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Tank 241-SX-104 Leak Assessment Completion Report

Washington River Protection Solutions LLC
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Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract: Between 1984 and 1988 a decrease in the interstitial liquid level in tank 241-SX-104 was observed. Following an investigation, the tank was declared to be an "assumed leaker." In August, 2009 a formal leak assessment panel was convened to review the 1984 – 1988 event and make a final determination of the tank's leak integrity. The panel determined that the tank had not leaked during 1984 – 1988. The most likely causes of the observed interstitial liquid level decrease were liquid evaporation from the tank, and the slow dissipation of liquid observation well installation water through the waste that complicated identification of the true interstitial liquid level. The panel recommended that the leak integrity status of tank 241-SX-104 be changed from "assumed leaker" to "sound." The Executive Safety Review Board concurred with the panel's recommendation on January 28, 2011.

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Revision 0

Tank 241-SX-104 Leak Assessment Completion Report

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Date Published
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washington river protection solutions

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Office of River Protection

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EXECUTIVE SUMMARY

Tank SX-104 is a 1,000,000 gallon capacity, 75-ft diameter, mild steel-lined concrete single-shell tank located on the east side of the 241-SX tank farm. The tank was placed in service during the first quarter of 1955, and continued to receive and store waste until August, 1980, when it was removed from service.

Between 1984 and 1988 the interstitial liquid level (ILL) in the tank slowly decreased, exceeding the allowable 0.3 ft decrease criterion in February, 1988. A leak investigation completed in July, 1988 declared the tank to be an "assumed leaker." Additional ILL decreases were observed in 1998 and 2008. The associated assessments concluded that the 1998 and 2008 ILL decreases were not the result of a tank leak.

In 2007, the Tank Farm contractor, 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 Assess Tank Farm Leaks in Support of Retrieval and Closure Planning.*

In February, 2009 a review of select 241-SX tank farm single-shell tanks, including tank SX-104, was conducted in accordance with the RPP-32681 process. The review concluded that there was no evidence of a leak from the tank. The conclusion was based on new information that was not available to the 1988 investigators. The new assessment concluded there was no evidence tank SX-104 lost containment, and no leak inventory was assigned for the tank. Data collected from spectral gamma logging of the laterals beneath the tank corroborated the conclusion.

Based on the 2009 review, a formal leak assessment of tank SX-104 was performed during August, 2009. The method of analysis used for the formal leak assessment process was Engineering Procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. The formal leak assessment process is based on a probabilistic analysis to assess the mathematical likelihood (probability) that a 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 Rev. 0, *Tank Leak Assessment Technical Background*.

The leak assessment used a panel of experienced Washington River Protection Solutions, LLC engineers, managers, and consultants to review the tank SX-104 historical data and evaluate the tank's leak integrity. The panel consisted of: D. J. Washenfelder (Assessment Coordinator, Technical Integration); D. A. Barnes (Lead Surveillance System Engineer, Tank Surveillance); J. W. Ficklin (West Maintenance); J. G. Field (Engineer, Closure & Corrective Measures); M. A. Fish (Single-Shell Tank System Engineer, West System Engineering); D. G. Harlow (Consultant, Technical Integration); and E. C. Shallman (Materials Engineer, Technical Integration). The team met between August 10, 2009 and August 25, 2009 to gather and review

information, develop the Leak and Non-Leak Hypotheses, and reach a consensus recommendation for tank SX-104.

Based on review of the in-tank and ex-tank data, the panel developed plausible hypotheses for the observed tank behavior:

Leak Hypothesis:

"The decrease in tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank."

Non-Leak Hypothesis:

"The decrease in tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, possibly complicated by redistribution of liquid observation well installation water."

There was consensus among the members of the assessment team that the available in-tank and ex-tank data indicated that the non-leak hypothesis was more consistent with the data, and that the tank was not likely leaking during the 1984-1988 time frame. The team concluded that the most likely cause of the ILL decrease was evaporation and the slow dissipation of the liquid observation well (LOW) installation water.

The slow dissipation of the LOW installation water due to the low permeability of the waste was possibly not identified during the 1988 investigation. This was likely the result of the hand-plotting technique used at the time for neutron moisture scan data. The technique resulted in difficult to interpret charts and the frequent use of judgment to identify the ILL. A subtle trend could have gone unnoticed.

Evaporation, currently available LOW gamma and neutron logging information, and waste characteristics coupled with the stable baseline readings in the drywells reduce the estimated active leak probability to about one chance in nine that the observed in-tank and ex-tank data would be present if the tank were leaking.

The recommendation of the leak assessment team was that the integrity status of tank SX-104 be changed from "assumed leaker" to "sound".

The results of this assessment were presented to the Washington River Protection Solutions LLC Executive Safety Review Board on January 28, 2011. The Board concurred with the recommendation of the assessment team.

TABLE OF CONTENTS

TABLE OF APPENDICIES

TABLE OF FIGURES

TABLE OF TABLES

Abbreviations and Acronyms

BDGRE	Buoyant displacement gas release event
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-ORP	U.S. Department of Energy Office of River Protection
DOE-RL	U.S. Department of Energy Richland Operations Office
DSSF	Double-shell slurry feed
FIC	Food Instrument Corporation (surface level measurement instrument)
FY	Fiscal Year
GRE	Gas release event
IDMS	Integrated Data Management System
ILL	Interstitial liquid level
LFL	Lower flammability limit
LOW	Liquid observation well
PCSACS	Personal Computer Surveillance Analysis Computer System
PSS	PUREX sludge supernatant
RAS	Radionuclide Assessment System
REDOX	Reduction-Oxidation [Fuels Separation] Plant
SGLS	Spectral Gamma Logging System
SST	Single-shell tank
TD	Total depth

Units

cfm	cubic feet per minute
Ci	curie
ft	foot
gal	gallon
in	inch
kgal	kilogallon (10^3 gallons)
pCi	picocurie (10^{-12} curies)
pCi/gm	picocuries (10^{-12} curies) per gram soil
yr	year

1.0 INTRODUCTION

This document provides the results of a formal leak assessment performed on tank 241-SX-104 (tank SX-104). The leak assessment process is described in engineering procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. The formal leak assessment was initiated August 10, 2009, to reevaluate the 1988 leak investigation following the recommendation made in RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*.

Tank SX-104 is a 1,000,000 gallon capacity, 75-ft diameter, mild steel-lined concrete single-shell tank located on the east side of the 241-SX tank farm. The tank was placed in service during the first quarter of 1955, and continued to receive and store waste until August, 1980, when it was removed from service.

Between 1984 and 1988 the interstitial liquid level (ILL) in the tank slowly decreased, exceeding the allowable 0.3-ft decrease criterion in February, 1988. A tank integrity evaluation completed in July, 1988 declared the tank to be an “assumed leaker” (Memo 13331-88-049, *Evaluation of Integrity of Tank 241-SX-104*).

Starting February, 1997 and continuing through January, 1998 the rate of decrease in the tank SX-104 ILL changed from about 1-in per year to 6-in per year; the waste surface response to changes in atmospheric pressure increased from between 0.7-in and 3.0-in of level change per inch of mercury to almost 6.0-in of level change per inch of mercury. A leak investigation concluded that the variations were the result of changes in waste porosity combined with increases in capillary strength from the reduced porosity. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquid to the waste surface from the increased capillary strength. External drywell spectral gamma scans in January, 1998 showed no changes from the 1995 baseline scans. The assessment recommended that the tank not be declared a re-leaker (HNF-2617, *241-SX-104 Level Anomaly Assessment*).

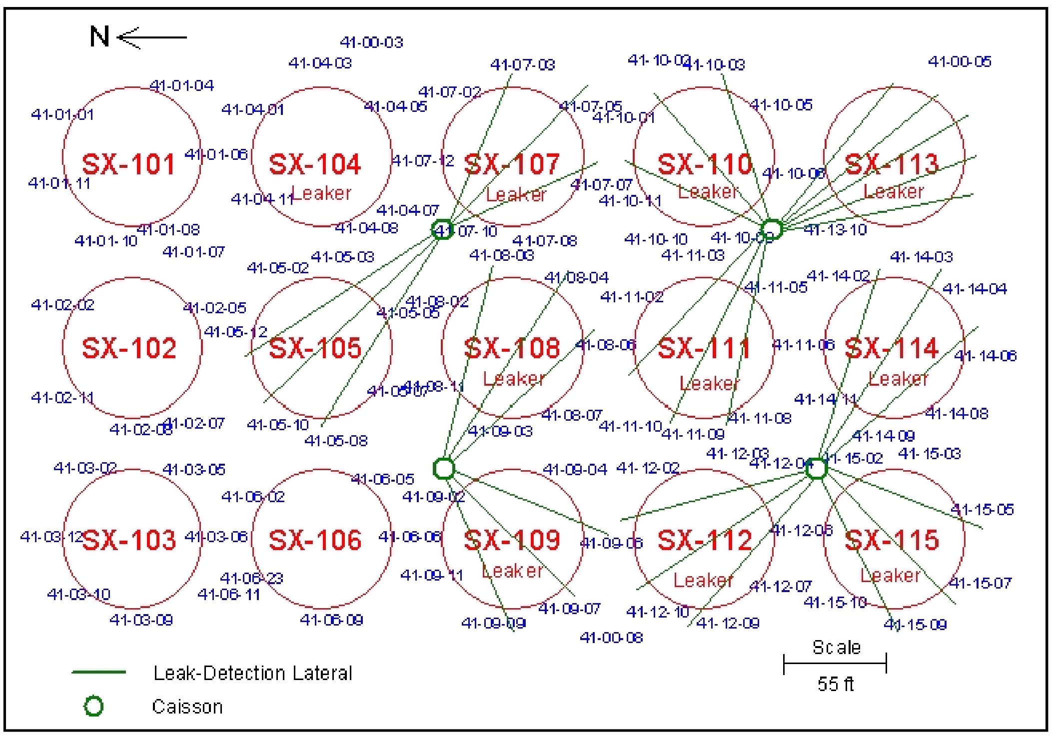
In December, 2006 a new liquid observation well (LOW) was installed in Riser 7A. Interstitial liquid level monitoring using the new well showed the predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization of the level by January, 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable 1.2-in decrease criterion. Further decreases were measured on May 6, and May 12, 2008. On May 19, 2008, a formal leak assessment was initiated to determine if the tank was re-leaking.

The formal leak assessment concluded that “the water used to install the liquid observation well in December, 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge-saltcake mixture, and the interstitial liquid’s capability to generate and release small amounts of gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak.” The consensus of the assessment team was that tank SX-104 was not actively leaking (RPP-ASMT-38450, *Tank 241-SX-104 Leak Assessment Report*).

A process was developed jointly in 2007 with the U. S. Department of Energy Office of River Protection (DOE-ORP) and the Washington State Department of Ecology to re-assess selected tank leak estimates and to update single-shell tank leak and unplanned releases volume and inventory estimates (RPP-32681, *Process to Estimate Tank Farm Vadose Zone Inventories)*. Subsequent to the 2008 leak assessment report, the 241-SX tank farm tanks which had been previously designated as leaking tanks were re-assessed using the process. The re-assessment concluded that it was reasonably certain that tank SX-104 had not leaked, and no inventory was assigned for a leak from this tank (RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*).

Figure 1-1. 241-SX Farm Plot Plan

Tank SX-104 is located on the east side of 241-SX tank farm, the first tank in the tank SX-104, SX-105, SX-106 cascade. Including tank SX-104, ten of the 241-SX tanks are classified as "assumed leakers" (from GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms SX Tank Farm Report).



2.0 METHOD OF ANALYSIS

The method of analysis used was Engineering Procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. The formal leak assessment process 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*.

The leak assessment used a panel of experienced engineers and managers to review the historical data and re-evaluate the basis for declaring the tank an "assumed leaker." The panel consisted of: D. J. Washenfelder, (Assessment Coordinator, Technical Integration); D. A. Barnes, (Lead Surveillance System Engineer, Tank Surveillance); J. W. Ficklin (Base Operations/West Maintenance); J. G. Field (Engineer, Closure & Corrective Measures); M. A. Fish (Single-Shell Tank System Engineer, West System Engineering);); D. G. Harlow (Senior Technical Advisor, Technical Integration); and E. C. Shallman (Materials Engineer, Technical Integration). The team met between August 10, 2009 and August 25, 2009 to gather and review information, develop the Leak and Non-Leak Hypotheses, and reach a consensus recommendation for tank SX-104.

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3.0 TANK HISTORY

Tank SX-104 was constructed in 1953 and 1954 as part of the 241-SX tank farm, located in 200 West Area. The 241-SX tank farm contains fifteen single-shell tanks; ten of the fifteen are classified as "assumed leakers."

Tank SX-104 is the first in a three tank cascade series including tanks SX-105 and SX-106. The tank entered service in the first quarter of 1955. Tank SX-104 received Reduction-Oxidation Plant (REDOX) waste and REDOX ion exchange waste (post-221-B B Plant cesium removal waste) from initial startup in 1955 until the second quarter of 1975. From the third quarter of 1975 until the tank's removal from service and deactivation in August, 1980, it served as a 242-S Evaporator/Crystallizer bottoms tank. During the fourth quarter of 1977, the tank received partial neutralized 242-S slurry product. In the first quarter of 1980, the contents of the tank were classified as double-shell slurry feed.

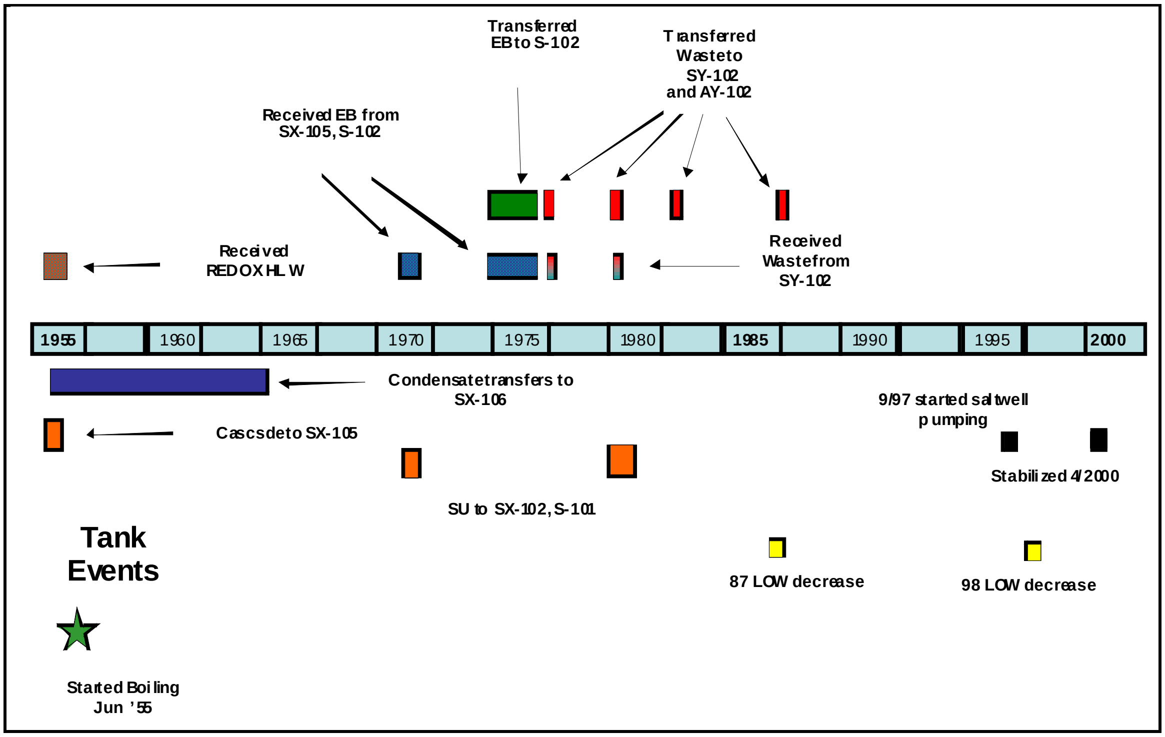
Tank SX-104 experienced gas release events (GREs) between 1984 and November, 1996 (RPP-7771, *Flammable Gas Safety Issue Resolution*). Waste samples taken in May, 1988 were nearly saturated with dissolved salts and gelled at laboratory temperatures (WMH-9856353, *Analyses Results for the Final Report for Tank 241-SX-104*) that along with other indicators such as surface crust helped to explain the gas retention phenomenon. Interstitial liquid level decreases exceeding leak detection criteria occurred in February, 1988 resulting in the tank being classified an "assumed leaker". Between May, 1988 and August, 1988, 99.9 kgal of liquid were pumped out of the tank. Tank SX-104 was suspected of re-leaking in 1998 and again in 2008. On both occasions analyses determined that the tank was not re-leaking.

Saltwell pumping for interim stabilization began on September 26, 1997; 200 gal were pumped in September before the transfer line between tank SX-104 and the 244-S double-contained receiver tank became plugged. Pumping was resumed on March 19, 1998, following the installation of a water dilution system in the saltwell in order to pump the waste to tank 241-SY-102. Pumping was interrupted on March 23, 1998, then restarted on July 23, 1998, continuing until July 27, 1999, when the rear seal of the jet pump ruptured and a major spray leak ensued within the pump pit. A total of 115.1 kgal of liquid waste was transferred to tank SY-102 before the failure occurred. On April 26, 2000, the tank was declared interim stabilized.

Currently tank SX-104 contains approximately 310 kgal of saltcake, 136 kgal of sludge, and 48 kgal drainable liquid (HNF-EP-0182, *Waste Tank Summary Report for Month Ending June 30, 2010*). The waste temperature is about 130°F, or 54°C – high enough to keep the interstitial liquid in the liquid state. The 1998 laboratory cooling curve studies demonstrated that solidification did not begin until the samples were cooled to 25°C, and was complete at 22°C (8C510-PC98-024, *Tank 241-SX-104 Dilution Testing, Interim Report*).

Figure 3-1. Tank SX-104 Timeline (1955 to 2000)

(from RPP-ENV-3965, Rev. 0, Hanford SX-Farm Leak Assessment Report)



4.0 LEAK ASSESSMENT HISTORY

Tank SX-104 was declared an "assumed leaker" in 1988 following a 6-in decrease in the ILL exceeding the 0.3-ft decrease criterion. The tank was reevaluated for leakage in 1998 due to anomalous ILL readings on December 10 and 11, 1997 and again in 2008 responding to an ILL decrease on May 1, 2008 that exceeded the allowable 1.2-in criterion. In 2009 a leak assessment was performed on all of the 241-SX Tank Farm tanks which had been previously suspected of having leaked waste. Based on the 2009 review, a formal leak assessment of tank SX-104 was performed during August, 2009.

4.1 1988 LEAK ASSESSMENT

On February 19, 1988, an ILL decrease of greater than 0.3-ft was detected using a gamma probe in the LOW installed in Riser 16.(TFSO-EFS-88-085, *The Liquid Observation Well (LOW) Interstitial Liquid Level (ILL) in Tank 241-SX-104 Exceeded the 0.3 Foot Decrease Criteria with the Gamma Probe*). This event resulted in an Environmental Protection Deviation Report (88-03, *Liquid Observation Wells (LOWs) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3 Foot Decrease Criteria with the Gamma Probe*). An engineering investigation was undertaken to review all available tank data (SD-CP-TI-132, *In-situ Gamma Spectroscopy Scans of Dry Wells Surrounding 241-SX-104 Tank;* 13331-88-416, *Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104*).

The engineering investigation determined that the period to be reviewed should cover the period between April, 1985, and April, 1988, in order to address all of the relevant data and overlapping LOW log periods. The 6-in ILL decrease was calculated to be equivalent to a loss of 34 gal/week over the three year period. This was corrected for waste volume contraction due to the 6°F bulk waste temperature decrease during the period, and used a 35% waste porosity. A neutron probe regression analysis over the first 20 months of the three year period calculated a loss of ~50 gal/week.

After the first 20 months of the three year period, the neutron probe logs showed the ILL stabilizing, whereas the gamma probe logs continued to show a slow decrease. The surface level readings were erratic indicating gas releases were occurring. The surface level showed a slow decrease but had not yet reached the 5-in decrease action criterion.

Photographs were also taken. Although surface changes were noted, nothing significant could be identified that would explain the decrease. The photographs were not obstructed by haze or fog in the tank, indicating there may have been a flow of air through the vapor space which would have increased evaporation. The gross gamma logs for drywells near tank SX-104 showed no evidence of soil contamination above normal background. The engineering investigation could find no conclusive evidence that the tank was in fact leaking, but also could not attribute the ILL decrease to evaporation with a 95% certainty.

Subsequently, a peer review team was formed and conducted a leak evaluation using the decision rules in force at the time (13311-88-049, *Evaluation of Integrity of Tank 241-SX-104*; RHO-CD-896, *Review of Classification of Nine Hanford Single-Shell "Questionable Integrity" Tanks*). Each member of the team believed that the liquid level decrease was caused by a combination of high-heat content within the solids and active ventilation through a central sludge cooler. However, three out of the five team members felt that the available data were insufficient to provide 95% certainty that the tank was sound. The tank was re-classified as an assumed leaker (WHC-UO-88-028-TF-03, *Tank 241-SX-104 Has Been Classified as an Assumed Leaker*). The leak loss was estimated to be 5.3 kgal over three years, based on the LOW liquid level decrease. For reporting purposes, the volume was rounded to 6 kgal.

4.2 1998 LEAK ASSESSMENT

Tank SX-104 was suspected of "re-leaking" in 1998 due to observed ILL variations of up to 6-in. These variations were attributed to the effects of changes in barometric pressure combined with a reduction in waste porosity and increases in capillary strength due to the reduced porosity. These conclusions were based on ILL observations following water additions in February, 1997, and February, 1998. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquid to the waste surface from the increased capillary strength. Drywell spectral gamma scans in January, 1998, showed no changes from the 1995 baseline scans, and the assessment team recommended that the tank not be declared a "re-leaker" (HNF-2617, *241-SX-104 Level Anomaly Assessment*).

4.3 2008 LEAK ASSESSMENT

In December, 2006 a new LOW was installed in Riser 7A nearer the center of tank than the previous LOW installation. A water lance was used to install the LOW, and the new LOW showed a predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization as the installation water dissipated into the waste. The stabilization appeared to be complete by January, 2008.

However, on May 1, 2008, the ILL reading showed a decrease that exceeded the allowable 1.2-in decrease criterion. The quarterly neutron LOW scan from the same time period was found to be significantly below baseline and the recent data (-6.2 standard deviations, approximately 2.5-in lower than expected). Further decreases were recorded on May 6, 2008, and May 12, 2008. A formal leak assessment was initiated on May 19, 2008 to determine if the tank was re-leaking.

The leak assessment team concluded:

> "... the water used to install the liquid observation well in December, 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge-saltcake mixture and the interstitial liquid's capability to generate and release small amounts of gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was

> identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak."

The recommendation of the assessment team was that the leak assessment be closed without modification of the integrity status of tank SX-104; and that the pre-assessment LOW quarterly surveillance frequency be reinstituted (RPP-ASMT-38450, *Tank 241-SX-104 Leak Assessment Report*).

4.4 2009 LEAK ASSESSMENT

Tank SX-104 was assessed in January-February, 2009 as part of the 241-SX tank farm assessment using the process described in RPP-32681, *Process to Estimate Tank Farm Vadose Zone Inventories*. This process, developed jointly in 2007 with DOE-ORP and the Washington Department of Ecology, is used to re-assess selected tank leak estimates and to update single-shell tank leak and unplanned releases volume and inventory estimates.

Regarding tank SX-104, the assessment concluded:

> "Tank SX-104 was classified as "questionable integrity" based on ILL decreases from 1994 to 1998; ILL decreases were also observed in 1998 and 2008. Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are also several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment and no leak inventory was assigned for this tank. The tank was previously classified as "questionable integrity" primarily due to the procedural aspects of a 95% confidence associated with the no-leak alternative. The current assessment concluded that it is reasonably certain the tank is sound. As a result no leak inventory is assigned for this tank." (RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*).

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5.0 IN-TANK DATA

The in-tank data sources for tank SX-104 include the ILLs, surface level measurements, temperature readings, and photographs. The review period which addresses the ILL decrease that exceeded the leak detection criterion in 1988 extends from the second quarter CY1984 to the second quarter CY1988.

5.1 LIQUID OBSERVATION WELLS

Liquid Observation Wells – LOWs – are a nominal 3.5-in diameter, centrifugally cast fiberglass pipe, closed at the bottom with a 2.5-in thick epoxy-bonded plug. The LOWs are installed through a tank riser at grade, and extend to near the bottom of the tank (B-436-P1, *Procurement Specification for Liquid Observation Well Assembly*). The LOWs are logged for the interstitial liquid level by ranging a neutron source over the length of the LOW, and measuring the degree of neutron thermalization. Neutron thermalization depends on the moisture content of the waste surrounding the LOW. The inflection point where neutron thermalization begins to increase is considered to be the ILL.

Five LOWs have been installed in tank SX-104 since January, 1982. To date, four have failed. The second LOW installation was used to log the tank's ILL between July 20, 1984, and July 14, 1988, and covers most of the period reviewed during the 1988 leak assessment.

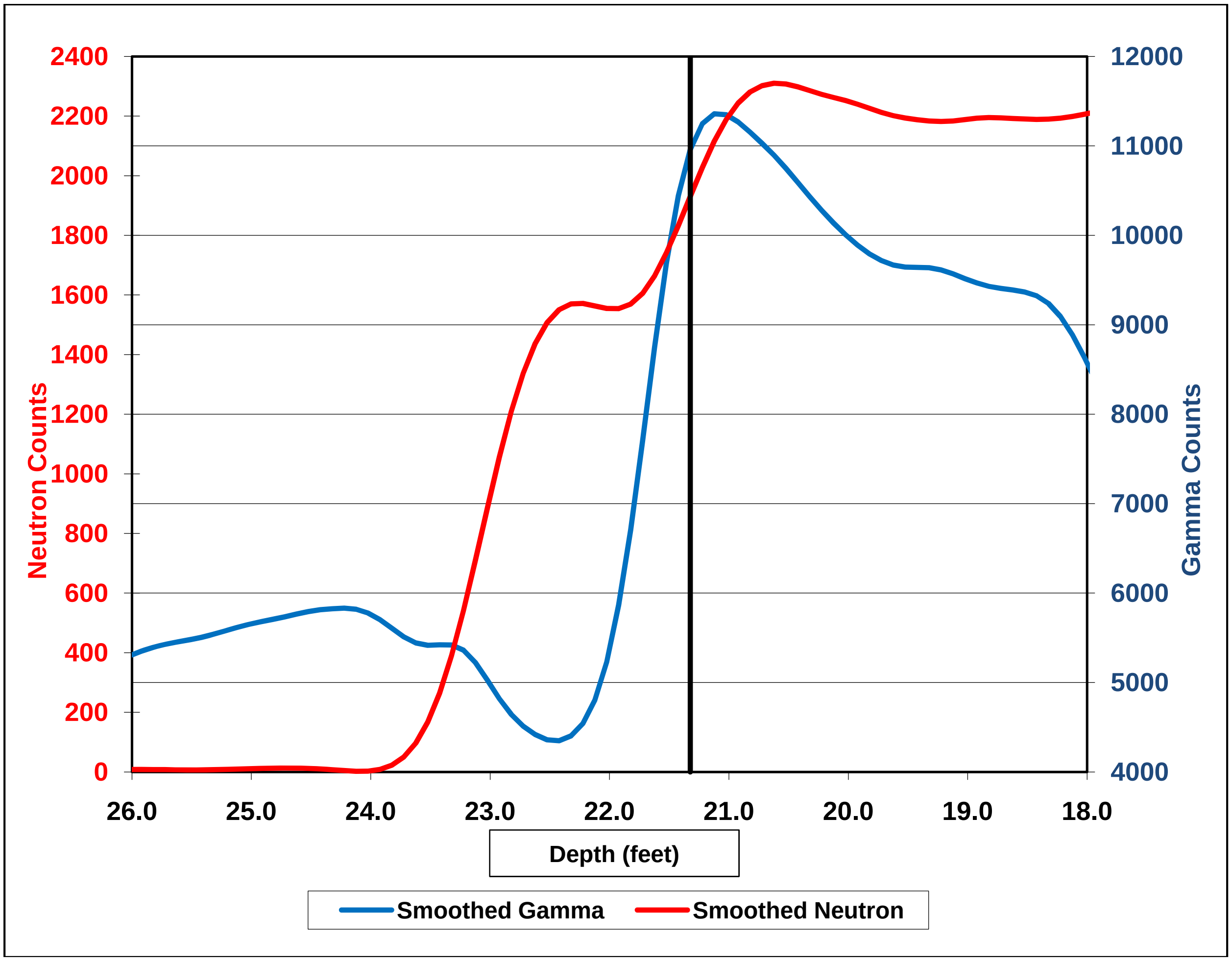
LOW installation involves lancing a hole through the waste with high pressure water, then inserting the new LOW into the cavity. Abnormally high neutron values are common following installation because of the free water remaining at the installation site. The water dissipates through the waste structure over time at a rate depending on the porosity and permeability of the waste. Experience has shown that in high permeability waste the system achieves equilibrium in a matter of weeks; in low permeability waste redistribution can take years. During redistribution the apparent ILL continues to decline slowly until it eventually stabilizes. During this period of slow redistribution the steady decrease in ILL can mimic a tank leak if redistribution of installation water is not recognized as the cause. During extended periods of redistribution, the identification of the cause of the decrease is further complicated by ongoing evaporation of interstitial liquid, and the thermal contraction of the waste that occurs as it continues to cool.

5.1.1 Interstitial Liquid Level Determination

Both neutron and gamma log data were collected during the 1984 – 1988 time period. The plotted data in Figure 5-1 look different because the gamma probe is responding to Cs-137 present in the interstitial liquid below the solid waste surface, while the neutron probe is responding to the free water on the waste surface, that is beginning to dissipate downward. Since the gamma probe is less affected by the installation water, it typically provides a more accurate indication of the ILL immediately after initial installation of the LOW.

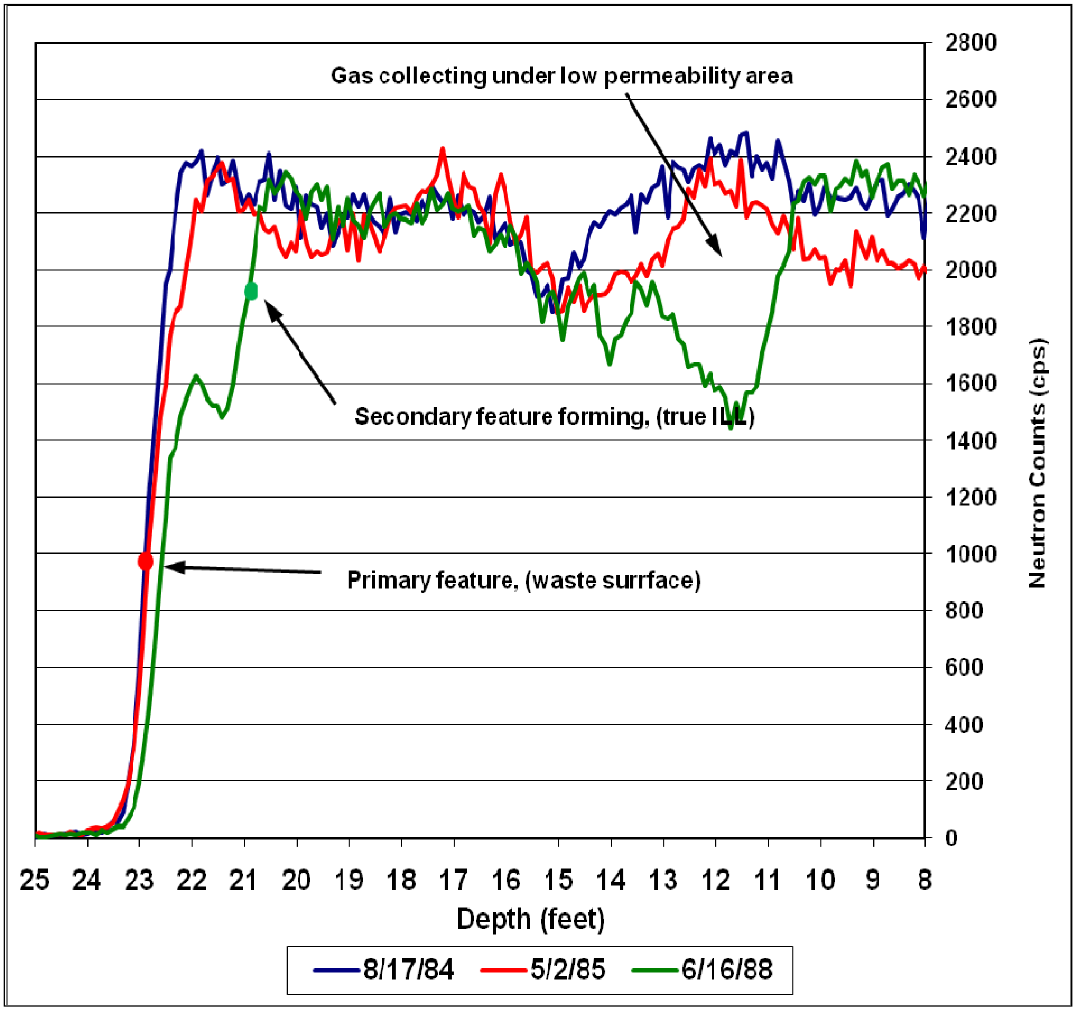
Figure 5-1 illustrates the gamma and neutron measurements logged about four years after the LOW was installed in the tank. The gamma data show an ILL at about 21-ft 3-in, while casual examination of the neutron data suggest the ILL is about 23-ft – the waste surface. Notice however, that the neutron log has also identified a secondary inflection feature further down in the waste, and that it overlays the gamma log inflection point.

Figure 5-1. Neutron and Gamma ILL Logs – June 16, 1988



The primary neutron feature has been interpreted as tracking the LOW installation water as it slowly dissipates through the waste. The secondary neutron feature is believed to be the actual ILL. When the LOW was first installed, the secondary feature is not evident, as can be seen in Figure 5-2. The 1984 log indicates high water content from the waste surface to the tank bottom, consistent with the presence of installation water remaining on the waste surface, and filling the waste cavity surrounding the LOW. Over the next four years, the installation water has dissipated throughout the waste, unmasking the secondary feature that represents the actual ILL. This behavior has been identified in other single-shell tanks; a secondary neutron feature is used to track the ILL in sixteen of them (RPP-RPT-38419, *Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks*).

Figure 5-2. Development of ILL Secondary Neutron Feature 1984 – 1988



The 1988 leak assessment tracked and evaluated changes in the ILL based on interpreting the primary neutron feature – a feature that did not represent the actual ILL in the tank. It is possible that the appearance of the secondary neutron feature was dismissed during the analysis if it was identified at all. It is also possible that the use of hand-calculations and the attendant judgment needed to select the inflection point's location may have increased the variability of the logs, and contributed to the failure to recognize the significance of the secondary neutron feature further down in the waste. The 1988 assessment simply does not address these points.

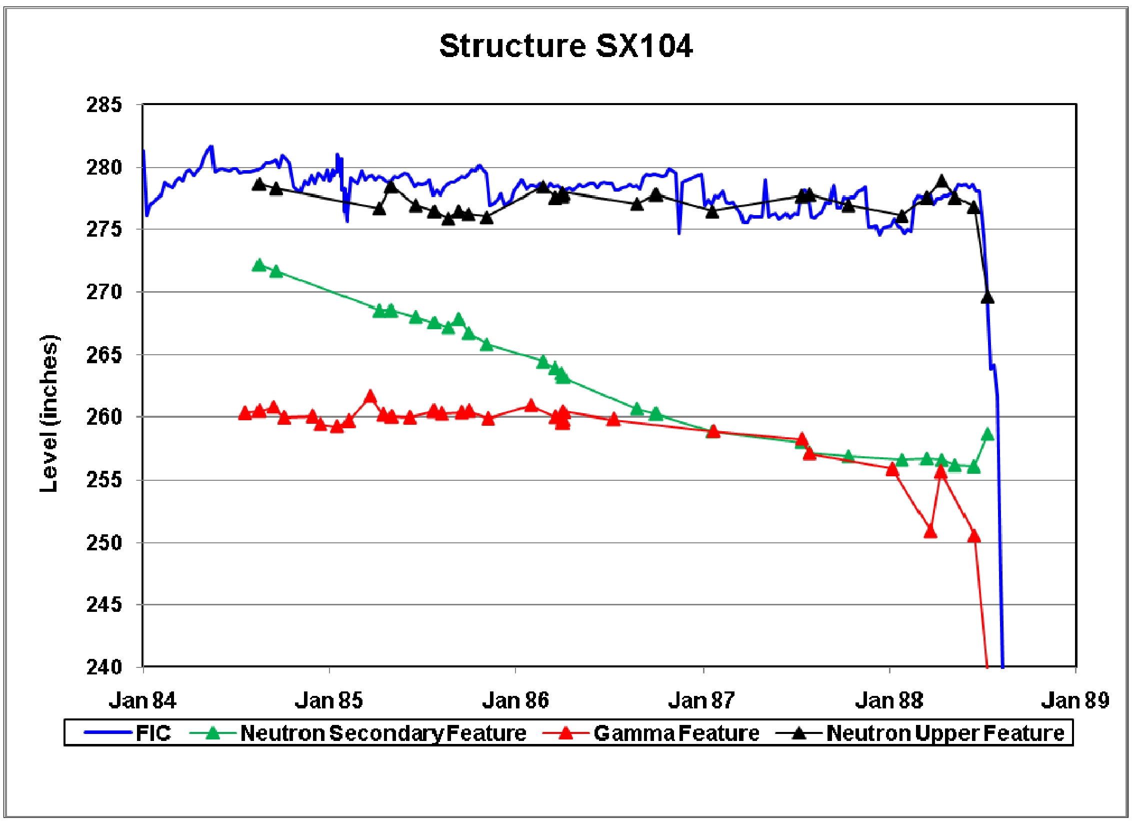
Figure 5-3 presents the neutron and gamma log data for the ILL, together with the surface level for the period between 1984 and 1988 when the tank was declared an "assumed leaker" and was pumped. The figure illustrates the following:

- The primary neutron feature (black) follows the manual tape surface level data well. Both respond to the waste surface.
- The secondary neutron feature (green) is well below the surface, but starts higher than the gamma because of the presence of the LOW installation water. It declines

steadily for more than two years as the water distributes through the waste, and begins to stabilize near the end of the time period, just before pumping begins.

