of seal water in the system to prevent cross contamination. It is unlikely the water level was maintained perfectly during ventilation system operation and is currently unmonitored. The primary ventilation system is highly contaminated and any reverse flow of air could contribute to LDP contamination (H-2-44618, H-2-44624, H-2-44670, H-2-44671).

Contamination from any of these sources would be relatively low compared to the concentration of the tank waste. There is no direct transport of concentrated radioactive materials from the tank to the LDP except for a tank leak draining into the LDP.

Attachment 4. Leak Detection Pit Work Instructions and Results

Leak Detection Pit Swab Sample Work Instructions (from TFC-WO-14-2710):

5. SPECIFIC WORK INSTRUCTIONS

WARNING:

DO NOT remove legacy zip cords that extend into cover block penetration during performance of step 5.1

5.1 **PERFORM 241-AX leak detector pit work area preparations per the following steps:**

5.1.1 **PERFORM pre-job contamination and dose rate survey of Leak Detector Pits and record RSR number below in Data Table 1.**

5.1.1.1 **DOCUMENT subsequent survey report numbers on Survey Report Form A-6006-444 located in the work package prior to the end of shift.**

5.1.2 **ENSURE/perform a cleanup of the leak detector pit cover block work area by removing tumble weeds, gravel, debris and dispose per the waste planning checklist.**

5.1.2.1 **ENSURE/ install ground cover and drape around cover block penetration.**

DATA TABLE 1

Leak Detector Pit preliminary RSR survey and work area prep.				
Component ID	RSR Survey Number	Pit Debris Removed (✓)	Ground Cover/Drape Installed (✓)	FWS initial/Date
241-AX-104 **(required)**				
241-AX-102 **(required)**				
241-AX-103 (optional)				
241-AX-101 (optional)				

Note: Sections 5.2 through 5.5 in the work instructions were for each of the 241-AX Farm leak detection pits and were essentially the same for each pit. Following are instructions for the AX-104 leak detection pit.

5.2 PERFORM 241-AX-104 LEAK DETECTOR PIT SWAB(S).

5.2.1 ENSURE/post Vapor Control Zone (VCZ) at a minimum of 10ft around the work area.

5.2.2 ENSURE/post work area as Airborne Radioactivity Area (ARA).

5.2.3 REMOVE cover block pipe plug, wooden plug or shield plug into bagging, as applicable.

5.2.4 PULL existing zip cord (if present) and sniffer tubing (if present) through damp rag into bagging.

5.2.4.1 HPT MONITOR zip cord and/or sniffer tubing for contamination during removal as applicable.

NOTE – Steps 5.2.5 and 5.2.6 may be performed concurrently.

5.2.5 PERFORM open riser/port bag sampling for IH per the following:

5.2.5.1 INSTALL Instrument Sampling pump(s).

5.2.5.2 PERFORM IH bag sampling.

5.2.5.3 REMOVE IH sampling tube.

5.2.6 INSTALL camera.

5.2.6.1 OBSERVE for obstructions inside pit.

5.2.6.2 MARK on cover block, the direction of the 24" diameter leak detector well riser (inside pit).

5.2.6.3 REMOVE camera. (N/A if camera is to remain installed to assist in extension tool & WSC placement).

NOTE – Cover block is 2 ½ feet thick while the pit floor is 6 ¾ feet below the top of the cover block.

5.2.7 INSTALL extension tool (if needed) & cable w/attached weighted sample collector (WSC) through cover block penetration.

NOTE – Camera may be re-installed to facilitate cable/WSC placement.

5.2.8 INSTALL camera as necessary. (N/A if previously installed).

NOTE – The 24" diameter leak detector well opening is offset from the cover block opening. The 24" leak detector well bottom is approximately 59 feet from the top of the cover block.

5.2.9 LOWER cable/WSC until WSC is in the 24" leak detector well opening.

5.2.10 PERFORM the following steps IF insertion attempt is unsuccessful: (otherwise N/A steps in 5.2.10).

5.2.10.1 REMOVE the camera (if installed), extension tool (if installed) and the cable/WSC from the leak detector pit.

5.2.10.2 HPT PERFORM survey of camera (if installed), extension tool and cable/WSC if removed from leak detector pit.

5.2.10.3 REPEAT steps 5.2.6 through 5.2.9 as necessary until cable/WSC is in 24" leak detector well opening.

5.2.11 INSERT/lower the cable/WSC into the 24" diameter leak detector well until it reaches the bottom of the leak detector well (indicated by slack in cable).

NOTE – Liquid level readings are requested by Engineering for baseline data and need to be recorded in ft (') and in (").

5.2.11.1 OBTAIN liquid level (once) while lowering cable (N/A if reading can't be obtained).

5.2.11.1.1 RECORD liquid level for 1st swab _____' ft _____" in.

5.2.11.2 RECORD cable length (as measured from top of cover block to bottom of leak detection pit) on Attachment A for Swab #1.

5.2.12 PULL/remove cable/WSC from Leak Detector Well up into the pit.

5.2.13 REMOVE camera from Leak Detector Pit through a damp rag.

5.2.14 REMOVE extension tool (if installed) from Leak Detector Pit through a damp rag.

5.2.15 REMOVE cable/WSC from Leak Detector Pit through a damp rag and into bag.

5.2.15.1 HPT PERFORM shallow dose rate and contamination survey during removal of cable/WSC.

5.2.15.2 CUT and DROP cable/WSC into leak detector pit for any of the following;

- **Increase in the shallow dose rates**
- **Direct contamination levels are ≥ 50,000 dpm/probe area beta-gamma**
- **Removable contamination ≥ 50,000 dpm/100cm² beta-gamma or ≥70 dpm/100cm² alpha.**

5.2.16 OBTAIN a beta-gamma contamination survey of WSC.

5.2.17 DOCUMENT results of contamination survey on Attachment A for Swab #1.

5.2.18 REMOVE technical smear from WSC.

NOTE – Drying of the smear and WSC along with documenting contamination levels may be done at any time, but shall be completed prior to the completion of this work package.

5.2.19 DRY smear and WSC; Obtain contamination levels and document on Attachment B.

5.2.20 SKIP to step 5.2.22 IF any of the following is recorded in Attachment A:

- **≥ 50,000 dpm/probe area beta/gamma**
- **Increase in shallow dose rates during removal**
- **Removable contamination ≥ 50,000 dpm/100cm² beta-gamma or ≥ 70 dpm/100cm² alpha.**

5.2.21 REPEAT steps 5.2.6 through 5.2.19 for Swab #2 or Swab #3 as applicable.

5.2.21.1 DOCUMENT results on Attachments A & B for Swab #2 & Swab #3 as applicable.

5.2.21.2 PROCEED to step 5.2.22 if all samples have been collected.

5.2.22 REINSTALL cover block pipe plug, wooden plug or shield plug as applicable.

5.2.23 DOWNPOST ARA as survey and air sample results allow.

5.2.24 DOWNPOST Vapor Control Zone (VCZ) as IH sampling allows.

5.2.25 REMOVE ground cover/drape.

5.2.26 ENSURE pit cover block area is cleaned up and all equipment is removed.

5.2.27 PERFORM post-job contamination and dose rate survey of 241-AX-101 and record RSR number below.

_____ _____

RSR (Survey) Number Date

Additional Description of Leak Detection Pit Swab Sampling.

As shown in Photo #1, originally it was planned to place the swab around the weight that was lowered into the into the leak detection pit; however, the swab diameter was too large for the leak detection pit access riser. As a result, the swab was placed inside the weight that was lowered into the pit (See Photo #2) and the swab only contacted the bottom of the pit. In the AX-102 leak detection pit the swab was dry because no liquid was present. Consequently, the swab may not have contacted the bottom of the pit. However, the weight that did contact the bottom of the pit was scanned separately and like the swab sample shoed less than 1,000 dpm beta-gamma.

The swab samples, zip line and other radiological surveys were conducted using a GM/probe for beta-gamma and PAM/probe for alpha.

Photo #1

Photo #2

Sample Results:

AX-101 and AX-103Leak Detection Pits

RPP-ASMT-57574, Rev. 0

** Electronically Approved – COR-1401241 on 5/29/2014 **

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401241	Page 1 of 5

Date	Start/Stop Time	Area/Location	RWP/Rev.
5/27/2014	0800 / 1500	200E / AX Farm / N/A / AX-101 & 103	CO-821

Purpose of Survey:

- ☐ Material Release
  - Number: N/A
  - Released to: N/A
- ☐ Rem Shipment: N/A
- ☐ Required Task: N/A
- ☑ Job Coverage: TFC-WO-14-2710
- ☐ Other: N/A

Description of Work / Comments:

Swab samples of AX-101 and AX-103 leak detector pit.

Comments: Additional RCT's Tom Thielen (0069909), Clay Rowan (0030573), Tony Hays (0033389), Jim Drake (0046031), Kyle Blatter (6203140).

No anomalies.

Dose Rate Measurements

Note* F = Field (≥30cm) C = Contact(≤1 cm)

No.	Description	Dist. (cm) Note*	WO mR/hr	WC mR/hr	CF Non-Penetrating	CF Penetrating	Neutron Dose mrem/hr	Shallow Dose mrem/hr	Deep Dose mrem/hr
D1	Pre, during and post job survey of work activity AX-101	30	<0.5	<0.5	2	1	N/A	<0.5	<0.5
D2	Pre, during and post job survey of work activity AX-103	30	<0.5	<0.5	2	1	N/A	<0.5	<0.5

Contamination Measurements

† Manually Calculated by RCT

No.	Description	Background cpm		Direct Gross cpm/100 cm²		Total dpm/100 cm²		Correction Factor		Removable				
											Gross (cpm)		dpm/100 cm²	
		βγ	α	βγ	α	βγ	α	βγ	α	Type	βγ	α	βγ	α
C1	Pre and post job survey AX-101	50	N/A	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C2	well cap AX-101	50	N/A	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†

Date Submitted: 05/27/2014 15:50:00

BD-6003-343-SS (Rev. 2)

*** Electronically Approved – COR-1401241 on 5/29/2014 ***:*

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401241	Page 2 of 5

Contamination Measurements (Continued)

† Manually Calculated by RCT

		Background cpm		Direct Gross cpm/100 cm²		Total dpm/100 cm²		Correction Factor		Removable				
											Gross (cpm)		dpm/100 cm²	
No.	Description	βγ	α	βγ	α	βγ	α	βγ	α	Type	βγ	α	βγ	α
C3	zip line (initial survey) AX-101	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	0	<1000†	<20†
C4	zip line (completion of task) AX-101	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	0	<1000†	<20†
C5	Swabs #1, 2, 3 (Wet) AX-101	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	0	<1000†	<20†
C6	Swabs #1, 2, 3 (Dry) AX-101	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	250	0	2000†	<20†
C7	Camera from pit, AX-101	50	N/A	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C8	Pre and post job survey AX-103	50	N/A	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C9	Shield plug AX-103	50	N/A	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C10	Swabs #1, 2, 3 (Wet) AX-103	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	0	<1000†	<20†
C11	Swabs #1, 2, 3 (Dry) AX-103	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	450	0	4000†	<20†
C12	Camera from pit, AX-103	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C13	SCBA's, masks, IH instrumentation, RCT instruments, camera, work package, clipboard, air samples, lalpel's,	50	N/A	50	N/A	<5000†	N/A†	10	N/A	Smear	50	N/A	<1000†	N/A†

AX-102 Leak Detection Pit

RPP-ASMT-57574, Rev. 0

** Electronically Approved – COR-1401235 on 5/28/2014 **.

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401235	Page 1 of 7

Date	Start/Stop Time	Area/Location	RWP/Rev.
5/22/2014	0645 / 1553	200E / N/A / N/A / AX Farm	CO-821

Purpose of Survey:

- [ ] Material Release
  - Number: N/A
  - Released to: N/A
- [ ] Ram Shipment: N/A
- [ ] Required Task: N/A
- [x] Job Coverage: TFC-NO-14-2710
- [ ] Other: N/A

Description of Work / Comments:

AX Farm, Swab samples of AX102 leak detector pit.

Comments: Additional RCT's Tom Thielen (0069909), Clay Rowan (0030573), Tony Hays (0033389), Jim Drake (0046031), Kyle Blatter (6203140).

No anomalies.

Dose Rate Measurements

Note*: F = Field (≥30cm) C = Contact(≤1 cm)

No.	Description	Dist. (cm) Note*	WO mR/hr	WC mR/hr	CF Non-Penetrating	CF Penetrating	Neutron Dose mrem/hr	Shallow Dose mrem/hr	Deep Dose mrem/hr
D1	Pre, during and post job survey of work activity	30	<0.5	<0.5	2	1	N/A	<0.5	<0.5

Contamination Measurements

† Manually Calculated by RCT

No.	Description	Background cpm βγ	Background cpm α	Direct Gross cpm/100 cm² βγ	Direct Gross cpm/100 cm² α	Total dpm/100 cm² βγ	Total dpm/100 cm² α	Correction Factor βγ	Correction Factor α	Removable Type	Removable Gross (cpm) βγ	Removable Gross (cpm) α	Removable dpm/100 cm² βγ	Removable dpm/100 cm² α
C1	Pre and post job survey	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C2	well cap	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C3	zip line (initial survey)	50	0	N/A	N/A	N/A	N/A	10	7	Smear	100	0	500	<20

Date Submitted: 05/22/2014 16:00:00

BD-6003-343-SS (Rev. 2)

** Electronically Approved – COR-1401235 on 5/28/2014 **

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401235	Page 2 of 7

Contamination Measurements (Continued)

† Manually Calculated by RCT

		Background cpm		Direct Gross cpm/100 cm²		Total dpm/100 cm²		Correction Factor		Removable				
											Gross (cpm)		dpm/100 cm²	
No.	Description	βγ	α	βγ	α	βγ	α	βγ	α	Type	βγ	α	βγ	α
C4	zip line (completion of task)	50	0	N/A	N/A	N/A	N/A	10	7	Smear	50	0	<1000	<20
C5	Swabs #1, 2, 3 (all dry)	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C6	SCBA's, masks, IH instrumentation, RCT instruments, camera, work package, clipboard, air samples, lalpel's,	50	0	50	0	<5000†	<100†	10	7	Smear	50	0	<1000†	<20†
C7	Camera from pit,	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†

AX-104 Leak Detection Pit

RPP-ASMT-57574, Rev. 0

** Electronically Approved – COR-1401219 on 5/21/2014 **

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401219	Page 1 of 7

Date	Start/Stop Time	Area/Location	RWP/Rev.
5/20/2014	0645 / 1600	200E / N/A / N/A / AX Farm	CO-821

Purpose of Survey:

- ☐ Material Release
  - Number: N/A
  - Released to: N/A
- ☐ Rem Shipment: N/A
- ☐ Required Task: N/A
- ☑ Job Coverage: TFC-WO-14-2710
- ☐ Other: N/A

Description of Work / Comments:

AX Farm, swab samples, leak detector pit shaft AX-104.

Comments: Additional RCT's Mike Copeland (0074270), Matt Young (0073722), Mike Widdis (0084244), Clay Rowan (0030573), Tony Hays (0033389).

No anomalies found during task.