- The gamma logs (red) identify the actual ILL from the beginning of the period, since the LOW installation water has no initial impact on the Cs-137 gamma activity. The gamma ILL remains fairly stable as the installation water dissipates. The visible decrease is attributed to evaporation.
- Immediately at the start of pumping the neutron secondary feature has an uptick as water is added to the tank in preparation for pumping. The gamma ILL is unaffected until the Cs-137 – bearing interstitial liquid begins to be removed by pumping.
- The slow redistribution of liquid indicates the waste has very low porosity and permeability. This observation is also supported by the formation of what appears to be a large gas pocket located ten to fourteen feet above the tank bottom in Figure 5-2. If the permeability of the waste was good the gas would have migrated to the waste surface and been released.

Figure 5-3. Neutron and Gamma ILLs and Surface Level 1984 – 1988



5.1.2 1988 and 2009 Interstitial Liquid Level Comparative Analysis

The neutron and gamma ILL graphs from the 1988 investigation report were reviewed to understand how the tank data resulted in the review team classifying the tank as an "assumed leaker." A gamma plot was recreated from the 1988 investigation report and compared with the

Personal Computer Surveillance Analysis Computer System (PCSACS) software-generated gamma plot for the same time period. The PCSACS plots uses software to select the inflection point for the gamma logs. In 1988 the inflection point was calculated by hand. This required the use of judgment, and most probably increased the variability among the individual logs. Figure 5-4 compares the computer-generated gamma log inflection points to the manual points used in the 1988 evaluation. Both curves use the same log data. The 1988 hand calculations appear to skew the ILL high in the early portion of the evaluation period. This created an artificial drop in the ILL that is not present in the computer generated ILL curve. The hand-calculated drop was a key factor in exceeding the leak detection criterion.

Figure 5-4. Comparison of 2009 Computer-Generated and 1988 Hand-Calculation Methods of Identifying Gamma ILLs

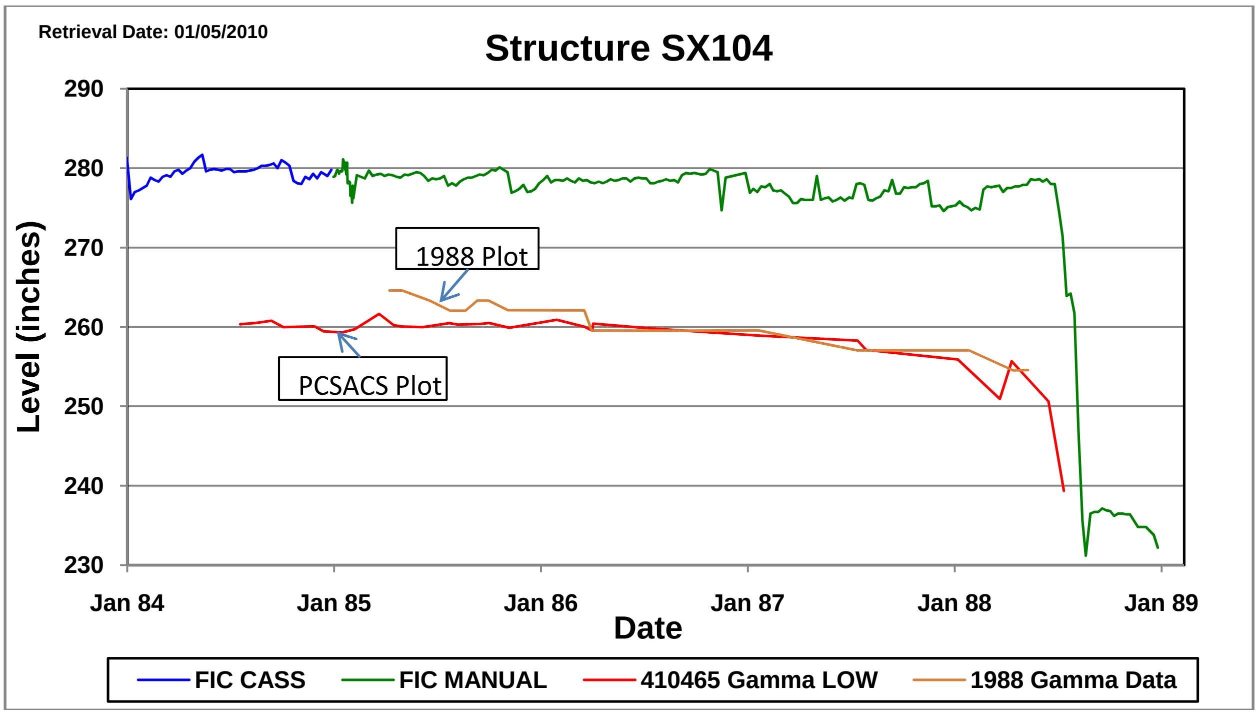


Figure 5-5 compares the computer-generated neutron log inflection points to the hand-calculated points used in the 1988 evaluation. Both curves use the same log data. The graph of the 1988 data is relatively flat during the initial period, suggesting that the evaluation encountered some difficulties interpreting the neutron logs. It is possible that the slow dissipation of the installation water used to create the waste cavity for the new LOW was not recognized, and that the ILL interface being tracked during the early period was actually the installation water interface, not the ILL interface. A high permeability of 35% was assumed during the 1988 evaluation. This assumption seems unrealistically high considering the gel-like characteristic of the waste.

Tank SX-104 Interstitial Waste Origin

It is believed that the tank SX-104 interstitial liquid is a product of the second Partial Neutralization (PN) process test – the "Nitric Acid Partial Neutralization/Acid Injection Process Test" – that was conducted at the 242-S Evaporator/Crystallizer. The test was run intermittently between November 14, and December 19, 1975 (ARH-CD-597, *Nitric Acid Partial Neutralization/Acid Injection Process Test Evaluation*). There is no mention of the PN slurry tank in the process test report. However, a February, 1976 analytical report provides PN slurry sample results from tank SX-104; since no other slurry tanks are mentioned, it is likely that all of the PN/Acid Injection process test product was slurried to tank SX-104. Although the process test proposal called for sampling each of the three phases of the test, the analytical report only has two sample results (*Analysis of 242-S Slurry Receiving Tank 104-SX During Partial Neutralization Process Test*).

Waste Characteristics – 1988 Samples

The May, 1988 samples gelled at laboratory temperature. The sample results show a [PO_4] = 0.1M ± 20%, and a [P] = 0.15M (12221-PCL88-147, *Analysis of Tank 241-SX-104 Samples*). The 1988 samples were reported to be "nearly saturated in dissolved salts." Initial acidification resulted in the formation of solids believed to be aluminum hydroxide.

Waste Characteristics – 1998 Samples

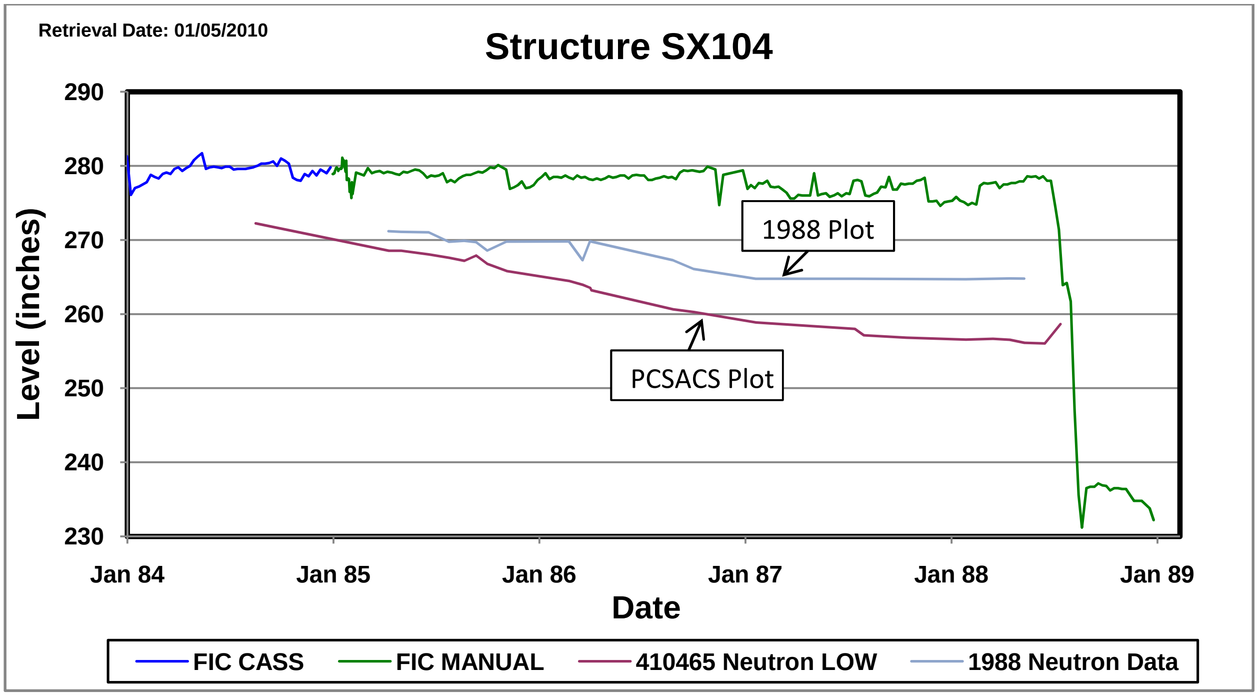
The tank was grab sampled in April 1997, and again in June, 1998. Results from the April, 1997 sampling event were used to ensure chemical compatibility of the waste with materials that might come in contact with tank SX-104 liquids pumped during saltwell pumping activities, and to address flammable gas concentrations in the tank headspace.

Three grab samples were taken in June, 1998 for dilution studies and inorganic analysis. The purpose of these samples is variously described as either supporting the re-leak assessment, or establishing water dilution requirements for saltwell pumping to reduce the risk of a plugged transfer line. The supernatant analytical results show [Na] = 10.13M, and [P] = 0.0255M (WMH-9856353, *Analyses Results for the Final Report for Tank 241-SX-104*).

Dilution and cooling tests were performed on the undiluted liquid. The undiluted samples formed gels composed of interlocked sodium phosphate dodecahydrate ($Na_3PO_4 \cdot 12H_2O$) needle crystals and $NaNO_3$ rhombohedra when cooled from 60°C to 22°C laboratory temperature. About 10 volume % free liquid remained on top of the gel. The samples remained clear from 60°C until the temperature reached 25°C, at which point precipitation began. Vigorous shaking disrupted the gel enough to settle about 55 volume % solids. The test was repeated with the same results. Samples diluted 2:1 (50%) and 1:1 (100%) did not form new solids during cooling (8C510-PC98-024, *Tank 241-SX-104 Dilution Testing, Interim Report*).

The sample results support the argument that the waste had low permeability and therefore slow dissipation of the LOW installation water. It is very likely that the slow dissipation went unrecognized, causing an artificially high ILL interface to be accepted.

Figure 5-5. Comparison of 2009 Computer-Generated and 1988 Hand-Calculation Methods of Identifying Neutron ILLs



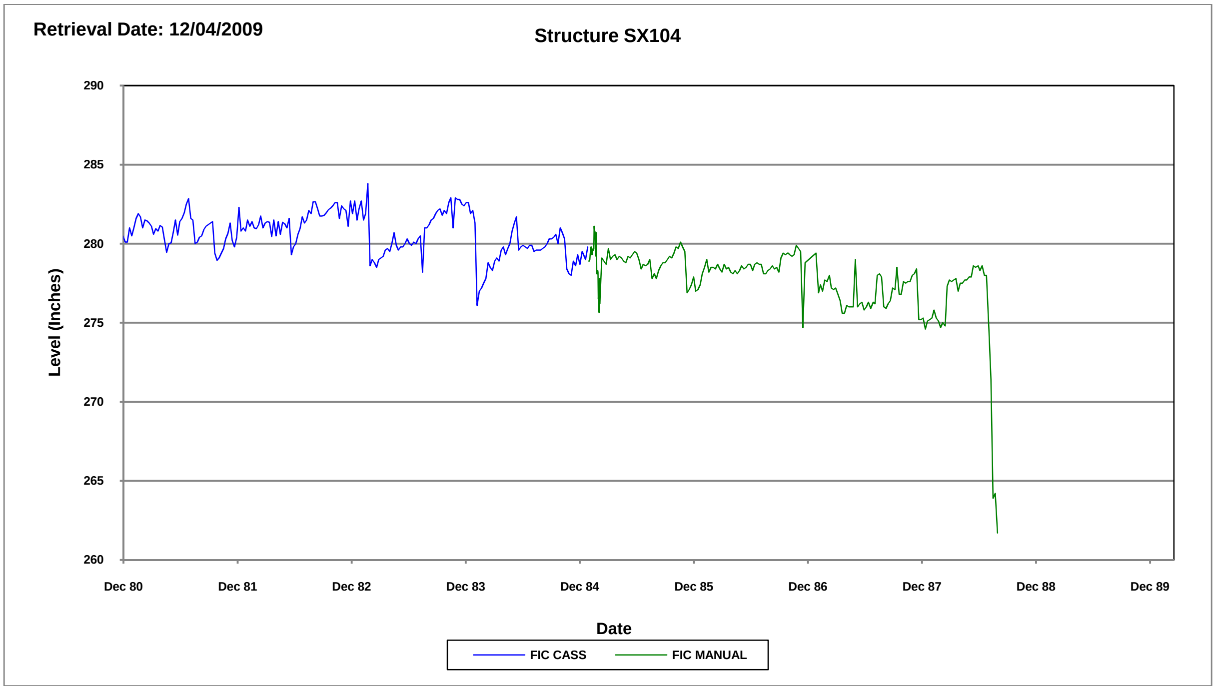
5.2 SURFACE LEVEL BEHAVIOR

Tank SX-104 was equipped with a Food Instrument Corporation (FIC) surface level measurement gauge during 1984 – 1988. Figure 5-6 shows that the surface level periodically increased and decreased during this time. This behavior is consistent with the accumulation and periodic release of trapped gas.

At the same time a waste surface crust was developing as the waste continued to evaporate and cool. The measurement variability introduced by the crust and the gas release events resulted in an unusually large -5.0-in surface level decrease action criterion.

Figure 5-6. Surface Level Change – 1980–1988

Photographs from the period show that surface beneath and in the vicinity of the FIC plummet was gradually subsiding. A regression analysis in the 1988 investigation report indicated that the surface had been decreasing over the seven year period at a 39 gal/week rate.

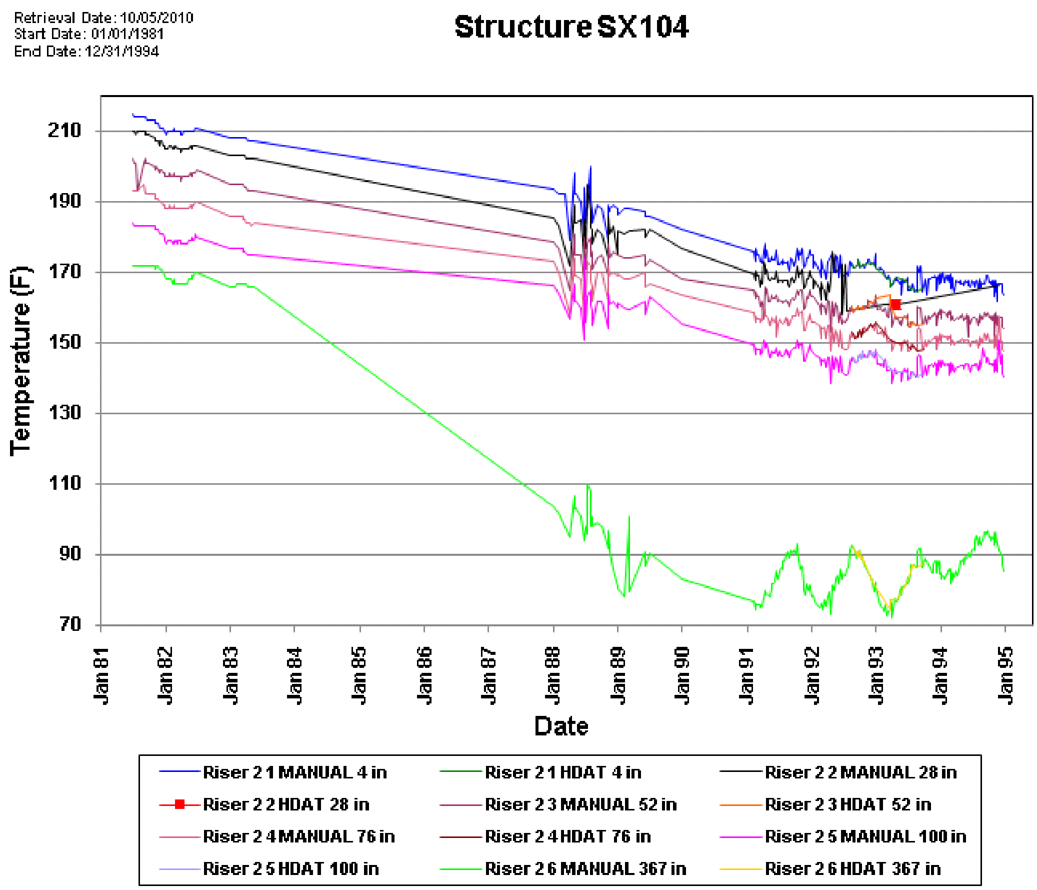


5.3 WASTE TEMPERATURE BEHAVIOR

Waste temperature data for the 1956 – 1964 time period are reported in RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories*. Tank waste reached a maximum of 300°F in December, 1956, and then ranged between 230°F and 260°F through December, 1960. By August, 1961 the temperature had decreased to about 200°F and stabilized there through November, 1964.

No recoverable temperature data records exist from November, 1964 until CY 1981, when PCSACS records begin. Figure 5-7 illustrates the waste temperature history for the 1981 – 1994 time period. During the 1984 – 1988 time period the bulk waste temperature cooled about 65°F. The waste volume contraction from cooling was estimated to be -0.49-in in the 1988 leak evaluation.

Figure 5-7. Waste Temperature History 1981 – 1994



5.4 IN-TANK PHOTOGRAPHS

The 1988 leak evaluation reported that no major changes were observed when 1984 and earlier photographs were compared with the 1988 photographs. The evaluation noted that the surface pools had changed or disappeared in the later photographs, and that the surface crust appeared to slope to the center of the tank as evidenced by peripheral surface cracks. It was also reported that the photographs were clear indicating there may have been a flow of air through the vapor space which would have increased evaporation of the high heat waste. Figures 5-8 and 5-9 show the 1984 and 1988 composite photographs of the waste surface.

Figure 5-8. Waste Surface Appearance – February 14, 1984

Between April, 1985, and April, 1988, the 6-in ILL decrease in the waste was calculated to be equivalent to a loss of 34 gal/week over the three year period. A neutron probe regression analysis over the first 20 months of the three year period calculated a loss of ~50 gal/week. The 1994 report (WHC-SD-WM-ER-332 Evaporation Analysis for Tank SX-104) calculated an evaporative loss of 17 gallons/week for 1% free surface liquid to 40 gallons/week for 3% free surface liquid. The free liquid surface was based on 1988 photo estimates (Figure 5-9). Comparing the 1988 photo with the 1984 photo below shows that in 1984, the free surface area was much larger than 3% - more in the range of 15 – 20%. This greater free surface liquid combined with a higher waste temperature in 1984 would result in a greater evaporation rate than previously reported. Evaporation played a much greater role in the ILL decrease than the 1988 investigation suspected.

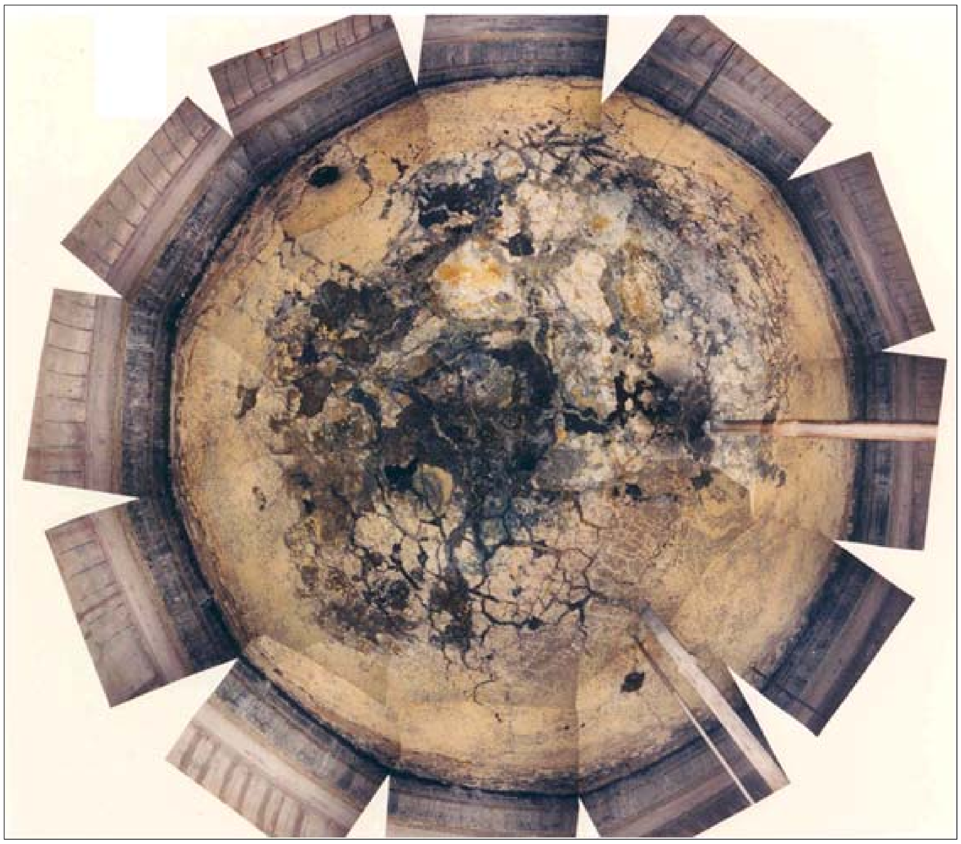
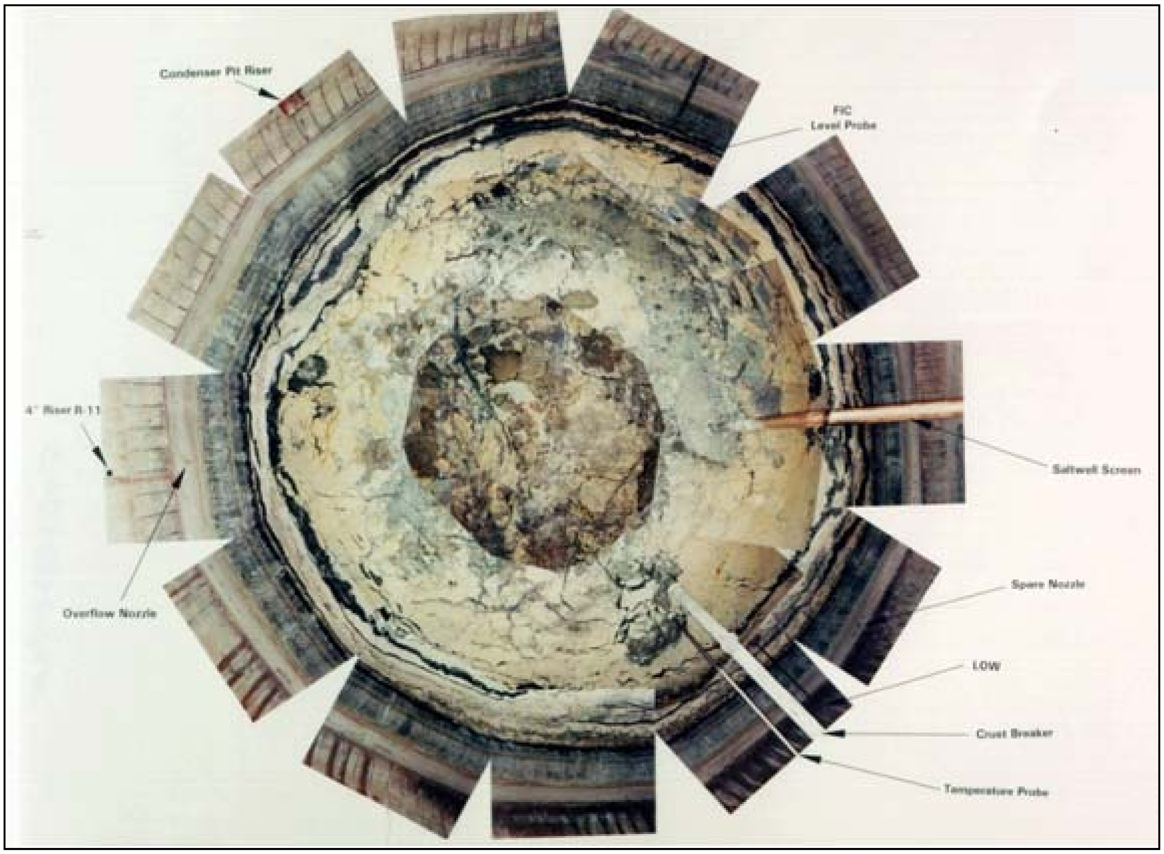


Figure 5-9. Waste Surface Appearance – September 8, 1988



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6.0 EX-TANK DATA

The ex-tank data sources are limited to the drywells surrounding tank SX-104. The tank was not retrofitted with laterals beneath the tank foundation as occurred in several of the other 241-SX tank farm tanks.

6.1 TANK SX-104 DRYWELLS

6.1.1 Drywell Locations and Distances from Tank Structure

Six drywells surround tank SX-104 located at distances varying from ~ 1.5-ft to ~13-ft from the outer edge of the tank's concrete footing. The metal liner has a 37-ft 6-in radius. The concrete wall enclosing the metal liner is 2-ft thick. The concrete footing extends 1-ft 10-in beyond the outer surface of the concrete wall.

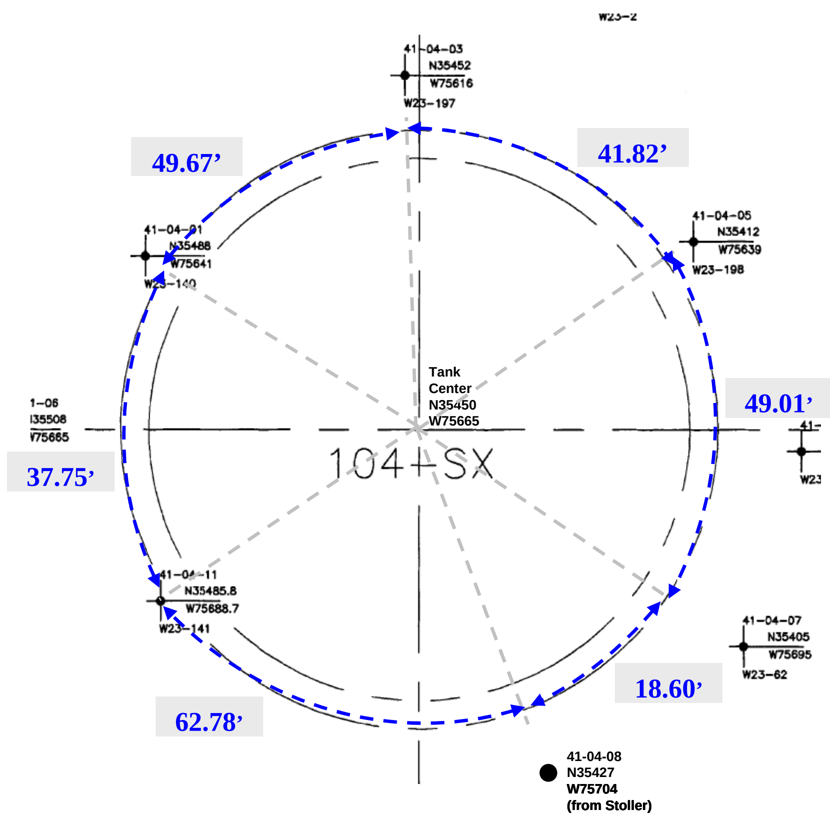
Table 6-1. Tank SX-104 Drywell Locations and Separation Distances

Drywell	Drywell Distance from Tank Center (ft.)	Drywell Distance from Outside Radius of 2-ft Concrete Tank Wall (ft.)	Drywell Distance from Outside Radius of 1-ft 10-in Concrete Tank Footing (ft.)	Clockwise Footing Perimeter Distance to Next Adjacent Drywell (ft.)
41-04-01	44.944	5.444	3.569	49.67
41-04-03	49.041	9.541	7.666	41.82
41-04-05	46.043	6.543	4.668	49.01
41-04-07	54.083	14.583	12.708	18.60
41-04-08	45.277	5.777	3.902	62.78
41-04-11	42.934	3.434	1.559	37.75

The distances between drywells around the tank range from 18.60-ft between drywells 7 and 8 to 62.78-ft between drywells 8 and 11. These are illustrated in Figure 6-1.

Figure 6-1. Tank 241-SX Drywell Locations

The 1988 and 1998 waste samples gelled at laboratory temperature; the waste would be expected to behave similarly at soil temperature (assumed to be 55°F, or ~13°C). The waste properties might prevent a small leak from migrating far enough to be detected in one of the drywells.



6.1.2 Drywell Historical Gross Gamma Logs 1975 – 1994

Historical gross gamma logs for the period 1975 – mid-1994 are compiled in HNF-3136, *Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*. According to the document, the drywell surveillance program, “…was designed to identify tank failures in which a rapid release of at least 19,000 L (5,000 gal) of liquid entered the subsurface soils.” The gross gamma logs from HNF-3136 are reproduced in Figure 6-2. Note that, in addition to the six drywells surrounding tank SX-104, three nearby drywells – 41-01-03, 41-01-06, and 41-07-12 – were tracked as part of the tank SX-104 drywell data.

Figure 6-2. Historical Gross Gamma Logs 1975 – 1994

(from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs, October, 1999)

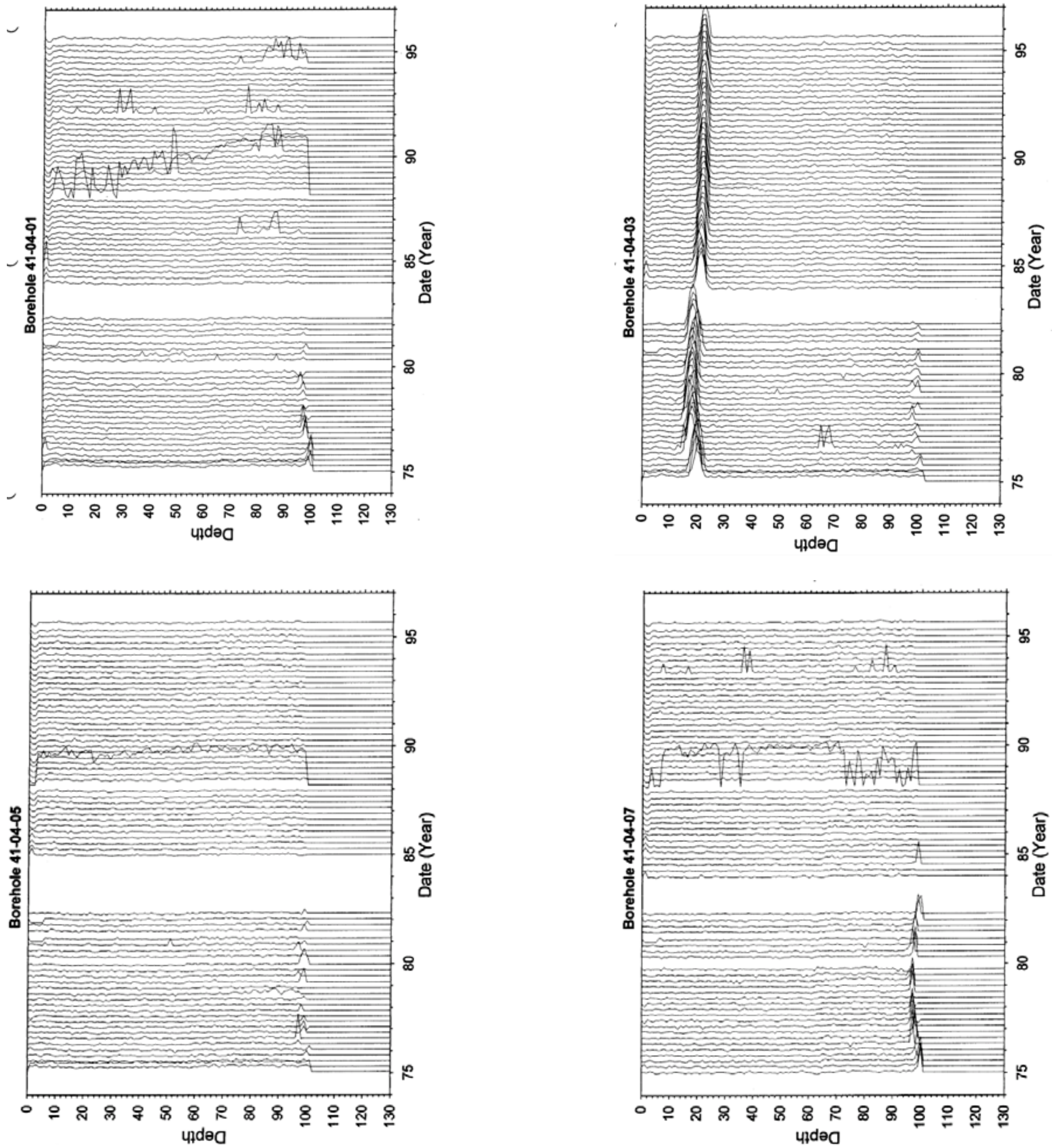


Figure 6-2. Historical Gross Gamma Logs 1975 – 1994 (cont.)

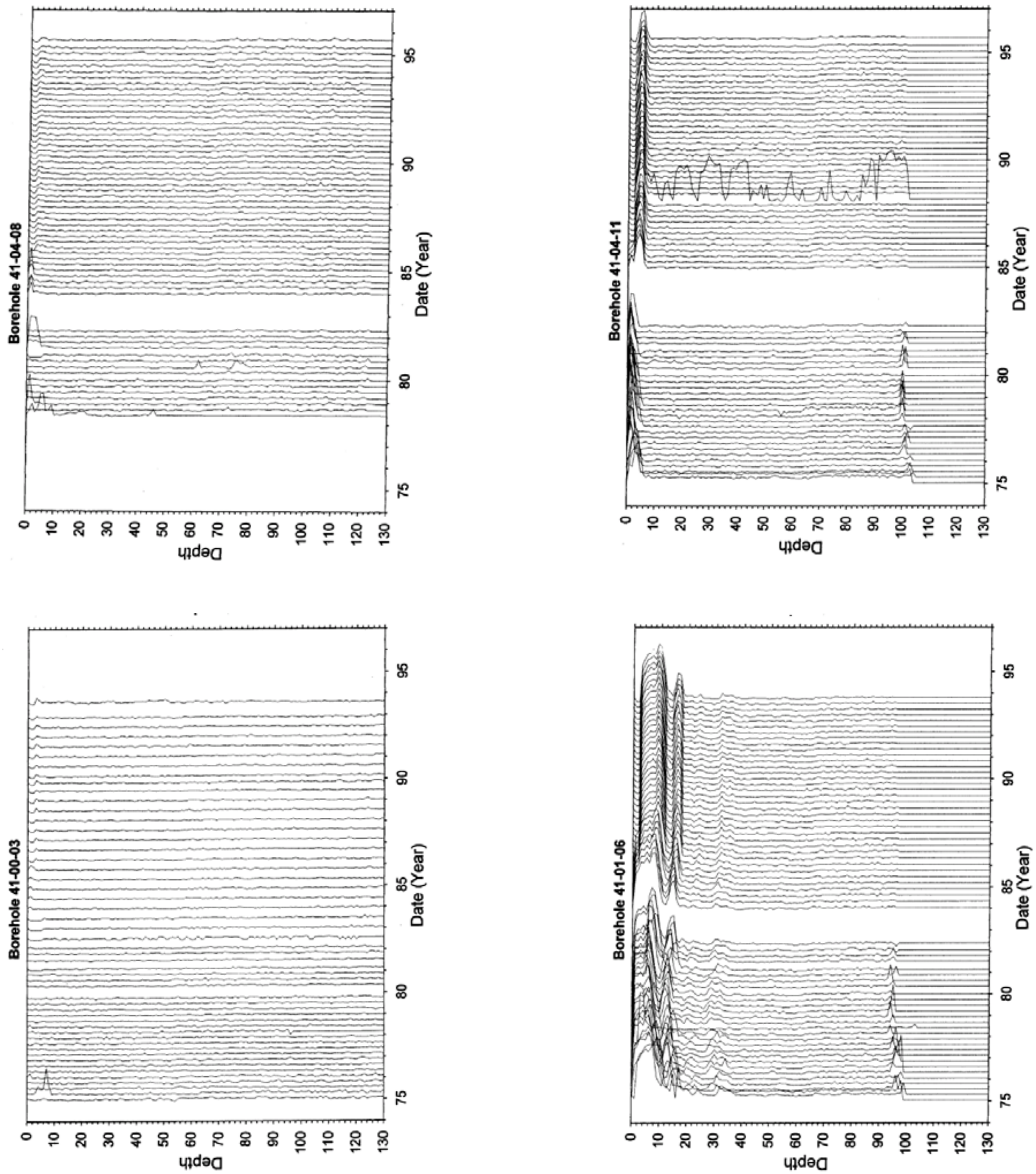
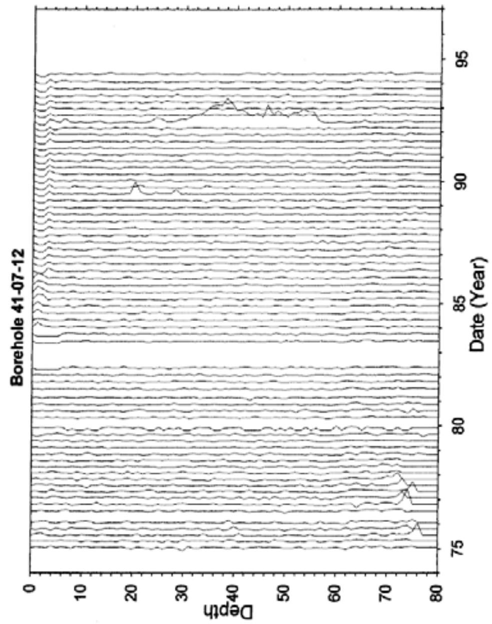


Figure 6-2. Historical Gross Gamma Logs 1975 – 1994 (cont.)