Dose Rate Measurements

Note*: F = Field (≥30cm) C = Contact(≤1 cm)

No.	Description	Dist. (cm) Note*	WO mR/hr	WC mR/hr	CF Non-Penetrating	CF Penetrating	Neutron Dose mrem/hr	Shallow Dose mrem/hr	Deep Dose mrem/hr
D1	Pre, during and post job survey of work activity for AX Farm swab samples of leak detector pit	30	<0.5	<0.5	2	1	N/A	<0.5	<0.5

Contamination Measurements

† Manually Calculated by RCT

No.	Description	Background cpm βγ	Background cpm α	Direct Gross cpm/100 cm² βγ	Direct Gross cpm/100 cm² α	Total dpm/100 cm² βγ	Total dpm/100 cm² α	Correction Factor βγ	Correction Factor α	Removable Type	Removable Gross (cpm) βγ	Removable Gross (cpm) α	Removable dpm/100 cm² βγ	Removable dpm/100 cm² α
C1	Swab #1 (wet)	50	0	N/A	N/A	N/A	N/A	10	7	Smear	800	0	7500	<20
C2	Swab #2 (wet)	50	0	N/A	N/A	N/A	N/A	10	7	Smear	800	0	7500	<20
C3	Swab #3 (wet)	50	0	N/A	N/A	N/A	N/A	10	7	Smear	200	0	1500	<20
C4	Camera cable	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†

Date Submitted: 05/21/2014 06:24:00

BD-6003-343-SS (Rev. 2)

** Electronically Approved – COR-1401219 on 5/21/2014 **

WASHINGTON RIVER PROTECTION SOLUTIONS LLC RADIOLOGICAL SURVEY REPORT (Submitted for Approval)	RSR No. COR-1401219	Page 2 of 7

Contamination Measurements (Continued)

† Manually Calculated by RCT

		Background cpm		Direct Gross cpm/100 cm²		Total dpm/100 cm²		Correction Factor		Removable				
											Gross (cpm)		dpm/100 cm²	
No.	Descriptor	βγ	α	βγ	α	βγ	α	βγ	α	Type	βγ	α	βγ	α
C5	Swab guide	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C6	tape measure (cable)	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C7	Air bottles (during change outs)	50	0	50	0	<5000†	N/A†	10	7	Smear	50	0	<1000†	N/A†
C8	Masks, SCBA units, air bottles, phones, radios, camera's, EPD's, work package, IH instruments, RCT instruments, air samples	50	0	50	0	<5000†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C9	pit opening	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†
C10	swab #1, 2, 3 (dry) highest reading	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	1000	0	9500†	<20†
C11	Pre ground surveys of AX 101, 102, 103, 104	50	0	N/A	N/A	N/A†	N/A†	10	7	Smear	50	N/A	<1000†	N/A†

A2. MEETING #2, JUNE 12, 2014

MEETING SUMMARY

SUBJECT: Tank AX-104 Integrity Assessment Meeting #2				
TO: Distribution	BUILDING: 2750E/A-229			
FROM: D. G. Baide	CHAIRMAN: J. G. Field			
DEPARTMENT-OPERATION-COMPONENT Engineering – Tank and Pipeline Integrity	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 06/12/2014	**NUMBER ATTENDING** 8

Distribution:
D. G. Baide[1]
J. G. Field[1]
C. L. Girardot[1]
D. G. Harlow[1]
K. J. Hull[1]
N. W. Kirch[1]
J. G. Schofield[1]
D. W. Strasser[1]
D. J. Washenfelder

[1]Attendee and Team Member

Purpose:

The purpose of the meeting was to continue the tank AX-104 integrity assessment. Specifically to look at surface level data, drywell data and leak detection pit data and occurrence reports for liquid level decreases or increases gamma activity near tank AX-104.

AX-104 Discussion

The June 5, 2014 meeting summary was reviewed and discussed. Actions identified in the meeting were completed. The meeting summary was approved with minor edits. The tank integrity elicitation process described in TFC-ENG-CHEM-D-42, Tank Leak Assessments, was briefly discussed. The process requires an evaluation of whether or not a tank leaked based on liquid level data: surface level data and LOW interstitial liquid level data, and based on total gamma and spectral gamma drywell data. It was noted that the elicitation process does not include evaluations for LDP data. As a result LDP evaluations will be factored into liquid surface level and total gamma data considerations. It was noted that Tank AX-104 does not have an LOW.

Information from the draft tank AX-104 integrity assessment report, sections 1-6, was presented and discussed (Attachment 1). Additional archive liquid level data from 1965 to 1968 was also reviewed. The assessment team members determined that the liquid level changes shown appear to be accounted for. Although many liquid level changes occurred due to transfers and boiling waste temperatures, only one occurrence report was issued for liquid level decreases in tank AX-104. OR-77-19, showed a decrease of over 1 inch in 72 hours. The decrease was attributed to a filter installed on January 26, 1977 in a six inch riser to improve air cooling in the tank. It was noted that liquid levels were over

300 inches on the scans. An action was taken to present the depth of the tank footing, height of the tank liner, and height of spare inlet or cascade ports to team participants, to assess whether the tank may have been overfilled. Similarly May 1981 and other tank photo's will be reviewed and presented in the next meeting to investigate "surface irregularities" and a possible buckling pattern in the tank bottom, indicated in the AX-104 interim stabilization evaluation (HNF-SD-RE-TI-178).

Next, drywell data and was reviewed and the location of drywells with respect to the vapor header and leaks from dresser couplings along the vapor header. Several occurrence reports were issued related to gamma activity in drywells surrounding tank AX-104, including OR 75-47, OR 76-08, OR 76-59, and OR 77-202. Gamma activity observed in drywells 11-04-11 and 11-04-01 was clearly attributed to vapor header leaks in the occurrence reports. The key question in OR 77-202 was the source of the gamma activity at ~65 ft bgs in drywell 11-04-08; tank AX-104 was designated an "assumed leaker" based on this occurrence report. Several actions were taken to further assess potential sources that could account for the low levels of gamma activity in drywell 11-04-08. The level of gamma activity in the drywell was well below expected levels from a tank leak and more like what would be expected from a condensate release. It was noted that like the gamma activity in drywells 11-04-11 and 11-04-01, the gamma activity in drywell 11-04-08 decayed at the rate of Ru-106, with a half-life of ~1 year. Ruthenium-106 is highly mobile in soils, therefore it is plausible for Ru-106 to have migrated from the dresser coupling leak to the opposite side of the tank near drywell 11-04-08. However, if the gamma activity migrated from the vapor header release on the opposite side of the tank, the Ru-106 plume at should have been detected at drywells 11-04-10 and/or 11-04-19; neither of these drywells detected subsurface gamma activity. Historical logs for drywell 11-04-10 are not included in Attachment 1 and will be presented for the next meeting. It was noted that Attachment A shows only shows logging results after 1980 for drywell 11-04-08. An action was taken to determine if earlier logging results are available.

Drawings will be reviewed and presented in the next meeting showing pipelines and encasements surrounding tank AX-104 to determine if any other potential sources are close to drywell 11-04-08. The proximity of the leak detection pit to the tank and drywells and the ventilation header and connections will also be discussed.

Next Meeting:
The next assessment team meeting is tentatively scheduled for June 12, 2014, 8:00 A.M., Room TBD.

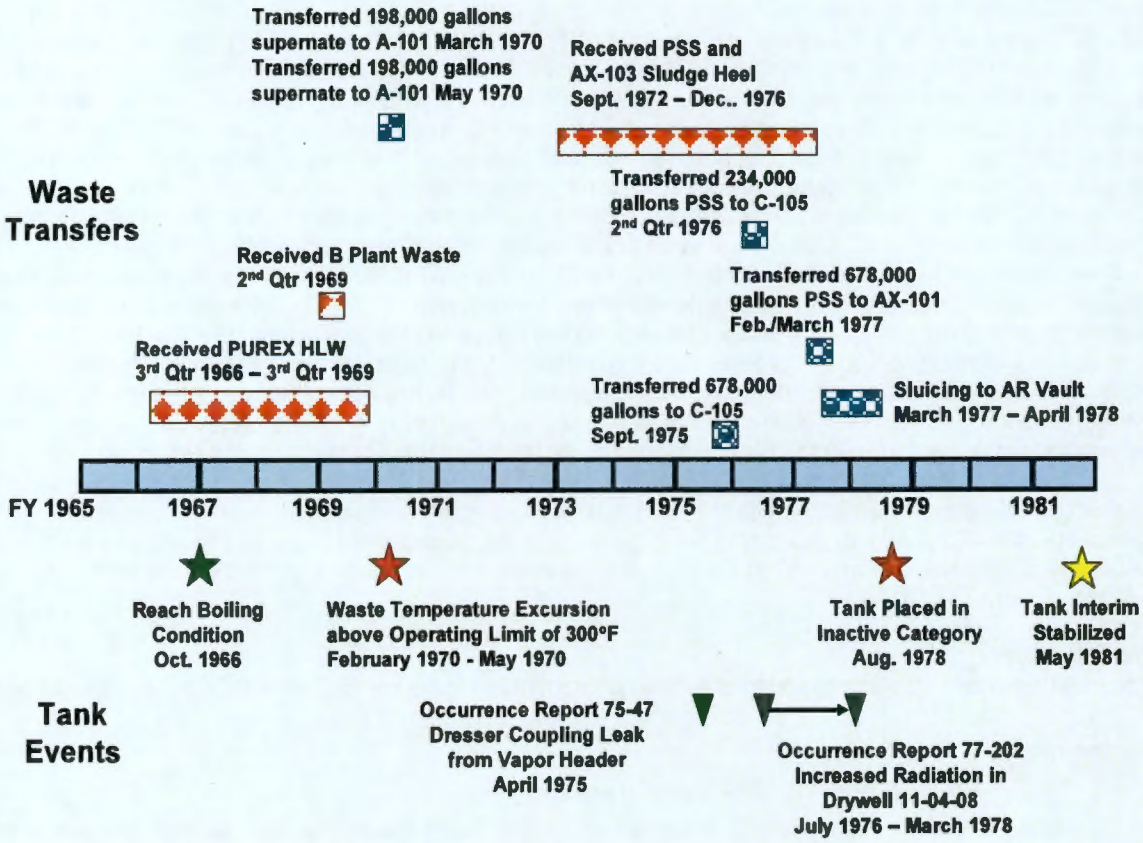
Actions:

1. JGF – Prepare June 12, 2014 meeting summary.
2. KJH – Provide description/drawings showing pipelines surrounding tank AX-104 and particular any pipelines or possible leak sources near drywell 11-04-08.
3. JGF – Provide May 1981 and other in-tank photographs for evaluation of tank buckling.
4. JGF – Provide tank drawings showing elevations of footing, spare inlets/cascade lines and tank liner.
5. JGF – Provide historical logs for drywell 11-04-10 and earlier logs for drywell 11-04-08.
6. CLG – Prepare complete liquid level drawing for the final report incorporating historical archive levels and levels shown in occurrence report.
7. All – Review AX-104 meeting minutes.

Attachment 1

Information Presented from Draft AX-104 Integrity Assessment Report

Tank AX-104 Operational Timeline (1965-1981)



Reference: RPP-ENV-37956, *Hanford A and AX-Farm Leak Inventory Assessments Report*

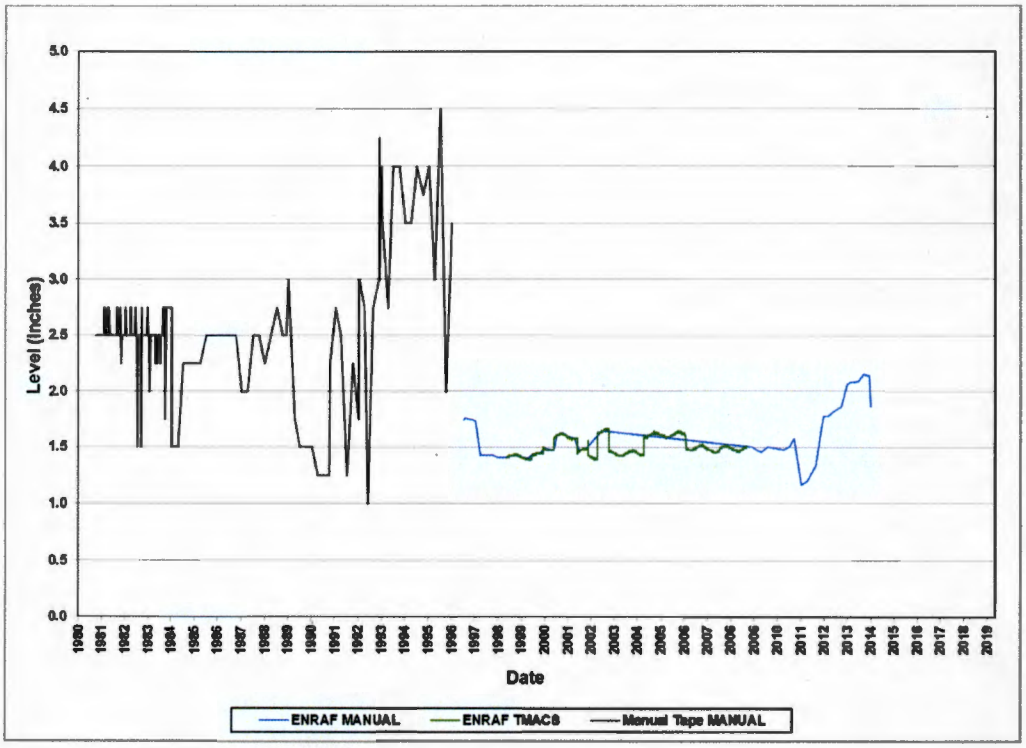
Tank 241-AX-104 Liquid Level Measurements and Changes (1973 to 1986)

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/18/73	37.50			0.00	Manual tape
07/16/73	36.75		-0.75	-0.75	Steady decrease
07/17/73	38.00			-0.75	Transfer
07/30/73	37.50		-0.50	-1.25	New tape installed
08/03/73	37.25		-0.25	-1.50	Steady decrease
11/09/73	42.00			-1.50	Transfer
12/03/73	38.00		-4.00	-5.50	Steady decrease
12/19/73	42.50		+4.50	-1.00	Steady increase
01/05/74	48.75			-1.00	Transfers
01/22/74	46.00		-2.75	-3.75	Steady decrease
02/01/74	50.00			-3.75	Transfers
07/08/74	40.00		-10.00	-13.75	Steady decrease
08/10/74	282.25			-13.75	Transfers
04/30/75	248.00			-13.75	Steady decrease evaporation
05/01/75	246.80			-13.75	FIC installed
03/10/76	185.15			-13.75	Steady decrease/ associated with evaporation
03/26/76	129.15			-13.75	Transfers
04/13/76	125.85			-13.75	Steady decrease/ evaporation
04/24/76	132.70			-13.75	Transfers
09/08/76	102.35			-13.75	Steady decrease/ evaporation
03/03/77	58.65			-13.75	Transfers
03/28/77	52.15			-13.75	Steady decrease/ evaporation
08/24/77	7.10			-13.75	Sluicing and transfers
09/23/77	3.15			-13.75	Steady decrease/ evaporation, now using manual tape
11/07/77	11.50			-13.75	Sluicing and transfers
12/04/77	10.00			-13.75	Steady decrease/ evaporation
12/05/77	10.50			-13.75	Water added-- circulators
01/23/78	9.00			-13.75	Steady decrease/ evaporation
02/02/78	11.70			-13.75	Now using FIC gage
02/28/78	10.90			-13.75	Slow decrease/ evaporation

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
04/26/78	5.60			-13.75	Sluicing and transfers
05/08/78	5.00		-0.60	-14.35	Steady decrease
05/11/78		1.70		-14.35	Transfers
05/24/78	1.20		-0.50	-14.85	Slow decrease
06/06/78		3.70		-14.85	Transfer and leaking valve
11/10/78	0.80			-14.85	Slow decrease/ evaporation
03/11/79	1.40		+0.60	-14.25	Erratic readings
03/16/79		2.50		-14.25	Leak in AX-B pit
07/29/79	1.00			-14.25	Slow decrease/ evaporation
07/30/79				-14.25	FIC o/s
07/31/79	2.00			-14.25	Manual tape installed
09/05/79		2.50	+0.50	-13.75	Slow increase
12/10/80	2.50			-13.75	Stable
12/12/81	2.50			-13.75	Stable
10/07/82	2.50			-13.75	Stable
12/12/82	1.50			-13.75	Readings fluctuate between 1.50 and 2.50 in.
11/07/83		2.25		-13.75	New MT installed
12/12/83	2.75		+0.50	-13.25	Stable
10/04/84	2.25		-0.50	-13.75	Stable
10/04/85	2.50		+0.50	-13.50	Stable
10/01/86	2.50			-13.50	Stable

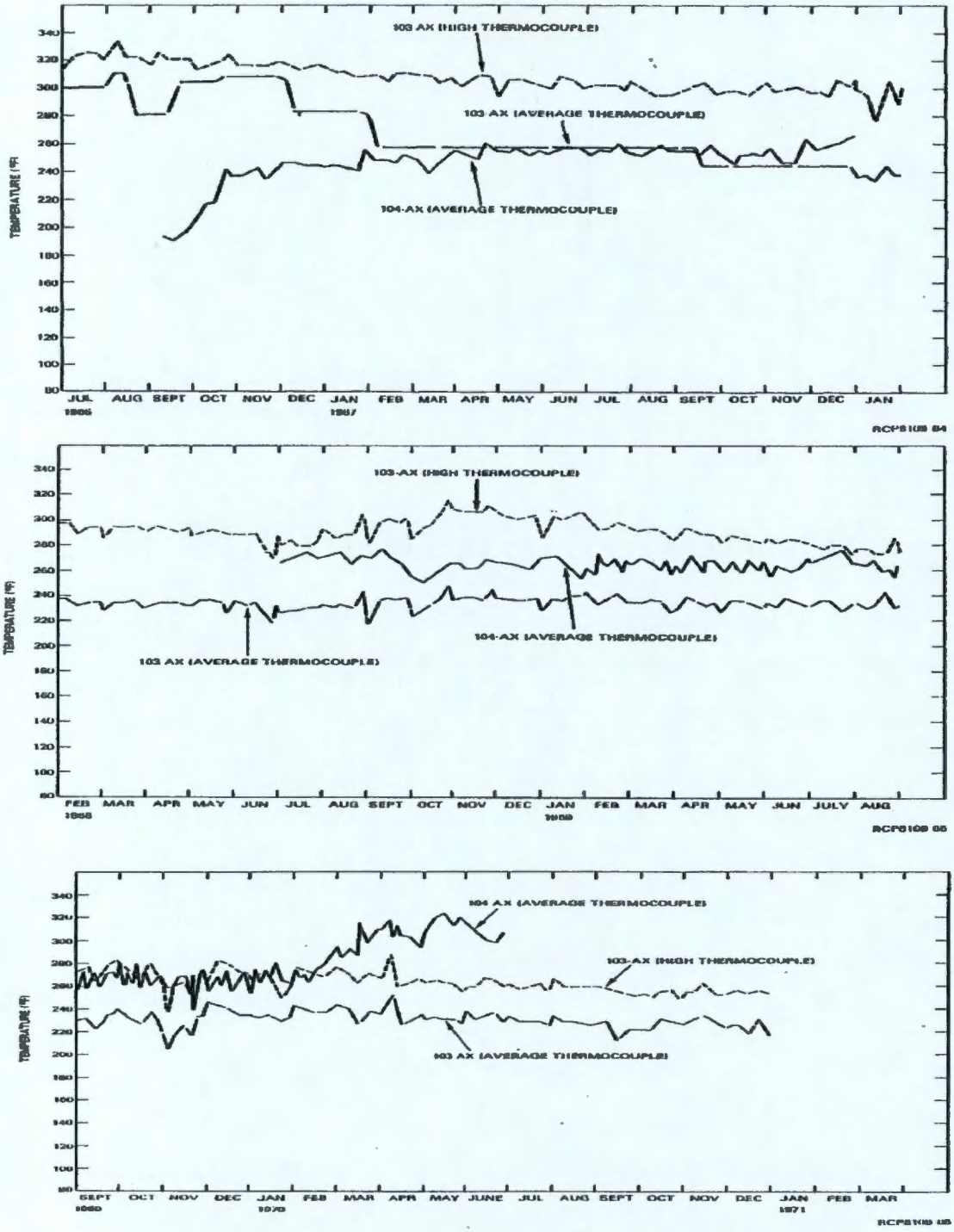
Reference: WHC-SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria.*

Tank 241-AX-104 Waste Surface Level Measurements



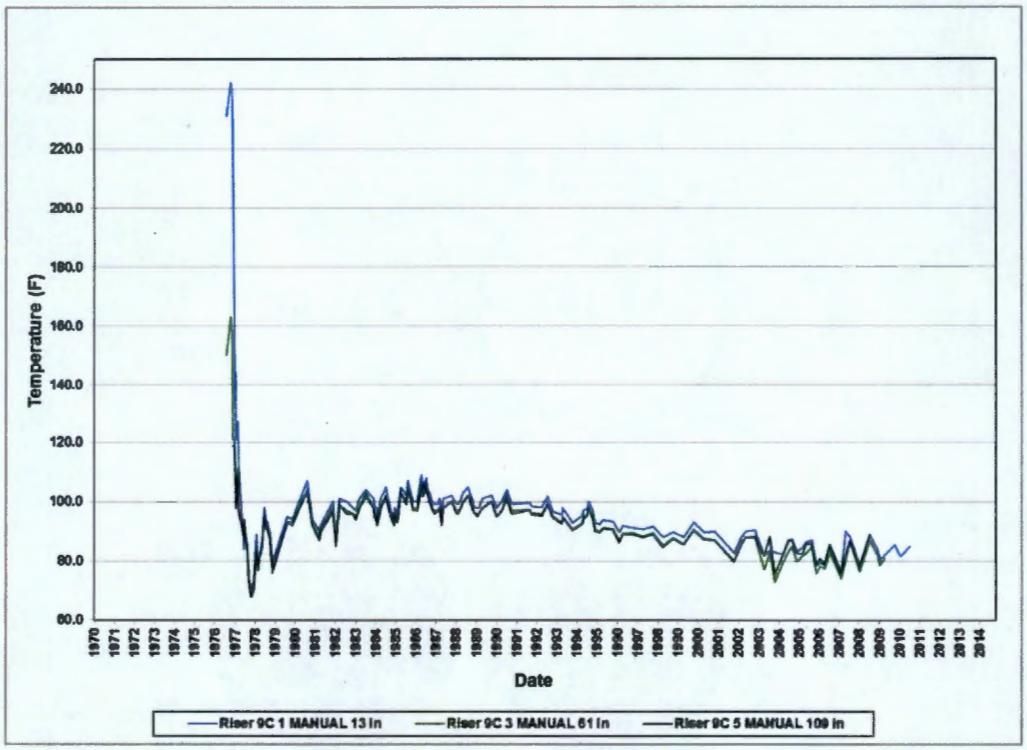
Reference: Surveillance Analysis Computer System, PCSACS

AX-104 Temperature, 1966-70



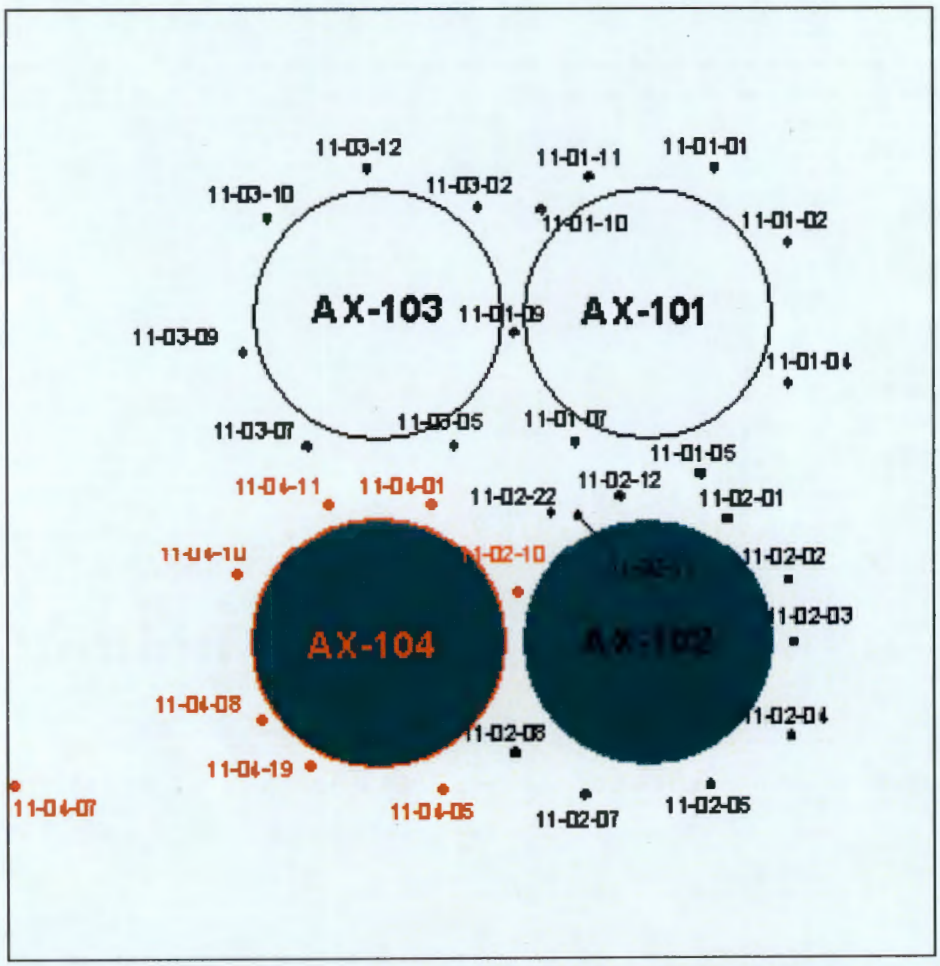
Reference: RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories*

AX-104 Temperature, 1976-2010



Reference: Surveillance Analysis Computer System, PCSACS

241-AX Tank Farm Drywells



Reference: GJ-HAN-52, *Vadose Zone Characterization Project and the Hanford Tank Farms, Tank Summary Data Report for Tank AX-104.*

Note: Blue shading shows tanks currently designated "assumed leakers"

Tank AX-104 Drywell Construction

Drywell	Initial Drilling	Depth – ft	Hanford Coordinates	
			North	West
11-04-01	12/31/1974	100	41672	47547
11-02-10	2/28/1975	100	41644	47519
11-04-05	2/28/1975	100	41583	47544
11-04-07	3/31/1975	96	41588	47586
11-04-19	3/31/1978	125	41591	47588
11-04-08	2/28/1975	100	41605	47604
11-04-10	3/31/1975	100	41650	47612
11-04-11	1/31/1975	125	41672	47581
Tank AX-104	N/A	N/A	41629	47565

Distance from Selected Tank AX-104 Drywells to Tank Features

From	To	
Drywell	Tank Sidewall – ft	Tank Footing Edge – ft
11-04-01	7.07	3.07
11-02-10	8.84	4.86
11-04-05	11.03	7.03
11-04-07	6.52	2.53
11-04-19	4.88	0.88
11-04-08	6.25	2.25
11-04-10	11.94	7.94
11-04-11	6.36	2.34

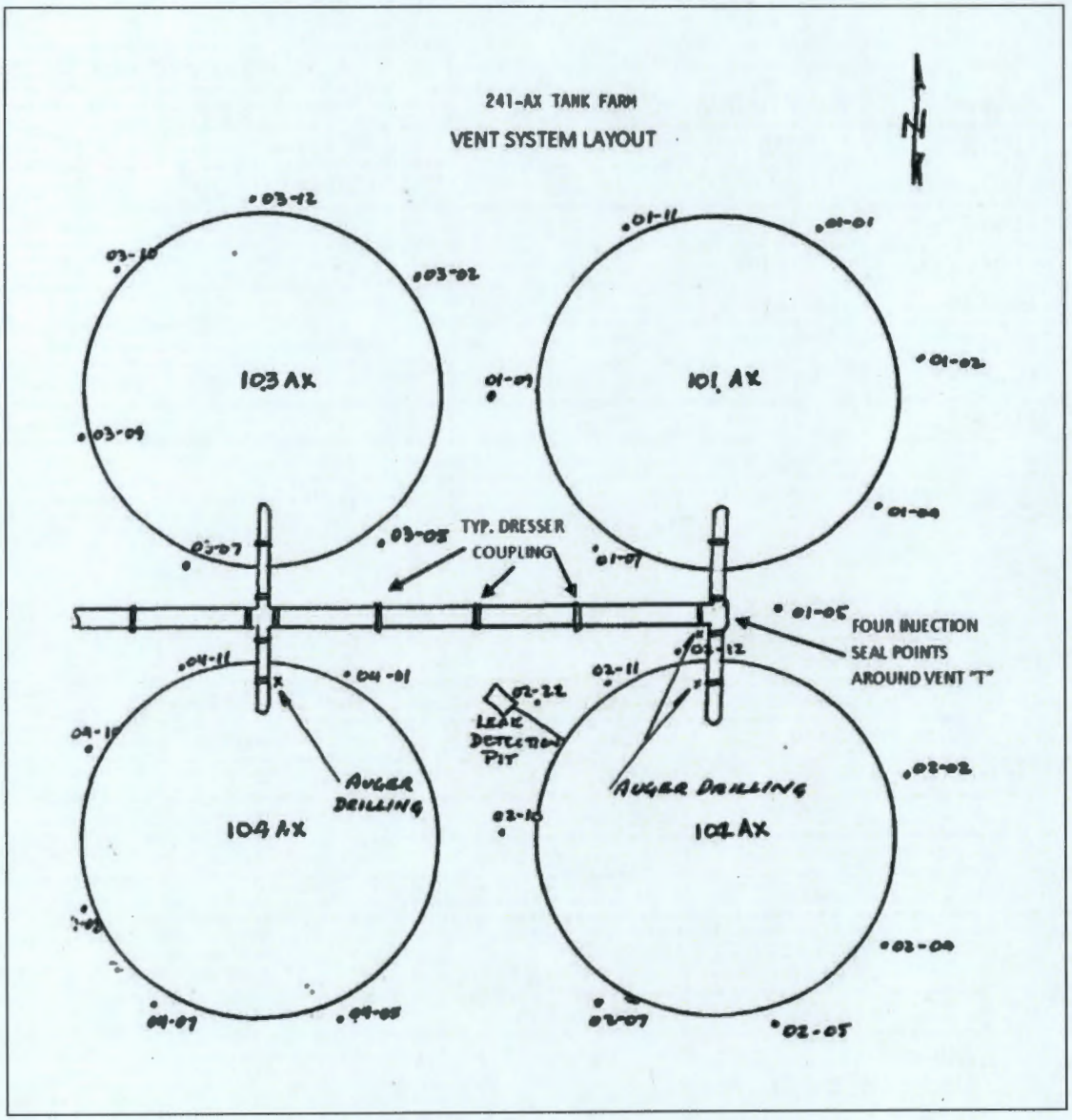
References:

Mactec – ers Log Data Reports

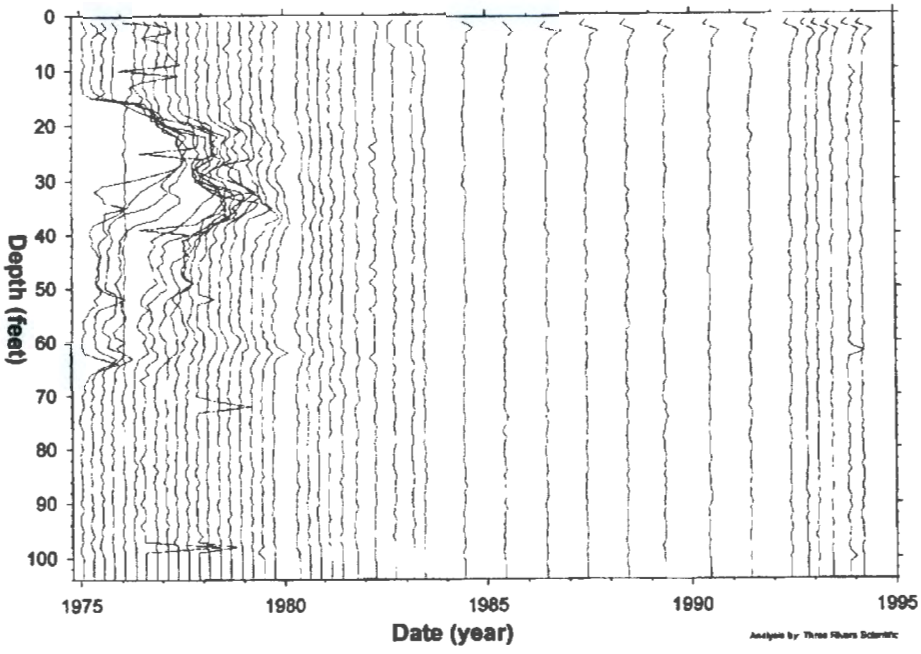
H-2-44562, *Structural Waste Storage tanks Composite Section & Details*

H-2-36935, *Wells in 241-AX Farm As Built*

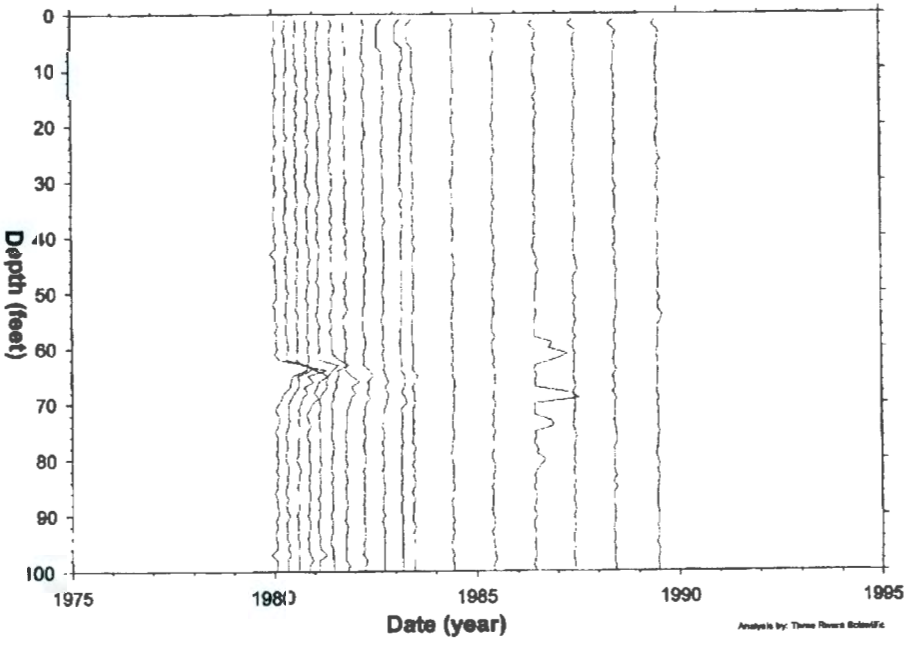
241-AX Tank Farm Ventilation System Plan



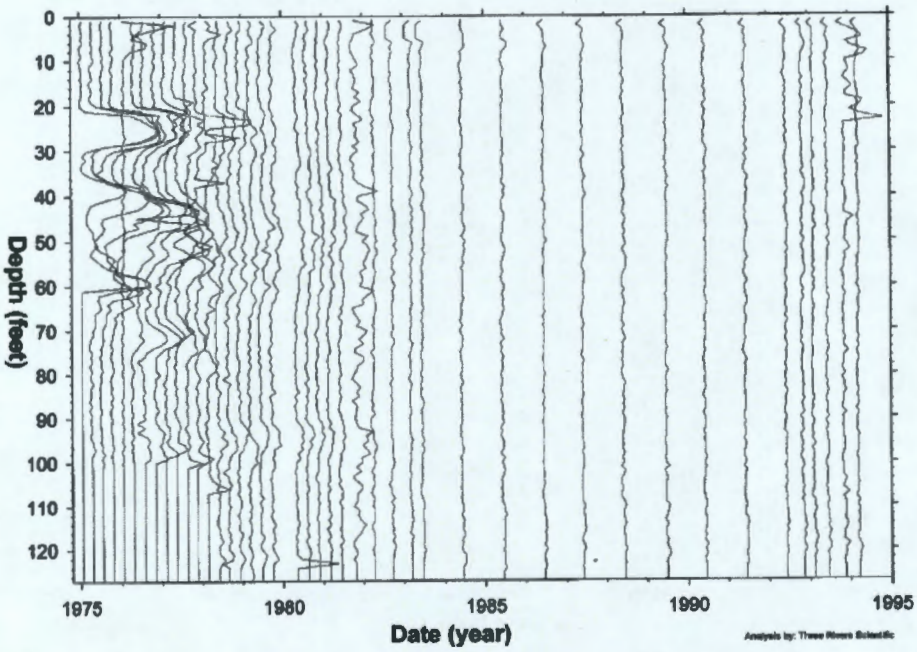
Drywell 11-04-01 Historical Gross Gamma Logs



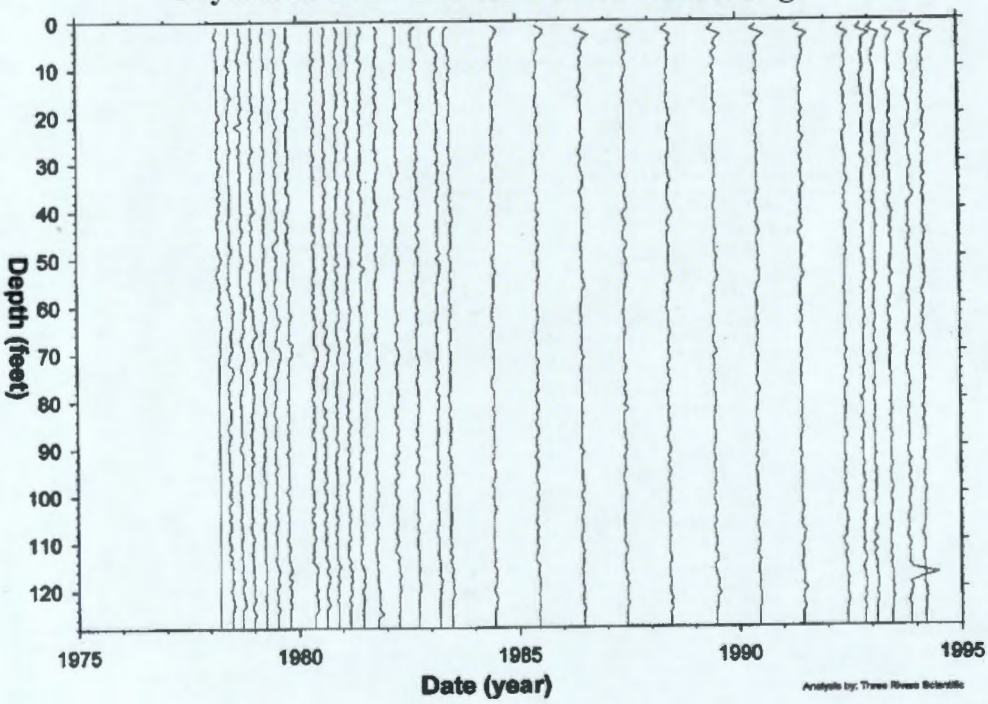
Drywell 11-04-08 Historical Gross Gamma Logs



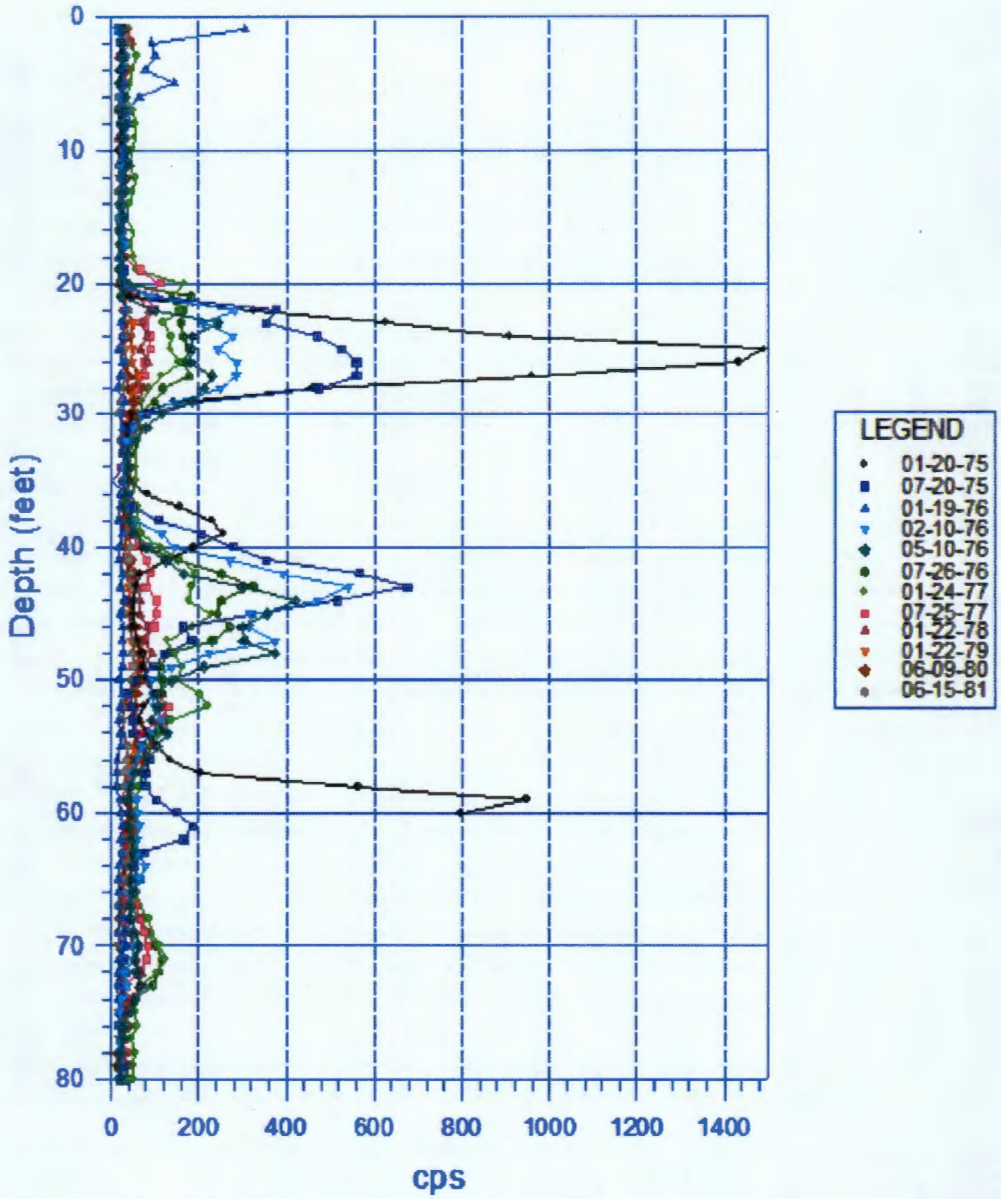
Drywell 11-04-11 Historical Gross Gamma Logs



Drywell 11-04-19 Historical Gross Gamma Logs

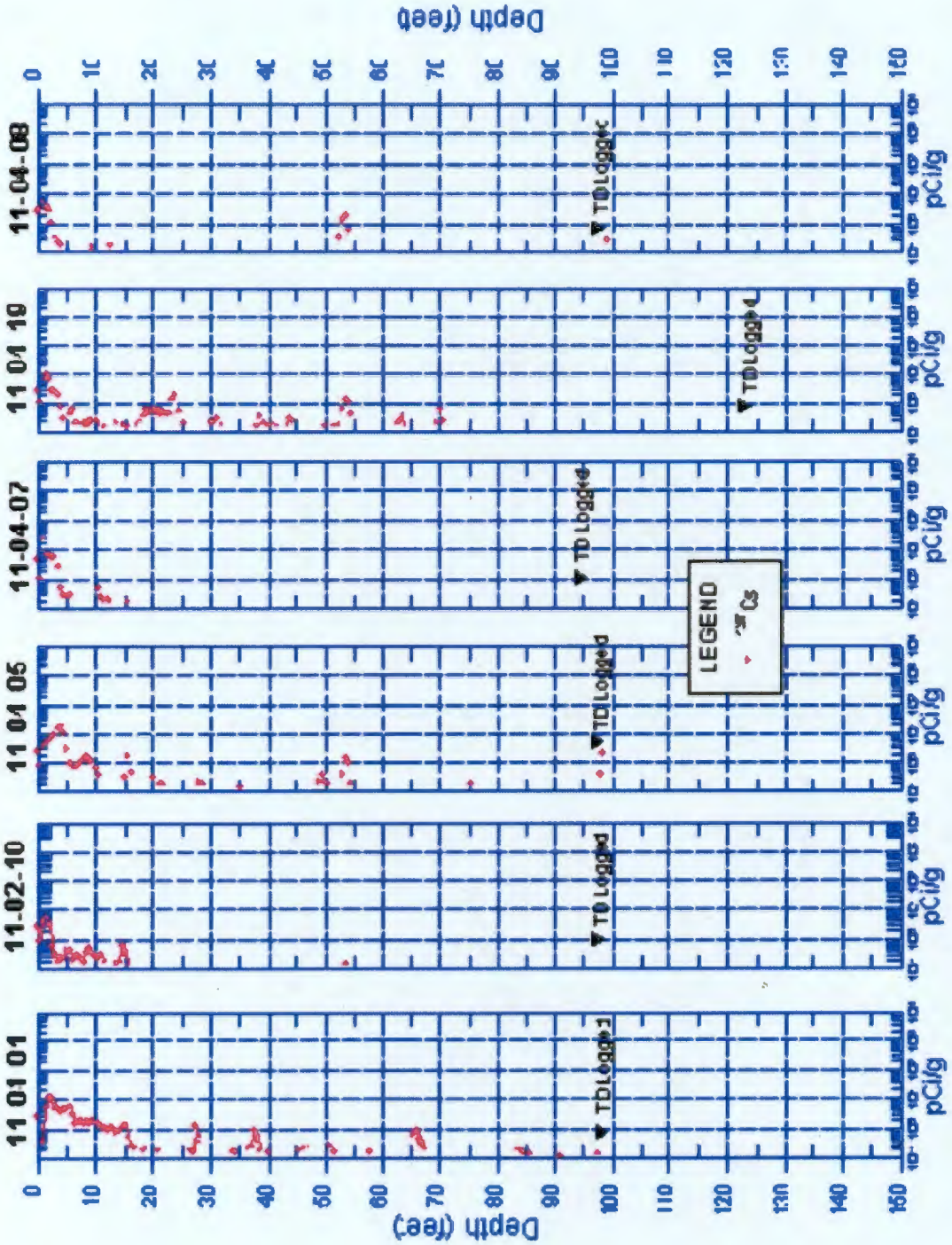


Tank 241-AX-104 Historical Gamma Logging Results for Drywell 11-04-11.