6.1.3 Drywell Spectral Gamma Logs 1995 – 1998

Between April and June, 1995, the Vadose Zone Characterization Project completed spectral gamma system logging of drywells 41-04-01, -03, -05, -07, -08, -11, 41-07-12, and 41-01-06, surrounding and in the vicinity of tank SX-104. The logs showed extensive surface contamination from surface spills or pipeline leaks around the tank, and that the surface contamination had been migrating downward. However after analyzing the distribution of soil contamination around the tank, there was no strong evidence that the tank had ever leaked. The summary data report recommended that the current and historical data be reviewed to determine if the tank should continue to be listed as an "assumed leaker" (GJ-HAN-3, *Tank Summary Data Report for Tank SX-104*).

In January, 1998, spectral gamma system logs were repeated in response to a decrease in the ILL during 1997. The scans were compared to the baseline data from the 1995 scans. The evaluation showed that no increase in soil contamination had occurred since the 1995 scans. Neutron moisture scans showed a moisture peak at the interface between the undisturbed soil at the base of the tank and backfilled soil above the foundation. The evaluation concluded that there was no evidence of a leak from tank SX-104.

Figure 6-3. Spectral Gamma System Logs 1995 – 1998

(from GJ-HAN-3 Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-104, September, 1995)

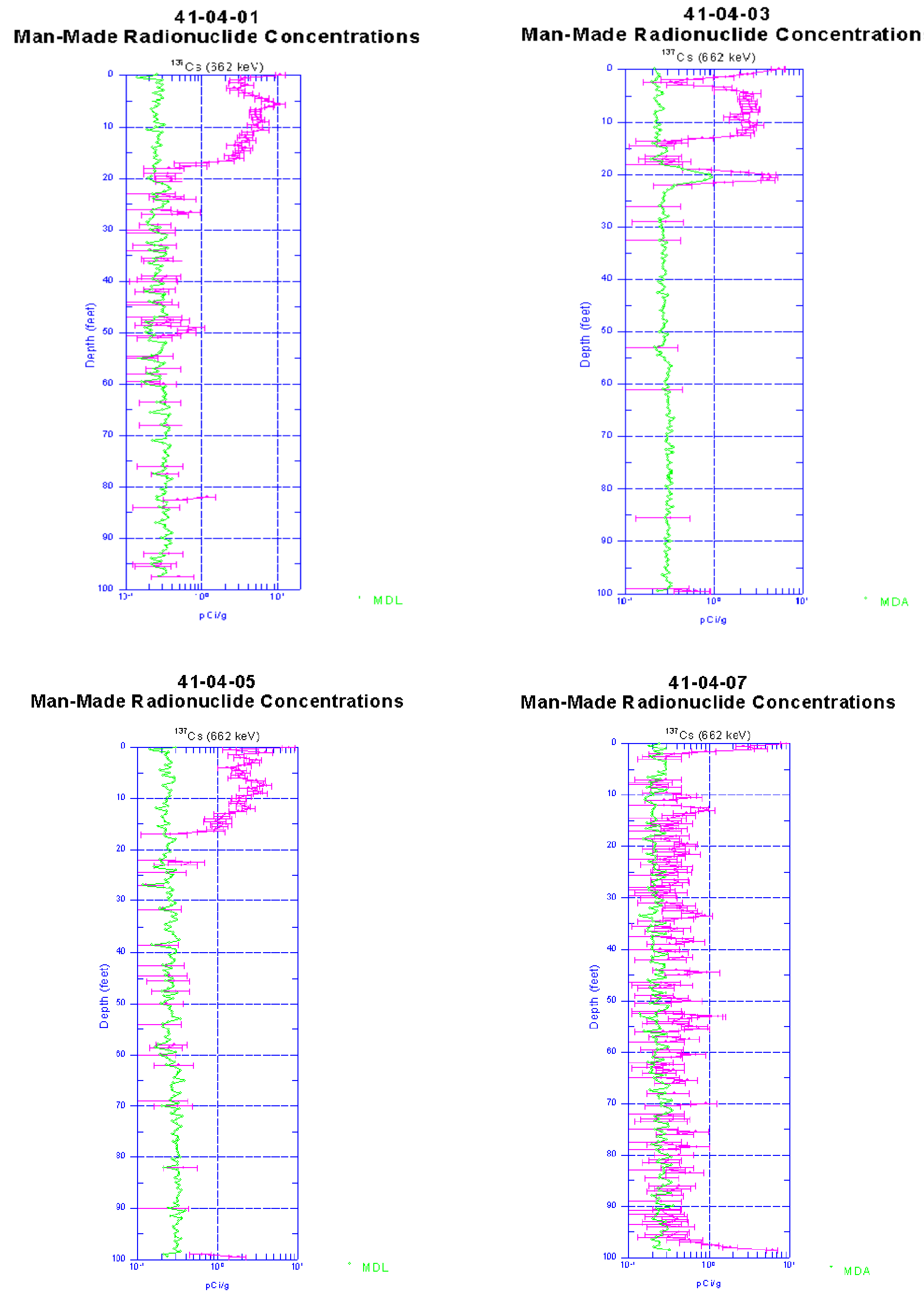
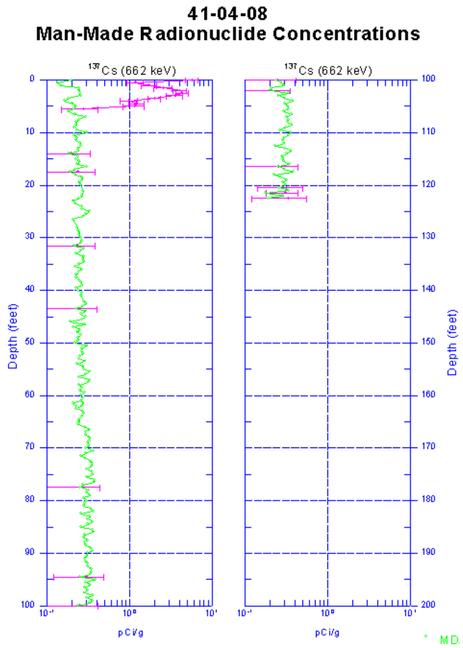
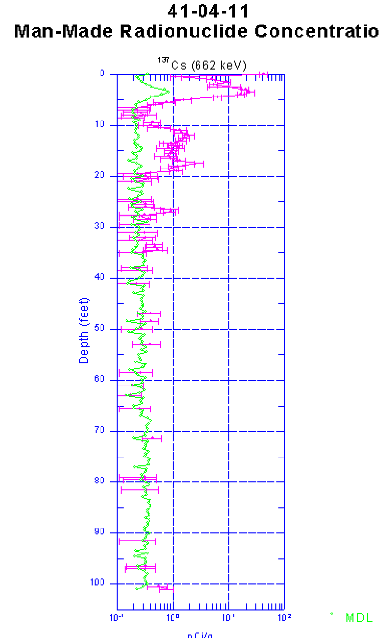
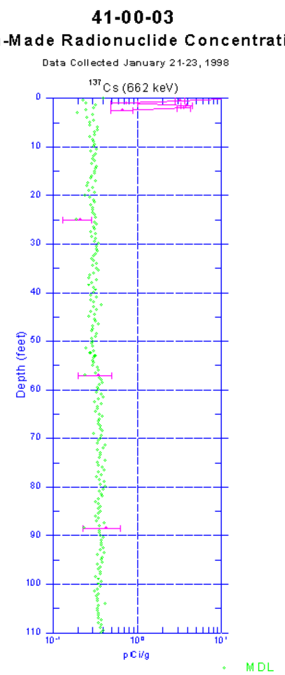


Figure 6-3. Spectral Gamma System Logs 1995 – 1998 (cont.)







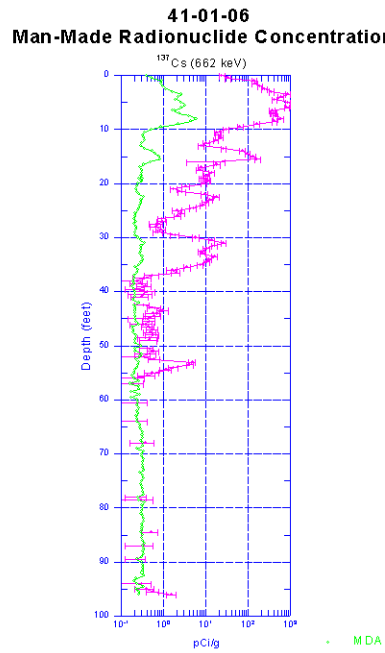
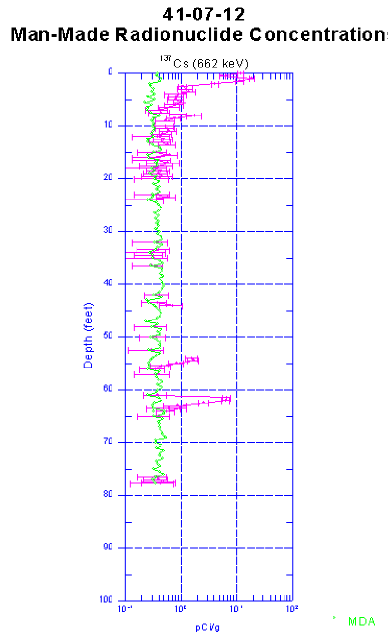


Figure 6-3. Spectral Gamma System Logs 1995 – 1998 (cont.)



6.1.4 Drywell Gross Gamma and Spectral Gamma Log Interpretation

Table 6-2 summarizes the 1975 – mid-1994 gross gamma logs and the 1995 Spectral Gamma logs for the tank SX-104 drywells, and the nearby drywells:

Table 6-2. Tank SX-104 Drywell Gross Gamma and Spectral Gamma Logs Interpretation

Drywell	Drywell Notes (2)	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995 (2)
41-04-01		No significant levels of gamma-ray contamination are present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100-ft (1). The Tank Farms gross gamma log for this borehole shows some increase in activity from about 5 to 10-ft and a slight increase in the background at 60-ft (2).	Cs-137 is the only man-made contaminant detected in this borehole. It was measured primarily from the surface to about 20-ft and then at discontinuous locations to total depth (TD) at concentrations above minimum detectable, but less than 1 pCi/g. A small zone of Cs-137 activity at 50 ft corresponds with the bottom of the tank. The combination plot for this borehole shows the radioactivity from Cs-137 dominates the total gamma log from 0 to 20-ft. The slight increase in Cs-137 concentration at 50-ft is not apparent in the total gamma log.

Table 6-2. Tank SX-104 Drywell Gross Gamma and Spectral Gamma Logs Interpretation

Drywell	Drywell Notes (2)	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995 (2)
41-04-01		No significant levels of gamma-ray contamination are present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100-ft (1). The Tank Farms gross gamma log for this borehole shows some increase in activity from about 5 to 10-ft and a slight increase in the background at 60-ft (2).	Cs-137 is the only man-made contaminant detected in this borehole. It was measured primarily from the surface to about 20-ft and then at discontinuous locations to total depth (TD) at concentrations above minimum detectable, but less than 1 pCi/g. A small zone of Cs-137 activity at 50 ft corresponds with the bottom of the tank. The combination plot for this borehole shows the radioactivity from Cs-137 dominates the total gamma log from 0 to 20-ft. The slight increase in Cs-137 concentration at 50-ft is not apparent in the total gamma log.
41-04-03		Stability of Cs-137 contamination at 21-ft. cannot be determined (1). The gross gamma log for this borehole shows only the 20-ft activity peak (2).	Concentrations of Cs-137 were found from the surface to about 14-ft (up to approximately 5 pCi/g), and a small spatial peak was measured at 20-ft. The 20-ft peak also contained concentrations of Eu-154 at approximately 2.7 pCi/g and Co-60 at approximately 0.3 pCi/g. The elevated background activity from 20-ft is most likely due to bremsstrahlung radiation, which is the result of high concentrations of a high-energy beta emitter such as Sr-90.
41-04-05		No significant levels of gamma-ray contamination is [sic] present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100-ft (1). The Tank Farms gross gamma log shows some poorly defined increased activity peaks in the upper 20-ft of the borehole (2).	The presence of Cs-137 was detected from the surface down to about 17-ft at concentrations above 1 pCi/g. It was also found at discontinuous locations throughout the rest of the borehole at concentrations just above minimum detection.
41-04-07	The drilling records for this borehole indicate that the casing was perforated with a casing knifing tool from the surface to TD with four cuts per in when drilled in September 1954. Spectral Gamma Logging System (SGLS) data from this borehole show low concentrations of Cs-137 from the surface to TD. It appears as though the contamination traveled down the inside of the casing. The Tank Farms gross gamma log shown in the combination plot and the older gross gamma logs did not	No significant levels of gamma-ray contamination are present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100-ft (1). The Tank Farms gross gamma log shown in the combination plot and the older gross gamma logs did not show any contamination (2).	Low concentrations of Cs-137 from the surface to TD. It appears as though the contamination traveled down the inside of the casing. Most of the contamination is below 1 pCi/g .

Table 6-2. Tank SX-104 Drywell Gross Gamma and Spectral Gamma Logs Interpretation

Drywell	Drywell Notes (2)	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995 (2)
	show any contamination; therefore, it is not possible to determine when this borehole became contaminated. Because this borehole is contaminated from top to bottom with low concentrations of Cs-137, it serves no useful purpose for monitoring (2).		
41-04-08	Drilled in 1978 in the adjacent clocked position to 41-04-07. Possibly intended as a replacement due to contamination inside the 41-04-07 well casing extending from the surface to TD (2).	No significant levels of gamma-ray contamination is [sic] present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 123-ft (1).	Cs-137 was the only man-made radionuclide detected in this borehole, occurring from the surface down to about 6-ft and intermittently to TD. This contamination clearly originated from the surface.
41-04-11		Cs-137 and Eu-154 contamination from 2 – 10-ft. is stable over limited time scale. Time decay of peaks is consistent with the isotopes' half-lives(1). The Tank Farms gross gamma log shows the surface contamination (2).	The Cs-137 concentration above approximately 30-ft originated from downward migration of surface contamination. Elsewhere in the borehole, Cs-137 was measured at barely detectable concentrations and probably resulted from surface contamination migrating down the inside of the borehole. The presence of Eu-154 was detected near the surface at low concentrations (3 pCi/g). It also originated from surface contamination. The total gamma plot shows elevated total activity near the surface. Along the rest of the borehole, the total gamma log for this borehole reflects the [naturally-occurring radioisotopes] K-40, U-238, and Th-232 logs except for a small total gamma anomaly at 53-ft. This anomaly may be caused by an elevated Sr-90 concentration at this location.
41-00-03	Borehole 41-00-03 is an original groundwater monitoring borehole located to the east of tank SX-104. The double casing, grout, and uncertainty about the grout distribution prevents quantifying the contamination concentration in the sediment around this borehole. In addition, old Tank Farms gross gamma-ray log data do not show any significant elevated activity zones in this borehole. A decision was made to not log this borehole with the SGLS. However, the Log Data Report	No significant levels of gamma-ray contamination is [sic] present above gross gamma probe surveys' detection threshold between 1975 and 1993 in the vadose zone from 2 to 150-ft (1).	Spectral Gamma System log not available in (2).

Table 6-2. Tank SX-104 Drywell Gross Gamma and Spectral Gamma Logs Interpretation

Drywell	Drywell Notes (2)	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995 (2)
	included in (2) for this drywell indicates that it was logged in three log runs January 21 – 23, 1998 (2).		
41-01-06	Borehole 41-01-06 is located north of tank SX-104, on the south side of SX-101.	Stability of Cs-137 contamination at 100-ft. cannot be established. Cs-137 contamination at 8, 16, 25, and 34-ft. is stable (1). The Tank Farms gross gamma log shows the surface contamination and a slight peak at 30-ft (2).	Cs-137 was measured continuously from the surface to about 55-ft. Two prominent contaminated areas occurred in a zone between 30 and 38-ft and a peak at 53-ft. This Cs-137 may have originated from the surface, but the quantity of contamination found at 30 ft may be indicative of a subsurface source. The peak at 53 ft is probably the result of contamination concentrating at the base of the tank.
41-07-12	Borehole 41-07-12 is located south of tank SX-104 and north of tank SX-107. This is an older borehole that was originally drilled in February 1962 to a depth of 75-ft. In 1978, the borehole was deepened to 90-ft and a 4-in. casing was placed inside the original 6-in. casing. Grout was placed into the annulus between the casings from the surface to 18-ft, and a grout plug was placed in the bottom of the borehole. The radioelement concentrations reported in the logs for this borehole are not accurate for the 0 to 18-ft depth region (2).	No significant levels of gamma-ray contamination is [sic] present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 77-ft (1). The Tank Farms gross gamma log is also of little to no value because of poor sensitivity as a result of the double casing and poor spatial resolution (2).	The presence of Cs-137 was identified from the surface to about 20-ft. It was also detected as two prominent peaks at 55 and 63-ft. The Cs-137 concentration increases in these two peaks from 0 or near minimum detection to above 1 pCi/g in less than 0.5-ft show the spatial collimating effect of the double casing. The origin of the two Cs-137 peaks is puzzling. They may originate from a subsurface source, but the evidence is not conclusive.

Table References

1. HNF-3136 Rev. 0, *Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*, October, 1999
[D8109566]/WMNW/TRS-ES-VSMA-001, *Analysis Techniques Applied to The Dry Well [sic] Surveillance Gross Gamma Ray Data at the SX Tank Farm*, February 1998
2. GJ-HAN-3, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-104*, September 1995 (\\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html)

6.1.5 Drywell Radionuclide Assessment System Logs 2008

During May, 2008, the six tank SX-104 drywells and nearby drywells 41-01-06, 41-05-03, and 41-07-12 were relogged using the Radionuclide Assessment System (RAS). None of the drywells, except 41-04-07 and 41-07-12, exhibited any change in the total-gamma profiles since 1995, save for decreases attributable to decay of gamma-emitting radionuclides. The changes in drywells 41-04-07 and 41-07-12 are directly quoted from the report:

> "41-04-07 exhibits an apparent slight decrease in gross counts from about 80 to 100 ft between 1995, 1998, and 2008. This decrease cannot be attributed to the decay of previously observed gamma-emitting radionuclides. There are a number of other

borehole and tool-related variables that can occasionally result in systematic slight increases or decreases in gross counts, which would result in a profile that mimics previous profiles, though higher or lower in counts. The important factors here are that the profiles mimic each other over the interval from 80 to 100 ft, and count rates decrease from one log to the next. The changes appear to be systematic slight decreases, and are not attributable to a gamma-emitting contaminant influx.

"41-07-12 exhibits noticeable changes from 60 to 65 ft compared against previous total gamma profiles. According to the drilling log, this borehole was deepened in 1978 to 90 ft. The original 6-in casing was extended to 85 ft, and 4-in casing was emplaced inside the original 6-in casing to a depth of 88 ft. The bottom of the borehole was backfilled with grout from 88 to 85 ft. In the 1998 Reassessment of the Vadose Zone Contamination at Tank SX-104 and Comparison to the 1995 Baseline (GJO-HAN-3) pointed to evidence that, contrary to the drilling log, the 6-in casing may terminate just below 60 ft. The neutron moisture data (reported as raw counts) exhibit a very sharp increase in count rate at about 62 ft, and apparent ^{40}K concentrations (not reproduced for this report) also increase at about this depth. There is a short interval of continuous ^{137}Cs contamination from 61 to 64 ft that was first interpreted in 1995 to be possibly related to a leak from SST SX-107 (GJO-HAN-9). The data were reinterpreted in the 1998 report, using shape-factor analysis, to be likely adhered to the casing rather than distributed in the formation. Because of the 4-in casing, the RAS investigation of this borehole on May 27, 2008 employed the "Medium" detector, which includes a much smaller (and consequently much less sensitive) NaI crystal than the "Large" detector used in the other larger-diameter boreholes. Importantly, NaI detectors are susceptible to magnetic interferences, whereas HPGe detectors are not. There are also differences in the detector housing geometries that may cause different shielding effects at such a boundary. The changes observed between 60 and 65 ft in the recent gamma-profile may be caused by these or other differences between the two tools, and are likely not related to actual changes in the gamma profile." (*Report on Drywell Investigations around SST SX-104* [see Appendix E)

7.0 HYPOTHESES

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

Leak Hypothesis:

"The decrease in tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank."

No-Leak Hypothesis:

"The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, possibly complicated by redistribution of liquid observation well installation water."

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8.0 CONCLUSION

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. The 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 no-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 the tank was not likely leaking during the 1984 – 1988 engineering evaluation time frame.

Considering evaporation, together with the original questionable ILL data and the stable baseline readings in the drywells, the odds that the tank leaked are about one chance in nine. That is, there is about one chance in nine, based on the judgment of the leak assessment team that the observed in-tank and ex-tank data would be present if tank SX-104 was leaking. The team concluded that tank waste characteristics impeded the redistribution of the LOW installation water in the waste, and prevented the true ILL neutron tracking feature from being identified. When the correct, latent, neutron feature was identified and tracked, the data showed a stable ILL that was coming to equilibrium and overlaying the gamma ILL with no indication of a leak.

The recommendation of the assessment team was that the integrity status of tank SX-104 be changed from “Assumed Leaker” to “Sound.”

The results of this assessment were presented to the Executive Safety Review Board on January 28, 2011. The Board concurred with the recommendation of the assessment team.

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APPENDIX A – HISTORICAL EVAPORATION DETAILS

A liquid level decrease of greater than 0.3-ft was detected using a gamma probe in the LOW installed in Riser 16 of tank SX-104 in 1988. This decrease resulted in an Unusual Occurrence Report , as well as an Environmental Protection Deviation Report in 1988 (WHC-UO-88-028-TF-03, *Tank 241-SX-104 Has Been Classified as an Assumed Leaker*; EPDR 88-03, *Environmental Protection Deviation Report: Liquid Observation Wells (LOWs) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3 Foot Decrease Criteria with the Gamma Probe*). An engineering investigation was undertaken to review all available tank data including in situ gamma-ray spectra scans specifically commissioned to determine the cause of the liquid level decrease (13331-88-416, *Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104*).

The engineering investigation could find no conclusive evidence that the tank was in fact leaking, but also could not attribute the ILL decrease to evaporation with a 95% certainty. The worst case volume loss was calculated as 34 gallons/week. The spectral gamma drywell scans did not identify any subsurface contamination indicative of a tank leak, although this does not preclude the possibility of a leak.

In 1988 tank SX-104 and five other SX tank farm tanks were connected to the 241-SX Sludge Cooler via the tank SX-109 vent system. All six tanks contained large volumes of drainable liquid and four carried relatively large heat loads. The 1988 engineering investigation provided an example calculation of the effects of a tank vapor flow using a flow rate of 20 cfm to illustrate how a relatively small flow could account for a tank liquid loss by evaporation. The example calculation at 20 cfm resulted in a vapor liquid loss of 51 gallons/week, compared to the worst case ILL decreases volume loss of 34 gallons/week. The postulated 20 cfm rate could not be confirmed, however.

The engineering investigation reviewed the tank SX-104 surface level history from 1981 – 1988 which not only showed data variability but a statistically significant decreasing trend. A regression analysis over the seven year period was the basis for the 39 gallon/week decrease.

A 1984 drawing, H-2-90866, "*HVAC Airflow Diagram*," shows tanks SX-101 – SX-106 connected via a common manifold to tank SX-109. From tank SX-109 ductwork extends to the 241-SX Sludge Cooler filter and exhaust system. The drawing indicates a combined flow rate of 1100 cfm from these seven tanks which if equally distributed calculates to 157 cfm for each tank. The engineering investigation reported that routine psychometric measurements were taken at the tank SX-109 outlet air riser. The results indicated that an average rate of water removal was in the range of 302±197 gallons/week. The source was reported to be any or all of the seven tanks on this system. There was a discussion on the slope of portions of the vent system but any assumption for reflux condensate drainage was considered tenuous.

A 1994 report used a flow rate of 60 cfm (provided by Shift/Surveillance Engineering) which is probably closer to the actual forced ventilation flow, but is still less than one-half the flowrate based on an equal distribution of 1100 cfm across the seven tanks indicated on the drawing (WHC-SD-WM-ER-332, *Evaporation Analysis for Tank SX-104*). The 1994 report used the WVPCRUST model and various assumptions and parameters which resulted in a range of 17 gallons/week at 1% free surface liquid to 40 gallons/week at 3% free surface liquid. The free surface liquid was based on 1988 photo estimates of as much as 3% free surface area. Other parameter values appear to be estimated from the 1989 – 1993 time frame.

Examination of 1984 photos shows a liquid surface area in the range of 15-20%. This greater free surface liquid combined with a higher starting temperature would result in a greater evaporation rate. The period 1984 to 1988 would ultimately need to be integrated to address the changing conditions over the time period; however there are too many unquantifiable variables to perform a high-confidence evaporation analysis integrating this time period. Regardless, the increased flow rates, temperatures, and free surface liquid indicate that evaporation would have had a much greater effect than suspected in the 1988 investigation.

According to RPP-5660, *Collection and Analysis of Selected Tank Headspace Parameter Data*, the tank SX-104 passive ventilation breathing rate was measured with a pitot tube at 30 cfm. This rate was later was used to calculate the time to reach 25% and 100% Lower Flammability Limit (LFL) from the hydrogen generation rate.

The 20 cfm used in the 1988 engineering investigation for forced ventilation appears to be conservative compared to the rates inferred from the 241-SX Sludge Cooler airflow, the measured passive breathing rate, and those used in the 1994 report. Even an increase to 30 cfm, which would seem reasonable given the population of independently derived flowrates, would result in ~76 gallons per week equivalent decrease, a rate which is more than sufficient to account for the apparent ILL decrease in the 1981 – 1988 time period.

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APPENDIX B – TANK SX-104 LEAK ASSESSMENT TEAM MEETING MINUTES #1 – #4

Meeting #1 Minutes

MEETING MINUTES

SUBJECT: Tank SX-104 Leak Assessment Meeting #1				
TO: Distribution	BUILDING: 2750E/B-225			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 08/10/2009	NUMBER ATTENDING 8

Distribution:
D. A. Barnes+*
D.G. Baide
M.V. Berriochoa
J. W. Ficklin+*
J. G. Field+*
M. A. Fish+*
D. G. Harlow+*
K.J. Hull
N. M. Kirch+*
G.K. Mason*

Attendees*
Team Members+

Background:
The 1,000,000 gallon tank 241-SX-104 (tank SX-104) located in 200 West area was built in 1954 and is the first tank in a cascade series of three tanks including tank 241-SX-105 and tank 241-SX-106. Tank SX-104 received Reduction Oxidation (REDOX) waste from the first quarter of 1955 until the third quarter 1971. The tank continued to receive wastes including evaporator bottoms and recycle wastes, REDOX ion exchange waste, and partial neutralized feed waste until it was classified as double-shell slurry feed and removed from service in 1980. The tank was saltwell jet pumped 1988-1989. The tank was on the flammable gas watch list with an estimated retained gas volume and experienced 3 hydrogen release events prior to saltwell pumping and interim stabilization September 1997.

A cluster of four surface level increases exceeding criteria occurred between June 1976 and October 1977 attributed to floating crusts and “slurry growth” and was considered typical of the contained waste. No in-leakage was found and the tank was considered sound (OR 76-85, OR 76-125, OR 77-17, and OR77-188).

1988 SX-104 Assessment
A gradual liquid level decrease exceeding criteria detected using a neutron-neutron probe through a liquid observation well (LOW) prompted an Environmental Protection Deviation Report (88-03, Liquid Observation Wells (LOWS) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3 Foot Decrease Criteria with the Gamma Probe). An engineering investigation was undertaken (Internal Memo 13331-88-416, Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104, [13331-

88-416]) during which all available tank data were reviewed and in situ gamma-ray spectra were acquired in various boreholes surrounding the tank (SD-CP-TI-132, In-situ Gamma Spectroscopy Scans of Dry Wells Surrounding 241-SX-104 Tank). An Unusual Occurrence Report (8855768, Revision of Unusual Occurrence Report for Tank 241-SX-104 Number WHC-UO-028-TF-03) and an Event Fact Sheet TFSO-EFS-88-085 were issued to document the event and investigation.

The engineering investigation concluded there was no proof that the tank was leaking. However, the LOW decrease could not be attributed to evaporation with 95% certainty and the tank was classified as an assumed leaker and subsequently jet pumped. An estimated worst case liquid loss of 5,300 gal over a three-year period was based on the LOW liquid-level decrease.

1998 SX-104 Assessment
Interstitial liquid level (ILL) variations of up to 6 in. were observed in the tank and it was suspected of re-leaking in 1998. The ILL changes were shown to correlate with barometric pressure changes attributed to changes in waste porosity based on empirical measurements from water additions in February 1997 and February 1998, combined with increases in capillary strength from the reduced porosity. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquids to the waste surface from the increased capillary strength. Drywell spectral gamma scans in January 1998 showed no changes from the 1995 baseline scans. The assessment recommended that the tank not be declared a re-leaker (HNF-2617). The assessment did not review the original 1987 classification of the tank as an assumed leaker.

2008 SX-104 Assessment
Interstitial liquid level monitoring December 2006 using a new well in Riser 7a showed the predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization of the level by January 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable -1.2 in criterion with further decreases on May 6 and May 12, 2008. On May 19, 2008 a formal leak assessment was initiated to determine if the tank was re-leaking (RPP-ASMT-38450, Tank 241-SX-104 Leak Assessment Report). Additional drywell and LOW gross gamma measurements were obtained and weekly neutron LOW scans were performed through June 2008. No change in dry well data was observed. Gross gamma measurements showed a potential different and more stable liquid level than was being tracked by the neutron probe and the water used to install the liquid observation well in December 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge-amounts of gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak. The consensus of the assessment team was that tank SX-104 was not actively leaking (RPP-ASMT-38450). The assessment did not review the original 1987 classification of the tank as an assumed leaker.

2009 SX Farm Leak Assessments
Tank SX-104 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventorie*s. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory estimates as emergent field data is obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report,* generated the following conclusion:

> "*Tank SX-104 was classified as questionable integrity based on ILL decreases from 1994 to 1998. ILL*

decreases were also observed in 1998 and 2008. Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are also several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment and no leak inventory was assigned for this tank. The tank was previously classified as "questionable integrity" because a 95% confidence in and no -leak alternative was not established. However, the current assessment concluded it is reasonably certain the tank did not leak. Therefore, no inventory is assigned for a leak from this tank".

Next Meeting:
The next assessment team meeting is scheduled for 8-14-09, 0900 in 2750/B225

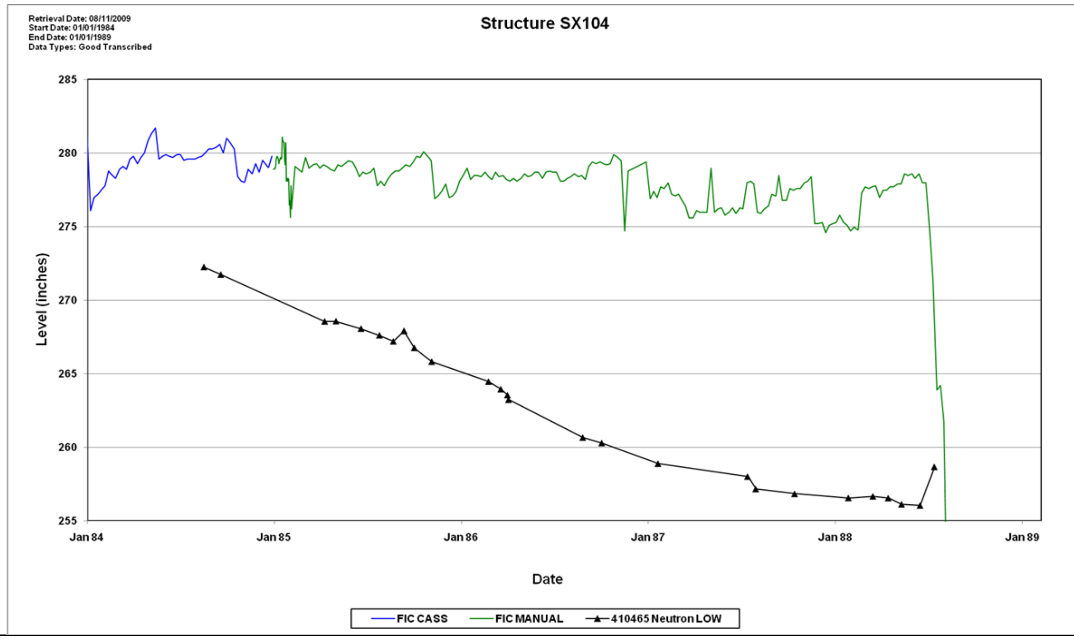
Discussion:
The conclusion for tank SX-104 stated above provided the basis for evaluation of a potential change in the tank SX-104 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process.* A tank SX-104 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process. These are the minutes of the first meeting of the tank SX-104 Evaluation Team including the presentation slides (attached).

Team Member Actions Status:
Leak assessment actions from the August 10th meeting are listed below:

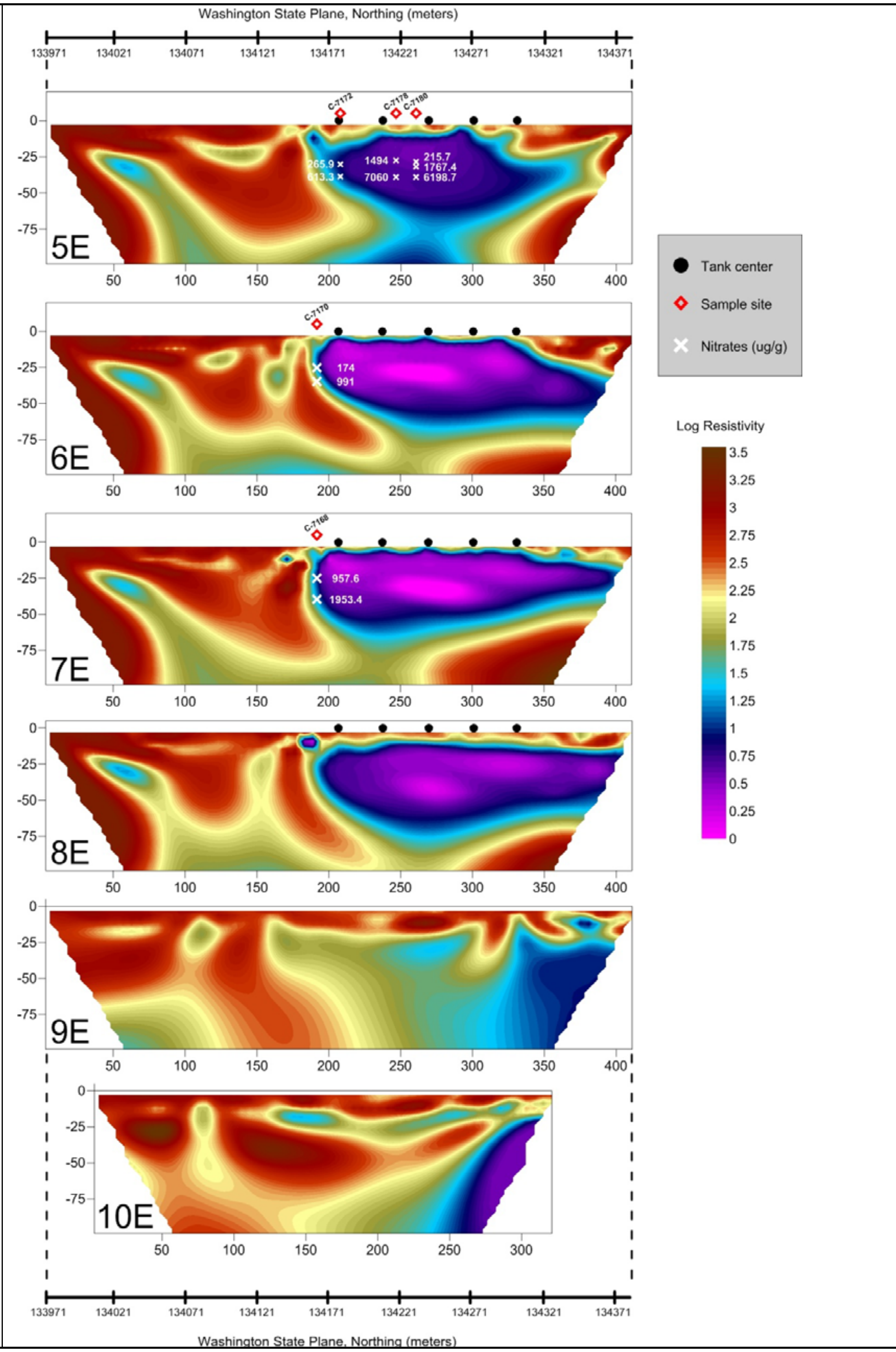
	Member	Action
1.	D.A. Barnes	WVP Crust Model for SX-104. *Status:* Complete, SX104 Evap Analysis using WVPCRUST model: WHC-SD-WM-ER-332, Rev 0 This document analyzes the liquid loss immediately following SWP from about 1989 through 1991, so may not be directly applicable to the 1984-89 pre-SWP timeframe. It contains a discussion of the WVPCRUST model, particularly liquid diffusion through the crust.
2.	D.A. Barnes	Review information available on GREs and changes in surface level available from CASS data. *Status:* SX111 & SX112 LOW comparison to SX104: Two files attached. LOW in SX111 was installed in August 2003 and SX112 was installed in February 2004. Since both LOWs were installed well after SWP was completed, no direct comparison of "GRE behavior" to pre-SWP SX104 is possible. (Files not applicable and were not attached).

<table>
<tr>
<td>3.</td>
<td>D.A. Barnes</td>
<td>
LOW information on SX-111 and SX-112 leakers for comparison with SX-104 LOWs.

Status: SX104 LOW plot, looking for evidence of GRE: See plot below. Surface shows buildup/drop behavior of GREs. The FIC gauge is accurate to about 0.10 inches if it contacts a surface with high conductivity. The LOW data shows steady loss, but not enough resolution to determine GRE activity. Early loss is consistent with redistribution of LOW installation liquid over time, although 2-3 years seems long in this case unless the waste was very low permeability. The trend seems to be flattening out the last year before failure.