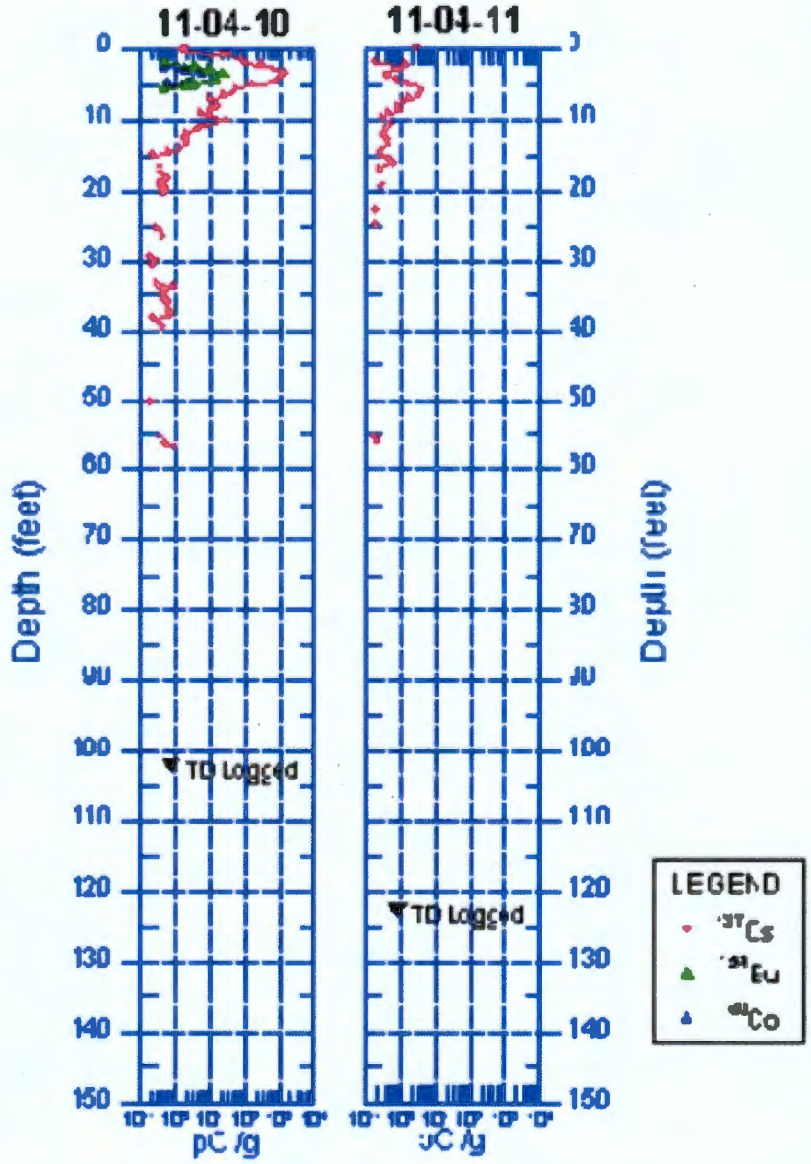


Reference: RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*

1996 Spectral Gamma Logging Results for Drywells near Tank 241-AX-104.



1996 Spectral Gamma Logging Results for Drywells near Tank 241-AX-104.



Reference: GJ-HAN-12, *Vadose Zone Characterization Project at The Hanford Tank Farms, AX Tank Farms Report.*

Note: Maximum value of log scales shown for 11-04-10 and 11-04-11 is 10,000 pCi/g.

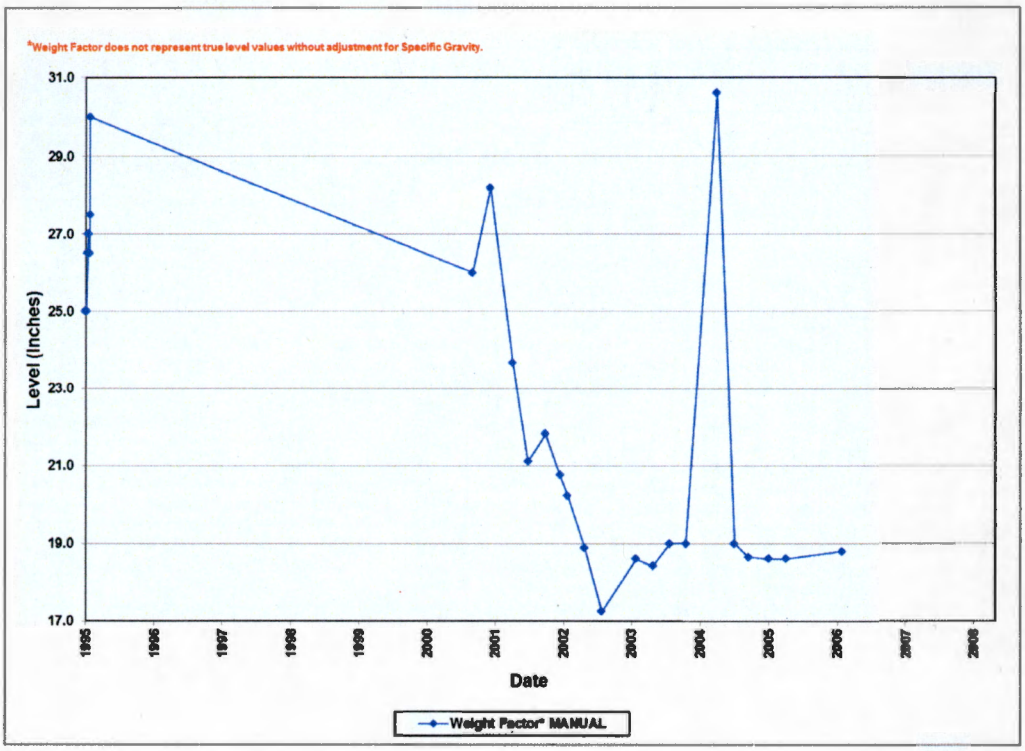
AX-104 Leak Detection Pit Liquid and Radiation Levels (1973-1986)

Date	Liquid level (in.)	Radiation level (c/min)
06/15/73	24	300
09/15/73	24	0
12/15/73	24	0
04/15/74	24	0
05/15/74	23	0
06/15/74	23	0
07/15/74	22.8	0
08/15/74	21.1	0
09/15/74	20.7	0
10/15/74	21.1	0
11/15/74	21.1	0
12/15/74	20.7	0
01/15/75	21.1	0
02/15/75	20.7	0
03/15/75	20.7	0
04/15/75	21.1	0
05/15/75	20.7	0
06/15/75	20.7	0
07/15/75	21.1	0
08/15/75	21.1	0
08/25/75	21.6	0
09/21/75	21.1	0
12/18/75	21.6	0
12/28/75	21.1	0
01/08/76	21.6	0
03/31/76	21.0	0
04/26/76	22.0	0
05/26/76	22.5	0
06/26/76	21.0	0
09/15/76	21.5	0
10/29/76	16.0	0
11/03/76	16.0	0
12/05/76	15.0	0

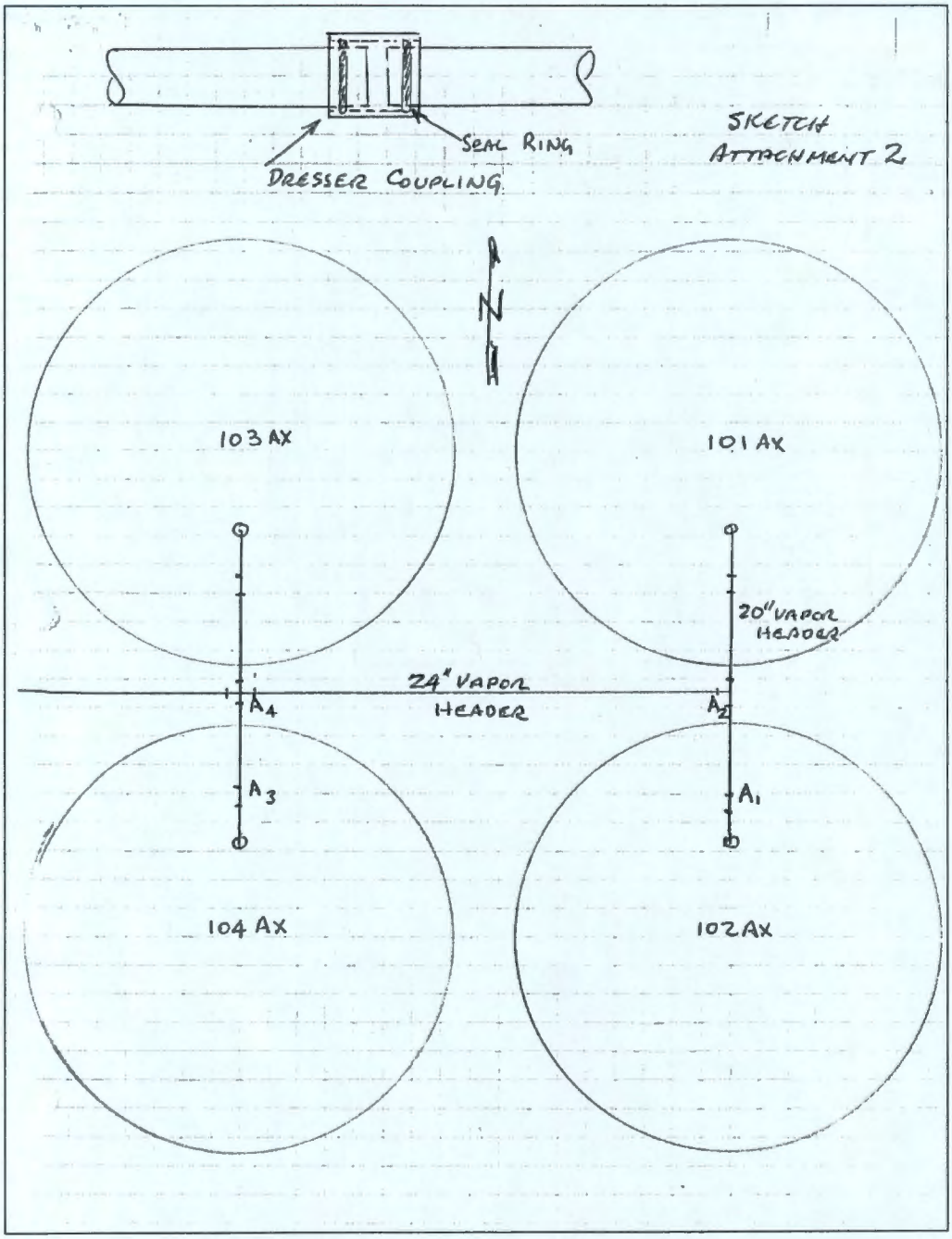
Date	Liquid level		Radiation level (c/min)	Comments
	Gage	Weight factor (in.)		
12/27/76		14.0	0	LL slow decrease
12/28/76	4.8	0.0	<40	Radiation pen jumping
12/29/76	4.9	0.0	1	
12/30/76	5.0	21.0	1 to 4	Radiation pen erratic
12/30/76	5.0	21.0	<30	Radiation pen erratic
01/05/77		16.5	8 to 20	LL decrease
01/06/77	4.9	0.0	8	
01/07/77	4.9	20.0	10	
07/09/77	4.5	17.0	1 to 25	LL very slow decrease
10/26/77	0.0	0.0	0 to 30	LL steady decrease
03/02/78	0.0	0.0	2 to 60	LL stable at 0 in., radiation erratic
03/03/78	0.0	0.0	580	Radiation increase
03/29/78	0.0	0.0	500	Stable
03/30/78	0.0	0.0	800	Radiation increase
12/20/78	0.0	0.0	850	Radiation varies 600 to 1,000 c/min
08/21/79	1.0	6.5	100	Water added
12/31/79	1.0	2.0	107	Stable
12/11/80	0.8	1.5	200	LL slow decrease
01/25/81	0.0	0.0	400	LL steady decrease, radiation increase
01/27/81	1.5	6.5	80	Water added
02/25/81	1.0	3.0	150	LL steady decrease, radiation increase
02/26/81	2.5	10.5	100	Water added
05/13/81	0.5	0.0	3	LL steady decrease, radiation increase
05/14/81	2.2	9.0	120	Water added
09/23/81	0.0	0.0	300	LL steady decrease, radiation increase
09/24/81	2.5	10.0	200	Water added
01/13/82	1.0	1.0	100	LL steady decrease, radiation stable
01/14/82	3.0	12.5	90	Water added
04/18/82	3.0	8.5	100	LL stable, radiation stable
12/12/82	3.5	17.0	90	Readings vary from 0.3 to 3.8 in. due to evaporation, water additions, and rain. Radiation stable

Date	Liquid level		Radiation level (c/min)	Comments
	Gage	Weight factor (in.)		
03/25/83	9.5	30.0	140	Rain, radiation stable
03/29/83	0.5	0.0	120	Pumped
07/01/83	4.8	18.0	100	Added water
07/21/83	4.8	18.0	160	Stable
07/26/83	1.0	1.5	70	Bailed out
08/25/83	2.1	10.0	100	Added water
12/12/83	3.5	16.0	100	LL increase/radiation stable
02/04/84	2.0	3.2	100	Pumped
07/25/84	2.5	6.0	120	LL increase
07/26/84	0.0	0.0	100	Instrument calibration
10/20/84	1.0	3.0	80	Water added
11/14/84	1.2	4.0	95	LL slow increase
02/19/85	3.8	16.0	60	Ll slow increase
02/20/85	1.1	4.4	65	Pumped
08/19/85	2.0	8.0	55	LL erratic increase
10/24/85	0.5	3.0	50	LL erratic decrease
10/27/85	1.5	7.5	50	Water added
11/19/85	1.5	7.5	60	Stable
01/20/86	3.5	18.0	40	Water added
01/21/86	16.5	18.0	40	New dial gage
03/07/86	14.0	14.0	50	LL slow decrease
03/08/86	9.0	9.0	40	Pumped
05/19/86	14.0	15.0	50	LL slow increase
05/20/86	3.5	4.0	60	Pumped
06/22/86	0.0	0.0	100	LL slow decrease
07/08/86	7.0	8.0	40	Water added
08/20/86	3.0	3.0	60	LL slow decrease
08/21/86	9.3	9.0	30	Water added
11/08/86	0.0	0.0	175	LL slow steady decrease
11/13/86	8.5	9.0	150	Water added
12/13/86	2.2	2.5	60	LL slow steady decrease

AX-104 Leak Detection Pit Liquid Level (1996 to 2006)



Auger Sampling Locations



Reference: Occurrence Report 75-60, *Increasing Radiation in A Dry Well Adjacent to 102-AX*, Attachment II

Strawman Leak Hypothesis:

"The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104."

No-Leak Hypothesis:

"The change in radioactivity in dry well 11-04-08 resulted from the AX farm vent system configuration coupled with the failure of the vent system Dresser couplings."

A3. MEETING #3, JUNE 19, 2014

MEETING SUMMARY

SUBJECT: Tank AX-104 Integrity Assessment Meeting #3				
TO: Distribution	BUILDING: 2750E/A-229			
FROM: D. G. Baide	CHAIRMAN: J. G. Field			
DEPARTMENT-OPERATION-COMPONENT Engineering – Tank and Pipeline Integrity	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 06/19/2014	**NUMBER ATTENDING** 7

Distribution:
D. G. Baide[1]
J. G. Field[1]
C. L. Girardot[1]
D. G. Harlow[1]
K. J. Hull[1]
N. W. Kirch
J. G. Schofield[1]
D. W. Strasser[1]
D. J. Washenfelder

[1]Attendee and Team Member

Purpose:

The purpose of the meeting was to continue the tank AX-104 integrity assessment. Specifically to go over action items, to further discuss action items from the previous meeting, to identify potential sources for the low levels of gamma activity in drywell 11-04-08 and to develop leak and non-leak hypotheses.