</td>
</tr>
<tr>
<td>4.</td>
<td>J.G. Field</td>
<td>Send out SGE report showing high moisture content in north half of tank farm.
Status: Complete, SGE sent 8/11/09.</td>
</tr>
</table>


Washington State Plane, Northing (meters)
5E
6E
7E
8E
9E
10E
Tank center
Sample site
Nitrates (ug/g)
Log Resistivity

5.	J.G. Field	Send SX-104 excerpt from RPP-ENV-39658 Rev 0 DRAFT *Status:* Complete, SX-104 excerpt sent 8/11/09
6.	M.A. Fish	Sludge Cooler operation and configuration and drawings. Which tanks? Where did condensate drain? *Status:*
7.	D.G. Harlow	List of UOs and 1988 LOW Decrease Information *Status:* Complete, List sent 8/11/09, attached
8.	D.J. Washenfelder	Drywell Gross Gamma history from HNF-3136, R.R. Randall and R.K. Price, *Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs*. Any short-lived radionuclides present? *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title

Documents:

Number	Title
RPP-ENV-39658, Rev. 0	Hanford SX-Farm Leak Assessment Report (DRAFT)

Drawings:

Number	Title

Meeting #2 Minutes

MEETING MINUTES

SUBJECT: Tank SX-104 Leak Assessment Meeting #2				
TO: Distribution	BUILDING: 2750E/B-225			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 08/14/2009	NUMBER ATTENDING 9

Distribution:
D.A. Barnes+*
D.G. Baide
M.V. Berriochoa
J.W. Ficklin+*
J.G. Field+*
M.A. Fish+*
D.G. Harlow+*
K.J. Hull
J.M. Johnson* (ORP)
N.M. Kirch+*
E.C. Shallman*

Attendees*
Team Members+

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2008 SX-104 Assessment
Interstitial liquid level monitoring December 2006 using a new well in Riser 7a showed the predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization of the level by January 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable -1.2 in criterion with further decreases on May 6 and May 12, 2008. On May 19, 2008 a formal leak assessment was initiated to determine if the tank was re-leaking (RPP-ASMT-38450, Tank 241-SX-104 Leak Assessment Report). Additional drywell and LOW gross gamma measurements were obtained and weekly neutron LOW scans were performed through June 2008. No change in dry well data was observed. Gross gamma measurements showed a potential different and more stable liquid level than was being tracked by the neutron probe and the water used to install the liquid observation well in December 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge-amounts of gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak. The consensus of the assessment team was that tank SX-104 was not actively leaking (RPP-ASMT-38450). The assessment did not review the original 1987 classification of the tank as an assumed leaker.

2009 SX Farm Leak Assessments
Tank SX-104 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventorie*s. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory estimates as emergent field data is obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report,* generated the following conclusion:

"Tank SX-104 was classified as questionable integrity based on ILL decreases from 1994 to 1998. ILL decreases were also observed in 1998 and 2008. Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are also several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment and no leak inventory was assigned for this tank. The tank was previously classified as "questionable integrity" because a 95% confidence in and no -leak alternative was not established. However, the current assessment concluded it is reasonably certain the tank did not leak. Therefore, no inventory is assigned for a leak from this tank".

The conclusion for tank SX-104 stated above provided the basis for evaluation of a potential change in the tank SX-104 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process.* A tank SX-104 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process. These are the minutes of the second meeting of the tank SX-104 Evaluation Team; presentation slides were included in SX-104 Leak Assessment Meeting Minutes #1.

Next Meeting:
The next assessment team meeting is scheduled for 8-20-09, 0900 in 2750/B225. This meeting is to finalize the Leak-No Leak hypotheses and score the Elicitation Forms.

Discussion:

The WVP Crust Model was discussed as it might relate to the 1984-1988.

- The model had not been applied to the 1984-1988 interstitial liquid level (ILL) decrease. Supporting memo is not available but analysis results says process should be changed because tank was probably not leaking but 95% confidence drove the conclusion to a leaking tank.
- As indicated in Action # 1. The evaporation analysis documented in WHC-SD-WM-ER-332, Rev 0 may not be directly applicable depending on the amount of free liquid and diffusion through the crust which was probably different at least in the earlier part of the 4 year period. This prompted a review of the 1984 through 1988 photos action # 9.
- The secondary feature in the ILL was present in October 1987, 1985, and 1984 and follows the 2006-2008 ILL decrease behavior
- The dish tank bottom could affect the reference point which could amount to an 18-inch offset.
- There is a potential problem in comparing ILL in 1984-1988 (in salt cake) to 2006 (sludge), but could still account for the phenomena if the waste characteristics are similar
- Drywell radiation readings show nothing however there is some moisture indicated by the neutron probes.

A draft Leak – No-Leak hypothesis was formulated as follows:

Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank.

No-Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, [possibly complicated by redistribution of liquid observation installation water – conditional on Dave Barnes review Action # 10].

Team Member Actions Status:
Leak assessment actions from the August 10th meeting are listed below along with actions 9. and 10. from this meeting:

	Member	Action
1.	D.A. Barnes	WVP Crust Model for SX-104. *Status:* Complete, SX104 Evap Analysis using WVPCRUST model: WHC-SD-WM-ER-332, Rev 0 This document analyzes the liquid loss immediately following SWP from about 1989 through 1991, so may not be directly applicable to the 1984-89 pre-SWP timeframe. It contains a discussion of the WVPCRUST model, particularly liquid diffusion through the crust.
2.	D.A. Barnes	Review information available on GREs and changes in surface level available from CASS data. *Status:* Complete, SX111 & SX112 LOW comparison to SX104: Two files attached. LOW in SX111 was installed in August 2003 and SX112 was installed in February 2004. Since both LOWs were installed well after SWP was completed, no direct comparison of “GRE behavior” to pre-SWP SX104 is possible. (Files not applicable and were not attached).
3.	D.A. Barnes	LOW information on SX-111 and SX-112 leakers for comparison with SX-104 LOWs. *Status:* Complete, SX104 LOW plot, looking for evidence of GRE: See plot below. Surface shows buildup/drop behavior of GREs. The FIC gauge is accurate to about 0.10 inches if it contacts a surface with high conductivity. The LOW data shows steady loss, but not enough resolution to determine GRE activity. Early loss is consistent with redistribution of LOW installation liquid over time, although 2-3 years seems long in this case unless the waste was very low permeability. The trend seems to be flattening out the last year before failure, included in SX-104 Leak Assessment Meeting Minutes #1.
4.	J.G. Field	Send out SGE report showing high moisture content in north half of tank farm. *Status:* Complete, SGE sent 8/11/09, included in SX-104 Leak Assessment Meeting Minutes #1 SGE shows moisture for the North end of the 241-SX farm. However, the resistivity measurement does not correlate with clean drywells. Nearby pond and crib could account for salts that drive the resistivity versus waste leaks. Therefore SGE is inconclusive.
5.	J.G. Field	Send SX-104 excerpt from RPP-ENV-39658 Rev 0 DRAFT. *Status:* Complete, SX-104 excerpt sent 8/11/09.

6.	M.A. Fish	Sludge Cooler operation and configuration and drawings. Which tanks? Where did condensate drain? *Status:* Preliminary information reviewed on recent drawing of vent system. Ventilation for the first seven SX farm tanks are routed through tank SX-107, H-14-020134 shows the route. Need more information including 106-SX Sludge Cooler. Earlier documentation (HW—31884) indicates that the first six SX farm tanks are routed through tank SX-106 . Further review is in progress and will include timing and implication of any vent system routing changes.
7.	D.G. Harlow	List of UOs and 1988 LOW Decrease Information. *Status:* Complete, List sent 8/11/09, included in SX-104 Leak Assessment Meeting Minutes #1.
8.	D.J. Washenfelder	Drywell Gross Gamma history from HNF-3136, R.R. Randall and R.K. Price, *Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs*. Any short-lived radionuclides present? *Status:* Complete, sent 8/12/09, included in SX-104 Leak Assessment Meeting Minutes #1
9.	D.A. Barnes	Explore the ILL readings 1984-1988 and the potential for increased effects from a different diffusion band and free liquid surface. *Status:*
10.	E.C. Shallman	Compare available photos 1984 through 1988 for liquid surfaces and changes *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title

Documents:

Number	Title
RPP-ENV-39658, Rev. 0	Hanford SX-Farm Leak Assessment Report (DRAFT)
HW--31884	Project CA 539 241-SX Tank Farm Description and Use of Facilities

Drawings:

Number	Title

Meeting #3 Minutes

MEETING MINUTES

SUBJECT: Tank SX-104 Leak Assessment Meeting #3				
TO: Distribution	BUILDING: 2750E/B-225			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 08/20/2009	NUMBER ATTENDING 6

Distribution:
D.A. Barnes+
D.G. Baide
M.V. Berriochoa
J.W. Ficklin+*
J.G. Field+
M.A. Fish+*
D.G. Harlow+*
K.J. Hull
J.M. Johnson* (ORP)
E.C. Shallman*

Attendees*

Team Members+

Background:
The 1,000,000 gallon tank 241-SX-104 (tank SX-104) located in 200 West area was built in 1954 and is the first tank in a cascade series of three tanks including tank 241-SX-105 and tank 241-SX-106. Tank SX-104 received Reduction Oxidation (REDOX) waste from the first quarter of 1955 until the third quarter 1971. The tank continued to receive wastes including evaporator bottoms and recycle wastes, REDOX ion exchange waste, and partial neutralized feed waste until it was classified as double-shell slurry feed and removed from service in 1980. The tank was saltwell jet pumped 1988-1989. The tank was on the flammable gas watch list with an estimated retained gas volume and experienced 3 hydrogen release events prior to saltwell pumping and interim stabilization September 1997.

A cluster of four surface level increases exceeding criteria occurred between June 1976 and October 1977 attributed to floating crusts and “slurry growth” and was considered typical of the contained waste. No in-leakage was found and the tank was considered sound (OR 76-85, OR 76-125, OR 77-17, and OR77-188).

1988 SX-104 Assessment
A gradual liquid level decrease exceeding criteria detected using a neutron-neutron probe through a liquid observation well (LOW) prompted an Environmental Protection Deviation Report (88-03, Liquid Observation Wells (LOWS) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3

Foot Decrease Criteria with the Gamma Probe). An engineering investigation was undertaken (Internal Memo 13331-88-416, Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104) during which all available tank data were reviewed and in situ gamma-ray spectra were acquired in various boreholes surrounding the tank (SD-CP-TI-132, In-situ Gamma Spectroscopy Scans of Dry Wells Surrounding 241-SX-104 Tank). An Unusual Occurrence Report (8855768, Revision of Unusual Occurrence Report for Tank 241-SX-104 Number WHC-UO-028-TF-03) and an Event Fact Sheet TFSO-EFS-88-085 were issued to document the event and investigation.

The engineering evaluation (Internal Memo 13311-88-049, Evaluation of Integrity of Tank 241-SX-104) concluded there was no proof that the tank was leaking. However, the ILL decrease could not be attributed to evaporation with 95% certainty and the tank was classified as an assumed leaker and subsequently jet pumped. An estimated worst case liquid loss of 5,300 gal over a three-year period was based on the LOW liquid-level decrease.

1998 SX-104 Assessment
Interstitial liquid level (ILL) variations of up to 6 in. were observed in the tank and it was suspected of re-leaking in 1998. The ILL changes were shown to correlate with barometric pressure changes attributed to changes in waste porosity based on empirical measurements from water additions in February 1997 and February 1998, combined with increases in capillary strength from the reduced porosity. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquids to the waste surface from the increased capillary strength. Drywell spectral gamma scans in January 1998 showed no changes from the 1995 baseline scans. The assessment recommended that the tank not be declared a re-leaker (HNF-2617). The assessment did not review the original 1987 classification of the tank as an assumed leaker.

2008 SX-104 Assessment
Interstitial liquid level monitoring December 2006 using a new well in Riser 7a showed the predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization of the level by January 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable -1.2 in criterion with further decreases on May 6 and May 12, 2008. On May 19, 2008 a formal leak assessment was initiated to determine if the tank was re-leaking (RPP-ASMT-38450, Tank 241-SX-104 Leak Assessment Report). Additional drywell and LOW gross gamma measurements were obtained and weekly neutron LOW scans were performed through June 2008. No change in dry well data was observed. Gross gamma measurements showed a potential different and more stable liquid level than was being tracked by the neutron probe and the water used to install the liquid observation well in December 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge-amounts of gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak. The consensus of the assessment team was that tank SX-104 was not actively leaking (RPP-ASMT-38450). The assessment did not review the original 1987 classification of the tank as an assumed leaker.

2009 SX Farm Leak Assessments
Tank SX-104 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventorie*s. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory estimates as emergent field data is obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report,* generated the following conclusion:

"Tank SX-104 was classified as questionable integrity based on ILL decreases from 1994 to 1998. ILL

decreases were also observed in 1998 and 2008. Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are also several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment and no leak inventory was assigned for this tank. The tank was previously classified as "questionable integrity" because a 95% confidence in and no -leak alternative was not established. However, the current assessment concluded it is reasonably certain the tank did not leak. Therefore, no inventory is assigned for a leak from this tank".

The conclusion for tank SX-104 stated above provided the basis for evaluation of a potential change in the tank SX-104 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process.* A tank SX-104 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process. These are the minutes of the third meeting of the tank SX-104 Evaluation Team.

Next Meeting:
A follow-up meeting is scheduled for 8-25-09, 1300 in 2750/B203 to score the Elicitation Forms for the SX-104 Leak Assessment team members not able to attend the 8-20-09 meeting..

Discussion:

The following items were discussed from the items in previous meeting.

- As indicated in Action # 1. The evaporation analysis documented in WHC-SD-WM-ER-332, Rev 0 may not be directly applicable depending on the amount of free liquid and diffusion through the crust which was probably different at least in the earlier part of the 4 year period. This prompted a review of the 1984 through 1988 photos action # 9. Photos from 1984 and 1988 were reviewed and the consensus was that much more than 3% of the surface area, possible as high as 20-25% in the earlier part of the period could be free liquid and contribute to evaporation including increased crust diffusion. Evaporation analysis has been added as Action #11.
- The secondary feature in the ILL was present in October 1987, 1985, and 1984 and follows the 2006-2008 ILL decrease behavior which coupled with an evaporation analysis may account for the 1984-1988 ILL decrease.
- The dish tank bottom could affect the reference point which could amount to an 18-inch offset and will be considered in follow-on actions as appropriate.
- There is a potential problem in comparing ILL in 1984-1988 (in salt cake) to 2006 (sludge), but could still account for the phenomena if the waste characteristics are similar. This should be considered in Action #11
- The SX farm sludge cooler was in existence in 1982 and prints indicated 1100cfm total for the first seven tanks. There are however dampers for each individual tank and no specific flow rates for individual tanks were found.

Expert elicitation forms were filled out by the team members present assuming that the evaporation analysis to be provided by Dave Barnes coupled with the ILL decrease behavior would account for the 1984-1988 ILL decrease. With this in mind it was agreed that scoring of the Elicitation Form could proceed based on the assumption that evaporation could more fully explain the ILL decrease reported in Internal Memo 13331-88-416, Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104 and evaluated in Internal Memo 13311-88-049, Evaluation of Integrity of Tank 241-SX-104. The scoring resulted in the following individual scores: 0.02, 0.06, 0.03, and 0.18. The remaining team members will be meeting to score their elicitation forms in a follow-up meeting.

If the evaporation analysis cannot explain the interstitial liquid level decrease an additional scoring meeting will need to be scheduled.

A Leak – No-Leak hypothesis was formulated as follows:

Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank.

No-Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, possibly complicated by redistribution of liquid observation installation. This is the No- Leak Hypothesis which was finalized based on discussions and data from Dave Barnes relevant to Action # 10 obtained after this meeting.

Team Member Actions Status:

Leak assessment actions from the August 10th and 20th meetings are listed below along with new action #11:

	Member	Action
1.	D.A. Barnes	WVP Crust Model for SX-104. *Status:* Complete, SX104 Evap Analysis using WVPCRUST model: WHC-SD-WM-ER-332, Rev 0 This document analyzes the liquid loss immediately following SWP from about 1989 through 1991, so may not be directly applicable to the 1984-89 pre-SWP timeframe. It contains a discussion of the WVPCRUST model, particularly liquid diffusion through the crust.
2.	D.A. Barnes	Review information available on GREs and changes in surface level available from CASS data. *Status:* Complete, SX111 & SX112 LOW comparison to SX104: Two files attached. LOW in SX111 was installed in August 2003 and SX112 was installed in February 2004. Since both LOWs were installed well after SWP was completed, no direct comparison of “GRE behavior” to pre-SWP SX104 is possible. (Files not applicable and were not attached).
3.	D.A. Barnes	LOW information on SX-111 and SX-112 leakers for comparison with SX-104 LOWs. *Status:* Complete, SX104 LOW plot, looking for evidence of GRE: See plot below. Surface shows buildup/drop behavior of GREs. The FIC gauge is accurate to about 0.10 inches if it contacts a surface with high conductivity. The LOW data shows steady loss, but not enough resolution to determine GRE activity. Early loss is consistent with redistribution of LOW installation liquid over time, although 2-3 years seems long in this case unless the waste was very low permeability. The trend seems to be flattening out the last year before failure, included in SX-104 Leak Assessment Meeting Minutes #1.
4.	J.G. Field	Send out SGE report showing high moisture content in north half of tank farm. *Status:* Complete, SGE sent 8/11/09, included in SX-104 Leak Assessment Meeting

		Minutes #1 SGE shows moisture for the North end of the 241-SX farm. However, the resistivity measurement does not correlate with clean drywells. Nearby pond and crib could account for salts that drive the resistivity versus waste leaks. Therefore SGE is inconclusive.
5.	J.G. Field	Send SX-104 excerpt from RPP-ENV-39658 Rev 0 DRAFT. *Status:* Complete, SX-104 excerpt sent 8/11/09.
6.	M.A. Fish	Sludge Cooler operation and configuration and drawings. Which tanks? Where did condensate drain? *Status:* Preliminary information reviewed on recent drawing of vent system. Ventilation for the first seven SX farm tanks are routed through tank SX-109, H-14-020134 shows the route. Need more information including SX Sludge Cooler. Earlier documentation (HW—31884) indicates that the first six SX farm tanks were routed through tank SX-106. Further review is in progress and will include timing and implication of any vent system routing changes. Additional prints show 1100 cfm for the first seven tanks including SX-109 mentioned above. The sludge cooler was reported to be in existence in 1982 and earlier.
7.	D.G. Harlow	List of UOs and 1988 LOW Decrease Information *Status:* Complete, List sent 8/11/09, included in SX-104 Leak Assessment Meeting Minutes #1.
8.	D.J. Washenfelder	Drywell Gross Gamma history from HNF-3136, R.R. Randall and R.K. Price, *Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs*. Any short-lived radionuclides present? *Status:* Complete, sent 8/12/09, included in SX-104 Leak Assessment Meeting Minutes #1.
9.	D.A. Barnes	Explore the ILL readings 1984-1988 and the potential for increased effects from a different diffusion band and free liquid surface. *Status:* Preliminary information indicates similarities of the 1984-1988 ILL and the 2006-2008 ILL with the redistribution of LOW installation liquid.
10.	E.C. Shallman	Compare available photos 1984 through 1988 for liquid surfaces and changes. *Status:* Complete, photos from 1984 and 1988 were reviewed and the consensus was that much more than 3% of the surface area, possible as high as 20-25% in the earlier part of the period could be free liquid and contribute to evaporation including increased crust diffusion. This will affect the evaporation model calculations.
11.	D.A. Barnes	Provide an evaporation analysis for the 1984-1988 salt cake storage period using the information provided by the 1984 and 1988 photos to estimate the liquid surface area available and the crust diffusion parameters. *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title

Documents:

Number	Title
RPP-ENV-39658, Rev. 0	Hanford SX-Farm Leak Assessment Report (DRAFT)
HW--31884	Project CA 539 241-SX Tank Farm Description and Use of Facilities

Drawings:

Number	Title

Meeting #4 Minutes

MEETING MINUTES

SUBJECT: Tank SX-104 Leak Assessment Meeting #4				
TO: Distribution	BUILDING: 2750E/B-225			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 08/25/2009	NUMBER ATTENDING 4

Distribution:
D.A. Barnes+*
D.G. Baide
M.V. Berriochoa
J.W. Ficklin+
J.G. Field+*
M.A. Fish+
D.G. Harlow+*
K.J. Hull
J.M. Johnson (ORP)
E.C. Shallman+*

Attendees*

Team Members+

Background:
The 1,000,000 gallon tank 241-SX-104 (tank SX-104) located in 200 West area was built in 1954 and is the first tank in a cascade series of three tanks including tank 241-SX-105 and tank 241-SX-106. Tank SX-104 received Reduction-Oxidation (REDOX) waste from the first quarter of 1955 until the third quarter 1971. The tank continued to receive waste including evaporator bottoms, recycle waste, REDOX ion exchange waste, and partially neutralized feed waste until it was classified as double-shell slurry feed and removed from service in 1980. The tank was saltwell jet pumped 1988-1989. The tank was on the flammable gas watch list with an estimated retained gas volume of 250 m^3 and experienced three hydrogen release events prior to saltwell pumping and interim stabilization September 1997.

A cluster of four surface level increases exceeding criteria occurred between June 1976 and October 1977 attributed to floating crusts and “slurry growth” and was considered typical of the contained waste. No in-leakage was found and the tank was considered sound (OR 76-85, OR 76-125, OR 77-17, and OR 77-188).

1988 SX-104 Assessment
A gradual liquid level decrease exceeding criteria detected using a neutron-neutron probe through a liquid observation well (LOW) prompted an Environmental Protection Deviation Report (88-03, Liquid Observation

Wells (LOWS) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3 Foot Decrease Criteria with the Gamma Probe). An engineering investigation was undertaken (Internal Memo 13331-88-416, Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104) during which all available tank data were reviewed and in situ gamma-ray spectra were acquired in various drywells surrounding the tank (SD-CP-TI-132, In-situ Gamma Spectroscopy Scans of Dry Wells Surrounding 241-SX-104 Tank). An Unusual Occurrence Report (8855768, Revision of Unusual Occurrence Report for Tank 241-SX-104 Number WHC-UO-028-TF-03) and an Event Fact Sheet (TFSO-EFS-88-085) were issued to document the event and investigation.

A management peer review (Internal Memo 13311-88-049, Evaluation of Integrity of Tank 241-SX-104) concluded there was no proof that the tank was leaking. However, the ILL decrease could not be attributed to evaporation with 95% certainty and the tank was classified as an assumed leaker and subsequently jet pumped. An estimated worst case liquid loss of 5,300 gal over a three-year period was based on the LOW liquid-level decrease.

1998 SX-104 Assessment
Interstitial liquid level (ILL) variations of up to 6 in. were observed in the tank and it was suspected of re-leaking in 1998. The ILL changes were shown to correlate with barometric pressure changes attributed to changes in waste porosity based on empirical measurements from water additions in February 1997 and February 1998, combined with increases in capillary strength from the reduced porosity. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquids to the waste surface from the increased capillary strength. Drywell spectral gamma scans in January 1998 showed no changes from the 1995 baseline scans. The assessment recommended that the tank not be declared a re-leaker (HNF-2617). The assessment did not review the original 1988 classification of the tank as an assumed leaker.

2008 SX-104 Assessment
Interstitial liquid level monitoring December 2006 using a new LOW in Riser 7A showed a predictable increase in ILL from the installation water, followed by a natural decline and re-stabilization of the level by January 2008 as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable -1.2 in criterion with further decreases on May 6 and May 12, 2008. On May 19, 2008 a formal leak assessment was initiated to determine if the tank was re-leaking (RPP-ASMT-38450, Tank 241-SX-104 Leak Assessment Report). Additional drywell and LOW gross gamma measurements were obtained and weekly neutron LOW scans were performed through June 2008. No change in dry well data was observed. Gross gamma measurements showed a potential different and more stable liquid level than was being tracked by the neutron probe. The water used to install the liquid observation well in December 2006 obscured the true interstitial liquid level feature because of localized impermeability in the sludge, probably created by trapped gas. These waste characteristics impeded the redistribution of the liquid observation well installation water in the waste. When the correct, latent, feature was identified and tracked, the data showed a stable interstitial liquid level and no indication of a new leak. The consensus of the assessment team was that tank SX-104 was not actively leaking (RPP-ASMT-38450). The assessment did not review the original 1988 classification of the tank as an assumed leaker.

2009 SX Farm Leak Assessments
Tank SX-104 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory

estimates as emergent field data are obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report*, generated the following conclusion:

> *"Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are also several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment and no leak inventory was assigned for this tank. The tank was previously classified as "questionable integrity" because a 95% confidence in a no -leak alternative was not established. However, the current assessment concluded it is reasonably certain the tank did not leak. Therefore, no inventory is assigned for a leak from this tank".*

The conclusion for tank SX-104 stated above provided the basis for evaluation of a potential change in the tank SX-104 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process.* A tank SX-104 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process. These are the minutes of the fourth and final meeting of the tank SX-104 Evaluation Team.

Discussion:

The following items were discussed from the items in previous meeting.

- As indicated in Action # 1. The 1994 evaporation analysis documented in WHC-SD-WM-ER-332, Rev 0, which provided best estimates for 1%, 2% and 3% free liquid, may not be directly applicable. This is because the amount of free liquid and diffusion up through the crust in the earlier 1984 period was probably different than the later 1988 period. This prompted a review of the 1984 through 1988 photos - Action # 10. Photos from 1984 and 1988 were reviewed and the consensus was that much more than 3% of the surface area, possible as high as 15-20% in the earlier part of the period (1984) could be free liquid and contribute to evaporation including increased crust diffusion. Evaporation analysis has been added as Action #11.
- The secondary feature in the ILL was probably present in 1984-1988 and followed the 2006-2008 ILL decrease behavior. The ILL decrease behavior coupled with evaporation may account for the 1984-1988 ILL decrease. See Action #9 for an in depth review of the LOW neutron and gamma profiles.
- The dish tank bottom could affect the reference point which could amount to a 14.875-inch offset (H-2-39511) and will be considered in follow-on actions as appropriate.
- There is a potential problem in comparing ILL in 1984-1988 (salt cake) to 2006 (sludge), but could still account for the phenomena if the waste characteristics are similar. The 1984-1988 salt cake was actually re-evaporation of salt cake feed which, according to RPP-RPT-38419, Rev 0, *Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks*, results in significant particle size reduction, producing a waste that behaves very much like sludge. Any evaporation which would further reduce the concentration would magnify the effect.
- The SX farm sludge cooler was operating in 1982 and prints indicated 1100 cfm total for the first seven tanks, although there are dampers for each individual tank and no specific flow rates for individual tanks were found.

Expert elicitation forms were filled out by the team members present assuming that an evaporation analysis coupled with the ILL decrease behavior would account for the 1984-1988 ILL decrease. With this in mind it was agreed that scoring of the Elicitation Form could proceed based on the assumption that evaporation and ILL decrease behavior could more fully explain the ILL decrease reported in Internal Memo 13331-88-416, *Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104* and evaluated in Internal Memo 13311-88-049, *Evaluation of Integrity of Tank 241-SX-104*. The scoring resulted in the following individual scores: 0.02, 0.06, 0.13 (corrected), 0.14 added (Shallman), and 0.18. The following are the remaining team member's individual scores from this follow-up meeting: 0.07 and 0.19.

Evaporation coupled with slow diffusion of LOW installation water through crust could account for the 1984-1988 SX-104 ILL decrease behavior, see status of action #9 and #10.

There was therefore consensus of the assessment team that tank SX-104 had a high probability of not leaking during the ILL decrease in the 1984-1988 period

A Leak – No-Leak hypothesis was formulated as follows:

Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank.

No-Leak Hypothesis: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, possibly complicated by redistribution of liquid observation well installation water. This is the No- Leak Hypothesis which was finalized based on discussions and data from Dave Barnes relevant to Action # 9 obtained after the August 20th meeting.

Team Member Actions Status:
Leak assessment actions from the August 10th through 20th meetings (including August 20th follow-up) are listed below along with new action #11:

	Member	Action
1.	D.A. Barnes	WVP Crust Model for SX-104. *Status:* Complete, SX104 Evap Analysis using WVPCRUST model: WHC-SD-WM-ER-332, Rev 0 provides an provides an analysis of the liquid loss (evaporation) immediately following saltwell pumping (SWP) from about 1989 through 1991, which may not be directly applicable to the 1984-89 pre-SWP timeframe. It contains a discussion of the WVPCRUST model, particularly liquid diffusion up through the crust. The 1984-1988 period deals with evaporation up through the crust as well as the dissipation of LOW installation water down through the waste structure. See item #9 and #10 below.

2.	D.A. Barnes	Review information available on GREs and changes in surface level available from CASS data. *Status:* Complete, SX111 & SX112 LOW comparison to SX104: Two files reviewed. LOW in SX111 was installed in August 2003 and SX112 was installed in February 2004. Since both LOWs were installed well after SWP was completed, no direct comparison of "GRE behavior" to pre-SWP SX104 is possible. (Files not applicable and were not attached).
3.	D.A. Barnes	LOW information on SX-111 and SX-112 leakers for comparison with SX-104 LOWs. *Status:* Complete, SX104 LOW plot, looking for evidence of GRE: Surface shows buildup/drop behavior of GREs. The FIC gauge is accurate to about 0.10 inches if it contacts a surface with high conductivity. The LOW data show steady loss, but not enough resolution to determine GRE activity. Early loss is consistent with redistribution of LOW installation liquid over time, although 2-3 years seems long in this case unless the waste was very low permeability. The trend seems to be flattening out the last year before failure, included in SX-104 Leak Assessment Meeting Minutes #1, Also see item #9 below.
4.	J.G. Field	Send out SGE report showing high moisture content in north half of tank farm. *Status:* Complete, SGE sent 8/11/09, included in SX-104 Leak Assessment Meeting Minutes #1 SGE shows moisture for the North end of the 241-SX farm. However, the resistivity measurement does not correlate with clean drywells. Nearby pond and crib could account for salts that drive the resistivity versus waste leaks. Therefore SGE is inconclusive.
5.	J.G. Field	Send SX-104 excerpt from RPP-ENV-39658 Rev 0 DRAFT. *Status:* Complete, SX-104 excerpt sent 8/11/09.
6.	M.A. Fish	Sludge Cooler operation and configuration and drawings. Which tanks? Where did condensate drain? *Status:* Complete. **Drawing date 1973** Drawing # H-2-46238, "*Engineering Flow Diagram 241-SX Tank Farm Tanks 101, 104 & 106*" dated 1973 states for tank SX-104 - for vessel vent system see H-2-39579 (typical). H-2-39579 shows tanks SX-101 to SX-106 connected via a common manifold. From SX-106 a second ventilation connection went to condenser buildings 241-SX-401 & 402. It appears all six tanks were ventilated via SX-106 to the condenser buildings and then to atmosphere with no forced ventilation. H-2-39576 "*Vapor manifold & Condensate System Details Waste Disposal facility 241-SX*" shows that each tank had a control valve on the vapor manifold. **Drawing date 1984 (As-built for Project B-384)** Drawing # H-2-90866 "*HVAC Airflow Diagram*" shows tanks SX-101 to SX-106

		connected via a common manifold to SX-109. From SX-109 a second ventilation connection went to the "Sludge Cooler" filter and exhaust system. It appears all seven tanks were ventilated via this common header, the drawing showing a combined flow rate of 1100 cfm from these seven tanks. Equally distributed calculates to 157 cfm each. According to RPP-5660 *Collection and Analysis of Selected Tank Headspace Parameter Data* Table 3-17 "Submitted Ventilation Rate References," tank SX-104 ventilation rate was measured with a pitot tube and published in 1997 (p55).The 1997 reference (HNF-SD-WM-CN-116 *Calculation Note: Hydrogen Generation Rates at Steady-State Flammable Gas Concentrations for Single Shell Tanks"*. Table 3. "Actively Ventilated Single Shell Tanks" (p10) shows the active ventilation rate of SX-104 as 30 cfm. The 20 cfm used in the original 1988 Engineering Investigation would have been for forced ventilation, and was conservative compared to the measured ventilation rate. The Barrington document (WHC-SD-WM-ER-332) used a ventilation rate of 60 cfm (provided by Shift/Surveillance Engineering) which is probably closer to the actual forced ventilation flow, but is still less than ½ the flowrate based on an equal distribution of 1100 cfm across the 7 tanks indicated on the above 1984 drawing, H-2-90866. The original evaporation rate could have been easily underestimated by as much as a factor of ~8, assuming the air was saturated leaving the tank.
7.	D.G. Harlow	List of UOs and 1988 LOW Decrease Information *Status:* Complete, List sent 8/11/09, included in SX-104 Leak Assessment Meeting Minutes #1.
8.	D.J. Washenfelder	Drywell Gross Gamma history from HNF-3136, R.R. Randall and R.K. Price, *Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs*. Any short-lived radionuclides present? *Status:* Complete, sent 8/12/09, included in SX-104 Leak Assessment Meeting Minutes #1.
9.	D.A. Barnes	Explore the ILL readings 1984-1988 and the potential for increased effects from a different diffusion band and free liquid surface. *Status:* Complete. See Attachment 1 below.

10.	E.C. Shallman	Compare available photos 1984 through 1988 for liquid surfaces and changes. *Status:* Complete, photos from 1984 and 1988 were reviewed and the consensus was that much more than 3% of the surface area, possibly as high as 15-20% in the earlier part of the period could be free liquid and contribute to evaporation including increased crust diffusion. The 3% surface area was used in a study, WHC-SD-WM-ER-332 Rev. 0, *Evaporation Analysis for the Tank SX-104*, based on the 1988 photos and other parameters. This study concluded that observed level decreases (0.756± 0.231 in/yr) could be explained by evaporation. This was apparently for the October 1989 to October 1991 period as explained in RPP-ENV-39658. The implication is that a possibly greater evaporation rate could have been experienced in the 1984-1988 period and provided a higher confidence level in the evaporation scenario. However as important as evaporation is in explaining some of the ILL decrease, the neutron and gamma profile review in Action #9 in combination provides a more complete explanation of the 1984-1988 ILL decrease.
11.	D.A. Barnes D. G. Harlow E. C. Shallman	Provide an evaporation analysis for the 1984-1988 salt cake storage period using the information provided by the 1984 and 1988 photos to estimate the liquid surface area available and the crust diffusion parameters. *Status:* Cancelled. The uncertainties associated with the nine variables involved in an evaporation analysis which change over the four year time period preclude a definitive evaporation analysis. The evaporation analysis would also need to be integrated with the dissipation of the LOW installation water down through the waste structure. Any results would not appreciably add to the understanding of the ILL decrease over and above that which is provided in the attached explanation for Action #9 coupled with evaporation at the seemingly low rate of the 20 cfm example in the 1988 assessment.

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title

Documents:

Number	Title
RPP-32681	Process to Estimate Tank Farm Vadose Zone Inventories
TFC-ENG-CHEM-D-42, Rev. B-2	Tank Leak Assessment Process
13240-88-32	Internal Memo: Data Review, Tank 241-SX-104
13311-88-049	Evaluation of Integrity of Tank 241-SX-104
13331-88-416	Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104
OR 76-125	Occurrence Report: Surface Level Increase Exceeding Criteria for 104-SX
OR 76-85	Occurrence Report: Liquid Level Increase Exceeding Criteria for Tank 104-SX
Or 77-17	Occurrence Report: Surface Level Increase Exceeding Criteria for 104-SX
OR 77-188	Occurrence Report: Tank 104-SX Liquid Level Increase Exceeding Criterion
EPDR 88-03	Environmental Protection Deviation Report: Liquid Observation Wells (LOWs) Interstitial Liquid Level (ILL) in Tanks 241-SX-104 and 241-SX-105 Has Exceeded the 0.3 Foot Decrease Criteria With the Gamma Probe
HW--31884	Project CA 539 241-SX Tank Farm Description and Use of Facilities
LMHC-9851233A R3	Tank 241-SX-104 Level Anomaly Assessment
RPP-ASMT-38450 Rev. 0	Tank 241-SX-1004 Leak Assessment Report
RPP-ENV-39658, Rev. 0	Hanford SX-Farm Leak Assessment Report (DRAFT)
RPP-RPT-38419 Rev. 0	Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks
SD-WM-TI-35 Vol.1 & 2, Rev. 0	Waste Storage Tank Status and Leak Detection Criteria
TFSO-EFS-88-085	Event Fact Sheet: The Liquid Observation Well (LOW) Interstitial Liquid Level (ILL) in Tank 241-SX-104 Has Exceeded the 0.3 Foot Decrease Criteria With the Gamma Probe
WHC-SD-WM-ER-324	SD/SW Quadrant HTCE for SX-Farm

WHC-SD-WM-ER-332, Rev.0	Evaporation Analysis For Tank SX-104
WHC-UO-88-024-TF-03	Unusual Occurrence Report: Tank 241-SX-104 has been classified as an assumed leaker
WHC-UO-88-028-TF-03	Unusual Occurrence Report: Tank 241-SX-104 has been classified as an assumed leaker (Edit)
HNF-3136	Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs
HNF-SD-WM-CN-116	Calculation Note: Hydrogen Generation Rates at Steady-State Flammable Gas Concentrations for Single Shell Tanks

Drawings:

Number	Title
H-2-39511	75 Ft. Storage Tanks Composite Section 241-SX
H-2-39576	Vapor manifold & Condensate System Details Waste Disposal facility 241-SX
H-2-46238	Engineering Flow Diagram 241-SX Tank Farm Tanks 101, 104 & 106
H-2-90866	HVAC Airflow Diagram
H-14-020134	Ventilation Tank Primary System (241-SX Tank Farm) P&ID

APPENDIX C – TANK SX-104 LEAK ASSESSMENT IN-TANK / EX-TANK DATA

Table C-1. In-Tank Data

Tank 241-SX-104 Leak Assessment In-Tank Data Form (from HNF-3747, Rev. 0)			
SURFACE LEVEL MEASUREMENTS (SLM)	**Observation**		
ENRAF			
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
FIC			
Unexplained, repeatable drop>tolerance	Yes	No	NA
RPP-ASMT-38450: The 2008 leak assessment reviewed the difference between the waste surface level and the ILL for the three periods covered by leak assessments: the April, 1985 – April, 1988 period reviewed during the 1988 leak investigation; the February, 1997 – February, 1998 reviewed during the 1998 leak investigation and after 99.9 kgal had been pumped from the tank following the 1988 investigation; and the December, 2006 – July, 2008 period after an additional 115.1 kgal had been pumped from the tank during interim stabilization that ended in 1999. In 1988 prior to submersible pumping the 99.9 kgal, the tank apparently had a significant floating crust with a liquid/slurry surface about 22" below the crust. The 1988 pumping removed a large amount of the near-surface liquid; the change in ILL that occurred indicates that the liquid/slurry had a porosity of ~ 88%. Between the 1998 and the present investigation, an additional 115.1 kgal were pumped from the tank with a jet pump. This activity withdrew mostly interstitial liquid from the tank based on the ~33% porosity estimated from the change in the ILL. Calculated porosity reported on the SX-104 stabilization form was 34% (HNF-SD-RE-TI-178 p. 254)			
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
MANUAL GAUGE			
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

LIQUID OBSERVATION WELL (LOW) MEASUREMENTS	Observation		
Unexplained, repeatable drop>tolerance	Yes	No	NA
RPP-ASMT-38450: **ILL Behavior 1982-2008 -** Five liquid observation wells have been installed in tank SX-104 since 1982. The first four were installed in either Riser 14 or Riser 16, and have all failed. The failure cause is most likely the result of waste subsidence caused by the removal of about 215 kgal of interstitial liquid. **ILL Behavior December 2006 – July 2008**: - In December, 2006 the fifth liquid observation well was installed in Riser 7A. According to work package CLO-WO-06-000490 241-SX-104, Install LOW in Riser 7, about 200 gal of water were used to on November 29, 2006 to water lance a cavity in the waste to accept the new liquid observation well. Interstitial liquid level monitoring using the new well immediately after installation on December 7, 2006, showed the predictable increase in ILL from the installation water. Subsequent neutron scans showed the ILL following a natural, predictable decline. The ILL re-stabilized by January, 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease of -1.740-in that exceeded the allowable OSD-T-151-00031 Rev. G-2 Operating Specification for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection +/- 3 standard deviations from the trend baseline, or -1.2 in specification limit. The ILL measurement frequency was increased from quarterly to weekly. Further decreases were measured on May 6, and May 12, 2008. Subsequent to May 12, 2008, the ILL restabilized, and has remained stable through the mid-July, 2008 assessment period. Gamma scans were completed on June 10, 2008 and June 17, 2008. They show an interface very close to the ILL interface calculated from a newly-identified ILL secondary feature (June 10th ILL 73.284 in, γ 72.384 in; June 17th ILL 73.440 in, γ72.036 in). No further γscans were made.			
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

CORROBORATING EVIDENCE	Corroborates SLM or LOW Data Given		
Thermocouple	Leak	Alt. Hypoth.	NA
Salt well screen	Leak	Alt. Hypoth.	NA
Standard Hydrogen Monitoring System	Leak	Alt. Hypoth.	NA
Photos/Videos	Leak	Alt. Hypoth.	NA.
Weather conditions	Leak	Alt. Hypoth.	NA
Barometric pressure	Leak	Alt. Hypoth.	NA
Precipitation	Leak	Alt. Hypoth.	NA
Temperature	Leak	Alt. Hypoth.	NA
RPP-ENV-39658 Rev. 0 (Draft): Available thermal histories for single-shell tanks are summarized in RHO-CD-1172, Survey of the Single-Shell Tank Thermal Histories. The thermal history for tank SX-104 starts in August 1956 and continues through November 1964 (RHO-CD-1172 pages B-73 through B-88). Temperature plots (Appendix A) show tank SX-104 waste temperature reached a maximum of 300°F in Dec. 1956 then decreased and varied between 230 and 260 oF through December 1960. By August 1961 temperature decreased to 200F +/- 10 and stayed at that level through November 1964. There is a gap in the temperature data for tank SX-104 until Surveilance Analysis Computer System (SACS) records started in 1981.			

Surface flooding	Leak	Alt. Hypoth.	NA
Process history	Leak	Alt. Hypoth.	NA
RPP-ENV-39658 Rev. 0 (Draft): **REDOX High-Level Waste Storage (1955 -1963)**: Tank SX-104 was put into service February 2, 1955 (RHO-R-39). the tank received Reduction Oxidation Plant (REDOX) waste from the 1st quarter of 1955 until November 1956. Cooling water was added as needed and waste cascaded to tank SX-105 from July through December 1955. The tank started evaporating in June of 1955 and condensate was sent to tank SX-106 (HWN-1991-45). The tank continued to transfer condensate to tank SX-106 through 1963. **Miscellaneous Waste Storage (1971 - 1975)**: In September 1971, 496 kgal of supernatant were transferred to tank SX-102 (ARH-2074C-10). Tank SX-104 then received 669 kgal of REDOX evaporator bottoms from tank SX-105 and REDOX ion exchange (B Plant cesium removal) waste) from SX-105 in the 4th quarter of 1971 (ARH-2074D-10). There were no transfers from 1972 through the 2nd quarter of 1975. **242-S Evaporator/Crystallizer Bottoms Receiver (1976 - 1977)**: From the 3rd quarter of 1975 until the 2nd quarter of 1976, tank SX-104 received 242-S Evaporator/Crystallizer bottoms and recycle wastes and transferred recycle supernatant to tanks S-102 and S-107(ARH-CD-336 B [D196203742], ARH-CD-336 C [D196203834], ARH-CD-702A [D197215021]). Tank SX-104 received concentrated evaporator feed and residual evaporation liquid during the t3rd quarter of 1976 until the 3rd quarter of 1977. **242-S Evaporator/Crystallizer Partial Neutralized Waste and Double-Shell Slurry Feed Receiver (1977 - 1980)**: During the 4th quarter of 1977, the tank			
Interim Stabilization (1997 - 2000): Saltwell pumping began on September 26, 1997; 200 gal were pumped before the transfer line to 244-S plugged. Pumping resumed on March 19, 1998, following the installation of a dilution system to dilute the waste in the saltwell in order to make it easier to pump the waste. Pumping was interrupted on March 23, then restarted on July 23, 1998, and continued until July 27, 1999, when the rear seal of the jet pump ruptured and a major spray leak ensued within the pump pit. A total of 115 kgal was transferred to tank SY-102 before failure occurred. Waste volume calculations showed 48 kgal of drainable interstitial liquid remaining in the tank, of which approximately 44 kgal was estimated to be pumpable. On April 26, 2000, the tank was declared interim stabilized based on the major equipment failure (HNF-SD-RE-TI-178 and CHG-000191 [D8283753]).			
Occurrence reports	Leak	Alt. Hypoth.	NA
Environmental Protection Deviation Report 88-03, February 1988 (D197202901): The ILL decrease exceeded the -0.3' decrease criterion measured with the LOW gamma probe. The neutron probe indicated a stable ILL. The January 14, 1988 in-tank photograph showed an irregular surface and small pools of liquid. The FIC measurements were erratic. **Unusual Occurrence Report WHC-UO-88-024-TF-03, August 1988 (D193015352)**: Following the ILL decrease documented in the February, 1988 EPDR, an evaluation was initiated. Three years of LOW scans were reviewed, and the decrease verified by the gamma, neutron, and acoustic probes. The FIC measurements had been erratic since 1984. Small surface pool changes were noted when the January and May, 1988 photos were compared with February, 1984 photos. 99.9 kgal were pumped from the tank between May18, 1988 and August 16, 1988. The UOR was forwarded via letter 885768 to R. E. Gerton, Director Waste Management Division, US DOE on September 28, 1988 [D193015352] as a corrected copy of the UOR sent via 8854920 on August 3, 1988 [292-001167]. The August 3rd version incorrectly stated that pumping had temporarily ceased because of the failure of the 244-S DCRT. Actually the pump had failed. This error was corrected in the later copy.			
Construction history	Leak	Alt. Hypoth.	NA
Gas Release Events	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA

	Temperature			
	RPP-ENV-39658 Rev. 0 (Draft): Available thermal histories for single-shell tanks are summarized in RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories*. The thermal history for tank SX-104 starts in August 1956 and continues through November 1964 (RHO-CD-1172 pages B-73 through B-88). Temperature plots show tank SX-104 waste temperature reached a maximum of 300 °F in Dec. 1956, then decreased and varied between 230 and 260 °F through December, 1960. By August, 1961 temperature decreased to 200°F ± 10 °F and stayed at that level through November 1964. There is a gap in the temperature data for tank SX-104 until Surveilance Analysis Computer System (SACS) records started in 1981.			
	Waste characteristics	Leak	Alt. Hypoth.	NA
	Prior to pumping in 1998 the tank had a 12-18 inch thick surface crust (WHC-SD-WM-ER-332) overlying a liquid. Prior to saltwell pumping and interim stabilization in 9/1997 the tank was on the flammable gas watch list with an estimated retained gas volume of 250 m3 . The tank experienced 3 hydrogen release events (GREs) the last one occurring 11/22/96 (RPP-7771).			
	In-tank operations	Leak	Alt. Hypoth.	NA
	Steam Bumps - July 1955: On July 15, 1955 the tank experienced a steam bump when the ALC was restarted after an ~ 13-hr outage. The primary condenser cooling water temperature increased from 74°F to 148°F over a 20 minute period; exhaust HVAC pressures of +3-in wg and +3.3-in wg were recorded at different locations. The bump duration was 70 minutes, with a calculated heat evolution rate of 4.7 MBtu/hr. On July 16, 1955 following an ~ 18.5-hr outage a second bump occurred, increasing the condensate flow from 0.5 gpm to 12.0 gpm, falling back to 3.6 gpm an hour later, then rapidly rising to 8.0 gpm and stabilizing at 5.0 gpm for 3 hours before returning to normal. Calculated heat evolution rate was 3.0 MBtu/hr. Airflow to the ALC was reduced from 13.15 cfm to 6-8 cfm on July 15 to decrease aersols.	Leak	Alt. Hypoth.	NA
	Previous Leak Assessments	Leak	Alt. Hypoth.	NA
	13331-88-416, July 1988 (D193015350): Following the ILL decrease documented in the February, 1988 EPDR, an engineering evaluation was initiated. Three years of LOW scans were reviewed, and the decrease verified by the gamma, neutron, and acoustic probes. The gamma profile below the ILL was noted to be extremely dynamic, suggesting internal waste changes, but the cause was not pursued. Based on the ILL decrease, and correcting for thermal contraction as the waste cooled, the letter provided a waste leak volume estimate of 5,303 gal. The FIC measurements had been erratic since 1984. Small surface pool changes were noted when photos from April, 1981 through April, 1988 were compared. Gamma scans of drywells surrounding the tank showed no evidence of increased soil contamination. Neutron moisture scans indicated that previous known moisture peaks at 50-ft - 55-ft BGS had increased in many drywells throughout the farm, indicative of a moisture source outside of the tank farm boundary. Evaporation was discounted because of the six tanks connected on the SX-402 vent system to tank SX-109 and from there to the 241-SX Sludge Cooler, only SX-104 and SX-105 showed ILL decreases. Others had significant drainable liquid inventories and several had similar heat loads. The engineering evaluation concluded that the ILL surveillance anomaly could not be satisfactorily with a 95% confidence level (i.e., 95% confidence that the tank was not leaking). The UOR WHC-UO-88-024-TF-03, issued August 1988 (D193015352) declared the tank to be an assumed leaker based on the evaluation.			

	LMHC-9851233A R3, April 1998: In 1998 the tank was suspected of re-leaking due to observed variations in ILL of up to 6-in. The variations were attributed to changes in waste porosity based on empirical measurements from water additions in February, 1997 and February, 1998, combined with increases in capillary strength from the reduced porosity. The downward slope of the ILL baseline was attributed to evaporation due to increased wicking of interstitial liquids to the waste surface from the increased capillary strength. Drywell spectral gamma scans in January, 1998 showed no changes. The assessment recommended that the tank not be declared a re-leaker (HNF-2617 Rev. 0 241-SX-104 *Level Anomaly Assessment* attached to letter LMHC-9851233A R3, *Subcontract number 80232764-9-K001; Tank 241-SX-104 Level Anomalies* [D198088171]). **RPP-ASMT-38450, August 2008**: In December, 2006 a new liquid observation well was installed in Riser 7A. Interstitial liquid level monitoring using the new well showed the predictable increase in interstitial liquid level from the installation water, followed by a natural decline and re-stabilization of the level by January, 2008, as the free water dissipated through the waste. However, the May 1, 2008 reading showed a decrease that exceeded the allowable -1.2-in criterion. Further decreases were measured on May 6, and May 12, 2008. On May 19, 2008, a formal leak assessment was initiated to determine if the tank was re-leaking.			
	Other (specify)	Leak	Alt. Hypoth.	NA

Table C-2. Ex-Tank Data

Tank 241-SX-104 Leak Assessment Ex-Tank Data Form
(from HNF-3747, Rev. 0)

SPECTRAL GAMMA LOGS (SGL)	Observation		
Radionuclides			
Man-made?	Yes	No	NA
Multiple?	Yes	No	NA
Distribution			
Peak at bottom of tank?	actual data		No or NA
Peak near surface?	actual data		No or NA
Increased activity in between?	actual data		No or NA
Increased activity below tank?	actual data		No or NA
RPP-ENV-39658 Rev. 0 Draft: Between April and June, 1995, the Vadose Zone Characterization Project performed spectral gamma analyses of the drywells 41-04-01, -03, -05, -07, -08, -11, 41-07-12, 41-01-06, surrounding and in the vicinity of SX-104, and attempted 41-00-03. The results showed extensive surface contamination from surface spills or pipeline leaks around the tank, and that the surface contamination had been migrating downward. However, after analyzing the distribution of soil contamination around the tank, the report concluded that there was no evidence that the tank had ever leaked; and recommended a review to determine if the tank should continue to be listed as an "Assumed Leaker" (GJ-HAN-3). In January, 1998 spectral gamma scans of the drywells were repeated in response to a decrease in the ILL during 1997. The scans were compared to the baseline data from the 1995 scans. The evaluation showed that no increase in soil contamination had occurred since the 1995 scans (GJPO-HAN-4). Neutron moisture scans showed a moisture peak at the interface between the undisturbed soil at the base of the tank and backfilled soil above the foundation. The evaluation concluded that there was no evidence of a leak from SX-104 (HNF-2617).			
GJ-HAN-3 *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-104*, September 1995: There is evidence of a pipeline leak or other type of near-surface contamination source at the 20-ft depth in borehole 41-04-03, which is on the northeast side of tank SX-104. Because it is not extensive and is not seen in other boreholes, it can be concluded that this near-surface contamination is a relatively minor source in terms of total gallons released or total radionuclide content. There is extensive near-surface contamination from surface spills or pipeline leaks around tank SX-104. Every borehole showed evidence of surface contamination that had migrated to varying depths. In some cases, the borehole may have enhanced the downward migration, or the contamination was carried down during drilling. After analyzing the distribution of vadose zone contamination around tank SX-104, it is concluded that there is no strong evidence of a leak from this tank. Current and historical liquid-level data should be reviewed at some time in the future to determine if this tank should continue to be listed as an assumed leaker.			

Activity across boreholes

Multiple boreholes?	Yes	No	NA

Activity over time

Increased activity?	Yes	No	NA

HISTORICAL GROSS GAMMA LOGS (GGL)	Observations	

Distribution

Sign. peak at bottom of tank? **RPP-ENV-39658 Rev. 0 Draft:** Historical gross gamma logs for the period 1975 – mid-1994 are compiled in HNF-3136 Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs.	actual data	No or NA
Sign. peak near surface?	actual data	No or NA
Sign. increased activity in between?	actual data	No or NA
Sign. increased activity below tank?	actual data	No or NA

Activity across boreholes

Multiple boreholes?	Yes	No	NA
Consistent across boreholes?	Yes	No	NA

Activity over time

Abrupt increase (bottom)?	Yes	No	NA
Abrupt increase (elsewhere)?	Yes	No	NA
Gradual increase (bottom)?	Yes	No	NA
Gradual increase (elsewhere)?	Yes	No	NA

CORROBORATING EVIDENCE	Corroborates SGL or GGL Data Given		
Moisture Probe	Leak	Alt. Hypoth.	NA
Psychrometrics	Leak	Alt. Hypoth.	NA
Bore hole core sample	Leak	Alt. Hypoth.	NA
Laterals	Leak	Alt. Hypoth.	NA

Weather conditions			
Barometric pressure	Leak	Alt. Hypoth.	NA
Precipitation	Leak	Alt. Hypoth.	NA
Temperature	Leak	Alt. Hypoth.	NA
Surface flooding	Leak	Alt. Hypoth.	NA
Process history	Leak	Alt. Hypoth.	NA
Drywell drilling logs	Leak	Alt. Hypoth.	NA
Occurrence reports	Leak	Alt. Hypoth.	NA
Surface spills	Leak	Alt. Hypoth.	NA
Transfer line leaks	Leak	Alt. Hypoth.	NA
Construction history	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
Waste characteristics	Leak	Alt. Hypoth.	NA
In-tank operations	Leak	Alt. Hypoth.	NA
Other (specify)	Leak	Alt. Hypoth.	NA
Other (specify)	Leak	Alt. Hypoth.	NA

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APPENDIX D – EXPERT ELICITATION

Table D-1. Expert Opinion: D. A. Barnes

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20
(From HNF-3747, Rev. 0)

Elicitation Date: 8/25/2009
Elicitation from: D. A. Barnes
Elicitation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

	True State L	True State NL	Liklihood Ratio L:NL	Comments	Definitions
	p(L)	p(NL)	Ω_0	No pre-analysis bias imposed. A value of 0.50 is completely neutral.	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)
	0.50	0.50	1.00		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

				Comments	Definitions
Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	FIC sitting on crust, also erratic due to poor conductivity and mechanical issues. Not responding to liquid movement below the crust, so not relevant to the discussion.	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.
	0.50	0.50	1.00		

In-Tank Data Liquid Observation Well - Part 3

				Comments	Definitions
Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	LOW data was re-analyzed using secondary ILL feature that was forming approximately 2 feet below the surface. The loss rate was consistent with evaporation and a slow re-distribution of the installation water. A long re-distribution time is consistent with poor waste permeability. Formation of trapped gas pockets in the waste also confirm poor waste permeability, (i.e., the gas would have risen to the surface and escaped in a more permeable environment.) Data supports a slow re-distribution of installation water with evaporation and thermal shrinking as the waste cools. The gamma surveys strongly confirm this analysis. A tank leak is less probable.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.35	0.65	0.54		

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)	Surface level data is NA	Considering that in-tank data sources may be interdependent: p(SLM|LOW,L) = ["posterior"] probability that the suface 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 intersititial 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.**
	0.50	0.50	1.00		

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)	Surface level data is NA	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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.
	NA	NA	1.00		

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)	Drywell history shows no contamination around base of tank at any location that might indicate a possible 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
	0.30	0.70	0.43		

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 data confirms clean formation near base of tank using higher resolution equipment. Data does not support a leak hypothesis.	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.
	0.40	0.60	0.67		

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	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.
	NA	NA	1.00		

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)
	0.50	0.50	1.00

Both the gross gamma and spectral data show clean formations, and the data from each system supports the other. Both systems are considered equally applicable.

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)
1.00	0.54	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.43	0.67	1.00	1.00

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

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

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.54

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)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.43

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)
	0.23

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
0.19	0.81	0.23

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)

Table D-2. Expert Opinion: J. W. Ficklin

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date: 8/20/2009
Elicitation from: J. W. Ficklin
Eliciation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

True State L	True State NL	Liklihood Ratio L:NL		
p(L)	p(NL)	Ω_0	Laterals not installed; SX Farm tanks are among the most-recently constructed SST tank farms.	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)
0.50	0.50	1.00		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	$p(SLM \mid L)$ (If no SLM, enter NA here and in Parts 4 and 5)	$p(SLM \mid NL)$	L(SLM)	Ranking based on evaporation rates (considerable liquid surface present in spots, none of which appeared to be under the FIC plummet however) and photo evidence. Also considered tank contents/waste dynamics (also evident in photos).	Considering the surface level measurement data reviewed for the leak assessment: $p(SLM \mid L)$ = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. $p(SLM \mid NL)$ = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. $p(SLM \mid NL)$ = 1 - $p(SLM \mid L)$ L(SLM) = $p(SLM \mid L)/p(SLM \mid NL)$. 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.
	0.20	0.80	0.25		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	$p(LOW \mid L)$ (if no LOW, enter NA here and in Parts 4 and 5)	$p(LOW \mid NL)$	L(LOW)	The presence of a secondary feature is evident; this mirrors a similar feature characteristic of this tank in later years as well as in several other SST tanks.	Considering the interstitial liquid level data reviewed for the leak assessment: $p(LOW \mid L)$ = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. $p(LOW \mid NL))$ = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. $p(LOW \mid NL)$ = 1 - $p(LOW \mid L)$ L(LOW) = $p(LOW \mid L)/p(LOW \mid NL)$. If LOW intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.20	0.80	0.25		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

<table>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td><td>LOW readings did not support liquid level readings.</td><td>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 intersititial 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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

<table>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td><td></td><td>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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td><td>No leak migration was indicated in scan records.</td><td>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</td></tr>
<tr><td></td><td>0.20</td><td>0.80</td><td>0.25</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td><td>Although only 1 scan was obtained, it strongly suggests migration of surface contamination downward.</td><td>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.</td></tr>
<tr><td></td><td>0.20</td><td>0.80</td><td>0.25</td><td></td><td></td></tr>
</table>

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

<table>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td><td></td><td>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.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	$p(SGL \mid GGL,L)$	$p(SGL \mid GGL,NL)$	$L(SGL \mid GGL)$
	0.20	0.80	0.25

SGL & LOW scans fairly coincide, neither supporting a leak hypothesis.

Considering that ex-tank data sources may be interdependent:

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

$p(SGL \mid GGL,NL)$ = ["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. $p(GGL \mid SGL,NL) = 1 - p(SGL \mid GGL,L)$

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

Combined Liklihood Ratios

L(SLM)	L(LOW)	$L(SLM \mid LOW)$	$L(LOW \mid SLM)$
0.25	0.25	1.00	1.00

L(GGL)	L(SGL)	$L(GGL \mid SGL)$	$L(SGL \mid GGL)$
0.25	0.25	1.00	0.25

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

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

In-Tank Liklihood 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: $L(SLM,LOW) = L(LOW \mid SLM) \times L(SLM)$
If SLM and LOW and LOW most important: $L(SLM,LOW) = L(SLM \mid LOW) \times L(LOW)$

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)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.06

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: $L(SGL, GGL) = L(SGL \mid GGL) \times L(GGL)$
If GGL and SGL and SGL most important: $L(SGL, GGL) = L(GGL \mid SGL) \times L(LSGL)$

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.02

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

Posterior Probability for Leak Hypothesis

$p(L \mid in,ex)$	$p(NL \mid in,ex)$	Ω_1
0.02	0.98	0.02

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

Table D-3. Expert Opinion: J. G. Field

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date: 8/25/2009
Elicitation from: J. G. Field
Elicitation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

	True State L	True State NL	Liklihood Ratio L:NL		
	p(L)	p(NL)	Ω_0	Several of the SX Farm tanks are confirmed leakers caused by bulging bottoms from receipt of the same REDOX waste in SX-104. Consequently an edge is given to probabilty of a leak in this farm.	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)
	0.60	0.40	1.50		

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)	Surface level measurement remain unchanged on a hard surface. No preference assigned.	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.
	0.50	0.50	1.00		

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)	Although the LOW decreased, it is known to have decreased at least 2 other times under similar conditions. In both cases the possibility of a leak was refuted. In this case as before the LOW results appear to have been misinterpreted. Correct interpretation does not show the same decrease. Even if the LOW decrease is real it is explained with 90% probability by evaporation. Studies and information since the previous assessment indicate higher moisture of the crust which would increase evaporaton from the crust (compared to the previous assumptions that the crust was dry and like cement) and cracks or holes in the surface of the crust and openings on the edges appear to support sufficient evaporation.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.10	0.90	0.11		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

<table>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td><td>The cobination of surface level and Low measurements do not provide any additional information re. the basis for the LOW liquid level decrease.</td><td>Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the suface 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 intersititial 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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

<table>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td><td>NA</td><td>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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

If there is no surface</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td><td>Gamma logs do not show any evidence of increased activity near the time of liquid level decreases. This does not confirm the absence of a leak due to the proximity of drywells from the tank. However, if drywell activity had increased at the tank level it would indicate the presence of a leak. As a result a slight edge is given to "no leak" to drywell activity results.</td><td>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</td></tr>
<tr><td></td><td>0.40</td><td>0.60</td><td>0.67</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td><td>1998 and later spectrall gamma logs do not show any evidence of increased activity. This does not confirm the absence of a leak due to the proximity of drywells from the tank. However, if drywell activity had increased at the tank level it would indicate the presence of a leak. As a result a slight edge is given to "no leak" to drywell activity results.</td><td>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.</td></tr>
<tr><td></td><td>0.40</td><td>0.60</td><td>0.67</td><td></td><td></td></tr>
</table>

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

<table>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td><td>NA</td><td>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.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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)
	0.40	0.60	0.67

Total gamma measurements were determined to be more important because they were obtained near the time of the LOW liquid level decrease.

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)**
1.00	**0.11**	**1.00**	**1.00**
L(GGL)	**L(SGL)**	**L(GGL|SGL)**	**L(SGL|GGL)**
0.67	**0.67**	**1.00**	**0.67**

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

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

In-Tank Liklihood 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)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio			**L(SGL,GGL)**
			0.44

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)**
			0.05

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**
	0.07	0.93	0.07

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)

Table D-4. Expert Opinion: M. A. Fish

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date: 8/20/2009
Elicitation from: M. A. Fish
Eliciation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

True State L	True State NL	Liklihood Ratio L:NL		
p(L)	p(NL)	Ω_0	No leak effect significance was attributed to the tank being either a single shell tank or its contents temperature history.	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)
0.50	0.50	1.00		

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)	After examining photographs of the tank waste surface the surface level measurements (FIC) were taken on a hard waste crust which is not indicative of ILL variations. Hence surface level measurements are not considered germane to this tank leak assessment.	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
	0.50	0.50	1.00		

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)	The LOW readings indicates two ILL features. The lower ILL feature is consistent with the LOW installation water being absorbed into the waste and is assumed to be the correct level. Also the waste photographs 1984 to 1988 clearly show a reduction in visable pools of water up to 1988 indicating waste evaporation is taking place.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.25	0.75	0.33		

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)		
	0.50	0.50	1.00	No significant contamination using either GGL or SGL was attributable to an SX-104 tank leak.	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)
1.00	0.33	1.00	1.00
L(GGL)	**L(SGL)**	**L(GGL|SGL)**	**L(SGL|GGL)**
0.43	0.43	#VALUE!	1.00

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

SLM & No LOW?		
LOW & No SLM?		
SLM & LOW; SLM most important? (Mark Part 4 NA)		
SLM & LOW; LOW most important? (Mark Part 5 NA)	X	The surface level measurements (FIC) were taken on a hard waste crust which is not indicative of ILL variations.

In-Tank Liklihood Ratio			L(SLM,LOW)	
			0.33	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	The GGL readings cover a longer time period and GLL information is therefore considered more important.
GGL & SGL; SGL most important? (Mark Part 9 NA)		

Ex-Tank Liklihood Ratio			L(SGL,GGL)	
			0.43	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)	
			0.14	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	
0.13	0.88	0.14	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)

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

<table>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td><td>After examining photographs of the tank waste surface the surface level measurements (FIC) were taken on a hard waste crust which is not indicative of ILL variations. Hence surface level measurements are not considered germane to this tank leak assessment.</td><td>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 intersititial 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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

<table>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td><td></td><td>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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td><td>The gross gamma drywell scans show no evidence of a leak. It is possible that a small leak could have occurred but missed the dry wells.</td><td>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</td></tr>
<tr><td></td><td>0.30</td><td>0.70</td><td>0.43</td><td></td><td></td></tr>
</table>

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

<table>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td><td>The spectral gamma drywell scans show no evidence of a leak. It is possible that a small leak could have occurred but missed the dry wells.</td><td>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.</td></tr>
<tr><td></td><td>0.30</td><td>0.70</td><td>0.43</td><td></td><td></td></tr>
</table>

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

<table>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td><td></td><td>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.</td></tr>
<tr><td></td><td>N/A</td><td>#VALUE!</td><td>#VALUE!</td><td></td><td></td></tr>
</table>

Table D-5. Expert Opinion: D. G. Harlow

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date: 8/20/2009
Elicitation from: D. G. Harlow
Eliciation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

	True State: L	True State: NL	Liklihood Ratio: L:NL		
	p(L)	p(NL)	Ω₀	Tank SX-104 is one of ten leaker classified tanks in the 15 tank SX tank farm. The tank was a boiling waste tank that reached a maximum of 300°F. The tank did not have laterals installed that could potentially have been extended from the lateral support system for tanks SX-105/SX-107	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 suface 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)
	0.50	0.50	1.00		

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)	The irregular waste surface level measurements shows buildup/drop behavior of gas releases and don't contribute to whether this tank leaked or not.	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 suface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.50	0.50	1.00		

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)	The updated intrepretation of intersitiial liquid level measured in the LOW taking into account redistribution of LOW installation liquid over time and evaporation.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.20	0.80	0.25		

<table>
<tr><th colspan="4">Surface Level Measurement - Liquid Observation Well Interdependence - Part 4</th><th></th><th></th></tr>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td><td>Surface level measurement does not support the LOW</td><td>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 intersititial 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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Liquid Observation Well - Surface Level Measurement Interdependence - Part 5</th><th></th><th></th></tr>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td><td></td><td>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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Ex-Tank Data - Gross Gamma Drywell Logs - Part 6</th><th></th><th></th></tr>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td><td>Gross gamma logs show surface contamination and don't indicate a leak but there is a possibility that a leak of this waste (gel like) material may not have migrated to a drywell</td><td>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</td></tr>
<tr><td></td><td>0.20</td><td>0.80</td><td>0.25</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7</th><th></th><th></th></tr>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td><td>Spectral gamma logs are indicative of surface level activity and are consistent with gross gamma logs.</td><td>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.</td></tr>
<tr><td></td><td>0.20</td><td>0.80</td><td>0.25</td><td></td><td></td></tr>
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<table>
<tr><th colspan="4">Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8</th><th></th><th></th></tr>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td><td></td><td>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.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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)
	0.50	0.50	1.00

Neither the gross gamma logs or the spectral gamma logs suport a tank leak.

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)**
1.00	**0.25**	**1.00**	**1.00**

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

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

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

In-Tank Liklihood 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)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	**L(SGL,GGL)**
	0.25

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)**
	0.06

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**
0.06	0.94	0.06

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)

Table D-6. Expert Opinion: E. C. Shallman

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date: 8/20/2009
Elicitation from: E. C. Shallman
Elicitation by: Leak Assessment Team

Hypotheses:

Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a

Non-Leaker: The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

	True State: L	True State: NL	Liklihood Ratio L:NL	Rationale	Definitions
	p(L)	p(NL)	Ω_0	In SX Farm, 10 of the 15 tanks are assumed leakers. This fact, coupled with the self-heating temperatures and the fact that it is an SST, gives it a slightly better than even chance of being a leaker.	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 radicactivity 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)
	0.60	0.40	1.50		

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)	The Surface Level Measurements give very little data. It seems to be holding steady, which may or may not be indicitave of a leak. I just don't think this information helps the assessment, so it's a 0.5.	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.
	0.50	0.50	1.00		

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)	The LOW measurements (interstitial liquid level) seem to give more information than the surface level measurements, particularly given Mr. Barnes' analysis of the secondary feature. However, if the tank was really leaking, I think the numbers would be different, so it's a 0.4.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.40	0.60	0.67		

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)	If in fact the tank were leaking, I believe that the surface level measurements would fluctuate more widely than they seem to in this case, particularly given the steep decline in LOW measurements. 0.4.	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 intersititial 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.**
	0.40	0.60	0.67		

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)	As the Surface Level Measurements don't seem to offer much information, this is NA'd, per directions.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.
	NA	NA	1.00		

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 gross gamma logs yield little to no information. For the most part, they seem to either indicate clean drywell activity, or Tank Farm activity (spills, etc.) in the shallow regions. 0.2.	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
	0.20	0.80	0.25		

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)	Again, these logs seem to offer little information of any importance. They seem to support the Tank Farm Activity analysis from above, 0.3.	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.
	0.30	0.70	0.43		

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 are, in my opinion, more likely to yield useful information, simply due to the number of samples taken over the years. One spectral analysis does not give enough information to negate the usefullness of the gross gamma log. This section is NA'd per directions.	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.
	NA	NA	1.00		

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)
	0.50	0.50	1.00

If the tank was a leaker, and we observed the gross gamma log that we have, there's a pretty good cahnce in my opinion that the spectral gamma log would yield the same information, so it's a toss up. 0.5.

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)
1.00	0.67	0.67	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.25	0.43	1.00	1.00

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

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

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.44

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)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.25

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)
	0.11

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
0.14	0.86	0.17

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)

Table D-7. Expert Opinion: D. J. Washenfelder

Tank 241-SX-104 Leak Assessment Expert Elicitation Form 2009-08-20

Elicitation Date:	8/20/2009
Elicitation from:	D. J. Washenfelder
Eliciation by:	Leak Assessment Team

Hypotheses:

Leaker:	The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a
Non-Leaker:	The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by

Prior Probability - Part 1

True State: L	True State: NL	Liklihood Ratio: L:NL	Comments	Definitions
p(L)	p(NL)	Ω_0	10 of 15 tanks in SX Tank Farm are assumed leakers. Tank SX-104 waste tempertures ranged between ~ 220 - 300°F between 1956 and 1964 according to RHO-CD-1172. The tank was designated to be an "assumed leaker" based on an ILL decrease in 1988 based on a split decision of the leak assessment panel. In 1998 a similar ILL decrease was explained by changes in barometric pressure acting on interstitial liquid changes in waste porosity.	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)
0.40	0.60	0.67		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

				Comments	Definitions
Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	Both 1984 and 1988 photographs show a rough, dry, cracked waste surface. The ENRAF measurements made on this waste surface are not meaningful for a leak integrity determination.	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.
	0.50	0.50	1.00		

In-Tank Data Liquid Observation Well - Part 3

				Comments	Definitions
Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	A comparision of the behavior of the ILL during the 1984 - 1988 period with the behavior during 2006 - 2008 following installation of a new LOW shows a similar pattern occuring. In 2006 the water lance used to excavate the waste cavity for the LOW installation left standing free water at and near the waste surface. This water eventually began slowly dissipating through the waste until it encountered a below-surface impermeable layer which hindered further dissipation and creating a secondary ILL feature. The ILL began stabilizing and the secondary feature became more apparant. The 1984 - 1988 behavior looks similar. If the tank was leaking, then the ILL should continue to drop. When the "new feature" was tracked in 2008, the ILL behavior is consistent with the LOW installation water re-distributing through the waste.	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 intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	0.33	0.67	0.49		

<table>
<tr><th colspan="4">Surface Level Measurement - Liquid Observation Well Interdependence - Part 4</th><th></th><th></th></tr>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td><td></td><td>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 intersititial 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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Liquid Observation Well - Surface Level Measurement Interdependence - Part 5</th><th></th><th></th></tr>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td><td></td><td>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 intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Ex-Tank Data - Gross Gamma Drywell Logs - Part 6</th><th></th><th></th></tr>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td><td>Most of the historical gross gamma peaks from logs made between 1975 and 1995 are near surface indicating the source is probably spills. There are no spikes at or below the foundation. The 1988 evaluation found increased moisture levels at the base of the tank, but these were also present in other parts of the tank farm, and east of the tank farm, indicating the source was probably not SX-104.

The liquid waste is solid at ground temperature, based on laboratory observations, so it is unlikely that a leak plume from the tank would migrate very</td><td>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</td></tr>
<tr><td></td><td>0.40</td><td>0.60</td><td>0.67</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7</th><th></th><th></th></tr>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td><td>Spectral gamma logs taken in 1995, 1998, and 2008 showed no changes in baseline, consistent with earlier gross gamma logs.</td><td>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.</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4">Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8</th><th></th><th></th></tr>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td><td></td><td>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.</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td><td></td><td></td></tr>
</table>

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)
	0.50	0.50	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 Liklihood Ratios

L(SLM)	**L(LOW)**	**L(SLM|LOW)**	**L(LOW|SLM)**
1.00	**0.49**	**1.00**	**1.00**

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

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

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

In-Tank Liklihood Ratio	**L(SLM,LOW)**
	0.49

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)	

Ex-Tank Liklihood Ratio	**L(SGL,GGL)**
	0.67

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)**
	0.33

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**
0.18	0.82	0.22

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)

APPENDIX E – REPORT ON DRYWELL INVESTIGATIONS AROUND TANK SX-104 JUNE 3, 2008

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Report on Drywell Investigations around SST SX-104

As part of an investigation into recent liquid level drops in SST SX-104 as measured from the liquid observation well (LOW), CHG asked Stoller to prepare borehole monitoring request forms (BMRs) for deploying the Radionuclide Assessment System (RAS) in nine boreholes around SX-104 (see SX-Farm map). Clockwise from north, the boreholes are 41-04-01, 41-04-03, 41-04-05, 41-07-12, 41-04-07, 41-04-08, 41-05-03, 41-04-11, and 41-01-06. BMRs were provided to CHG on the same day they were requested, Thursday May 13, 2008.

All of these boreholes were logged with the high-resolution SGLS in 1995 and again in 1998 as part of the Vadose Zone Characterization Project at the Hanford Tank Farms. (Borehole 41-05-03 was only partially relogged in 1998.) Before May 2008, only 41-01-06 had been monitored for changes to the gamma profiles, the last time in July 2003. No changes were observed in the total-gamma profile in 41-01-06 between the baseline and 2003.

As of May 27, 2008, all nine boreholes that are proximal to SST SX-104 have been investigated with the RAS. These are highlighted in yellow on the map. Except for 41-04-07 and 41-07-12, all boreholes exhibit no changes in the total-gamma profiles since 1995, save for decreases attributable to decay of gamma-emitting radionuclides identified during baseline logging.