AX-104 Discussion

The June 12, 2014 meeting summary was reviewed and discussed. The meeting summary was approved with minor edits. Actions identified in the June 12 meeting and additional information found for tank AX-104 were then discussed.

Tank drawings were presented showing the elevation of tank AX-104 footings, spare fill lines, top of liner and elevation at the excavation level beneath the tank. Drawings show that the bottom footing of the tank is 53.25 ft below ground level; the excavation elevation is 626 ft, ~55 ft below ground level (ARH-LD-128). The top of the liner is 32.5 ft (390) in above the base of the tank and the spare fill line is 2 ft below the top of the liner (366 in) above tank bottom. This is well above the maximum reported depth of the waste (300 in.), therefore it appears that the waste level did not overflow the spare fill lines or top of liner. There are no cascade lines between the AX Farm tanks.

Tank AX-104 photographs were then reviewed. The 1981 photos appeared to show a slight ridge along a few weld seems in the tank, that may have been referred to as surface irregularities, but there was no indication of uplift or tank buckling in the 1981 photos or other photos that were examined.

Historical logs for drywell 11-04-08 were available in the Welty report (HNF-SD-M-TI-356) starting in 1975. Peak total gamma readings were <50 counts/sec from 3/1975 to 1/1976. The gamma levels began to increase in August 1976. OR 77-202 was issued in Nov. 1977 when the gamma level exceeded 200 counts/sec at 64 ft bgs. A maximum peak reading of 348 c/s was observed in June 1978 after which the gamma activity began to decay to <50 c/s by December 1982. The rapid decay of gamma activity in the drywell indicated that the gamma was Ru-106. Additional logging data was also presented and discussed for drywell 11-04-10. No gamma activity was observed below the tank bottom level, however peak gamma activity was measured at about 5 ft bgs in 1975. The gamma activity appears to have increased in the early 1980s and then remained relatively constant through 1995. In 1996 near surface plumes of Cs-137 and Eu-154 were measured using the spectral gamma logging system. The presence of Eu-154, the sharp peak and low levels (<100 pCi/g) of Cs-137 indicate that the spectral gamma measured at drywell 11-04-10 may have been contained in a near surface transfer line nearby. However, the presence of <1 pCi/g of Cs-137 between 10 ft bgs and 40 ft bgs indicates that a transfer line may have leaked or other releases may have occurred.

Correspondence in 1978 from R. Routson and S. Stalos concluded that the gamma activity in drywell 11-04-08 was from a leak in tank AX-104, because a condensate header leak would have intersected other drywells also (contained in HNF-4872, Rev. A, Volume II).

The locations of pipelines and other potential leak sources around the tank were discussed. In addition to transfer lines running between tanks AX-103 and AX-104, parallel to the vapor header line, the transfer line also runs along the North side of tank AX-104. Two valve boxes are located near the South West corner of the tank, near drywell 11-04-08. Another condensate line runs North and South about 50 ft to the west of tank AX-104. Participants believed that the low Ru-106 activity was likely appeared to be an indication of a condensate, but questioned whether a release from 50 ft away would reach drywell 11-04-08.

The following Leak and Non-leak hypotheses will be considered for the elicitation process to estimate the probability that the tank leaked.

Leak Hypothesis:

"The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104."

No-Leak Hypothesis:

"The change in radioactivity in dry well 11-04-08 resulted from a source or sources other than a tank leak and may include the AX farm ventilation system, transfer line leaks, operations releases and/or other sources."

Pipeline drawings will be further reviewed in the next meeting and the elicitation process will be started.

Next Meeting:

The next assessment team meeting is scheduled for June 26, 2014, 8:00 A.M., Room A229.

Actions:

1. JGF – Prepare June 19, 2014 meeting summary and elicitation forms.
2. KJH – Provide description/drawings showing pipelines surrounding tank AX-104 and particular any pipelines or possible leak sources near drywell 11-04-08.
3. All – Review AX-104 meeting minutes.

A4. MEETING #4, JUNE 26, 2014

MEETING SUMMARY

SUBJECT: Tank AX-104 Integrity Assessment Meeting #4				
TO: Distribution	BUILDING: 2750E/A-229			
FROM: D. G. Baide	CHAIRMAN: J. G. Field			
DEPARTMENT-OPERATION-COMPONENT Engineering – Tank and Pipeline Integrity	**AREA** 200-E	**SHIFT**	**DATE OF MEETING** 06/26/2014	**NUMBER ATTENDING** 7

Distribution:
D. G. Baide[1]
J. G. Field[1]
C. L. Girardot
D. G. Harlow[1]
K. J. Hull[1]
N. W. Kirch[1,2]
J. G. Schofield
D. W. Strasser[1]
D. J. Washenfelder[1,2]

[1] Attendee
[2]Not a voting participant

Purpose:
The purpose of the meeting was to continue the tank AX-104 integrity assessment. Specifically to review additional pipe and transfer line drawings, to discuss thoughts and impressions from each participant, based on the information reviewed, and to walk through the elicitation process to quantify probability estimates for each participant.

Review of Previous Meeting:
The June 19, 2014 meeting summary was reviewed and discussed. The meeting summary was approved with minor edits. It was suggested that sometimes it is difficult to distinguish between gross gamma data and spectral data and it is important to clearly differentiate between the two in the integrity assessment report.

It was noted that previous errors in the distance between tank AX-104, drywalls surrounding the tank and the AX-104 leak detection pit were corrected. The appropriate coordinates for drywell 11-04-07 will be included in the AX-104 integrity assessment report. The position away from the tank appears to be correct (see email attached). Neither historical total gamma nor spectral gamma subsurface radioactivity was measured in drywell 11-04-07.

AX-104 Pipe and Transfer Line Drawings:

The following tank drawings showing transfer lines, condensate lines, valve pits, and flush pits near tank AX-104 were reviewed:

- H-2-44590, Structural Encasement – Tank farm Area Footing Plan & Elevations, PUREX 241AX Tank Farm.
- H-2-44588, Structural Encasement 241-AX-151 to 241-AX-152 Elevations and Sections.
- H-2-69241, Piping Plan 241-AX Tank Farm.

The drawings show support beams along the ventilation headers extending to the base of the AX Farm tanks. It was noted that soils may be more loosely compacted around the support beams creating a preferential flow pathway. The excavation slopes from the west side toward tank AX-104 and the ventilation header running between tanks AX-103 and AX-104 and between tanks AX-101 and AX-102 also has a gradual slope from West to East.

It was noted that valve pits in the drawings were constructed before 1975 and may be a source of spills, however, like a tank leak, a waste leak from a valve pit or valve flush pit would be expected to show higher gamma activity and additional radionuclides present as compared to the low levels of Ru-106 that were measured in drywell 11-04-08.

In addition to the ventilation header lines between the AX farm tanks and about 50 ft to the West of Tank AX-104, Drawing H-2-69241 shows a condensate drain line from tank AY-102 that runs beneath the 241-AX-A valve pit and close to the 11-04-08 drywell (See Figure 1). The conclusion in OR 77-202 that tank AX-104 may have leaked was based on the determination that it is highly improbable that waste could have flowed from the ventilation header running between the tanks to drywell 11-04-08 and not have been seen in drywell 11-04-10 or 11-04-19. However, OR 77-202 and related correspondence do not mention potential runoff from side slopes, valve and flush pit releases or the condensate drain line from tank AY-102 as other potential sources. Tank integrity assessment team members concluded that these appeared to viable sources for the gamma activity observed at drywell 11-04-08.

In discussing tank AX-104 drawings, it was noted that there was no mastic between the steel liner and concrete for the AX farm tanks as for other SSTs. Consequently, if the liner leaked, waste should move more readily to the bottom of the tank and to the leak detection pit.

Round the Table Observations:

Each of the participants shared observations and thoughts regarding the information presented and discussed during the 4 AX-104 integrity assessment meetings. All of the participants indicated that the data did not appear to support a tank leak. The following general observations were made: Liquid level decreases reported in OR 77-19 have been explained and did not appear to be a concern in the past; the LDP liquid level continually decreased and should increase for a tank leak; radioactivity at drywell 11-04-08 likely didn't originate from the ventilation header dresser coupling leaks between the tanks and it appears to be too low to be from a tank leak, but appears to be consistent with a condensate leak; if the tank leaked, other radionuclides such as Cs-137 or Co-60 would be expected in spectral gamma scans; a leak from ventilation lines near drywell 11-04-08, flush pit leaks or surface runoff and migration are viable sources for the Ru-106 in drywell 11-04-08

Elicitation:

Dennis Washenfelder then walked through the elicitation process and probability scores were assigned by each team participant present. Scores from participants not present will be obtained independent of the meeting. Individual elicitation scores and bases will be included in the AX-104 integrity assessment report.

Next Meeting:

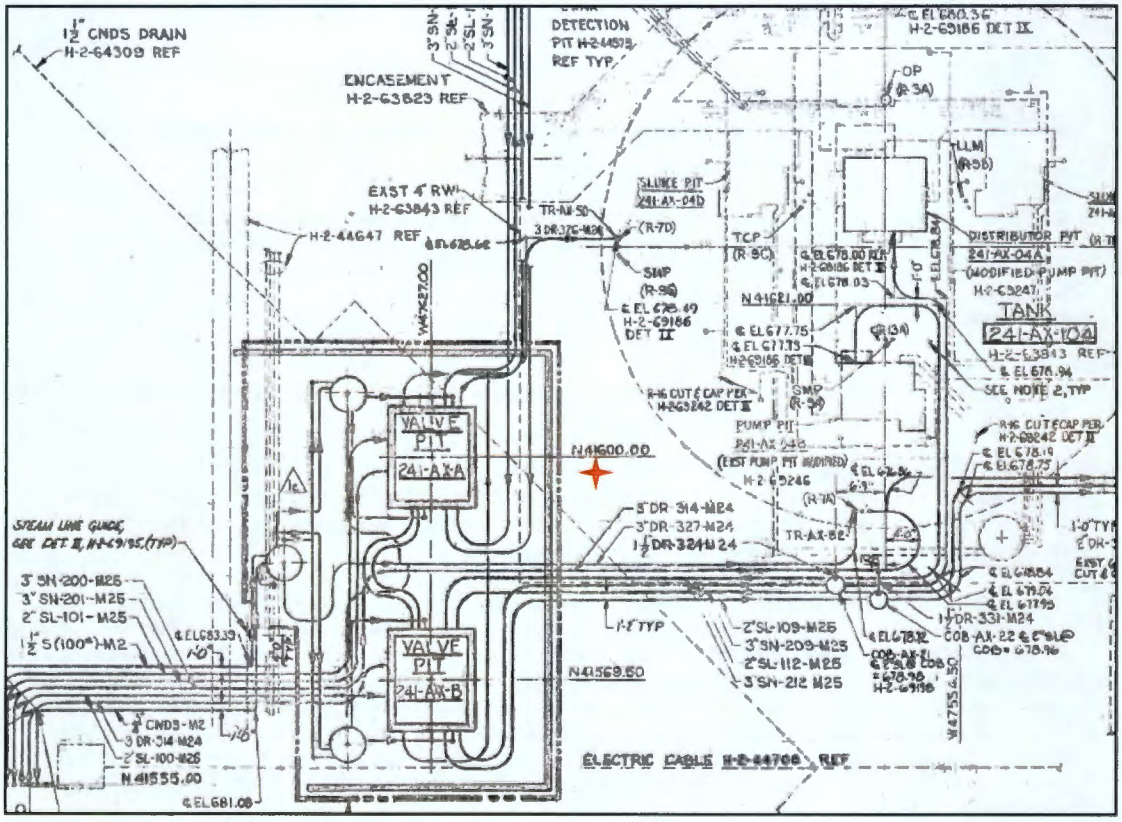
This meeting concludes the AX-104 assessments. Elicitation scores and inputs will be obtained independently from participants who were not able to attend this meeting. The meeting summary and elicitation results will be included in the AX-104 integrity assessment report. The report will be distributed for review the week of July 7.

Actions:

1. JGF – Prepare and distribute June 26, 2014 meeting summary for review.
2. JGF – Verify correct coordinates for drywell 11-04-07.
3. All – Provide elicitation scores (if not yet completed) and basis for assigned scores. Scores provided during Meeting #4 may be adjusted if desired.
4. All – Review AX-104 Meeting #4 summary.

JGF – Prepare draft AX-104 integrity assessment report and distribute for review.

Figure 1. Piping Near Drywell 11-04-08 in AX Tank Farm (From H-2-69241)



Drywell 11-04-08

Attachment: Email Regarding Location of Drywell 11-04-07.

Field, Jim G

From:	Paul Henwood <phenwood@stoller.com>
Sent:	Wednesday, March 12, 2014 6:03 PM
To:	Field, Jim G; 'mba461@ecy.wa.gov'; Alzheimer, Jim (Washington Department of Ecology); Caggiano, Joseph; Johnson, Jeremy M; Fort, Leslie A; Mathey, Jared (Washington Department of Ecology); Hopkins, Andrea M
Subject:	AX Farm Leak Assessment
Attachments:	T241AX.pdf

I was asked by the leak assessment team to determine why borehole 11-04-07 was drilled at such a distance from tank AX-104. The Tank Summary Data Report stated the following:

Borehole 11-04-07 is located approximately 50 ft from the south-southwest side of tank AX-104 and was given the Hanford Site designation 299-E25-121. According to the driller's record, the borehole construction began in March 1975 to a depth of 96 ft and is assumed to have been completed with 6-in. casing. The driller's record does not indicate whether the borehole was perforated or grouted.

Hanford Wells (Chamness and Merz 1993) places the location of this borehole within 1 ft of borehole 11-04-19. As-built drawing H-2-36935 identifies borehole 11-04-07 in the same location as Hanford Wells, but the drawing does not show borehole 11-04-19. Waste Storage Tank Status and Leak Detection Criteria (Welty 1988), the PUREX Source Aggregate Area Management Study Report (DOE 1992), and field observations noted on the Log Data Sheet place the boreholes at the locations shown on Figure 2. An internal memorandum referred to borehole 11-04-19 being drilled to the southeast of borehole 11-04-08 (Stalos 1978). It is possible the boreholes were mislabeled sometime after 1978. Therefore, the locations shown on Figure 2 are presented as the most accurate. However, given the discussion above, the locations are suspect at best and should be used accordingly.

Borehole 11-04-19 is approximately 3 ft from the south-southwest side of tank AX-104. It was given the Hanford Site designation 299-E25-147. This borehole was drilled in March 1978 to a depth of 125 ft and was completed with 6-in. casing. According to the driller's record, the borehole was grouted but not perforated. An 8-in. starter casing was installed to a depth of 18 ft, but was removed after completion of the borehole. Sixty-three gal of grout was added between the 8-in. and 6-in. pipes, and 9 gal of grout was added to the bottom of the borehole.

My interpretation/speculation follows:

Borehole 11-04-07 (299-E25-121) was drilled in 1975 along with the other AX-104 boreholes except 11-04-19 which was drilled in 1978. I don't know why it would be so distant from the tank but a borehole is field verified to be located approximately 50 ft southwest from the tank. It may have been drilled for reasons other than close monitoring of tank AX-104 such as a coincident investigation of two valve pits (241-AX-A and 241-AX-B) and a diversion box (241-AY-152) in the near vicinity (see attached). I suspect it was intended to be drilled much deeper (e.g., 150 ft) but hit an obstruction at 96 ft and the drilling was terminated. In any event, it appears it was given a tank farm number designating it in the 7 o'clock position.