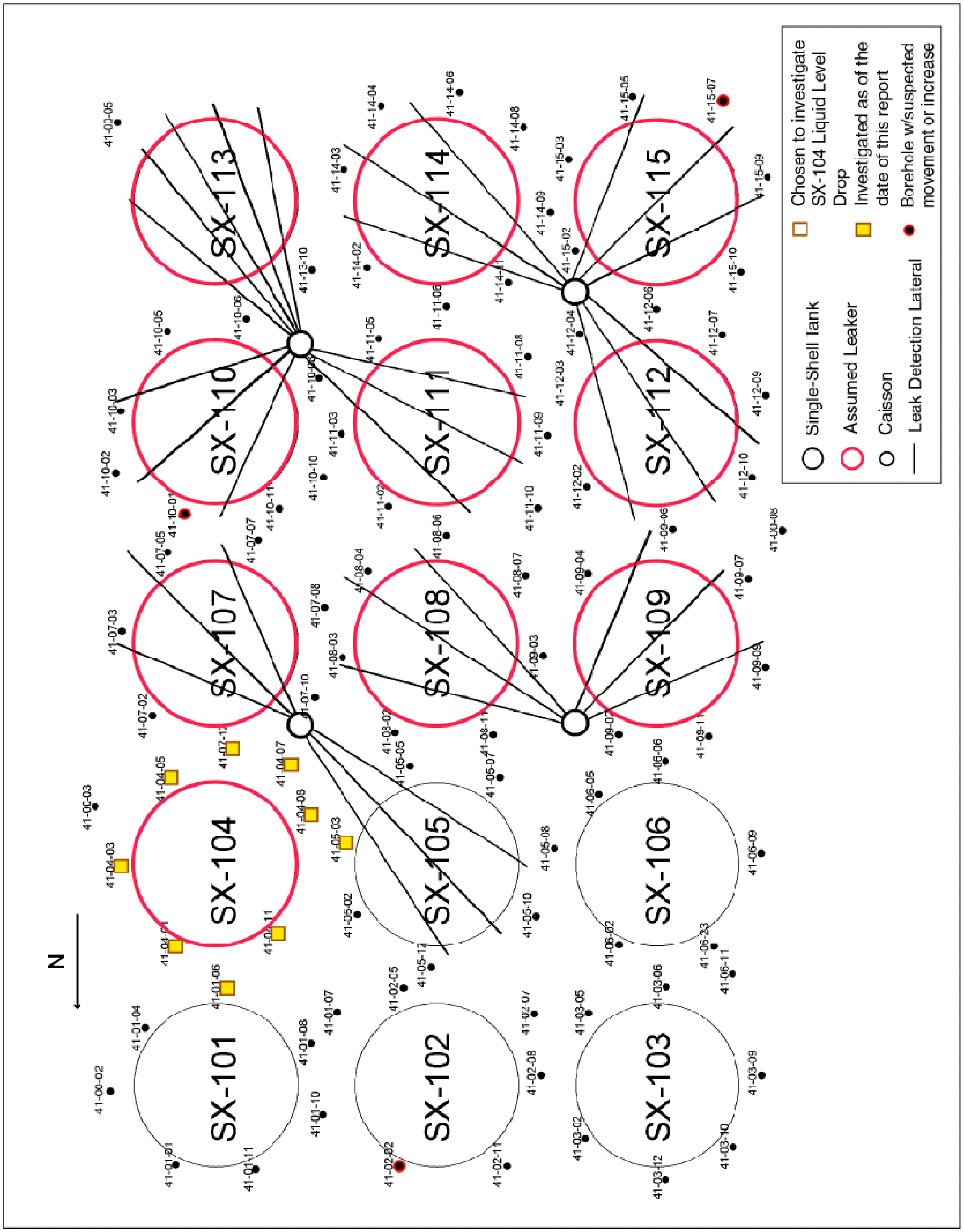
41-04-07 exhibits an apparent slight decrease in gross counts from about 80 to 100 ft between 1995, 1998, and 2008. This decrease cannot be attributed to the decay of previously observed gamma-emitting radionuclides. There are a number of other borehole and tool-related variables that can occasionally result in systematic slight increases or decreases in gross counts, which would result in a profile that mimics previous profiles, though higher or lower in counts. The important factors here are that the profiles mimic each other over the interval from 80 to 100 ft, and count rates decrease from one log to the next. The changes appear to be systematic slight decreases, and are not attributable to a gamma-emitting contaminant influx.

41-07-12 exhibits noticeable changes from 60 to 65 ft compared against previous total gamma profiles. According to the drilling log, this borehole was deepened in 1978 to 90 ft. The original 6-in casing was extended to 85 ft, and 4-in casing was emplaced inside the original 6-in casing to a depth of 88 ft. The bottom of the borehole was backfilled with grout from 88 to 85 ft. In the 1998 Reassessment of the Vadose Zone Contamination at Tank SX-104 and Comparison to the 1995 Baseline (GJO-HAN-21) pointed to evidence that, contrary to the drilling log, the 6-in casing may terminate just below 60 ft. The neutron moisture data (reported as raw counts) exhibit a very sharp increase in count rate at about 62 ft, and apparent ^{40}K concentrations (not reproduced for this report) also increase at about this depth. There is a short interval of continuous ^{137}Cs contamination from 61 to 64 ft that was first interpreted in 1995 to be possibly related to a leak from SST SX-107 (GJ-HAN-9). The data were reinterpreted in the 1998 report, using shape-factor analysis, to be likely adhered to the casing rather than distributed in the formation. Because of the 4-in casing, the RAS investigation of this borehole on May 27, 2008 employed the "Medium" detector, which includes a much smaller (and consequently much less sensitive) NaI crystal than the "Large" detector used in the other larger-diameter boreholes. Importantly, NaI detectors are susceptible to magnetic interferences, whereas HPGe detectors are not. There are also differences in the detector housing geometries that may cause different shielding effects at such a boundary. The changes observed between 60 and 65 ft in the recent gamma-profile may be caused by these or other differences between the two tools, and are likely not related to actual changes in the gamma profile.

Included are summary sheets of borehole information and logging activities, as well as plots of total gamma, gamma-emitting radionuclide contaminants (observed with the SGLS), and moisture (where available). The neutron moisture data were acquired and analyzed by Waste Management Federal Services in early 1998.

June 3, 2008

Arron Pope
Geophysicist
S.M. Stoller Corporation


N
SX-101
SX-102
SX-103
SX-104
SX-105
SX-106
SX-107
SX-108
SX-109
SX-110
SX-111
SX-112
SX-113
SX-114
SX-115
Single-Shell Tank
Assumed Leaker
Caisson
Leak Detection Lateral
Chosen to investigate SX-104 Liquid Level Drop
Investigated as of the date of this report
Borehole w/suspected movement or increase

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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Borehole Number (Alias): 41-04-01 (299-W23-140) (A7976)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35488	West: 75641	Elevation (ft): 663.05
Coordinates (WA Plane):	North: 134277.912	East: 566842.671	Elevation (m): 203.142
Drill Date: 3/15/72	Type: Cable Tool	Depth (ft): 100.0	Depth Datum: TOC
D/W (ft): 94.1	D/W Date: 5/12/95	D/W Reference: RUST	
Comments: None.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/15/95	SGLS	2	1	0-97.5	RUST	Baseline
01/13/98	SGLS	1	2	0-97.5	MACTEC	Baseline repeat
2/3/1998	N-N	RLSM3.1	1	0-98	WMFS	Moisture
05/14/08	RAS	Large	A	0-97.5	Stoller	No apparent changes

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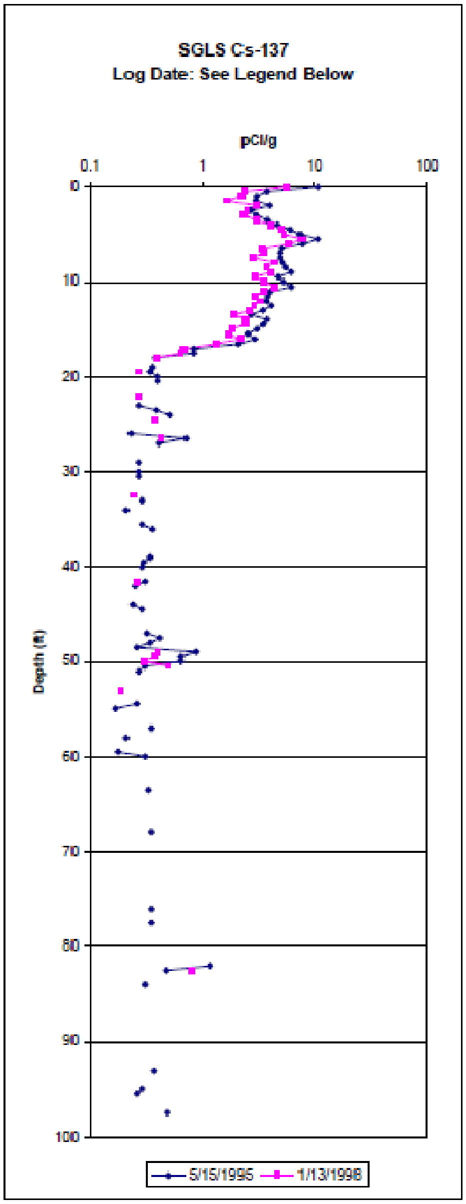
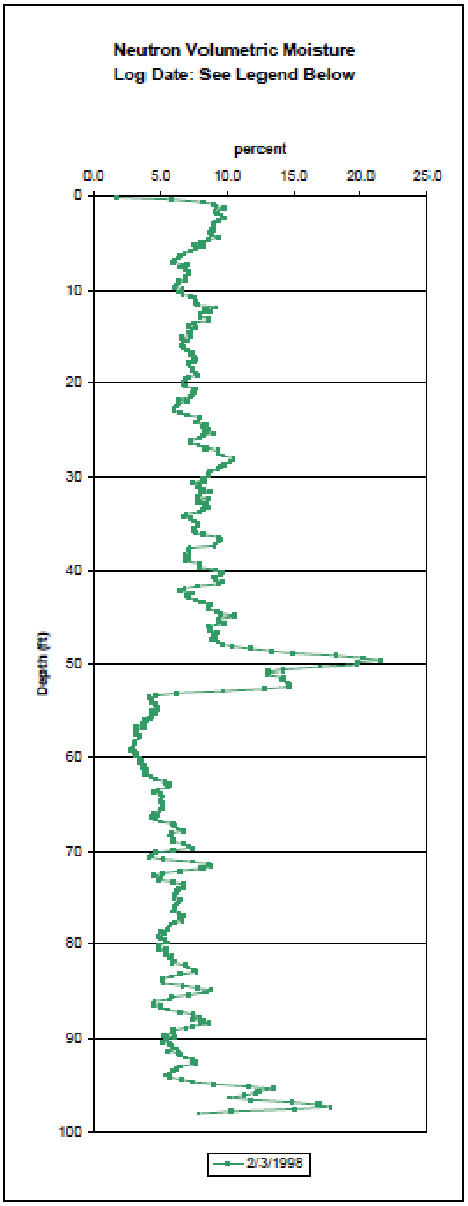
Borehole 41-04-01





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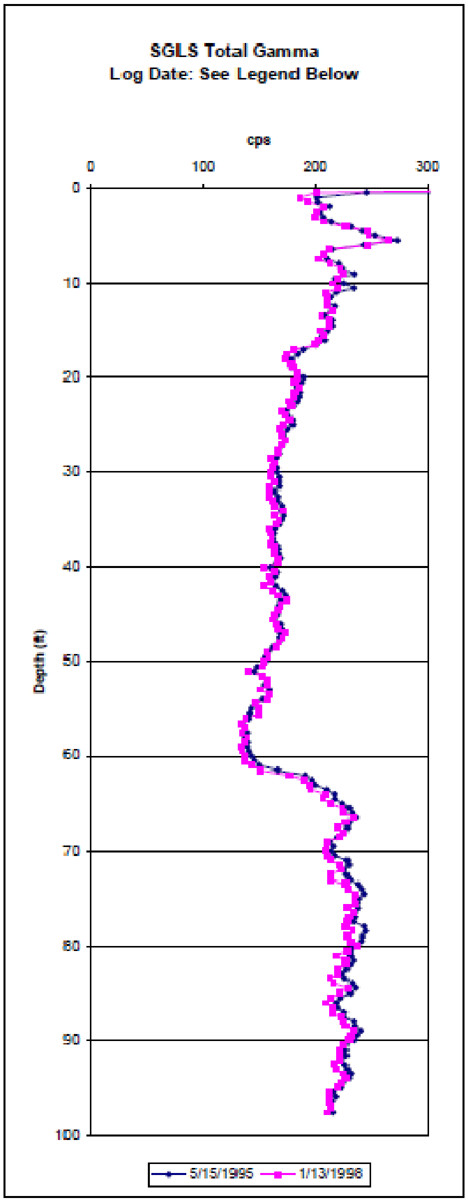
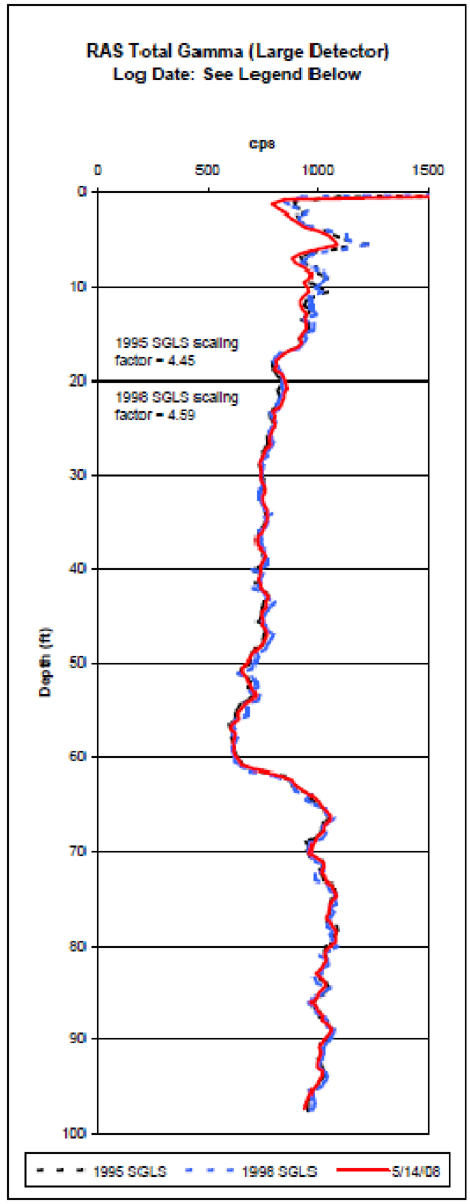
Borehole 41-04-01





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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-04-03 (299-W23-197) (A8033)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35452	West: 75616	Elevation (ft): 663.00
Coordinates (WA Plane):	North: 134266.762	East: 566850.167	Elevation (m): 203.138
Drill Date: 11/12/74	Type: Cable Tool	Depth (ft): 100.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 5/15/95	D/W Reference: RUST	
Comments: None.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/16/95	SGLS	1	1	0-99.5	RUST	Baseline
01/15/98	SGLS	1	2	0-99.5	MACTEC	Baseline repeat
2/3/1998	N-N	RLSM3.1	1	0-100	WMFS	Moisture
05/14/08	RAS	Large	A	0-97.5	Stoller	No apparent changes

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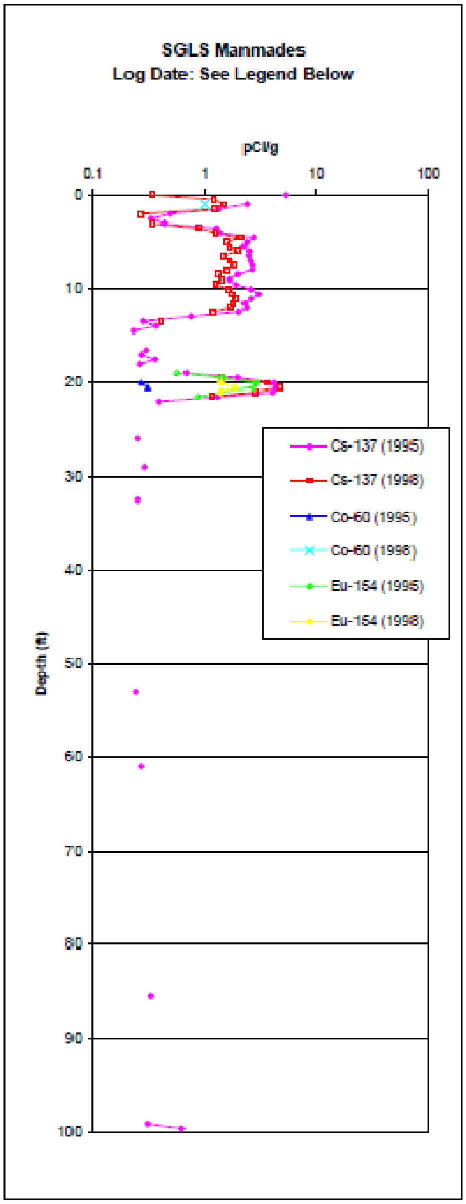
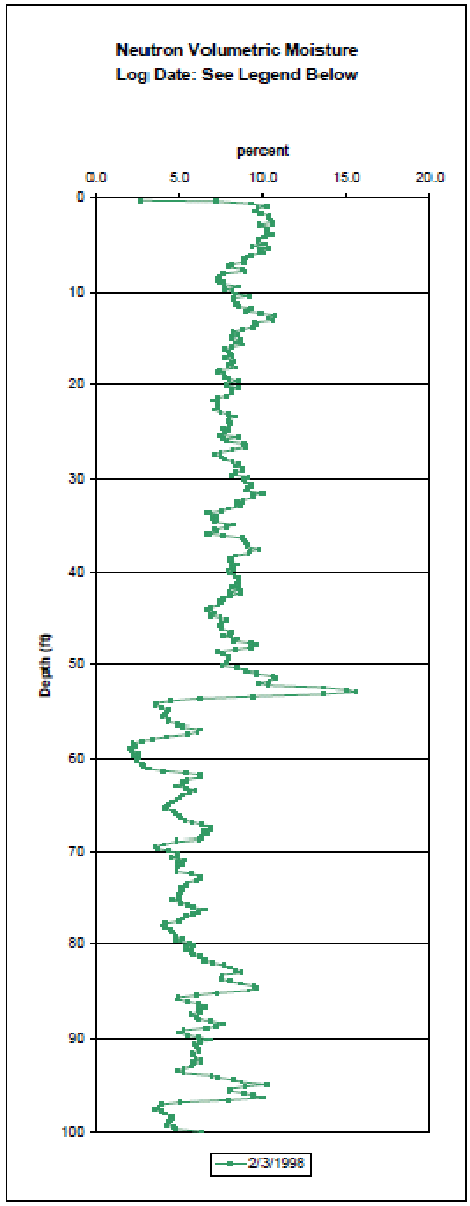
Borehole 41-04-03





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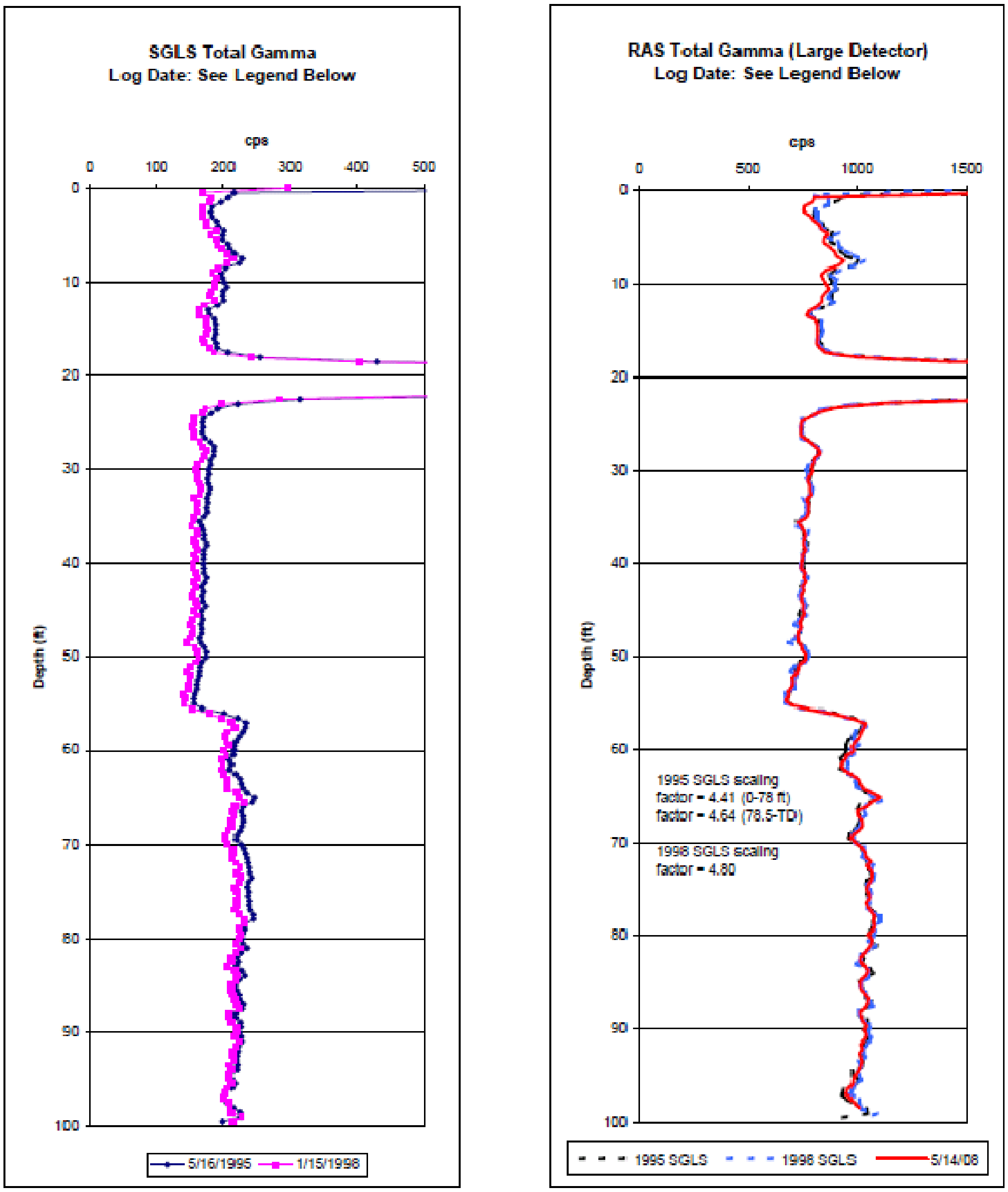
Borehole 41-04-03



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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-04-05 (299-W23-198) (A8034)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35412	West: 75639	Elevation (ft): 663.00
Coordinates (WA Plane):	North: 134254.598	East: 566843.399	Elevation (m): 203.129
Drill Date: 11/14/74	Type: Cable Tool	Depth (ft): 100.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 5/16/95	D/W Reference: RUST	
Comments: None.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/16/95	SGLS	1	1	0-99.5	RUST	Baseline
01/16/98	SGLS	1	2	0-100	MACTEC	Baseline repeat
1/30/1998	N-N	RLSM3.1	1	0-100	WMFS	Moisture
05/19/08	RAS	Large	A	0-97.5	Stoller	No apparent change

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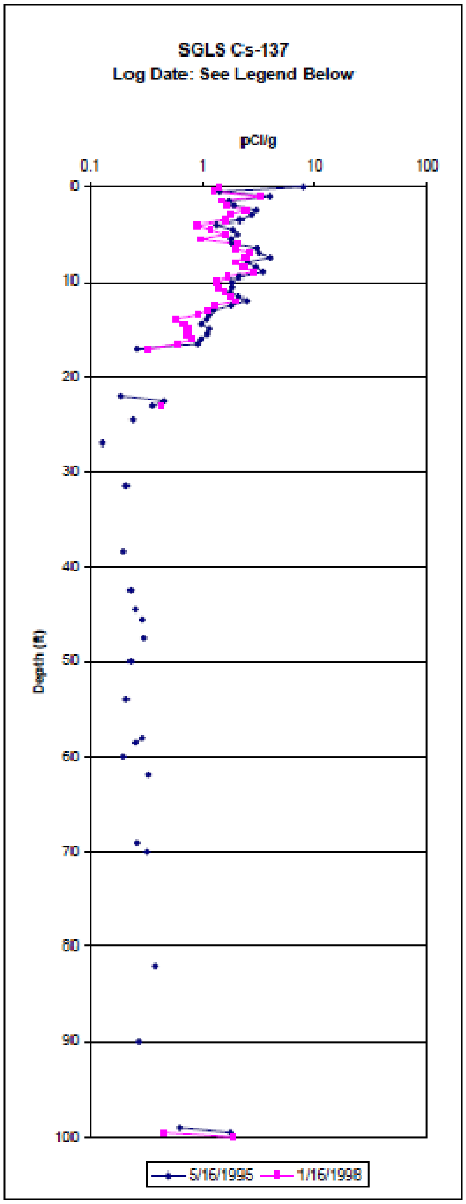
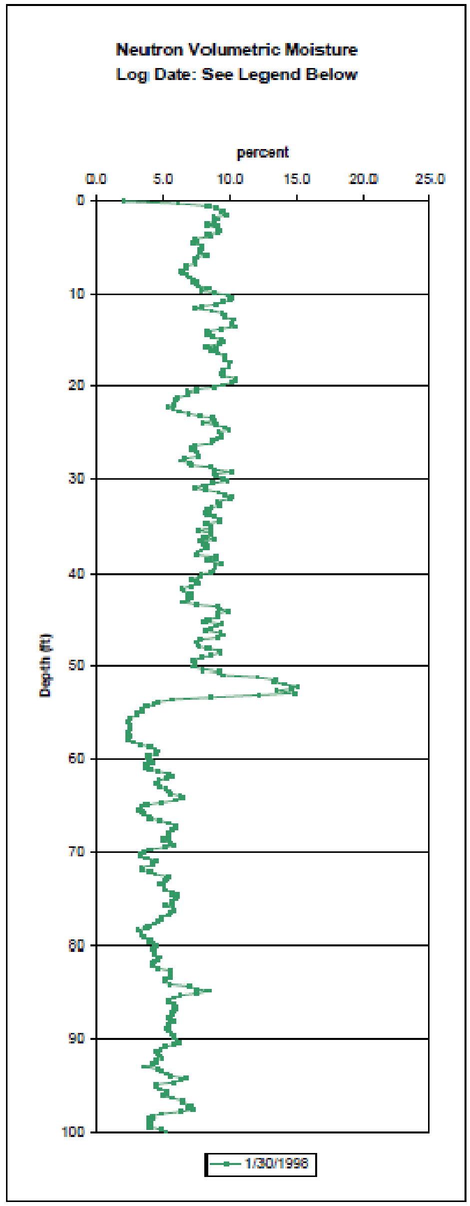
Borehole 41-04-05





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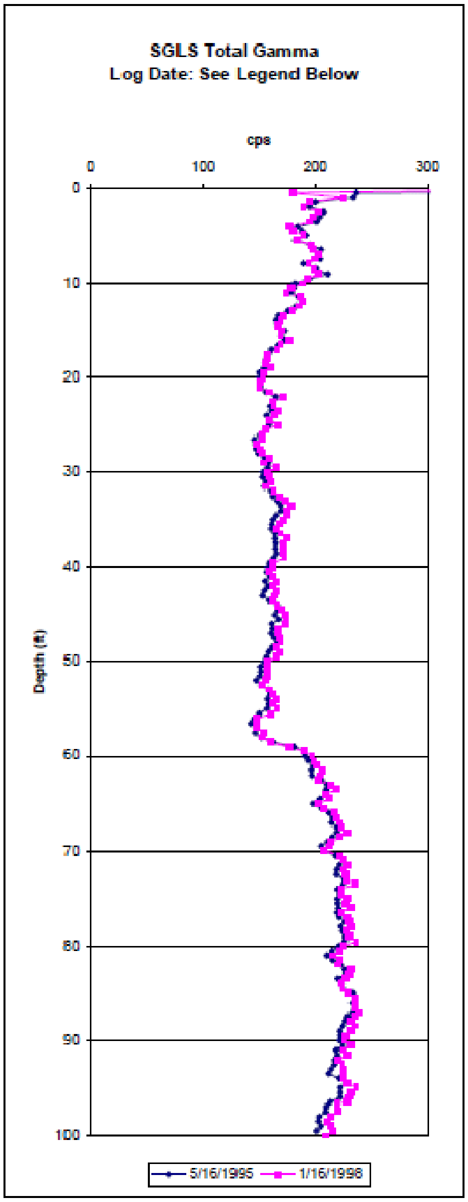
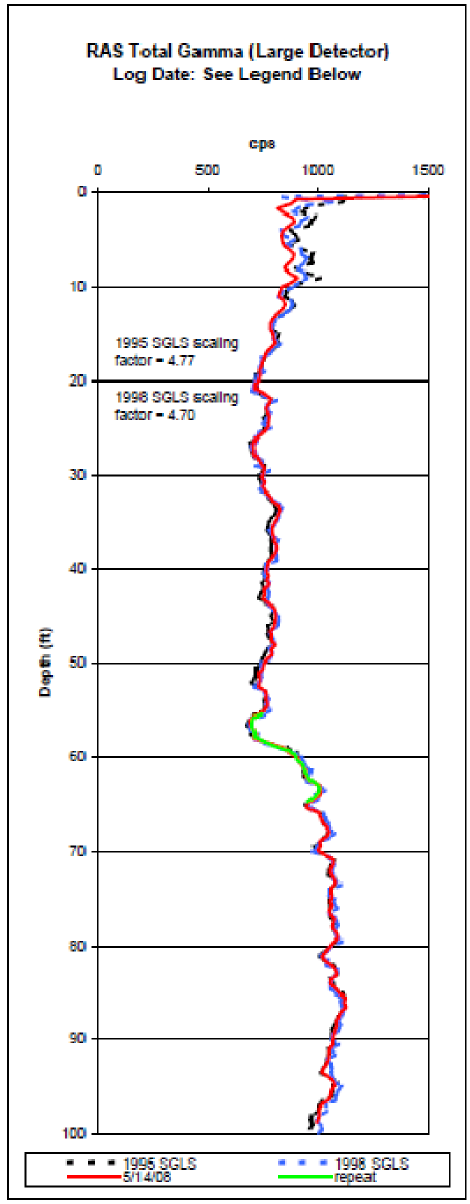
Borehole 41-04-05





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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-07-12 (299-W23-73) (A7909)

Borehole Information

Site: SX Farm, Tank SX-107			
Coordinates (HAN Plant):	North: 35397	West: 75668	Elevation (ft): 663.17
Coordinates (WA Plane):	North: 134250.076	East: 566834.497	Elevation (m): 203.144
Drill Date: 2/16/62	Type: Cable Tool	Depth (ft): 85.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 6/8/95	D/W Reference: RUST	
Comments: None.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	75	6	0.28	0	Stoller
Steel	0	88	4	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
06/08/95	SGLS	1	1	0-77.5	RUST	Baseline
01/15/98	SGLS	1	2	0-77.5	MACTEC	Baseline repeat
1/30/1998	N-N	RLSM3.1	1	0-75	WMFS	Moisture
05/27/08	RAS	Medium	A	0-77.5	Stoller	No apparent changes

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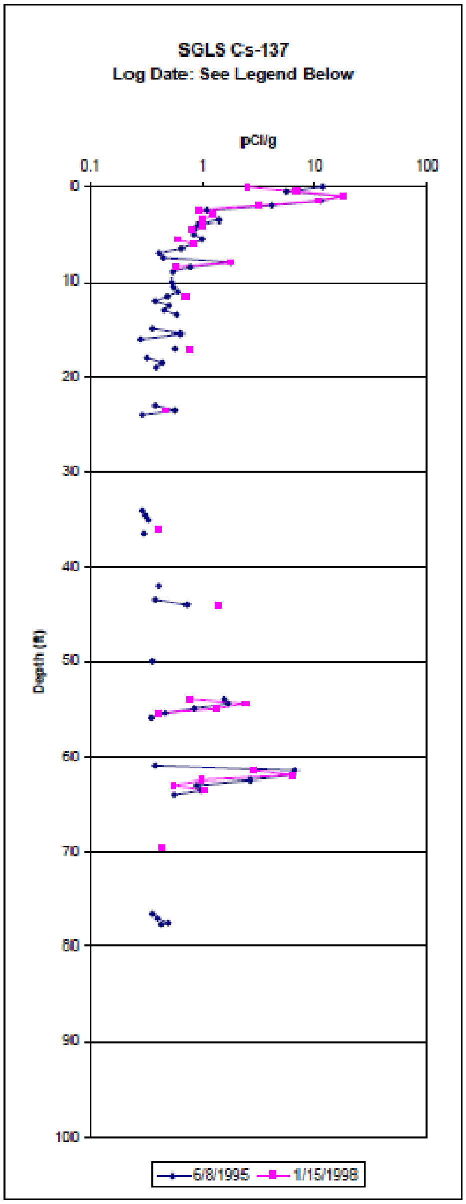
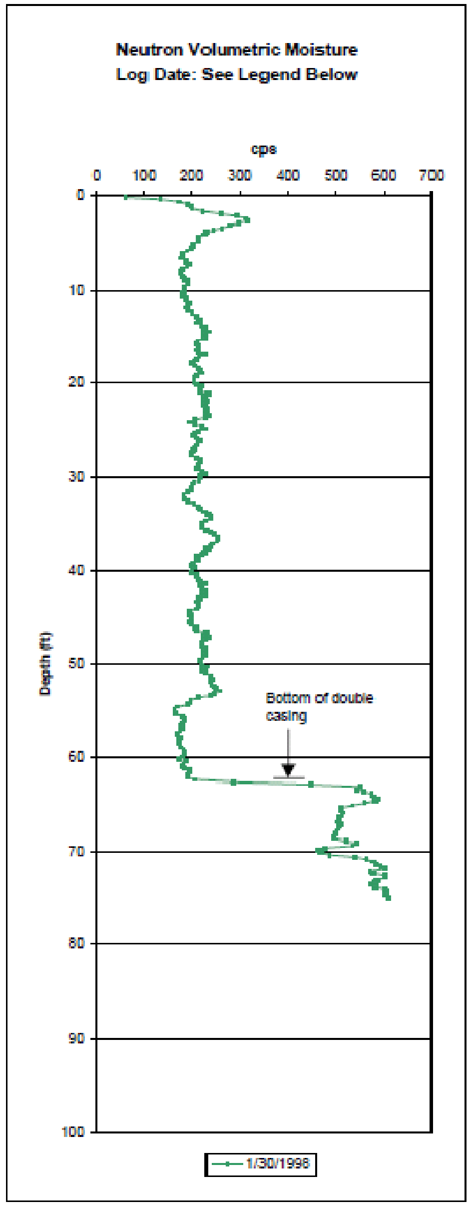
Borehole 41-07-12





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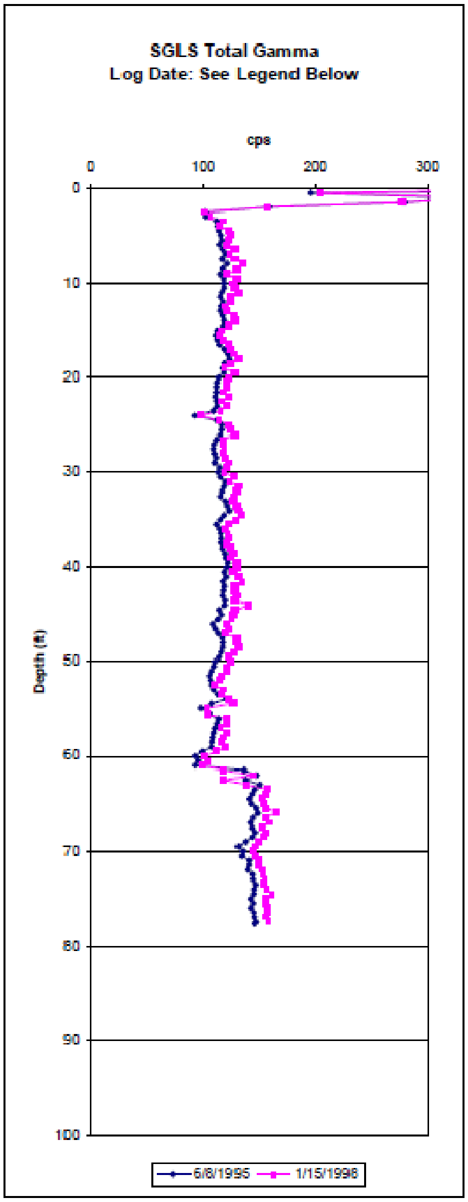
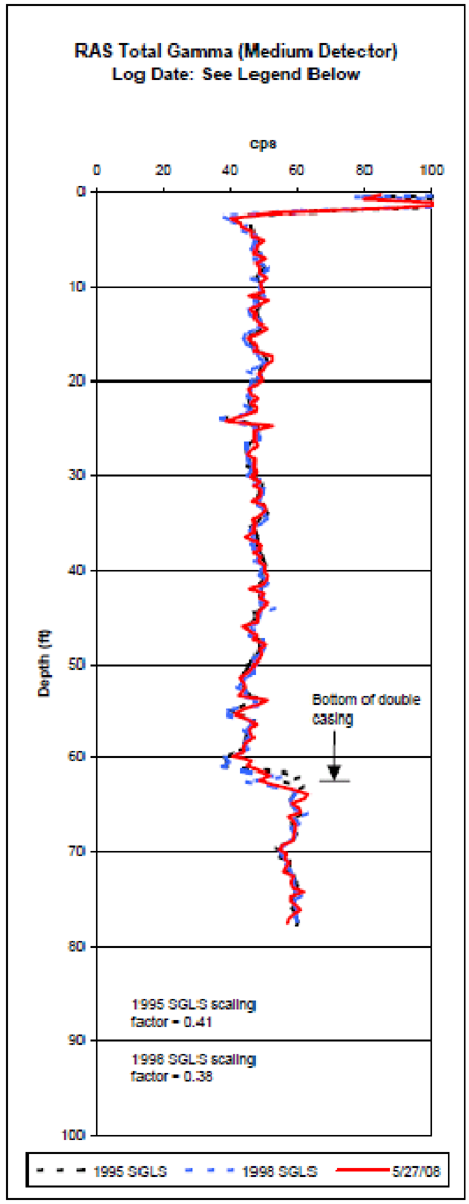
Borehole 41-07-12





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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-04-07 (299-W23-62) (A7898)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35405	West: 75695	Elevation (ft): 667.99
Coordinates (WA Plane):	North: 134254.065	East: 566824.696	Elevation (m): 203.211
Drill Date: 9/30/54	Type: Cable Tool	Depth (ft): 100.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 5/17/95	D/W Reference: RUST	
Comments: None.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/17/95	SGLS	1	1	0-98.5	RUST	Baseline
01/20/98	SGLS	1	2	0-99	MACTEC	Baseline repeat
2/5/1998	N-N	RLSM3.1	1	0-99	WMFS	Moisture
05/21/08	RAS	Large	A	0-98	Stoller	No apparent change