Borehole 11-04-19 (299-E25-147) appears to be located correctly. It was probably drilled in 1978 due to a concern of a possible tank leak as contamination had shown up in 11-04-08. Contemporaneous maps and narratives in 1979 indicate the location very near to the southwest location from tank AX-104, "southeast of 11-

1

04-08." I believe it was convention to name the location from military time (1900, thus 11-04-19) because the 07 clock position was already occupied.

Therefore, I believe the approximate locations and sequence of events support the map below. However, the Hanford coordinates used for borehole 11-04-07 in the map below were adjusted from the Hanford wells database on the basis of field tape measurement from 11-04-19; Hanford Wells coordinates North 41,588, West 47,586 were changed to North 41,585, West 47,686. To be completely accurate, another survey should be performed and the Hanford Well Information System (HWIS) updated, if necessary.

Also noted are five shallow boreholes (less than 20 ft) that were drilled around the 241-AX-152DS Diversion Box, 241-AX-152CT Catch Tank, and 241-AX-A Valve Pit (see attached). Information from these boreholes could be included in our Leak Assessment Report, if available. Otherwise, they could be included in the AX SGLS re-baseline.

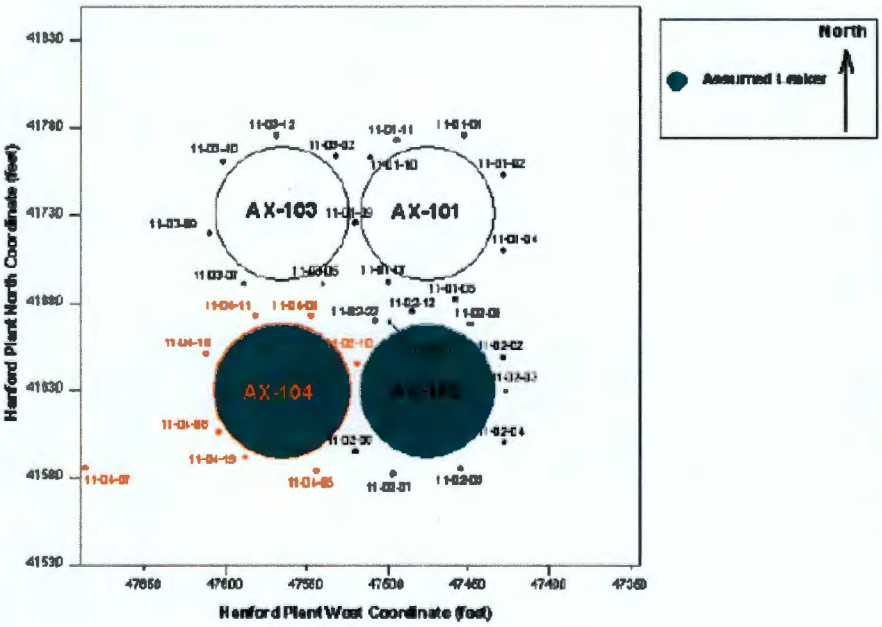


Figure 2. Plan View of Tanks and Boreholes in the AX Tank Farm

Antivirus, version of virus signature database 9534 (20140312) _____

The message was checked by ESET NOD32 Antivirus.

http://www.eset.com

_____ Information from ESET NOD32 Antivirus, version of virus signature database 9534 (20140312)

_____ Information from ESET NOD32 Antivirus, version of virus signature database 9530 (20140311)

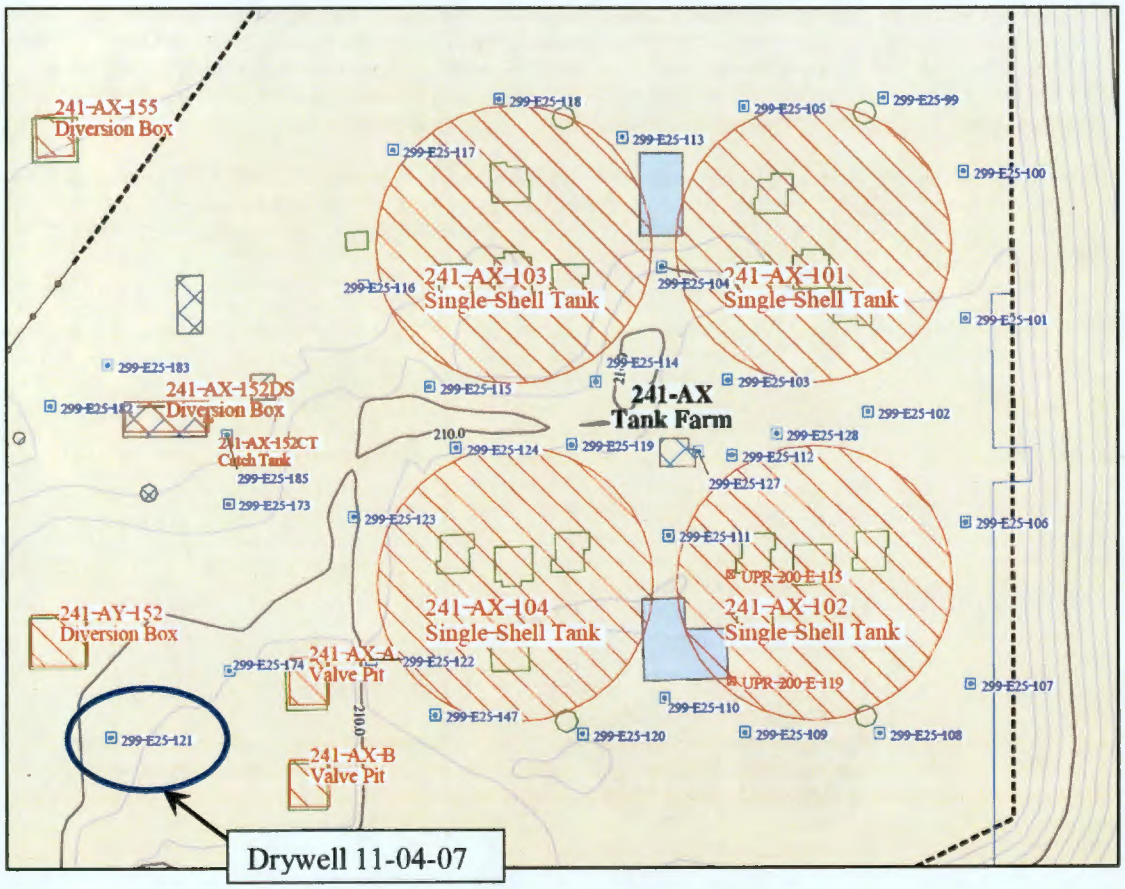
_____

The message was checked by ESET NOD32 Antivirus.

http://www.eset.com

_____ Information from ESET NOD32

Figure from email attachment (p 72 of Hanford Site Atlas).
Snapshot showing correct location of Drywell 11-04-07 (299-E25-121)



A5. EXECUTIVE SAFETY REVIEW BOARD MEETING, AUGUST 25, 2014

EXECUTIVE SAFETY REVIEW BOARD
Meeting Minutes

Meeting No: 2014-25
Date: August 25, 2014
Time: 1:00 p.m. – 2:00 p.m.
Location: 2425 Stevens / CR 208
ESRB email: ^ESRB

ESRB Members and Delegates (*in attendance):	
* ESRB Chair / Project Manager – Dave Olson	Internal Audit Manager – Rick Kofmehl
* ESRB Vice Chair / Chief Operating Officer - Wyatt Clark	* One System IPT Manager – Bill Condon
* ESRB Sponsor / ESH&Q Manager – Robert Wilkinson (Delegate: Steve Metzger)	* Organizational Performance Improvement Manager – John McDonald
* Business Operations Manager – Brian Thomas (Delegate: Janyce Shelt)	* Production Operations Manager – Kent Smith
* Chief Engineer – David Little (Delegate: Walt Isom)	* Project Integration Manager – Amy Basche
* Chief of Staff – Ray Skwarek	* Quality Assurance Manager – Will Eaton
* Contractor Assurance Manager / ESRB Facilitator – Mike Peloquin	* SST Retrieval & Closure Manager – Doug Greenwell
* Deputy Project Manager – Chris Burroughs	* Tank Farm Projects Manager – Rob Gregory
* General Counsel – Gloria Johnson (Delegate: Steve Cherry)	
ESRB Support: Betsy Blank	
Guests/Support Staff in Attendance:	
William Duffy	Jim Keene
Diane Cato	Darren Merrill
Rosalyn Page	Lonnie Flowers
Grant Ryan	Keely Hurley
Jessica Joyner	Ashley Kunz
Jim Field	Pamela Bailey (ORP)
Rod Holland	Brandon Williamson (ORP)
Presentations: • AX-104 Integrity Assessment Briefing • WIPP JONs Review Against Tank Farm Processes • ESRB Action Review	

The Executive Safety Review Board (ESRB) met on August 25, 2014. The above attendee list identifies ESRB voting members, delegates, support staff, presenters, and guests in attendance.

The meeting began with a safety topic regarding a PNNL lessons learned involving an accident between a cyclist and a truck, resulting in a broken hand and 56 stitches in his leg. Drivers are responsible to treat bicycles as legal vehicles-and equal users of the road-and to be alert to their whereabouts. Cyclists must recognize the unique risks-and vulnerability-they face compared to drivers. Driving safety is also especially important this time of year with school starting. Be alert to the location of children and be ready to react to quick movements or unexpected situations.

8/27/14

Actions from ESRB Meeting:

- Complete *Assessment of Hazard Analyses Supporting Tank Operations Contractor Hazard Category 2 and 3 Facilities* (FY2014-ENG-S-0393). Determine applicability of JON 3 from the WIPP radiological release event in relation to tank farm processes, and identify opportunities for correction or improvement. Submit PERs based on results of the assessment.
  - Assigned to: Diane Cato
  - Due date: 9/30/14
- Using results of the *Assessment of Hazard Analyses Supporting Tank Operations Contractor Hazard Category 2 and 3 Facilities* (FY2014-ENG-S-0393), determine applicability of JONs 5 and 6 from the WIPP radiological release event in relation to tank farm processes, and identify opportunities for correction or improvement. Submit PERs based on results of the assessment.
  - Assigned to: Diane Cato
  - Due date: 10/30/14
- Assist ORP in achieving the goal of clearly specifying the use of performance reporting results to encourage conservative reporting and communicate lessons learned. Recommended action is to work with ORP to remove these types of criteria and incentivize reporting of these types of issues. Refer to JON 26 for details.
  - Assigned to Mike Peloquin
  - Due date: 10/30/14
- Evaluate the criteria used to determine prioritization of maintenance and repairs to maintain a high state of operational readiness. Determine if criteria are consistent throughout TOC (TFP, RET/CLO, Production OPS, LABS). Refer to JON 29 for details.
  - Assigned to Keely Hurley
  - Due date: 10/30/14

AX-104 Integrity Assessment Briefing

Jim Field presented results of the integrity assessment for Tank 241-AX-104 and requested ESRB concurrence with the assessment recommendation that this tank be reclassified as "sound." Information presented to the ESRB included the WRPS leak assessment process, the basis for determining that AX-104 was an assumed leaker, and characteristics of this tank.

Conclusions/Recommendations:

- Low probability of tank leak (<4%)
  - Tank liquid level decreases accounted for by evaporation
  - Low radiation levels, and liquid level decreases in LDP are contrary to a tank leak
  - Low radiation levels in drywells
  - Other probable sources identified for radioactivity in drywells
- Recommendations:
  - Issue AX-104 Integrity Assessment Report (RPP-ASMT-57574)
  - Change tank AX-104 integrity status from "Assumed Leaker" to "Sound" following review with ORP and Ecology

ESRB Members concurred with the assessment recommendation that Tank 241-AX-104 be reclassified as "sound." Next steps for WRPS Engineering will be to brief ORP and Ecology, and update the Waste Tank Summary Report" (HNF-EP-0182).

WIPP JONs Review against Tank Farm Processes

Two major events occurred at the U.S. Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. On February 5, 2014, an underground mine fire involving a salt haul truck occurred, and less than a week later, there was a significant radiological release event, both occurring at the WIPP facility.

In response to these events, WRPS Subject Matter Experts (SMEs) evaluated the Judgments of Need (JONs) from the DOE Office of Environmental Management Accident Investigation Report against tank farm processes to determine applicability and identify potential opportunities for improvement. The purpose of this presentation was for the SMEs to brief ESRB Members on results of the evaluation on the radiological release event JONs. A second presentation is scheduled in September to review evaluations related to the salt haul truck event.

The areas evaluated related to the WIPP radiological release event were Nuclear Safety, Emergency Preparedness, Integrated Safety Management, Contractor Assurance, Conduct of Operations, Maintenance, Engineering, Radiological Controls, and staffing. Areas of applicability were noted, with evidence presented to demonstrate where tank farm processes were in place. For JONs which were applicable and where opportunities for improvement exist, actions were recommended for either further evaluation or correction.

Based on SME evaluations of WIPP JONs, five JONs were identified as Applicable with actions required or recommended:

- JON 3 – Nuclear Safety - *Assessment of Hazard Analyses Supporting Tank Operations Contractor Hazard Category 2 and 3 Facilities* (FY2014-ENG-S-0393) initiated on 8/04/14, with completion by 9/30/14.
- JON 5 – 6 - Nuclear Safety - Actions to address these JONs are dependent on the outcome of completing the assessment recommended for JON 3.
- JON 26 – Contractor Assurance - WRPS needs to assist ORP in achieving the goal of clearly specifying the use of performance reporting results to encourage conservative reporting and communicate lessons learned. Recommended action is to work with ORP to remove these types of criteria and incentivize reporting of these types of issues.
- JON 29 - Maintenance - Evaluation of criteria used to determine prioritization of maintenance and repairs to maintain a high state of operational readiness. Evaluation will also be needed to determine if criteria are consistent throughout TOC (TFP, RET/CLO, Production OPS, LABS).

Actions identified above will be entered as ESRB actions in ESTARS and tracked through to closure.

Two ESRB actions were recently closed and three ESRB actions remain open.

The following ESRB actions were recently closed:

- WRPS-ESRB-2014-0019, assigned to John McDonald, to document the Chemical Vapor Solutions Team (CVST) governance as part of the formal process.

- The action closure referenced text from TOC Charter 21, which states that the CVST will report periodically to the President's Accident Prevention Council and interact with the Employee Accident Prevention Councils as needed to integrate activities on tank vapors.

- WRPS-ESRB-2014-0017, assigned to Mike Peloquin, required an evaluation of the Root Cause Analysis process to determine if (a) qualifications for Team Lead are appropriate or if allowances can be made for performance of team lead function under the direction or guidance of another qualified analyst, (b) process or protocol improvements are warranted to gain efficiency, (c) there is a need to train and qualify additional root cause analysts.
  - The action closure stated that (a) Team Lead qualifications are adequate and were developed from previous weaknesses identified in the process. (b) There are some process efficiencies in being worked and a LEAN review will consider others. (c) There is a need for additional trained cause analysts. CAS is working with Production Operations, Projects and others to determine who should be trained. WRPS currently has an approved 3-day course and two outside vendor bids for an onsite course. CAS will work with the frontline projects to determine which course to proceed with.

No information in this meeting resulted in the need to issue a PER.

No information from in this meeting needs to be added to the Risk Matrix.

ESRB MEETING NO. 2014-25 RECORDS:

1. ESRB Attendance Roster, 8/25/14
2. ESRB Agenda, 8/25/14
3. Approved Meeting Minutes and Attachments for 8/25/14

APPROVED BY: Stephen L. Weber FOR DATE: 8/28/14
R. E. Wilkinson, ESRB Sponsor

Distribution:

A. Basche	R. Gregory	M. Peloquin
C. Burrows	G. Johnson	R. Skwarek
W. Clark	R. Kofmehl	D. K. Smith
W. Condon	D. Little	B. Thomas
W. Eaton	J. McDonald	R. Wilkinson
R. D. Greenwell	L. D. Olson	

APPENDIX B –
TANK AX-104 LEAK ASSESSMENT TEAM EXPERT ELICITATION FORMS

Expert Opinion: J. G. Field

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date: 6/26/2014

Elicitation from: J. G. Field

Elicitation by: D. J. Washenfelder

Hypotheses:

Leaker: The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.

Non-Leaker: The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State L	True State NL	Likelihood Ratio L:NL	Basis
p(L)	p(NL)	Ω_0	AX Farm tanks are high heat tanks, more likely to have leaked.
0.60	0.40	1.50	

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	
Surface Level Measurement	0.30	0.70	0.43	Liquid level decreases exceeding criteria were determined to be due to increased evaporation and liquid levels in the LDPs continually decreased; indicating the tank did not leak. However, surface level measurements and evaporation estimates are uncertain for high heat tanks and it was speculated that the AX-104 LDP may have leaked.

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, RIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
Liquid Observation Well	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

If there is no surface

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.20	0.80	0.25

Gross gamma monitoring in drywell 11-04-08 between 1973 and 1995 clearly shows low gamma radioactivity near the base of the tank that has decayed away; indicating the presence of Ru-106 contamination. Agree with previous studies that it is unlikely that the Ru-106 was from the dresser coupling leak near the North edge of the tank. However, if the tank leaked, Ru-106 should have been much higher and other contaminants should have been observed. Higher gamma acivity should also have been observed in the AX-104 LDP. The low levels of gamma activity remaining in the LDP can be explained by ventillation header line connections to the LDP. The most likely cause appears to be a condensate leak; possibly from a line about 50 ft to the West that migrated downslope toward the drywell, but more likely from a condensate line from AY-102 that runs near 11-04-08 (see H-2-69241).

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.40	0.60	0.67

The SGLS shows no gamma activity near the base of the tank, further confirming that no Cs-137 or other gamma contaminants were present near the drywell. However Ru-106 decayed away before the SGLS measurements were made.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non-leaker. p(SGL|NL) = 1 - p(SGL|L)

L(SGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.20	0.60	0.25

The SGLS and gross gamma results are consistant, but the historical gross gamma drywell logs and LDP monitoring data provide the better information showing contaminants are present near the drywell, indicating the tank probably did not leak and showing possible sources for the gamma contaminants. The SGLS logging results do not change probability estimates based on gross gamma alone.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.43	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.25	0.67	1.00	0.25

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio		L(SLM,LOW)
		0.43

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

See Cell F53

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		**L(SGL,GGL)**	If GGL and no SGL: L(SGL,GGL) = L(GGL) If SGL and no GGL: L(SGL,GGL) = L(SGL) If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL) If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)
Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**	L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.04	0.96	0.04

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1 = L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Expert Opinion: C. L. Girardot

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date:	6/26/2014
Elicitation from:	C. L. Girardot
Elicitation by:	D. J. Washenfelder
Hypotheses:	
Leaker:	The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.
Non-Leaker:	The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State		Likelihood Ratio
L	NL	L:NL
p(L)	p(NL)	Ω_0
0.50	0.50	1.00

Many SSTs have previously been identified as assumed leakers. Many high heat SSTs in A and SX Farms have also been identified as having a liner leak. However, the design of AX Farm tanks was likely better than A and SX Farms. AX Farm was a new design so there could have many issues during construction that were not reported/recovered.

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is other a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	0.30	0.70	0.43

The tank was undergoing sluicing in 1977 so liquid level data was changing frequently and could have masked a small leak. However, there were no reports indicating any liquid level anomalies. The LDP liquid level did not show any increases (the LDP level was actually decreasing) which should have been expected if the tank was leaking.

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

If there is no surface

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (If no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.25	0.75	0.33

The gross gamma logs and the leak detection pit data counteract one another. Gross gamma indicates radioactivity about 10 ft below the bottom of the tank which could indicate a tank leak. However, the gross gamma values declined with time indicating earlier data was likely Ru-106. Sampling of the LDP indicates very low levels of radioactivity. If the tank was leaking then radioactivity in the LDP should have been orders of magnitude higher than what was actually encountered.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (If no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.05	0.95	0.05

Spectral gamma logs indicate very low level Cs-137 in the drywells, likely background levels. Nothing that appears to indicate a tank leak.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non-leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	0.10	0.90	0.11

If the tank was leaking then the spectral gamma logs should indicate higher levels of Cs-137 than what was actually reported. The earlier gross gamma logs indicate radioactivity but was likely the mobile Ru-106 which could have come from a variety of sources other than the tank itself.

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likilihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.43	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.33	0.05	0.11	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	x
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likilihood Ratio		L(SLM,LOW)
		0.43

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	x

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		**L(SGL,GGL)**	If GGL and no SGL: L(SGL,GGL) = L(GGL) If SGL and no GGL: L(SGL,GGL) = L(SGL) If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL) If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)
Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**	L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.0025	1.00	0.00

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. $(L|in,ex) = \Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Expert Opinion: D. G. Harlow

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date:	6/26/2014
Elicitation from:	D. G. Harlow
Elicitation by:	D. J. Washenfelder
Hypotheses:	
Leaker:	The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.
Non-Leaker:	The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State		Likelihood Ratio	
L	NL	L:NL	
p(L)	p(NL)	Ω_0	Tank AX-104 was a high heat tank with a several month period near 450°F which may have affected the tank liner.
0.60	0.40	1.50	

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: It is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	Liquid level decreases were reported to be caused by evaporation. The LDP liquid level which can increase from severl non tank leak sources showed a slow decrease over time probably from evaporation.
	0.10	0.90	0.11	

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (If no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	NA
	NA	NA	1.00	

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)	NA
	NA	NA	1.00	

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)	NA
	NA	NA	1.00	

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L/LOW|SLM) = 1.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	There is a possibility that initial gross gamma logs might have indicated a tank liner leak especially drywell 11-04-08. The drywells between 11-04-08 and the known radioactivity between the tanks did indicate radioactivity suggesting that the 11-04-08 drywell was from a tank leak. However subsequent gross gamma logs indicated lower and lower radioactivity which was not indicative of a tank leak. In addition a tank liner leak would seem to follow the liner down to the drain slots under the tank to the LDP as opposed to finding a way through the concrete and out to drywell 11-04-08. The gross gamma sample levels in the LDP were also not indicative of a tank leak.
	0.25	0.75	0.33	

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)	Spectral gamma indicated very little Cs 137 which was several orders of magnitude lower than what might be expected from a tank leak.
	0.05	0.95	0.05	

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non-leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)	The gross gamma logs showed the possibility of a tank leak at first and the spectral gamma data didn't support a leaking tank.
	0.35	0.65	0.54	

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)	Taken together the data defines the situation better than either of the data sets individually, and they do not contradict each other.
	NA	NA	1.00	

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likelihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.11	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.33	0.05	0.54	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likelihood Ratio		L(SLM,LOW)
		0.11

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	X

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		**L(SGL,GGL)**	If GGL and no SGL: L(SGL,GGL) = L(GGL) If SGL and no GGL: L(SGL,GGL) = L(SGL) If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL) If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)
Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**	L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1	
0.0047	1.00	0.00	Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0 p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$ p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*\|L)/p(*\|NL).

Expert Opinion: J. S. Schofield

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date: 6/26/2014

Elicitation from: J. S. Schofield

Elicitation by: D. J. Washenfelder

Hypotheses:

Leaker: The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.

Non-Leaker: The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State		Likelihood Ratio
L	NL	L:NL
p(L)	p(NL)	Ω_0
0.33	0.67	0.49

Chose 33% because roughly 16% of SSTs have probably leaked, and would be a higher probability for a high heat tank to leak, even though AX tanks are newest SST design.

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	0.025	0.98	0.03

Would always see a level decrease in this tank with the high heat. Would only see a leak if it was much greater than evaporation rate. If tank leaked, leak would obviously be small based upon all other available data. Subjectively chose low value of 2.5% because LDP showed no leak evidence due to lack of radiation on smears.

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, RIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.10	0.90	0.11

Subjectively feel there is a 50% chance any leak will show up in a drywell. Rate would be less for a small leak, more for a large leak. However, since gross gamma was only Ru-Rh-106 and feel there should be some Cs-137 regardless of soil retention, judged there was only a 20% chance the actual results seen would be due to tank leak. This was further reduced to 10% since there was nothing in the leak detection pit smears, and the LDP is being addressed as another ex-tank LD method for this assessment.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.10	0.90	0.11

Chose 10%. I feel if there is a tank leak, some Cs-137 will be present despite soil holdup. Thus the spectral gamma showing no Cs-137 if there were a leak was judged to be 10% for consistency with part 6.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non-leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	0.50	0.50	1.00

There is a 99+% chance gross gamma will show up if the spectral gamma shows something, but the spectral gamma didn't show any Cs-137. The gross gamma showing Ru-Rh-106 could occur from other sources than a tank leak, so selected 50%.

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likilihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.03	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.11	0.11	1.00	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	x
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likilihood Ratio		L(SLM,LOW)
		0.03

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	x

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		L(SGL,GGL)

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis		L(in,ex)

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.0014	0.9986	0.0014

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Expert Opinion: K. J. Hull

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date: 6/26/2014

Elicitation from: K. J. Hull

Elicitation by: D. J. Washenfelder

Hypotheses:

Leaker: The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.

Non-Leaker: The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State		Likelihood Ratio	
L	NL	L:NL	
p(L)	p(NL)	Ω_0	AX-104 is a high heat tank is more likely to have leaked than not.
0.60	0.40	1.50	

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	While there is some level drop, this is is seen as evaporation. There is no major change that is outside of normal evaporation that would lead me to conclude a leak.
	0.15	0.85	0.18	

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	
	NA	NA	1.00	

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	There is a possibility that initial gross gamma logs might have indicated a tank liner leak at drywell 11-04-08. The drywells between 11-04-08 and the known dresser coupling leaks to the north side of AX-104 did indicate contamination suggesting that the 11-04-08 drywell was from a tank leak. However subsequent gross gamma logs indicated a decay rate greater than that indicative of a tank leak. In addition, a tank leak would likely follow the liner down to the LDP drain slots preferentially over finding a way through the concrete. The LDP should indicate a leak if one is indicated at drywell 11-04-08. The gross gamma sample levels in the LDP are not indicative of a tank leak.
	0.30	0.70	0.43	

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)	Cs-137 and other gamma contaminants are not present in SGLS indicating the low probability of tank leak at drywell 11-04-08.
	0.10	0.90	0.11	

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)	Gross gamma indicated the possibility of a tank leak but the spectral gamma log did not support that finding.
	0.15	0.85	0.18	

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.18	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.43	0.11	0.18	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likihood Ratio		L(SLM,LOW)
		0.18

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	X

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		L(SGL,GGL)

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis		L(in,ex)

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.01	0.99	0.01

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = Ω_1/(Ω_1+1)
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Expert Opinion: D. G. Baide

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date: 6/26/2014

Elicitation from: D. G. Baide

Elicitation by: D. J. Washenfelder

Hypotheses:

Leaker: The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.

Non-Leaker: The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State L	True State NL	Likelihood Ratio L:NL	
p(L)	p(NL)	Ω_0	Tank AX-104 thermal history shows significant time when the tank was above the operating limit of 300 degrees F.
0.60	0.40	1.50	

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	Liquid level decreases exceeding criteria were credited to increased evaporation. The decreasing LDP liquid levels tend to indicate the tank did not leak.
	0.20	0.80	0.25	

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (If no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (If no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (If no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	The initial gross gamma logs for drywell 11-04-08 could indicated a tank leak, but the rate of decay tends to represent Ru-106 that more likely is associated with condensate leakage. The activity shows up only at the base of the tank with no trace down the sidewall; no migration was seen; and no activity indicative of a tank leak showed up in the LDP. The likely causes appear to be either a condensate leak from a line on the west side of the tank or possibly from the valve pits also located to the west.
	0.35	0.65	0.54	

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (If no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)	Spectral gamma showed very little Cs-137 at the base of the tank which would be expected from a tank leak.
	0.10	0.90	0.11	

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)	Gross gamma logs indicated the possibility of a tank leak but the spectral gamma data didn't support a leaking tank.
	0.15	0.85	0.18	

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)	The results of the gross gamma and spectral gamma are not contradictory.
	NA	NA	1.00	

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likilihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.25	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.54	0.11	0.18	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likilihood Ratio		L(SLM,LOW)
		0.25

If SLM and no LOW: L(SLM,LOW) = L(SLM)
if LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	X

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Ex-Tank Likelihood Ratio		**L(SGL,GGL)**

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**
		0.00

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.01	0.99	0.01

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Expert Opinion: D. W. Strasser

RPP-ASMT-57574, Rev. 0

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Elicitation Date: 6/26/2014

Elicitation from: D. W. Strasser

Elicitation by: D. J. Washenfelder

Hypotheses:

Leaker: The change in radioactivity in drywell 11-04-08 was caused by a leak from tank AX-104.

Non-Leaker: The change in radioactivity in drywell 11-04-08 resulted from a source or sources other than a tank leak, and may include AX farm ventilation system, transfer line leaks, operations releases or other sources.

Prior Probability - Part 1

True State L	True State NL	Likelihood Ratio L:NL	
p(L)	p(NL)	Ω_0	Tank AX-104 was a high heat tank with a several month period near 450°F. This makes it more likely to be a leaker due to the temperature effects on the tank liner.
0.60	0.40	1.50	

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1-p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	
Surface Level Measurement	~ 0.30	0.70	0.43	Liquid level decreases reported in OR 77-19 have been explained and did not appear to be a concern in the past.

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

	p(LOW|L) (If no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
Liquid Observation Well	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
(From HNF-3747, Rev. 0)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.30	0.70	0.43

There is a possibility that initial gross gamma logs at drywell 11-04-08 might have indicated a tank liner leak. The drywells between 11-04-08 and the known radioactivity between the tanks did indicate radioactivity suggesting that the 11-04-08 drywell was from a tank leak. However subsequent gross gamma logs indicated lower and lower radioactivity which was not indicative of a tank leak. In addition a tank liner leak would seem to follow the gap between the liner and concrete down to the drain slots under the tank to the LDP as opposed to finding a way through the concrete wall and out to drywell 11-04-08. The gross gamma sample levels in the LDP were also not indicative of a tank leak.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non-leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.20	0.80	0.25

If the tank leaked, other radionuclides such as Cs-137 or Co-60 would be expected in spectral gamma scans. A leak of condensate from ventilation lines near drywell 11-04-08, flush pit leaks or surface runoff and migration are viable sources for the Ru-106 in drywell 11-04-08.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non-leaker. p(SGL|NL) = 1 - p(SGL|L)

L(SGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
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Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	0.20	0.80	0.25

The gross gamma logs showed the possibility of a tank leak at first and the spectral gamma data didn't support a leaking tank.

Considering that ex-tank data sources may be interdependent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

p(SGL|GGL,NL) = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker. p(SGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Likilihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.43	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.43	0.25	0.25	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Likilihood Ratio		L(SLM,LOW)
		0.43

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	X

Ex-Tank Likilihood Ratio		L(SGL,GGL)
		0.00

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Tank 241-AX-104 Leak Assessment Expert Elicitation Form
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Combined Likelihood Ratio for Leak Hypothesis		L(in,ex)
		0.03

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.04	0.96	0.04

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1-p(L|in,ex)

Notes and Key:

Manual entries (Elicited probabilities)

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).