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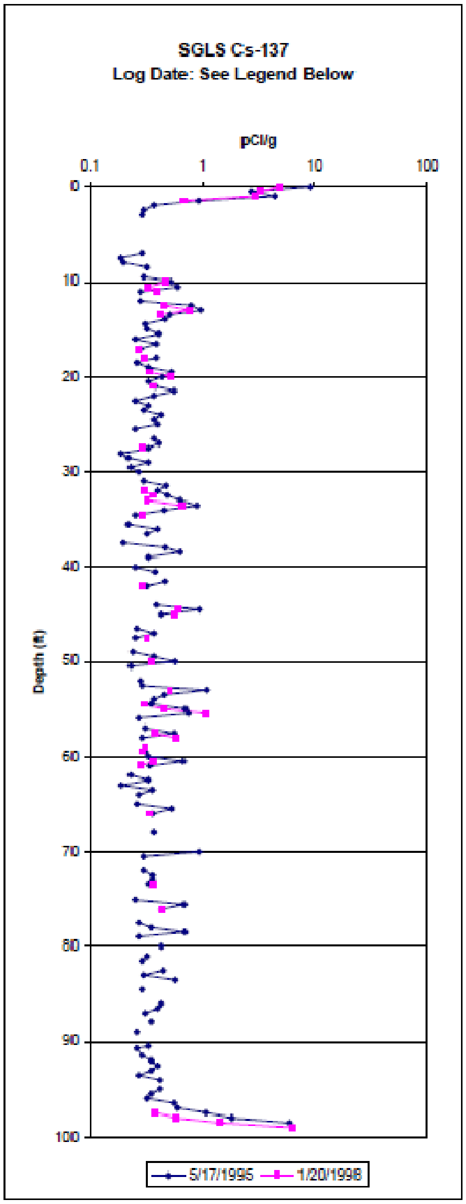
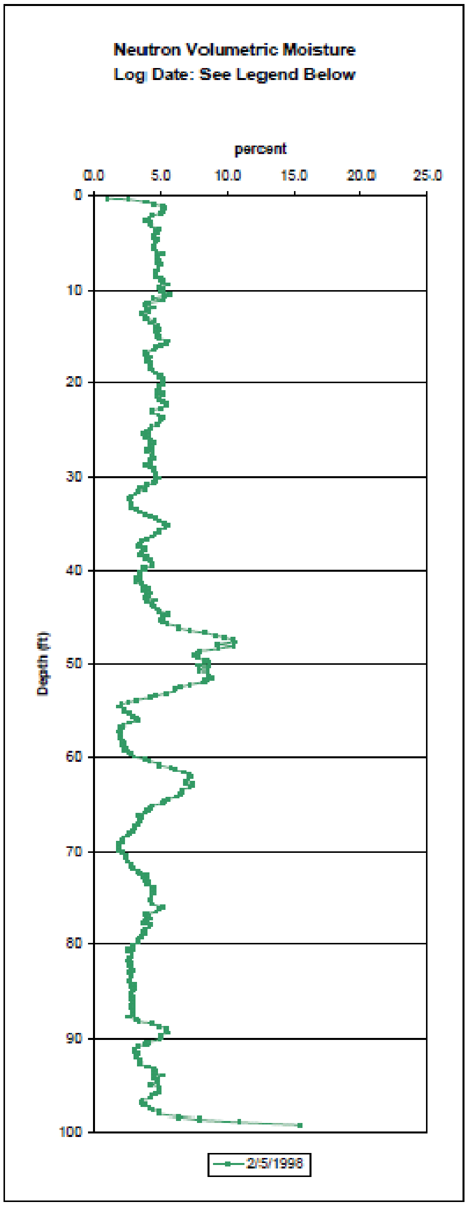
Borehole 41-04-07





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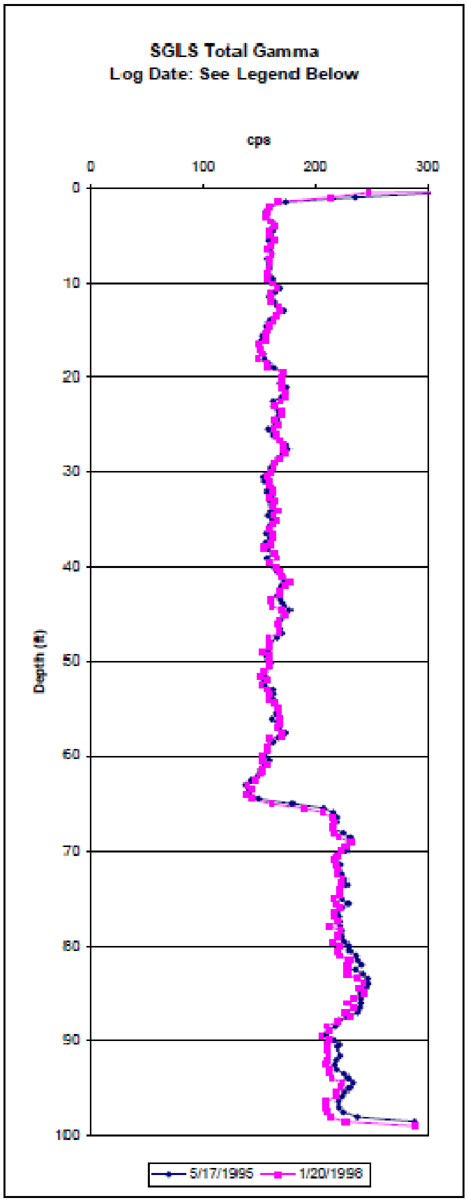
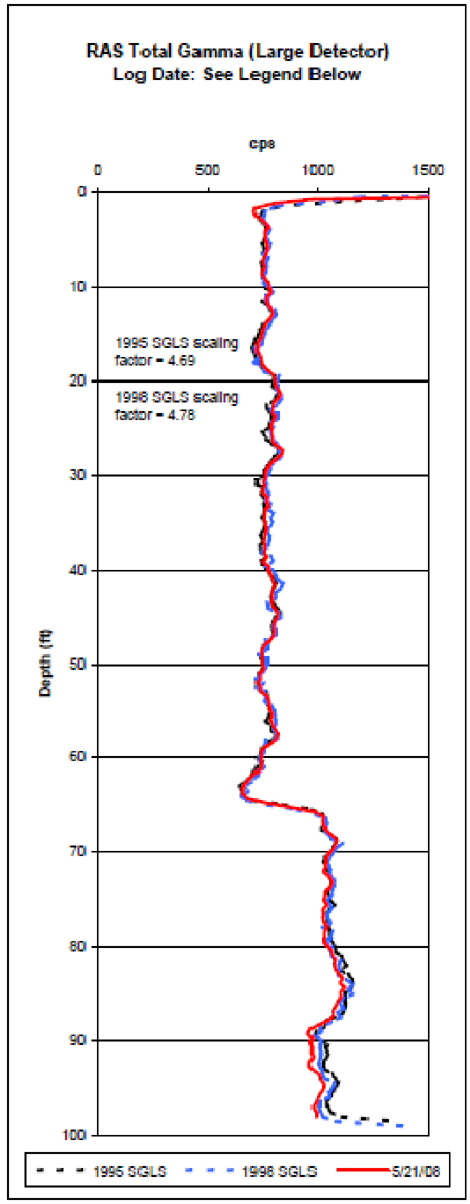
Borehole 41-04-07





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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-04-08 (299-W23-225) (A8052)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35427	West: 75704	Elevation (ft): 663.00
Coordinates (WA Plane):	North: 134259.152	East: 566823.573	Elevation (m): 203.229
Drill Date: 4/4/78	Type: Cable Tool	Depth (ft): 125.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 1/16/98	D/W Reference: RUST	
Comments: Annular grout from 0 to 18 ft.			

Casing Information

Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	125	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/18/95	SGLS	1	1	0-122.5	RUST	Baseline
01/16/98	SGLS	1	2	0-123	MACTEC	Baseline repeat
2/5/1998	N-N	RLSM3.1	1	0-123	WMFS	Moisture
05/22/08	RAS	Large	A	0-122	Stoller	No apparent change

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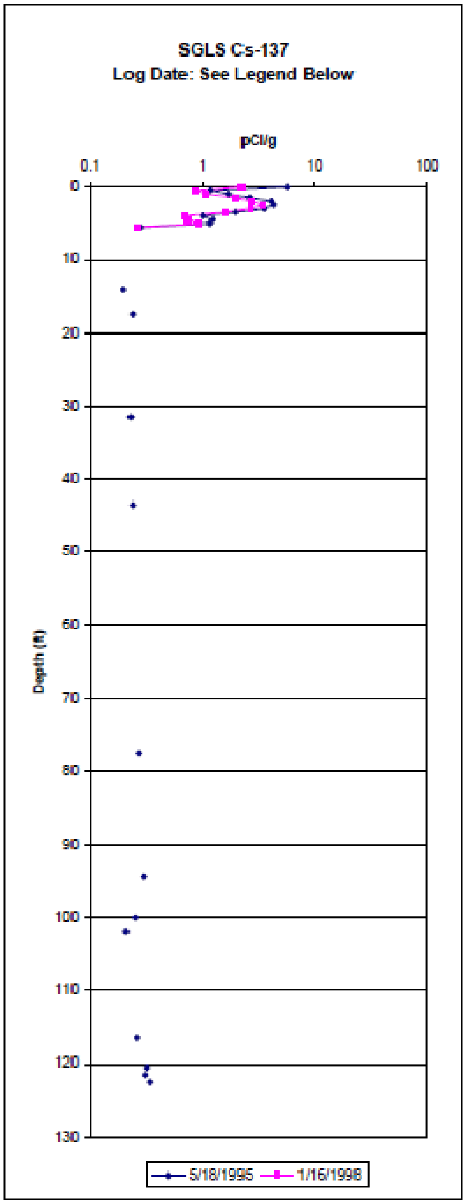
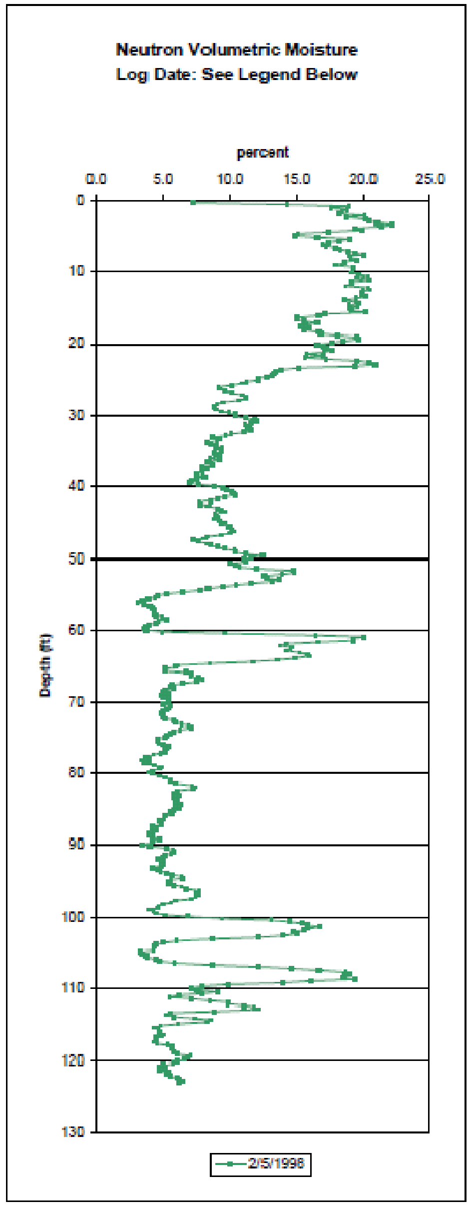
Borehole 41-04-08





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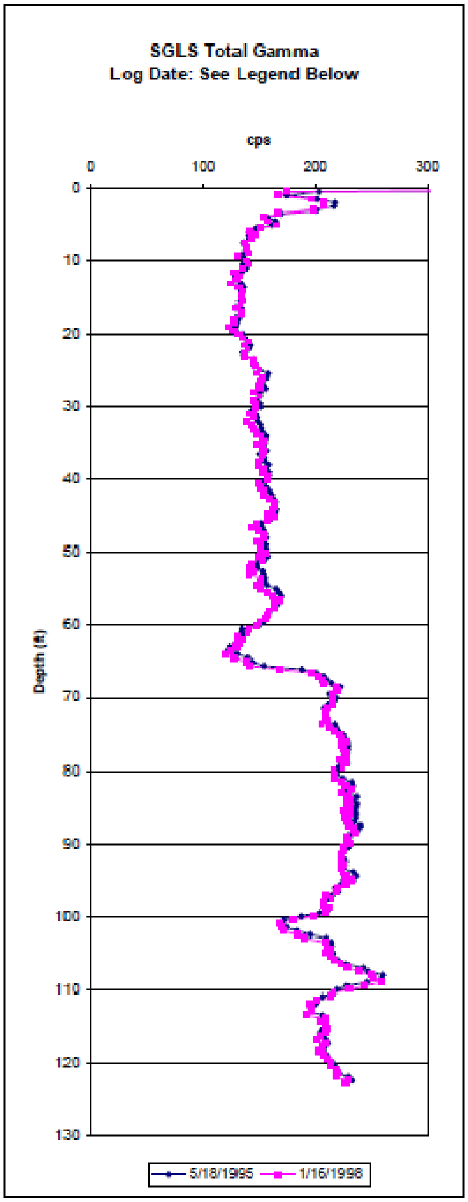
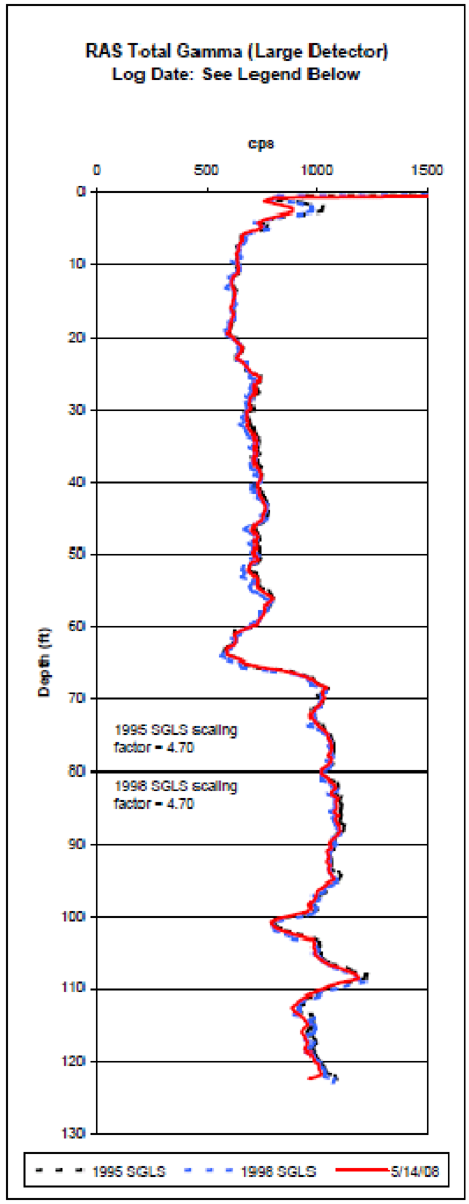
Borehole 41-04-08





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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-05-03 (299-W23-131) (A7967)

Borehole Information

Site: SX Farm, Tank SX-105			
Coordinates (HAN Plant):	**North: 35440**	**West: 75720**	**Elevation (ft): 662.76**
Coordinates (WA Plane):	**North: 134263.199**	**East: 566818.69**	**Elevation (m): 203.105**
Drill Date: unknown	**Type: Cable Tool**	**Depth (ft): 125.0**	**Depth Datum: TOC**
D/W (ft): dry	**D/W Date: 5/23/95**	**D/W Reference: RUST**	
Comments: None.			

Casing Information

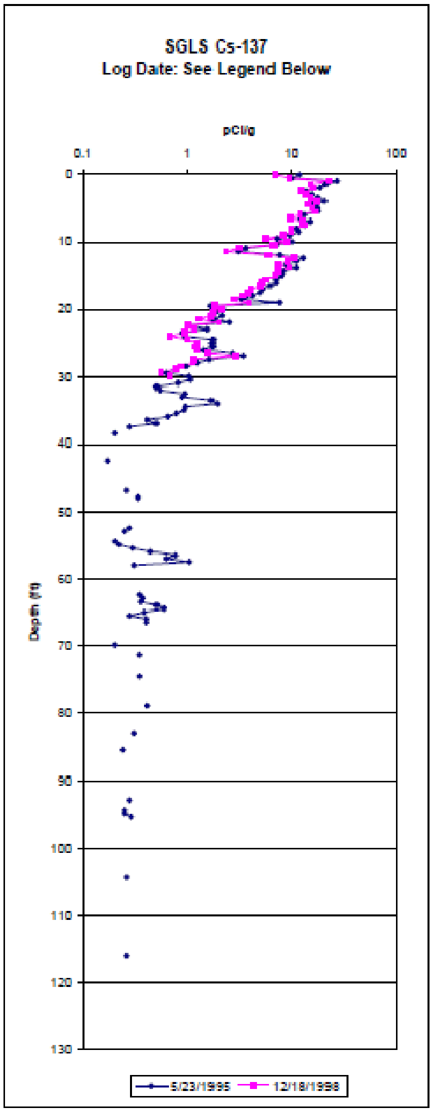
Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/23/95	SGLS	2	1	0-122.5	RUST	Baseline
12/18/98	SGLS	2	2	0-30	MACTEC	Baseline repeat
05/27/08	RAS	Large	A	0-123	Stoller	No apparent changes

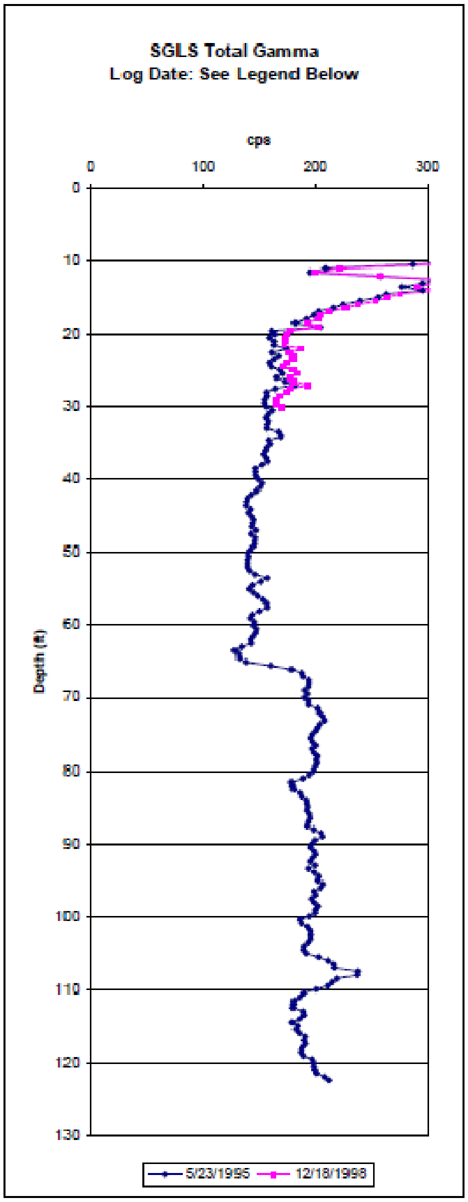
Stoller
Hanford Office

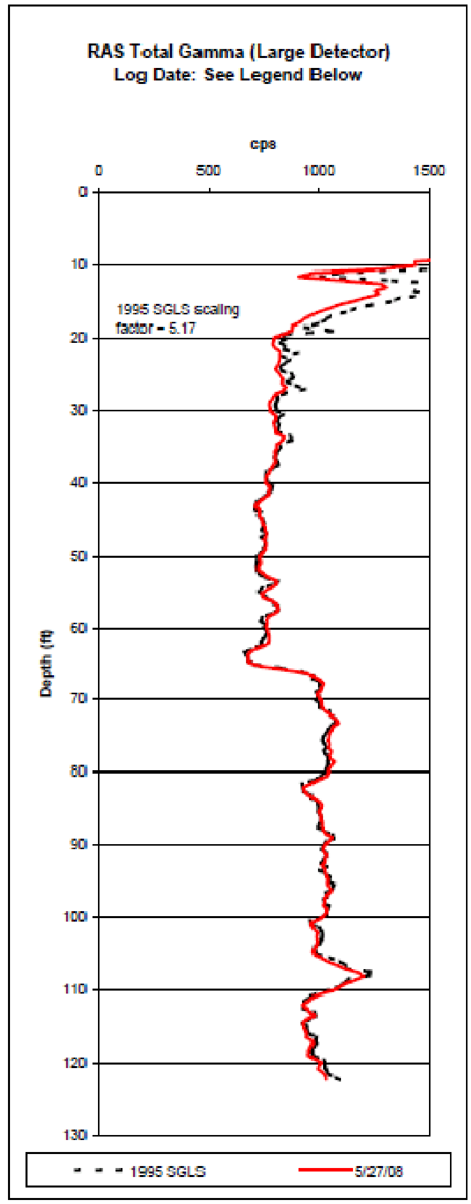
Borehole 41-05-03



Stoller
Hanford Office

Borehole 41-05-03





Stoller Hanford Office

Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

Borehole Number (Alias): 41-04-11 (299-W23-141) (A7977)

Borehole Information

Site: SX Farm, Tank SX-104			
Coordinates (HAN Plant):	North: 35483	West: 75689	Elevation (ft): 662.82
Coordinates (WA Plane):	North: 134277.107	East: 566828.092	Elevation (m): 203.073
Drill Date: 3/9/72	Type: Cable Tool	Depth (ft): 100.0	Depth Datum: TOC
D/W (ft): dry	D/W Date: 1/20/98	D/W Reference: MACTEC	
Comments: None.			

Casing Information

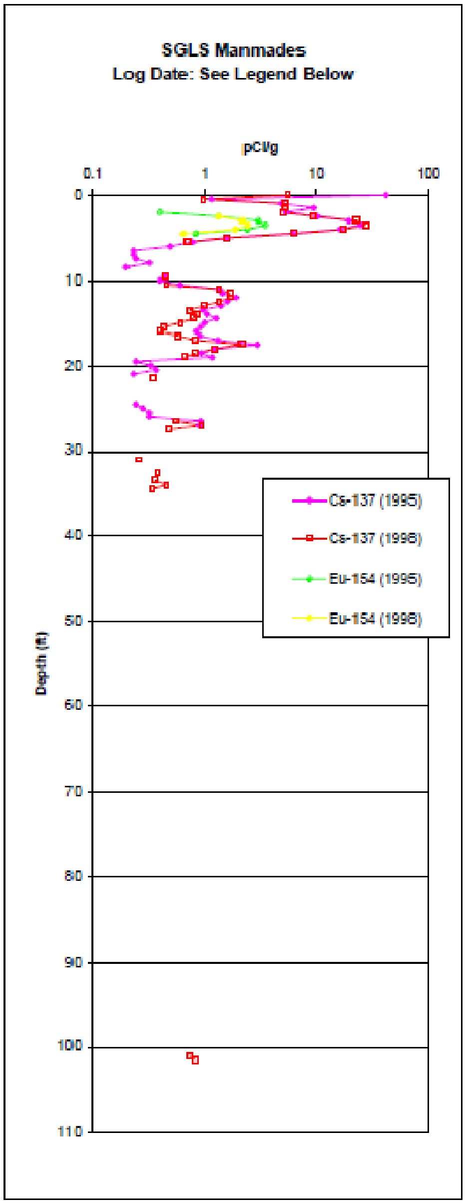
Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	MACTEC

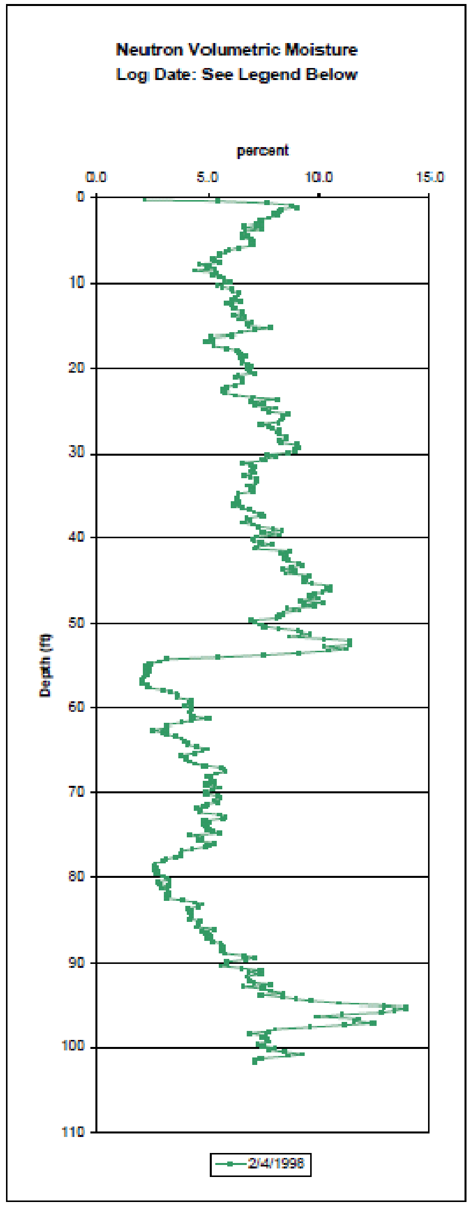
Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
05/19/95	SGLS	1	1	0-101	RUST	Baseline
01/20/98	SGLS	1	2	0-101.5	MACTEC	Baseline repeat
2/4/1998	N-N	RLSM3.1	1	0-101	WMFS	Moisture
05/22/08	RAS	Large	A	0-99.5	Stoller	No apparent changes

Stoller
Hanford Office

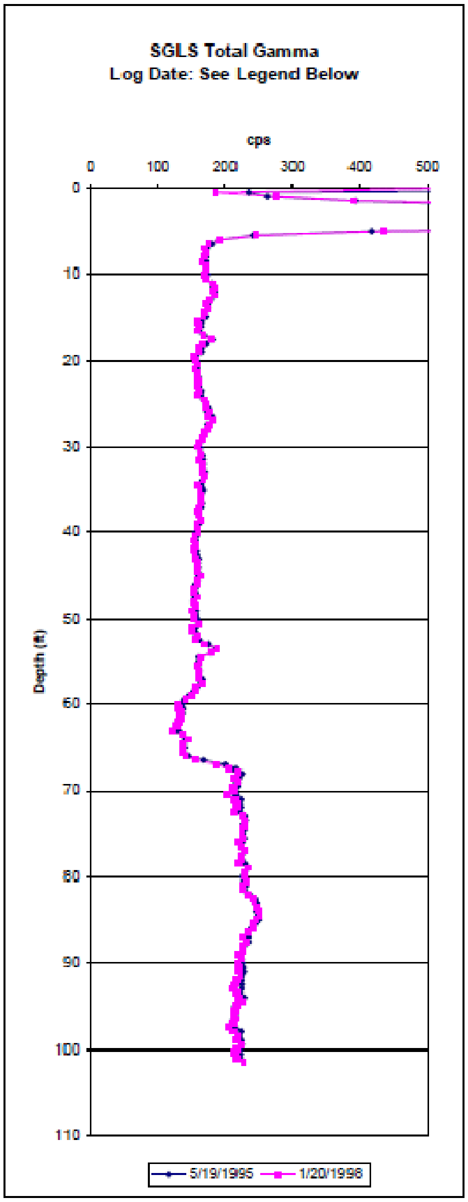
Borehole 41-04-11

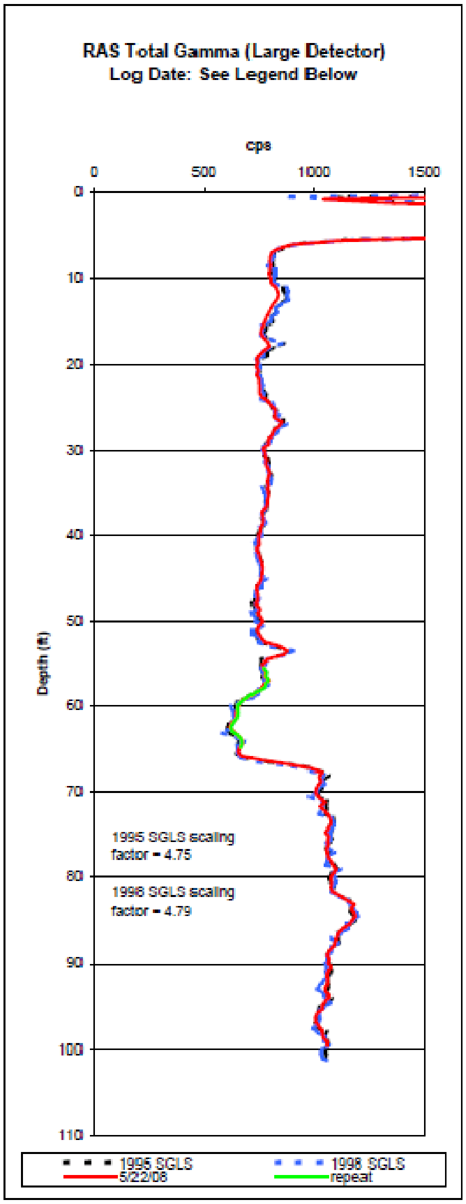




Stoller
Hanford Office

Borehole 41-04-11





Stoller Hanford Office

Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Borehole Number (Alias): 41-01-06 (299-W23-133) (A7969)

Borehole Information

Site: SX Farm, Tank SX-101			
Coordinates (HAN Plant):	North: 35508	West: 75665	Elevation (ft): 662.92
Coordinates (WA Plane):	North: 134283.901	East: 566835.306	Elevation (m): 203.102
Drill Date: 12/27/1971	Type: Cable Tool	Depth (ft): 96.0	Depth Datum: TOC
Depth/Water (ft): Dry	D/W Date: 7/9/03	D/W Reference: Stoller	
Comments: None.			

Casing Information

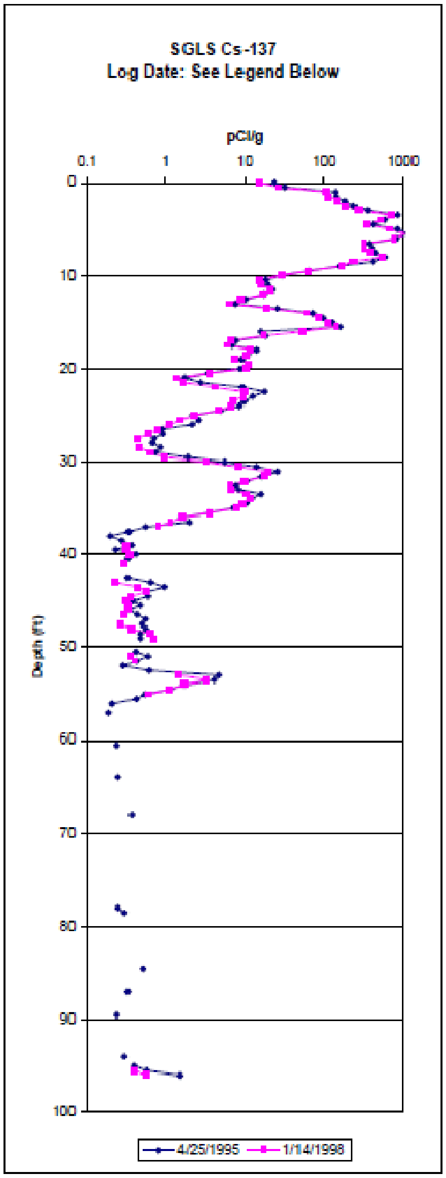
Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	100	6	0.28	0	Stoller

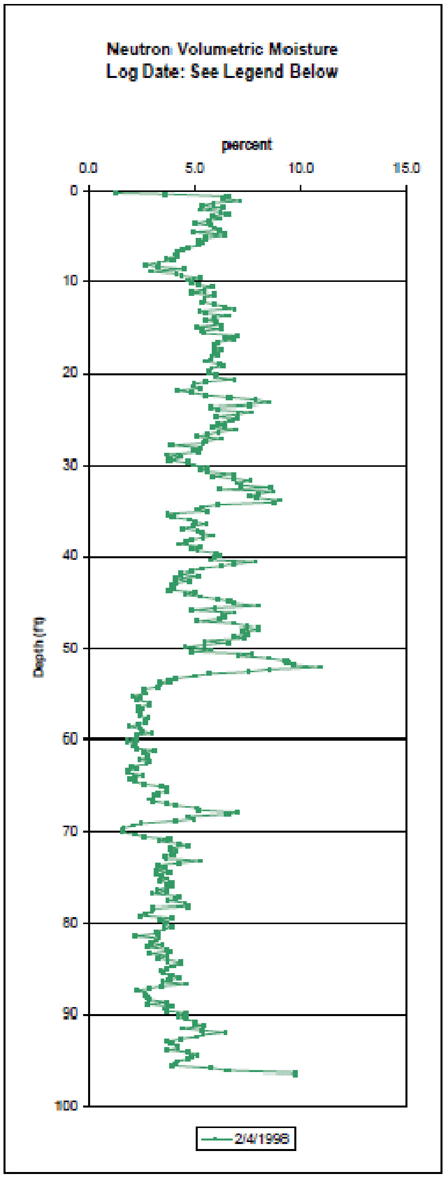
Log Run Information

Log Date	System	Detector	Event	Log int. (ft)	Contractor	Comments
4/25/1995	SGLS	G1A	NA	0-96	RUST	Baseline
1/14/1998	SGLS	G1A	NA	0-96	MACTEC-ERS	Baseline-Repeat
2/4/1998	N-N	RLSM3.1	1	0-96.5	WMFS	Moisture
9/6/2001	RAS	Large	A	25-80	MACTEC-ERS	No Change
9/9/2002	RAS	Large	B	25-80	Stoller	No Change
7/10/2003	RAS	Large-New	C	25-80	Stoller	No Change
5/23/2008	RAS	Large	D	0-95.5	Stoller	No apparent change

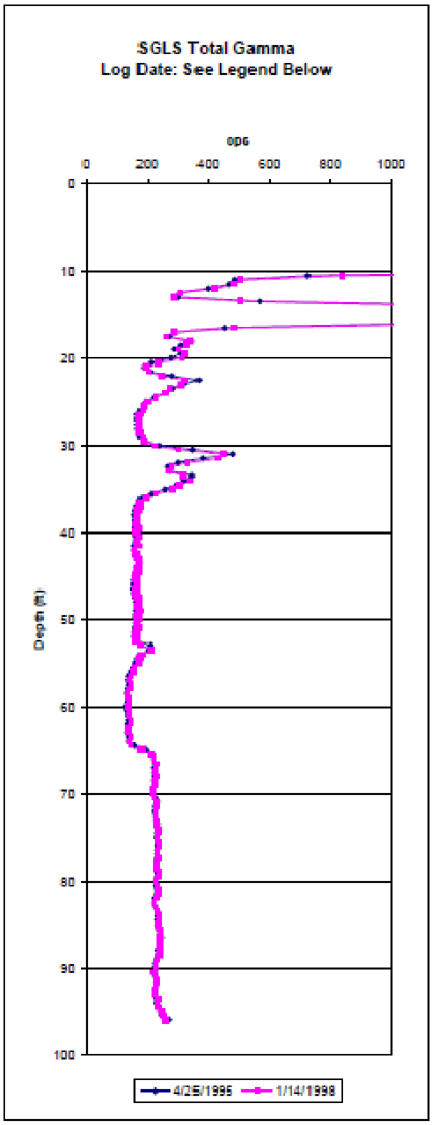
Stoller
Hanford Office

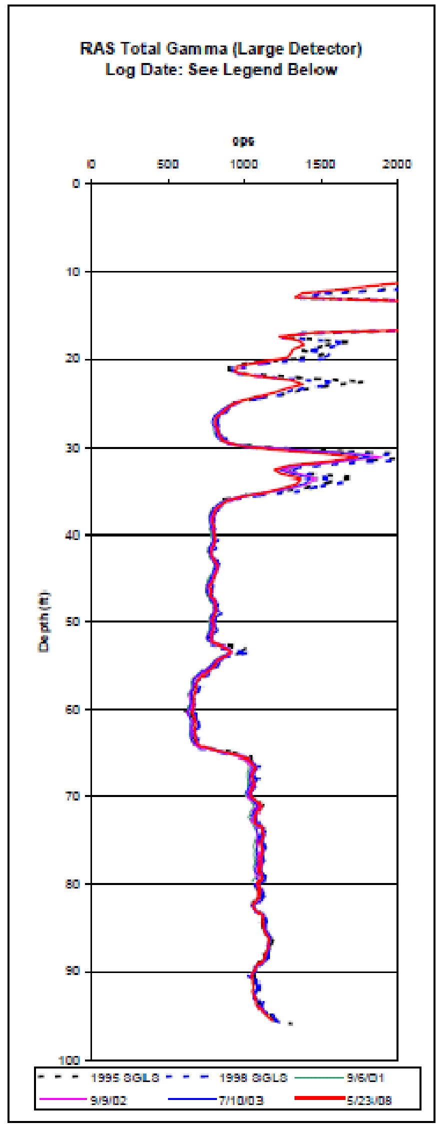
Borehole 41-01-06





Borehole 41-01-06





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APPENDIX F – TANK SX-104 OCCURRENCE REPORTS NOT AVAILABLE IN IDMS

OCCURRENCE REPORT

JUL 26 1976

CONTRACTOR	FACILITY	WORK AREA
Atlantic Richfield Hanford Company	241-SX Tank Farm, Tank 104-SX	200 West

REPORT NO.				DATE AND TIME OF OCCURRENCE
76-85	[ ] PRELIMINARY 6/11/76	[ ] INTERIM	[X] FINAL	June 8, 1976

OCCURRENCE SUBJECT

LIQUID LEVEL INCREASE EXCEEDING CRITERIA FOR TANK 104-SX

1. DESCRIPTION OF OCCURRENCE AND DESIGNATION OF APPARENT CAUSE

[ ] DESIGN [X] MATERIAL [ ] PERSONNEL [ ] PROCEDURE [ ] OTHER

An initial level increase of 2.10 inches exceeded the action criteria of 2 inches. The increase has continued slowly and is now four inches above the baseline. This increase is typical of crust formation and "growth" exhibited by 242-S Evaporator Slurries as they salt out.

bcc: DC Bartholomew
G Burton, Jr.
HE Campbell, Jr.
GT Dukelow
DG Harlow
MC Jacobs
HF Jensen
EJ Kosiancic
S Marchetti
BJ McMurray
GC Owens
BJ Saueressig
HP Shaw
GT Stocking
JA Teal
JH Warren
AT White
RA Zinsli
Central File

2. OPERATING CONDITIONS OF THE FACILITY AT TIME OF OCCURRENCE (IF APPLICABLE)

The tank is a slurry receiver in the 242-S Evaporator-Crystallizer System.

(OVER) 54-3000-568 (2-75)

3. IMMEDIATE EVALUATION, CORRECTIVE ACTION TAKEN AND RESULTS

The surface level increase is evaluated as a gradual buildup and growth of crust. Photographs were taken July 15 and gives evidence of the salt cake buildup. The condition of liquid level increase is considered typical of this type waste material.

4. RECOMMENDATIONS

A. TEMPORARY CORRECTIVE ACTION

None indicated.

B. PERMANENT CORRECTIVE ACTION

None.

C. IS DESIGN CHANGE NECESSARY? ☐ YES ☒ NO	IF YES, WHEN	
D. IS FURTHUR EVALUATION NECESSARY? ☐ YES ☒ NO	IF YES, BY WHOM	WHEN
E. PERMANENT CORRECTIVE ACTION TO BE IMPLEMENTED BY:	NAME	DATE

5. SIMILAR OCCURRENCE; BY REPORT NUMBER AND OCCURRENCE SUBJECT

Att.

cc: w/att.
OJ Bennett, ERDA-RL
OJ Elgert, ERDA-RL (3)
PG Rhoades, ERDA-RL
JH Straub, ERDA-RL

D. E. Kelley DE Kelley /jml — Manager, Planning, Scheduling & Operation Control 7/22

	TITLE	DATE
ORIGINATED BY H. F. Jensen [signature]	Manager, Tank Farm Surveillance	7/21/76
REVIEWED BY J. A. Teal [signature]	Manager, Tank Farm Operations	21 July 76
D. C. Bartholomew DC Bartholomew	Manager, Engineering	7/22/76
G. Burton, Jr. [signature] 23 jml	VP, Production and Waste Management	
APPROVED BY (PER CONTRACTOR OPERATING INSTRUCTIONS) E. J. Kosiancic [signature]	Manager, Tank Farm Management	7/21/76

TANK 104-SX

LIQUID LEVEL

Date	Liquid Level (inches)	Change from Previous Reading (inches)	Cumulative Change (inches)	Comments
6/13/73	341.10	-	-	
7/24/73	347.10	-0.10	-0.10	Calibration
8/27/73	347.00	-0.10	-0.20	
9/27/73	346.70	-0.30	-0.50	
10/24/73	346.50	-0.20	-0.70	
11/10/73	346.40	-0.10	-0.80	
12/29/73	346.10	-0.30	-1.10	
1/28/74	345.60	-0.50	-1.60	
2/01/74	345.65	-	-1.60	Water added
3/01/74	345.20	-0.45	-2.05	
4/01/74	344.85	-0.35	-2.40	
5/15/74	344.30	-0.55	-2.95	
6/12/74	344.00	-0.30	-3.25	
7/10/74	343.60	-0.40	-3.65	
8/07/74	343.30	-0.30	-3.95	
9/11/74	342.90	-0.40	-4.35	
10/02/74	342.60	-0.30	-4.65	
11/02/74	342.30	-0.30	-4.95	
12/01/74	342.00	-0.30	-5.25	
1/05/75	341.60	-0.40	-5.65	
2/06/75	341.30	-0.40	-6.05	
3/08/75	341.00	-0.30	-6.35	
4/19/75	340.60	-0.40	-6.75	
5/14/75	340.30	-0.30	-7.05	
6/01/75 to 7/14/75	156.80	-0.10	-7.15	Transfer
to 4/30/76	Active	-	-7.15	Slurry receiver
5/01/76	250.45	-	-7.15	
5/02/76	250.50	-	-7.10	Baseline
5/15/76	251.10	+0.65	-6.50	
5/31/76	252.20	+1.10	-5.40	
6/08/76	252.60	+0.40	-5.00	Flushed FIC (252.65)
6/18/76	253.00	+0.40	-4.60	
6/29/76	253.50	+0.50	-4.10	
7/12/76	254.00	+0.50	-3.60	
7/18/76	254.30	+0.30	-3.30	

HFJ:7/21/76

Original signatures for final issuance of Occurrence Report 76-85.

D. E. Kelley 7/22/76	Manager, Planning, Scheduling & Operation Control	
ORIGINATED BY H. F. Jensen	TITLE Manager, Tank Farm Surveillance	DATE 7/21/76
REVIEWED BY J. A. Teal	TITLE Manager, Tank Farm Operations	DATE 21 July 76
D. C. Bartholomew	Manager, Engineering	7/22/76
G. Burton, Jr.	VP, Production and Waste Management	
APPROVED BY (PER CONTRACTOR OPERATING INSTRUCTIONS) E. J. Kosiancic	TITLE Manager, Tank Farm Management	DATE 7/21/76
A. T. White	Manager, Quality Assurance and Safety	

54-3000-588R (2-75)

OCCURRENCE REPORT

SEP 28 1976

CONTRACTOR	FACILITY	WORK AREA
Atlantic Richfield Hanford Company	241-SX Tank Farm, Tank 104-SX	200 West

REPORT NO.				DATE AND TIME OF OCCURRENCE
76-125	[X] PRELIMINARY	[ ] INTERIM	[X] FINAL	9/21/76

OCCURRENCE SUBJECT

SURFACE LEVEL INCREASE EXCEEDING CRITERIA FOR 104-SX

1. DESCRIPTION OF OCCURRENCE AND DESIGNATION OF APPARENT CAUSE

[ ] DESIGN [X] MATERIAL [ ] PERSONNEL [ ] PROCEDURE [ ] OTHER

A liquid level increase of 3.05 inches from the baseline value established following a slurry reception in 104-SX tank exceeds the action criteria of +3.00 inches.

The increase is believed due to flotation and growth of salt crust. This is similar to observations in other tanks receiving 242-S Evaporator slurries. Photographs taken 7/15/76 attest to a salt crust growth during the past few months following similar waste materials received in the tank. The attached liquid (surface) level plot indicates the increase rate is slowly leveling out.

bcc: DC Bartholomew
G Burton, Jr.
Legal
GT Dukelow
RA Freeman
DG Harlow
MC Jacobs
HF Jensen
EJ Kosiancic
CW Malody
S Marchetti
BJ McMurray
GC Owens
BJ Saueressig
HP Shaw
JA Teal
JH Warren
AT White
RA Zinsli
Central File

2. OPERATING CONDITIONS OF THE FACILITY AT TIME OF OCCURRENCE (IF APPLICABLE)

The tank is considered sound and is used as a receiver of 242-S Evaporator bottoms.

(OVER)

54-3000-588 (5-79)

3. IMMEDIATE EVALUATION, CORRECTIVE ACTION TAKEN AND RESULTS

The surface level increase is evaluated as a gradual buildup of floating salt crust. Photographs taken 7/15/76 confirm considerable salt buildup from previous transfers. A review of the previous Occurrence Report indicates that the addition of 100 inches of slurry early in August accelerated the level increase rate. Indications are, as shown on the attached plot, that the rate of increase is beginning to level out.

4. RECOMMENDATIONS

A. TEMPORARY CORRECTIVE ACTION

Present conditions do not dictate any corrective action. Action criteria was recently revised to 3.00 inches acknowledging the physical characteristics of this type evaporator product.

B. PERMANENT CORRECTIVE ACTION

None indicated at this time.

C. IS DESIGN CHANGE NECESSARY? ☐ YES ☒ NO	IF YES, WHEN	
D. IS FURTHUR EVALUATION NECESSARY? ☐ YES ☒ NO	IF YES, BY WHOM	WHEN
E. PERMANENT CORRECTIVE ACTION TO BE IMPLEMENTED BY: NAME		DATE

5. SIMILAR OCCURRENCE: BY REPORT NUMBER AND OCCURRENCE SUBJECT

76-85 "Liquid Level Increase Exceeding Criteria for 104-SX"

Att.

cc: w/att.
JC Cummings, ERDA-RL
OJ Elgert, ERDA-RL (3)
PG Rhoades, ERDA-RL
JH Straub, ERDA-RL

ORIGINATED BY	H. F. Jensen	TITLE: Manager, Tank Farm Surveillance	DATE: 9/22/76
REVIEWED BY	J. A. Teal	TITLE: Manager, Tank Farm Operations	DATE: 23 Sept 76
	E. J. Kosiancic	Manager, Engineering	9-23-76
	A. T. White	Manager, Quality Assurance and Safety	9/27/76
	D. E. Kelley	Manager, Planning, Scheduling and Operation Controls	9/24/76
	C. W. Malody	Manager, Production and Waste Management	9/27/76
APPROVED BY (PER CONTRACTOR OPERATING INSTRUCTIONS)	D. C. Bartholomew	TITLE: Manager, Operations	DATE: 9/27/76

54-3000-568R (5-76)

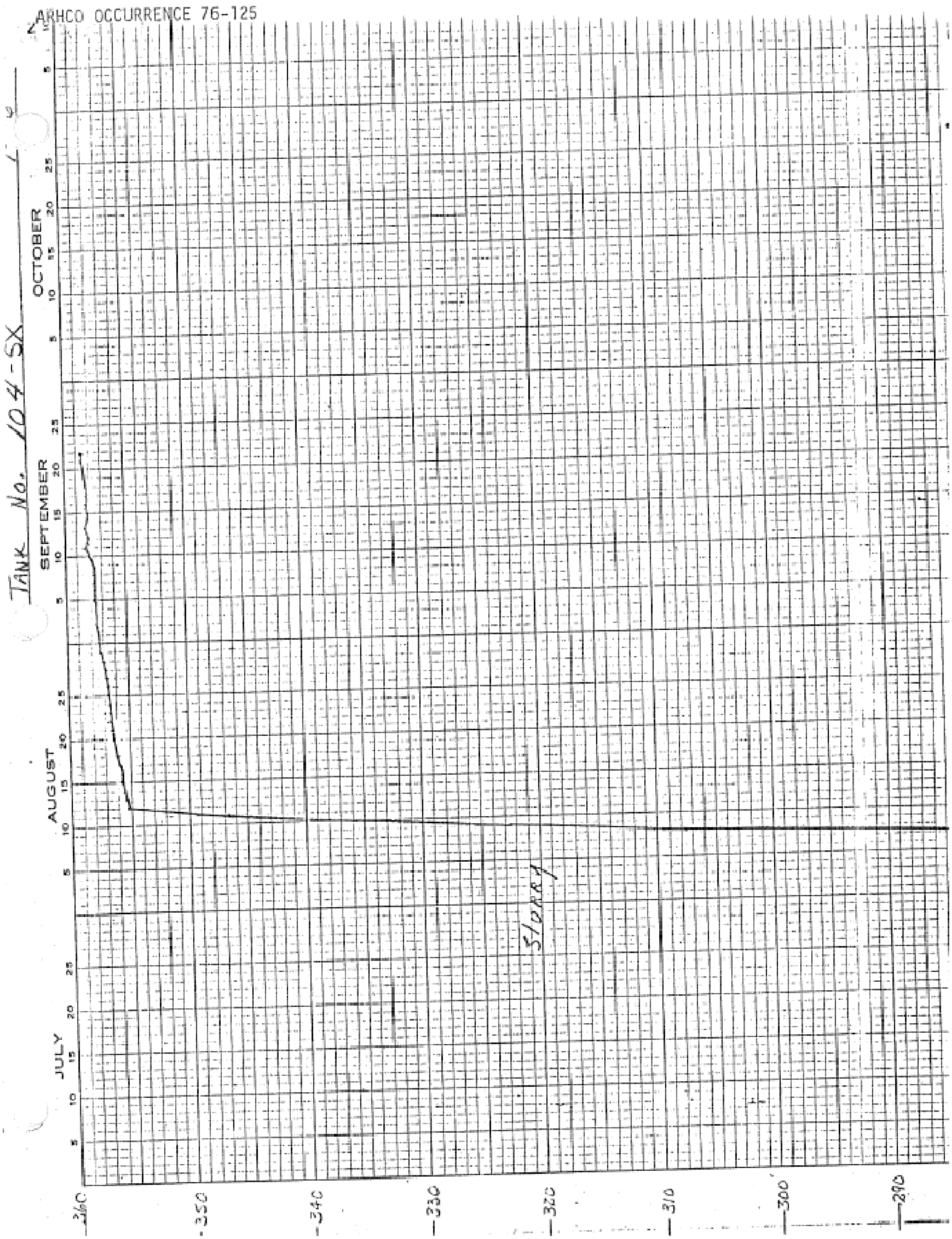
ARHCO OCCURRENCE 76-125

TANK 104-SX

LIQUID LEVEL

Date	Liquid Level (inches)	Change From Previous Reading (inches)	Cumulative Change (inches)	Comments
5/14/75	340.30			
6/01/75 to 7/14/75	156.80			Transfer
7/14/75 to 4/30/76	Active	-		Slurry Receiver
5/01/76	250.45	-		
5/02/76	250.50	-		Baseline
5/15/76	251.10	+0.65	+0.65	
5/31/76	252.20	+1.10	+1.75	
6/08/76	252.60	+0.40	+2.15	Flushed FIC (252.65)
6/18/76	253.00	+0.40	+2.55	
6/29/76	253.50	+0.50	+3.05	
7/12/76	254.00	+0.50	+3.55	
7/18/76	254.30	+0.30	+3.85	Baseline
8/06/76	254.50	+0.20	+4.05	
8/07/76 to 8/13/76	355.45	-	+4.05	Rec'd. Slurry (Baseline
8/31/76	357.20	+1.75	+5.80	
9/15/76	358.10	+0.90	+6.70	
9/15/76	358.35	+0.25	+6.95	After Flushing Gauge
9/21/76	358.50	+0.15	+7.10	

HFJ:kam 9/23/76


ARHCO OCCURRENCE 76-125
TANK No. 104-SX
OCTOBER
SEPTEMBER
AUGUST
JULY
Slurry
360
350
340
330
320
310
300
290

Westinghouse
Hanford Company

ATA File
History

P.O. Box 1970 Richland, WA 99352

September 22, 1988

8855768

Mr. R. E. Gerton, Director
Waste Management Division
U. S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Gerton:

REVISION OF UNUSUAL OCCURRENCE REPORT FOR TANK 241-SX-104
NUMBER WHC-UO-028-TF-03

Attached is the revision pertaining to Unusual Occurrence Report number WHC-UO-88-028-TF-03. The referenced report contained an editorial error Section 8 paragraph 2). The reference report stated that pumping temporarily ceased due to failure of a tank. The pumping was temporarily ceased due to a pump failure. This error has been corrected in the attached revision.

This report has undergone a classification and Unclassified Controlled Nuclear Information (UCNI) review and the report is satisfactory for public release.

Very truly yours,

H. F. Daugherty, Manager
Defense Waste Management Division

skb

Attachment

DOE-HQ - Director, Quality Assurance

DOE-OR - William Cooper
J. L. Meinhardt

DOE-RL - J. L. Rhoades
A. W. Kellogg (w/o attachment)
G. J. Bracken

R01318

Hanford Operations and Engineering Contractor for the US Department of Energy

Unusual Occurrence (Critique) Report
Contractor: Westinghouse Hanford Company

1. Report Number WHC-UO-88-028-TF-03
Reference: EFS TFSO-EFS-88-085

Status and Date of Report: ______Initial ________ Date of Event/Occurrence 7-13-88
______Interim ________ Time of Event/Occurrence______
__X__Final 8-30-88

Division/Department or Project: Tank Farm Surveillance Analysis & Support

2. Facility, System, and/or Equipment

Tank 241-SX-104

3. Subject of Event/Occurrence

Tank 241-SX-104 has been classified as an assumed leaker.

4. Apparent Cause: Design ____ Material __X__ Personnel____ Other____

Apparent Tank Leak

5. Description of Event/Occurrence

The Liquid Observation Well (LOW) Interstitial Liquid Level (ILL) exceeded the 0.3 foot decrease criteria in Tank 241-SX-104 with the Gamma Probe. Environmental Protection Deviation Report 88-03 was issued February 19, 1988, and an investigation into the tank integrity was commenced. Integrity investigation was completed on July 13, 1988, and a decision was made to issue a UOR.

6. Operating Conditions of Facility at Time of Event/Occurrence

Inactive, Underground Single-Shell Waste Storage Tank

7. Immediate Evaluation:

LOW scans covering three years were evaluated for trends. The decrease in the interstitial liquid level was verified by data from three probes (Gamma, Neutron, and Acoustic). A review of the Automatic FIC surface level measurement shows an erratic decrease since 1984. Photographs (2-14-84) show a crusted irregular surface of solids. Small pools of liquid are visible. Photographs (01-14-88 and 05-05-88) show no major change in the overall surface, but minor changes in the size of the small liquid pools. Surface level measurement anomalies can be expected.

8. Immediate Action Taken and Results:

1) Increased monitoring of tank level was commenced. Scans with the Gamma, Neutron, and Acoustic Probes were obtained and verified previous criteria violation data. Action: TFSA&S, Completed

2) Following confirmation of decreasing tank level, pumping of Tank 241-SX-104 was commenced on May 18, 1988 (Total net pumped 42,200 gallons). The pumping of the waste to the 244-S Double Container Receiving Tank was temporarily ceased on

July 14, 1988 due to pump failure. The pump was replaced on July 29, 1988 and pumping commenced. The submersible pumping was completed on August 16, 1988 (Total net pumped 99,900 gallons). In-tank photographs have been requested (August 30, 1988) for reference prior to the initiation of jet pumping. Action: TFS&O

3) A Peer Review group was formed in accordance with procedure RHO-CD-1193 on May 17, 1988. The Peer Review Group declared Tank 241-SX-104 an assumed leaker on July 13, 1988. Action: Peer Review Group Chairman, Completed

9. Is Further Evaluation and/or Corrective Action Necessary? Yes ___ No _X_
If Yes, Before Further Operation? Yes ___ No ___ N/A - Tank is Deactivated
If Yes, By Whom?
When?

10. Final Evaluation and Lessons Learned

The Peer Review Team classified Tank 241-SX-104 an assumed leaker on July 13, 1988 because tank integrity could not be determined with a confidence level of 95%.

11. Corrective Action Taken___X___ Recommended______ To Be Supplied______

Tank 241-SX-104 is currently being pumped for tank stabilization and isolation.

12. Programmatic/Project Cost and Schedule Impact:

N/A

13. Impact Upon National Codes and Standards, Including NE Standards

N/A

14. Similar Unusual Occurrence Report Numbers:

UOR#	OR#
83-16	76-85
83-11	76-125
	77-17
	77-188

15. Signatures:

Originator [signature] Date 8-30-88
Engineer, Tank Farm Surveillance Analysis & Support

Approved by RK WATY Date 8-30-88
Manager, Tank Farm Surveillance Analysis & Support

Approved by RJ Baumhardt Date 8-31-88
Manager, Tank Farm Surveillance & Operations

Approved by [signature] Date 9/2/88
Manager, Defense Waste Management Division

Approved by [signature] for Date 9/8/88
Manager, Chemical Plant Quality Assurance

Approved by [signature] Date 9-5-88
Manager, Nuclear Facility Safety

Approved by [signature] Date 9/12/88
Manager, Environmental Assurance

Classification [signature] 9-14-88 Not UCNI   X Unclassified
__ Classified

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APPENDIX G – EXECUTIVE SAFETY REVIEW BOARD BRIEFING JANUARY 28, 2011

washington river protection solutions

241-SX-104 Leak Assessment

D. J. Washenfelder

January 28, 2011

Tank SX-104 Leak Assessment Summary

- Declared an "assumed leaker" by 3 to 2 vote in 1988 due to 6-in decrease in interstitial liquid level 1984 – 1988 (34 gallons lost/week)
  - 1995, 1998, 2008, 2010 reviews concluded tank unlikely to have leaked
- Evaporation – 17 – 51 gallons/week per 1988, 1994 estimates, and
- Misinterpretation of interstitial liquid level behavior account for leak declaration
- Recommendation:

  Change tank SX-104 leak integrity status from "Assumed Leaker" to "Sound"

Page 2

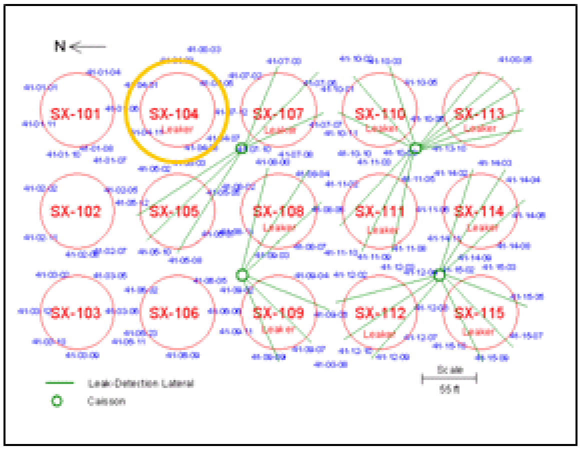
Tank SX-104 Leak History (1)

- **Declared an "assumed leaker" by 3 to 2 vote in 1988[1,2]**
  - 6-in interstitial liquid level (ILL) decrease during 1984 - 1988 exceeded -0.3-ft decrease criterion
  - Estimated loss -5,300 gal, equivalent to 34 gal/week[3]
  - No Drywell changes above background
  - HVAC evaporation discounted by comparison with similarly-ventilated SX tanks
  - Team members believed evaporation caused decrease, but data were insufficient to conclude tank was sound with 95% certainty

1. Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104, July 1988 [D193016360]
2. 13311-88-0498 Evaluation of Integrity of 241-SX-104, July, 1988 [D193016336]
3. Rounded up to 6,000 gal in HNF-EP-0182, Waste Tank Summary Report for Month Ending ...

Page 3

Tank SX-104 Orientation and Drywells

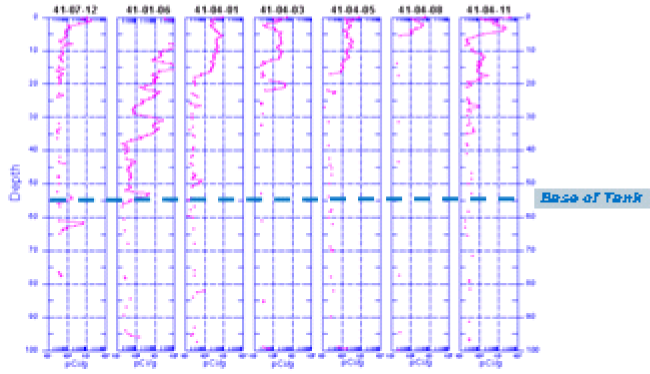


- 1 Mgal single-shell tank used from 1955 – 1980
- Ringed with 6 drywells

Page 4

SX-104 Soil Contamination – Drywell Radiation Summary

Cs-137 Concentration of Surrounding Drywells (1995)



GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, Appendix C, Tank Farm Correlation Plots

No detectable drywell changes were found during the 1986, 1998, 2006, or 2010 leak investigations.

Page 5

SX-104 Soil Contamination Plume – NW View

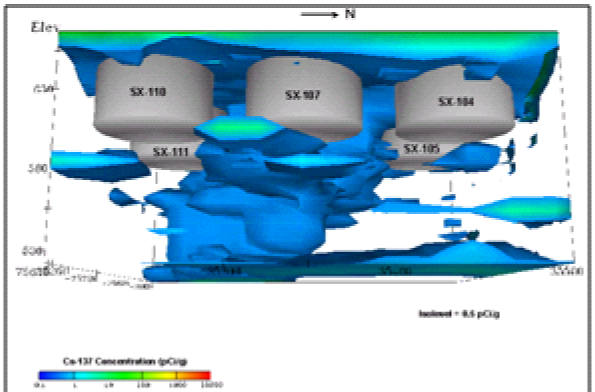


Figure 23. Visualization of Tanks SX-104 and SX-107 Cs-137 Plume Viewed From the East

GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, [illegible] Figures

Page 6

SX-104 Soil Contamination Plume – NE View

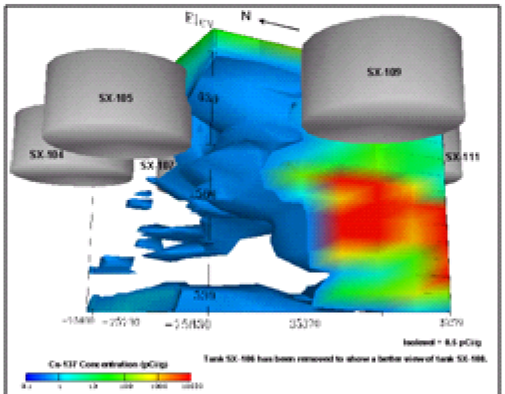


Figure 27. Visualization of Tank SX-108 Cs-137 Plume Viewed From the Northwest

GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, 10.0 Figures

Page 7

Tank SX-104 Leak Assessment Elements

- ***Evaporation***
- ***Interstitial Liquid Level Behavior***

Page 8

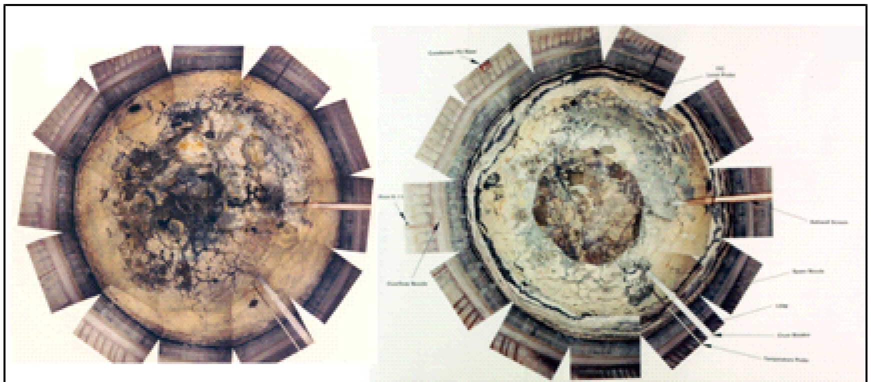
Interstitial Liquid Level Decrease – Influence of Evaporation

- *In 1984 tanks SX-101 – SX-104 were connected to 241-SX Sludge Cooler system via tank SX-109*
  - *Drawing indicates aggregated flowrate of 1100 cfm, or ~ 157 cfm/tank[1]*
- *1988 Leak assessment hypothesized a 20 cfm rate – a loss of 51 gallons/week*
  - *Measured loss at tank SX-109 outlet was 302 ± 197 gallons/week distributed across the 7 tanks – 43 gallons/week*
  - *Actual loss from tank during 1984 – 1988 period was ~ 34 gallons/week*
- *1994 Evaporation Analysis assumed 60 cfm*
  - *17 gallons/week for 1% free surface area*
  - *40 gallons/week for 3% surface area*
- *2000 Passive Breathing evaluation measured 30 cfm at tank[2]*

1. H-2-90866, 1984, "HVAC Airflow Diagram"
2. RPP-6660, 2000, "Collection and Analysis of Selected Tank Headspace Parameter Data," Rev. 0

Page 9

Evidence for Evaporation



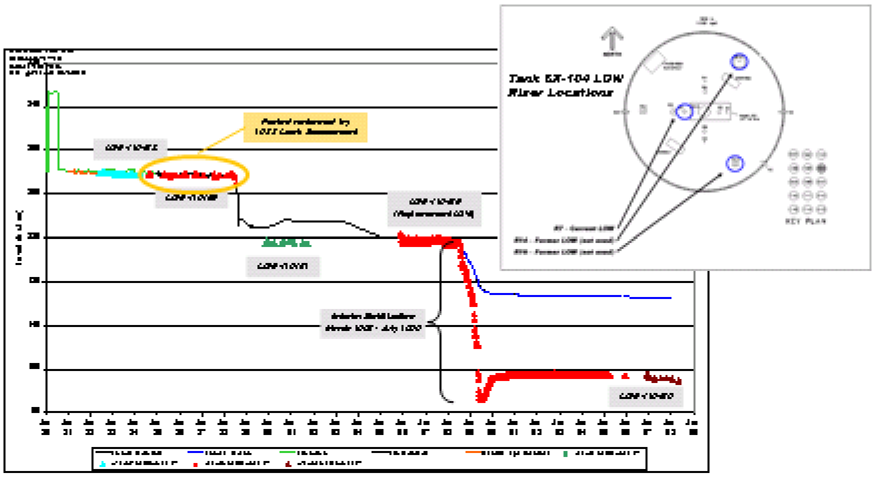
Waste Surface Appearance – February 14, 1984 *Waste Surface Appearance – September 8, 1988*

1994 review of possible evaporation estimated free liquid surface area as 1% - 3%.[1] 1984 photograph suggests larger evaporation surface was available – probably 15% - 20%.

[1] WHC-SD-WM-ER-318 Rev. 0 Evaporation Analysis for Tank SX-104, 1994

Page 10

Interstitial Liquid Level History – 1980 - 2008

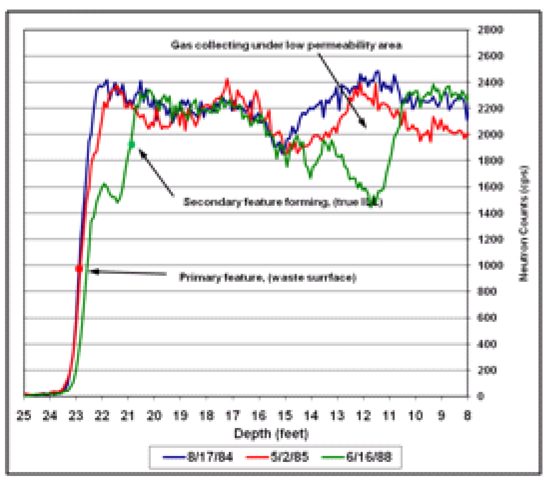


The second LOW installation was used to log the tank's ILL between July 20, 1984, and July 14, 1988, and covers most of the period reviewed during the 1988 leak assessment.

Page 11

Interstitial Liquid Level Interpretation Difficulty 1984 - 1988

- ***New LOW installed in 1984***
  - *The 1984 log indicates high water content from the waste surface to the tank bottom, consistent with the presence of installation water remaining on the waste surface and filling the LOW cavity.*
- ***Over the next four years, the installation water dissipated through the waste, unmasking the secondary feature that represents the actual ILL.***
  - *This behavior has been identified in other single-shell tanks; a secondary neutron feature is used to track the ILL in 18 of them.*[1]

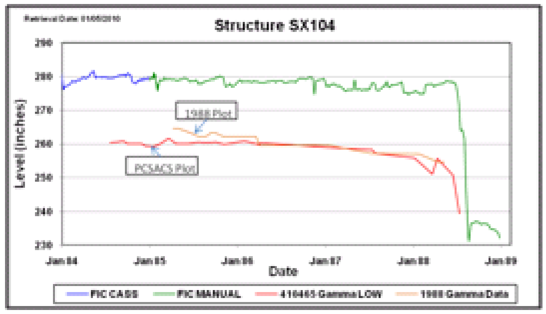


[1] RPP-RPT-[illegible] Rev. [illegible], "Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks," [illegible]

Page 12

Hand-Calculated vs. Machine-Calculated Gamma Interstitial Liquid Level 1984 – 1988

- ***In 1988 the inflection point for the ILL was still calculated by hand.***
  - *This required the use of judgment, and probably increased the variability among the individual logs.*
- ***The PCSACS plots now use software to select the inflection point for the gamma logs.***
- ***The 1988 hand calculations skew the ILL high in the early portion of the evaluation period. This created an artificial drop in the ILL that is not present in the PCSACS-generated ILL curve.***

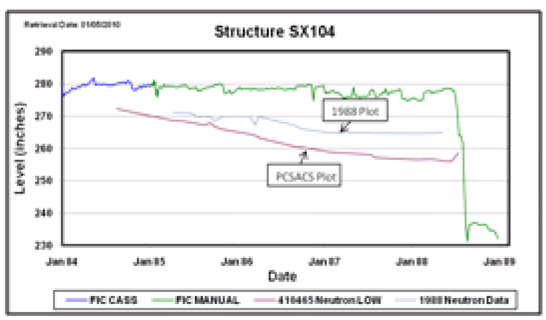


Comparison of hand-calculated gamma ILL plot ("1988 Plot") with the Personal Computer Surveillance Analysis Computer System (PCSACS) software-generated gamma ILL plot using log data from 1988 Leak Evaluation.

Page 13

Hand Calculated vs. Machine Calculated Neutron Interstitial Liquid Level 1984 – 1988

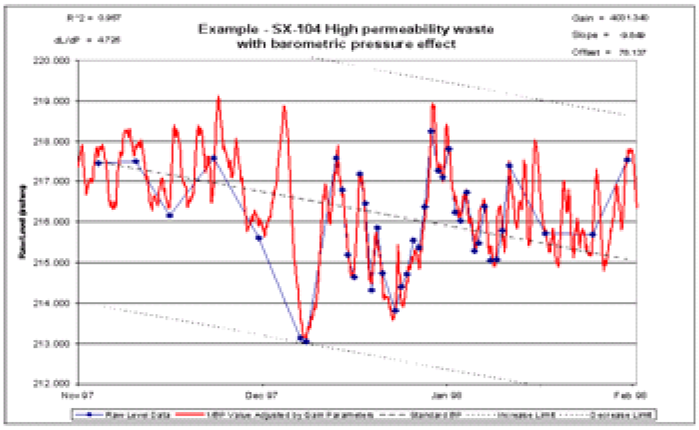
- ***Hand-calculated neutron ILLs show a bias similar to the gamma ILLs.***
  - *Latent presentation of the secondary feature probably influenced both gamma and neutron ILL hand calculations.*
  - *Neutron ILLs are influenced by installation water to a greater degree than gamma ILLs, so hand- and machine-calculated neutron ILLs show greater divergence.*



Comparison of hand-calculated neutron ILL plot ("1988 Plot") with the Personal Computer Surveillance Analysis Computer System (PCSACS) software-generated neutron ILL plot using log data from 1988 Leak Evaluation.

Page 14

1998 Interstitial Liquid Level Complications - Barometric Response



- *Tank SX-104 holds waste with gas-retaining properties created from 242-S Evaporator/Crystallizer partial neutralization (acid-injection campaigns).*
- *This waste caused tank A-103 to be mistakenly declared an 'assumed leaker,' and was implicated in burping tank SY-101.*

Page 15

Tank SX-104 Leak – No-Leak Hypotheses

- ***Leak Hypothesis:***

  "The decrease in tank SX-104 interstitial liquid level between 1984 and 1988 was caused by a leak from the tank."

- ***No-Leak Hypothesis:***

  "The decrease in Tank SX-104 interstitial liquid level between 1984 and 1988 was caused by evaporation, possibly complicated by redistribution of liquid observation well installation water."

Page 16

Tank SX-104 Leak Assessment Variables (I) – Evaporation Rate

- 1984 – 1988 ILL decrease equivalent to ~ 34 gallons/week
  - 1988 Leak Evaluation showed 20 cfm ventilation rate could evaporate 51 gallons/week
  - 1994 study assumed 60 cfm and 1% - 3% free surface area equivalent to 17 – 40 gallons/week
    - 1984 photo suggest 15% - 20% liquid surface area available for evaporation
  - 2000 passive breathing rate measured as 30 cfm
    - Waste ~ 55°F cooler than in 1988
    - No forced ventilation
- Range of credible airflow rates can account for 34 gal/week ILL decrease

Page 17

Tank SX-104 Leak Assessment Variables (II) – Interstitial Liquid Level Interpretation

- Water used in 1984 LOW installation camouflaged ILL secondary feature
  - In 1984 - 1988 hand-calculation and judgment were used to select neutron ILL inflection points
    - Interpretation introduced variability
    - Cross-talk between primary (installation water) and secondary (true) ILL features resulted in false interpretations
    - Significance of ILL secondary feature not recognized in 1988
  - Misunderstood gas retention characteristics of waste form increased interpretation uncertainty

Page 18

Tank SX-104 Leak Assessment Variables (III) – Drywell Data

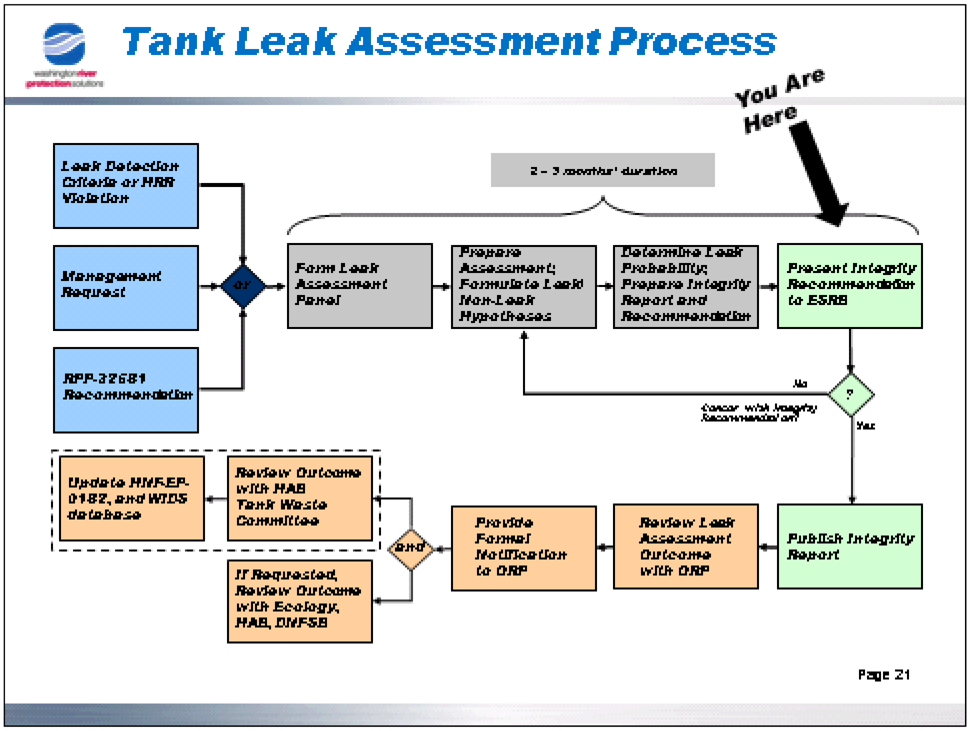
- No external evidence of leakage
  - 1988 Leak Evaluation concluded no change in drywells above background
  - Identical conclusions reached by independent groups in 1995, 1998, 2008, and 2010

Page 19

Leak Assessment Conclusion and Recommendation

- Conclusion: The No-Leak hypothesis is most likely explanation for the 1984 – 1988 interstitial liquid level decrease.
- Recommendation: Change tank SX-104 leak integrity status from "Assumed Leaker" to "Sound"
- Post-ESRB Review Actions:
  - Review leak assessment outcome with DOE-ORP and Washington State Department of Ecology
  - Brief Hanford Advisory Board Tank Waste Committee, if requested

Page 20


Tank Leak Assessment Process
You Are Here
2 – 3 months' duration
Leak Detection Criteria or MRR Violation
Management Request
RPP-32681 Recommendation
or
Form Leak Assessment Panel
Prepare Assessment; Formulate Leak/ Non-Leak Hypotheses
Determine Leak Probability; Prepare Integrity Report and Recommendation
Present Integrity Recommendation to ESRB
?
No
Yes
Publish Integrity Report
Review Leak Assessment Outcome with ORP
Provide Formal Notification to ORP
and
Review Outcome with HAB Tank Waste Committee
Update HNF-EP-0182, and WIDS database
If Requested, Review Outcome with Ecology, HAB, DNFSB
Page 21